UGC

UGC MODEL CURRICULUM

PHYSICS

UNIVERSITY GRANTS COMMISSION
NEW DELHI
2001

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FOREWORD

Renewing and updating of the Curriculum is the essential ingredient of any vibrant university academic system. There ought to be a dynamic Curriculum with necessary additions and changes introduced in it from time to time by the respective university with a prime objective to maintain updated Curriculum and also providing therein inputs to take care of fast paced development in the knowledge of the subject concerned. Revising the Curriculum should be a continuous process to provide an updated education to the students at large.

Leaving a few, there have been many universities where this exercise has not been done for years together and it is not uncommon to find universities maintaining, practicing and teaching still on the Curriculum as old as few years or even more than a decade. Not going through the reasons for this inertia, the University Grants Commission, realising the need in this context and in relevance to its mandate of coordinating and maintaining standard of higher education, decided to adopt a pro-active role to facilitate this change and to ensure that the university Curriculum are soon updated to provide a standard education all over the country.

Curriculum Development Committee for each subject was constituted with the respective Convenor as its nodal person. The Committee besides having five subject experts drawn from the university system, was given a wider representation of various sub subject experts attending meetings of the Committee as the esteemed co-opted members which kept on changing from time to time as the need arose. The Committees, therefore, had representations from a large number of experts and had many meetings before final updated Model Curricula were presented to UGC.

The University Grants Commission and I as its Chairman are grateful to the nodal persons, a large number of permanent and co-opted members in different subjects and their sub disciplines for having worked seriously with committed devotion to have produced a UGC Model Curriculum in 32 subjects within a record period of 18 months.

The exercise would not have been possible without the support of our entire academic community. We can only hope that the results will fulfil their expectations and also those of university community and Indian society.

The UGC Model Curriculum has been produced to take care of the lacuna, defects/ shortcomings in the existing Curricula in certain universities, to develop a new Model Curriculum aiming to produce the one which is compatible in tune with recent development in the subject, to introduce innovative concepts, to provide a multi disciplinary profile and to allow a flexible cafeteria like approach including initiating new papers to cater to frontier development in the concerned subject.

The recommendations have been compiled by panels of experts drawn from across the country. They have attempted to combine the practical requirements of teaching in the Indian academic context with the need to observe high standards to provide knowledge in the frontier areas of their disciplines. It has also been aimed to combine the goals and parameters of global knowledge with pride in the Indian heritage and Indian contribution in this context.

Today all knowledge is interdisciplinary. This has been duly considered. Flexible and interactive models have been presented for the universities to extend them further as they would like. Each institution may have to work out certain uniform structures for courses at the same level, so that effective interaction between subjects and faculties is possible. The tendency across the country is now to move from the annual to the semester system, and from award of marks to award of credits. There is perceptible growing interest in modular framing as well.

The recommendations while taking all these features into account, have also made provisions for institutions who may not be in a position to undertake radical structural reform immediately. In any country, especially one as large and varied as India, academic institutions must be allowed enough autonomy and freedom of action to frame courses according to specific needs. The recommendations of the Curriculum Development Committees are meant to reinforce this. The purpose of our exercise has been to provide a broad common framework for exchange, mobility and free dialogue across the entire Indian academic community. These recommendations are made in a spirit of openness and continuous improvement.

To meet the need and requirement of the society and in order to enhance the quality and standards of education, updating and restructuring of the curriculum must continue as a perpetual process. Accordingly, the University Grants Commission constituted the Curriculum Development Committees. If you need to seek any clarification, you may contact Dr. (Mrs.) Renu Batra, UGC Deputy Secretary and Coordinator of CDC who shall accordingly respond to you after due consultation with the respective nodal person of the concerned subject.

The University Grants Commission feels immense pleasure in forwarding this Model Curriculum to the Hon'ble Registrars of all Universities with a request to get its copies made to be forwarded also to the concerned Deans and Heads of Departments requesting them to initiate an early action to get their Curriculum updated. The University Grants Commission Model Curricula is being presented to the Registrar of the university with **options** either to adopt it in toto or adopt it after making necessary amendments or to adopt it after necessary deletion/ addition or to adopt it after making any change whatsoever which the university may consider right. This UGC Model Curriculum has been provided to the universities only to serve as a base and to facilitate the whole exercise of updating the Curriculum soon.

May I request Hon'ble Vice Chancellor and the Hon'ble Registrar including the esteemed Deans, Heads of Departments, Members of the Faculty, Board of Studies and Academic Council of the Universities to kindly update their Curriculum in each of the 32 subjects in consultation with Model Curriculum provided here. This has to be done and must be done soon. May I request the Academic administration of the universities to kindly process it immediately so that an updated Curriculum is adopted by the university latest by July, 2002.

The University Grants Commission requests the Hon'ble Registrars to confirm that this time bound exercise has been done and send a copy of the university's updated Curriculum in each subject to UGC by July 31, 2002. It is a must. It has to be done timely, failing which, the UGC may be forced to take an appropriate unpleasant action against the concerned university.

The UGC looks forward for your active participation in this joint venture to improve the standards to achieve excellence in higher education.

December 2001

HARI GAUTAM
MS (SURGERY) FRCS (EDIN) FRCS (ENG)
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CHAIRMAN, UGC

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PREFACE

The University Grants Commission constituted the present Curriculum Development Committee (CDC) in October 2000 for framing the Curricula in Physics at the undergraduate and post graduate levels. In addition to updating the curricula as existing presently in the Universities, the UGC also set forth the task of bringing in new and innovative ideas/concepts so that the formulated model curricula in Physics becomes in tune with the changing scenarios and incorporate new and rapid advancements and multidisciplinary skills, societal relevance, global interface, self sustaining and supporting learning. The following forms the recommendations of the CDC at a glance. Detailed recommendation are given later:

RECOMMENDATIONS OF CDC AT A GLANCE

1. The undergraduate curriculum physics in the universities are of two different types. One of these is the so called B.Sc. (General), which in many universities is simply termed as B.Sc. and the other is labelled as B.Sc. (Physics), which is also categorized as B.Sc.(Hons) in Physics. Several of the Universities are following the former kind of physics undergraduate courses whereas others are adopting the latter type. The CDC has recommended that both types of courses should be taught in each university. Keeping this in view, both the types of undergraduate syllabi has been separately framed by the Committee.
2. The CDC has felt that students at undergraduate *i.e.* B.Sc. level besides grasping the basic concepts of physics should in addition have broader vision. Therefore, they should be exposed to societal interface of physics and role of physics in the development of technologies. In view of this, CDC has developed syllabi and recommended teaching of such courses as Science, Technology and Society, and Communications and Technical Skills.
3. The post graduate courses form final formal training in physics for the students and rigorous training would require phased teaching for its full decimation. The CDC has, therefore, recommended that for postgraduate *i.e.* M.Sc. semester system should be followed.
4. The curriculum development committee felt that for M.Sc. in order to impart teaching should be oriented so as to provide the student depth of knowledge in physics. In the light of this, the Committee has recommended that the regular class room teaching should be supplemented with tutorials (brainstorming ideas and problem solving efforts) pertaining to each theory and experimental/practical course.
5. The CDC has recommended that the M.Sc. students should venture albeit in a preliminary way into research field both in theory and experiment. In order to accomplish this research oriented "Project" paper which is compulsory, has been introduced in the final semester.
6. In addition to the state of the art specializations in Physics embodying Condensed Matter Physics, Nuclear and Particle Physics and Electronics, in order to keep pace with the present front line developments, the CDC has recommended and introduced a new specialization on 'Informatics'.
7. In order to have flexibility in curriculum and permit the students to shape their career as per their choice in the domain of physics, cafeteria approach has been followed. Each special paper is subdivided into two "Modules". Thus there are ten modules corresponding

to five special papers. A. M.Sc. student can opt for any four modules out of these ten modules in each of the III and IV Semesters.

8. The CDC has recommended another new feature for postgraduate teaching in physics. It has kept one paper in the final semester, as 'Elective Paper' where student will have the option of selecting any one out of a large number (as many as fifteen) of Elective Papers each of these being on a 'Frontier Topic in Physics'.

RECOMMENDATIONS OF CDC IN DETAIL

It will be opportune to mention that prior to the efforts of the present CDC in Physics there have been two earlier attempts for development/renovation of Physics curricula/ syllabi in Physics. One of these was the work on Curricula Development in Physics done in University of Pune during 1988-90. The report prepared was discussed in a subsequent CDC workshop held at University of Delhi held in December 1990. This monumental effort looked into various lacunae of existing syllabi, teaching methods, examination systems and admission procedures and came out with a comprehensive report on curriculum development in physics. Many of the suggestions and recommendations made by this Committee are valid even today and have been incorporated wherever relevant in the present effort on curriculum development in physics.

Another effort on curriculum development in physics was made by UGC sponsored Physics Panel CDC meeting at Banaras Hindu University, Physics Department during 1 and 2 Feb. 1999. In this meeting, chairmen of Board of Studies from different universities of the country participated. The earlier CDC report of 1989-90 as developed at Pune University was discussed in detail. The BHU meeting after extensive deliberations and discussions came to the conclusion that the B.Sc. theory syllabi as outlined in CDC syllabi in Physics (1989/90) were well prepared and needed only updating. But, it was felt that the laboratory/practical syllabi needed considerable revision bringing in modern and frontier experiments. As regards the M.Sc. syllabi, it was resolved at the BHU meeting that these needed a thorough revision and updating for both theory and practicals. As a consequence of the above conclusions of the BHU meeting, a model syllabi for M.Sc. Physics courses was developed based on the feedback from the participants from various universities.

The present Curriculum Development Committee in its several deliberations noted that several changes had taken place since the first attempt made in 1989-91 to formulate physics syllabi. The social perspectives and expectations have undergone a sea change during this period. The recommendations made in the first CDC report, therefore, need modifications. The present CDC Committee also perused and pondered over the recommendations and conclusions of the BHU : CDC committee in 1999 and made suitable and appropriate changes and brought in new required inputs. Based on the above said considerations, the present CDC made the following recommendations in the form of framework and detailed syllabi for undergraduate (B.Sc.) and post graduate (M.Sc.) courses.

(A) Undergraduate (B.Sc.) Frame work and Syllabi

These are divided into three parts (a) Common, (b) for B.Sc. (General), and (c) for B.Sc. (Physics).

(a) Common Recommendations

1. Every university should preferably run both B.Sc. (General or Pass) and B.Sc. (Physics or Honours), as three-year degree courses after standard XII.
2. B.Sc. (General) student will study three science subjects at equal footing plus some other components such as Science Communication, Science and Society etc.
3. B.Sc. (Physics) curriculum is meant for motivated students who wish to pursue Physics further.

(b) Recommendations for B.Sc. (General)

1. The combinations of three subjects, which the students can opt for will be decided by each university.
2. The student would take three courses in each of his three science subjects plus one course from other components, every year, making a total of 10 courses per year.
3. Each course will have 3 hours of teaching per week, making a total of 30 contact hours per week.
4. Among the 3 courses in Physics every year, two shall be for Theory and one for Laboratory Practicals.
5. This gives 90 hours for each course with 30 weeks of teaching every year.
6. Thus in the three years of the degree course, the student will study 9 courses in Physics, of which there will be 6 Theory Courses and 3 Laboratory Practicals.

(c) Recommendations for B.Sc. (Physics)

1. The student registering for this course will study Physics as a major component (about 54%), two ancillary or supporting subjects, Mathematics (25%) and Chemistry (about 8.3%), and Other Components such as Communication skills, science and society, history of physics etc (about 12.5%).
2. The contents of the ancillary subjects and other components will be decided by the Physics Community in consultation with experts of relevant subjects.

3. The student will study 8 courses every year, with 4 contact hours of teaching per week for each course, giving 120 hours per course spread over 30 weeks of teaching, and 32 contact hours per week for all the 8 courses together.
4. Tutorials should be introduced in both Theory and Laboratory. Theory tutorials should supplement classroom teaching and should contain problem solving, assignments, etc. Laboratory Tutorials should supplement Laboratory Practicals and should contain variations or extensions of experiments, history of experiments, error analysis, computer simulations, etc.
5. In every course, theory and corresponding practicals should go together. The experiments should be related to the theory content.
6. It is also recommended that there should be 1:1 ratio between theory and practicals, including their respective tutorials. Theory to Tutorial ratio, as well as Laboratory to Lab Tutorial ratio should be 3:1.
7. The four components in each course which are Theory, Theory Tutorials, Laboratory and Lab Tutorials, should be merged together in each course, and there should be a common thread running through these components defined by the course title. The 120 hours available for each course will be divided among the four components of teaching as follows:

Theory	Theory Tutorials	Laboratory	Lab Tutorials
45	15	45	15

B.SC. (GENERAL)

The student will study three subjects with equal weightage in all the three years, along with supporting subjects such as a course on Science, Technology and Society, one or two on Languages etc. The course structure for the three years is suggested in Table 1.

Table 1: Course pattern for B.Sc. (General)

	Sub 1	Sub 2	Sub 3	Other Components
Ist year	3	3	3	1
IInd year	3	3	3	1
IIIrd year	3	3	3	1

Notes: Each course shall have three contact hours per week for B.Sc. (Gen). Out of the 3 courses for Physics every year, two shall be devoted to theory and one for laboratory.

The Physics courses shall be as in Table 2.

Table 2: Physics Courses in B.Sc. (General)

Year	Course	Title of the course
I	1	Mechanics, Oscillations and Properties of Matter
	2	Electricity, Magnetism and Electromagnetic theory
	3	Laboratory I
II	4	Kinetic Theory, Thermodynamics and Statistical Physics
	5	Waves, Acoustics and Optics
	6	Laboratory II
III	7	Relativity, Quantum Mechanics, Atomic, Molecular and Nuclear Physics
	8	Solid State Physics, Solid State Devices and Electronics
	9	Laboratory III

B.SC. (PHYSICS/HONOURS)

The Course structure is summarized in Table 3.

Table 3: Course Pattern for B.Sc. (Physics)

	Physics	Maths	Chemistry	Other Components
Ist year	3	3	1	1
IInd year	4	2	1	1
IIIrd year	6	1	1	

Notes:

1. This envisages that a student takes 8 courses per year, in all subjects together.
2. Each course will have 4 contact hours per week, including theory, laboratory, and tutorials for both.
3. Considering 30 weeks of teaching, this means that each course will be with 120 contact hours, including all components.
4. It is recommended that the distribution of contact hours for the four components should be in the following ratio:

Theory	Theory Tutorial	Laboratory	Lab Tutorial
3	1	3	1

The titles of the courses will be as in the Tables 4 (Physics), 5 (Mathematics), 6 (Chemistry), and 7 (other components)

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Table 4: Physics Courses in B.Sc. (Physics)

Year	Course No	Title
I	P1	Mechanics of Particles, Rigid Bodies and Continuous Media
	P2	Kinetic Theory, Thermodynamics and Statistical Physics
	P3	Oscillations, Waves and Acoustics
II	P4	Electricity and Magnetism
	P5	Electronics
	P6	Optics
	P7	Quantum Mechanics
III	P8	Atomic and Molecular Physics
	P9	Solid State Physics and Solid State Devices
	P10	Electrodynamics, Electromagnetic Waves and Relativity
	P11	Nuclear and Particle Physics
	P12	Elective
	P13	Project

Table 5: Mathematics Courses in B.Sc. (Physics)

Year	Course No	Title
1.	M1	Vectors, Matrices, Complex numbers and Probability
	M2	Coordinate Systems, Analytical Geometry and Calculus
	M3	Computer Programming, Multivariable Calculus and Differential Equations
II	M4	Probability distributions, Modern Algebra and Vector Calculus
	M5	Computer Programming, Special Functions and Functions of Complex variables
III	M6	Statistics, Integral Transforms, and Elements of Analysis.

Table 6: Chemistry Courses in B.Sc. (Physics)

Year	Course No.	Title
I	C1	Chemistry I
II	C2	Chemistry II

Table 7: Other Components in B.Sc. (Physics)

Year	Course No.	Title
I	S1	Language
II	S2	Science, Technology and Society
III	S 3	Communication and Technical skills

(B) Postgraduate (M.Sc.) Frame work and Syllabi

For the postgraduate (M.Sc.) syllabus, the Committee came to the conclusion that the Universities should follow semester system. The committee felt that in order to impart teaching where the student would achieve depth of knowledge, it is essential to supplement the class room teaching of the regular syllabus with tutorials pertaining to each theory paper. These tutorials will consist of exploration of brainstorming ideas and problems associated with specific topics of the relevant papers. Similarly for development of experimental skills for maintenance of sophisticated equipments, designing new experiments and developing devices based on regular experiments, tutorials have been introduced associated with all the lab/practical courses. For students to adventure into preliminary research field both in theory and experiment the concept of project has been introduced in the final semester. In the project, the student will explore new developments from books and journals collecting literature/data and write a dissertation based on his work and studies.

It is recommended that there will be 30 clock hours/periods per week and since there will be 13 weeks available per semester, the total number of clock hours/periods available for teaching will be 390. Out of these there will be 232 hours/periods for theory teaching [45 clock hours/periods for each of the proposed four theory papers (total 180 hours/periods) and one hour of tutorial for each paper per week making a total of 52 hours/period for tutorials for theory papers]. The remaining 158 hours/periods will be devoted to lab./practical courses. These will include two hours/periods per week for lab./practical tutorial courses. Thus there will be 26 tutorial hours/periods for each lab./practical course.

In the first and second semesters four core papers/courses in theory (total of 8 papers/courses) will be taught. Each paper/course will be accompanied by tutorials. There will be lab. courses in both the first and second semesters, which will again be accompanied by corresponding tutorials.

In the third semester, there will be two core papers and two special papers. The fourth semester will have one core paper, an elective paper, and two special papers. Each special paper will consist of two modules. The modular system has been introduced so as to provide 'cafeteria' like approach to students where they can have the choice to frame their career in the desired time schedule. The special papers will be from any of the specialization of Physics. In order to keep pace with the developments in the fast developing Information and communication technologies and to bring out the relevance of physics towards these technologies, in addition to the specialization of Condensed Matter Physics, Electronics, Atomic and Molecular Physics and Subatomic Physics (Nuclear and Particle), a new specialization on 'Informatics' has been added. It is hoped that this specialization will provide flavour of physics relevant to the Information Technology. In this field, India is already a leading player. It will provide a rapid access to education and new vistas in newer modes of instruction including distance education. Thus there will be 10 papers or 20 modules in each specialization in each of the third and fourth

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semesters. A student should opt for any 4 modules in semesters third and fourth each. The third semester will have special lab. course together with tutorials. The fourth semester will instead of lab./practical course will have project.

The various core, elective and special papers are listed below :

Semester I	**Marks**
Mathematical Physics	100
Classical Mechanics	100
Quantum Mechanics I	100
Electronic Devices	100
Lab. Course : Practicals	200
Semester II	
Quantum Mechanics II	100
Statistical Mechanics	100
Electrodynamics and Plasma Physics	100
Atomic and Molecular Physics	100
Lab. Course : Practicals	200
Semester III	
Condensed Matter Physics	100
Nuclear and Particle Physics	100
Special Paper I	100
Special Paper II	100
Lab. Course : Practicals	200
Semester IV	
Computational Methods and Programming	100
Elective Paper	100
Special Paper III	100
Special Paper IV	100
Projects	200

ANNEXURE

CURRICULUM DEVELOPMENT COMMITTEE IN PHYSICS UNIVERSITY GRANTS COMMISSION, NEW DELHI

Members who contributed to the framing of the Recommended Syllabi

a. UGC-CDC Committee Members (1989-90, University of Pune, Pune)

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36. Dr. Ratnabala Banerjee (Ex-Secretary, CDC, Education Officer, UGC, New Delhi)
37. Sri S.P. Sachdeva (Secretary CDC, Under Secretary UGC, New Delhi)

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Omkar Nath Srivastava

December, 2001

(O.N. Srivastava)
Convenor and Nodal Person
UGC-CDC in Physics

PREAMBLE

The initial work on Curriculum Development in Physics was done in University of Pune during 1988-90. A large number of experts from all over the country were involved in the deliberations which resulted in a Report on undergraduate and M.Sc. model curriculum. If one looks at this Report, it is clear that a large amount of brainstorming and thinking has gone into it. Some very far-reaching suggestions were made which are valid even today.

The major recommendations were that (a) Both B.Sc. (General) and B.Sc. (Physics) degree programmes should be run by each university; (b) Laboratory teaching should be integrated with theory teaching; (c) Theory Tutorials and Laboratory Tutorials should be introduced as additional components for each course, all components to be merged into the same course; (d) The Lab experiments should be innovative, open-ended, and dynamic, so that a Centre would be free to introduce additional experiments at the same level. The theory Tutorials and Lab Tutorials were suggested in great details. This way, every course, for example, electromagnetism, optics, or any other, would form a whole course, together with classroom lectures, lab experiments, classroom tutorials and lab tutorials. Even courses on computer languages, and simulation type of experiments for courses such as quantum mechanics, statistical mechanics, and mathematics were suggested as long as 12 years ago.

The earlier CDC Committee also noted that when subjects like Physics, Chemistry, Mathematics are taught separately and independently, there is a good deal of overlap in the course material. The Committee carefully examined the syllabi of Chemistry and Mathematics and tried to avoid this overlap. Therefore the Committee recommended that a student registering himself for the B.Sc. (Physics/Honours) degree programme, should be treated as a student of Physics for all the three years. The bifurcation of subjects such as B.Sc. (Physics), B.Sc. (Chemistry), B.Sc. (Zoology) etc, will thus take place right at the first year of the university. A student will decide after his HSC whether he wants to go for the three-subject B.Sc. (General) or the one-subject B.Sc. (Honours), and if the latter, which subject he wants to choose.

In the B.Sc. (Physics) curriculum therefore, we have also proposed the syllabi of the ancillary subjects, such as Chemistry, Mathematics, Humanities, etc. We have also provided optional papers at the Third Year level. These courses will include application-oriented courses as well as advanced physics courses, such as biophysics, soil physics, materials science, computational physics, advanced quantum mechanics, nonlinear dynamics, etc. The B.Sc (Physics) programme is thus an ambitious programme, intended for selected and motivated students who are really interested in pursuing careers in Physics or taking up Physics-related

jobs. It is hoped that we will be able to produce good B.Sc. (Physics) students if this programme is implemented.

It is more than a decade since these recommendations were made. Social perspectives and expectations have undergone a sea of change during this period. The present Committee is aware that UG and PG teaching must be made more relevant to the new and emerging scenario. The recommendations made in the earlier CDC Report (brought out by UGC in 1991) have been suitably modified. The present Committee has maintained the basic structure proposed by the earlier Committee. The main proposals of this Report are summarized below, followed by detailed syllabi.

Recommendations

These are divided into three parts (a) Common, (b) for B.Sc. (General), and (c) for B.Sc. (Physics).

(a) Common Recommendations

Every university should preferably run both B.Sc. (General or Pass) and B.Sc. (Physics or Honours), as three-year degree courses after standard XII.

B.Sc. (General) student will study three science subjects at equal footing plus some other components such as Science Communication, Science and Society etc.

B.Sc. (Physics) curriculum is meant for motivated students who wish to pursue Physics further.

(b) Recommendations for B.Sc. (General)

The combinations of three subjects, which the students can opt for will be decided by each university.

The student would take three courses in each of his three science subjects plus one course from other components, every year, making a total of 10 courses per year.

Each course will have 3 hours of teaching per week, making a total of 30 contact hours per week.

Among the 3 courses in Physics every year, two shall be for Theory and one for Laboratory Practicals.

This gives 90 hours for each course with 30 weeks of teaching every year.

Thus in the three years of the degree course, the student will study 9 courses in Physics, of which there will be 6 Theory Courses and 3 Laboratory Practicals.

(c) Recommendations for B.Sc. (Physics)

The student registering for this course will study of Physics as a major component (about 54%), two ancillary or supporting subjects, Mathematics (25%) and Chemistry (about 8.3%), and Other Components such as Communication skills, science and society, history of physics etc (about 12.5%).

The contents of the ancillary subjects and other components will be decided by the Physics Community in consultation with experts of relevant subjects.

The student will study 8 courses every year, with 4 contact hours of teaching per week for each course, giving 120 hours per course spread over 30 weeks of teaching, and 32 contact hours per week for all the 8 courses together.

Tutorials should be introduced in both Theory and Laboratory. Theory tutorials should supplement classroom teaching and should contain problem solving, assignments, etc. Laboratory Tutorials should supplement Laboratory Practicals and should contain variations or extensions of experiments, history of experiments, error analysis, computer simulations, etc.

In every course, theory and corresponding practicals should go together. The experiments should be related to the theory content.

It is also recommended that there should be 1:1 ratio between theory and practicals, including their respective tutorials. Theory to Tutorial ratio, as well as Laboratory to Lab Tutorial ratio should be 3:1.

The four components in each course which are Theory, Theory Tutorials, Laboratory and Lab Tutorials, should be merged together in each course, and there should be a common thread running through these components defined by the course title. The 120 hours available for each course will be divided among the four components of teaching as follows:

Theory	Theory Tutorials	Laboratory	Lab Tutorials
45	15	45	15

B.SC. (GENERAL)

The student will study three subjects with equal weightage in all the three years, along with supporting subjects such as a course on Science, Technology and Society, one or two on Languages etc. The course structure for the three years is suggested in Table 1.

Table 1: Course pattern for B.Sc. (General)

	Sub 1	Sub 2	Sub 3	Other Components
Ist year	3	3	3	1
IInd year	3	3	3	1
IIIrd year	3	3	3	1

Notes: Each course shall have three contact hours per week for B.Sc. (Gen). Out of the 3 courses for Physics every year, two shall be devoted to theory and one for laboratory.

The Physics courses shall be as in Table 2.

Table 2: Physics Courses in B.Sc. (General)

Year	Course	Title of the course
I	1	Mechanics, Oscillations and Properties of Matter
	2	Electricity, Magnetism and Electromagnetic theory
	3	Laboratory I
II	4	Kinetic Theory, Thermodynamics and Statistical Physics
	5	Waves, Acoustics and Optics
	6	Laboratory II
III	7	Relativity, Quantum Mechanics, Atomic, Molecular and Nuclear Physics
	8	Solid State Physics, Solid State Devices and Electronics
	9	Laboratory III

The course contents will be as under

Course 1: MECHANICS, OSCILLATIONS AND PROPERTIES OF MATTER

1.1 Mechanics (30):

Laws of motion, motion in a uniform field, components of velocity and acceleration in different coordinate systems. Uniformly rotating frame, centripetal acceleration, Coriolis force and its applications. (5)

Motion under a central force, Kepler's law. Gravitational law and field. Potential due to a spherical body, Gauss and Poisson equations for gravitational self-energy. (7)

System of particles, center of mass, equation of motion, conservation of linear and angular momenta, conservation of energy, single-stage and multistage rockets, elastic and inelastic collisions. (8)

Rigid body motion, rotational motion, moments of inertia and their products, principal moments and axes. Euler's equations. (10)

1.2 Oscillations (25):

Potential well and periodic oscillations, case of harmonic oscillations, differential equation and its solution, kinetic and potential energy, examples of simple harmonic oscillations, spring and mass system, simple and compound pendulum, torsional pendulum, bifilar oscillations, Helmholtz resonator, LC circuit, vibrations of a magnet, oscillations of two masses connected by a spring. (10)

Superposition of two simple harmonic motions of the same frequency along the same line, interference, superposition of two mutually perpendicular simple harmonic vibrations of the same frequency, Lissajous figures, case of different frequencies. (5)

Two coupled oscillators, normal modes, N coupled oscillators, damped harmonic oscillators, power dissipation, quality factor, examples, driven harmonic oscillator, transient and steady states, power absorption, resonance in systems with many degrees of freedom. (10)

1.3 Motion of charged particles in electric and magnetic fields (15)

(Note: The emphasis here should be on the mechanical aspects and not on the details of the apparatus mentioned, which are indicated as applications of principles involved.)

E as an accelerating field, electron gun, case of discharge tube; linear accelerator. **E** as deflecting field – CRO, sensitivity, fast CRO. (4)

Transverse **B** field; 180^{0} deflection, mass spectrograph or velocity selector, curvatures of tracks for energy determination for nuclear particles; principle of a cyclotron. (4)

Mutually perpendicular **E** and **B** fields – velocity selector, its resolution. (2)

Parallel **E** and **B** fields; positive ray parabolas, discovery of isotopes, elements of mass spectrography, principle of magnetic focusing (lens). (3)

1.4 Properties of matter (20)

Elasticity, small deformations, Hooke's law, elastic constants for an isotropic solid, beams supported at both the ends, cantilever, torsion of a cylinder, bending moments and shearing forces. (7)

Kinematics of moving fluids, equations of continuity, Euler's equation, Bernaulli's theorm, viscous fluids, streamline and turbulent flow. Poiseulle's law. Capillary tube flow, Reynold's number, Stokes law. (8)

Surface tension and surface energy, molecular interpretation of surface tension, pressure on a curved liquids surface, wetting. (5)

Text and Reference Books

E M Purcell, Ed: "Berkeley Physics Course, Vol. 1, Mechnics" (McGraw-Hill).

R P Feymman, R B Lighton and M Sands; "The Feymman Lectures in Physics", Vol. 1

(B I Publications, Bombay, Delhi, Calcutta, Madras).

D P Khandelwal; "Oscillations and Waves" (Himalaya Publishing House, Bombay).

R K Ghosh; "The Mathematics of Waves and Vibrations" (Macmillan 1975).

Course 2: ELECTRICITY, MAGNETISM AND ELECTROMAGNETIC THEORY

2.1 Mathematical Background

Scalars and vectors, dot and cross products, triple vector product, gradient of a scalar field and its geometrical interpretation, divergence and curl of a vector field, line, surface and volume integrals, flux of a vector field, Gauss's divergence theorem, Green's theorem and Stokes theorem. (7)

Functions of two and three variables, partial derivatives, geometrical interpretation of partial derivatives of functions of two variables. Total differential of a function of two and three variables, higher order derivatives, applications. (6)

Repeated integrals of a function of more than one variables, definition of a double and a triple integral, evaluation of double and triple integrals as repeated integrals, change of variables of integration, Jacobian applications. (7)

2.2 Electrostatics (30)

Coulombs law in vacuum expressed in vector forms, calculations of **E** for simple distributions of charged at rest, dipole and quadrupole fields. (8)

Work done on a charge in an electrostatic field expressed as a line integral, conservative nature of the electrostatic field. Electric potential ϕ, $\mathbf{E} = -\nabla\phi$, torque on a dipole in a uniform electric field and its energy, flux of the electric field, Gauss's law and its application for finding **E** for symmetric charge distributions, Gaussian pillbox, fields at the surface of a conductor. Screening of **E** field by a conductor, capacitors, electrostatic field energy, force per unit area of the surface of a conductor in an electric field, conducting sphere in a uniform electric field, point charge in front of a grounded infinite conductor. (12)

Dielectrics, parallel plate capacitor with a dielectric, dielectric constant, polarization and polarization vector, displacement vector **D**, molecular interpretation of Claussius-Mossotti equation, boundary conditions satisfied by **E** and **D** at the interface between two homogenous dielectrics, illustration through a simple example. (10)

2.3 Electric Currents (steady and alternating) (10)

Steady current, current density **J**, non-steady currents and continuity equation, Kirchoff's law and analysis of multiloop circuits, rise and decay of current in LR and CR circuits, decay constants, transients in LCR circuits, AC circuits, complex numbers and their applications in solving AC circuit problems, complex impedance and reactance, series and parallel resonance,

Q factor, power consumed by an AC circuit, power factor, Y and Δ networks and transmission of electric power.

2.4 Magnetomstatics (10)

Force on a moving charge; Lorentz force equation and definition of **B**, force on a straight conductor carrying current in a uniform magnetic field, torque on a current loop, magnetic dipole moment, angular momentum and gyromagnetic ratio.

Biot and Savart's Law, calculation of **H** order in simple geometrical situations, Ampere's Law $\nabla.\mathbf{B} = 0$, $\nabla \times \mathbf{B} = \mu_o \mathbf{J}$, field due to a magnetic dipole, magnetization current, magnetization vector, Half order field, magnetic permeability (linear cases), interpretation of a bar magnet as a surface distribution of solenoidal current.

2.5 Time Varying Fields (10)

Electromagnetic induction, Faraday's law, electromotive force, $\mathcal{E} = \int \mathbf{E}.\mathbf{dr}$, integral and differential forms of Faraday's law, mutual and self inductance, transformers, energy in a static magnetic field. Maxwell's displacement current, Maxwell's equations, electromagnetic field energy density. (10)

2.6 Electromagnetic Waves (10)

The wave equation satisfied by **E** and **B**, plane electromagnetic waves in vacuum, Poynting's vector, reflection at a plane boundary of dielectrics, polarization by reflection and total internal reflection, Faraday effect, waves in a conducting medium, reflection and refraction by the ionosphere. (10)

Text and Reference Books

Berkeley Physics Course; Electricity and Magnetism, Ed. E.M. Purcell (McGraw-Hill).

Halliday and Resnik; "Physics", Vol 2.

D J Griffith; "Introduction to Electrodynamics" (Prentice-Hall of India).

Reitz and Milford; "Electricity and Magnetism (Addison-Wesley)

A S Mahajan and A A Rangwala; "Electricity and Magnetism" (Tata McGraw-Hill).

A M Portis; "Electromagnetic Fields".

Pugh and Pugh; "Principles of Electricity and Magnetism" (Addison-Welsley).

Panofsky and Phillips; "Classical Electricity and Magnetism" (India Book House).

S S Atwood; "Electricity and Magnetism" (Dover).

Course 3: LABORATORY I

3.1 Mechanics, Oscillations and Properties of Matter

3.1.1 Mechanics

1. Study of laws of parallel and perpendicular axes for moment of inertia.
2. Study of conservation of momentum in two dimensional oscillations.

