DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY

CIRCULAR NO.SU/Sci./M.Sc.Physics/52/2021

It is hereby inform to all concerned that, the syllabus prepared by the Board of Studies in Physics and recommended by the Dean, Faculty of Science & Technology the Hon'ble Vice-Chancellor has accepted the **Syllabus of M.Sc. Physics Ist to IVth semester with Bridge Course for affiliated Colleges and University Department** in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith.

This shall be effective from the Academic Year 2021-22 and onwards.

All concerned are requested to note the contents of this circular and bring notice to the students, teachers and staff for their information and necessary action.

University Campus,
Aurangabad-431 004.
REF.NO. SU/SCI/2021/3937-46
Date:- 25-10-2021.

Deputy Registrar,
Academic Section.

Copy forwarded with compliments to :-

1] **The Principal of all concerned Colleges,**
Dr. Babasaheb Ambedkar Marathwada University,

2] **Head of the Department, Department of Physics,**
Dr.Babasaheb Ambedkar Marathwada University, Aurangabad.

3] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

Copy to :-

1] The Director, Board of Examinations & Evaluation,Dr.BAMU,A'bad.
2] The Section Officer,[M.Sc.Unit] Examination Branch,Dr.BAMU,A'bad.
3] The Programmer [Computer Unit-1] Examinations, Dr.BAMU,A'bad.
4] The Programmer [Computer Unit-2] Examinations, Dr.BAMU,A'bad.
5] The In-charge,[E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr.BAMU,A'bad.
6] The Public Relation Officer, Dr.BAMU,A'bad.
7] The Record Keeper, Dr.BAMU,A'bad.

Dr. Babasaheb Ambedkar Marathwada University, Aurangabad - 431001 (MS)

Structure and Curriculum

For

M. Sc. (Physics) Program

(Choice Based Credit System)

(Effective from June 2021 onwards)

22/9/2021
Dean
Faculty of Science & Technology
Dr. Babasaheb Ambedkar Marathwada
University, Aurangabad

from any other Department in the university campus and 02 credits from the course 'Constitution of India'.

Credit-to- contact hour Mapping:

One contact hour per week is assigned 1 credit for theory and 0.5 credits for laboratory courses/ research project. Thus a 4 - credit theory course corresponds to 4 contact hours per week and same analogy will be applicable for laboratory courses / research project.

Course Structure:

Semester I (Core and Foundation Courses)				
Course	**Course Title**	**Teaching time/week**	**Marks**	Credits
PHYC-111	Mathematical Methods in Physics	4 hours	100	4
PHYC-112	Classical Mechanics	4 hours	100	4
PHYC-113	Quantum Mechanics	4 hours	100	4
PHYC-114	Statistical Mechanics	4 hours	100	4
PHYF-115	Research Methodology	2 hours	50	2
IC-01	***Constitution of India***	***2 hours***	***50***	***2***
PHYL- 121	Lab course 1 (General Physics)	4 hours	50	2
PHYL- 122	Lab course 2 (Computational Physics based on PHYC -111, 112, 113 and 114)	4 hours	50	2
Total Credits for Semester I : 24 (Theory : 20 ; Laboratory : 04)				
Semester II (Foundation Courses)				
PHYF-211	Foundation Course in Electronics (Linear and Digital Electronics)	4 hours	100	4
PHYF-212	Foundation Course in Spectroscopy (Atomic and Molecular Physics)	4 hours	100	4
PHYF-213	Foundation Course in Nuclear Physics (General Nuclear Physics)	4 hours	100	4
PHYF-214	Foundation Course in Condensed Matter Physics (General Condensed Matter Physics)	4 hours	100	4
PHYL-221	Lab course 3 (Condensed Matter Physics + Nuclear Physics+ Spectroscopy)	4 hours	50	2
PHYL-222	Lab course 4 (Electronics + Computational Physics)	4 hours	50	2
PHYR-231	Research Project Part -I (Review of literature for Research Project and Formulation of Topic of Research Project)	4 hours	50	2
Total Credits for Semester II : 22 (Theory : 16 ; Laboratory : 04; Research project: 02)				

22/04/2021

Semester III (Foundation and Generic Elective Courses)				
PHYF-311	Electrodynamics	4 hours	100	4
PHYE-312	Generic Electives 1 (A1/ B1/ C1/ D1)	4 hours	100	4
PHYE-313	Generic Electives 2 (A2/ B2/ C2/ D2)	4 hours	100	4
PHYE-314	Generic Electives 3 (A3/ B3/ C3/ D3/ E3 / F3 / G3 / H3 / I3/J3) **(Any one)**	4 hours	100	4
PHYL-321	Lab course 5 (Based on Electives A1/ B1/ C1/ D1)	6 hours	50	3
PHYL-322	Lab course 6 (Based on Electives A2/ B2/ C2/ D2)	6 hours	50	3
PHYR-331	Research Project Part II (Experimental Work)	6 hours	50	3
Total Credits for Semester III : 25 (Theory : 16 ; Laboratory : 06 ; Research Project : 03)				
Semester IV (Generic and Open Elective Courses)				
PHYE-411	Generic Electives 4 (A4/ B4/ C4/ D4)	4 hours	100	4
PHYE-412	Generic Electives 5 (A5/ B5/ C5/ D5)	4 hours	100	4
PHYE-413	Generic Electives 6 (A6/ B6/ C6/ D6/E6/F6/G6/H6) **(Any one)**	4 hours	100	4
OELE-101	Open Elective (from other Departments) / SWAYAM course	4 hours	100	4
PHYL-421	Lab course 7 (Based on Electives A4/ B4/ C4/D4)	6 hours	50	3
PHYL-422	Lab course 8 (Based on Electives A5/ B5/ C5/ D5)	6 hours	50	3
PHYR-431	Research Project Part III (Dissertation and Presentation)	6 hours	50	3
Total Credits for Semester IV : 25 (Theory : 16 ; Laboratory : 06 ; Research Project : 03)				
Total Credits : 96 (Sem I : 24 + Sem II : 22 : Sem III : 25 + Sem IV : 25)				

22/09/2021

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List of Generic Elective Courses for Semester III

Sr. No.	Code	Name of Course	Semester
		A: Electronics ; B : Spectroscopy C : Nuclear Physics D : Condensed Matter Physics	
1	A1	8086 Microprocessor and Interfacing	III
2	B1	Atomic Spectroscopy	III
3	C1	Radioactivity and Nuclear Decay	III
4	D1	Crystallography	III
5	A2	Microwaves	III
6	B2	Molecular Spectroscopy	III
7	C2	Reactor Physics	III
8	D2	Electrical Properties of Solids and Superconductivity	III
		PHYE - 314; Elective 3 (Any one)	
9	A3	Industrial Electronics	III
10	B3	Modern Trends in Spectroscopy	III
11	C3	Nuclear Reactions and Nuclear Energy	III
12	D3	Physics of Nano materials	III
13	E3	X-Ray Diffraction	III
14	F3	Thin Film and Vacuum Technology	III
15	G3	Methods of Theoretical Physics	III
16	H3	Communication Electronics	III
17	I3	Nuclear Spectroscopy	
18	J3	Micro Electro Mechanical System (MEMS)	
		List of Generic Elective Courses for Semester IV	
1	A4	Advanced Sensor Technology	IV
2	B4	Applied Spectroscopy	IV
3	C4	Particle Physics, Nuclear forces and Cosmic rays	IV
4	D4	Magnetic Materials and Super fluidity	IV
5	A5	8051- Microcontroller	IV
6	B5	Lasers Nonlinear Optical mixing and Spectroscopic Phenomena	IV
7	C5	Radiation Measurements And Nuclear Dosimetry	IV
8	D5	Material Synthesis and Characterization	IV
		PHYE-413; Elective 6 (Any one)	
9	A6	Fundamentals of Sensors	IV
10	B6	The Physics of Dielectrics	IV
11	C6	Nuclear Fission, Fusion and Neutron Physics	IV
12	D6	Renewable Energy	IV
13	E6	Soil Physics	Iv
14	F6	Advance communication Electronics	IV
15	G6	Accelerator Physics	IV
16	H6	X-ray Spectroscopy	IV

Notes:

- Tutorial / assignments are integral components of all theory courses. Tutorials consist of conceptual as well as numerical problems / questions based the respective theory courses in the semester covering all four (04) units.
- Each course / paper should be taught for 60 contact hours (48 lectures and 12 tutorials).
- Teaching duration for LAB COURSES in first and second semesters should be of 04 hours and for those in third and fourth semesters should be 06 hours per week per batch.
- For LAB COURSES in First and Second semesters one batch of the students will be consisting 08 students and that of Third and Fourth semester 05 students (Specialization) for laboratory courses as well as project.
- Each of the theory courses is divided into four units.
- The content of theory course / paper as well laboratory (practical) course may be modified time to time (with the approval DC) to keep pace with the recent developments and trends in the subject.

Course Contents:

Learning objectives and learning outcomes will be integral part of course contents. Learning objectives will describe why the course is necessary? Why it should be taught as Core / Foundation / Elective? Why it should be taught at Semester I / Semester II / Semester III / Semester IV and learning outcomes will describe how the course will be beneficial? What are the job / research opportunities for the takers of the course? is the said course a pre-requisite for certain other courses? can one start an entrepreneurship after the said course or will the course help for such activity.