3.1.2 Oscillations

1. Study of a compound pendulum
2. Study of damping of a bar pendulum under various mechanics
3. Study of oscillations under a bifilar suspension
4. Potential energy curves of a 1-Double system and oscillations in it for various amplitudes
5. Study of oscillations of a mass under different combinations of springs

3.1.3 Properties of Matter

1. Study of bending of a cantilever or a beam
2. Study of torsion of a wire (static and dynamic methods)
3. Study of flow of liquids through capillaries
4. Determination of surface tension of a liquid by different methods
5. Study of viscosity of a fluid by different methods

3.2 Electricity, Magnetism and Electromagnetic Theory

3.2.1 Electrostatics

1. Characteristics of a ballistic galvanometer
2. Setting up and using an electroscope or electrometer

3.2.2 Moving Charges and Magnetostatics

1. Use of a vibration magnetometer to study a field
2. Study of B field due to a current
3. Measurement of low resistance by Carey-Foster bridge or otherwise
4. Measurement of inductance using impedance at different frequencies

5. Measurement of capacitance using impedance at different frequencies
6. Study of decay of currents in LR and RC circuits
7. Response curve for LCR circuit and resonance frequency and quality factor

3.2.3 Varying Fields and Electromagnetic Theory

1. Sensitivity of a cathode-ray oscilloscope
2. Characteristics of a choke
3. Measurement of inductance
4. Study of Lorentz force
5. Study of discrete and continuous LC transmission lines

3.3 Computer Programming I

1. Elementary Fortran programs, flowcharts and their interpretation
2. To print out all natural even/odd numbers between given limits
3. To find maximum, minimum and range of a given set of numbers
4. To compile a frequency distribution and evaluate moments such as mean; standard deviation etc.
5. To evaluate sum of finite series and the area under a curve
6. To find the product of two matrices
7. To find a set of prime numbers and Fibonacci series
8. Motion of a projective using computer simulation
9. Numerical solution of equation of motion
10. Motion of particle in a central force field
11. To find the roots of a quadratic equation

Text and Reference Books

B Saraf et al; "Mechanical Systems" (Vikas Publishing House, New Delhi)

D P Khandelwal; "A Laboratory Manual of Physics for Undergraduate Classes" (Vani Publication House, New Delhi)

C G Lambe; "Elements of Statistics" (Longmans Green and Co. London, New York, Toronto)

C Dixon; "Numerical Analysis"

S Lipsdutz and A Poe; "Schaum's Outline of Theory and Problems of Programming with Fortran " (McGraw-Hill Book Company, Singapore 1986)

Course 4: KINETIC THEORY, THERMODYNAMICS AND STATISTICAL PHYSICS

4.1 KINETIC THEORY OF MATTER (25)

Ideal Gas: Kinetic model, deduction of Boyle's law, interpretation of temperature, estimation of rms speeds of molecules. Brownian motion, estimate of the Avogadro number. Equipartition of energy, specific heat of monatomic gas, extension to di- and triatomic gases, Behaviour at low temperatures. Adiabatic expansion of an ideal gas, applications to atmospheric physics. (7)

Real Gas: Van der Waals gas, equation of state, nature of Van der Waals forces, comparison with experimental P-V curves. The critical constants, gas and vapour. Joule expansion of ideal gas, and of a Van der Waals gas, Joule coefficient, estimates of J-T cooling. (6)

Liquifaction of gases: Boyle temperature and inversion temperature. Principle of regenerative cooling and of cascade cooling, liquifaction of hydrogen and helium. Refrigeration cycles, meaning of efficiency. (5)

Transport phenomena in gases: Molecular collisions, mean free path and collision cross sections. Estimates of molecular diameter and mean free path. Transport of mass, momentum and energy and interrelationship, dependence on temperature and pressure. (7)

4.2 THERMODYNAMICS (25)

The laws of thermodynamics: The Zeroth law, various indicator diagrams, work done by and on the system, first law of thermodynamics, internal energy as a state function and other applications. Reversible and irreversible changes, Carnot cycle and its efficiency, Carnot theorem and the second law of thermodynamics. Different versions of the second law, practical cycles used in internal combustion engines. Entropy, principle of increase of entropy. The thermodynamic scale of temperature; its identity with the perfect gas scale. Impossibility of attaining the absolute zero; third law of thermodynamics. (8)

Thermodynamic relationships: Thermodynamic variables; extensive and intensive, Maxwell's general relationships, application to Joule-Thomson cooling and adiabatic cooling in a general system, Van der Waals gas, Clausius-Clapeyron heat equation. Thermodynamic potentials and equilibrium of thermodynamical systems, relation with thermodynamical variables. Cooling due to adiabatic demagnetization, production and measurement of very low temperatures (10)

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Blackbody radiation: Pure temperature dependence, Stefan-Boltzmann law, pressure of radiation. Special distribution of BB radiation, Wien's displacement law, Rayleigh-Jean's law, the ultraviolet catastrophy, Planck's quantum postulates, Planck's law, complete fit with experiment. Interpretation of behaviour of specific heats of gases at low temperature. (7)

4.3 STATISTICAL PHYSICS (25)

The statistical basis of thermodynamics: Probability and thermodynamic probability, principle of equal *a priori* probabilities, probability distribution and its narrowing with increase in number of particles. The expressions for average properties. Constraints, accessible and inaccessible states, distribution of particles with a given total energy into a discrete set of energy states. (6)

Some universal laws: The mu space representation, division of mu space into energy sheets and into phase cells of arbitrary size, applications to one-dimensional harmonic oscillator and free particles. Equilibrium before two systems in thermal contact, bridge with macroscopic physics. Probability and entropy, Boltzmann entropy relation. Statistical interpretation of second law of thermodynamics. Boltzmann canonical distribution law and its applications; rigorous from of equipartition of energy. (9)

Maxwellian distribution of speeds in an ideal gas: Distribution of speeds and of velocities, experimental verification, distinction between mean, rms and most probable speed values. Doppler broadening of spectral lines. (4)

Transition to quantum statistics: 'h' as a natural constant and its implications, cases of particle in a one-dimensional box and one-dimensional harmonic oscillator. Indistinguishability of particles and its consequences, Bose-Einstein, and Fermi-Dirac conditions; applications to liquid helium, free electrons in a metal, and photons in blackbody chamber. Fermi level and Fermi energy. (6)

Text and Reference Books

1. B B Laud, "Introduction to Statistical Mechanics" (Macmillan 1981).

2. F Reif: "Statistical Physics" (Mcgraw-Hill, 1988).

3. K Haung: "Statistical Physics" (Wiley Eastern, 1988).

Course 5: WAVES, ACOUSTICS AND OPTICS

5.1 Waves (11)

Waves in media: Speed of transverse waves on a uniform string, speed of longitudinal waves in a fluid, energy density and energy transmission in waves, typical measurements. Waves over liquid surface: gravity waves and ripples. Group velocity and phase velocity, their measurements. (5)

Superposition of waves: Linear homogeneous equations and the superposition principle, nonlinear superposition and consequences. (3)

Standing waves: Standing waves as normal modes of bounded systems, examples, Harmonics and the quality of sound; examples. Chladni's figures and vibrations of a drum. Production and detection of ultrasonic and infrasonic waves and applications. (4)

5.2 Acoustics (13)

Noise and Music: The human ear and its responses; limits of human audibility, intensity and loudness, bel and decibel, the musical scale, temperament and musical instruments. (4)

Reflection, refraction and diffraction of sound: Acoustic impedance of a medium, percentage reflection and refraction at a boundary, impedance matching for transducers, diffraction of sound, principle of a sonar system, sound ranging. (4)

Applied acoustics: Transducers and their characteristics. Recording and reproduction of sounds, various systems, Measurements of frequency, waveform, intensity and velocity. The acoustics of halls, reverberation period, Sabine's formula. (5)

5.3 Geometrical Optics (18)

Fermat's Principle: Principle of extremum path, the aplanatic points of a sphere and other applications. (4)

General theory of image formation: Cardinal points of an optical system, general relationships, thick lens and lens combinations. Lagrange equation of magnification, telescopic combinations, telephoto lenses and eyepieces. (5)

Aberration in images: Chromatic aberrations, achromatic combination of lenses in contact and separated lenses. Monochromatic aberrations and their reductions; aspherical mirrors and Schmidt corrector plates, aplanatic points, oil immersion objectives, meniscus lens. (4)

Optical instruments: Entrance and exit pupils, need for a multiple lens eyepiece, common types of eyepieces. (5)

5.4 Physical Optics (36)

Interference of a light: The principle of superpositions, two-slit interference, coherence requirement for the sources, optical path retardations, lateral shift of fringes, Rayleigh refractometer and other applications. Localised fringes; thin films, applications for precision measurements for displacements. (5)

Haidinger fringes: Fringes of equal inclination. Michelson interferometer, its application for precision determination of wavelength, wavelength difference and the wieth of spectral lines. Twymann-Green interferometer and its uses. Inensity distribution in multiple beam interference, Tolansky fringes, Fabry-Perot interferometer and etalon. (8)

Fresnel diffraction : Fresnel half-period zones, plates, straight edge, rectilinear propagation (2)

Fraunhofer diffraction: Diffraction at a slit, half-period zones, phasor diagram and integral calculus methods, the intensity distribution, diffraction at a circular aperture and a circular disc, resolution of images, Rayleigh criterion, resolving power of telescope and microscopic systems, outline of phase contract microscopy. (9)

Diffraction gratings: Diffraction at N parallel slits, intensity distribution, plane diffraction grating, reflection grating and blazed gratings. Concave grating and different mountings. Resolving power of a grating and comparison with resolving powers of prism and of a Fabry-Perot etalon(6)

Double refraction and optical rotation: Refraction, in uniaxial crystals, its electromagnetic theory. Phase retardation plates, double image prism. Rotation of plane of polarisation, origin of optical rotation in liquids and in crystals. (3)

5.5 Lasers (12)

Laser system: Purity of a special line, coherence length and coherence time, spatial coherence of a source, Einstein's A and B coefficients, Spontaneous and induced emissions, conditions for laser action, population inversion. (4)

Application of lasers: Pulsed lasers and tunable lasers, spatial coherence and directionality, estimates of beam intensity, temporal coherence and spectral energy density. (5)

Lasers and nonlinear optics: Polarization P including higher order terms in E and generation of harmonics, momentum mismatch and choice of the right crystal and direction for compensation.(3)

Text and Reference Books

1. A K Ghatak, "Physical Optics"
2. D P Khandelwal; "Optics and Atomic Physics" (Himalaya Publishing House, Bombay, 1988).
3. F Smith and J H Thomson; "Manchester Physics series; Optics" (English Language Book Society and John Wiley, 1977).
4. Born and Wolf; "Optics"
5. K D Moltev; "Optics" (Oxford University Press)
6. Sears; "Optics"
7. Jenkins and White; "Fundamental of Optics" (McGraw-Hill)
8. B B Laud; Lasers and Non-linear Optics (Wiley Eastern 1985)
9. Smith and Thomson; "Optics" (John Wiley and Sons).
10. Berkely Physics Coursse; Vol. III "Waves and Oscillations"
11. I G Main; "Vibrations and Waves" (Cambridge University Press)
12. H J Pain; "The Physics of Vibrations and Waves" (MacMillan 1975)

Course 6: LABORATORY II

Every institution may add any experiment of the same standard in the subject area.

6.1 Kinetic Theory, Thermodynamics and Statistical Physics

6.1.1 Kinetic Theory of Matter

1. Study of Brownian motion
2. Study of adiabatic expansion of a gas
3. Study of conversion of mechanical energy into heat
4. Heating efficiency of electrical kettle with varying voltages

6.1.2 Thermodynamics

1. Study of temperature dependence of total radiation
2. Study of temperature dependence of spectral density of radiation
3. Resistance thermometry
4. Thermo-emf thermometry
5. Conduction of heat through poor conductors of different geometries

6.1.3 Statistical Physics

1. Experimental study of probability distribution for a two-option system using a coloured dice
2. Study of statistical distributions on nuclear disintegration data (GM Counter used as a black box)

6.2.1 Waves and Acoustics

1. Speed of waves on a stretched string
2. Studies on torsional waves in a lumped system
3. Study of interference with two coherent sources of sound
4. Chladni's figures with varying excitation and loading points
5. Measurement of sound intensities with different situation
6. Characteristics of a microphone + loudspeaker system

6.2.2 Geometric Optics

1. Designing an optical viewing system
2. Study of monochromatic defects of images
3. Determining the principal points of a combination of lenses

6.2.3 Physical Optics

1. Study of interference of light (biprism or wedge film)
2. Study of F-P etalon fringes
3. Study of diffraction at a straight edge or a single slit
4. Use of Diffraction grating and its resolving limit
5. Resolving limit of a telescope system
6. Polarization of light by reflection; also cos-squared law
7. Study of optical rotation for any system

6.2.4. Lasers

1. Study of laser as a monochromatic coherent source
2. Study of divergence of a laser beam

6.3 Computer Programming II

- Calculation of days between two dates of a year
- To check if triangle exists and the type of the triangle
- To find the sum of the sine and cosine series and print out the curve
- To solve simultaneous equations by elimination method
- To prepare a mark-list of polynomials
- Fitting a straight line or a simple curve a given data
- Convert a given integer into binary and octal systems and vice versa
- Inverse of a matrix
- Spiral array

Text and Reference Books

D P Khandelwal; "Optics and Atomic Physics" (Himalaya Publishing House, Bombay 1988).

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D P Khandelwal; "A Laboratory Manual for Undergraduate Classes" (Vani Publishing House, New Delhi).

S Lipschutz and A Poe; "Schaum's Outline of Theory and Problems of Programming with Fortran" (McGraw-Hill Book Company 1986).

C Dixon; "Numerical Analysis".

Course 7: RELATIVITY QUANTUM MECHANICS, ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

7.1 Relativity (15)

Reference systems, inertial frames, Galilean invariance and conservation laws, propagation of light, Michelson-Morley experiment; search for ether. (5)

Postulates for the special theory of relativity, Lorentz transformations, length contraction, time dilation, velocity addition theorem, variation of mass with velocity, mass-energy equivalence, particle with a zero rest mass. (10)

7.2 Quantum Mechanics (30)

Origin of the quantum theory: Failure of classical physics to explain the phenomena such as black-body spectrum, photoelectric effect, Ritz combination principle in spectra, stability of an atom. Planck's radiation law, Einstein's explanation of photoelectric effect, Bohr's quantization of angular momentum and its applications to hydrogen atom, limitations of Bohr's theory. (5)

Wave-particle duality and uncertainty principle: de Broglie's hypothesis for matter waves; the concept of wave and group velocities, evidence for diffraction and interference of 'particles', experimental demonstration of matter waves. (4)

Consequence of de Broglie's concepts; quantisation in hydrogen atom; energies of a particle in a box, wave packets, Heisenberg's uncertainty relation for p and x, its extension to energy and time. (3)

Consequence of the uncertainty relation: gamma ray microscope, diffraction at a slit, particle in a box, position of electron in a Bohr orbit. (3)

Quantum Mechanics: Schrodinger's equation. Postulatory basis of quantum mechanics; operators, expectation values, transition probabilities, applications to particle in a one-and three-dimensional boxes, harmonic oscillator, reflection at a step potential, transmission across a potential barrier. (7)

Hydrogen atom; natural occurrence of n, l and m quantum numbers, the related physical quantities, comparison with Bohr's theory. (4)

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7.3 Atomic Physics (15)

Spectra of hydrogen, deuteron and alkali atoms spectral terms, doublet fine structure, screening constants for alkali spectra for s, p, d, and f states, selection rules. (6)

Singlet and triplet fine structure in alkaline earth spectra, L-S and J-J couplings. (3)

Week spectra: continuous X-ray spectrum and its dependence on voltage, Duane and Hunt's law. Characteristics X-rays. Moseley's law, doublet structure of X-ray spectra, X-ray absorption spectra. (3)

7.4 Molecular Physics (15)

Discrete set of electronic energies of molecules, quantisation of vibrational and rotational energies, determination of internuclear distance, pure rotational and rotation vibration spectra. Dissociation limit for the ground and other electronic states, transition rules for pure vibration and electronic vibration spectra. (7)

Raman effect, Stokes and anti-Stokes lines, complimentary character of Raman and infrared spectra, experimental arrangements for Raman spectroscopy. (3)

Spectroscopic techniques: Sources of excitation, prism and grating spectrographs for visible, UV and IR, absorption spectroscopy, double beam instruments, different recording systems. (5)

7.5 Nuclear Physics (15)

Interaction of charged particles and neutrons with matter, working of nuclear detectors, G-M counter, proportional counter and scintillation counter, cloud chambers, spark chamber, emulsions. (5)

Structure of nuclei, basic properties (I, μ, Q and binding energy), deuteron binding energy, p-p and n-p scattering and general concepts of nuclear forces. Beta decay, range of alpha particle. Geiger-Nuttal law. Gamow's explanation of beta decay, alpha decay and continuous and discrete spectra. (5)

Nuclear reactions, channels, compound nucleus, direct reaction (concepts) (3)

Shell model; liquid drop model, fission and fusion (concepts), energy production in stars by p-p and carbon cycles (concepts). (2)

Text and Reference Books

H S Mani and G K Mehta; "Introduction to Modern Physics" (Affiliated East-West Press, 1989)

A Beiser; "Prospective of Modern Physics"

H E White; "Introduction to Atomic Physics"

Barrow; "Introduction to Molecular Physics"

R P Feymann, R B Leighton and M Sands; "The Feymann Lectures on Physics", Vol. III (B I Publications, Bombay, Delhi, Calcutta, Madras)

T A Littlefield and N Thorley; "Atomic and Nuclear Physics" (Engineering Language Book Society)

H A Enge, "Introduction to Nuclear Physics", (Addision-Wesly)

Eisenberg and Resnik; "Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles" (John Wiley)

D P Khandelwal; "Optics and Atomic Physics", (Himalaya Publishing House, Bombay, 1988)

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Course 8: SOLID STATE PHYSICS, SOLID STATE DEVICES AND ELECTRONICS

8.1 Solid State Physics (30)

Overview: Crystalline and glassy forms, liquid crystals, glass transition. (2)

Structure: Crystal structure; periodicity, lattices and bases, fundamental translation vectors, unit cell, Wigner-Seitz cell, allowed rotations, lattice types, lattice planes, common crystal structures.(5)

Laue's theory of X-ray diffraction, Bragg's law, Laue patterns. (2)

Bonding: Potential between a pair of atoms; Lennard-Jones potential, concept of cohesive energy, covalent, Van der Walls, ionic, and metallic crystals. (3)

Magnetism: Atomic magnetic moment, magnetic susceptibility, Dia- Para-, and Ferromagnetism, Ferromagnetic domains, Hysteresis. (3)

Thermal properties: Lattice vibrations, simple harmonic oscillator, second order expansion of Lennard-Jones potential about the minimum, vibrations of one dimensional monatomic chain under harmonic and nearest neighbour interaction approximation, concept of phonons, density of modes (1-D). Debye model; lattice specific heat, low temperature limit, extension (conceptual) to 3-D. (8)

Band structure: Electrons in periodic potential; nearly free electron model (qualitative), energy bands, energy gap, metals, insulators, semiconductors. (3)

Motion of electrons: Free electrons, conduction electrons, electron collisions, mean free path, conductivity and Ohm's law. Density of states, Fermi energy, Fermi velocity, Fermi-Dirac distribution. (4)

8.2 Solid State Devices (15)

Semiconductors: Instrinsic semiconductors, electrons and holes, Fermi level. Temperature dependence of electron and hole concentrations. Doping; impurity states, n and p type semiconductors, conductivity, mobility, Hall effect, Hall coefficient. (7)

Semiconductor devices: Metal-semiconductor junction, p-n junction, majority and minority carriers, diode, Zener and tunnel diodes, light emitting diode, transistor, solar cell. (8)

8.3 Electronics (45)

Power supply: Diode as a circuit element, load line concept, rectification, ripple factor, zener diode, voltage stabilization, IC voltage regulation, characteristics of a transistor in CB, CE and CC mode, graphical analysis of the CE configuration, low frequency equivalent circuits, h-parameters, bias stability, thermal runaway. (15)

Field effect transistors: JFET volt-ampere curves, biasing JFET, ac operation of JFET, source follower, Depletion and enhancement mode, MOSFET, biasing MOSFET, FET as variable voltage resister, digital MOSFET circuits. (15)

Small signal amplifiers: General principles of operation, classification, distortion, RC coupled amplifier, gain frequency response, input and output impedance, multistage amplifiers, transformer coupled amplifiers, Equivalent circuits at low, medium and high frequencies; emitter follower, low frequency common-source and common-drain amplifier, Noise in electronic circuits. (15)

Text and Reference Books

C Kittel; "Introduction to Solid State Physics", Vth Edition (John Wiley and Sons, New York, 1976)

J S Blackmore; "Solid State Physics", IInd Edition (Cambridge University Press, Cambridge)

N W Ascroft and N D Mermin; "Solid State Physics" (Holt, Rinehart and Winston, New York, 1976)

B G Streetman; "Solid State Electronic Devices", IInd Edition (Prentice-Hall of India, New Delhi, 1986)

W D Stanley; "Electronic Devices, Circuits and Applications" (Prentice-Hall, New Jersey, USA. 1988)

J D Ryder; "Electronics Fundamentals and Applications", IInd Edition (Prentice-Hall of India, New Delhi, 1986)

J Millman and A Grabel; "Microelectronics", International Edition (McGraw-Hill Book Company, New York, 1988)

Course 9: LABORATORY III

This is a suggested list. Every institution may add any experiment of same standard in the same subject area.

9.1 RELATIVITY, QUANTUM MECHANICS, ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

9.1.1 Relativity (a few experiments need to be introduced)

9.1.2 Quantum Mechanics

1. Determination of Planck's constant
2. Determination of e/m using Thomson's tube
3. Determination of e by Millikan's method

9.1.3 Atomic Physics

1. Study of spectra of hydrogen and deuterium (Rydberg constant and ratio of masses of electron to proton)
2. Absorption spectrum of iodine vapour
3. Study of alkali or alkaline earth spectra using a concave grating
4. Study of Zeeman effect for determination of Lande g-factor.

9.1.4 Molecular Physics

1. Analysis of a given band spectrum
2. Study of Raman spectrum using laser as an excitation source.

9.1.5 Nuclear Physics

1. Study of absorption of alpha and beta rays.
2. Study of statistics in radioactive measurement

9.2 Solid State Physics, Solid State Devices and Electronics

9.2.1 Solid State Physics

1. Goniometric study of crystal faces
2. Determination of dielectric constant
3. Hysteresis curve of transformer core
4. Hall-probe method for measurement of magnetic field

Solid State Devices

1. Specific resistance and energy gap of a semiconductor
2. Characteristics of a transistor
3. Characteristics of a tunnel diode

9.2.3 Electronics

1. Study of voltage regulation system
2. Study of a regulated power supply
3. Study of Lissajous figures using a CRO
4. Study of VTVM
5. Study of RC and TC coupled amplifiers
6. Study AF and RF oscillators

9.3 Computer Programming III

1. Find roots of f(x) = 0 by using Newton-Raphson method
2. Find roots of f(x) = 0 by using secant method
3. Integration by Simpson rule
4. To find the value of y at a given value of x by Runga-Kutta Method
5. Eight Queens Problem
6. Magic Squares
7. String manipulations
8. Towers of Honoi (Nonrecursive)
9. Finding first four perfect numbers

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10. Quadratic interpolation using Newton's forward-difference formula of degree two.

Text and Reference Books

B G Strechman; "Solid State Electronic Devices", II Edition (Prentice-Hall of India, New Delhi, 1986)

W D Stanley; "Electronic Devices, Circuits and Applications" (Prentice-Hall, New Jersey, USA, 1988)

S Lipschutz and A Poe; "Schaum's Outline of Theory and Problems of Programming with Fortran" (McGraw-Hill Book Company, Singapore, 1986)

C Dixon; "Numerical Analysis".

In addition to the above, the student will do a course on Science, Technology and Society. This will be a compulsory but non-credit course. This means that it will be necessary for a student to obtain passing marks in this course, but these marks will not be added in the final score. The course details for this course are given below.

SCIENCE, TECHNOLOGY AND SOCIETY

(A) Communication Skills (45)

Appreciation and comprehension of articles written by renowned scientists, philosophers, technocrats, literateures etc. This is to be done by reading them in the class, question and answer process, précis writing and oral presentation method. (22)

Preparation and presentation of science reports; need, methods and approaches for formatting and writing of science reports, examples to be taken of popular science, pure science, applied science and technical reports, use of computer for word-processing technique. (15)

Oral presentation skill, students should be exposed and trained in the effective and appropriate ways of presentation of scientific material, skill for group discussion should also be covered. This is mostly a laboratory module. (8)

(B) Indian Contribution in Physics (15)

Kanad, Aryabhatta, C.V.Raman, Homi J. Bhabha, Vikram Sarabhai, Meghnad Saha, S.N. Bose, S. Chandrashekhar, Indian contribution in mathematics.

(C) Recent Developments in Science (30)

Nature of science; growth of science before and after second world war and its impact on the society; Technology; interconnection between science and technology, changing scenario of science and technology, its influence on the society and world politics, science and technology as vehicles for development, third world politics, science and technology, Indian efforts for self sufficiency. (15)

Present-day scientific and technological scenario in the world with reference to energy, materials, environment, medicine, communication, automation and information revolution; Indian scenario, where do we stand in comparison to other countries? Implications of rapidly changing scenario on human value system, man's existence, man and future. (15)

B.SC. (PHYSICS/HONOURS)

The Course structure is summarized in Table 3.

Table 3: Course Pattern for B.Sc. (Physics)

	Physics Components	Maths	Chemistry	Other
Ist year	3	3	1	1
IInd year	4	2	1	1
IIIrd year	6	1	-	1

Notes:

1. This envisages that a student takes 8 courses per year, in all subjects together.
2. Each course will have 4 contact hours per week, including theory, laboratory, and tutorials for both.
3. Considering 30 weeks of teaching, this means that each course will be with 120 contact hours, including all components.
4. It is recommended that the distribution of contact hours for the four components should be in the following ratio:

Theory	Theory Tutorial	Laboratory	Lab Tutorial
3	1	3	1

The titles of the courses will be as in the Tables 4 (Physics), 5 (Mathematics), 6 (Chemistry), and 7 (other components)

Table 4: Physics Courses in B.Sc. (Physics)

Year	Course No	Title
I	P1	Mechanics of Particles, Rigid Bodies and Continuous Media
	P2	Kinetic Theory, Thermodynamics and Statistical Physics
	P3	Oscillations, Waves and Acoustics
II	P4	Electricity and Magnetism
	P5	Electronics
	P6	Optics
	P7	Quantum Mechanics
III	P8	Atomic and Molecular Physics
	P9	Solid State Physics and Solid State Devices
	P10	Electrodynamics, Electromagnetic Waves and Relativity
	P11	Nuclear and Particle Physics
	P12	Elective
	P13	Project

Table 5: Mathematics Courses in B.Sc. (Physics)

Year	Course No	Title
I	M1	Vectors, Matrices, Complex numbers and Probability
	M2	Coordinate Systems, Analytical Geometry and Calculus
	M3	Computer Programming, Multivariable Calculus and Differential Equations
II	M4	Probability distributions, Modern Algebra and Vector Calculus
	M5	Computer Programming, Special Functions and Functions of Complex Variables
III	M6	Statistics, Integral Transforms, and Elements of Analysis.

Table 6: Chemistry Courses in B.Sc. (Physics)

Year	Course No.	Title
I	C1	Chemistry I
II	C2	Chemistry II

Table 7: Other Components in B.Sc. (Physics)

Year	Course No.	Title
I	S1	Language
II	S2	Science, Technology and Society
III	S 3	Communication and Technical Skills

The detailed Course Contents are given below:

For any course where Laboratory Experiments are mentioned, the concerned institution may replace one or more experiments with other experiments of the same standard in the concerned subject area.

PHYSICS COMPONENT IN B.SC. (PHYSICS)

Course P1: MECHANICS OF PARTICLES, RIGID BODIES AND CONTINUOUS MEDIA

Note: The mathematical background, *viz.* vector algebra and vector calculus, use of vector language is included in the mathematics modules.

THEORY LECTURES

1.1 MECHANICS OF PARTICLES (15)

Laws of motion; conservation of energy and momentum, applications to rotating frames, centripetal and Coriolis accelerations. Motion under a central force; conservation of angular momentum, Kepler's laws. Fields and potentials; gravitational field and potential due to spherical bodies, Gauss and Poisson equations, gravitational self-energy. Two-body problem; reduced mass, scattering and scattering cross-sections; illustrations. Rutherford scattering by hard spheres. Centre of mass and laboratory reference frames, binary stars.

1.2 MECHANICS OF RIGID BODIES (15)

System of particles; centre of mass, angular momentum, equations of motion. Conservation theorems for energy, momentum and angular momentum; elastic and inelastic collisions. Rigid body; degrees of freedom, Euler's theorem, angular velocity, angular momentum, moments of inertia and products of inertia, theorems of parallel and perpendicular axes, equation of motion for rotation. Molecular rotations (as rigid bodies); di- and tri-atomic molecules, intrinsic spin angular momentum in elementary particles. Precessional motion; top, gyroscope.

1.3 MECHANICS OF CONTINUOUS MEDIA (15)

Elastic constants for an isotropic solid, their inter-relation, torsion of a cylinder, bending of a beam. Kinematics of moving fluids; equation of continuity, Euler's equation,

Bernoullis theorem. Viscous fluids; streamline and turbulent flow, flow through a capillary tube, Reynold's number, Stokes law. Surface tension and surface energy; molecular interpretation, pressure on a curved liquid surface.

THEORY TUTORIALS

1.4.1 Mechanics of Particles

1. Components of velocity and acceleration in different coordinate systems
2. Discussion of Cavendish experiment for measuring G
3. Precise measurements of g and its variations
4. Coriolis force applications
5. Trajectory of an artificial satellite
6. Planetory motions
7. Rocket motion; variable mass, multistage rockets
8. Centre-of-mass and laboratory systems of coordinates

1.4.2 Mechanics of Rigid Bodies

1. Moments of inertia of shell, sphere, disc, cylinder
2. Theorems of parallel axes and perpendicular axes for moments of inertia
3. Moments of inertia of diatomic and triatomic molecules in specific examples
4. Rotational motion about an axis of symmetry
5. Discussion of the motion of a top
6. Applications of gyroscope

1.4.3 Mechanics of Continuous Media

1. Discussion about anisotropic solids
2. Cantilever and beams
3. Motion in a viscous medium
4. Capilarity
5. Wetting
6. Curvature and vapour pressure

LABORATORY EXPERIMENTS

1.5 MECHANICS OF PARTICLES

1. Study of free fall of a body; use of a digital timer to get time and velocity at different depths and analysis
2. Study of collision in two dimensions; PSC method
3. Study of potential energy curves in one dimension; use of linear air track and magnetic interaction
4. Kater's pendulum, precise setting and analysis
5. Study of damping of a bar pendulum under various kinds of damping mechanisms
6. Using scattering to deduce the nature of potential hump or well (two-dimensional)

1.6 MECHANICS OF RIGID BODIES

1. Study of collisions in two dimensions; PSSC method
2. Study of laws of parallel and perpendicular axes for estimation of moment of inertia
3. Computer simulation of equations of motion for a system of particles
4. Computer simulation of molecular rotations, as rigid bodies
5. Study of motion of a top and a gyroscope

1.7 MECHANICS OF CONTINUOUS MEDIA

1. Study of flexure of a bar
2. Study of torsion of a wire; dependence on radius, length, torque and material (static method)
3. Study of torsion of a wire or fibre; dynamic method
4. Study of flow of liquids through capillaries; laminar and turbulent flow stages, capillaries
5. Study of the surface tension of a liquid by three different methods
6. Studying the fall of solids through a liquid
7. Study of air flow through a capillary; U-tube with a long capillary fitted on one arm, mercury level difference pushing air

LABORATORY TUTORIALS

('D' Denotes demonstration experiments)

1.8.1 Error Analysis

1. Errors of a single observation; mean, standard deviation
2. Fitting of a straight line by least-squares method
3. Poisson and Gaussian distributions; fitting of a Gaussian distribution
4. Propagation of errors; errors in the final result and their interpretation
5. Graphical presentation of data; different kinds of plots

1.8.2 Mechanics of Particles and Rigid Bodies

1. Measuring short time intervals with a digital timer (D)
2. Collisions in one dimension, using a linear air track (D)
3. Collisions in two dimensions; balls on a horizontal plane or two pendulum bobs (D)
4. Conservation of energy, using grooved ramp or similar cases (D)
5. Getting potential energy curve using a linear air track (D)
6. Motion of a projectile, using computer simulation
7. Numerical solution of equation of motion, using a personal computer/ calculator
8. Motion of a particle in a central force field using numerical analysis and calculator/PC

1.8.3 Mechanics of Continuous Media

1. Cantilever bending; different loading positions and other parameters (D)
2. Method of interference fringes to measure small displacements for elasticity measurements (D)
3. Searle's method for Y, η and σ from a single set (D)
4. Rotation viscometer to measure viscosity of air (D)
5. Laminar and turbulent flow, comparison, flow of ink through water (D)
6. Terminal velocity for bodies falling through a fluid; a balloon in air, a solid sphere in liquid (D)
7. Angle of contact between different liquids and solid surfaces (D)

Text and Reference Books

E M Purcell, editor, Berkeley Physics Course, Vol. 1, "Mechanics"

R P Feynman, R B Leighton and M Sands, "The Feynman Lectures on Physics", Vol. I (B I Publications, Bombay-Delhi-Calcutta-Madras)

B Saraf et al. "Mechanical Systems" (Vikas Publishing House, New Delhi)

D P Khandelwal, "A Laboratory Manual of Physics for Undergraduate Classes" (Vant Publishing House, New Delhi)

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Course P2: KINETIC THEORY, THERMODYNAMICS AND STATISTICAL PHYSICS

2.1 KINETIC THEORY OF GASES (15)

Ideal gas: Review of the kinetic model of an ideal gas; interpretation of temperature. Equipartition of energy; specific heats of gases. Real gas: Van der Waals model; equation of state, nature of Van der Waals forces, critical constants. Transport Phenomena: Mean free path, transport of momentum (viscosity), of energy (thermal conduction) and matter (diffusion). Joule-Thomson and adiabatic cooling: Joule-Thomson expansion; constancy of U + pV, cooling in J-T expansion, adiabatic expansion of an ideal gas, principles of regenerative and cascade cooling, liquefaction of gases. Low temperatures: Production and measurement of very low temperatures.

2.2 THERMODYNAMICS (15)

The laws of thermodynamics: The zeroth law; indicator diagrams, work done, the first law, internal energy, Carnot cycle and its efficiency, Carnot's theorem, the second law. Entropy as a thermodynamic variable; reversible and irreversible processes. Principle of increase of entropy. *Thermodynamic scale of temperature; its identity with perfect gas scale, impossibility of* attaining the absolute zero (third law). Thermodynamic relationships: Maxwell's equations; application to Clausius-Clapeyron equation and Joule-Thomson effect. Thermodynamic potentials: Relation to thermodynamic variables; equilibrium in thermodynamic systems, simple applications. Black body radiation: Temperature radiation, Stefan-Boltzmann law, spectral distribution, Wien's displacement law. Rayleigh-Jeans law and the ultraviolet catastrophy, Planck's hypothesis, mean energy of an oscillator and Planck's law.

2.3 STATISTICAL PHYSICS (15)

The statistical basis of thermodynamics: Probability and thermodynamic probability; principle of equal *a priori* probabilities, probability distribution, its narrowing with increasing n, average properties, fluctuations, accessible and inaccessible states. Phase space representation: The mu space; its division into sheets of energy, phase cells of arbitrary size, one-dimensional oscillator, free particles, the functions $\phi(E)$ and $\Omega(E)$, definition of probability, average properties of the system in equilibrium state.

The bridge with thermodynamics: Thermal equilibrium between two systems, beta parameter and its identity with $(kT)^{-1}$, probability and entropy, Boltzmann entropy relation, statistical interpretation of the second law of thermodynamics. Boltzmann canonical distribution law; equipartition of energy.

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Maxwellian distribution of speeds in an ideal gas: Derivation of the distribution of speed and velocities; exponential distribution in atmosphere, Boltzmann law and distribution of nuclear speeds.

Transition to quantum statistics: Cases of particles in a box and simple harmonic oscillator. Setting phase-cell size as nature's constant (Planck's constant h); quantization of energy. Indistinguishability of particles, effect on absolute entropy. Bose-Einstein and Fermi-Dirac conditions, consequence for free electrons in a metal, Fermi level.

THEORY TUTORIALS

2.4.1 Kinetic Theory of Gases

1. Specific heat of gases and atomic solid at low temperatures
2. Random walk; Brownian motion
3. Joule expansion of an ideal gas; Van der Waals gas
4. Equation of state other than Van der Waals and comparision with experimental results
5. Molecular diameters; mean free path calculations
6. Expression for J-T coefficient for Van der Waals gas
7. Problems on adiabatic expansion of a gas
8. Measurement of very low temperatures; vapour pressure method, Curie's law

2.4.2 Thermodynamics

1. Various indicator diagrams
2. Equivalent statements of the second law
3. Elementary discussion of atmospheric physics
4. Discussion of various reversible and irreversible processes
5. Other applications of Maxwell's relations
6. Cooling due to adiabatic demagnetization
7. Radiation pyrometers
8. Periodic heat wave transmission
9. Radiative balance in the universe

2.4.3 Statistical Physics

1. Simple examples of combinatorial probability

2. Distribution of n particles with fixed total energy into discrete levels
3. Simple applications of Boltzmann distribution
4. Mean, RMS and most-probable speeds
5. Doppler broadening of spectral lines
6. Liquid helium, photons in a blackbody chamber
7. Fermi energy; near zero specific heat contribution

LABORATORY EXPERIMENTS

2.5 KINETIC THEORY OF GASES

1. Constant-volume or constant-pressure gas thermometer
2. Study of Browain motion
3. Resistance thermometry; temperature of a torch bulb filament from R value, platinum resistance thermometry
4. Study of characteristics of a thermistor
5. Study of adiabatic expansion of a gas including temperature changes
6. Thermal conduction in poor conductor: temperature distribution using thermocouples in cases of linear geometry (sheets or slabs), cylindrical geometry, spherical geometry

2.6 THERMODNAMICS

1. Thermoelectric refrigerator; efficiency measurements
2. Study of different thermocouples for temperature measurements
3. Study of variation of total radiation with temperature
4. Study of variation of $E(\lambda)$ in a given spectral range with temperature
5. Determination of solar constant or temperature of an oven through radiation measurement

2.7 STATISTICAL PHYSICS

1. Experimental study of probability distribution for a two-option system: A cubic dice with face colouring can be used with two options of weightage ratio 5:1 or 1:1; May use 12 such dice as a group for one observation, take about 200 observations.
2. Study of thermodynamic emission from metals
3. Statistical distribution study on nuclear disintegration data; GM counter used as a black box.
4. Comparative study of binomial, Poisson and Gaussian distributions
5. Computer generation of phase space plots of simple harmonic oscillator

LABORATORY TUTORIALS

2.8.1 Kinetic Theory of Gases

1. Critical discussion of liquid thermometers; scales, precision, response time
2. Correction to standard gas thermometers
3. Ranges of resistance thermometers and standardization points
4. Applications of thermistors
5. Analysis of Joule's free-expansion experiments

2.8.2 Thermodynamics

1. Critical examination of properties of refrigerant materials
2. Linear and surface thermocouples; their uses
3. Critical comparison of heat transfer by radiation, convection and conduction; with reference to homes, glass-houses etc
4. Periodic heat wave transmission; 15 minute cycle, with a system showing at least 2A phase lag across it
5. Selective transmittance by glass between visible and infrared

2.8.3 Statistical Physics

1. Data from n-option systems of several relative weightages to be examined and interpreted (extension of Expt 1 in Unit 2.7)
2. Plotting F-D distribution in the neighborhood of Fermi energy for different temperature values
3. Solar wind as a thermal expansion of solar corona at one million Kelvin
4. Study of dilute gas for experimental verification of Maxwell-Boltzman statistics
5. Number of microscopic states of perfect gas (Gibbs paradox)

Text and Reference Books

F Reif: "Berkeley Physics Course, Vol. 3, Statistical Physics"

D P Khandelwal and A K Pande; "Thermodynamics and Statistical Physics" (Himalaya Publication House, Bombay)

S P Puri; "Vibrations and Waves" (Tata McGraw-Hill)

C Kittel and H Kroemer; "Thermal Physics" (CBS Publishers, Delhi)

M W Zemanasky; "Heat and Thermodynamics" (McGraw-Hill)

D P Khandelwal' "Laboratory Manual of Physics for undergraduate classes" (Vani Publishing House, New Delhi)

K Huang; "Statistical Mechanics" (Wiley Eastern 1988)

B B Laud; "Introduction to Statistical Physics" (MacMillan 1981)

Course P3: OSCILLATIONS, WAVES AND ACOUSTICS

3.1 OSCILLATIONS (15)

Free oscillations of simple systems: Equilibrium; concept of potential well, small oscillations approximation, solutions, linear and transverse oscillations of a mass between two springs, diatomic molecule, reduced mass concept.

Damped and forced oscillations: Damped oscillations; critical damping, Q of an oscillator. Forced oscillator with one degree of freedom; Transient and steady state oscillations, resonance energy absorption, low and high frequency responses.

Free oscillations of system with two degrees of freedom: Two dimensional oscillator; normal modes, longitudinal and transverse oscillation of coupled masses, energy transfer between modes, coupled pendulum.

Fourier analysis: Fourier series and Fourier coefficients; simple examples, use of exponential representation for harmonic oscillations, expression for Fourier coefficients. Non-periodic disturbance; representation by Fourier integral, Fourier transform. Case of a wavetrain of finite length, constancy of $\Delta x. \Delta k$ (the uncertainty product).

3.2 WAVES (15)

Waves in a one-dimensional chain of particles; classical wave equation; wave velocity, boundary conditions and normal modes, dispersion relations, dispersive waves, acoustic and optical modes.

Waves in continuous media: Speed of transverse waves on a uniform string, speed of longitudinal waves in a fluid, energy density and energy transmission in waves, typical measurements, dispersion in waves, group velocity and phase velocity, their measurements.

Superposition of waves: Linear homogeneous equations and the superposition principle, interference in space and energy distribution; beats and combination tones.