Each course will have 04 units and will have 60 contact hours (48 lectures and 12 tutorials). Reference section consists of latest references of reputed authors and publishers by having all details of the books such as title, author(s), edition, publisher, year, ISBN or ISSN, etc. In case of e-reference, a web link is also included.

Attendance:

Students must have 75 % of attendance in each core, foundation, elective, laboratory and research project course for appearing examination/ scholarship otherwise he / she will be strictly not allowed for appearing the examination of each course. However, students having 65 % attendance with medical certificate may request Head of the Department for the condensation of attendance.

Departmental Committee:

The existing Departmental Committee (DC) will monitor the smooth functioning of M. Sc. programme.

Results Grievances / Redressal Committee

In Choice Base Credit System (CBCS) there is no redressal of assessed papers. In CBCS - system, the assessed papers are shown to the students and it is the duty of the student to go through the assessed papers and solve the grievances if any at the respective teacher only. It is the moral duty of the student to write SEEN and SATISFIED on the assessed answers book shown by the teacher in-charge of that respective paper. Once the assessed papers are submitted to the office, then the papers will not be shown/given to the students and any type of grievances/ complaints about the assessment will not be entertained.

Even if, there are some grievances, the student must give a written application to Head of the Department before declaration of the result about his/ her grievances. The Head of the Department will constitute a Grievances / redressal committee in the department to resolve all grievances relating to the evaluation. The committee shall consist of Head of the Department (Chairman), the concerned teacher of a particular course and senior faculty member of the Departmental Committee. The decision of Grievances / redressal committee will have to be approved by the Department committee. The decision of DC will be the final decision.

Evaluation Methods:

- The assessment will be based on 20:80 ratio of continuous internal assessment (CIA) and semester end examination (SEE).
- Combined passing in CIA and SEE. In case of failure/absence in CIA of a particular course, student will have to appear for the same CIA in the same semester, with the permission of the Head of the Department.
- In case a student fails in certain courses in a particular semester and the same courses are modified / revised / removed from the curriculum in due course of time, the student will have to appear as per the newly framed curriculum and or pattern in subsequent semester at his / her responsibility.

Continuous Internal Assessment (CIA):

- There will be 20 marks for Continuous Internal Assessment. Distribution of 20 marks will be as follows; there will be two internal tests of 20 marks each. The first internal test should be after completion of 40 to 50 % curricula and on the course completed (Unit I and II). Second internal test should be after completion of 100% curricula and on the 50 % remaining curricula (Unit III and IV). Continuous Internal Assessment will consist of 5 questions of 5 marks each and the first question will be the objective of 5 marks. There will be four questions of descriptive nature and the student has to solve three out of four. The average of the two internal tests will be considered as the CIA marks out of 20.

Semester End Examination (SEE):

- The semester end theory examination for each theory course will be of 80 marks. The total marks shall be 100 for 4 credit theory course (80 marks semester end exam + 20 marks CIA).

- Pattern of semester end question paper will be as below:

    - The semester end examination of theory course will have two parts (20+80 = 100 Marks)
    - Part A will be consisting of 10 questions having 2 marks each (multiple choice questions) as compulsory questions and it should cover entire course curriculum (20

Marks) having at least 2 questions from each unit of course curriculum.

- Part B will consists (06) questions (1.5 questions from each of 04 units and each question will be of 15 marks). The students will have to attempt any four questions out of six.
- 20 to 30% weightage can be given to problems/ numerical wherein use of non-programmable scientific calculator may be allowed.
- Number of sub questions (with allotment of marks) in a question may be decided by the examiner.

- Semester end examination (SEE) time table will be declared by the departmental committee (as per the University annual calendar). The paper setting and assessment of theory courses, laboratory courses and research project will be done by external and internal examiners. However, in case of non-availability of external examiner for either paper setting or assessment or both, department committee will be empowered to take appropriate decision.

- Assessment of laboratory courses and research project will be done by the external and internal examiners. Student must perform at least eight experiments from each laboratory course. The semester end practical examination will be conducted at the end of each semester.

- The Head of the Department shall send all results to the Controller of Examination for further processing.

Earning Credits:

At the end of every semester, a letter grade will be awarded in each course for which a student had registered. A student's performance will be measured by the number of credits that he/she earned by the weighted Grade Point Average (GPA). The SGPA (Semester Grade Point Average) will be awarded after completion of respective semester and the CGPA (Cumulative Grade Point Average) will be awarded at the end of the 4th semester.

Grading System:

- The grading reflects a student-own proficiency in the course. A ten point rating scale shall be used for the evaluation of the performance of the students to provide letter grade for each course and overall grade for the Master Programme. Grade points are based on the total number of marks obtained by him / her in all heads of the examination of the course. The grade points and their equivalent range of marks are shown in Table-I

Table - I : Ten point grade and grade description

Marks Obtained (%)	Grade Point	Letter Grade	Description
90-100	9.00- 10	O	Outstanding
80-89	8.00-8.90	A++	Exceptional
70-79	7.00-7.90	A+	Excellent

60-69	6.00-6.90	A	Very Good
55-59	5.50-5.90	B+	Good
50-54	5.00-5.40	B	Fair
45-49	4.50-4.90	C++	Average (Above)
41-44	4.1-4.49	C	Average
40	4.0	P	Pass
< 40	0.0	F	Fail (Unsatisfactory
	0.0	AB	Absent

- Non appearance in any examination / assessment shall be treated as the students have secured zero marks in that subject examination / assessment.
- Minimum P grade (4.00 grade points) shall be the limit to clear / pass the course / subject. A student with F grade will be considered as 'failed" in the concerned course and he / she have to clear the course by appearing in the next successive semester examinations.
- Every student shall be awarded grade points out of maximum 10 points in each subject (based on 10 point scale). Based on the grade points obtained in each subject, Semester Grade Point Average (SGPA) and then Cumulative Grade Point Average (CGPA) shall be computed. Results will be announced at the end of each semester and CGPA will be given on the completion of M. Sc. programme.

Computation of SGPA (Semester Grade Point Average) and CGPA (Cumulative Grade Point Average)

Grade in each subject / course will be calculated based on the summation of marks obtained in internal and semester end examination.

The computation of SGPA and CGPA will be as below

Semester Grade Point Average (SGPA) is the weighted average points obtained by the students in a semester and will be computed as follows

$$SGPA = \frac{\text{Sum (Course Credit X Number of Grade Points in concern Course Gained by the Student)}}{\text{Sum (Course Credit)}}$$

The SGPA will be mentioned on the mark sheet at the end of every semester.

- The Cumulative Grade Point Average (CGPA) will be used to describe the overall performance of a student in all semester of the course and will be computed as under.

$$CGPA = \frac{\text{Sum (All four Semester SGPA)}}{\text{Total Number of Semester}}$$

The SGPA and CGPA shall be rounded off to the second place of decimal.

Grade Card

Results will be declared by the Departmental Committee and the grade card (containing the grades obtained by the student along with SGPA) will be issued by the University after completion of every semester. The grade card will be consisting of following details.

- Title of the courses along with code opted by the student.
- Credits associated with the course.
- Grades and grade points secured by the student.
- Total credits earned by the student in a particular semester.
- Total credits earned by the students till that semester.
- SGPA of the student.
- CGPA of the student (at the end of the 4^{th} semester).

Cumulative Grade Card

The grade card sheet showing details grades secured by the student in each subject in all semester along with overall CGPA will be issued by the University at the end of 4^{th} semester.

Semester - I

M. Sc. (Physics) Curriculum

Semester - I

PHYC-111: Mathematical Methods in Physics

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives:

1. To facilitate the students to understand -
   a) The basic elements of complex mathematical analysis, including the integral transform and Laplace transform.
   b) To expand a function in terms of a Fourier series, with knowledge of the conditions for the validity of the series expansion.
   c) To apply integral transform (Fourier and Laplace) to solve mathematical problems of interest in physics, use Fourier transforms as an aid for analyzing experimental data.
   d) To solve partial differential equations of second order by use of series expansion (Fourier series) and integral transforms.

Learning Outcomes:

1. After finishing the course the student should be able to:
   a) master the basic elements of complex mathematical analysis, including the integral theorems, obtain the residues of a complex function and to use the residue theorem to evaluate definite integrals
   b) Solve ordinary differential equations of second order that are common in the physical sciences.
   c) Expand a function in terms of a Fourier series, with knowledge of the conditions for the validity of the series expansion.
   d) Apply integral transform (Fourier and Laplace) to solve mathematical problems of interest in physics, use Fourier transforms as an aid for analyzing experimental data.
   e) Solve partial differential equations of second order by use of standard methods like separation of variables, series expansion (Fourier series) and integral transforms.
   f) Solve some simple classical variational problems.

Course Contents:
Unit I: Fourier series (09 Contact Hours)

Definition, Evaluation of coefficient, Fourier series representation of even and odd function General properties of Fourier series, simple applications, convergence, integration, differentiation, problems.

Unit II: Integrals Transforms (13 Contact Hours)

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

Unit III: Laplace Transforms (13 Contact Hours)

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

Unit IV: Complex Analysis (13 Contact Hours)

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Unit V: Tutorials, assignments and seminar presentations based on unit I, II, III and IV
(12 Contact Hours)

References:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence,3rd ed., **2006,** Cambridge University Press /ISBN978052167918/2006
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications/ ISBN-13: 978- 0486691930/1996
3. Complex Variables, A.S. Fokas & M.J. Ablowitz, Cambridge University Press, **ISBN**-13: 978- 0521534291/2003.
4. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 8th Ed./ (**ISBN**: 978-0-07-333730-2/ 2004, Tata McGraw-Hill
5. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, Jones & Bartlett/ **ISBN**-13: 978-0763757724/2nd edition /1940.
6. Mathematical Physics- B.S. Rajput, Pragati Prakashan (Meerut). **ISBN** 10: 8175568712/23 edition/2005
7. Engineering Mathematics H. K. Dass/ S. Chand co. / 9788121914697/2012
8. Mathematical Physics- Kumar and Gupta/ **ISBN** 10: 8125930965/ Vikas Publishing House, New Delhi/2008.