Ultrasonics: Production, detection and applications of ultrasonic waves.

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3.3 ACOUSTICS (15)

Vibrations in bounded systems: Normal modes of a bounded system; harmonics, the quality of sound, Chladni's figures, vibration of a drum. Noise and Music: Limits of human audibility; intensity and loudness, bel and decibel. Musical scale, temperature scale, temperament and musical instruments.

Reflection, refraction and diffraction of sound: Acoustic impedance of a medium, percentage reflection and refraction at a boundary, impedance matching for transducers. Diffraction of sound; principle of a sonar system, sound ranging.

Applied acoustics: Transducer and their characteristics, recording and reproduction of sound, measurement of frequency, velocity, wave form and intensity. The acoustics of halls, reverberation period, Sabine's formula.

THEORY TUTORIALS

3.4.1 Oscillations

1. Examples of free oscillations from many different fields
2. Damping in different systems
3. Dependence of harmonics on the method of excitation; tone quality
4. Cases of plucked or blowed string
5. A rectangular pulse

3.4.2 Waves

1. Examples of dispersive waves
2. Waves over a liquid surface; gravity waves and ripple
3. Nonlinear superposition and consequences
4. Kundt's tube
5. Discussion of uncertainty of product $\Delta x \Delta k$ in pulses

3.4.3 Acoustics

1. The human ear and its response
2. Applications of ultrasonic waves
3. Comparison of different transducers

4. Noise and its measurement
5. Acoustic defects in hall and their correction

LABORATORY EXPERIMENTS

3.5 OSCILLATIONS

1. Study of a harmonic oscillation and its relaxation; rigid pendulum or torsional oscillations
5. Oscillations on a bifilar suspension
6. Oscillations in a general potential well; Linear air track and magnetic interaction may be used
7. Study of dependence of period of oscillations of a spring or rubber band on mass and spring constant
8. Study of coupled oscillations
9. Study of forced oscillations; rigid pendulums with one as a driver, transients

3.6 WAVES

1. Study of transverse wave speed on a string; dependence on density and tension (sonometer)
2. Study of wave velocity in a gas; Kundt's tube
3. Melde's experiment
4. Experiments with a torsion wave apparatus; reflection coefficient for different impedances, dispersion curve
5. Analyzing a given wave-form for its harmonic components; (a computer may be used)
6. Study of spatial interference with two coherent sources of sound

3.7 ACOUSTICS

1. Study of normal modes of a beaded string; including dispersion relation
2. Characteristics of a microphone or a loudspeaker system
3. Study of the acoustics of a hall
4. The measurements of waveforms for vowel sounds with a CRO
5. Study of reflection, refraction and absorption of sound waves; ultrasonic source, intensity measurements

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LABORATORY TUTORIALS

("D" denotes demonstration experiments)

3.8.1 Oscillations

1. Groved channels of parabolic and other shapes and oscillations therein; dependence of period on energy (D)
2. Helmholtz resonators (D)
3. Using diatomic molecule vibration frequencies to deduce force constants
4. Lissajous figures; bar pendulum, CRO (D)
5. Experimental applications of Fourier transforms

3.8.2 Waves

1. Waves in two and three dimensions
2. High, low and band pass filters of mechanical and electrical systems
3. Partial reflection and transmission of waves at boundaries; slinky or torsion wave system
4. Measurement of group and phase velocities
5. Applications of ultrasonic waves

3.8.3 Acoustics

1. The horn of a loudspeaker; acoustic impedance matching
2. Measurement of noise in decibels
3. Measurement of amplitudes of oscillations in sounds in air
4. Detecting infrasonic and ultrasonic sounds
5. Techniques for the measurements of reverberation period

Text and Reference Books

Berkely Physics Course, Vol. III, "Waves and Oscillations"

D P Khandelwal, "Oscillations and Waves" (Himalaya Publishing House, Bombay)

I G Main "Vibrations and Waves" (Cambridge University Press)

H J Pain; "The Physics of Vibration and Waves" (Wiley ELBS, 1976)

R K Ghosh; "The Mathematics of waves and vibrations" (Macmillan, 1975)

B Saraf et al. "Physics through Experiments, Vol. 1, Mechanical Systems" (Vikas Publication House, New Delhi)

D P Khandelwal. A Laboratory Manual of Physics for Undergraduate Students (Vani Publication House, New Delhi)

Course P4: ELECTRICITY AND MAGNETISM

(Note: Vector language is to be used all through)

THEORY LECTURES

4.1 ELECTRICITY (15)

Electric field: Coulomb's law; unit of charge (SI and other systems of units). Conservation and quantisation of charge; field due to different charge distributions, monopole, dipole, quadrupoles, line charge, sheet charge. Torque on a dipole in uniform field and non-uniform fields, flux of an electric field. Gauss's law; applications to deduce E fields, force per unit area on the surface of a charged conductor.

Potential: Line integral of electric field and electrical potential; field as the gradient of potential. Potential energy of a system of charges; pair of charges, line charge, sheet charge, spherical shell of charge, charged hollow disc. Field equations for **E** in vacuum. Energy associated with **E** field. Differential form of Gauss's law div **E** = $4\pi\mathbf{P}$, Poisson's equation, Laplace's equation, boundary conditions, and Uniquences theorems.

Electric field around conductors: Induced charges; field and potential inside a conductor, field near the surface of a conductor, method of images.

4.2 ELECTRIC AND MAGNETIC FIELDS IN MATTER (15)

Electric fields in matter: Atomic and molecular dipoles; induced dipoles, polarizability tensor, electronic and molecular contributions. Electrical field caused by polarized matter, **E** and **D** fields, permitivity, dielectric constant. Capacitor filled with a dielectric, field equations in presence of dielectric. The field of a polarized sphere, dielectric sphere in a uniform field. Energy in dielectric systems; polarisability and susceptibility, frequency dependence of polarizability, Claussius-Mossotti equation.

Magnetic field: magnetic field B seen through Lorentz force on a moving charge, unit for **B** defined through force on a straight current, torque on a current loop in **B** field, magnetic dipoles in atoms and molecules, gyromagnetic ratio.

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Magnetic field due to currents: Biot and Savart's law. Field equations in magnetostatics, Ampere's law. Fields due to a straight wire, magnetic dipole, circular current and solenoid. Magnetic fields in matter: Magnetizing current, magnetization vector, **H** and **B** fields, magnetic permeability, susceptibility. Comparison of magnetostatics and electrostatics. Field equations for **E**, **D**, **B**, **H**.

4.3 ELECTRICAL CURRENT AND CIRCUITS (15):

Electrical current: Current density and current; non-steady currents and continuity equations. Kirchoff's laws, network theorems and their applications, non-ohmic circuitry, thermistor. Varying current: rise and decay of currents in LR and CR circuits, time constant, integrating and differentiating circuits.

Alternating currents: Skin effect for resistance at high frequencies; complex impedance, reactance, impendances of LCR series and parallel circuits, resonance, **Q** factor, power dissipation and power factor. AC bridges; Anderson's and Owens bridges.

Generators and rectifiers: Three-phase electrical power supply, delta and star connections, rectifiers, voltage regulation, current regulation, methods for high DC voltage generation.

THEORY TUTORIALS

4.4.1 Electrostatics

1. Dipole approximation for an arbitrary charge distribution
2. Calculation of quadrupole fields
3. Field lines and equipotentials
4. Coulomb energy of an ionic crystal
5. Gauss's theorem when charges are in motion; invariance
6. Solutions of Laplace and Poisson equations
7. Field around two spherical conductors, with one having a charge
8. Conducting sphere in a uniform **E** field; solution through use of complex variables

4.4.2 Electrical and Magnetic Fields in Matter

1. Capacitance of two coaxial metal tubes
2. E and D fields in parallel plate capacitor

3. Boundary conditions for **E** and **D** at the interface between two dielectrics
4. Atomic interpretation of magnetism
5. Magnetic shell concept and its use
6. **E** and **B** fields as seen from moving reference frames
7. Definition of Ampere through force between two conductors
8. Calculation of **B** in simple geometrical situations
9. Conducting sphere in a uniform electrical field

4.4.3 Electrical Current and Circuits

1. ∇.**J** for time independent and time dependent charge distributions
2. Resistance of a coaxial cable
3. Voltage regulation
4. Electrolytic capacitors
5. Analysis of multiloop circuits using Kirchoff's laws
6. Solution of AC circuit problems using complex numbers

LABORATORY EXPERIMENTS

4.5 ELECTROSTATICS

1. Setting up and using a gold leaf electroscope
2. Study of characteristics of a ballistic galvanometer
3. Measurement of electric charges and related quantities using an electrometer
4. Study of potential distribution in a given geometrical configuration
5. Mapping of electric fields for specified configurations

4.6 ELECTRIC AND MAGNETIC FIELDS IN MATTER

1. Study of magnetic field using a vibration magnetometer
2. Study of the rise and decay of current in a RC circuit
3. Study of the rise and decay of current in a RL circuits
4. Measurement of dielectric constant of a liquid (any method)
5. Obtaining the B-H curve of a ferromagnetic material (any method)

4.7 ELECTRICAL CURRENT AND CIRCUITS

1. Characteristics of a choke
2. Low resistance measurement; C.F. Bridge or any other method
3. Study of the impedance of an inductor at varying frequencies to measure **R** and **L**
4. Study of the impedance of a capacitor of varying frequencies to measure **C**
5. Response curve for LCR circuits series resonances
6. Using an AC bridge to measure **L** or **C**
7. Study of a discrete LC transmission line
8. Potentiometer for precision measurement of thermo-emf or low resistance

LABORATORY TUTORIALS AND DEMONSTRATION EXPERIMENTS

4.8.1 Electrostatics

1. Wimshurst machine or van de Graaf generator producing high DC voltages
2. Insulation characteristics of different materials (**D**)
3. Seeing the leakage of charge on a capacitor with an electroscope
4. Study of CRO for the measurement of electrical quantities (**D**)
5. Units and dimensions for measurements of electrical quantities
6. Electrical shielding

4.8.2 Electric and Magnetic Fields in Matter

1. Making a 'parallel plate' capacitor in compact form
2. Electrolytic capacitors
3. Winding a non-inductive resistor coil
4. Choke coil
5. Power factor adjustment in home appliances
6. Measurements of very weak magnetic fields and small fluctuations

4.8.3 Electric Currents and Circuits

1. Four-point connections for low resistances
2. Capacitance and inductance of connection wires
3. AC Potentiometer
4. Changing the ranges of ammeter and
5. Various testing equipment for electrical components
6. Voltage regulators

7. Potential dividers and their internal resistance
8. Voltmeter characteristics; ohms per volt

Text and Reference Books

E M Pucell, Ed. "Berkely Physics Course Vol.1, Electricity and Magnetism" (McGraw- Hill).

D Halliday and R Resnick, "Physics", Vol:2 (Wiley Eastern, New Delhi)

D J Griffiths, "Introduction to Electrodynamics" (Prentice-Hall of India)

Reitz and Milford; "Electricity and Magnetism" (Addison-Wesley)

A S Mahajan and A A Rangawala "Electricity and Magnetism " (Tata McGraw-Hill)

A M Portis; "Electromagnetic fields"

Pugh and Pugh; "Principles of Electricity and Magnetism" (Addison-Wesley)

Panofsky and Phillips; "Classical Electricity and Magnetism" (India Book Co.)

S S Atwood; "Electricity and Magnetism" (Dover publication)

D P Khandelwal: A Laboratory Manual for Physics for Undergraduate Students (Vani Publications, New Delhi)

B Saraf et al. "Physics through Expriments, Vol. II, EMF Constant and Varying" (Vikas Publications, New Delhi)

A F Kip; "Fundamentals of Electricity and Magnetism", International Student Edition (McGraw-Hill and Kogakusha, 1969)

Course P5: ELECTRONICS

5.1 SEMICONDUCTOR DIODES, BJT, FET (15)

Basic circuit analysis: Circuit models, Kirchoff's law, single equation loops, single node pair circuit, voltage and current divider rules, principle of superposition, Thevenin and Norton's theorems, two-port analysis of an electrical network.

Semiconductor diodes: p-n junction diode, I-V characteristics, Schockley model, application in rectifiers, clippers and limiters, Zener diode and its applications, optoelectronic diodes: LED, photodiodes, optocouplers.

Bipolar junction transistors (BJT): pnp and npn structures; active and saturation regions, characteristics of BJT, common-emitter configuration, input and output characteristics, B-parameter, common-base configuration, output characteristics. Two-port analysis of a transistor, definition of h-parameters, loadline concept, emitter follower, biasing methods, stability factor, low frequency model.

Field effect transistor (FET): Classification of various types of FETs, constructional details of junction field-effect transistor, drain characteristics of JFET, biasing of JFET, operating regions, pinch-off voltage, idea of metal-oxide-semiconductor transistor (MOS transistor)

5.2 AMPLIFIERS (15)

Frequency response of amplifiers: LC and CR response, bandwidth and rise time, amplifier, flat band equivalent circuits with and without input and output loading, cascade connections. Decibel power, gain and loss. Conversion to voltage and current gain, Bode's plots.

Operational amplifiers: Differential amplifiers, principles of operational amplifiers, transfer characteristics, offset parameters, differential gain, CMR, applications of operational amplifiers, linear circuits.

Oscillators and wave-form generators: Positive feedback, Barkhausen criterion, RC oscillator, Wien Bridge oscillator, phase shift oscillator, Colpitt's oscillator, Hartley oscillator, operational amplifier, square wave generator, 555 timer for astable operation. Calculations of frequency and amplitude of oscillator, unijunction oscillator.

5.3 DIGITAL CIRCUITS (15)

Binary system, Boolean algebra, OR, NAND gates, TTL logic families, NMOS and CMOS circuits, ECL gates, binary address, arithmetic function circuits, digital comparator, decoder, demultiplexer, data selector, encoders, ROM, addressing of ROM, PROM, EROM, SR, JK flip-flops, ripple counters, synchronous counters, elements of MP, CPU, busses, I/Os, memories.

THEORY TUTORIALS

5.4.1 Semiconductor Diodes, Bjt, Fet

Drill problems, design problems, trouble-shooting in circuit loops. (2)

Design of rectifiers, half wave and full wave rectifiers, measurement of waveforms across the load as well as across the diode, clipper circuit, design of Zener regulator. Calculation of current limiter for LEDs. Design of logic gates with diodes. (1)

Calculation of quiesent point, drawing of a loadline, computation of base input resistor and collector load resistor. Calculation of transistor parameters from the graphs of characteristics, measurement of V_{CE} and V_{BE} at the active and saturation condition for pnp and npn transistors. (1)

Design of current source using JFET, design of voltage controlled resistance, Designing JFET swithches, calculation of loadline and operating point. (1)

5.4.2 Amplifiers

Circuit design for break frequency, calculation of rise time for low-pass filter, calculation of steady state voltages across elements in a filter, determination of frequency response of BJT and FET amplifiers, calculation of gain and decimal power of amplifiers. (2)

Determination of offset voltages and currents, determination of saturation levels, measurement of CMRR, estimation of differential gain, differential inputs for saturation, estimation of gain-bandwidth product and closed-loop 3 dB frequencies. (2)

Design of phase shift, Wien bridge oscillators, op-amp, multivibrators, astable and monostable oscillator, why 555, calculation of frequencies. (1)

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5.4.3 Digital Circuits

Solving Boolean expressions, inter-conversion from BVD to Hex to digital number, calculation of Fan-in, Fan-out capabilities, study of timing diagrams for logic circuits, relative merits of NMOS, CMOS, TTL, ECL families, construction of time table for logic circuits, design of simple decoders, demultiplexures, decoders, parity encoders, programming of EPROM, circuit design for 7-segment displays, construction of bistable latches, race problems in FF and parallel to serial and vice versa converters, application of counters. (5)

LABORATORY EXPERIMENTS

5.5 DEVICES, AMPLIFIERS AND OSCILLATOR CIRCUITS

1. Use of p-n junction for the measurement of temperature
2. Study of the effect of negative feedback on the frequency response of an RC coupled amplifier
3. Design and construction of a phase-shift oscillator
4. Design, build and test a logarithmic amplifier
5. Study of a function generator using operational amplifiers

5.6 BINARY OPERATIONS AND COUNTERS

1. Study of NAND and NOR circuits (discrete and integrated circuits)
2. Study of multiplexures and demultiplexures
3. Study of half-adder and full-adder circuits
4. Study RS, D, and JK flip-flops
5. Study of Modulo-3, Modulo-5 and Modulo-7 binary counter circuits

5.7 DATA CONVERTERS

1. Study of digital-to-analog converter circuit (R-2R net work type)
2. Study of a tracking analog-to-digital converter (counter type)
3. Write assembly language programme, load and run on the microprocessor development board the following:
4. Enter a two-digit number through the key board
5. Convert it into hex numbers
6. Display the result
7. To measure an analog input connected to the ADC at the parallel ports

(a) Generate saw-tooth, square and triangular waves using DAC connected at the output ports (timing loops)

(b) Control of recd relay switches connected at the output port

5.8 LABORATORY TUTORIALS

5.8.1

1. To study identification of resistors and capacitors using Electronics Industries Association (EIA) colour code
2. Study the contents of a data manual for electronic devices and its uses
3. To study the uses of laboratory meters of all types
4. To study internal resistance in a battery
5.

5.8.2

1. To get familiar with the operation and calibration of the oscilloscope
2. To study voltage divider networks and the use of bleeder resistor as a voltage regulator
3. Measurement of frequency and phase of sinusoidal wave-form using oscilloscope (Lissajous figures)

5.8.3

1. To observe the effect of matching the secondary impedance of a transformer to the primary impedance
2. To measure and compare the reverse bias characteristics of various types of semiconductor diodes
3. To trace the wave form of a sinusoidal input with/without series/shunt diode connected at the output in series with a suitable resistance

Text and Reference Books

J. D. Ryder, "Electronic fundamentals and applications: Integrated and discrete systems", 5th edition (Prentice-Hall of India).

J. Millman and A. Grabel, "Microelectronics", Second Edition (McGraw-Hill International Edition).

A. P. Malvino, "Digital Principles and Applications", Fourth Edition (International Student edition).

W. D. Stanley, "Electronic Devices: Circuits and Applications" (Prentice-Hall).

L. Schilling and Velove, "Electronic Circuits", Third edition (McGraw-Hill).

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COURSE P6: OPTICS

6.1 GEOMETRICAL OPTICS (15)

Fermat's principle: Principle of extremum path; the aplanatic points of a sphere and other applications.

General theory of image formation: Cardinal points of an optical system; general relationships, thick lens and lens combinations, telephoto lenses.

Aberration in images: chromatic aberrations; achromatic combination of lenses in contact and separated lenses. Monochromatic aberrations and their reduction; aspherical mirrors and Schmidt corrector plates, oil immersion objectives, meniscus lenses.

Optical instruments: Entrance and exit pupils, need for a multiple lens eyepiece, common type of eyepieces.

6.2 PHYSICS OPTICS I (15)

Interference of light: The principle of superposition; two-slit interference, coherence requirements for the sources, localized fringes in thin films, transition from fringes of equal thickness to those of equal inclination. Michelson interferometer; its uses for determination of wavelength, wavelength difference and standardization of the meter. Intensity distribution in multiple beam interference; Tolansky fringes, Fabry-Perot interferometer and etalon.

Fresnel diffraction: Half-period zones, circular apertures and obstacles, straight edge, explanation of rectilinear propagation.

Fraunhofer diffraction: Diffraction at a slit, a circular aperture and a circular disc. Resolution of images; Rayleigh criterion, resolving power of a telescope and a microscope, outline of phase contrast microscopy.

Diffraction grating: Diffraction at N parallel slits; plane diffraction grating, concave grating, resolving power of gratings and prisms.

6.3 PHYSICAL OPTICS II (15)

Double refraction and optical rotation: Double refraction in uniaxial crystals, explanation in terms of electromagnetic theory, phase retardation plates. Rotation of plane of polarization, origin of optical rotation in liquids and in crystals.

Dispersion and scattering: Theory of dispersion of light; absorption bands and anomalous dispersion. Theory of Rayleigh scattering; scattering of X-rays and determination of Z of an atom.

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Laser system: Purity of a spectral line; coherence length and coherence time, spatial coherence of a source; Einstein's A and B coefficients; coherence of induced emissions. Conditions for laser action; existence of a metastable state, population inversion by pumping and cavity. Application of lasers: Spatial coherence and directionality, estimates of beam intensity. Temporal coherence and spectral energy density. Lasers and nonlinear optics: Polarization P including higher order terms in E and generation of harmonics. Momentum mismatch and choice of right crystal and direction for compensation.

THEORY TUTORIALS

6.4.1 Geometrical Optics

1. Laws of reflection and refraction from Fermat's law
2. Problems on thick lenses and lens combinations
3. Bending of a lens to reduce spherical aberration
4. Entrance and exit pupils in telescopes and microscopes
5. Hollow-cone and illumination in microscopes

6.4.2 Physical Optics

1. Application of localized interference in thin films for precision measurements of displacements
2. Twymann-Green interferometer and its uses
3. Comparison of intensity distribution with Fourier transform of slit, generalization
4. Visibility of weaker stars in the high aperture telescopes
5. Hollow cone illumination, Ultramicroscope. Reference to radio telescope, radar, sonar etc. and to electron microscope and field ion microscope
6. Reflection grating and blazed grating
7. Michelson's echelon gratings
8. Resolving power of a Fabry-Perot etalon

6.4.3 Physical Optics II

1. Rayleigh refractometer and other applications
2. Phase retardation plates and double image prisms
3. Violation of principle of superposition at high intensity (e.g. lasers)
4 Energy level schemes for ruby, He-Ne and semiconductor lasers
5. Pulsed lasers; average and instantaneous powers

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6. Tunable lasers; use in precision spectroscopy
7. High pulse rates and time resolved spectroscopy
8. Negative temperature phase for population inversion
9. Frequency multiplication through nonlinear optics

LABORATORY EXPERIMENTS

6.5 GEOMETRICAL OPTICS

1. Dispersive power of material and linear dispersion in a prism spectrum using a graticule in the eyepiece
2. Determining the focal length of a high power microscope objective
3. Studying the cardinal points, magnification etc of a lens system; various methods
4. Measurement of absorption by a solution
5. Study of aberrations of a thick lens

6.6 PHYSICAL OPTICS

1. Study of interference fringes in a biprism arrangement
2. Study of interference fringes in thin films of the following (not all)
   a. Thermal expansion of a crystal using interference fringes
   b. Bending of a glass plate under load
   c. Bending of a rod under load
   d. Use of Newton's rings to determine the radii of curvature of surfaces
   e. Use of fringes in a wedge film (to compare the thickness of different sheets of paper or tissues or hair or a diameter of a wire)
3. Michelson's interferometer
4. Studying the diffraction of light at a single aperture
5. Resolving limit of the eye and of a telescope with a variable aperture
6. Fresnel diffraction at a straight edge and a slit
7. Fraunhoffer diffraction at a single slit
8. Study of carona rings with graded lycopodium powder using torch filament lamp with green and red filters (resolving power of telescope)
9. Study of spectra produced by a plane transmission grating
   a. Normal incidence setting for obtaining spectra of first two orders on one side for two wavelengths
   b. Minimum deviation setting and first order spectrum for two wavelengths
10. Resolving limit of grating and prism

11. Setting of a concave grating and photography of the spectra

6.7 PHYSICAL OPTICS II

1. Study of polarization of light by simple reflection
2. Study of optical rotation by solutions (using a vertical setup for easy change of length and a simple polaroid to avoid distraction)
3. Studying the parameters of a given laser
4. Study of laser as a monochromatic coherent source
5. Study of divergence of a laser beam

LABORATORY TUTORIALS

6.8.1 Geometrical Optics

1. Demonstration of anomalous dispersion
2. Demonstration of chromatic aberration
3. Demonstration of different monochromatic aberrations
4. Direct vision spectroscope
5. Beam expander lens for laser
6. Electron microscope

6.8.2 Physical Optics I

1. Fresnel diffraction for circular obstacle/aperture/zone plate, and at straight wire/slit
2. Demonstration of interference and diffraction phenomena using He-Ne laser source
3. Michelson's stellar interferometer and its resolving power
4. Large telescopes
5. Fabry-Perot interferometer/etalon

6.8.3 Physical Optics II

1. Pile of plates as a polarizer
2. Production and examination of circularly and elliptically polarized light
3. Studying the quality of a polaroid and checking the law of Malus
4. Half-wave and biquartz devices
5. Application of rotating polarization in chemistry
6. Study of Faraday rotation in ionoshere and optically active crystals

Text and Reference Books:

A K Ghatak; "Physical Optics"

D P Khandelwal; Optics and Atomic Physics (Himalaya Publishing House, Bombay 1988)

F G Smith and J H Thomson, "Manchester Physics Series: Optics" (English Language Book Society and John Wiely and Sons Ltd. London, 1977)

M Born and Wolf; "Optics"

K D Meller; "Optics" (Oxford University Press)

Sears; "Optics"

Jenkins and White; "Fundamentals of Optics" (McGraw-Hill)

B B Laud; "Lasers and Non-linear Optics" (Wiley Eastern, 1985)

Smith and Thomson; "Optics" (John Wiley and Sons, 1980)

D P Khandelwal; A Laboratory Manual of Physics for UG students (Vani Publication)

V Y Rajopadhye and V L Purohit; Text book of experimental Physics

R S Longhurst; "Geometrical and Physical Optics" (Longmans, 1966)

COURSE P7: QUANTUM MECHANICS

THEORY LECTURES

7.1 INTRODUCTION TO SCHRÖDINGER THEORY (15)

Rise and fall of Planck-Bohr quantum theory. Duality of radiation and matter, de Broglie's hypothesis, justification for the relation $\lambda = h/p$, experimental confirmation.

Phase and group velocities of a wave; formation of a wave packet, illustrations. Uncertainty principle relating to position and momentum, relating to energy and time, applications. Complementarity principle, photon interpretation of two-slit interference.

Einstein-de Broglie relations as a link between particle and wave properties, general equation of wave propagation, propagation of matter waves, time dependent and time independent Schrödinger equations, physical meaning of Ψ, conditions to be satisfied by Schrödinger equation as an operator equation. Postulatory approach to wave mechanics, operators, observables and measurements.

Simple one-dimensional problems; particle in a box with rigid walls, concept of a potential well, wave functions and energies for the ground and excited states; quantization of energy, qualitative discussion of the solution for a shallow potential well.

7.2 OPERATOR FORMULATION IN QUANTUM MECHANICS (15)

Operators, eigenvalues and eigenfunction; linear operators, product of two operators, commuting and noncommuting operators, simulataneous eigenfunctions, orthogonal functions. Hermitian operators, their eigenvalues, Hermitian adjoint operators, expectation values of an operator.

Application of operator methods; simple harmonic oscillator, step-up and step-down operators, eigenfunctions and eigenvalues of the ground state and excited states; zero-point energy. Probability density and its variation with degree of excitation; Orthogonality of wave functions.

Other one-dimensional problems; step potentials, penetration through rectangular barrier, transmission coefficients, barriers of special shapes, quantum mechanical tunneling. Particle in a three-dimensional cubical box, degeneracy.

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7.3 ANGULAR MOMENTUM AND SPIN (15)

central forces; orbital angular momentum, operators for its Cartesian components, commutation relations, mutual as well as with L^2, operators L^+ and L^-, their interpretation as step operators, eigenvalues of L_z, half-integral values for quantum numbers. Angular momentum operators in spherical polar coordinates; evaluation of their eigenfunctions explicitly in terms of the coordinates, their degeneracy.

Schrödinger equation for hydrogen atom in spherical polar coordinates, separation into radial and angular variables, qualitative discussion of spherical harmonics.

Angular momentum and magnetic moment of electron due to orbital motion; Bohr magneton, Stern-Gehrlach experiment, Uhlenbeck and Goudsmit's hypothesis of electron spin; Pauli's method of spin variable, along with the three coordinates in Schrödinger equation. Eigenvalues and eigenfunctions of the spin operator, Pauli spin operators and commutation relations.

THEORY TUTORIALS

7.4.1 Introduction to Schrödinger Theory

1. Planck's hypothesis; a critical analysis
2. Insignificance of de Broglie hypothesis in macro-physics
3. The uncertainty relation between conjugate variables
4. Discussion of the resemblance of Schrödinger equation to the diffusion equation
5. Analogy between Hamilton's principle and Fermat's principle

7.4.2 Operator Formulation in Quantum Mechanics

1. Matrix representation of an operator
2. Relations between different Hermite polynomials
3. Basic ideas behind Heisenberg's matrix mechanics
4. Harmonic oscillator according to Heisenberg-Born method
5. Three-dimensional harmonic oscillator
6. Wave function in a deep potential well for a free particle when the bottom of the well is not flat but has one small step

7.4.3 Angular Momentum and Spin

1. Ehrenfest' theorems; classical limit of quantum mechanics
2. Parity operator and its eigenvalues; does it commute with the Hamiltonian?
3. Express L^2 in spherical polar coordinates by using the fact that L is not only an operator, but has a vector property
4. Proof of commutation relations of angular momentum operators
5. Interpretation of hydrogen atom wave functions

LABORATORY EXPERIMENTS

7.5 INTRODUCTION TO SCHRÖDINGER THEORY

1. Measurement of *e* by Milliken's method
2. Determination of e/m by Thompson's method
3. Determination of Planck's constant
4. Measurement of wavelength of matter waves for electron beam
5. Determination of e/m by using Zeeman effect

7.6 OPERATOR FORMALISM IN QUANTUM MECHANICS

1. Study of field emission as a tunneling phenomenon
2. Numerical simulation of wave-functions of simple harmonic oscillator
3. Computation of wave functions and their interpretation for various potentials
4. Computation of transmission coefficients for barriers of different shapes
5. Simulation of wave functions for a particle in a critical box

7.7 ANGULAR MOMENTUM AND SPIN

1. Study of fine structure in a doublet spectrum and its quantum mechanical interpretation
2. Interpretation of angular wavefunctions of hydrogen atom and its application to the study of pure rotation spectra of molecules
3. Study of Paschen-Back effect and its quantum mechanical interpretation

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LABORATORY TUTORIALS

7.8.1 Introduction to Schrödinger Theory

1. Graphical study of laws of black body radiation
2. Evaluation of mean energy of simple harmonic oscillator using radiation
3. Computer simulation of two-slit photon interference experiment
4. Classical to quantum mechanical correspondence of wave functions when quantum number becomes large.
5. Thought experiments to demonstrate uncertainty relations

7.8.2 Operator Formalism in Quantum Mechanics

1. Quantization of harmonic oscillator energy levels using different formalisms and establishing their equivalence
2. Quantization of rigid rotator energy levels using different formalisms and establishing their equivalence
3. Illustration of zero-point energy for some simple molecules
4. Selection rules, orthogonality of wave functions and their experimental verification
5. Interpretation of degeneracy in some simple cases and its removal

7.8.3 Angular Momentum and Spin

1. Graphical study of different wave functions for simple systems
2. Preparation of polar diagrams for spherical harmonics
3. Discussion of Stern-Gerlach experiment
4. Comparison of quantum mechanical and vector models of angular momentum and their experimental verification
5. Interpretation of Pauli's principle for some simple systems

Text and Reference Books

P T Mathews; "Quantum Mechanics"

R Dicke and J Wittke; "Introduction to Quantum theory"

D Park; "Quantum theory"

A P French and E F Taylor; "Quantum Mechanics"

Gasiorowitz; "Quantum Physics"

Ghatak and Loknathan; "Quantum Mechanics"

P M Mathews and S Venkatesan; "Quantum Mechanics"

COURSE P8: ATOMIC AND MOLECULAR PHYSICS

THEORY LECTURES

8.1 MONOVALENT AND DIVALENT ATOMS (15)

Background from quantum theory: The four quantum numbers; spectral terms arising from L-S coupling, s, p, d, f notation, selection rules. Half-life of excited states; width of a spectral line.

Spectra of mono- and divalent atoms: Doublet fine structure of hydrogen lines; screening constants for monovalent atoms, series limits, doublet structure of alkali spectrum, spectra of helium and alkaline earth atoms, singlet and triplet series.

Effect of magnetic field on energy levels: Gyromagetic ratios for orbital and spin motions; vector model, Lande g factor, strong and weak field effects, illustrative cases of H, Na, Ca and Hg.

X-ray spectra: The continuum X-ray spectrum; Duane and Hunt limit. Characteristic X-rays; Moseley's law, doublet fine structure, H-like character of X-ray states. X-ray absorption spectra, absorption edges.

8.2 DIATOMIC AND TRIATOMIC MOLECULES (15)

Sharing of electrons; formation of molecular orbitals, H_2^+ ion, H_2 molecule, electronic levels, singlet and triplet characters. Rotational energy levels, internuclear distance. Vibrational energy levels, force constants, anharmonicity, dissociation energy, isotope effects on rotational and vibration energies.

Spectra of diatomic molecules: Pure rotation spectra; selection rules. Vibration-rotation spectra; selection rules, P, Q, and R branches. Electronic band systems, sequences and progressions, Franck-Condon principle.

Triatomic and complex molecules: Normal modes of a triatomic molecule; Selection rules for infrared absorption, molecular orbitals in complex molecules, approximation for treating H.O.C vibrations relative to 'rest' of the molecule.

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Raman effect: Raman shifts, Stokes and anti-Stokes lines, selection rules in Raman versus IR spectra.

8.3 EXPERIMENTAL TECHNIQUES (15)

Emission spectroscopy: Emission source, prism and grating spectrographs, constant deviation systems, monochromators, resolution and dispersion in various spectrographs, high resolution spectroscopy.

Absorption spectroscopy: Continuum source for absorption studies, single-beam and double-beam instruments, different recording systems.

Laser techniques: Laser as intense source for Raman excitation, laser imaging of objects, tunable lasers for high resolution spectroscopy, pulsed lasers for time resolved spectroscopy.

X-ray techniques: X-ray general absorption to deduce Z for atoms. X-ray diffraction to determine λ or d. Laue's theory for X-ray diffraction.

THEORY TUTORIALS

8.4.1 Mono- and Divalent Atoms

1. Matrix elements of dipole moment; emission and absorption probabilities
2. One-electron atomic systems
3. Width of spectral lines; natural, Doppler and others
4. Isotope effect and deduction of m/M from hydrogen and deuterium spectra
5. Polarization and intensities of Zeeman lines
6. J-J coupling
7. Fine structure of X-ray absorption edges

8.4.2 Diatomic and Triatomic Molecules

1. Quantum numbers for electronic states of diatomic molecules
2. Experimental evidence for theory for H_2 molecule
3. Isotope effect on electronic, vibrational and rotation energies
4. The structures of H_2O, CO_2, and N_2O molecules from IR and Raman spectra
5. Phosphorescence and fluorescence

8.4.3 Experimental Techniques

1. Continuum source for UV, V and IR regions
2. Littrow arrangements
3. Fabry-Perot or Lummer-plate in high resolution
4. Concave grating, different types of mountings
5. X-rays for the study of crystal structures

LABORATORY EXPERIMENTS

8.5 MONO-AND DIVALENT ATOMS:

1. Flame spectra of some salts
2. Spectrum of atomic hydrogen and Rydberg constant
3. Absorption spectrum of a coloured solution or fluorescence spectrum of a salt (e.g. uranyl nitrate)
4. Interpreting a given Zeeman spectrum with a polariod
5. Constant deviation prism

8.6 DIATOMIC AND TRIATOMIC MOLECULES

1. Absorption spectrum of I_2 vapour
2. Analysing the data of a given band system
3. Analysing a given vibration rotation spectrum
4. Studying the Raman spectrum of a sample (may use laser excitation)
5. Observe and analyse swan bands in the spectrum of a buffer flame

8.7 EXPERIMENTAL TECHNIQUES

1. Studying the linear dispersion in a given prism or a grating spectrometer
2. Setting up a Littrow system and calibrating its drum
3. Studying the lifetime of a phospher through decay study
4. Use of Fabry-Perot Interferometer for high resolution spectroscopy
5. Applications of tunable lasers for high resolution spectroscopy

8.8.1 Mono- and Divalent Atoms

1. Arc and spark spectra sources of mono- and divalent atoms
2. How quantitative analysis is made from atomic emission spectra

3. Experimental setup for the study of Zeeman effect
4. Bragg spectrometer
5. Recording systems for spectroscopic studies

8.8.2 Diatomic and Triatomic Molecules

1. Source for emission spectra of diatomic molecules
2. Detectors for infrared spectra
3. Lasers in Raman spectroscopy
4. Analysis of band spectrum of air at low pressures
5. Interpretation of Raman and IR spectra of simple triatomic molecules

8.8.3 Experimental Techniques

1. Fourier transform spectroscopy
2. Grating spectrograph for soft X-ray region
3. Prism for IR and UV spectrographs
4. Spherical Fabry-Perot Spectrometer for high resolution measurement
5. Experimental techniques for time-resolved spectroscopy

Text and Reference Books

G Herzberg; "Atomic spectra and atomic structure"

H Khun: "Atomic spectra"

Walker and Straugha; "Spectroscopy, Vol I, II, III

G Herzberg; "Molecular spectra and Molecular structure"

H Barrow; "Theory of atomic spectra"

R C Johnson; "Introduction to Molecular spectra"

Herschlaf, "Fluorescence and phosphorescence"

Olon; "Experiments in Modern Physics"

COURSE P9: SOLID STATE PHYSICS

THEORY LECTURES

9.1 CRYSTAL GEOMETRY AND CRYSTALLOGRAPHY (15)

Crystal geometry: Crystal lattice; crystal planes and Miller indices, unit cells. Typical crystal structures; coordination number, packing fraction. Symmetry elements; rotation, inversion and reflection, point groups and crystal classes, space groups.

Crystallography: Bloch functions; Bloch's theorem, diffraction of X-rays by a crystal lattice. Laue's formulation of X-ray diffraction; reciprocal lattice, Brillouin zones, Laue spots, rotating crystal and Debye-Scherrer methods, geometrical structure factor, atomic form factor. Neutron and electron diffraction methods.

9.2 BINDING, LATTICE VIBRATIONS AND METALS (15)

Types of binding in solids: Covalent binding and its origin, Ionic binding, energy of binding, transition between covalent and ionic binding, metallic binding, Van der Waals binding, hydrogen bond.