PHYC-112: Classical Mechanics

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Course Objectives: The themes dealt with in this paper:

Classical Mechanics is a course where it all started
Newton demonstrated that the same forces and laws of mechanics that apply to apples and everyday objects (the terrestrial) also govern the behavior of the moon and the planets (the celestial).
In a wide array of physical situations, classical mechanics is all you need to be able to predict the motion of apples, baseballs, bones, bridges, cars, cats, and so on.
The universality of the laws and their wide range of applicability, classical mechanics is an essential course for students of physics.

Course Outcomes (COs): The present unit attempts to achieve the following learning outcomes: **At the end of the course the student should be able to;**

CO-1	Classical mechanics is a hot area of active research once more.

Learning Objectives:

> Classical mechanics is a course where it all started. Newton demonstrated that the same forces and laws of mechanics that apply to apples and everyday objects (the terrestrial) also govern the behavior of the moon and the planets (the celestial).

> He showed that nature had a high degree of structure and order, and that we could hope to uncover it and so physics was born.

> Newton's laws of motion, or mechanics, were not only universal, they proved to be useful. In a wide

CO-2	Chaos has lead to significant advances in mathematics and physics (for example, it offers some explanation for the phenomenon of ergodicity in statistical mechanics) and fundamentally changes the way we look a predictability and solvability of dynamical systems
CO-3	While classical mechanics, by definition, does not include the 21^{st} century advances of quantum mechanics and relativity, it is nevertheless an essential prerequisite for study of these topics.
CO-4	We use concepts of forces and energy throughout physics, so a strong grounding in classical mechanics is essential.
CO-5	Students will study the phenomenon of chaos, fully solve two-body orbit problems and derive Kepler's Laws, and develop the theory of effective forces that arise in no inertial frames.

array of physical situations, classical mechanics is all you need to be able to predict the motion of apples, baseballs, bones, bridges, cars, cats, and so on. For these two reasons alone: the universality of the laws and their wide range of applicability, classical mechanics is an essential course for students of physics.

> There's more: recent developments in classical mechanics have led to the theory of Chaos.

Learning Outcomes:

- Classical mechanics is a hot area of active research once more.
- Chaos has lead to significant advances in mathematics and physics (for example, it offers some explanation for the phenomenon of ergodicity in statistical mechanics) and fundamentally changes the way we look a predictability and solvability of dynamical systems.
- And there's even more: while classical mechanics, by definition, does not include the 21st century advances of quantum mechanics and relativity, it is nevertheless an essential prerequisite for study of these topics. For example, the Hamiltonian in quantum mechanics originates from the classical mechanics Hamiltonian that we will encounter.
- We use concepts of forces and energy throughout physics, so a strong grounding in classical mechanics is essential. While students studied classical mechanics already in B.Sc, in this course we will encounter more advanced techniques and solve a wider variety of problems. For example, we will encounter a reformulation of classical mechanics by Lagrange (and Hamilton) which makes it easier to deal with complicated situations such as more general coordinates or constraints on the motion. We will study the phenomenon of chaos, fully solve two-body orbit problems and derive Kepler's Laws, and develop the theory of effective forces that arise in no inertial frames.
- We will close with the profound Liouville's theorem for Hamiltonian mechanics and its implications in chaotic and planetary systems.

Course Contents:

Unit I : Constrained Motion

Constraints, Classification of Constraints, Principal of Virtual Work, D'Alembert's principal and its applications (Problems only), (One or Two Problems should be discussed with D'Alembert's, Lagrangian, Hamiltons from same set of problems). **Lagrangian formulation:**Generalized coordinates, Langrange's equations of motion, properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation.

Unit II: Hamilton's formulation

Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Lagrangian and Hamiltonian of relativistic particles and light rays. **Variational Principle**: Variational principle, Euler's equation, applications of variational principle, shortest distance problem, brachistrochrone, Geodesics of a Sphere

Unit III: Canonical transformation and central force

Generating function, Conditions for canonical transformation and problem, theory of chaos, Two body central force problem, stability of orbits, condition for closure, integrable power laws, Kepler's problems, orbits of artificial satellites, Virial theorem. **Poisson Brackets**: Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, (Statement only), invariance of PB under canonical transformation.