Lattice Vibrations: Elastic and atomic force constants; Dynamics of a chain of atoms, chain of two types of atoms, optical and acoustic modes, interaction of light with ionic crystals, Einstein's and Debye's theories of specific heats of solids.

Conduction in metals: Drude's theory, DC conductivity, Hall effect and magnetoresistance, AC conductivity, plasma frequency, thermal conductivity of metals, Fermi-Dirac distribution, thermal properties of free-electron gas, Sommerfeld's theory of conduction in metals.

9.3 SEMICONDUCTORS, MAGNETISM AND SUPERCONDUCTIVITY (15)

Conduction in semiconductor: Bands in solids; metals, insulators and semiconductors. Motion of free electrons on a chain of atoms, reduced mass, electrons and holes, donor and acceptor impurities, donor impurity levels. Thermal excitation of carriers, electrical conductivity, Hall effect, cyclotron resonance.

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Magnetism: Diamagnetism, Paramagnetism due to free ions and conduction electrons; Curie's law, ferromagnetism, domains, hysterisis loop, outline of antiferro- and ferrimagnetism, ferrites.

Superconductivity: Zero resistivity; critical temperature, critical B field. Meissner effect; Type I and Type II superconductors, specific heat and thermal conductivity.

TUTORIALS

9.4.1 Crystal Geometry and Crystallography

1. Seven systems and 14 Bravais lattices
2. Spacing of planes from Miller indices
3. Reciprocal lattices for two dimensional cases
4. Bragg's law from Laue formulation
5. Geometrical structure factor for typical cases
6. Packing fraction calculations
7. Liquid crystals
8. Crystal defects and their propagation

9.4.2 Binding, Lattice Vibrations and Metals

1. Hardness in covalent crystals and malleability in metallic crystals
2. Fractional ionic bindings
3. Thermodynamics of crystalline-glass transition
4. Elastic constants as tensors
5. Elastic waves – longitudinal and transverse
6. Madelung constant
7. Drift velocity of electrons in conduction
8. Difficulties with the free electron model for metals
9. Thermionic emission from solids

9.4.3 Semiconductors, Magnetism and Superconductivity

1. Typical band gaps in semiconductors
2. Contribution of holes in some metallic conductors
3. Mobilities of electrons and holes
4. Information from cyclotron resonance
5. Different types of magnetic order

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6. Space charge in semiconductors
7. Thermistors and their properties
8. High T_c superconductors and prospects of their applications

LABORATORY EXPERIMENTS

9.5 CRYSTAL GEOMETRY AND CRYSTALLOGRAPHY

1. Using a goniometer to measure crystal face angles
2. Using a given Laue pattern to deduce the parameters for the concerned sample
3. Using a given rotation diffractogram to deduce the parameters for the concerned sample
4. To prepare three dimensional models of lattices
5. To study the given model for determining bond angles, number of near neighbours bond lengths symmetries etc.

9.6 BINDING, LATTICE VIBRATIONS AND METALS

1. Computer simulation of Lennard-Jones potential; binding parameters, elastic constants
2. Computer simulation of 1-D and 2-D lattice vibrations
3. Computer simulation of Kronig-Penney model
4. Study of Thermionic emission
5. Study of DC and AC conductivity of solids

9.7 SEMICONDUCTORS, MAGNETISM AND SUPERCONDUCTIVITY

1. Obtaining B-H curve for a ferromagnetic sample (any method)
2. Magnetic susceptibility of (say) ferric chloride solution and deducing magnetic moment of the ion
3. Hall probe in magnetic field measurement
4. Temperature dependence of conductivity of a semiconductor
5. Characteristics of a solar cell

LABORATORY TUTORIALS

9.8.1 Crystal Geometry and Crystallography

1. From the model of a crystal, to deduce the coordination numbers and packing fractions
2. Simulation of 3-D models of a given kind of crystal and their study

3. Setups for Bragg reflection, Laue spots and rotating crystal methods with X-rays
4. Techniques of electron diffraction and their applications
5. Techniques of neutron diffraction and their applications

9.8.2 Binding, Lattice Vibrations and Metals

1. Computer simulation of 3-D Fermi surfaces
2. Specific heat of simple solids at low temperatures
3. 3-D Fermi surfaces in metals and semiconductors
4. Cohesive energy of solid argon
5. Measurement of magnetoresistance

9.8.3 Semiconductors, Magnetism and Superconductivity

1. Observing magnetic domains
2. Solar cell; fabrication and characteristics
3. Electromagnets, permanent magnets, ferrite magnets
4. Methods used in fabrication of p-n and n-p-n type junctions
5. Magnetism based methods of obtaining and measuring very low temperatures

Text and Reference Books

R H Bube; "Electrons in Solids: An Introductory Survey" (Academic Press, 1981)

R H Bube; "Electronics Properties of Crystalline Solids" (Academic Press, 1973)

A J Dekker; "Solid State Physics" (Prentice-Hall, 1957)

H J Goldsmid; "Problems in Solid State Physics" (Pion, 1968)

W A Harrison; "Electronic structure and the properties of solids" (Freeman, 1980)

C Kittel; "Introduction to Solid State Physics" (Wiley, Vth Ed., 1976)

J P McKelvey; "Solid state and semiconductors physics" (Krieger, 1982)

H M Bosenberg; "The Solid State" (Oxford University Press, IInd Ed. 1979)

J S Blackemore; "Solid State Physics" (Cambridge University Press, IInd Ed. 1985)

S L Altmann; "Band Theory of Metals, The Elements" (Pergamon Press, 1970)

COURSE P10: ELECTRODYNAMICS, ELECTROMAGNETIC WAVES AND RELATIVITY

THEORY LECTURES

10.1 TIME-DEPENDENT FIELDS AND MAXWELL'S EQUATIONS (15)

*Motion of charged particles in **E** and **B** fields:* Case of cathode ray oscillograph, positive ray parabola, velocity selector, magnetic focusing, cyclotron and betatron, mass spectrography.

Faraday's law for electromagnetic induction: Faraday's law in integral and differential forms; self-inductance of a solenoid and of a straight conductor, energy stored in an inductor and in the magnetic field. Displacement current; modified Ampere's law, Maxwell's equation for time-dependent electromagnetic field in vacuum, and in material media, boundary conditions.

Electromagnetic potentials: Magnetic vector potential **A** and scalar potential ϕ. Poisson's equation for **A** in terms of current density, solutions for line and surface currents, Coulomb and Lorentz guage transformations, Lorentz law in terms of potentials.

10.2 ELECTROMAGNETIC WAVES (15)

Maxwell's equations and electromagnetic waves: Plane-wave solution for Maxwell's equation; orthogonality of **E**, **B** and propagation vector. Poynting vector; energy and momentum propagation, reflection and transmission at dielectric boundaries, normal incidence, oblique incidence, polarization by reflection, Brewster's angle.

Electromagnetic waves in conductors: Modified field equation; attenuation of the wave, reflection at and transmission through a conducting surface.

Radiation from accelerated charges: Modification of Coulomb's law to include velocity and acceleration dependent terms in **E** field. Radiation from an oscillating dipole and its polarization, concept of retarded potentials.

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10.3 SPECIAL THEORY OF RELATIVITY (15)

The Lorentz transformations: Galilean transformations; Newtonian relativity. Instances of their failure; electromagnetism, aberration of light, Michelson-Morley experiment. Einstein's basic postulates and geometric derivation of Lorentz transformations; invariance of Maxwell's equations, length contraction, simultaneity, synchronization and time dilation, Einstein's velocity addition rule, Doppler effect in light.

Relativistic dynamics: Variation of mass with velocity, mass energy equivalence, relativistic formulae for momentum and energy.

The structure of spacetime: Four-vectors; invariance of an interval, timelike, spacelike and lightlike intervals, Minkowski world.

Relativistic electrodynamics: Electric field of a point charge in uniform motion; transverse components, magnetism as a relativistic phenomenon, transformation of **E** and **B** fields.

THEORY TUTORIALS

10.4.1 Time Dependent Fields and Maxwell's Equations

1. Mutual and self inductance
2. Transformers
3. Cyclotron and betatron
4. Velocity selector, resolution
5. Illustrations of boundary conditions for simpler systems

10.4.2 Electromagnetic Waves

1. Early theories of light
2. Electromagnetic spectrum
3. Anisotropic media
4. **E** and **B** fields for typical intensity of light
5. Penetration of light in second medium at total internal reflection
6. Comparison of velocity dependent and acceleration dependent fields of accelerated charge

10.4.3 Special Theory of Relativity

1. Invariance of Maxwell's equations
2. Propagation of light in a moving dispersive medium
3. Illustration of aberration of light
4. Twin paradox
5. Transformation of E and B fields with reference frame

LABORATORY EXPERIMENTS

10.5 TIME-DEPENDENT FIELDS AND MAXWELL'S EQUATIONS

1. Study of induced emf for a magnet crossing a coil (CDPE Jaipur experiment)
2. Determination of e/m using a magnetron
3. Sensitivity of a cathode ray oscillograph
4. Magnetic focusing of a beam and estimation of e/m
5. Study of one-dimensional potential for magnetic interactions; using a linear air track and digital timer (CDPE Jaipur experiment)
6. Study of fall of a magnet though a metallic cylinder (CDPE Jaipur experiment)

10.6 ELECTROMAGNETIC WAVES

1. Wave guides, phase and group velocities
2. Lecher wires
3. Study of plane of polarization using quarter and half wave plates
4. Study of Joule heating in a good conductor (sheet) during the propagation of electromagnetic waves
5. Study of conductivity in an ionized gas (plasma)

10.7 SPECIAL THEORY OF RELATIVITY

1. Determination of speed of light using ratio of emu to esu units
2. Study of Michelson-Morley experiment using Michelson interferometer
3. Simulation study of variation of mass with velocity
4. Simulation study of length contraction
5. Positron annihilation experiment for demonstration of mass-energy equivalence

LABORATORY TUTORIALS

10.8.1 Time Dependent Fields and Maxwell's Equations

1. Velocity selector and its resolution
2. Mass spectrographs
3. Lorentz force leading to Faraday's law
4. Experimental evidence for displacement current
5. Cathode ray oscillograph

10.8.2 Electromagnetic Waves

1. Cerenkov radiation
2. The Hertzian dipole and its radiation field
3. Propagation of EM waves in absorbing medium
4. Skin depth in metals; evidence for it
5. Radiation pressure

10.8.3 Special Theory of Relativity

1. Experiments that verify time dilation
2. Synchrocyclotron
3. Application of mass-energy equivalence principles
4. Illustration for relativistic formulation of momentum and energy
5. Relativistic invariance of electromagnetism

Text and Reference Books

D.J. Griffiths; "Introduction to Electrodynamics" (Prentice-Hall of India 1989)

Reitz and Milford; Introduction to Electrodynamics (Addision-Wesley)

A.M. Portis; "Electromagnetic Fields"

J.B. Marion; "Classical electromagnetic radiation" (Academic Press)

R.P. Feymann, R.B. Leighton and M. Sands; "The Feymann Lectures Physics", Vol. II (B.I. Publication)

B. Saraf et.al.; "Physics through experiments ; Vol. I – EMF, constant and varying" (Vikas Publishing House)

D. R. Corson and P. Lorrain; "Introduction to Electromagnetic Fields and Waves" (Freeman-Taraporevala, Bomaby 1970)

E. C. Jordan and K.G. Balmain; "Electromagnetic Waves and Radiating Systems", II Edition (Prentice-Hall of India, New Delhi 1971)

COURSE P11: NUCLEAR AND PARTICLE PHYSICS

THEORY LECTURES

11.1 STRUCTURE AND PROPERTIES OF THE NUCLEUS (15)

Structure on nucleus; discovery of the nucleus, composition. Basic properties; charge, mass, size, spin, magnetic moment, electric quadrupole moment, binding energy, binding energy per necleon and its observed variation with mass number of the nucleus, Coulomb energy, volume energy, surface energy, other corrections, explanation of the binding energy curve. Liquid drop model of the nucleus.

Nuclear forces: two-nucleon system, deuteron problem, binding energy, nuclear potential well, pp and pn scattering experiments, meson theory of nuclear forces, e.g. Bartlett, Heisenberg, Majorana forces and potentials, mirror nuclei, nuclear energy levels, nuclear gamma rays.

Radioactivity: decay constant and half-life; methods of measurement of half life, spectra of emitters, Geiger-Nuttal law, Gamow's explanation. Beta decay, Fermi's theory, neutrino and antineutrino. Nuclear radiation, energy levels.

11.2 NUCLEAR REACTIONS (15)

Detectors for charged particles; Ion chamber, Geiger counter, resolving time, cloud chamber, photographic emulsions and bubble chamber.

Accelerators: Need for accelerators; Cockroft, Walton, Van de Graaf, cyclic accelerators, cyclotron, synchrocyclotron, variable energy cyclotron, phase stability, superconducting magnets.

Nuclear reactions; Rutherford's experiments of nuclear transmutation, conservation theorems, Q value, threshold energy, cross-section of nuclear reactions.

Artificial radioactivity: Nuclear fission, Neutron reactions, Fermi and transuranic elements, chain reaction, criticality, moderators.

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11.3 COSMIC RAYS AND ELEMENTARY PARTICLES (15)

Discovery of cosmic rays; hard and soft components, discovery of muon, pion, heavy mesons and hyperons, mass and life time determination for muon and pion.

Primary cosmic rays: Extensive air showers, solar modulation of primary cosmic rays, effect of earth's magnetic field on the cosmic ray trajectories.

Resonant particles; discovery and important properties. Strangeness, conservation of strangeness in particle interactions, quark hypothesis, high energy electron scattering from protons, basic interactions of quarks and leptons, interrelation between particle physics and cosmology.

THEORY TUTORIALS

11.4.1 Structure and Properties of Nucleus

1. Nuclear spin and moments
2. Shell model of the nucleus; Schmidt lines
3. Collective model
4. Biological effects of radiation
5. Comparative study of interaction energy in nuclear forces with other forces

11.4.2 Nuclear Reactions

1. Power reactors, breeder reactors
2. Problems of nuclear safety
3. Energy production in stars, Tokamak experiment
4. Shell model of the nucleus
5. Collective model

11.4.3 Cosmic Rays and Elementary Particles

1. Yukawa's theory and cosmic ray mesons
2. Discovery of positron
3. Discovery of **V** particles, their discrimination into heavy mesons and hyperons
4. SU(2) and SU(3) symmetries
5. New flavours of quarks

LABORATORY EXPERIMENTS

11.5 STRUCTURE AND PROPERTIES OF NUCLEUS

1. Study of absorption of alpha rays in matter
2. Study of counting statistics in radioactive emissions
3. Thickness gauging by beta rays
4. Leak detection by radioactive sources
5. Determination of uptake rate of iodine by plants

11.6 NUCLEAR REACTIONS

1. Efficiency and dead time of a G.M. tube
2. Study of photomultiplier pulse shapes
3. Resolution of scintillator counter and its application
4. Compton scatting
5. Rutherford alpha scattering

11.7 COSMIC RAYS AND ELEMENTARY PARTICLES

1. Half life measurements of short lived isotopes
2. Resolving time of a coincidence unit and its applications
3. Measurement of energy of cosmic rays using photographic emulsion methods
4. Computer simulation of cosmic ray trajectories
5. Determination of life-time for mesons

LABORATORY TUTORIALS

11.8.1 Structure and Properties of Nucleus

1. Radiation units
2. Techniques for the measurement of nuclear spin
3. Techniques for the measurements of quadrupole moment
4. Methods of estimation of nuclear charge, mass and size
5. Methods of measurement of half-life for radioactive elements

11.8.2 Nuclear Reactions

1. Basic theory of nuclear detectors

2. Interaction of charged particles and neutrons with matter
3. Neutron detectors
4. Colloiding beam techniques
5. Nuclear chain reactions and nuclear energy

11.8.3 Cosmic Rays and Elementary Particles

1. Millikan's experiments with cosmic rays
2. Use of balloons in cosmic ray research
3. Experimental evidence of neutrino
4. Energy spectra of cosmic rays and solar cosmic rays
5. High energy interactions in cosmic rays

Text and Reference Books

Meyeroff; "Elements of Nuclear Physics"

Kaplan; "Nuclear Physics"

Cohen; "Concepts of Nuclear Physics"

Segre; "Nuclei and Particles"

Burcham; "Nuclear Physics"

Rossi; "Cosmic Rays"

Perkins; "High Energy Physics"

R. M. Singru; "Introduction to Experimental Nuclear Physics" (Wiley Eastern)

K. Siegbahn; "Alpha, Beta and Gamma Spectroscopy" (North Holland, Amsterdam)

COURSE P12: ELECTIVES

Here we give a list of elective courses and the blow-up for a few.

1. Applied Optics
2. Advanced Electronics
3. Astrophysics
4. Low Temperature Physics
5. Biophysics
6. Materials Science
7. Energy Sources
8. Microelectronics
9. Vacuum Physics
10. Atmospheric Physics
11. Information Technology
12. Environmental Physics

COURSE 12 (5): BIOPHYSICS

12.1 STRUCTURE AND FUNCTION OF CELL AND ORGANELLES (15)

What is biophysics ? History of biophysics, life – order or chaos.

Plant and animal cells; eucosiotic, procariotic cells, composition of cell in terms of water, protein, phospholipid, lipid etc. Function of cell membrane; cytoplasm, nucleus, mitochondria, microsomes and other cell organelles.

Biological molecules; water, glucose, carbohydrates, Lipids, proteins, nucleic acids, ATP. Structure and function in relation to bond formation. Genetic code, symmetry, revision of DNA structure. Protein synthesis, transcription, translation etc. Intercellular interactions, molecular recognition.

12.2 NEUROPHYSICS (15)

Neuron anatomy: Cell, dendrift, axon, background of neuron physiology. Physical and chemical background of membrane potential.

Nernst equation; resting potential, ionic pumps, pores of different ionic species, action potential.

Voltage clamp technique; conduction changes and Hodgkin-Huxley analysis. Cable equation; propagation of action potential, compound action potential.

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12.3 PHOTOSYNTHESIS (15)

Photosynthetic process; quantum efficiency. Photosystem I and II; nature of electron transport. Bioenergetics; Gibbs free energy, equilibrium constants in chemical reactions.

Interconversion of energies; electrical and chemical half cell potentials. Redox potentials, ATP structure and reactions. Changes in Gibbs free energy in ATP formation, redox couple, bioenergetics in chloroplasts.

THEORY TUTORIALS

12.4.1 Structure and Function of Cell and Organelles

1. Cell differentiation; types of cells found in living systems
2. Differences and similarities between plant and animal cells
3. Discussion on genetic code
4. Membrane structure and function
5. Enzyme and their catalytic action

12.4.2 Neurophysics

1. Anatomy of human nervous system
2. Types of neurons in brain
3. Space clamp technique
4. Structure and function of muscles
5. Different compound action potentials observed in human body

12.4.3 Photosynthesis

1. Plant and photosynthetic apparatus
2. Role of membrane in photosynthesis
3. Examples on interconversion of chemical and electrical energy
4. Photosystem I and II models proposed
5. Mitochondrial bioenergetics

LABORATORY EXPERIMENTS

12.5 STRUCTURE AND FUNCTION OF CELL AND ORGANELLES

1. Determination of extinction coefficient and verification of Lambert-Beer law
2. Measurement of activation energy of transitions using UV spectroscopy
3. Effect of solvent polarity on infrared transitions.
4. Study of DNA melting
5. Experimental setup for the study of intercellular interactions.

12.6 NEUROPHYSICS

1. Changes in potential across frog skin in response to the change in ionic concentration
2. Measurement of conduction velocity in frog siatic nerve
3. Recording an electrocardiogram and R-R interval analysis
4. Measurement of skin resistance
5. Hodgkin-Huxley equations; educational software/recording of spike train in cockroach mechanoreception

12.7 PHOTOSYNTHESIS

1. Study of absorption spectrum in chlorophyll
2. Measurement of a half cell potential
3. Measurement of oxygen evolution in a photosynthetic system
4. Isolation of chloroplast and study of absorption characteristics
5. Thermoluminescence in spinach leaves

LABORATORY TUTORIALS

12.8.1 Structure and Function of Cell and Organelles

1. Absorption by atoms and molecules
2. Construction and working of colorimeter and spectrophotometer
3. Structure and function of DNA
4. Solvent polarization
5. Study of bond formation

12.8.2 Neurophysics

1. Various properties of skin
2. Anatomy of muscles and nerves in frog leg
3. Structure and function of heart
4. Computational analysis
5. Neural coding

12.8.3 Photosynthesis

1. Extraction of chlorophyll
2. Discussion of relation between chemical potential and half cell potential
3. Construction and working of oxygen electrode
4. Structure and function of chloroplast
5. Discussion on activation energy

Text and Reference Books

I.W. Sherman and V.G. Sherman; "Biophysics and Human Approach" (Oxford University Press 1979).

E.R. Kandel and J.H. Schwar; "Principles of Neural Science" (Elsevier, North Holland, 1982).

P.S. Nobel; "Biophysical Plant Physiology and Ecology" (University of Calofornia, Los Angelies, and W.H. Freeman & Co, San-Franscisco 1983).

S. W. Kuffler and J.G. Nicholts; "Neuron to Brain: (Sinacuer associates Inc. 1975).

R.E. Dickerson and J. Geis ; "The Structure and Action of Proteins" (Harper and Row 1975).

R.B. Setlow and E.C. Polland; "Molecular Biophysics" (Addison Wesley Publishing Co. USA 1962)

COURSE 12 (12) ENVIRONMENTAL PHYSICS

1. Essentials of Environmental Physics: Structure and thermodynamics of the atmosphere; Composition of air; Greenhouse effect; Transport of matter, energy and momentum in nature; Stratification and stability of atmosphere; Laws of motion; Hydrostatic equilibrium; General circulation of the tropics; Elements of weather and climate of India.
2. Solar and Terrestrial Radiation: Physics of radiation; Interaction of light with matter; Rayleigh and Mie scattering; Laws of radiation (Kirchoff, Planck, Beer, Wien, etc); Solar and terrestrial spectra; UV radiation; Ozone depletion problem; IR absorption; Energy balance of the earth atmosphere system.
3. Environmental Pollution and Degradation: Elementary fluid dynamics; Diffusion; Turbulence and turbulent diffusion; Factors governing air, water, and noise pollution; Air and water quality standards; Waste disposal; Heat island effect; Land and see breeze; Puffs and plumes; Gaseous and particulate matter; Wet and dry deposition; Dispersal mechanism of air and water pollutants; Mixing height and turbulence; Gaussian plume models; Dispersion models; Environmental degradation; Thermal and radioactive pollution; Nuclear radiation; Health hazards and safety.
4. Environmental Changes and Remote Sensing: Energy sources and combustion processes; Renewable sources of energy; Solar energy, wind energy, bioenergy, hydropower, fuel cells, and nuclear energy; Forestry and bioenergy; Deforestation; Degradation of soils; Agriculture and land use changes; Changing composition of local, regional and global environment; Remote sensing techniques.
5. Global and Regional Climate: Elements of weather and climate; Stability and vertical motion of air; Horizontal motion of air and water; Pressure gradient forces, viscous forces, and inertia forces; Reynold's number; Enhanced greenhouse effect; Energy balance – a zero-dimensional greenhouse model; Global climate models; Cloud radiative feedback and ice albedo feedback processes; Projections of global climate changes; Downscaling techniques; Future scenarios of Indian climate; Introductory modeling; Elements of chaos; Lorenz model.

Text and Reference Books

Egbert Boeker and Rienk van Groundelle, Environmental Physics (John Wiley)

J T Houghton, The Physics of Atmosphere (Cambridge Univ Press, 1977)

J Twidell and J Weir, Renewal Energy Resources (ELBS, 1988)

Sol Wieder, An Introduction to Solar Energy for Scientists and Engineers (John Wiley, 1982)

R N Keshavamurthy and M Shanker Rao, The Physics of Monsoons (Allied Publishers, 1992)

G J Haltiner and R T Williams, Numerical Weather Prediction (John Wiley, 1980)

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MATHEMATICS COMPONENT IN B.SC. (PHYSICS)

Course M1: VECTORS, MATRICES, COMPLEX NUMBERS AND PROBABILITY

M1.1 VECTOR ALGEBRA AND VECTOR FUNCTIONS OF ONE VARIABLE (15)

Vector algebra: equality, zero vector, addition, multiplication by a scalar. Scalar and vector products, various triple and multiple products. Work done by a force, angular velocity and angular momentum. Scalar and vector fields, vectors depending on a single parameter (e.g. time), derivative of a vector with respect to the parameter. Linear dependence and independence of vectors. Vector functions of two and three parameters.

M1.2 DETERMINANTS AND MATRICES (15)

Matrix algebra, equality, zero matrix, addition, multiplication by a scalar, transpose and adjoint, commutator. Inverse and its existence; inverse of product of matrices.

Rank of matrix; invariance of rank in elementary transformations.

Linear equations; homogeneous and inhomogeneous equations, consistency and solutions.

Orthogonal and unitary matrices, orthogonal and unitary transformations.

M1.3 COMPLEX NUMBERS, PROBABILITY AND ELEMENTARY STATISTICS (15)

Algebra of complex numbers; equality, zero, addition, multiplication by a real number, Argand diagrams. Complex conjugate, triangle inequality. Cartesian and Polar representation of a complex number, De Moiver's theorem.

Common functions of a complex variable, separation into real and imaginary parts (trigonometric, exponential, logarithm, hyperbolic).

Sample space, events, probability in discrete sample space. Discrete random variables, mean. Joint distributions.

Statistical description, frequency distribution, cumulative distribution, tabulation of data.

THEORY TUTORIALS

M1.4.1 Vector Algebra and Vector Functions of One Variable

1. Need for scalars and vectors, Galilean invariance

2. The contingent nature of components of a vector, magnitude, direction, angle etc.
3. Producing scalars and vectors from other scalars and vectors, relevance in physical laws
4. Multiple products
5. Orthogonal transformations

M1.4.2 Determinants and Matrices

1. Review of determinants, distinction between matrices and determinants
2. Inverse of a matrix
3. Rank of a matrix
4. Linear equations
5. The most general orthogonal and unitary matrices of order 2

M1.4.3 Complex Numbers, Probability and Elementary Statistics

1. Argand diagram for z, z^*, iz etc
2. Evaluation of functions of a complex number.
3. Expectation values, variances and moments.
4. Correlations
5. Notion of statistical population and types of populations.

LABORATORY EXPERIMENTS (WORK SESSIONS)

M1.5 VECTOR AND VECTOR FUNCTIONS OF ONE VARIABLE

1. Properties of triple products, multiple products
2. Infinitesimal rotations as vectors
3. Variable velocity and acceleration
4. Change of components under orthogonal coordinate transformations
5. Total differential and chain rule

M1.6 DETERMINANTS AND MATRICES

1. Special matrices
2. Independent parameters of various special matrices
3. Reduction of a matrix to normal from
4. Rank of product of matrices
5. Geometrical interpretation of linear equations

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M1.7 COMPLEX NUMBERS, PROBABILITY AND ELEMENTARY STATISTICS

1. Powers and roots of a complex number
2. *n n*-th roots of unity, powers and roots continued
3. Applications of complex numbers in Physics
4. Conditional probability and independence of two or more variables
5. Simple random sampling with and without replacement

LABORATORY TUTORIALS

M1.8.1, M1.8.2 and M1.8.3 shall each have one hour discussion sessions illustrating applications of topics covered in M1.5, M1.6 and M1.7 respectively.

Text and Reference Books

F A Hinchey, "Vectors and Tensors" (Wiley Eastern)

Schaum Series, "Vectors"

A W Joshi; "Matrices and Tensors in Physics", 3rd Edition (New Age International Ltd, 1998)

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COURSE M2: COORDINATE SYSTEMS, ANALYTICAL GEOMETRY AND CALCULUS

THEORY LECTURES

M2.1 Coordinate Systems and Elementary Calculus (15)

Cartesian coordinate systems, 2-D polar system, 3-D cylindrical and spherical polar systems. Transformation from one system to another, orthogonal transformations of cartesian coordinate system. Most general 3-D coordinate system.

Differentiability of a function of one variable, Rolle's theorem, Lagrange and Cauchy mean-value theorems, indeterminate forms, L'Hospital's rule; Successive differentiation, Leibnitz's rule.

Taylor's and Maclaurin's theorem, maxima and minima using Taylor's theorem.

M2.2 Analytical Geometry (15)

General equation of a conic (2nd Degree), reduction to standard form. Point distance formula, section formula, Change of origin.

General equation of a plane, intercept form, normal form, angle between two planes and between a line and a plane.

General and standard equation of a sphere, intersection of two spheres.

Cylinder and cone, enveloping cones of central conicoids in standard form.

M2.3 Calculus (15):

Radius of curvature, intrinsic equations, parametric curves, plotting of elementary functions.

Integration and its techniques, integration involving elementary functions such as algebraic, trignometric, hyperbolic, logarithmic, inverse, exponential, and their combinations. Reduction formulae (definite and indefinite), theory of Riemann integration, rectification.

Ordinary differential equations of first order and first degree, homogeneous and inhomogeneous equations. Exact solutions, nonlinear equations reducible to linear form.

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THEORY TUTORIALS

M 2.4.1 Coordinate Systems and Elementary Calculus

1. Symmetry of each coordinate system and suitability in physical problems
2. Exercises
3. Exercises
4. Exercises
5. Exercises

M 2.4.2 Analytical Geometry

1. Angle between two lines
2. Line as intersection of two planes
3. Exercises
4. Exercises
5. Normal line

M 2.4.3 Calculus

1. Exercises
2. Exercises
3. Equations with separable variables
4. Exercises
5. Exercises

LABORATORY EXPERIMENTS (WORK SESSIONS)

M 2.5 COORDINATE SYSTEMS AND ELEMENTARY CALCULUS

1. Displacement and velocity vectors in various coordinate systems
2. Volume element in each system
3. Limits, Continuity, uniform continuity, boundedness
4. Differentiation of a determinantal function
5. Theorems on maxima and minima

M2.6 ANALYTICAL GEOMETRY

1. Principal axes and corresponding transformation

2. Symmetric and parametric equations of lines
3. Equations of a line and shortest distance between two lines
4. Tangent plane to a sphere and its condition
1. Second degree conicoids in standard form

M 2.7 CALCULUS

1. Equations of plane curves, polar coordinates, pedal equations (p, ψ) equations
2. Cycloid, catenary, cardioid, spiral etc
3. Surface area and volume of solid of revolution
4. Equations of first order and higher degree, solvable for x, for y, for p, Clairaut's form
5. Elementary examples of second order linear equations with constant coefficients

LABORATORY TUTORIALS (DISCUSSION SESSIONS)

M 2.8.1 Coordinate Systems and Elementary Calculus

1. Exercises
2. Exercises
3. Exercises
4. Exercises
5. Exercises

M 2.8.2 Analytical Geometry

1. Lines and direction cosines, direction ratios
2. Distance of a point from a plane and a line Section of a sphere by a plane
3. Tangent plane to a conicoid
4. Exercises

M 2.8.3 Calculus

1. Exercises
2. Exercises
3. Integrating factors
4. Linear differential equations and the principle of superposition
5. Elementary examples of second order ODE with constant coefficients

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COURSE M3: COMPUTER PROGRAMMING, MULTIVARIABLE CALCULUS AND DIFFERENTIAL EQUATIONS

THEORY LECTURES

M 3.1 COMPUTER PROGRAMMING (15)

Higher and lower level languages, compilers, information storage and processing. Algorithms, programmes, floating point arithmetic, binary numbers.

Fortran language, character set, structure of a programme, types of variable names, real and integer constants, expressions, types of Fortran statements, arithmetic replacement statements.

Arrays and dimension statements, transfer control statements, IF, GO TO, loop structure under DO statement, logical expressions and assignments.

M 3.2 MULTIVARIABLE CALCULUS (15)

Functions of two and three variables, limits, continuity and differentiability. Chain rule, homogeneous functions, chain rule for homogeneous functions, geometric meaning of differentiability.

Mean-value theorem, Taylor's and Maclaurin's theorem for a function of two variables, extrema of functions.

Multiple integrals, linear differential forms, line integrals and differential forms, differetiation under the integral sign.

Multivariable calculus and implicit functions, change of coordinate system. Surface and volume integrals, Green's theorem, Stokes' theorem for 3D case.

M 3.3 DIFFERENTIAL EQUATIONS (15)

Linear equations with constant coefficients.

Homogeneous equations of higher order.

Frobenius method of series solution.

Partial differential equations.