Unit IV: Rotational and oscillatory motion

Rotating frames of reference, inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Focoult's pendulum, small oscillations, Normal co-ordinates and applications to vibrations of linear in triatomic molecules. Liouville's theorem for Hamiltonian mechanics and its implications in chaotic and planetary systems.

References:

1. Classical Mechanics, by H. Goldstein, 2nd Edition (Published by Narosa Publishing House Pvt. Ltd., New Delhi (2001) ISBN 10:8185015538 / ISBN 13:9788185015538
2. Classical Mechanics, by H. Goldstein, Charles Poole, John Safco, 3 rd Edition (Published by Pearson Education Asia (2014)) ISBN 10:8131758915 / ISBN 13:9788131758915
3. Classical Mechanics, by N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991) ISBN 10: 0074603159 ISBN 13: 9780074603154
4. Mechanics, by A. Sommerfeld (Academic Press, 1952) ISBN 10: 0126546703 ISBN 13: 9780126546705
5. Introduction to Dynamics, by I. Perceival and D Richards (Cambridge Univ. Press. 1982). ISBN-10: 0521281490 / ISBN-13: 978-0521174060
6. Classical Mechanics, P. V. Panat (Narosa Pub. House Pvt. Ltd.) 2008 ISBN: 9788173196317 / 8173196311
7. Classical Mechanics, by Gupta, Kumar and Sharma, Pragati Prakashan, Meerut (2012). ISBN number 9350063808 / 9789350063804
8. Classical Dynamics of Particles and Systems by Marion and Thomtron, Third Edition, Horoloma Book Jovanovich College Publisher (2003) ISBN-10: 0534408966 ISBN-13: 978-0534408961
9. Introduction to Classical Mechanics by R. G. Takawale and P. S. Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi. ISBN 10:0070966176 / ISBN 13: 978007096617

PHYC-113: Quantum Mechanics
(Credits: 04; Contact Hours: 60)
Lectures: 48 Tutorials: 12

Learning Objectives:
- To answer fundamental questions in physics
- To further the ability to design and exploit physical phenomena for applications.

Learning Outcomes of the Course:
- Ability to learn important quantum mechanical concepts such as electronic levels in the hydrogen atoms or the rate at which electrons scatter from a defect
- Applications to typical problems encountered in technology-related applications
- Solving problems concerning real applications, number / concept oriented problems in nuclear physics, spectroscopy, condensed matter physics, semiconductor physics, etc.

Course Contents:

Unit I - Quantum Mechanics in 1-D: Exact Solution of Schrodinger Equation in 1-D - The **Free Particle**: Continuous States; **The Potential Step**: Cases E > Vo and E < Vo [tunneling]; Tunneling effect; **The Potential Barrier** and Well Cases E > Vo and E < Vo [tunneling]; The **Harmonic Oscillator** :

Solution with ladder operator method [Zettili pp 239-248]

Unit II - Quantum Mechanics in 3-D : Angular Momentum : Physical Symmetries and Conservation Laws: Introduction Rotation Symmetry and Angular Momentum (Qualitative description) Orbital Angular Momentum L Commutator algebra of ***L*** and ***p***, ***L*** and ***r***, L^2 and r^2; Eigen values and Eigenfunctions; Spin Angular Momentum: Stern Gerlach experiment General angular momentum: definition of ***J***, commutator of ***J*** and components of ***J***, ladder operators J_+ and J_-, commutators of ladder operators, ladder operator with J and J_z, eigen values of J_+, J_-, J^2, components of ***J***;

Unit III- Approximation methods: (a) The WKB approximation. Application to bound states connecting formulae Bohr Sommerfield Quantization rules, WKB application to transmission problem, (b) Variational method: Particle in a box, harmonic oscillator, H2+ ion; (c) Time independent Perturbation theory, non-degenerate and degenerate cases; (d) Time dependent perturbation theory, Fermi's rule, Harmonic perturbation

Unit IV- Scattering Theory: Introduction , Scattering Amplitude and Differential and Total Cross Sections, Method for determination of differential scattering cross section: (a) Partial Wave Analysis (no detailed derivation expected; only problems based on end formula are to be taught); (b) The Born Approximation: The First Born Approximation (derivation from Liboff p 623 and problems), Validity of the First Born Approximation

References:

(1) Quantum Mechanics : Concepts and Applications, Nouredine Zettili (ISBN 978-0-47002678-6 ISBN 978-0-470-02679-3 John Wiley & Sons 2009)
(2) Introductory Quantum Mechanics, Richard L Liboff, (Addison-Wesley Pub Co., 1980 ISBN 0-201-12221-9 ABCDEFGHIJ-HA-8987).