THEORY TUTORIALS

M3.4.1 Computer Programming

1. Computer as a machine
2. STOP, END statements
3. Arithmetic IF and logical IF
4. Input and Output statements
5. Illustrations for control statements

M3.4.2 Multivariable Calculus

1. Partial derivatives of higher order
2. Converse of Euler's theorem
3. Asymptotes of curves and singular points
4. Conservative vector fields
5. Statements of implicit functions theorems and inverse function theorems

M3.4.3 Differential Equations

1. Complimentary functions
2. Exact differential equations of higher order
3. Some of the simplest PDEs
4. Illustration of Frobenius method
5. Comparative study of different approaches for solutions

LABORATORY EXPERIMENTS (WORK SESSIONS)

M3.5 COMPUTER PROGRAMMING

1. Elementary Fortran programmes, flow-charts
2. Sorting of numerical data
3. Sum of a finite series
4. Magic square
5. Factorial

M3.6 MULTIVARIABLE CALCULUS

1. Young and Schwartz theorems for $f_{xy}(a, b) = f_{yx}(a, b)$
2. Tangent planes, generalization to higher dimensions

3. Lagrange's method of undetermined multipliers
4. Dependence of line integrals on end points and on paths
5. Jacobain of transformation

M3.7 DIFFERENTIAL EQUATIONS

1. Particular integrals for f(D)y= X where X is of the form e^{ax}, sin(ax+b), cos(ax+b), x^m etc
2. Equations of second order y" + P(x) y' + Q(x)y = X
3. Legendre and Hermite equations and polynomials
4. Wave equation in 1-D and 3-D
5. Poisson and Laplace equations

LABORATORY TUTORIALS (DISCUSSION SESSIONS)

M3.8.1 Computer Programming

1. Exercises
2. Exercises
3. Exercises
4. Exercises
5. Exercises

M3.8.2 Multivariable Calculus

1. Illustrations for concepts; limits, continuity and differentiability
2. Applications of Taylor's and Maclaurin's theorem in Physics
3. Integration of total differentials
4. Jacobian of transformation for cartesian to spherical polar and cylindrical coordinate systems
5. Gauss's and Green's theorems

M3.8.3 Differential Equations

1. Exercises
2. Solutions by change of independent variable and dependent variable
3. Systems of differential equations
4. Diffusion equation
5. Exercises

COURSE M4: PROBABILITY DISTRIBUTIONS, MODERN ALGEBRA AND VECTOR CALCULUS

THEORY LECTURES

M4.1 PROBABILITY DISTRIBUTIONS

Binomial distribution, mean, variance and moments, binomial coefficients, random walk. (4)

Poisson distribution, mean, variance, mode, median, recurrence relations and applications. (3)

Continuous distributions, probability distribution function, mean, variance and mode (3)

Normal distribution, standard normal distribution. (3)

X^2 and F distribution. (3)

M4.2 MODERN ALGEBRA

Sets, operations on sets, relations, maps (2)

Groups theory, definition, homomorphism and automorphism, Cayley's and Lagrange's theorems. (3)

Ring theory, definition, commutative rings, integral domains. (2)

Fields, extension fields. (2)

Vector spaces, linear independence, bases, isomorphism, subspaces. (2)

Transformations on vector spaces, linear transformations, inverse, matrices, change of basis, similarity and null spaces, rank and nullity, eigenvalues, multiplicity. (4)

M4.3 VECTOR SPACES AND VECTOR CALCULUS

Inner product spaces, orthogonality in vector spaces, completeness, natural isomorphisms, hermitian and unitary transformations. (5)

Diagonalization. (2)

Directional derivative of a scalar field, gradient, divergence and curl, integration. (4)

Gauss theorem, Green's theorem, Stokes theorem. (4)

THEORY TUTORIALS

M4.4.1 Probability Distributions

1. Bernauli trials
2. Additive property of Poisson distribution
3. Probability distribution function
4. Mean and variance of the normal distribution
5. Statement of central limit theorem

M4.4.2 Modern Algebra

1. Integers and other sets
2. Examples of groups, rings
3. Points of polynomials and fields
4. Examples of vector spaces in physics
5. Dimension of a vector space

M4.4.3 Vector Spaces and Vector Calculus

1. Schwarz inequality
2. Normal transformation
3. Exercises
4. Exercises
5. Exercises

LABORATORY EXPERIMENTS (WORK SESSIONS)

M4.5 PROBABILITY DISTRIBUTIONS

1. Multinomial and negative binomial distributions
2. Computation of probabilities
3. Poisson approximation to binomial
4. Joint probability and conditional probability distributions
5. Normal approximation to binomial and Poisson distributions

M4.6 MODERN ALGEBRA

1. Permutation groups, cycle groups, sets and cosets

2. Homomorphism on rings, ideals and quotient rings
3. Elements of Galois theory
4. Dual spaces
5. Direct sums and tensor products of vector spaces

M4.7 VECTOR SPACES AND VECTOR CALCULUS

1. Linear functionals
2. Self-adjoint transformations
3. Line integrals
4. Surface integrals
5. Volume integrals

LABORATORY TUTORIALS (DISCUSSION SESSIONS)

M4.8.1 Probability Distributions

1. Law of large numbers
2. Independence of two or more variables
3. Theorems on expectations
4. Symmetry of normal distribution
5. Student's t distribution

M4.8.2 Modern Algebra

1. Subgroups
2. Euclidean rings
3. Solvability of radicals
4. Bilinear forms
5. Reducibility of a vector space

M4.8.3 Vector Spaces and Vector Calculus

1. Isometries
2. Canonical forms
3. Vector identities
4. Exercises
5. Exercises

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COURSE M5: COMPUTER PROGRAMMING, SPECIAL FUNCTIONS AND FUNCTIONS OF A COMPLEX VARIABLE

THEORY LECTURES

M5.1 COMPUTER PROGRAMMING

Fitting a straight line to a given data. (4)

Finding roots of f(x) = 0 using (a) bisection method, (b) Regula-Falsi method. (6)

Solving a system of simultaneous, liner algebraic equations using Gaussian elimination. (5)

M5.2 SPECIAL FUNCTIONS

Definitions of gamma functions, recurrence relation. (3)

Definition of beta function, relation between beta and gamma functions. (4)

Legendre polynomials, Legendre equation, series solution, reduction to polynomial. (4)

Hermite equation, series solution, reduction to polynomials. (4)

M5.3 FUNCTIONS OF A COMPLEX VARIABLE

Analyticity of a function, Cauchy-Riemann conditions. (3)

Cauchy's integral theorem. (3)

Order of zeros and poles. (4)

Jordan's lemma, contour integration with simple poles. (5)

THEORY TUTORIALS

M5.4.1 Computer Programming

1. Exercises
2. Exercises
3. Exercises
4. Exercises
5. Exercises

M5.4.2 Special Functions

1. Various forms of gamma function by transformation of variables
2. Applications of beta functions in physics
3. Properties of Legendre polynomials
4. Properties of Hermite polynomials
5. Exercises

M5.4.3 Functions of A Complex Variable

1. Revision of limit and derivative
2. Harmonic functions
3. Zeros and singularities
4. Illustrations of Contour integration
5. Exercises

LABORATORY EXPERIMENTS (WORK SESSIONS)

M5.5 COMPUTER PROGRAMMING

1. Find roots of f(x) = 0 using Newton-Raphson method
2. Find roots of f(x) = 0 using secant method
3. Integration by trapezoidal rule
4. Integration by midpoint rule
5. Integration by trapezoidal and midpoint rule (continued)

M5.6 SPECIAL FUNCTIONS

1. Integrals related to the gamma function
2. Examples and problems on gamma and beta functions
3. Recurrence relations for Legendre polynomials
4. Recurrence relations for Hermite polynomials
5. Generating functions for Legendre and Hermite polynomials

M5.7 FUNCTIONS OF COMPLEX VARIABLES

1. Integration along a path
2. Cauchy's integral formula
3. Taylor and Laurent series

4. Evaluation of residues
5. Exercises

LABORATORY TUTORIALS (DISCUSSION SESSION)

M5.8.1 Computer Programming

1. Exercises
2. Exercises
3. Exercises
4. Exercises
5. Exercises

M5.8.2 Special Functions

1. Exercises
2. Exercises
3. Occurrence of Legendre polynomials in physical problems
4. Occurrence of Hermite polynomials in physical problems
5. Exercises

M5.8.3 Functions of a Complex Variable

1. Exercises
2. Exercises
3. Exercises
4. Exercises
5. Exercises

COURSE M6: STATITICS, INTEGRAL TRANSFORMS AND ELEMENTS OF ANALYSIS

M6.1 STATISTICS AND THEORY OF ERRORS

Concept of central tendency of statistical data, measures of central tendency, statistical average, arithmetic mean, geometric mean, harmonic mean, mode, median, quartiles and deciles. (5)

Concept of dispersion, range, mean deviation, mean squared deviation, change of origin and scale. (2)

Skewness, positive and negative skewness, coefficient of skewness, kurtosis. (3)

Regression coefficients and their properties, explanation and unexplained variations. (3)

Tests of significance, large sample tests of significance. (2)

M6.2 FOURIER SERIES AND TRANSFORMS

Representation of a periodic function by a Fourier series, functions of period 2π, general period, Fourier coefficients. (5)

Laplace transform; LT of common functions, linearity property, derivative and integration of LT.(5)

FT and LT for solving partial differential equations and ordinary differential equations with initial values. (5)

M6.3 ELEMENTS OF ANALYSIS

The real number system, algebraic axioms, ordering axioms, Archimedian axioms. (3)

Elementary topology, metric spaces, definition and examples, closure, convergence and limits, compact sets. (3)

Convergent sequences, subsequences, Cauchy sequences, upper and lower limits. (2)

Continuity and compactness, continuity and connectedness, differentiation, the derivative. (2)

Mean-value theorems, Taylor theorem, Riemann-Stieltjes integral. (3)

Sequences and series of functions, uniform convergence, differentiation, integration, equicontinuous families. (3)

THEORY TUTORIALS

M6.4.1 Statistics and Theory of Errors

1. Requirements of a good statistical average
2. Weighted mean
3. Measures of dispersion
4. Level of significance
5. Correlation coefficient

M6.4.2 Fourier Series and Transforms

1. Periodic functions
2. Even and odd functions
3. First shifting theorem for LT
4. Inverse LT of simple functions
5. Illustration of LT in physics

M6.4.3 Elements of Analysis

1. Integers and rationals
2. Open and closed sets
3. Test of convergence, absolute convergence
4. Monotone functions
5. L'Hospital rule

LABORATORY EXPERIMENTS (WORK SESSIONS)

M6.5 STATISTICS AND THEORY OF ERRORS

1. Absolute and relative measures of dispersion
2. Correlations, binomial data, positive and negative correlations
3. Regression, lines of regression and least squares method
4. Random sample statistics, sampling distribution of a statistics
5. Goodness of fit using and student's distribution

M6.6 FOURIER SERIES AND TRANSFORMS

1. Fourier series representations for functions defined over a finite interval

2. Aperiodic functions, Fourier transform
3. Applications of FT to physical problems, frequency response
4. LT of derivatives and integrals of a function
5. Solution of simple differential equations with initial values

M6.7 ELEMENTS OF ANALYSIS

1. Completeness of a metric space and complete metric spaces
2. Weierstrass theorem
3. Addition and multiplication of series
4. Ascot-Arzela theorem
5. Stone-Weierstrass theorem

LABORATORY TUTORIALS (DISCUSSION SESSIONS)

M6.8.1 Statistics and Theory of Errors

1. Raw moments and central moments
2. Correlation
3. Standard error
4. One- and two-tailed tests of significance
5. Discussion of unexplained variations

M6.8.2 Fourier Series and Transforms

1. Conditions for existence of a Fourier series
2. Complex Fourier series
3. Exercises
4. Exercises
5. Exercises

M6.8.3 Elements of Analysis

1. Dense subsets
2. Series and power series
3. Rearrangements of series
4. Properties of Riemann-Stieltjes integral
5. Uniform convergence and continuity

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CHEMISTRY COMPONENT IN B.SC. (PHYSICS)

COURSE C1: CHEMISTRY I

THEORY LECTURES

C1.1 THE LIQUID STATE AND THERMOCHEMISTRY

Liquids, P-V-T relations of gases and liquids. Principle of continuity of states, Application of Van der Waals equation to the isothermals of carbon-di-oxide. Determination of Van der Waals constants; critical constants of gases. Principle of corresponding states. (4)

Structure of liquids, Kinetic molecular model of liquids, vapour pressure, surface tension, viscosity, intermolecular forces, hydrogen bond. (2)

Measurement of thermal changes; heat of reaction at constant volume and constant pressure, thermochemical equations. (2)

Hess's law of heat of summation, Heat of combustion, heat of solution and dilution, thermoneutrality of salt solutions, heat of neutralization of acids and bases, heat of formation of ions, other heats of reactions, variation of heat of reactions with temperature. (4)

The Helmholtz free energy A; A for reactions, The Gibbs free energy F; F for reactions and significance of F. (3)

C1.2 PERIODIC TABLE AND CHEMICAL BONDING

Nature and types of elements; monatomic elements, diatomic molecules, discrete polyatomic molecules, giant molecules, metals, chemistry of the elements in relation to their position in the periodic table, hydrogen and helium, elements of the first and second short periods, remaining non-transition elements, transition elements of the d and f blocks. (6)

Quantum mechanics, atomic orbitals, molecular orbitals, bonding hybrid orbitals, bond energies and distances, bond polarities. (3)

Overlap of orbitals, stability of hydrogen molecule over helium. General homonuclear diatomic molecules, localized bond approach, valence states and hybridization, resonance, molecular shapes, bond lengths and covalent radii, Van der Waals radii . (6)

C1.3 SOLUTES, SOLVANTS AND SOLUTIONS

Types of ionic crystal structures; simple cubic, face centered cubic. Pauling univalent and crystal radii. Radius ratio effect, Born-Haber cycle, Schottky and Frenkle defects. (4)

Solvant properties, donor and acceptor properties, protic and aprotic solvants, molten salts,

definition of acids and bases, leveling and differential solvants, Trends in strengths of hydroacids and oxyacids, Hard and soft acids and bases. (4)

Standard acids and bases, primary standards, acid-base titrations. Equivalence point, neutral point and end point. Theory of visual pH indicator, multiple range indicators. (3)

The phase rule; definitions, Gibbs phase rule, one component systems, two component systems, determination of solid liquid equilibria and nature of solid phases. (4)

THEORY TUTORIALS

C1.4.1 The Liquid State and Thermochemistry

1. Liquefaction of gases
2. Water, an unusual liquid
3. Illustrations of thermochemical equations
4. Estimation of heat of reactions
5. Calculations of free energies for reactions

C1.4.2 Periodic Table and Chemical Bonding

1. Chemistry of IA and IIA groups
2. Configuration, isolation and trends in periodic properties
3. Theoretical estimation of bond distances
4. Theoretical estimation of covalent radii
5. Theoretical estimation of Van der Waals radii

C1.4.3 Solutes, Solvants and Solutions

1. Estimation of Pauling radii for ionic solutes
2. Illustration of acid and base properties in ionic salts
3. Molten salts
4. Errors in acid-base titrations
5. Examples of two-component systems

LABORATORY EXPERIMENTS

C1.5 THE LIQUID STATE AND THERMOCHEMISTRY

1. Determination of heat of water of crystalization of BaC or $MgSO_4$

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2. Determination of heat of solution of KNO_3 or NH_4
3. Determination of heat of vapourization by syringe method
4. Preparation of standard sodium carbonate solution and standardization of a given solution of HCL
5. Preparation of standard solution of potassium dichromate and standardization of a given sample of $Na_2S_2O_3$
6. Determination of percentage purity of NaHCO in a given sample
7. Determination of the viscosity of pure liquids and binary mixtures

C1.6 PERIODIC TABLE AND CHEMICAL BONDING

1. Determination equivalent weight Mg/Al by edudiometric method
2. Estimation of Madelung constant
3. Determination of covalent bond energies by numerical simulation
4. Determination of Van der Waals bond energies by numerical simulation
5. Study of variation of chemical properties in d or f blocks

C1.7 SOLUTES, SOLUTIONS AND SOLVANTS

1. Determination of partition function of iodine between water and carbon tetrachloride or benzene or chloroform
2. Partition coefficient of benzoic acid between water and carbon tetrachloride or benzene or chloroform
3. Estimation of total iron in the solution of Fe(II+III) using external indicator
4. Estimation of boron from boron and boric acid
5. Estimation of copper content in a solution using iodometry

LABORATORY TUTORIALS

C1.8.1 The Liquid State and Thermochemistry

1. Techniques for measurements of vapour pressure
2. Techniques for measurements of surface tension
3. Techniques for measurements of viscosity
4. Techniques for measurements of intermolecular forces
5. Determination of Van der Waals constants

C1.8.2 Periodic Table and Chemical Bonding

1. Variation of chemical properties with increase in atomic weights in the same columns of periodic table
2. Variation of chemical properties across the periods of the table
3. Experimental techniques for determination of bond energies
4. Experimental techniques for determination of covalent radii
5. Experimental technique for determination of Van der Waals radii

C1.8.3 Solutes, Solvanys and Solutions

1. Titration curves for strong and weak acids and bases
2. Titrations of polybasic acids and polyacidic bases
3. Buffer action and buffer solutions
4. Experimental determination of ionic radii
5. Experimental study of solid-liquid equilibria

Text and Reference Books

C N R Rao; "University General Chemistry", Ist Edition (MacMillan)

S H Maron and J D Lando; "Fundamentals of Physical Chemistry" (Collier-Macmillan)

S H Pine, J B Hendvickson, D G Cram and G S Hammod; "Organic Chemistry", IVth International Students Edition (McGraw-Hill)

F A Cotton and Willson, "Basic Inorganic Chemistry" (Wiley Eastern)

S H Maron and C F Prutton; "Principles of Physical Chemistry", IVth Edition (MacMillan)

Willard, Furman and Bacon; "A Short Course in Quantitative Analysis" (Van Nostrand)

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COURSE C2: CHEMISTRY II

THEORY LECTURES

C1.1 CHEMISTRY OF MAIN GROUP ELEMENTS

Position of the elements in periodic table; diagonal relationship, electronic configuration of the elements, anomalous behavior of first member of each group, occurrence and isolation of the elements. Trends in properties of the elements with respect to the following: sizes of atoms and ions, ionization potentials, electronegativity, oxidation states, reactivity. (6)

Properties, bonding and shapes of oxides, halides and hydrides of these elements. Boric acid and borates. Allotropes of carbon. Oxyacids of halogens; pseudohalogens. (3)

Chemistry of transition metals; trends in properties of elements with reference to sizes of atoms and ions, density, melting and boiling points, ionization potentials, oxidation states, reactivity, catalytic activity, colour, magnetic properties, ability to form complexes. Compounds of chromium, manganese, iron, cobalt, nickel and copper. (6)

C2.2 FREE ENERGY AND CHEMICAL EQUILIBRIA

Standard states for gases, liquids and solids, concepts of activity and fugacity, activity coefficients, reaction isotherms, free energies of formation. (4)

Equilibrium criteria; physical equilibria for pure substances, Clapeyron equation, vapour pressure of liquids and its variation with temperature, boiling points of liquids, sublimation pressures of solids. (4)

Homogeneous chemical equilibria, effects of external conditions. (2)

Equilibria for acids, bases and salts, ionic equations and solubility, the common ion effect, Bronsted theory, hydrolysis strengths, ionization of water, the pH scale, buffer solutions. (5)

C2.3 CHROMATOGRAPHY AND STEREOCHEMISTRY

Chromatographic methods: Thin layers, gas-liquid, liquid-solid and ion exchange chromatographies. (4)

Stereochemistry and molecular geometric isomorphism, restricted rotation about double bonds, designations of various configurations. (3)

Confirmations of cyclic compounds, representation of three dimensional molecules, restricted rotation about single bonds, angle strain, equatorial and axial bonds, confirmation of cis and trans decalin. (4)

Chirality and optical activity, symmetry properties of organic molecules, optical activity and absolute configuration, several chiral centers, torsional asymmetry, Fischer projection formula.(4)

THEORY TUTORIALS

C2.4.1 Chemistry of the Main Group Elements

1. Illustrations for diagonal relationship
2. Anamolous behaviour of first members of all groups and its explanation
3. Estimation of electronegativity and reactivity
4. Examples of pseudohalogens
5. Magnetic properties of transition elements

C2.4.2 Free Energy and Chemical Equilibria

1. Determination of activity coefficients
2. Applications of Clapeyron equation
3. Examples of equilibrium systems
4. Computations for ionization of water
5. Estimation of pH in specific example

C2.4.3 Chromatography and Stereochemistry

1. Classification of chromatographic methods
2. Examples of restricted rotation in single and double bonds
3. Cyclohexane as an illustration for the study of equatorial and axial bonds
4. Optical activity and its applications
5. Biphenyles to illustrate torsional asymmetry

LABORATORY EXPERIMENTS

C2.5 CHEMISTRY OF MAIN GROUP ELEMENTS

1. Qualitative analysis of mixtures containing two cations and two anions
2. Study of sizes of atoms and ions
3. Determination of ionization potential for a period/column
4. Study of bonding and shapes of oxides
5. Study of magnetic properties of transition metals

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C2.6 FREE ENERGY AND CHEMICAL EQUILIBRIA

1. Determination of activity coefficients
2. Study of reaction isotherms
3. Determination of free energy of formation
4. Study of vapour pressure of liquids and its temperature dependence
5. Study of hydrolysis strengths

C2.7 CHROMATOGRAPHY AND STEREOCHEMISTRY

1. Separation of amino acids by thin layer chromatography
2. Separation of amino acids by paper chromatography
3. Study of gas-liquid chromatography
4. Study of liquid-solid chromatography
5. Study of ion-exchange chromatography

LABORATORY TUTORIALS

C2.8.1 Chemistry of the Main Group Elements

1. Qualitative analysis of mixtures
2. Preparation of potassium trioxalate chromate
3. Molecular weight by using Landberger's apparatus
4. Molecular weight by Cryoscopic method
5. Study of density and colour of transition elements

C2.8.2 Chemistry of the Main Group Elements

1. Method of analysis of an organic compound, using type of elements, functional groups and melting and boiling points
2. Method of purification by crystallization
3. Applications of Clapeyron equation
4. Living cell as an illustration of chemical equilibrium
5. Study of buffer solutions

C2.8.3 Chromatography and Stereochemistry

1. Comparative study of different chromatography techniques
2. Illustration of stereochemical principles by models

3. Study of designations of various configurations
4. Study of restricted rotation and bonds
5. Study of optical activity and configurations

Text and Reference Books

S H Maron and C F Prutton; "Principles of Physical Chemistry", IVth Edition (Macmillan)

C N R Rao; "University General Chemistry" (MacMillan)

F A Cotton and G Wilkison; "Basic Inorganic Chemistry" (Wiley Eastern)

A Vogel; "Text book of practical organic chemistry", IVth edition (Longmans)

Pine, Hendrickson, Gram and Hammond; "Organic Chemistry", IVth International Students Edition (McGraw-Hill)

OTHER COMPONENTS IN B.SC. (PHYSICS)

Language syllabus of Course S1 is not given here. It may be any one of the Indian languages or English, French, German, Sanskrit, etc.

COURSE S2: Science, Technology and Society

S2.1: History of Physics (15)

Greek and Indian philosophers; Archimedes, Kanad, Aryabhatta, Tycho Brahe, Kepler, Galilieo, Newton; The emphasis on observations; The pinnacle of Classical Physics; The turning point; Quantum hypothesis and relativity – a change of paradigm;

S2.2 Recent History (15)

Nature of science; growth of science before and after second World War, and its impact on society; technology, and interconnection between science and technology; changing scenario of science and technology; its influence on society and world politics, science and technology as vehicles for development, third world and science and technology; Indian efforts for self-sufficiency.

S2.3 Present Status (15)

Present day scientific and technological scenario in the world with reference to energy,

materials, environment, medicine, communication, automation, and information revolution; Indian contributions – S N Bose, C V Raman, Homi J Bhabha, Vikram Sarabhai, Meghnand Saha, S Chandrashekhar etc; Indian scenario, Where do we stand in comparison to other countries? Implications of rapidly changing scenario on human value system; man's existence and future.

S2.4 The Physical World-View (15)

The world at very large distances: heavenly bodies -- planets, stars, star-clusters, nebulae, galaxies, pulsars, quasars. The expanding universe, determination of velocity and distance of a heavenly body, Doppler shift, cosmic background radiation at 3 K, big bang theory.

Formation and evolution of stars and galaxies: First generation stars, white dwarf, red giants and neutron stars, black holes. Second generation stars, our galaxy and sun.

The solar system: Kepler's law's, exploration of our planetary system, the earth: Structure, geography and geology.

The material sciences: Conventional materials, tailoring of materials, new materials and techniques.

S2.5:Mathematical Developments (15)

Mathematical developments: The Indian number system, algebra (Leelavati), Euclidean geometry and Pythagorian theories, Zeno's and related paradoxes, zero and infinity, calculus, modern concepts (set theory etc).

S2.6: Life on the Earth (15)

Origin of life; reducing and oxidising atmosphere, complex molecules and macromolecules – amino acids etc. Laboratory experiments on origin of life, life on other planets and worlds, parity and living systems.

Evolution of life: Unicellular to complex systems, biochemical unity of life, cell differentiation and organs, protein synthesis and nuclear acids – genetic code and heredity, flora and fauna.

S2.7: Consciousness and Psychology (15)

Emergence of consciousness: Evolution of higher life forms – development of central nervous system and brain, cooperative living or formation of animal society (e.g. deers, wild dogs, apes,

ants etc), development of language and specializations, emergence of the supreme generalist – man.

Human Psychology: Man in different situations – mythical, stone age, agricultural and modern.

Some open questions: Next stage of evolution, spirituality and the ultimate goal of life.

Some Reference Material

G. Gamow; "Biography of Physics", Hutchinson, London (1962)

B. Cohen; "The Newtonian Revolution", Cambridge (1980)

F. Dyson; "Distributing the Universe ", Harper and Row (1979)

A. Pais; "Subtle is the Lord", Clarendon (1982)

J. D. Bernal; "Science and Siciety"

E. Schrodinger; "The Meaning of Life"

T.C.L. Robinson, Ed.; "The Future of Science", Wiley (1977)

Dharampal ; "Indian Science and Technology in 18th Century", Impex India (1971)

Satya Prakash; "Founders of Sciences in Ancient India", The Research Institute of Ancient Scientific Studies, New Delhi (1965)

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Course S3: COMMUNICATION AND TECHNICAL SKILLS

S3.1: Appreciation and comprehension of articles written by renowned scientists, philosophers, technocrats, literateures etc. This is to be done by reading them in the class, question and answer sessions, precis writing and oral presentation method.

S3.2: Preparation and presentation of science reports, need, methods and approaches for formatting and writing of science reports, case studies of science reports, examples to be taken from popular science, pure science, applied science and technical reports, use of computer for word-processing.

S3.3: Oral presentation skill, effective and appropriate ways of presentation of scientific material, skills for group discussion (this is mostly a laboratory module).

S3.4: Machine practice, carpentry, welding and electrical skills (Scope: Jobs for the purpose of practice should be given to students and relevant text material should be covered during the workshop practice hours).

S3.5 and S3.6: Glass blowing, vacuum systems and their use in industry and research, practical knowledge of measurements of temperature, pressure, electrical, electronic, optical, and magnetic parameters. Use of sensors/transducers, Gauges and gadgets needed for the above measurements. (Theory component to be treated in lecture and tutorial sessions; demonstration and practice components to be treated in the laboratory tutorials and laboratory sessions. Scope: Students should be exposed to limits and advantages as well as handling mechanisms for these equipments.)

S3.7 and S3.8: Electronic skills, designing of simple electronic circuits, selection of electronic components, testing of these components, making of printed circuit boards, relevant practical information on technical specifications and selection of different board materials, techniques of designing and layout of complex PCBs, soldering skills, modern approaches for automation of design and making of electronic circuits, testing of circuits for appropriate and pre-decided functioning, fault finding and repairs.

Break-up of Courses and Detailed Syllabi/Courses

M.Sc. Physics

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M.SC. PHYSICS (I SEMESTER): MATHEMATICAL PHYSICS

Vector Spaces and Matrices; linear independence: Bases; Dimensionality; Inner product; Linear transformations; Matrices; Inverse; Orthogonal and unitary matrices; Independent elements of a matrix; Eigenvalues and eigenvectors; Diagonalization; Complete orthonormal sets of functions.

Differential Equations and Special Functions; Second order linear ODEs with variable coefficients; Solution by series expansion; Legendre, Bessel, Hermite and Lagaurre equations; Physical applications; Generating functions; recursion relations.

Integral Transforms, Laplace transform; First and second shifting theorems; Inverse LT by partial fractions; LT of derivative and integral of a function; Fourier series; FS or arbitrary period; Half-wave expansions; Partial sums; Fourier integral and transforms; FT of delta function

Text and Reference Books

Mathematical Methods for Physics, by G Arfken

Matrices and Tensors for Physicists, by A W Joshi

Advanced Engineering Mathematics, by E Kreyszig

Special Functions, by E D Rainville

Special Functions, by W W Bell

Mathematical Method for Physicists and Engineers. by K F Reily, M P Hobson and S J Bence

Mathematics for Physicists, by Mary L Boas

M.Sc. Physics (I Semester): Tutorial: Mathematical Physics

Exercises on linear dependence and independence of a set of vectors; Obtaining inverse of a matrix; Generating the most general matrix of a certain type; Eigenvalues and eigenvectors.

Potential due to a discrete or continuous charge distribution; Vibrations of a circular membrane; Solving the 1-D harmonic oscillator Schrodinger equation; Relation of the hydrogen atoM.Sc.hrodinger equation with Laguerre equation and solution.

Solution of initial value problems by using Laplace transform; LT and inverse LT of various functions; Solution of time-dependent problems by Fourier transform; FT of Gaussian function; Applications of FT of Dirac delta function.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.SC. PHYSICS (I SEMESTER): CLASSICAL MECHANICS

Preliminaries; Newtonian mechanics of one and many particle systems; conservation laws, work-energy theorem; open systems (with variable mass).

Constraints; their classification; D'Alembert's principle' generalized coordinates.

Lagrange's equations; gyroscopic forces; dissipative systems; Jacobi integral; gauge invariance; generalized coordinates and momenta; integrals of motion; symmetries of space and time with conservation laws; invariance under Galilean transformations.

Rotating frames; inertial forces; terrestrial and astronomical applications of coriolis force.

Central force; definition and characteristics; Two-body problem; closure and stability of circular orbits; general analysis of orbits; Kepler's laws and equation; artificial satellites; Rutherford scattering.

Principle of least action; derivation of equations of motion; variation and end points; Hamilton's principle and characteristic functions; Hamilton-Jacobi equation.

Canonical transformation; generating functions; Properties; group property; examples; infinitesimal generators; Poisson bracket; Poisson theorems; angular momentum PBs; small oscillations; normal modes and coordinates.

Text and Reference Books

Classical Mechanics, by N C Rana and P S Joag (Tata McGraw-Hill, 1991)

Classical Mechanics, by H Goldstein (Addison Wesley, 1980)

Mechanics, by A Sommerfeld (Academic Press, 1952)

Introduction to Dynamics, by I Perceival and D Richards (Cambridge Univ. Press. 1982).

M.Sc. Physics (I Semester): Tutorial: Classical Mechanics

Simple Pendulum with rigid support, and with variable length; two connected masses with string passing over a pulley; virtual work, rolling mass inside or outside a circular ring.

Rotating frames; electromagnetic analogy of inertial forces; Foucault's pendulum.

Stability of orbits under a central force; orbital elements of planetary orbits; launching of artificial satellites.

Various Poisson brackets; their relation with PBs in quantum mechanics.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

UGC

M.SC. PHYSICS (I SEMESTER): QUANTUM MECHANICS I

Why QM? Revision; Inadequacy of classical mechanics; Schrodinger equation; Continuity equation; Ehrenfest theorem; Admissible wave functions; Stationary states.

One-dimensional problems, wells and barriers; Harmonic oscillator by Schrodinger equation and by operator method.

Uncertainty relation of x and p, States with minimum uncertainty product; General formalism of wave mechanics; Commutation relations; Representation of states and dynamical variables; Completeness of eigenfunctions; Dirac delta function; bra and ket notation; Matrix representation of an operator; Unitary transformation.

Angular momentum in QM; Central force problem: Solution of Schrodinger equation for spherically symmetric potentials; Hydrogen atom.

Time-independent perturbation theory; Non-degenerate and degenerate cases; Applications such as Stark effect.

Text and Reference Books

L I Schiff, Quantum Mechanics (McGraw-Hill)

S Gasiorowicz, Quantum Physics (Wiley)

B Craseman and J D Powell, Quantum Mechanics (Addison Wesley)

A P Messiah, Quantum Mechanics

J J Sakurai, Modem Quantum Mechanics

Mathews and Venkatesan Quantum Mechanics

M.Sc. Physics (I Semester): Tutorial: Quantum Mechanics I

Black body radiation and Planck's hypothesis; Insignificance of de Broglie hypothesis in macro-physics; Hamilton's and Format's principles.

One-dimensional step, barrier, well; Particle energy below and above barrier height; Similarly for well; Plotting of harmonic oscillator wave functions; problems involving matrix representations of an operator.

Commutation relations; uncertainty; Transformations.

Angular momentum states; Addition of angular momenta; L, S, J values for various atoms in the periodic table.

Anharmonic perturbations of the form x^3 and x^4 Various other time-independent perturbations.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.SC. PHYSICS (I SEMESTER): ELECTRONIC DEVICES

Transistors: JEET, BJT, MOSFET and MESFET : Structure, Working, Derivations of the equations for I-V characteristics under different conditions. High Frequency limits.

Microwave Devices: Tunnel diode, transfer electron devices (Gunn diode). Avalanche Transit time devices, Impatt diodes, and parametric devices.

Photonic Devices: Radiative and non-radiative transitions. Optical Absorption, Bulk and Thin film Photoconductive devices (LDR), diode photodetectors, solar cell-(open circuit voltage and short circuit current, fill factor). LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), diode lasers (conditions for population inversion, in active region, light confinement factor. Optical gain and threshold current for lasing, Fabry-Perrot Cavity Length for lasing and the separation.

Memory Devices: Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non-volatile - NMOS, magnetic, optical and ferroelectric memories, charge coupled devices (CCD).

Other Electronic Devices: Electro-Optic, Magneto-Optic and Acousto-Optic Effects. Material Properties related to get these effects. Important Ferro electric, Liquid Crystal and Polymeric materials for these devices. Piezoelectric, Electrostrictive and magneto strictive Effects, Important materials exhibiting these properties, and their applications in sensors and actuator devices. Acoustic Delay lines, piezoelectric resonators and filters. High frequency piezoelectric devices-Surface Acoustic Wave Devices.

Text and Reference Books

Semiconductor Devices - Physics and Technology, by SM Sze Wiley (1985)

Introduction to semiconductor devices, M.S. Tyagi, John Wiley & Sons

Measurement, Instrumentation and Experimental Design in Physics and Engineering by M. Sayer and A. Mansingh, Prentice Hall, India (2000)

Optical electronics by Ajoy Ghatak and K. Thyagarajan. Cambridge Univ. Press

M.Sc. Physics (I Semester) : Tutorial : Electronic Devices

The problems given in the Text and Reference books will form tutorial course.

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M.SC. PHYSICS (I SEMESTER): LABORATORY/PRACTICAL COURSE

1. Design of a Regulated Power Supply
2. Design of a Common Emitter Transistor Amplifier
3. Experiment on Bias Stability
4. Negative Feedback (Voltage series/shunt and current series/shunt)
5. A stable, Monostable and Bistable Multivibrator.
6. Characteristics and applications of Silicon Controlled Rectifier.
7. Testing goodness of fit of Poisson distribution to cosmic ray bursts by chi-square test.
8. Determination of Half Life of 'In'.
9. Determination of range of Beta-rays from Ra and Cs.
10. X-ray diffraction by Telexometer.
11. Determination of Ionization Potential of Lithium.
12. Determination of e/m of electron by Normal Zeeman Effect using Febry Perot Etalon.
13. Determination of Dissociation Energy of Iodine (I) Molecule by photography the absorption bands of I in the visible region.
    (a) Measurement of wavelength of He-Ne Laser light using ruler.
    (b) (b) Measurement of thickness of thin wire with laser.

M.Sc. Physics (I Semester): Tutorial: Laboratory/Practical Course

1. Network Analysis – Thevemin and Nortan's equivalent circuits
2. Basics of p-n junction - Diffusion current, Drift current, Junction width, Forward and Reverse Biasing; Significance of Fermi level in stabilizing the junction
3. Zener Diode – characteristics and voltage regulation
4. Transistor biasing and stability
5. Wein's bridge and phase shift
6. Solving Boolean expressions
7. Mechanism and production of electrical pulse through absorption of nuclear radiation in medium
8. Deadtime efficiency, counting techniques, energy resolution
9. Lattice extinctions in X-ray diffraction
10. Atomic scattering power and geometrical structure factor

M.SC. PHYSICS (II SEMESTER): QUANTUM MECHANICS II

1. Variational method; WKB approximation; Time-dependent perturbation theory; Harmonic perturbation; Fermi's golden rule; Adiabatic and sudden approximations.
2. Collision in 3-D and scattering; Laboratory and CM reference frames; Scattering amplitude; differential scattering cross section and total scattering cross section; Scattering by spherically symmetric potentials; Partial waves and phase shifts; Scattering by a perfectly rigid sphere and by square well potential; Complex potential and absorption.
3. Identical particles; Symmetric and antisymmetric wave functions; Collision of identical particles; Spin angular momentum; Spin functions for a many-electron system.
4. Semiclassical theory of radiation; Transition probability for absorption and induced emission; Electric dipole and forbidden transitions; Selection rules.

Text and Reference Books

L I Schiff, Quantum Mechanics (McGraw-Hill)

S Gasiorowicz, Quantum Physics (Wiley)

B Craseman and J D Powell, Quantum Mechanics (Addison Wesley)

A P Messiah, Quantum Mechanics

J J Sakurai, Modem Quantum Mechanics

Mathews and Venkatesan. Quantum Mechanics

M.Sc. Physics (II Semester): Tutorial: Quantum Mechanics II

1. Helium atom and hydrogen molecule; Various time-dependent perturbations; Density of continuum states; Transition probabilities.
2. Partial wave analysis of scattering from standard simple potentials; Scattering cross section; Optical theorem.
3. Slater determinants; spin and statistics; Difference in collision process between classical and quantum identical particles.
4. Magnetic dipole transitions; Stimulated emission; Higher order transitions.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

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M.SC. PHYSICS (II SEMESTER): STATISTICAL MECHANICS

1. Foundations of statistical mechanics; specification of states of a system, contact between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox.
2. Microcanonical ensomble, phase space, trajectories and density of states, Liouville's theorem, canonical and grand canonical ensembles; partition function, calculation of statistical quantities, Energy and density fluctuations.
3. Density matrix, statistics of enseombles, statistics of indistinguishable particles, Maxwell-Boltzman, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation.
4. Cluster expansion for a classical gas, Virial equation of state, ising model, mean-field theories of the ising model in three, two and one dimensions Exact solutions in one-dimension.
5. Landau theory of phase transition, critical indices, scale transformation and dimensional analysis.
6. Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem. The Fokker-Planck equation.

Text and Reference Books

Statistical and Thermal Physics, by F Reif

Statistical Mechanics, by K Huang

Statistical Mechanics, R K Pathria

Statistical Mechanics, R. Kubo

Statistical Physics, Landau and Lifshitz

M.Sc. Physics (II Semester): Tutorial: Statistical Mechanics

1. Calculation of number of states and density of states 1D free-particle in a box
2. Linear harmonic and harmonic oscillators
3. Statistics of occupation number calculation of thermodynamic quantities
4. Black body radiation and photon statistics
5. Evaluation of second virial coefficient
6. Fluctuations of thermodynamic variables.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.SC. PHYSICS (II SEMESTER): ELECTRODYNAMICS AND PLASMA PHYSICS

1. Review of Four-Vector and Lorentz Transformation in Four-Dimensional Space, Electromagnetic Field Tensor in Four Dimensions and Maxwell's Equations, Dual Field Tensor, Wave Equation for Vector and Scalar Potential and Solution Retarded Potential and Lienard-Wiechert Potential, Electric and Magnetic fields due to a Uniformly Moving Charge and An Accelerated Charge, Linear and Circular Acceleration and Angular Distribution of Power Radiated, Bremsstrahlung, Synchrotron Radiation and Cerenkov Radiation, Reaction Force of Radiation.
2. Motion of charged Particles in Electromagnetic Field: Uniform E and B Fields, Nonuniform Fields, Diffusion Across Magnetic Fields, Time Varying E and B Fields, Adiabatic Invariants: First, Second Third Adiabatic Invariants.
3. Elementary Concepts: Derivation of moment Equations from Boltzmann Equation, Plasma Oscillations, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma Confinement.
4. Hydrodynamical Description of Plasma: Fundamental equations. Hydromagnetic Waves: Magnetosonic and Alfven Waves.
5. Wave Phenomena in Magnetoplasma: Polarization, Phase Velocity, Group Velocity, Cut-offs, Resonance for Electromagnetic Wave Propagating Parallel and Perpendicular to the Magnetic Field, Propation at Finite Angle and CMA Diagram, Appleton - Hartee Formula and Propagation through Inosphere and Magnetosphere: Helicon, Whistler, Faraday Rotation.

Text and Reference Books

Panofsky & Phillips: Classical Electricity and Magnetism

Bittencourt: Plasma Physics

Chen: Plasma Physics

Jackson: Classical Electrodynamics

M.Sc. Physics (II Semester): Tutorial : Electrodynamics and Plasma Physics

1. The electric field vector E of an electromagnetic wave in free space is given by

   $E_x = E_z = O$ and $E_y = A \cos w (t - z/c)$

   Using Maxwell's equations, find the expressions for the components of magnetic field vector. Also Calculate the energy flow per unit area along

   A circular plate capacitor of radius R and separation d is being charged by an alternating current so that there is a uniform electric field inside the capacitor. Show that the energy flow within the capacitor is the same as given by the Poyntings vector.
2. Starting from the equation for the conservation of linear momentum

$$\frac{d}{dt}\int_V \left(\vec{P}_{mech} + \vec{P}_{field}\right)_\alpha dt = \oint_s \sum_\beta T_{\alpha\beta}\eta_\beta d_\alpha$$

Where P_{mech} is the mechanical momentum density of a system of particles inside a volume V and P_{field} is the field momentum density

$$\vec{P}_{field} = \left(\frac{1}{4\pi c}\right)\left(\vec{E} \;\; x \;\; \vec{B}\right)$$

and $T_{\alpha\beta}$ is the Maxwell stress tensor, deduce the equation for the conservation of angular momentum for a combined system of particles and fields. [Hint: Consider the field angular momentum density

$$\vec{L}_{field} = \vec{r} \;\; x \;\; \vec{P}_{field} = \left(\frac{1}{4\pi c}\right) \;\; \vec{r} \;\; x \;\; \left(\vec{E} \;\; x \;\; \vec{B}\right)$$

3. A linear accelerator accelerates protons to almost relativistic speeds. Determine the fraction of power radiated by the protons to the power supplied in terms of the gradient of the linear electric field.

$$\vec{r} \;=\; \vec{r} \;\; Cos(\,\omega t + \alpha\,)$$

A charged particle oscillates according to the harmonic law

Determine the total average intensity of the emitted radiation.

4. From the definition of the dual tensor

$$G_{\mu\nu} = \frac{1}{2}\varepsilon_{\mu\nu\rho\sigma}F^{\rho\sigma}$$

Where $\varepsilon_{\mu\nu\rho\sigma}$ is a completely antisymmetric Unit tensor of rank four, express $F^{\mu\nu}$ $G_{\mu\nu}$ as a function of the fields $\vec{E}$ and $\vec{B}$.

Hence show that $\vec{E}.\vec{B}$ and $B^2 - E^2$ are Lorentz invariants.

5. Consider a magnetic field configuration that is cylindrically symmetric and a charged particle is injected into it. Use the adiabatic invariants of motion to describe conditions in which the injected particle would bounce back from the direction of increasing field gradient.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.SC. PHYSICS (II SEMESTER) : ATOMIC AND MOLECULAR PHYSICS

Quantum states of one electron atoms-Atomic orbitals-Hydrogen spectrum-Pauli's principle-Spectra of alkali elements-Spin orbit interaction and fine structure in alkali Spectra-Equivalent and non-equivalent electrons-Normal and anomalous Zeeman effect- Paschen Back effect-Stark effect-Two electron systems-interaction energy in LS and JJ Coupling-Hyperfine structure (qualitative)-Line broadening mechanisms (general ideas)

Types of molecules-Diatomic linear symmetric top, asymmetric top and spherical top molecules-Rotational spectra of diatomic molecules as a rigid rotor-Energy levels and spectra of non rigid rotor-intensity of rotational lines-Stark modulated microwave spectrometer (qualitative)

Vibrational energy of diatomic molecule-Diatomic molecule as a simple harmonic oscillator-Energy levels and spectrum-Morse potential energy curve-Molecules as vibrating rotator-Vibration spectrum of diatomic molecule-PQR branches IR spectrometer (qualitative)

Text and Reference Books

Introduction to Atomic spectra—H.E.White(T)
Fundamentals of molecular spectroscopy—C.B.Banwell (T)
Spectroscopy Vol I, II & III—Walker & Straughen
Introduction to Molecular spectroscopy—G.M.Barrow
Spectra of diatomic molecules—Herzberg
Molecular spectroscopy—Jeanne L McHale
Molecular spectroscopy—J.M.Brown
Spectra of atoms and molecules—P.F.Bernath
Modern spectroscopy—J.M.Holias

M.Sc. Physics (II Semester) : Tutorial : Atomic and Molecular Physics

1. Write all possible term symbols for the following electron configurations. a) [Be]2p3p (b) [He] 2s2p (c) [Be] 2p3d
2. Helium atom has two forms: orthohelium and parahelium. Describe these two forms of helium and the term symbols for each state. Calculate the equilibrium ratio of the two forms of He at 300K. Explain why orthohelium is metastable?
3. Given that the bond dissociation energy of oxygen is 5.9eVand its vibrational frequency is 1580 cm^{-1}. Estimate the maximum vibrational quantum number possible for oxygen?
4. Why is the harmonic oscillator model aphysical at long bond lengths? How is this model at short bond lengths?

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

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M.SC. PHYSICS (II SEMESTER) : LABORATORY / PRACTICAL COURSE

1. Experiment on FET and MOSFET characterization and application as an amplifier.
2. Experiment on Uni-Junction Transistor and its application.
3. Digital I: Basic Logic Gates, TTL, NAND and NOR.
4. Digital II: Combinational Logic.
5. Flip-Flops.
6. Operational Amplifier (741).
7. Differential Amplifier.
8. Measurement of resistivity of a semiconductor by four probe method at different temperatures and Determination of band gap.
9. Determination of Lande's factor of DPPH using Electron-Spin resonance (E.S.R.) Spectrometer.
10. Measurement of Hall coefficient of given semicoundutor: Identification of type of semiconductor and estimation of charge carrier concentration.
11. To study the fluorescence spectrum of DCM dye and to determine the quantum yield of fluorescence maxima and full width at half maxima for this dye using monochromator.
12. To study Faraday effect using He-Ne Laser.

M.Sc. Physics (II Semester) : Tutorial : Laboratory/Practical Course

1. Effect of capacitance and load resistance on output of an amplifier
2. Integrated circuit timer familiarization
3. Op-amp differentiator
4. Multiplexers and Demultiplexers
5. Resistors and counters
6. Radiation level and activity measurement
7. Shielding, mass absorption coefficient
8. Coincidence circuits, counters, timers
9. Coherence and it's relevance in diffraction
10. Identification of charge type by Hall voltage measurement
11. How does four probe method solve the problem of contact resistance ?

M.SC. PHYSICS (III SEMESTER) : CONDENSED MATTER PHYSICS

Crystal Physics and Defects in Crystals

Crystalline solids, unit cells and direct lattice, two and three dimensional Bravais lattices, closed packed structures.

Interaction of X-rays with matter, absorption of X-rays. Elastic scattering from a perfect lattice. The reciprocal lattice and its applications to diffraction techniques. The Laue, powder and rotating crystal methods, crystal structure factor and intensity of diffraction maxima. Extinctions due to lattice centering.

Point defects, line defects and planer (stacking) faults. The role of dislocations in plastic deformation and crystal growth. The observation of imperfections in crystals, X-ray and electron microscopic techniques.

Electronic Properties of Solids

Electrons in a periodic lattice: Bloch theorem, band theory, classification of solids, effective mass. Tight-bonding, cellular and pseudopotential methods. Fermi surface, de Hass von Alfen effect, cyclotron resonance, magnetoresistance, quantum Hall effect. Superconductivity : critical temperature, persistent current, Meissner effect.

Weiss theory of ferromagnetism. Heisenberg model and molecular field theory. Spin waves and magnons. Curie-Weiss law for susceptibility, Ferri- and antiferro-magnetic order . Domains and Bloch-wall energy.

Text and Reference Books

Verma and Srivastava: Crystallography for Solid State Physics

Azaroff : Introduction to Solids

Omar : Elementary Solid State Physics

Aschroft & Mermin: Solid State Physics

Kittel: Solid State Physics

Chaikin and Ľubensky: Principles of Condensed Matter Physics

M.Sc. Physics (III Semester) : Tutorial : Condensed Matter Physics

1. Given that the primitive basis vectors of a lattice **a**=(a/2)(**i**+**j**), **k**=(a/2)(**j**+**k**) and **c**=(a/2)(**k**+**j**), where **i, j,** and **k** are the usual three unit vectors along cartesian coordinates, what is the Bravais lattice ?
2. Show that tin an ideal hexagonal-close-packed (hcp) structure, where the atomic spheres touch each other, the ratio *c/a* is given by

$$\frac{c}{a}=\left(\frac{8}{3}\right)^{1/2}=1.633$$

3. The *packing ratio* is defined as the fraction of the total volume of the cell that is filled by atoms. Determine the maximum values of this ratio for equal spheres located at the points of simple-cubic, body-centered-cubic, and face-centered-cubic crystals.
4. Consider a face-centered-cubic cell. Construct a primitive cell within this larger cell, and compare the two. How many atoms are in the primitive cell, and how does this compare with the number in the original cell ?
5. a. Determine which planes in an fcc structure have the highest density of atoms
   b. Evaluate this density in atoms/cm^2 for Cu.
6. a. Show for a simple square lattice (two dimensions) that the kinetic energy of a free electron at a corner of the first zone is higher than that of an electron at midpoint of a side face of the zone by a factor of 2.
   b. What is the corresponding factor for a simple cubic lattice (three dimensions) ?
   c. What bearing might the result of (b) have on the conductivity of divalent metals ?
7. Consider the free electron energy bands of an fcc crystal lattice in the approximation of an empty lattice, but in the reduced zone scheme in which all **k**'s are transformed to lie in the first Brillouin zone. Plot roughly in the [111] direction the energies of all bands up to six times the lowest band energy at the zone boundary at **k**=(2π/a) (½,½,½). Let this be the unit of energy. This problem shows why band edges need not necessarily be at the zone center. Several of the degeneracies (band crossings) will be removed when account is taken of the crystal potential.
8. a. For the delta-function potential and with P< 1, find at k=0 the energy of the lowest energy band. (b) For the same problem find the band gap at $k=\pi/a$.
9. Consider a square lattice in two dimensions with the crystal potential
   U(x,y)=-4U Cos(πx/a) Cos(πy/a)
   Apply the central equation to find approximately the energy gap at the corner point (π/a, π/a) of the Brillouin zone. It will suffice to solve a 2 x 2 determinantal equation.
10. Explain qualitatively why the Hall constant RH is inversely proportional to the electron concentration **N**.

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Demonstrate qualitatively that the Hall constant for a current of positive charges is positive.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.SC. PHYSICS (III SEMESTER) : NUCLEAR AND PARTICLE PHYSICS

Nuclear Interactions and Nuclear Reactions

Nucleon - nucleon interaction - Exchange forces and tensor forces - Meson theory of nuclear forces - Nucleon - nucleon scattering - Effective range theory - Spin dependence of nuclear forces - Charge independence and charge symmetry of nuclear forces - Isospin formalism - Yukawa interaction.

Direct and compound nuclear reaction mechanisms - Cross sections in terms of partial wave amplitudes - Compound nucleus - Scattering matrix - Reciprocity theorem - Breit - Wigner one - level formula - Resonance scattering.

Nuclear Models

Liquid drop model - Bohr - Wheeler theory of fission - Experimental evidence for shell effects - Shell model - Spin - Orbit coupling - Magic numbers - Angular momenta and parities of nuclear ground states - Qualitative discussion and estimates of transition rates - Magnetic moments and Schmidt lines - Collective model of Bohr and Mottelson.

Nuclear Decay

Beta decay - Fermi theory of beta decay - Shape of the beta spectrum - Total decay rate- Angular momentum and parity selection rules - Comparative half - lives - Allowed and forbidden transitions - Selection rules - Parity violation - Two-component theory of neutrino decay - Detection and properties of neutrino - Gamma decay - Multipole transitions in nuclei - Angular momentum and parity selection rules - Internal conversion - Nuclear isomerism.

Elementary Particle Physics

Types of interaction between elementary particles - Hadrons and leptons - Symmetry and conservation laws - Elementary' ideas of CP and CPT invariance - Classification of hadrons - Lie algebra, SU(2) - SU(3) multiplets - Quark model - Gell - Mann - Okubo mass formula for octet and decuplet hadrons - Charm, bottom and top quarks.

Text and Reference Books

A. Bohr and B.R. Mottelson, Nuclear Structure, Vol. 1 (1969) and Vol.2, Benjamin, Reading, A, 1975.

Kenneth S.Kiane, Introductory Nuclear Physics,Wiley, New York,1988.

Ghoshal, Atomic and Nuclear Physics Vol. 2.

P. H. Perkins, Introduction to High Energy Physics, Addison-Wesley, London, 1982.

Shirokov Yudin, Nuclear Physics Vol. I & 2, Mir Publishers, Moscow, 1982.

D. Griffiths, Introduction to Elementary Particles, Harper and Row, New York, 1987.

H. A. Enge, Introduction to Nuclear Physics, Addison- Wesley, 1975.

G. E. Brown and A. D. Jackson, Nucleon - Nucleon Interaction, North - Holland, Amsterdam, 1976.

S. de Benedetti, Nuclear Interaction, John Wiley & Sons, New York, 1964.

M. K. Pal, Theory of Nuclear Structure, Affiliated East - West, Madras, 1982.

Y.R. Waghmare, Introductory Nuclear Physics, Oxford - IBH, Bombay, 1981.

J.M. Longo, Elementary Particles, Me Graw - Hill, New York, 1971.

R.D.Evans, Atomic Nucleus, Me Graw Hill, New York,1955.

I. Kaplan, Nuclear Physics, 2nd Ed., Narosa, Madras, 1989.

B. L. Cohen, Concepts of Nuclear Physics, TMGH, Bombay, 1971.

R. R. Roy and B. P. Nigam, Nuclear Physics, Wiley - Eastern Ltd., 1983.

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M.Sc. Physics (III Semester) : Tutorial : Nuclear and Particle Physics

1. Scattering Matrix
2. Nucleon-Nucleon Phase Shifts
3. Double Scattering Experiment to measure Polarization
4. General Properties of Nuclear forces
5. The Q-Equation
6. Calculation of Absorption Cross Section
7. Resonance Reaction
8. Kurie Plot
9. Comparative Half-Lives
10. Selected Rules
11. Parity Violation Experiment
12. Neutrino Helicity
13. Isospin Symmetry
14. Lie Algebra

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (III Semester) : Special Paper I

CONDENSED MATTER PHYSICS

Module 1 : Lattice Dynamics and Optical Properties of Solids

Interatomic forces and lattice dynamics of simple metals, ionic and covalent crystals. Optical phonons and dielectric constants. Inelastic neutron scattering. Mossbauer effect. Debye-Waller factor. Anharmonicity, thermal expansion and thermal conductivity. Interaction of electrons and phonons with photons. Direct and indirect transitions. Absorption in insulators, Polaritons, one-phonon absorption, optical properties of metals, skin effect and anomalous skin effect.

Module 2 : Electron-Phonon Interaction

Interaction of electrons with acoustic and optical phonons, polarons. Superconductivity: manifestations of energy gap. Cooper pairing due to phonons, BCS theory of superconductivity, Ginzsburg-Landau theory and application to Josephson effect : d-c Josephson effect, a-c Josephson effect, macroscopic quantum interference. Vortices and type II superconductors, high temperature superconductivity (elementary).

Text and Reference Books

Madelung: Introduction to Solid State Theory

Callaway: Quantum Theory of Solid State

Huang: Theoretical Solid State Physics

Kittel: Quantum Theory of Solids

M.Sc. Physics (III Semester) : Tutorial : Special Paper I

CONDENSED MATTER PHYSICS

Module 1 : Lattice Dynamics and Optical Properties of Solids

1. From the dispersion relation derived for a monatomic linear lattice of N atoms with nearest neighbor interactions, show that the density of modes is

$$D(\omega) = \frac{2N}{\pi} \cdot \frac{1}{\left(\omega_m^2 - \omega^2\right)^{1/2}}$$

where ω_m is the maximum frequency. Suppose that an optical phonon branch has the form $\omega(K) = \omega_o - AK^2$, near K=0 in three dimensions. Show that $D(\omega) = (L/2\pi)^3(2\pi/A^{3/2})(\omega_o - \omega)^{1/2}$ for

$\omega<\omega_o$ and $D(\omega)=0$ for $\omega>\omega_o$. Here the density of modes is discontinuous.

2. Estimate for 300K the root mean square thermal dilation $\Delta V/V$ for a primitive cell of sodium. Take the bulk modulus as 7×10^{10} erg cm^{-3}. Note that the Debye temperature 158 K is less than 300 K, so that the thermal energy is of the order of $k_B T$. Use this result to estimate the root mean square thermal fluctuation $\Delta a/a$ of the lattice parameter.

3. Consider a classical harmonic oscillator with small anharmonic terms so that the potential energy is

   $V(x) = ax^2 + bx^3 + cx^4$

   Using the partition function approach, show that the mean energy (ξ) and mean thermal displacement from equilibrium (x) are :

   $$(\xi) \approx k_B T\left[\frac{15b^2}{16a^2} - \frac{3c}{4a^2}\right] \quad (K_B T)^2, \qquad (x) \approx -\left(\frac{3b}{4a^2}\right) k_B T$$

   The former leads to a high temperature contribution to the specific heat that is linear in temperature. The latter is an indication of the origin of thermal expansion (and the proper sign of the b coefficient).

4. For the monatomic linear chain, show how the transformation to the amplitude (and conically conjugate momenta) of complex waves exp. (ikx) simplifies the Hamiltonian. Then transform to the creation and annihilation operators and obtain for the Hamiltonian Σ_k $\hbar\omega_k$ (b_k b_k+1/2). For a normal mode containing n_k phonons we write the phonon state as $|n_k>$ which has energy $\xi_k = (n_k + 1/2)\hbar\omega_k$. Show that

   $b_k |n_k> = (n_k+1)^{1/2} |n_k+1>$

   $b_k |n_k> = (n_k)^{1/2} |n_k-1>$

   hence the name creation and annihilation operators. Show that the **number operator** $b_k b_k$ has the property

   $b_k b_k |n_k> = (n_k |n_k>$

   hence $\hbar\omega_k (b_k b_k+1/2) |n_k> = \xi_k |n_k>$

Module 2 : Electron-Phonon Interaction

5. Use the deformation potential approximation to calculate the relaxation time $\tau(E)$ for the interaction between electrons and LA-phonons in a nondegenerate semiconductor with parabolic conduction band. How large is the exponent r in $\tau(E) = \tau_o E^r$?

6. In an anisotropic solid and general relationship between the components of the current density and of the electric and magnetic fields applied is

   $i_l = a_{ij}E_j + a_{ijk}E_j B_k + a_{ijkl}E_j B_k B_l + ...$

a. Which components of the tensors a_{ij}, a_{ijk}, a_{ijkl} vanish for cubic symmetry ? What relationships occur between the remaining components.

b. What are the deviations from the isotropic case for conductivity, Hall coefficient, and magnetoresistance?

7. Assume a nondegenerate mixed semiconductor. Electrons and holes thus take part simultaneously in the transport phenomena.

a. Using the relaxation time approximation, compute the transport coefficients of (4.85 of Madelung's book) and from these the electrical conductivity, the thermoelectric power, the Peltier coefficient, and the thermal conductivity.

b. Why does the Peltier coefficient have different sign in n-type and p-type semiconductors? Under what conditions does the Peltier coefficient vanish in an intrinsic semiconductor (n=p)?

c. In addition to an electron and a hole component, the expression for the thermal conductivity contains an additional term which only appears in the case of mixed conduction. What is the physical explanation for this "ambi-polar" term?

d. Use the relaxation time approximation to calculate the coefficient for the isothermal Nernst effect. How is the result to be interpreted? In what circumstances does the Nernst coefficient change sign with change of conductivity type?

8. a. Draw diagrams showing some possible two-phonon processes in which a neutron enters with momentum **p** and leaves with momentum **p'**. In labeling the diagram stake due account of the conservation laws.

b. Repeat (a) for three-phonon processes.

9. a. Repeat the method of graphical solution given in Figure 24.6 (Ashcroft/Mermin's book) for the case of phonon emission.

b. Verify that when the incident neutron energy is zero, no solutions are possible.

c. In qualitative terms, how does the number of solutions depend on the incident wave vector $\mathbf{k}_i$?

10. Appendics L and N of Ashcroft/Mermin's book:

a. Using the definition of W given in Eq. (n.17 of Ashcroft/Mermin's book) and the expansion (L.14 of Ashcroft/Mermin's book) for **u(R),** show that the Debye-Waller factor has the form :

$$e^{-2W} = exp\left\{-v\int \frac{d\mathbf{k}}{(2\pi)^d}\sum_s \frac{h}{2M\omega_s(\mathbf{k})}(\mathbf{q}.\varepsilon_s(\mathbf{k}))^2 Coth\frac{1}{2}\beta h\omega(\mathbf{k})\right\} \quad (24.28)$$

where v is the appropriate cell volume.

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b. Show that $e^{-2W} = o$ in one and two dimensions. (Consider the behaviour of the integrand for small k.) What are the implications of this for the possible existence of one-or two-dimensional crystalline ordering ?

c. Estimate the size of the Debye-Waller factor for a three-dimensional crystal.

11. The average rate of dissipation of energy for an electromagnetic wave is **W = <E.J>** where the average is over a complete cycle. Show that $W=(\omega\varepsilon_2/8\pi)E_o^2 = \sigma E_o^2/2 = \sigma_1 E^2$.

12. For the **Lorentz oscillator** show that σ_1 always peaks at ω_o independently of γ/ω_o. for modest values of γ/ω_o show that ε_2 peaks at at $\omega_o[1-a(\gamma/\omega_o)^2]$. When does ε_2 peak at $\omega=0$?

13. Using time dependent perturbation theory, show that the results in Eq. 13-29 (Burner's book) can be obtained for allowed electric dipole transitions. (See any quantum mechanics book).

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (III Semester) : Special Paper I

ELECTRONICS

Module 1 : Operational Amplifiers

Differential amplifier - circuit configurations - dual input, balanced output differential amplifier - DC analysis - AC analysis, inverting and non inverting inputs CMRR - constant current bias level translator.

Block diagram of a typical Op-Amp-analysis. Open loop configuration inverting and non-inverting amplifiers. Op-amp with negative feedback - voltage series feed back - effect of feed back on closed loop gain input persistence output resistance bandwidth and output offset voltage - voltage follower.

Practical op-amp input offset voltage - input bias current - input offset current, total output offset voltage, CMRR frequency response.

DC and AC amplifier summing scaling and averaging amplifiers instrumentation amplifier, integrator and differentiator.

Oscillators principles - oscillator types - frequency stability - response - The phase shift oscillator. Wein bridge oscillator - LC tunable oscillators - Multivibrators - Monostable and Astable - comparators - square wave and Triangle wave generators.

Voltage regulators - fixed regulators - adjustable voltage regulators switching regulators

Module 2 : Communication Electronics

Amplitude modulation - Generation of AM waves - Demodulation of AM waves - DSBSC modulation. Generation of DSBSC waves, Coherent detection of DSBSC waves, SSB modulation, Generation and detection of SSB waves. Vestigial sideband modulation. Frequency Division multiplexing (FDM).

Digital Electronics

1. Combinational Logic

The transistor as a switch, OR, AND and NOT gates - NOR and NAND gates Boolean algebra - Demorgan's theorems - Exclusive OR gate, Decoder/Demultiplexer Data selector/multiplexer - Encoder.

2. Sequential Logic

Flip - Flops : A I - bit memory - The RS Flip - Flop, JK Flip - Flop - JK master slave Flip - Flops - T Flip - Flop - D Flip - Flop - Shift registers - synchronous and asynchronous counters - cascade counters.

Microprocessors

Introduction to microcomputers - memory - input/output - Interfacing devices

8085 CPU - Architecture - BUS timings - Demultiplexing the address bus generating control signals - Instruction set - addressing modes - Illustrative programmes - writing assembly language programmes looping, counting and indexing - counters and timing delays - stack and subroutine.

Text and Reference Books

"Electronic Devices and circuit theory" by Robert Boylested and Louis Nashdsky PHI, New Delhi -110001,1991

"OP-Amps & Linear integrated circuits," by Ramakanth A. Gayakwad PHI, Second Edition, 1991

"Digital principles and Applications" by A.P. Malvino and Donald P. Laach, Tata Megraw - Hill company. New Delhi, 1993.

"Microprocessor Architecture, programming and Applications with 8085/8086 by Ramesh S. Gaonkar, Wiley - Eastern Ltd., 1987 (for unit v)

M.Sc. Physics (III Semester) : Tutorial : Special Paper I

ELECTRONICS

1. Operational Amplifiers
2. Design considerations of opamp oscillators
3. Design considerations of instrumentation amplifiers
4. Mathematical operation using opamps

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5. Radiowave propagation in free space
6. Tropospheric & ionospheric propagation
7. Applications of counters & shift registers
8. Dedicated systems using microprocessors

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (III Semester) : Special Paper I

ATOMIC AND MOLECULAR PHYSICS

Module I

Basic principles of interaction of spin and applied magnetic field-Concepts of NMR spectroscopy-Concepts of 'spin spin' and 'spin lattice' relaxation-Chemical shift-Spin spin coupling between two and more nuclei (qualitative) experimental setup CW NMR Spectrometer Chemical analysis using NMR

Mossbauer effect-Recoil less emission of gamma rays-Chemical shift-Magnetic hyperfine interaction-Experimental setup

Electron spin resonance-Effects of LS coupling fine and hyperfine structure-G Values-Simple experimental setup

Module II

Time dependence in quantum mechanics-Time dependent perturbation theory-Rale expression for emission-Perturbation theory calculation of polarisability-Quantum mechanical expression for emission rate-Time correlation function and spectral Fourier transform pair-Properties of time correlation functions and spectral time shape-Fluctuation dissipation theorem-Rotational correlation function and pure rotational spectra-Re orientational spectroscopy of liquids

Text and Reference Books

Molecular spectroscopy—Jeane L McHale

Molecular quantum mechanics—P. W. Alkins & R. S - Friedman

Mossbauer spectroscopy—M.R.Bhide

NMR and chemistry-J.W.Akitt

Structural methods in inorganic chemistry—E.A.V.Ebsworth,D.W.H.Rankin & S.Cradock.

M.Sc. Physics (III Semester) : Tutorial : Special Paper I

ATOMIC AND MOLECULAR PHYSICS

1. Predict the appearance of high resolution (^1H) NMl spectrum of the following compounds: i). Acetaldehyde ii) Acetone iii) Acetic acid iv) n-Butanone v) Propionic acid vi) Benzene vii) Tolune viii) Ethyl benzene ix) Isobutane
2. The NMR spectrum of a certain organic compound containing a single atom of bromine is given. Identify the compound. (give the spectrum of Ethy Bromide)
3. The NMR spectrum of a compound with empirical formula C_4H_8O. Identify the compound (give the spectrum of ehyl ketone)
4. Explain the splitting pattern of high resolution ^1H NMR spectrum of:
   a) 1,1 dibromoethane b) ethane c) l-chloropropane

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (III Semester) : Special Paper I

NUCLEAR AND PARTICLE PHYSICS

The Nucleon - Nucleon Interaction and Nuclear Radiation Detection

Module I : The Nucleon - Nucleon Interaction

Nucleon - Nucleon Interaction and Hadron Structure : Phenomenological Nucleon - Nucleon potentials - Meson theory - Derivation of Yukawa interaction- Electromagnetic properties of deuteron - Polarisation in nucleon - nucleon scattering - Scattering matrix - Probing charge distribution with electrons - Form factors - Proton form factors - Deep inelastic electron - proton scattering - Bjorken scaling and partons - Quarks within the proton - Gluons as mediators of strong interaction.

Particle Phenomenology : Pion - Nucleon scattering - Isospin analysis - Phase shifts - Resonance and their quantum numbers - Production and formation experiments Relativistic kinematics and invariants - Mandelstam variables - Phase space - Decay of one particle into three particles - Dalitz Plot.

Module II: Nuclear Radiation Detectors

Ionizing radiations : Ionization and transport phenomena in gases - Avalanche multiplication.

Detector Properties : Detection - Energy measurement - Position measurement Time measurement.

Gas Counters : Ionization chambers, - Proportional counters - Multiwire proportional counters - Geiger - Muller counters - Neutron detectors.

Solid State Detectors : Semiconductor detectors - Integrating solid state devices - Surface barrier detectors.

Scintillation counters : Organic and inorganic scintillators - Theory, characteristics and detection efficiency.

High Energy Particle Detectors : General principles - Nuclear emulsions - Cloud chambers - Bubble chambers - Cerenkov counter.

Nuclear Electronics : Analog and digital pulses - Signal pulses - Transient effects in an R-C circuit - Pulse shaping - Linear amplifiers - Pulse height discriminators - Single channel analyser - Multichannel analyser.

Text and Reference Books

G. E. Brown and A. D. Jackson, Nucleon - Nucleon Interaction, North - Holland, Amsterdam, 1976.
S. de Benedetti, Nuclear Interaction, John Wiley and Sons, New York, 1964.
P. Marmier and E.Sheldon, Physics of Nuclei and Particles, Vol. I & II, Academic Press, New York, 1970.
H. A. Enge, Introduction to Nuclear Physics, Addison - Wesley, 1975.
S. S. Kapoor and V. S. Ramamurthy, Nuclear Radiation Detectors, Wiley - Eastern, New Delhi, 1986.
W. H. Tait, Radiation Detection, Butterworths, London, 1980.
W. J. Price, Nuclear Radiation Detection, Mc Graw Hill, New York, 1964.

M.Sc. Physics (III Semester) : Tutorial : Special Paper I

NUCLEAR AND PARTICLE PHYSICS

1. Scattering Matrix
2. Electromagnetic Form Factors of the Deuteron
3. Comparison Between Experimental p-p Scattering Phase Parameters and Parameters Derived From a Pion Exchange Potential.
4. Nucleon - Nucleon Scattering at Elevated Energies and its Interpretation.
5. Numerical Solutions to the Lippman - Schwinger Equation.
6. Relation Between Various Sets of Invariants.
7. Nucleon - Nucleon Phase Shifts and Phenomenological Potentials.
8. Internal Conversion Electrons, Auger Electrons.
9. Energy Spectra of α, β and γ radiation.
10. Interaction of Radiation with Matter: Photoelectric Effect, Compton Scattering, Pair Production.
11. Calculation of Detector Efficiency and Resolution.
12. Pulse Height Spectrometry, Pulse Shape Discrimination.
13. Dead - Time Measurement.
14. Gas Quenching.
15. Mass Attenuation Coefficient as a Function of Photon Energy for Sodium Iodide.
16. Effect of RC Time Constant on Pulse Shape.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

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M.Sc. Physics (III Semester) : Special Paper I

INFORMATICS (MATERIALS AND DATA COMMUNICATION)

Module 1

Semiconductor Quantum structures, Heterostructures, Mismatch Heterostructures, Coherently Strained Structures, Partially Relaxed Strained Layer Structures, Methods of Formation Heterostructures some of the examples of heterostructures, Bandgap engineering, Strained Layer Epitaxy, Light emitting Diodes, Etched Well surface emitting LED, Continuous operation lasers Heteroquantum Lasers, CW Heteroquantum Laser, Stripe Geometry.

Module 2

Fourier series and transforms and their applications to data communication.

Introduction to Probability and Random Variables. Introduction to Information Theory and Queuing Theory.

Introduction and Evolution of Telecommunication, Fundamentals of electronic communication: Wired, Wireless, Satellite and optical Fibre, Analog/digital, Serial/parallel, Simplex/half and full duplex, Synchronous/Asynchronous, Bit/baud rates, Parity and error control (CRC, LRC, ARQ, etc.), Signal to Noise Ratio, etc.

Transmission types, codes, modes, speed and throughput. Modulation types, techniques and standards. Base band and carrier communication, Detection, Interference, Noise signals and their characterization, Phase Locked Loops.

Modems, Transmission media (guided & unguided), Common Interface standards.

Text and Reference Books

Data communication by Reid and Bartskor

Data Networks by Gallager

Data Communication by William Stalling

Communication networks by Leon -Garcia and Widjaja

Introduction to communication systems by S. Haykins

Analog and Digital Communication by S. Haykins

M.Sc. Physics (III Semester) : Tutorial : Special Paper I

INFORMATICS (MATERIALS AND DATA COMMUNICATION)

The tutorial will consist of problems solving from the Text and Reference books.

M.Sc. Physics (III Semester) : Special Paper II

CONDENSED MATTER PHYSICS

Module 1 : Crystal Physics and X-ray Crystallography

External symmetry elements of crystals. Concept of point groups. Influence of symmetry on physical properties: Electrical conductivity. Space groups, derivation of equivalent point positions (with examples from triclinic and monoclinic systems), experimental determination of space group. Principle of powder diffraction method, interpretation of powder photographs, analytical indexing: Ito's method. Accurate determination of lattice parameters - least-square method. Applications of powder method. Oscillation and Buerger's precession methods. Determination of relative structure amplitudes from measured intensities (Lorentz and polarization factors), Fourier representation of electron density. The phase problem, Patterson function.

Module 2 : Exotic Solids

Structure and symmetries of liquids, liquid crystals and amorphous solids. Aperiodic solids and quasicrystals; Fibonaccy sequence, Penrose lattices and their extension to 3-dimensions. Special carbon solids; fullerenes and tubules; formation and characterization of fullerenes and tubules. Single wall and multi-wall carbon tubules. Electronic properties of tubules. Carbon nanotubule based electronic based electronic devices. Definition and properties of nanostructured materials. Methods of synthesis of nanostructured materials. Special experimental techniques for characterization of nanostructured materials. Quantum size effect and its applications.

Text and Reference Books

Azaroff: X-ray Crystallography

Weertman & Weertman: Elementary Dislocation Theory

Verma & Srivastava: Crystallography for Solid State Physics

Kittel: Solid State Physics

Azaroff & Buerger: The Powder Method

Buerger: Crystal Structure Analysis

M.Ali Omar: Elementary Solid State Physics

The Physics of Quasicrystals, Eds. Steinhardt and Ostulond

Handbook of Nanostructured Materials and Nanotechnology (Vol. 1 to 4). Ed. Hari Singh Nalwa.

M.Sc. Physics (III Semester) : Tutorial : Special Paper II

CONDENSED MATTER PHYSICS

Module 1 : Crystal Physics and X-ray Crystallography

1. The powder pattern of aluminum, made with Cu $K\alpha$ radiation, contains ten lines, whose $\sin^2\theta$ values are 0.111,8, 0.1487, 0.294, 0.403, 0.439, 0.583, 0.691, 0.727 0.872 and 0.981. Index these lines and calculate the lattice parameter.
2. A pattern is made of a cubic substance with unfiltered chromium radiation. The observed $\sin^2\theta$ values and intensities are 0.265(m), 0.321(vs), 0.528(w), 0.638(s), 0.793(s) and 0.958(vs). Index these lines and state which are due to $K\alpha$ and which to $K\beta$ radiation. Determine the Bravais lattice and lattice parameter. Identify the substance based on ASTM chart.
3. The following data were obtained from a Debye-Scherrer pattern of a simple cubic substance, made with copper radiation. The given $\sin^2\theta$ values are for the $K\alpha_1$ lines only.

$h^2+k^2+l^2$	$\sin^2\theta$
38	0.9114
40	0.9563
41	0.9761
42	0.9980

Determine the lattice parameter *a*, accurate to four significant figures, by graphical extrapolation of *a* against $\cos^2\theta$.

4. a) The Bragg angle for reflection from the (110) planes in bcc iron is 22° for and X-ray wavelength of λ=1.54Å, compute the cube edge for iron.
   b) What is the Bragg angle for reflection from the (111) planes ?
   c) Calculate the density of bcc iron. The atomic weight of Fe is 55.8.
4. Show that if the crystal undergoes volume expansion, then the reflected beam is rotated by the angle

$$\delta\theta = -\frac{\gamma}{3}\tan\theta$$

where γ is the volume coefficient of expansion and θ is the Bragg angle.

6. Explain with the help of reciprocal lattice concept, the streaking of X-ray reflections in the oscillation photographs. How the streaks can be removed ?
7. Compare and contrast the powder and the single crystal X-ray diffraction techniques.
8. Bring out the problem associated with determination of crystal structures based on X-ray diffraction techniques.

9. What is anomalous X-ray scattering/dispersion and how it can assist in structure determination.

Module 2 : Crystal Physics and X-ray Crystallography

10. What is golden mean ratio ? How it is relevant in quasicrystals ?
11. Show whether periodicity can exist together with aperiodicity in a structure.
12. What are rational approximants in quasicrystals ? Bring out the relation between quasicrystals and rational approximants.
13. Band structure formula for crystals is not quite valid for nanostructures. Why ?
14. Distinguish between crystalline, amorphous solids and liquids.
15. The carbon nanotubules can be both semiconducting and metallic. Why ?
16. What are onion carbon structure ? How are they related with fullerene ?

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (III Semester) : Special Paper II

ELECTRONICS

Module 1

Analog and Digital Systems

Analog computation, active filters, comparators, logarithmic and anti-logarithmic amplifiers, sample and hold amplifiers, waveform generators. Square and triangular wave generators, pulse generator.

Read-only Memory (ROM) and applications. Random Access Memory (RAM) and applications.

Digital to-analog converters, ladder and weighted resistor types Analog to digital converters - counter type, successive approximation and dual slope converters, Applications of DACs and ADCs.

Optoelectronics

Photo detectors : Photo detectors with external photo effect, photo detectors with internal photo effect, photo conductors and photo resistors, junction photo detectors.

Circuits with Light Emitting Diodes, Diode tester. Polarity and voltage tester, measuring instruments with LED indication.

LED, Numeric and alphanumeric display units. Semiconductor switches and potential isolation, The phototransistor as a switch in the optocouplers, steady state performance, dynamic performance, use of optocouplers.

Module 2

Microwave Devices

Klystrons, Magnetrons and Travelling Wave Tubes, Velocity modulation, Basic principles of two cavity Klystrons and Reflex Klystrons, principles of operation of magnetrons. Helix Travelling Wave Tubes, Wave Modes.

Transferred electron devices, Gunn Effect, Principles of operation. Modes of operation, Read diode, IMPATT diode, TRAPATT Diode.

Microwave Communications

Advantages and disadvantages of microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on propagation, Fresnel zone problem, ground reflection, fading sources, detectors, components, antennas used in MW communication systems.

Radar Systems

Radar block diagram an operation, radar frequencies, pulse considerations. Radar range equation, derivation of radar range equation, minimum detectable signal, receiver noise, signal to noise ratio, Integration of radar pulses. Radar cross section. Pulse repetition frequency. Antenna parameters, system Losses and Propagation losses. Radar transmitters, receivers. Antennas, Displays.

Satellite Communications

Satellite communications : orbital satellites, geostationary satellites, orbital patterns, look angles, orbital spacing, satellite systems. Link modules.

Text and Reference Books

"Microelectronics" by Jacob Millman, Megraw-hill International Book Co., New Delhi, 1990

"Optoelectronics: Theory and Practice", Edited by Alien chappal. Me GrawHill Book Co., New York.

"Microwaves" by K.L. Gupta, Wiley Eastern Ltd., New Delhi, 1983

"Advanced Electronics Communications Systems" by Wayne Tomasi., Phi.Edn.