PHYC-114: Statistical Mechanics

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives:

- To explain various properties of matter in both equilibrium with environment and in nonequilibrium
- To understand behaviour of collection of quantum particles

Learning Outcomes:

- Applications to various modern discoveries such as Ohm's law, quantum Hall effect, Bose Einstein condensates
- In depth knowledge of the fundamental idea behind various phenomena in condensed matter physics
- Solution of numerical problems to help in various exams like JEST, GATE, etc.

Course Contents:

Unit I : Ideal Fermi-Dirac Gas: Fermi-Dirac distribution, Degeneracy, Electrons in metals, Thermionic emission, Magnetic susceptibility of free electrons (Pauli paramagnetism)

Unit II : Ideal Bose systems: Photons, Phonons in solids, Bose-Einstein Condensation Liquid He, Tisza 2-fluid model, Landau theory, superfluidity, Superconductivity

Unit III: Semiconductor Statistics: Statistical equilibrium of free electrons in semiconductors, Non-degenerate case, Impurity semiconductors, Degenerate Semiconductors, Occupation of donor levels, Electrostatic property of P-N junction

Unit IV: Special Topics in Statistical Mechanics: Non-Equilibrium States: Boltzmann transport equation, Particle diffusion, Electrical conductivity, Isothermal Hall effect, Quantum Hall effect; The 1-D Ising model

References

(1) Statistical Mechanics, Kerson Huang (ISBN 0-471-8158-7, John Wiley & Sons (1987)

(2) Statistical Mechanics, B K Agarwal and Melvin Eisner (ISBN 9788122433548, New Age International (p) Ltd 2013)

(3) Statistical Mechanics, B B Laud (ISBN-10: 8122432786 ISBN-13: 978- 8122432787 ASIN: B0075MAT4S, New Age International Publishers Ltd.-New Delhi 2012)

PHYF-115: Research Methodology

(Credits: 02; Contact Hours: 30)

Learning Objectives:

1. to define research and describe the research process and research methods
2. to understand qualitative research and methods used to execute and validate qualitative research
3. to know how to apply the basic aspects of the research process in order to plan and execute a research project.
4. to provide insight into the processes that lead to the publishing of research.
5. to be able to present, review and publish scientific articles

Learning Outcomes:

1. Students will be able to -

   a) understand and explain research process
   b) do systematic literature survey, formulation of a research topic, study design, analysis and interpretation of data.
   c) to design a research approach for a specific research issue of their choice.

d) select a suitable analytical method for a specific research approach.
e) demonstrate a good understanding of how to write a research report.
f) critically assess published quantitative research with regard to the statistical methods and approaches adopted
g) create a research document for implementation research project

Course Contents:

Unit I : Research Fundamentals:

Introduction: Definition, objectives of the research, characteristics of the research, what makes people to do research, importance of research,

Unit II : Identification of Research Problem :

Defining the research problem: Identification of research problems, selection of research problem, facts one should know regarding selection of research problem, the process of research problem definition, some facts involved in defining research problem, Case Studies.

Unit III : Formulation of Research Problem :

Formulation of the problems: steps involved in defining a problem, formulation of the problems, Formulation of hypothesis: Concept of hypothesis, hypothesis testing, Developing the research plan: implementation, interpreting and reporting the findings, Importance of hypothesis in decision making, Case Studies.

Unit IV: Research Report and Proposal Writing:

Introduction, research proposal writing: costing, the research proposal, rationale for the study, research objectives, research methodology, target respondents, research Centres, sample size and sample composition, sampling procedures, research project execution, research units; An insight into research report and proposal, research project synopsis, research report writing : types of research reports, guidelines for writing reports; Steps in writing report, report presentation, typing the report, documentation and bibliography, formatting guidelines for writing a good research report / research paper, Case Studies.

References:

1. Research Methodology by Dr. S. L. Gupta, Hitesh Gupta; International Book House Pvt Ltd (**2013),** ISBN-10: 8191064278, ISBN-13: 978-8191064278
2. Basic Research Methods-Gerard Guthrie SAGE Publications, India, Pvt Ltd, New Delhi (**2010),** ISBN-10: 8132104579, ISBN-13: 978-8132104575
3. Research Methodology-methods and techniques By C. R. Kothari, New Age International Publishers **(2011)** ISBN 978-81-224-1522-3
4. Principles of Research Methodology- Phyllis G. Supino, Jeffrey S. Borer; Springer, Verlag New York **(2012),** ISBN-ebook: 1461433592, ISBN (Hardcover): 9781461433590
5. Research Design Qualitative, Quantitative. and Mixed Methods Approaches- John W. Creswell; SAGE Publications Ltd, UK **(2011),** ISBN-9780857023452

6. Research Methodology -A Step-by-Step Guide for Beginners- Ranjit Kumar; Sage Publications Ltd**(2010)**, ISBN- 1849203016.
7. Scientific Writing and Communication- Angelika Hofmann; Oxford University Press, US **(2010),** ISBN-13-: 978-0 199947560, ISBN-10: 01 99947562
8. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded- Joshua Schimel, Oxford University Press, **(2011)**, ISBN: 9780199760237
9. Handbook of Scientific Proposal Writing- A.YavuzOruc; CRC Press, Taylor &Francis group **(2011)**, ISBN: 9781439869185.