M.Sc. Physics (III Semester) : Tutorial : Special Paper II

ELECTRONICS

1. Sampling Theorem - sample and hold circuits
2. Second and higher order filter design concepts
3. A/D & D/A interfacing
4. Photo electric effect
5. Photo emissive cells
6. Microwave amplification
7. Klystron and Gunn Oscillator characteristics
8. Concepts of wave guides
9. Microwave propagation
10. Design considerations of microwave links
11. Different types of Radar systems
12. (i) Weather Radars (ii) Cyclone detection radars (iii) Moving target indicators
13. Frequency considerations in satellite communications

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (III Semester) : Special Paper II

ATOMIC AND MOLECULAR PHYSICS

Module 1

Raman effect-Quantum theory-Molecular polarisability-Pure rotational Raman spectra of diatomic molecules-Vibration rotation Raman spectrum of diatomic molecules-intensity alterations in Raman spectra of diatomic molecules-Experimental setup for Raman spectroscopy-Application of IR and Raman spectroscopy in the structure determination of simple molecules

Module 2

Electronic spectra of diatomic molecules-Born Oppenheimer approximation-Vibrational coarse structure of electronic bands-Progression and sequences-intensity of electronic bands-Franck Condon principle-Dissociation and pre dissociation-Dissociation energy-Rotational fine structure of electronic bands-Electronic structure of diatomic (base ideas only)

Text and Reference Books

Introduction to Atomic spectra—H.E.White(T)

Fundamentals of molecular spectroscopy—C.B.Banwell (T)

Spectroscopy Vol I, II & III—Walker & Straughen

Introduction to Molecular spectroscopy—G.M.Barrow

Spectra of diatomic molecules—Herzberg

Molecular spectroscopy—Jeanne L McHale

Molecular spectroscopy—J.M.Brown

Spectra of atoms and molecules—P.F.Bemath

9. Modem spectroscopy—J.M.Holkas

M.Sc. Physics (III Semester) : Tutorial : Special Paper II

ATOMIC AND MOLECULAR PHYSICS

1. For HCN how many vibrational peaks do you expect its IR spectrum to have? What about its Raman spectrum?
2. Explain how you can have a $\Delta J=-1$ absorption in an IR (vibrational-rotational) spectrum?
3. The rotational absorption peaks of HCL IR spectrum, the peaks are not of the same height. The peaks started off [from the center of the spectrum] short and then got taler and then finally became short again. Why does this happen?
4. For the molecule CO ν (bar) =2170 cm^{-1} and B_e=1.931cm^{-1}. Now answer the following questions pertaining to its IR (vibrational and rotational) spectrum:
   a) Where will the center of the vibrational band be located? What vibrational transition does this correspond to? What rotational transition does this correspond to?
   b) How far away (in wave numbers) will the first rotational absorption be from the center?
   c) What is the spacing between rotational absorptions (in wavenumbers)?
   d) Sketch the overall vibrational-rotational spectrum?

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (III Semester) : Special Paper II

NUCLEAR AND PARTICLE PHYSICS

Nuclear Reactions, Nuclear Energy and Accelerators

Module I : Nuclear Reactions and Nuclear Energy

Nuclear Reactions : Elementary approach to potential scattering theory – S-wave neutron scattering in the compound nuclear reaction model - Derivation and discussion of Breit-Wigner resonance formula - Single level single channel R-matrix (R-function) theory - Statistical model of compound nuclear reaction - Pre-equilibrium reactions - Discussion of direct reactions - Ground state of deuteron - Magnetic moment - Quadrupole moment - S and D admixtures - Plane wave theory of deuteron - Stripping in zero range approximation - Spectroscopic factor and determination of nuclear level properties - Single nucleon transfer reactions -Theory of average cross sections - Properties of optical potentials - Heavy-ion collisions - Features of medium and low energy heavy - ion elastic scattering - Diffraction models - Nuclear fission and extended liquid drop model.

Nuclear Energy: The fission process-Neutrons released in the fission process Cross sections - The fission reactors - Fusion - Thermonuclear reactions - Energy production in stars.

Module II: Accelerators

Historical Developments: Different types of accelerators - Layout and components of accelerators - Accelerator applications.

Transverse Motion : Hamiltonian for Particle motion in accelerators - Hamiltonian in Frenet - Serret coordinate system - Magnetic field in Frenet - Serret coordinate system - Equation of betatron motion - Particle motion in dipole and quadrupole magnets - Linear betatron motion: Transfer matrix and stability of betatron motion - Courant - Snyder invariant and emittance - Stability of betatron motion - Sympletic condition - Effect of space - charge force on betatron motion.

Synchrotron Motion : Longitudinal equation of motion - The synchrotron Hamiltonian - The synchrotron mapping equation - Evolution of synchrotron phase Space ellipse.

Linear Accelerators : Historical milestones - Fundamental properties of accelerating structures - Particle acceleration by EM waves - Longitudinal particle dynamics in Linac - Transverse beam dynamic in a Linac.

Principle and Design Details of Accelerators : Basic principle and design details of accelerators viz electrostatic, electrodynamic, resonant with special emphasis on microtron, pelletron and cyclotron - Synchrotron radiation sources - Spectrum of the emitted radiation and their applications.

Text and Reference Books

Satchler, Introduction to Nuclear Reactions

H. A. Enge, Introduction to Nuclear Physics, Addison - Wesley ,1975.

B. L. Cohen, Concepts of Nuclear Physics, Tata Me Graw Hill , New Delhi, 1978.

P. Marmier and E. Sheldon, Physics of Nuclei and Particles, Vol. I &II Academic Press, 1969.

S. Y. Lee, Accelerator Physics, World Scientific, Singapore, 1999.

J. J. Livingood, Principles of Cyclic Particle Accelerators, D. Van Nostrand Co., 1961.

J. P. Blewett, Particle Accelerators, McGraw - Hill Book Co.

S. P. Kapitza and V. N. Melekhin, The Microtron, Harwood Academic Publishers.

W. Scharf, Particle Accelerators and Their Uses, Harwood Academic Publishers.

I.M. Kapchinsky, Theory of Resonance Linear Accelerators, Harwood Academic Publishers.

P. Lapostole and A. Septier, Linear Accelerators, North Holland.

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M.Sc. Physics (III Semester) : Tutorial : Special Paper II

NUCLEAR AND PARTICLE PHYSICS

1. The Q - Equation.
2. Conservation of Energy and Momentum in Nuclear Reactions
3. Threshold Energies
4. Reaction Theory
5. Cross sections in Matrix Formalism
6. Calculation of Absolute Cross Section
7. Calculation of Excitation Energy
8. Resonance Reactions
9. Necessity for High Energy Accelerators Classification of Accelerators
10. Layout and Components of Accelerators
11. Derivation of Betatron Equations of Motion
12. Courant - Snyder Parametrization
13. Experimental Tracking of Synchrotron Motion
14. EM Waves in Cylindrical Wave Guide
15. TM Modes in a Cylindrical Pillbox Cavity
16. Design of a Cyclotron for a Given Energy of Protons

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (III Semester) : Special Paper II

INFORMATICS (INTERNETWORKING TECHNOLOGY)

Module 1 :

Introduction to Unix/Linux and shell scripting.

Conceptual framework of computer languages. Introduction to C/C++. Data Types and Operators, Statements and Control Flow, Functions and Program Structure, Strings, The Preprocessor, Pointers, Memory Allocation, Input and Output, Sub program, Recursion, File Access.

Module 2 :

Object orientation concepts: classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, inheritance and polymorphism; analysis and design; Notations for object-oriented analysis and design; Case studies and applications using some object oriented programming languages.

Introduction to web enabling technologies and authoring tools/languages (webcasting, database integration, CGI, peri, Java, HTML, C#, etc.)

Text and Reference Books

Bahrami A., Object Oriented Systems Development using the Unified Modeling Language, McGraw Hill International Edition, 1999.

Booch, G., Object-Oriented Analysis and Design with Applications, Addison-Wesley, 2nd Edition, 1994.

Jesse Liberty, Beginning Object Oriented Analysis & Design Using C++, Wrox Press, 1998.

Timothy Budd, An Introduction to Object Oriented Programming, 2M' Ed., Addison Wesley, 1997.

M.Sc. Physics (III Semester) : Tutorial : Special Paper II

INFORMATICS (INTERNETWORKING TECHNOLOGY)

The tutorial will consist of problems solving from the Text and Reference books.

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M.Sc. Physics (III Semester) : Laboratory/Practical Course

CONDENSED MATTER PHYSICS

1. Measurement of lattice parameters and indexing of powder photographs.
2. Interpretation of transmission Laue photographs.
3. Determination of orientation of a crystal by back reflection Laue method.
4. Rotation/Oscillation photographs and their interpretation.
5. To study the modulus of rigidity and internal friction in metals as a function of temrature.
6. To measure the cleavage step height of a crystal by Multiple Fizeaue fringes.
7. To obtain Multiple beam Fringers of Equal Chromatic Order. To determine crystal step height and study birefringence.
8. To determine magnetoresistance of a Bismuth crystal as a function of magnetic field.
9. To study hysterisis in the electrical polarization of a TGS crystal and measure the Curie temperature.
10. To measure the dislocation density of a crystal by etching.

M.Sc. Physics (III Semester) : Tutorial : Laboratory/Practical Course

CONDENSED MATTER PHYSICS

1. Study of X-ray diffraction from liquid, amorphous materials.
2. Determination of dislocation density by Reflection X-ray topography.
3. To take Buerger Precession photograph of a crystal and index the reflections.
4. To measure the superconductivity transition temperature and transition width of high-temperature superconductors.
5. To determine the optical constants of a metal by reflection of light.
6. Model evaluation of dispersion curves of one-dimensional lattice.

M.Sc. Physics (III Semester) : Laboratory/Practical Course

ELECTRONICS

1. Pulse Amplitude Modulation/Demodulation
2. Pulse position/Pulse width Modulation/Demodulation
3. FSK Modulation Demodulation using Timer/PLL
4. Microwave characterization and Measurement
5. PLL circuits and applications
6. Fibre Optics communication
7. Design of Active filters
8. BCD to Seven segment display
9. A/D and D/A conversion
10. Experiments using various types of memory elements
11. Addition, substraction, multiplication & division using 8085/8086
12. Wave form generation and storage oscilloscope
13. Frequency, Voltage, Temperature measurements
14. Motor Speed control, Temperature control using 8086.
15. Trouble shooting using signature analyzer.
16. Assembler language programming on PC.
17. Experiments based on Computer Aided Design.

Setting up of new experiments will form tutorial for this laboratory course.

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M.Sc. Physics (III Semester) : Laboratory/Practical Course

ATOMIC AND MOLECULAR PHYSICS

1. Study of line spectra on photographed plates/films and calculation of plate factor.
2. Verification of Hartnman's dispersion formula.
3. Study of sharp and diffuse series of Potassium atom and calculation of spin orbit interaction constant.
4. Determination of metallic element in a given inorganic salt.
5. To record the spectrum of CN violet bands and to perform vibrational analysis.
6. To record the visible bands of AlO and to perform vibrational analysis.
7. To photograph and analyse the reddish glow discharge in air under moderate pressure.
8. To photograph and analyse the whitish glow discharge in air under reduced pressure.
9. To perform vibrational analysis of a band system of N_2.
10. To perform vibrational analysis of a band system of C_2.
11. To photograph and analyse the line spectrum of Calcium atom.
12. To record/analyse the fluorescence spectrum of a sample.
13. To record/analyse the Raman spectrum of a sample.
14. Study of Hyperfine structure of the green line of mercury.
15. To photograph the (0,0) band of CuH and to perform rotational analysis.

Setting up of new experiments will form tutorial for this laboratory course.

M.Sc. Physics (III Semester) : Laboratory/Practical Course

NUCLEAR AND PARTICLE PHYSICS

1. To determine the operating voltage, slope of the plateau and dead time of a G. M. counter.
2. Feathers' analysis using G. M. Counter.
3. To determine the operating voltage of a -photomultiplier tube and to find the photopeak efficiency of a NaI(Tl) crystal of given dimensions for gamma rays of different energies.
4. To determine the energy resolution of a NaI(Tl) detector and to show that it is independent of the gain of the amplifier.
5. To calibrate a gamma ray spectrometer and to determine the energy of a given gamma ray source.
6. To determine the mass attenuation coefficient of gamma rays in a given medium.
7. To study the Compton scattering using gamma rays of suitable energy.

8. To study the various modes in a multichannel analyser and to calculate the energy resolution, energy of gamma ray.
9. To determine the beta ray spectrum of Cs-137 source and to calculate the binding energy of K- shell electron of Cs-137.
10. To study the Rutherford scattering using aluminium as scatterer and Am -241 as a source.
11. To measure the efficiency and energy resolution of a HPGe detector.
12. Alpha spectroscopy with surface barrier detector - Energy analysis of an unknown gamma source.
13. Determination of the range and energy of alpha particles using spark counter.
14. The proportional counter and low energy X-ray measurements.
15. X- ray fluorescence with a proportional counter.
16. Neutron activation analysis.
17. Gamma - gamma coincidence studies.
18. Identification of particles by visual range in nuclear emulsion.
19. Construction and testing of a single channel analyser circuit.
20. Decoding and display of the outputs from the IC - 7490.

Text and Reference Books

S. S. Kapoor and V. S. Ramamurthy, Nuclear Radiation Detectors, Wiley Eastern Ltd, New Delhi, 1986.

R. M. Singru, Introduction to Experimental Nuclear Physics, John Wiley & Sons, 1974.

Alpha, Beta and gamma Ray Spectroscopy, K. Siegbahn, North - Holland, Amsterdam, 1965.

W. H. Tait, Radiation Detection, Butterworths, London, 1980.

K. Sriram and Y. R. Waghmare, Introduction to Nuclear Science and Technology, A.M. Wheeler, 1991.

Nicholson, Nuclear Electronics.

S. K. Khatroz, Nuclear Instrumentation.

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M.Sc. Physics (III Semester) : Tutorial : Laboratory/Practical Course

NUCLEAR AND PARTICLE PHYSICS

1. Mounting a Scintillation Crystal to a Photomultiplier Tube.
2. Pulse Cable Making
3. Pulse Shaping With an RC Circuit and to Display With an Oscilloscope.
4. Training in the Usage of Oscilloscope and Electronic Meters - Sensitivity and Resolution Study.
5. Usage of Radiation Monitors.
6. Setting up the Gamma Ray Spectrometer
7. Photoelectric Effect, Compton Effect, Pair Production and Back Scattering
8. Discriminators
9. Pulse Height as a Function of Applied Voltage for Gas Counters
10. Proportional Counter Characteristics
11. Scintillation Process in Intrinsic and Extrinsic Inorganic Crystals and Organic Crystals
12. Signal Formation in Solid State Devices
13. Neutron Activation Analysis

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (III Semester) : Laboratory/Practical Course

INFORMATICS

List of Experiments for Informatics

1. To study PCM-TDM
2. To study TDM-PAM
3. To study sampling and reconstruction (TDM-PAM)
4. To study Frequency Modulation
5. To study delta modulation, adaptive delta modulation, sigma delta modulation and demodulation techniques.
6. To study PSK, QPSK modulation techniques.
7. To generate PAM, wave form
8. Optical Communication (Optical Fibre Based Experiments)

M.Sc. Physics (III Semester) : Tutorial : Laboratory/Practical Course

INFORMATICS

1. Configuration of a network operating system (Windows NT, Windows 2000 server, Linux, Unix, Solaris).
2. Design a network of 10 nodes under Windows NT system with TCP/IP networking at 100 mbps speed using intelligent hubs.
3. Design a mail client.
4. Configuration of a Web (HTTP) server.
5. Configuration of US.
6. Configuration of a mail server.

M.Sc. Physics (IV Semester) : COMPUTATIONAL METHODS AND PROGRAMMING

Computational Method

Methods for determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions.

Solution of simultaneous linear equations, Gaussian elimination, pivoting, iterative Method, matrix inversion.

Eigenvalues and eigenvectors of matrices, Power and Jacobi Method.

Finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, Polynomial least squares and cubic Spline fitting.

Numerical differentiation and integration, Newton-Cotes formulae, error estimates, Gauss method.

Random variate, Monte Carlo evaluation of Integrals, Methods of importance sampling, Random walk and Metropolis method.

Numerical solution of ordinary differential equations, Euler and Runge Kutta methods, Predictor and corrector method. Elementary ideas of solutions of partial differential equations.

Programming

Elementary information about Digital computer Principles, Compilers, Interpreters and Operating systems. Fortran programming, Flow Charts, Integer and Floating Point Arithmetic, Expressions, built in functions, executable and non-executable statements, assignment, control and input-output elements, Subroutines and functions, Operation with files.

Text and References Books

Sastry: Introductory Methods of Numerical Analysis

Rajaraman: Numerical Analysis

Rajaraman: Fortran Programming

Vetterming, Teukolsky, Press and Flannery: Numerical Recipes

M.Sc.Physics (IV Semester):Tutorial

COMPUTATIONAL METHODS AND PROGRAMMING

1. Write a FORTAN program to obtain the roots of a quadratic equation with the provision that if the roots are complex, the execution should stop.
2. Invert and diagonalize 3x3 and 4x4 symmetric matrices. For example:

$$\begin{pmatrix} 2 & 0.5 & 0.1 \\ 0.5 & 3 & 0.1 \\ 0.1 & 0.1 & 4 \end{pmatrix} \qquad \begin{pmatrix} 3 & 1 & 1 & 0.5 \\ 1 & 4 & 1 & 1 \\ 1 & 1 & 5 & 1 \\ 0.5 & 1 & 1 & 6 \end{pmatrix}$$

3. Explain how arrays are transferred between a main program and its subprograms using common blocks and arguments.
4. Explain the use of sequential formatted files. What are Random Access files?
5. What are the different types of (i) IF statements and (ii) GO TO statements.
6. Distinguish between a Do Loop and an implied DO Loop. What restrictions are associated with Do loops?
7. Describe briefly the Newton Raphson iterative method for the solution of non-linear equations. Show that the procedure is second order convergent.
8. Use the Lagrange form to find the quadratic interpolation polynomial to the function f(x) having values.

x	:	1	2	3
f(x)	:	2	3	7

9. Find the condition involving coefficients a_{ij} so that Gauss – Seidel iterative method to solve the equations

$A_{11}x + a_{12}y = c$

$A_{21}x + a_{22}y = d$

will converge

10. Find equations for the co-efficients a and b of the curve $y = ae^{-bx}$ by the least squares method.
11. What is meant by numerical integration ? Derive Trapezoidal rule for numerical integration.
12. Give an outline of the fourth order Runge Kutta method of solving the differential equation

$dy/dx = f(x,y)$

illustrate your answer graphically.

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13. Find out c_0, c_1, x_0 and x_1 such that the Gaussion quadrature rule

$$\int_{-1}^{+1} f(x)dx = C_0 f(x_0) + c_1 f(x_1)$$

Is exact for polynomials of degree upto three. Hence evaluate the integral of exp(x) over x from x=0 to x=2.

14. What are the methods to solve partial differential equations? Write down the finite difference analogue of the Laplace equation:
$U_{xx} + U_{yy} = 0$

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

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M.Sc. Physics (IV Semester)

Elective Papers

Titles of Elective Papers

1. Quantum Electrodynamics
2. Physics of Liquid Crystals
3. Science and Technology of Solar Hydrogen and other Renewable Energies
4. Reactor Physics
5. Numerical Methods and Programming
6. Physics of Lasers and Laser Applications
7. Structures, Spectra and Properties of Biomolecules
8. Diagram Techniques
9. Physics of Electronic Devices & Fabrication of Integrated Circuits and Systems
10. Atmospheric Science
11. Plasma Physics
12. Quantum Many-body Physics
13. Nonlinear Dynamics
14. Environmental Physics
15. Physics of Nanomaterials

(Any one of the electives papers is to be opted in the IV Semester;
The full details of elective papers are annexed at the end of
post graduate course paper details).

M.Sc. Physics (IV Semester) : Special Paper III

CONDENSED MATTER PHYSICS

Module 1 : Electrons in Solids and Surface States

Interacting electron gas: Hartree and Hartree-Fock approximations, correlation energy. Screening, plasma oscillations. Dielectric function of an electron gas in random phase approximation. Limiting cases and Friedel oscillation, strongly-interacting Fermi system. Elementary introduction to Landau's quasi-particle theory of a Fermi liquid. Strongly correlated electron gas. Elementary ideas regarding surface states, metallic surfaces and surface reconstruction.

Module 2 : Disordered Systems

Point-defects: Shallow impurity states in semiconductors. Localized lattice vibrational states in solids. Vacancies, interstitials and colour centres in ionic crystals.

Disorder in condensed matter, substitutional, positional and topographical disorder, Short and long range order. Atomic correlation function and structural descriptions of glasses and liquids.

Anderson model for random systems and electron localization, mobility edge, qualitative application of the idea to amorphous semiconductors and hopping conduction.

Text and Reference Books

Madelung: Introduction to Solid State Theory

Callaway: Quantum Theory of Solid State

Huang: Theoretical Solid State Physics

Kittel: Quantum Theory of Solids

M.Sc. Physics (IV Semester) : Tutorial : Special Paper III

CONDENSED MATTER PHYSICS

Module 1 : Electrons in Solids and Surface States

Find a canonical transformation whereby the electron-plasmon interaction can be removed from the Hamiltonian (see equation 3/23 of Madelung's book). How do the effective electron mass and plasmon frequency change ?

Discuss the renormalization terms in (see equations 3.44 and 2.45 of Madelung's book) and show in particular that

the renormalization of the fermion mass near the Fermi surface ($k \approx k_F$) leads to a reduction in the electron velocity (mass-enhancement) and

that the renormalization of the boson frequency leads to a logarithmic divergence in the $\omega(\mathbf{q})$ spectrum at $1\text{-}2k_F$ (Kohn anomaly).

Calculate the 1s-, 2s-, and 2p-stats of a Wannier exciton in asemiconductor with anistropic effective electron mass (m ,$m_\perp$) and anistropic dielectric constant (ε , $\varepsilon_\perp$) (example : CdS).

Module 2 : Disordered Systems

Consider a one-dimensional chain of potentials with one defect. Transfer the method used in connection with Fig. 9.9 of Madelung's book to show the splitting-off of an energy level from an energy band as in Fig. 9.1 of Madelung's book. Use the LCAO (tight binding) method treated in Section 2.2.7 of Madelung's book.

How do the (2l+1)-fold degenerate energy levels of a free atom split up in a crystal field invariant to all proper rotations which transform a cube into itself ? The free atom is invariant to operations of the (infinite) rotation group. The characters of the irreducible representations of this group are : $\lambda^{(l)}(\varphi)=\text{Sin}\,(l+½)\varphi/\sin\varphi/2$. The point group of the crystal field has 24 elements in five classes and hence also five irreducible representations. Set up the character table for this group first.

Calculate the lifetimes of electrons and holes in a semiconductor with recombination centres (acceptors with levels E_R in the energy gap). Treat explicitly the limits of large and small defect concentration n_R. Discuss the recombination mechanism in both cases. Compare the two possible definitions : $\delta n(t) \sim \exp(-t/\tau)$ (decay time) and $\delta n = G\tau$ (steady state).

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (IV Semester) : Special Paper III

ELECTRONICS

Module 1

Digital Communications

Pulse-Modulation Systems : Sampling theorem-Low-Pass and Band-pass signals, PAM, Channel BW for a PAM signal. Natural sampling. Flat-top sampling. Signal recovery through Holding, Quantization of signals, Quantization, Differential PCM, Delta Modulation, Adaptive Delta modulation, CVSD.

Digital Modulation Techniques :BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK.

Mathematical Representation of Noise : Sources of noise. Frequency domain representation of nose, Effect of filtering on the probability Density of Gaussian noise, spectral component of noise, Effect of a filter on the power spectral density of noise. Superposition of noises. Mixing involving noise. Linear filtering, Noise Bandwidth, Quadrature Components of noise. Power spectral density of nc(t), ns(t) and their time derivatives

Data Transmission : Baseband signal receiver, probability of error. Optimum filter. White noise. Matched filter and probability of error. Coherent reception, Correlation, PSK, FSK, Non-coherent detection of FSK, Differential PSK, QPSK, Calculation of error probability for BPSK, BFSK and QPSK.

Module 2

Noise in pulse-code and Delta-modulation systems: PCM transmission, Calculation of Quantization noise, output-signal power. Effect of thermal noise, output signal-to-noise ratio in PCM, DM, Quantization noise in DM, output signal power, DM output - signal - to quantization - noise ratio. Effect of thermal noise in Delta modulation, output signal-to-noise ratio in DM.

Computer Communication Systems : Types of networks, Design features of a communication network, examples, TYMNET, ARPANET, ISDN, LAN.

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Mobile Radio and Satellites : Time Division multiple Access (TDMA), Frequency Division Multiple Access (FDMA), ALOHA, Slotted ALOHA, Carrier Sense Multiple access (CSMA). Poisson distribution, protocols.

Text and Reference Books

Taub and Schilling, Principles of Communication Systems, Second Edition, TMH, 1994

Simon Haykin, Communication Systems, Third Edition, John Wiley & Sons, Inc. 1994

M.Sc. Physics (IV Semester) : Tutorial : Special Paper III

ELECTRONICS

1. Digital Communications Theory Tutorials
2. Design of Digital filters using MATLAB
3. Cellular communications
4. Mobile communications via satellites
5. Bandwidth considerations in INTERNET
6. IS DN
7. Wide Area Network

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (IV Semester) : Special Paper III

ATOMIC AND MOLECULAR PHYSICS

Module 1

Spontaneous and stimulated emission-Einstein coefficients-idea of light amplification-Threshold conduction for laser oscillation-Pumping schemes-Role of resonant cairty-Three and four level systems-Ammonia MASER, ruby, HeNe, CO_2, dye and diode lasers-Laser application-Holography, material processing, Fusion reaction, laser isotope separation, Pollution monitoring, Optical Communication.

Saturation spectroscopy-Burning and detection of holes in Doppler broadened two level system-Experimental methods of saturation spectroscopy in laser-Ramsey fringes-Saturation techniques for condensed matter application

Module 2

Two photon absorption spectroscopy-Selection rules-Expression for TPA cross section photo acoustic spectroscopy-PAS in gaseous medium-Roseneweig and Greshow theory-Thermally thin, thick samples-Typical experimental setup-Application in spectroscopy-Stimulated Raman Scattering-Quantum mechanical treatment-Raman oscillation parametric instabilities-Electro magnetic theory of SRS

Text and Reference Books

Quantum electron—A. Yariv

Introduction to non linear laser spectroscopy—M.D.Levenson

Photoacoustics and its application—Roseneweig

M.Sc. Physics (IV Semester) : Tutorial : Special Paper I

ATOMIC AND MOLECULAR PHYSICS

1. Illustrate the combined use of infra red and Raman spectroscopy in deducing molecular geometry for the following systems:
2. CO_2, 2) H_20, 3) N_2O, 4) NO^-_3, 5) ClO^-_3, and 6) ClF_3
3. Correlate the Raman spectrum and molecular structure for the following systems:
4. carbon monoxide -2155cm^{-1}, b) Hydrogen cynide- two lines at 2062 cm^{-1} and 2094 cm^{-1}, c) Sulphuric acid, d) CO_2, e) N_2O and f)H_2O
5. As a project work let the student study different types of UV-VIS absorption spectrometers having different geometries. Let the student prepare details of different types of sources, filters, monochromators, gratings, and detectors used in these instruments. Again let the student fine out the difference between single beam and dual beam spectrometers.
6. Similar studies can be done on IR, FTIR and NMR spectrometers.
7. Let the student do a project work on the study of Raman spectrometers and the present Laser Raman Spectrometers'

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (IV Semester) : Special Paper III

NUCLEAR AND PARTICLE PHYSICS

Nuclear Models and Nuclear Reactor Theory

Module I : Nuclear Models

Single Particle Shell Model : Determinantal wave functions of the nucleus - single particle operator and their expectation values.

Extended Single Particle Model : Classification of shells - Seniority and reduced i - spin - Configuration mixing - Pairing force theory - Gap equation and ground state properties - Idea of quasi particles - Simple description of two - Particle shell model spectroscopy.

Collective Model of Nucleus : Deformable liquid drop and nuclear fission - Shell effects on liquid drop energy - Collective vibrations and excited states - Permanent deformation and collective rotations - Energy levels - Electromagnetic properties of even - even, odd-A deformed nuclei - Nilsson model and equilibrium deformation - Behaviour of nuclei at high spin - Back bending.

Module II: Nuclear Reactor Theory

Introduction : Fundamentals of nuclear fission - Fission fuels - Neutron chain reaction - Multiplication factor - Condition for criticality - Breeding phenomena - Different types of reactors - Fusion - Nuclear fusion in stars.

The Diffusion of Neutrons : Neutron current density - The equation of continuity - Fick's law - The diffusion equation - Boundary conditions - Measurement of diffusion parameters.

Neutron Moderation : Moderation without absorption - Energy loss in elastic collisions - Collision and slowing - Down densities - Moderation - Space dependent slowing down - Fermi's age theory - Moderation with absorption - NR and NRIM approximations - Temperature effects on resonance absorption.

Criticality : Criticality of an infinite homogeneous reactor - The one - region finite thermal reactor - The critical equation - Optimum reactor shapes - Multiregion Reactors - One group and two

group methods of calculation of criticality - Reflector savings - Critical reactor parameters and their experimental determination.

Reactor Kinetics : Infinite reactor with and without delayed neutrons - The stable period - Reactivity and its determination - The prompt jump and prompt critical condition - Changes in reactivity - Temperature coefficients - Fuel depletion effects.

Reactor Control : Control - rod worth - One control rod - Modified one group and two - group theories.

Text and Reference Books

M. A. Preston and R. K.Bhaduri, Structure of the Nucleus, Addison Wesley, 1975.

R. R. Roy and B. P. Nigam, Nuclear Physics, Wiley - Eastern Ltd., 1983.

M. K. Pal, Theory of Nuclear structure. Affiliated East West, Madras, 1982.

P. Marmier and E. Sheldon, Physics of Nuclei and Particles, Vol.II, Academic Press, New York, 1971.

H. A. Enge, Introduction to Nuclear Physics, Addison - Wesley, 1975.

J. R. Lamarsh, Introduction to Nuclear Reactor Theory, Addison Wesley , 1966.

P. F. Zweifel, Reactor Physics, Me - Graw Hill Kogakusha Ltd., Tokyo, 1973.

S. Glasstone and M C. Ediund, The Elements of Nuclear Reactor Theory, Van Nostrand Co., 1953.

A.M. Weinberg and E. P. Wigner, The Physical Theory of Neutron Chain Reactors, University of Chicago Press, 1958.

M.Sc. Physics (IV Semester) : Tutorial : Special Paper III

NUCLEAR AND PARTICLE PHYSICS

1. Shell Model Configuration and Configuration Mixing
2. Spin - Orbit Coupling
3. Nuclear Ground State and Angular Momenta
4. Magnetic Moments and the Shell Model - Schmidt Lines
5. Anisotropic Harmonic Oscillator Potential
6. Coupling of Particle and Collective Motion - Weak and Strong Couplings
7. Comparison of Nuclear Models
8. Thermal Neutron Cross Sections
9. Diffusion Equation in Plane, Spherical and Cylindrical Geometries
10. Criticality Calculations
11. Special Functions of Reactor Physics
12. The Reactor Transfer Function
13. Numerical Solution of the Multigroups Equation
14. The Collision Kernel
15. Reactor Stability Analysis

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (IV Semester) : Special Paper III

INFORMATICS (DATA COMMUNICATION)

Module 1

Multiplexing (FDM, TDM), Switching paradigms (circuit, packet and cell switching), Propagation Delay, Clock Synchronization. Network access control (centralized, decentralized, distributed). Overview of Satellite Communication, Broadcast Channel and Optical Fibre Communication Systems. Power and Energy spectra, Distortionless Transmission, Signal distortion over a Channel,

Module 2

Bandwidth and Rate of Transmission, Communication in Noisy channels, Optimum Signal Detection, Channel capacity, Hartley Shannon Law, Error Correcting Codes. Error control, Line control, Rate control, Repeaters, Concentrators, Regenerators. Link behavior, Pe, Burst error, Optimum picket size, Error control, Elementary coding ideas, ATM as a transport mechanism, An overview of Telecom Network, ISDN.

Text and Reference Books

1. Data communication by Reid and Bartskor
2. Data Networks by Gallager
3. Data Communication by William Stalling
4. Communication networks by Leon -Garcia and Widjaja
5. Introduction to communication systems by S. Haykins
6. Analog and Digital Communication by S. Haykins

M.Sc. Physics (IV Semester) : Tutorial : Special Paper III

INFORMATICS (DATA COMMUNICATION)

The tutorial will consist of problems solving from the Text and Reference books.

M.Sc. Physics (IV Semester) : Special Paper IV

CONDENSED MATTER PHYSICS

Module 1 : Imperfection in Crystals

Mechanism of plastic deformation in solids, Stress and srain fields of screw and edge dislocations. Elastic energy of dislocations. Forces between dislocations, stress needed to operate Frank-Read source, dislocations in fcc, hcp and bcc lattices. Partial dislocations and stacking faults in close-packed structures.

Experimental methods of observing dislocations and stacking faults. Electron microscopy: kinematical theory of diffraction contrast and lattice imaging.

Module 2 : Films and Surfaces

Study of surface topography by multiple-beam interferometry, Conditions for accurate determination of step height and film thicknesses (Fizeau fringes). Electrical conductivity of thin films, difference of behaviour of thin films from bulk, Boltzmann transport equation for a thin film (for diffused scattering), expression for electrical conductivity for thin film.

Elementary concepts of surface crystallography. Scanning, tunnelling and atomic force microscopy.

Text and Reference Books

1. Azaroff: X-ray Crystallography
2. Weertman & Weertman: Elementary Dislocation Theory
3. Verma & Srivastave: Crystallography for Solid State Physics
4. Kittel: Solid State Physics
5. Azaroff & Buerger: The Powder Method
6. Buerger: Crystal Structure Analysis
7. Thomas: Transmission Electron Microscopy
8. Tolansky: Multiple Beam Interferometry
9. Heavens: Thin Films
10. Chopra: Physics of Thin Films

11. Hirsh et al.: Electron Microscopy of Thin Crystals
12. Henry et al.: The Interpretation of X-ray Diffraction Photographs.

M.Sc. Physics (IV Semester) : Tutorial : Special Paper IV

CONDENSED MATTER PHYSICS

Module 1 : Imperfection in Crystals

Consider two parallel dislocations lying on the same slip plane. Their Burgers vectors lie parallel to the slip plane but are not parallel to each other. Their magnitudes are equal. Find all possible orientations of the Burgers vectors for which the component of the force between the dislocations that acts parallel to the slip plane is zero.

Prove that the stress σ_{zz} never exerts a force on a dislocation which Burgers vector lies parallel to the *x* direction regardless of the orientation of the dislocation line.

Find the stress system that will turn an edge dislocation into a helix if a supersaturation of vacancies exists.

Prove that the presence of an excess point defect concentration produces a torque on any closed dislocation loop that turns the loop to such a position that every segment of the loop is a pure edge dislocation.

Prove that a tensile or compressive stress acting parallel to a straight screw dislocation can turn the straight screw dislocation into a helix. The point defect concentration is at its equilibrium value.

Consider two parallel dislocations that do not necessarily lie on a common slip plane. Let the Burgers vector of each dislocation have a random orientation. Let the magnitudes of the Burgers vectors be equal. Obtain the general condition under which the total force exerted by one dislocation on the other is zero. Obtain the condition under which the total force is a maximum.

Show that the force between two parallel screw dislocations lying on the same slip plane and moving in the same direction with the same velocity approaches zero as the velocity approaches the transverse sound velocity.

Calculate the elastic energy contained in the stress filed of a moving screw dislocation. Show that it is equal to $\xi(1-V^2/2c^2)/\beta$, where ξ is the self-energy of a stationary screw dislocation and $\beta^2=1-V^2/2c^2$, V is the velocity of dislocation and c is the velocity of sound.

Show that the energy of a screw dislocation is infinite at the transverse sound velocity.

Consider a screw dislocation with a hollow core of radius r_0 (such dislocations actually have been observed). Calculate the self-energy of this dislocation. Include in your calculation the

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energy contributed by the surface energy γ per unit area of the surface of the core. Find the value of r_0 for γ=1000 ergs/cm^2 and γ=10 ergs/cm^2 when μ=3 x 10^{11} dynes/cm^2?

Module 2 : Films and Surfaces

Bring out the essential differences between conventional solid: bulk and films by taking the specific property of electrical conductivity.

What are thin and thick films? With reference to electronic conduction which films can be referred to as thin and which as thick taking into account the mean free path as a reference parameter.

Bring out the essential differences between diffuse and specular electron scattering from the film's surface.

Work out the approximations for the conductivity of a metallic film for $p=0$ and large and small values of k, where p is the fraction of electron specularly reflected and k is ratio of thickness of film and mean free path.

The temperature coefficient of resistance (TCR) of a thin metal film is positive ! If you measure the TCR of a metal film and find it to be positive, does it necessarily follow that the film is continuous ? In your answer utilize the fact that the resistivity between conducting islands has an activation energy associated with it.

What would you expect the Wiedemann-Franz ratio, $K/\sigma T$, to be equal to for a thin metal wire 100 angstroms in diameter ? That is, compared to the bulk value. Give reasoning ! (K=thermal conductivity, σ=electrical conductivity, and T=temperature).

Show that the change in thermoelectric power ΔS from that of the bulk value S_0 caused by thin-film size effects can be written as

Experimentally, what is the importance of this form for ΔS? (α_0 and α are temperature coefficient of resistance for bulk and thin film, k_0 is Boltzmann constant and other symbols have their usual meaning).

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (IV Semester) : Special Paper IV

ELECTRONICS

Module 1

Microprocessors & Micro Computers

Microprocessors and Architecture : Internal Microprocessor Architecture, Real mode and protected modes of memory addressing, memory paging.

Addressing modes : Data addressing modes. Program memory addressing modes, Stack-memory addressing modes.

Instruction Set : Data movement instructions, Arithmetic and Logic instructions, Program control instructions. Assembler details.

Programming the Microprocessor : Modular programming, using the keyboard and video display, Data conversions. Disk files. Example programs.

Hardware Specifications : Pin-outs and the Pin functions, clock-generator (8284A), Bus buffering and Latching, Bus timing. Ready and wait state. Minimum mode versus maximum mode.

Module 2

Memory Interface : Memory devices, Address decoding, 8088 and 80188 (8-bit) memory interface, 8086, 80186, 80286 and 80386 (16-bit) memory interface, 80386DX and 80486 (32-bit) memory Interface, Dynamic RAM.

Basic I/O Interface : Introduction to I/O interface, I/O port address decoding, 8255, 8279, 8254, 16550, ADC and DAC (excluding multiplexed display & keyboard display using 8255)

Interrupts : Basic interrupt processing, Hardware interrupts. Expanding the interrupt structure, 8259A PIC.

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Direct Memory Access : Basic DMA operation, 8237 DMA controller, Shared Bus operation, Disk memory systems, Video displays.

Text and Reference Books

Barry B. Brey, "The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium pro processor architecture, programming, and interfacing" Fourth Edition, PHI, 1999.

Douglas V. Hall, "Microprocessors and Interfacing, Programming and Hardware", second edition, McGraw Hill International Edition, 1992.

Muhammad Ali Maxidi and Janice Gillispie Mazidi, "The 80x86 IBM PC and Compatible Computers (Volumes I & II), second edition, Prentice-Hall International, 1998.

M.Sc. Physics (IV Semester) : Tutorial : Special Paper IV

ELECTRONICS

Bus Interface : The ISA Bus, EISA and VESA local Buses, PCI Bus.

Advanced Microprocessors : 80186, 80188 and 80286 Microprocessors : 80186/80188 Architecture, Introduction to 80286

80386 and 80486 Microprocessors : 80386 Microprocessor, Special 80386 registers, 80386 memory management. Protective mode. Virtual mode, memory paging mechanism, 80486 Microprocessor.

Pentium and Pentium Pro Microprocessor : Introduction to Pentium microprocessor, special Pentium registers. Introduction to Pentium pro processors.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (IV Semester) : Special Paper IV

ATOMIC AND MOLECULAR PHYSICS

Module 1

Vibronic interaction, Herzberg Teller theory, Fluorescence spectroscopy, Kasha's rule, Quantum yield, Non-radiative transition, Jablonski diagram, Time resolved fluorescence and determination of excited state lifetime.

Light detectors, Single photon counting technique, Phase sensitive detectors

Module 2

Laser optogalvanic spectroscopy, Matrix isolation spectroscopy, Fourier transform spectroscopy, Laser cooling.

Molecular symmetry and group theory, Matrix representation of symmetry elements of a point group, reducible and irreducible representations, character tables specially for C_{2v} and C_{3v} point groups, Normal coordinates and normal modes, Application of group theory to molecular vibrations.

Text Book and References

J M Hollas, High Resolution Spectroscopy

Cotton, chemical Application of group theory

Herzberg, Molecular spectra and Molecular structure II & III.

Demtroder, Laser spectroscopy and Instrumentation

King, Molecular Spectroscopy

Lakowicz, Principles of Fluorescence Spectroscopy.

M.Sc. Physics (IV Semester) : Tutorial : Special Paper IV

ATOMIC AND MOLECULAR PHYSICS

The (0,0) band in the 260nm band system of benzene does not appear in the spectrum. However (1,0) band appears quite intense. Give the reason.

What is difference between fluorescence and phosphorescence. What do you mean by lifetime of a state ? What is intersystem crossing ?

Draw the normal modes of a bent MX_2 molecule corresponding to symmetric and antisymmetric MX bond stretchings. Explain why one is called symmetric and other antisymmetric stretching.

Determine the point group of the following molecules giving reasons.

a molecule MX_4 in which the atom M lies at the apex and atoms X on the square base of a pyramid.

Benzene in which one H atom is replaced by chlorine atom.

Benzene in which alternate H atom is replaced by D.

CH_3Cl and CH_2DCl.

How can one obtain the number of molecular vibration of a given symmetry type in a molecule ? Illustrate your answer for a molecule with C_{2v} point group.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (IV Semester) : Special Paper IV

NUCLEAR AND PARTICLE PHYSICS

Strong, Weak and Electromagnetic Interactions and QCD and Quark-Gluon Plasma

Module I : Strong, Weak and Electromagnetic interactions

Strong interactions and symmetries : Uses of symmetry - Space time and internal symmetries - Lie groups generators and Lie algebra - Casimir operators - SU(2) irreducible representation - Weight diagram -Diagonal generators - SU(3) generators - U and V spin - Raising and lowering operators -Root diagram - Weight diagram - Multiplets of SU(n) - Baryons and meson multiplets -Symmetry breaking - Gell-Mann-Okubo mass formula - Charm,bottom and top quarks and higher symmetry - Bag model for hadrons.

Weak and Electromagnetic interactions : Invariance of Dirac equation - Bilinear covariants - Properties of gamma matrices -Leptonic,semileptonic and nonleptonic weak decays - Selection rule for leptons - Current-current interaction and V-A theory -Universality - Abelian and non-Abelian gauge invariance - Spontaneous symmetry breaking and Higgs mechanism - Standard model for electro weak unification.

Module II : QCD and Quark - Gluon Plasma

Perturbative QCD I : Colour gauge invariance and QCD Lagrangian - Deep inelastic scattering: The GLAP equations - an alternative approach to the GLAP equations - Common parametrizations of the distribution functions - Structure Functions The spin - dependent structure functions and the MIT bag model.

Perturbative QCD II : The Drell - Yan process - Small-x physics and the Gribov - Levin - Ryskin equation.

Nonperturbative QCD : QCD sum rules - The ground state of QCD - Equation of state of a quark - gluon plasma - Hadronizatiori phase transition.

Text and Reference Books

F. Halzen and A. D. Martin, Quarks and Leptons, John - Wiley & Sons, New York, 1984.

G. Kane, Modern Elementary Particle Physics, Addison - Wesley, 1987.

D.B. Lichtenberg, Unitary Symmetry and Elementary Particles, 2nd Edition, Academic Press, 1978.

R. K. Bhaduri, Models ofNucleon, Addison - Wesley, Reading, MA, 1988.

J. McL. Emmerson, Symmetry Principles in Particle Physics, Clarendon Press, Oxford, 1972.

M. Leon, An introduction to Particle physics. Academic Press, New York, 1973.

I.J. R. Aitchison and A. J. G. Hey, Gauge Theories of Particle Physics, Adam Hilger, Bristol, 1989.

D. H. Perkins, Introduction to High Energy Physics, Addison - Wesley, London, 1982.

W. Greiner and A. Schafer, Quantum Chromodynamics, Springer, Berlin, 1993

D. H. Perkins, Introduction to High Energy Physics, Addison - Wesley, London, IV Edition, 2000.

F. J. Yndurain, Quantum Chromodynamics - An Introduction to the Theory of Quarks and Gluons, Springer - Verlag, New York, 1983.

M.Sc. Physics (IV Semester) : Tutorial : Special Paper IV

NUCLEAR AND PARTICLE PHYSICS

1. The Hadron Spectrum
2. Algebra of Gamma Matrices
3. The Nucleonic Scattering Tensor with Weak Interaction
4. Higgs' Bosons and Spontaneous Symmetry Breaking
5. Gauge Invariance and Gauge Bosons
6. Lepton and Hadron Currents
7. Algebra of Gamma Matrices
8. Feynmen Rules for QCD
9. Kinematics, Cross Sections and Decay Rates
10. The Renormalised Coupling Constant of QCD
11. Asymptotic Freedom

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (IV Semester) : Special Paper IV

INFORMATICS (INTERNETWORKING TECHNOLOGY)

Module 1

Network types and architecture (broadcast, multicast, LAN, MAN, WAN, topology, token ring, FDDI, Cabling). Protocols, interfaces and services, X.25, ISDN, ATM, VPN, frame relay, wireless transmission, bridges. TCP/IP and ISOOSI Models. Routing, congestion and flow control, tunnelling, internetwork routing. Datalink protocols, Multiple access protocols, TCP, UDP, Transport layer error recovery, Application layer services and protocols. IP addressing, Network security.

Evolution of Internet, Internet architecture; goals and key issues related to Internetworking technologies; Internet connectivity (dial-up, dedicated lines, broadband, DSL, radio, VSAT, etc); Domain Name Scheme, Technology and tools relevant for web access (FTP, email, search tools, etc.). Internet security.

Module 2

Multimedia, techniques of data compression, voice, video, Mbone, and interactive video-on-demand over the Internet. Mobile computing.

Fundamentals of Network Management (NM), Need for NM, Elements of NM system (Manager, Agent and a protocol, SNMP), Functional areas of NM defined by ISO Fault Management, Configuration Management, Performance Management, Security Management, Accounting Management, NM standards, TMN, Web based NM (Introduction), case studies: HP Open-View, IBM Net-view, SUN Solaris Enterprise Manager.

Text and Reference Books

Bohdan O Szuprowicz : Multimedia Networking, McGraw-Hill, Singapore, 1995 (ISE)

Marilee Ford et al: Internetworking Technologies Handbook, Cisco Press, 1997.

Grady N, Drew: Using SET for Secure Electronic Commerce, PTRPrentice-Hall, 1998.

N. Buchanan: Advanced Data Communications and Networking, Chapman & Hall, London, 1997.

Dave Koiur: IP Multicasting: The Complete Guide to Interactive Corporate Networks, John Wiley & Sons, New York, 1998.

Computer Networks by William Stalling, PHI.

Computer Networks by S. Keshav, Addison Wesley.

M.Sc. Physics (IV Semester) : Tutorial : Special Paper IV

INFORMATICS (INTERNETWORKING TECHNOLOGY)

The tutorial will consist of problems solving from the Text and Reference books.

M.Sc. Physics (IV Semester) : Projects

PROJECTS

This course will be based on preliminary research oriented topics both in theory and experiment. The teachers who will act as supervisors for the projects will float projects and any one of them will be allocated to the student. At the completion of the project by the semester end, the student will submit Project Report in the form of Dissertation which will be examined by the examiners. The examination shall consist of (a) Presentation and (b) Comprehensive viva-voce.

Elective Papers

M.Sc. Physics (IV Semester) : Elective Paper

QUANTUM ELECTRODYNAMICS

Dirac equation, properties of Dirac matrices. Projection operators, Traces. Feynman's theory of positron.

Second quantization of Klein.Gordon Field, Creation and Annihilation operators, Commutation relations. Quantisation of electomagnetic field, creation and Annihilation operators, Commutation relations. Fock space representation, interacting fields, Dirac (interaction) picture, S-Matrix and its expansion. Ordering theorems, Feynman graph and Feynman rules. Application to some problems like Rutherford scattering and compton scattering, calculation of cross-sections using Feynman graphs.

Text and Reference Books

Bjorken & Drell: Relativistic Quantum Fields

Muirhead: The Physics of Elementary Particles

Schweber, Bethe and Hoffmann: Mesons and Fields

Sakurai: Advanced Quantum Mechanics

Mandal: Introduction to Field Theory

Lee: Particle Physics and Introduction to Field Theory

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

PHYSICS OF LIQUID CRYSTALS

Classification of Liquid Crystals

Symmetry, structure and classification of liquid Crystals, Polymorphism in thermotropics, Reentrant phenomena in liquid crystals, Blue phases, Polymer liquid crystals, Distribution functions and order parameters, macroscopic and microscopic order parameters. Measurement of order parameters, magnetic resonance, electron spin resonance, Raman Scattering and X-ray diffraction.

Theories of Liquid Crystalline Phase Transitions

Nature of phase transitions and critical phenomena in liquid crystals, hard particle, Maier-Saupe and Van der Waals theories for nematic - isotropic and nematic-smectic A transitions; Landau theory: Essential ingradients, application to nematic-isotropic, nematic-smectic A transitions *and* transitions involving smectic phases.

Continuum theory

Curvature elasticity in nematic and smectic A phases, distortions due to magnetic and electric Fields, magnetic Coherence length, Freedericksz transition, field-induced cholesteric-nematic transition.

Dynamical Properties of Nematics

The equations of nematodynamics, Laminar flow, molecular motions.

Optical properties of Cholesterics

Optical properties of an ideal helix, agents influencing the pitch, liquid crystal displays.

Ferroelectric Liquid Crystals

The properties of smectic C ,continuum description, smectic C -smectic A transition, applications.

Discotic Liquid Crystals

Symmetry and structure, mean-field description of discotic liquid crystals, continuum description Lyotropic liquid crystals and biological membrane. Applications of liquid crystals.

Text and Reference Books

Chandrasekhar: Liquid Crystals

Vertogen & de Jeu: Thermotropic Liquid Crystals:Fundamentals

de Gennes & Prost: The Physics of Liquid Crystals

Introduction to liquid crystals:Physics and Chemistry (1997, Taylor and Francis)

Elston & Sambles: The Optics of Thermotropic Liquid Crystal

Collyer: Liquid Crystal Polymers: From Structures to Applications

Goodby et al.: Ferroelectric Liquid Crystals :Principles, Properties & Applications

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

SCIENCE AND TECHNOLOGY OF SOLAR HYDROGEN AND OTHER RENEWABLE ENERGIES

Solar Energy

Fundamentals of photoveltaic Energy Conversion Physics and Material Properties Basic to Photovotaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Types of Solar Cells, p n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief descriptions of single crystal silicon and amorphous silicon solar cells, elementary ideas of advanced solar cells e.g. Tandem Solar Cells. Soid Liquid Junction Solar Cells, Nature of Semiconductor, Electrolyte Junction, Principles of Photoelectrochemical solar cells.

Hydrogen Energy

Relevance in relation to depletion of fossil fuels and enviormental considerations.

Hydrogen Production

Solar Hydrogen through Photoelectrolysis and Photocatalytic process. Physics of material characteristics for production of Solar Hydrogen.

Storage of Hydrogen

Brief discussion of various storage processes, special features of solid state hydrogen storage materials, structural and electronic characteristics of storage materials. New Storage Modes.

Safety and Utilisation of Hydrogen

Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Elementary concepts of other Hydrogen Based devices such as Air Conditioners and Hydride Batteries.

Other Renewable Clean Energies

Elements of Solar Thermal Energy, Wind Energy and Ocean Thermal Energy Conversion.

Text and Reference Books

Fonash: Solar Cell Devices - Physics

Fahrenbruch & Bube: Fundamentals of Solar Cells Photovoltaic Solar Energy

Chandra: Photoeloectrochemical Solar Cells

Winter & Nitch (Eds.): Hydrogen as an Energy Carrier Technologies Systems Economy

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

REACTOR PHYSICS

Interaction of Neutrons with Matter in Bulk

Transport and diffusion equations, transport mean free path, solution of diffusion equation for a point source in an infinite medium and for an infinite plane source in a finite medium, extrapolation length and diffusion length - the albedo concept.

Moderation of Neutron

Mechanics of elastic scattering, average logarithmic energy decrement, slowing down power and moderating ratio of a medium. Fermi's age theory, solution of age equation for a point source of fast neutrons in an infinite medium, slowing down length, Fermi age.

Theory of Homogeneous Bare Thermal Reactor

Critical equation, material and geometric bucklings, Neutron balance in a thermal reactor, four factor formula, typical calculations of critical size and composition in simple cases.

Heterogeneous Natural Uranium Reactors

Advantages and disadvantages of heterogeneous assemblies, various types of reactors and a brief discussion of their design features.

Problems of Reactor Control and Maintenance

Role of delayed neutrons, Inhour formula, temperature effects, fission product poisoning, use of coolants and control rods

Power Reactors

Fast breeder reactors, dual purpose reactors, concept of fusion reactors

Text and Reference Books

1. Glasstone & Edlund: The Elements of Nuclear Reactor Theory
2. Murray: Introductions of Nuclear Engineering

The problems given in the Text and Reference books will form tutorial course.

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M.Sc. Physics (IV Semester) : Elective Paper

NUMERICAL METHODS AND PROGRAMMING

Numerical Methods

Methods for determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions.

Solution of simultaneous linear equations, Gaussian elimination, pivoting, iterative Method, matrix inversion.

Eigenvalues and eigenvectors of matrices, Power and Jacobi Method.

Finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, Polynomial least squares and cubic Spline fitting.

Numerical differentiation and integration, Newton-Cotes formulae, error estimates, Gauss method.

Random variate, Monte Carlo evaluation of Integrals, Methods of importance sampling, Random walk and Metropolis method.

Numerical solution of ordinary differential equations, Euler and Runge Kutta methods, Predictor and corrector methods. Elementary ideas of solutions of partial differential equations.

Fortran Programming

Digital Computer Principles, Compilers, Interpreters, Operating Systems,.Fortran programming, Flow Charts, Integer and Floating Point Arithmetic, Expressions, built-in functions, executable and non-executable statements, assignment, control and input-output elements, Subroutines and functions, Operation with files.

Text and References Books

Sastry: Introductory Methods of Numerical Analysis

Rajaraman: Numerical Analysis

Rajaraman: Fortran Programming

Vetterming, Teukolsky, Press and Flannery: Numerical Recipes

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

PHYSICS OF LASERS AND LASER APPLICATIONS

Laser Characteristics

Gaussian beam and its properties. Stable Two-Minor Optical Resonators, Longitudinal and Transverse Modes of Laser Cavity. Mode Selection, Gain in a Regenerative Laser Cavity. Threshold for 3 and 4 level Laser Systems. Mode Locking Pulse Shortening - Picosecond & femtosecond operation, Spectral Narrowing and Stabilisation.

Laser Systems

Ruby Laser, Nd-YAG Laser, Semi Conductor Lasers, Diode-Pumped Solid State Lasers, Nitrogen Laser, Carbon-dioxide Laser, Excimer Laser, Dye Laser, High Power Laser Systems.

Laser Spectroscopic Techniques and Other Applications

Laser Fluorescence and Raman Scattering and their use in pollution studies, Non-Linear interaction of Light with matter, Laser induced multiphoton processess and their applications, Ultrahigh resolution Spectroscopy with lasers and its applications, Propagation of light in a medium with variable refractive index. Optical Fibers. Light wave communication. Qualitative treatment of Medical and Engineering applications of Lasers.

Text and Reference Book

Svelto: Lasers

Yariv: Optical Electronics

Demtroder: Laser Spectroscopy

Letekhov: Non-Linear Laser Spectroscopy

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

STRUCTURES, SPECTRA AND PROPERTIES OF BIOMOLECULES

Structural Aspects of Biomolecules

Conformational Principles, Conformation and Configuration Isomers and Derivatives. Structure of Polynucleotides, Structure of Polypeptides, Primary, Secondary, Tertiary and Quaternary Structures of Proteins, Structure of Polysaccharides.

Theoretical Techniques and Their Application to Biomolecules

Hard Sphere Approximation, Ramachandran Plot, Potential Energy Surfaces, Outline of Molecular Mechanics Method, Brief Ideas about Semi-empirical and Ab Initio Quantum Theoretical Methods, Molecular Charge Distribution, Molecular Electrostatic Potential and Field and their Uses.

Spectroscopic Techniques and Their Application to Biomolecules

Use of NMR in Elucidation of Molecular Structure, Absorption and Fluorescence Spectroscopy, Circular Dichroism, Laser Raman Spectroscopy, IR Spectroscopy, Photoacoustic Spectroscopy, Photo- biological Aspects of Nucleic Acids.

Structure-Function Relationship and Modeling

Molecular Recognition, Hydrogen Bonding, Lipophilic Pockets on Receptors, Drugs and Their Principles of Action, Lock and Key Model and Induced fit Model.

Text and Reference Books

Srinivasan & Pattabhi: Structural Aspects of Biomolecules

Govil & Hosur: Conformations of Biological Molecules

Price: Basic Molecular Biology

Pullman: Quantum Mechanics of Molecular Conformations

Lehninger: Biochemistry

Mehler & Cordes: Biological Chemistry

Smith and Hanawalt: Molecular Photobiology, Inactivation & Recovery

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

DIAGRAM TECHNIQUES

Formalism of Second Quantization

Quantum mechanical many body problem, boson and fermion systems, Creation and Annihilation operators, Commutation Relations, Vacuum state. The Hamiltonian in terms of creation and annihilation operators and its matrix elements for the simple cases of one- and two-particle systems.

Time Dependent Operators

Schrodinger, Heisenberg and Interaction picture Time development operator (TDO), its properties and equation of motion, The integral equation for TDO and formal solution by iterative method, Dyson chronological operator, S-matrix expansion, Universality of S-matrix Transition matrix, The adiabatic hypothesis and correspondence with usual perturbation theory.

Introduction to Graphs

Creation and destruction operator in the interaction picture, Particle and hole operators. Reduction of chronological products. Normal product. Contraction of operators and Wick's theorem. Graphical representation of the expansion. First order graphs, Higher order graphs. The interaction term and ground state energy. Ealuation of the contributions of various graphs to the perturbation series, Linked and unlinked diagrams.

Introduction to Green's Function

Differential equations and their Green's functions. Examples of time independent Schrodinger equation. Resolvent operators. The single particle Green's function. Physical interpretation. Fourier transform of the Green's functions. Lehmann Representation and Kramer-Kronig relationship. Analytic properties and physical meaning of the poles, Relation between Green's function and the properties of the ground state. Its relation with elementary excitations. Concept of quasi particles.

Text and Reference Books

Raimes: Many Electron Theory

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Mandl: Introduction to Quantum Field Theory

Abrikosov: Quantum Field Theoretical Methods in Statistical Physics

Fretter & Walecha: Quantum Theory of Many-particle Systems

March, Young & Sampantha: The Many Body Problems in Quantum Mechanics

Mattuch: Feynman Daigram Techniques

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

PHYSICS OF ELECTRONIC DEVICES & FABRICATION OF INTEGRATED CIRCUITS AND SYSTEMS

Semiconductor Materials

Energy Bands, Intrinsic carrier concentration. Donors and Acceptors, Direct and Indirect band semiconductors. Degenerate and compensated semiconductors. Elemental (Si) and compound semiconductors (GaAs). Replacement of group III element and Group V elements to get tertiary alloys such as $Al_xGa_{(1-x)}As$ or $GaP_yAs_{(1-y)}$ and quaternary $In_xGa_{(1-x)}P_yAs_{(1-y)}$ alloys and their important properties such as band gap and refractive index changes with x and y. Doping of Si (Group III (n) and Group V (p) compounds) and GaAs (group II (p), IV (n.p) and VI (n compounds). Diffusion of Impurities- Thermal Diffusion, Constant Surface Concentration, Constant Total Dopant Diffusion, Ion Implantation.

Carrier Transport in Semiconductors:

Carrier Drift under low and high fields in (Si and GaAs), saturation of drift velocity. High field effects in two valley semiconductors. Carrier Diffusion, Carrier Injection, Generation Recombination Processes- Direct, Indirect bandgap semiconductors. Minority Carrier Life Time, Drift and Diffusion of Minority Carriers (Haynes-Shockley Experiment) Determination of: Conductivity (a) four probe and (b) Van der Paw techniques. Hall Coefficient, Minority Carrier Life Time. Junction Devices: (i) p-n junction- Energy Band diagrams for homo and hetro junctions. Current flow mechanism in p-n junction, effect of indirect and surface recombination currents on the forward biased diffusion current, p-n junction diodes- rectifiers (high frequency limit), (ii) Metal-semiconductor (Schottky Junction): Energy band diagram, current flow mechanisms in forward and reverse bias, effect of interface states. Applications of Schottky diodes, (iii) Metal-Oxide-Semiconductor (MOS) diodes. Energy band diagram, depletion and inversion layer. High and low frequency Capacitance Voltage (C-V) characteristics. Smearing of C-V curve, flat band shift. Applications of MOS diode.

Transistors

JFET, BJT, MOSFET and MESFET: Structure, Working, Derivations of the equations for I-V characteristics under different conditions. High Frequency limits.

Microwave Devices

Tunnel diode, transfer electron devices (Gunn diode). Avalanche Transit time devices (Read, Impatt diodes, and parametric devices)

Photonic Devices

Radiative and non-radiative transitions. Optical Absorption. Bulk and Thin film Photo-conuctive devices (LDR), diode photodetectors, solar cell-(open circuit voltage and short circuit current, fill factor). LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), diode lasers (conditions for population inversion, in active region, light confinement factor. Optical gain and threshold current for lasing, Fabry-Perrot Cavity Length for lasing and the separation between modes).

OVER VIEW AND BASIC PRINCIPLE OF THE FOLLOWING

Memory Devices

Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non-volatile- NMOS, magnetic, optical and ferroelectric memories, charge coupled devices (CCD).

Other Electronic Devices

Electro-Optic, Magneto-Optic and Acousto-Optic Effects. Material Properties related to get these effects. Important Ferroelectric, Liquid Crystal and Polymeric materials for these devices. Piezoelectric, Electrostrictive and magneto strictive Effects, Important materials exhibiting these properties, and their applications in sensors and actuator devices. Acoustic Delay lines, piezoelectric resonators and filters. High frequency piezoelectric devices-Surface Acoustic Wave Devices. Pyroelectric effect. Inorganic oxide and Polymer pyroelectric materials and their applications.

Fabrication of Integrated Devices

Thin film Deposition Techniques: Vacuum Pumps and gauges - pumping speed, throughout. Effective conductance control. Chemical Vapor Deposition (CVD), MOCVD, PEMOCVD (Plasma enhanced chemical vapour deposition). Physical Vapor Deposition: Thermal Evaporation, Molecular Beam Epitaxy (MBE), Sputtering and Laser Ablation.
Lithography, Etching and Micro-machining of Silicon, Fabrication of Integrated Circuits and Integrated Micro-Electro-Mechanical-Systems (MEMS)

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Text and Reference Books

The Physics of Semiconductor Devices by D.A, Eraser, Oxford Physics Series (1986)

Semiconductor Devices- Physics and Technology, by SM Sze Wiley (1985).

Introduction to semiconductor devices, M. S. Tyagi, John Wiley & Sons

Measurement, Instrumentation and Experimental Design in Physics and Engineering by M.Sayer and A. Mansingh, Prentice Hall, India (2000).

Thin film phenomena by K.L.Chopra

The material science of thin films, Milton S. Ohring

Optical electronics by Ajoy ghatak and K. Thyagarajan. Cambridge Univ. Press

Material Science for Engineers, by James F. Shackelford, Prentice Hall

Deposition techniques for films and coatings, R.F Bunshah (Noyes publications)

Solid state electronics, Ben G. Streetman

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

ATMOSPHERIC SCIENCE

1. Physical Meteorology

Atmospheric composition, laws of thermodynamics of the atmosphere. Adiabatic process, potential temperature. The clausis clapyeron equation, laws of black body radiation, solar and terrestrial radiation, Albedo, Green house effect, Heat balance of earth-atmosphere system.

2. Dynamic Meteorology

Fundamental forces, non-inertial reference frames and apparent forces, structure of static atmosphere.

Momentum, continuity and energy equations, Thermodynamics of the dry atmosphere, elementary applications of the basic equations.

The circulation theorem, voracity, potential vorticity, vorticity and potential vorticity equations.

3. Monsoon Dynamics

Wind, temperature and pressure distribution over India in the lower, middle and upper atmosphere during pre, post and mid-monsoon season. Monsoon circulation in the meridonal (Y-Z) and zonal (X-Y) planes, energy cycle of monsoon. Dynamics of monsoon depressions and easterly waves. Intra seasonal and interannual variability of monsoon. Quasi-be weekly and 30-60 day oscillations. ENSO and dynamical mechanism for their existence.

4. Numerical Methods for atmospheric Models

Filtering of sound and gravity waves, filtered forecast equations, basic concepts of quasi-geostrophic and primitive equation models, one level and multi-level models. Basic concepts of initialization and objective analysis for wave equation, advection equation and diffusion equation.

5. Atmospheric Pollution

Role of meteorology on atmospheric pollution, Atmospheric boundary layer, air stability, local wind structure, Ekman spiral, turbulence boundary layer scaling.

Residence time and reaction rates of pollutants, sulphur compounds, nitrogen compounds, carbon compounds, organic compounds, aerosols, toxic gases and radio active particles trace gases.

6. Atmospheric Instrumentation Systems

Ground based instruments for the measurement of Temperature, Pressure, Humidity, Wind and Rainfall Rate.

Air borne instruments-Radisonde, Rawinsonde, Rockestsonde-satellite instrumentation (space borne instruments)

7. Radar Meteorology

Basic meteorology-radar principles and technology-radar signal processing and display-weather radar-observation of precipitating systems-estimation of precipitation-radar observation of tropical cyclones, use of weather radar in aviation, clear air radars-observation of clear air phenomena-other radar systems and applications.

Text and Reference Books

The Atmosphere by Frederick K.Lutgens and Edward J.Tarbuk (for chapter I and VI)

Dynamic Meteorology by Holton, J.R.,3rd edition, Academic Press N.Yf. (1992). The Physics of Monsoons, By R.N.Keshvamurthy and M.Shankar Rao, Allied Publishers, 1992 (for chapter 3)

Numerical Weather Prediction, by G.J. Haltiner and R.T.Villians, John Wiley and sons, 1980 (for chapter 4)

Principles of Air pollution meteorology by Tom Lyons and Prillscott, CBS publishers & Distributors (P) Ltd.

Radar Meterology by Henry Saugageot

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

PLASMA PHYSICS

Introduction to the Plasma State, elementary concepts and definitions of temperature and other plasma parameters, occurrence and importance of plasma for various applications.

Production of Plasma in the laboratory. Physics of glow discharge, electron emission, ionization, breakdown of gases, Paschen's laws and different regimes of E/p in a discharge, Townsend discharge and the evolution of a discharge.

Plasma diagnostics: Probes, energy analyzers, magnetic probes and optical diagnostics, preliminary concepts.

Single particle orbit theory: Drifts of charged particles under the effect of different combinations of electric and magnetic fields. Crossed electric and magnetic fields. Homogenous electric and magnetic fields, spatially varying electric and magnetic fields, time varying electric and magnetic fields, particle motion in large amplitude waves.

Fluid description of plasmas: distribution functions and Liouville's equation, macroscopic parameters of plasma, two and one fluid equations for plasma, MHD approximations commonly used in one fluid equations and simplified one fluid and MHD equations.

Waves in fluid plasmas: dielectric constant of field free plasma, plasma oscillations, space charge waves of warm plasma, dielectric constant of a cold magnetized plasma, ion-acoustic waves, Alfven waves, Magnetosonic waves.

Stability of fluid plasma.: The equilibrium of plasma, plasma instabilities, stability analysis, two stream instability, instability of alfven waves, Plasma supported against gravity by magnetic field, energy principle.

Kinetic description of plasma: microscopic equations for may body systems: Statistical equations for a many body system, Vlasov equation and its properties, drift kinetic equation and its properties.

Waves in Vlasov Plasma: Vlasov equation and its Linearlization, solutions of linearised Vlasov equation, theories of Langumuir waves, Landau damping, Ion Acoustic waves, Drift waves in magnetized plasmas.

Non-linear plasma theories: Non linear electrostatic waves, solitons, shocks, non linear Landau Damping.

Thermonuclear fusion: Status, problems and technological requirements.

Applications of cold low pressure and thermal plasmas

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Text and Reference Books

Introduction to Plasma Physics, FF Chen.

Principles of Plasma Physics, Krall and Trievelpiece

Introduction to Plasma Theory, DR Nicholson

The Plasma State, JL Shohet

Introduction to Plasma Physics, M Uman

Principles of Plasma Diagnostic, IH Hutchinson

Plasma Diagnostic Techniques, RH Huddelstone and SL Leonard

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

QUANTUM MANY BODY PHYSICS

Formation of Second Quantization

Wavefunctions for identical particles, Symmetrized basis for Fermions and Bosons, one particle & two-particle operators and their matrix elements in symmetrized basis. Number space representations of the basis, creation and annihilation operators, commutation relations, Representation of operators in terms of creation and annihilation operators. Equation of motion for operators in number space.

Simple Applications

Electron gas: Hartree Fock approximation, ground state energy and single particle energy in Paramagnetic and Ferromagnetic states. Role of exchange term, Ground State of Interacting Bosons, Bose-einstein Condensate, Spectrum of elementary excitations, Superfuidity.

Green's Functions and Linear Response Theory

One particle and Two particle Green's functions, Ground State energy and Linear response in terms of Green's functions, Analytic properties of Green's functions. Equations of Motion for Green's function.

Perturbation Theory

Interaction representation, Gall-Mann-Low Theorem for Ground State Energy, Perturbation Expansion for Green's functions, Wick's Theorem, diagrammatic representation, Dyson's equation, self energy, Polarization.

Application to Interacting Fermi Gas

Dilute Fermi gas, Landau Theory, Screening of Coulomb interaction, random Phase approximation for electron gas.

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M.Sc. Physics (IV Semester) : Elective Paper

NONLINEAR DYNAMICS

Introduction to Dynamical Systems

Physics of nonlinear systems, dynamical equations and constants of motion, phase space, fixed points, stability analysis, bifurcations and their classifications, Poincare section and iterative maps.

Dissipative Systems

One-dimensional noninvertible maps, simple and strange attractors, iterative maps, period doubling and universality, intermittency, invariant measure, Lyapunov exponents, higher-dimensional systems, Henon map, Lorenz equation. Fractal geometry, generalized dimensions, examples of fractals.

Hamiltonian Systems

Integrability, Liouville's theorem, action-angle variables, introduction to perturbation techniques, KAM theorem, area preserving maps, concepts of chaos and stochasticity.

Advanced Topics

One selection from quantum chaos, cellular automata and coupled map lattices, solitons and completely integrable systems, turbulence.

Text and Reference Books

Percival and D. Richards: Introduction to Dynamics

E.A. Jackson: Nonlinear Dynamics I & II

R.L. Devaney: Introduction to Dynamical Systems

Hao Bai-lin: Chaos

A.J. Lichtenberg and M.A. Lieberman: Regular and Stochastic Motion

M.C.Gutzwiller: Chaos in Classical and Quantum Mechanics

E. Ott

M.Tabor

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

ENVIRONMENTAL PHYSICS

1. Essentials of Environmental Physics

Structure and thermodynamics of the atmosphere. Composition of air. Greenhouse effect. Transport of matter, energy and momentum in nature. Stratification and stability of atmosphere. Laws of motion, hydrostatic equilibrium. General circulation of the tropics. Elements of weather and climate of India.

2. Solar and Terrestrial Radiation

Physics of radiation. Interaction of light with matter. Rayleigh and Mie scattering. Laws of radiation (Kirchoffs law, Planck's law, Beer's law, Wien's displacement law, etc.). Solar and terrestrial spectra. UV radiation. Ozone depletion problem. IR absorption energy balance of the earth atmosphere system.

3. Environmental Pollution and Degradation

Elementry fluid dynamics. Diffusion. Turbulence and turbulent diffusion. Factors governing air, water and noise pollution. Air and water quality standards. Waste disposal. Heat island effect. Land and see breeze. Puffs and plumes. Gaseous and particulate matters. Wet and dry deposition

4. Environmental Changes and Remote Sensing

Energy sources and combustion processes. Renewable sources of energy. Solar energy, wind energy, bioenergy, hydropower, fuel cells, nuclear energy. Forestry and bioenergy.

5. Global and Regional Climate

Elements of weather and climate. Stability and vertical motion of air. Horizontal motion of air and water. Pressure gradient forces. Viscous forces. Inertia forces. Reynolds number. Enhanced Greenhouse Effect. Energy balance- a zero-dimensional Greenhouse model. Global climate models.

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Text and Reference Books

Egbert Boeker & Rienk Van Groundelle: Environmental Physics (John Wiley).

J.T.Hougtion: The Physics of Atmosphere (Cambridge University Press, 1977).

J.Twidell and J.Weir: Renewable Energy Resources (Elbs, 1988).

Sol Wieder: An Introduction to Solar Energy for Scientists and Engineers (John Wiley, 1982).

R.N. Keshavamurthy and M. Shanker Rao: The Physics of Monsoons (Allied Publishers, 1992).

G.J. Haltiner and R.T.Williams: Numerical Weather Prediction (John Wiley, 1980).

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (IV Semester) : Elective Paper

PHYSICS OF NANOMATERIALS

Free electron theory [qualitative idea] and its features, Idea of band structure, Metals, insulators and semiconductors, Density of state in bands, Variation of density of states with energy, Variation of density of state and band gap with size of crystal.

Quantum Size Effect

Electron confinement in infinitely deep square well, confinement in two and one dimensional well, Idea of quantum well structure, Quantum dots, Quantum wires.

Determination of particle size, Increase in width of XRD peaks of nanoparticles, Shift in photoluminescence peaks, Variations in Raman spectra of nanomaterials

Different methods of preparation of nanomaterials, Bottom up : Cluster beam evaporation, Ion beam deposition, Chemical bath deposition with capping techniques and Top down : Ball Milling.

Text and Reference Books

Nanotechnology Molecularly designed materials by Gan-Moog Chow, Kenneth E. Gonsalves, American Chemical Society

Quantum dot heterostructures by D. Bimerg, M. Grundmann and N.N. Ledentsov, John Wiley & Sons, 1998.

Nano technology : Molecular speculations on global abundance by B.C. Crandall, MIT Press 1996.

Physics of low dimensional semiconductors by John H. Davies, Cambridge Univ. Press 1997.

Physics of semiconductor nano structures by K.P. Jain, Narosa 1997.

Nano fabrication and bio system : Integrating materials science engineering science and biology by Harvey C. Hoch, Harold G. Craighead and Lynn Jelinski, Cambridge Univ. Press 1996.

Nano particles and nano structured films; Preparation characterization and applications Ed. J.H Fendler, John Wiley & Sons 1998.

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M.Sc. Physics (IV Semester) : Tutorial : Elective Paper

PHYSICS OF NANOMATERIALS

1. Find surface to volume ratio for a spherical object as a function of radius.
2. A piece is cubic in shape with atoms distant 0.4nm along the three directions parallel to the edges. Find the ratio of number of atoms on the surface to the number of atoms in the cube for the cases when the edge lengths are 1.2nm, 1.6nm, 2.0 nm and 2.4nm.
3. What is melting point ? Does it have any meaning for an atom ? Explain. Comment on the melting point (quasi melting) of nanoparticles.
4. What is quantum confinement ?
5. Discuss the case of 2-dimensional electron gas (i.e. an electron being confined in a plane) and extend the discussion to quantum wire and quantum dot.
6. Discuss the determination of particle size by various methods (X-ray diffraction, transmission electron microscopy, scanning electron microscopy, scanning tunneling electron microscopy and atomic force microscopy). Which one would be the most suitable ?
7. Discuss (or comment) the possibility of enhanced photoemission efficiency in nanoparticles and wavelength dependence of the emitted radiation on size of nanoparticles.
8. Nanoparticles can give rise to new structural variants. Explain by taking examples of fullerenes and tubules of carbon. Comment on the diffraction effects from seamless tubular arrangement of atoms accomplished by folding atomic planes.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.