IC-01: Constitution India ((Credits: 02; Contact Hours: 30)

This course will be taught at common level. University will arrange teaching classes for this course.

PHYL-121: Lab course 1 (General Physics) Credits 02

Learning Objectives:

- To have hands on training on measurements of fundamental constants in physics as well as computational physics.
- To gain knowledge about usage of units and dimensions, concepts in quantum mechanics, statistical mechanics and electrodynamics.
- To understand computational methods and their applications to quantum mechanic
- To understand how to solve Schrodinger equation,

Learning Outcomes:

- To help a student in designing an experiment for measurements of desirables
- To gain knowledge in understanding various concepts in physics.

(General Physics) Course content:

(1) Determination of specific charge (e/m) of an electron by Thomson method

(2) Study of black body radiation and determination of the Planck constant h

(3) Verification of Bohr's theory using Franck Hertz apparatus

(4) Study of Boltzmann statistics and determination of Boltzmann constant kB

(5) Determination of thickness of a given thin wire using LASER

(6) Determination of wavelength of a given source using Michelson's interferometer

(7) Determination of compressibility of a given liquid using Raman Nath experiment

(8) Determination of spin on an electron using Stern Gerlach experiment

(9) Study of the x-ray telexometer

(10) Determination of thermionic work function of filament material

(11) Determination of charge on an electron by Millikan's oil drop method

(12) Calibration of Platinum resistance thermometer as a function of temperature and to determine unknown temperature.

(13) Determination of temperature of flame by sodium line reversal method.

(14) h/e of electron by photocell.

A student is expected to perform at least 8 experiments in each of the courses.

PHYL-122

Lab Course 2 (Computational Physics based on PHYC -111, 112, 113 and 114)

Credits 02 (This course is based on computation using MS-EXCEL)

Course content:

(1) Determine the roots of given equation/expression

(2) Evaluation of given integrals using Simpson's 1/3 rule

(3) Solution of Schrodinger equation for square / harmonic oscillator potential

(4) Solution of Schrodinger equation for triangular potential

(5) Plotting the hydrogen atom ground state 1s and 2s wave functions

(6) Determination of normalization constant for 1s wave function of hydrogen atom

(7) Plotting the hydrogen atom ground state 2p wave function

(8) Study of Gaussian Type Orbitals (GTOs) and Slater Type Orbitals (STOs)

(9) Comparison of Gaussian Type Orbitals (GTOs) with Slater Type Orbitals (STOs)

(10) Stefan's constant-black body radiation

(11) Study of variation of thermo e.m.f. as a function of temperature

(12) Study of energy bad gap of a semiconductor

(13) Determination of temperature coefficient of thermistor

A student is expected to perform at least 8 experiments in each of the courses.

Semester - II

PHYF-211: Foundation Course in Electronics

(Linear and Digital Electronics)

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Course Objectives:

1 ■ To establishes the general method for analyzing and predicting the performance of operational amplifiers and related circuits.

2 ■ To develop the students for designing realistic circuits to perform specified operations.

3 ■ To enable the students to select available devices for intended operations.

Course Outcomes (COs)
At the end of the course, students will be able to:

CO-1 Discuss the general properties of an operational amplifier.

CO-2 Define the terms, input impedance, output impedance , bandwidth, input offset voltage , input offset current , CMRR, open loop voltage and slew rate.

CO-3 Design an inverting and non inverting amplifier circuit or its special cases to meet the requirement.

CO-4 Analyze or design op-amp for the intended operations:
Astable Multivibrator, Monostable Multivibrator, Wien bridge Oscillator and some related circuits.

CO-5 Explain gates, its related circuits, truth table and its realization.

CO-6 Analyze or designing of combinational and sequential circuits.

Course content:

Unit I: Operational amplifier: (12 Contact Hours)
Symbol and terminals, the ideal op-amp, the practical op-amp. Operational amplifier parameters: Input offset voltage, Input offset current, Input bias current, Input impedance, Output impedance, Open loop voltage gain, Common - Mode rejection ratio, Slew rate. Inverting, non - inverting amplifier.

Unit II: Applications of Operational Amplifier and Timing Circuits: (12 Contact Hours)
Adder, Subtractor, Integrator, differentiator, Comparator & Schmitt's trigger; Wave form generators: Astable Multivibrator, Monostable Multivibrator, and Wien Bridge Oscillator. Integrated circuit timer: Block diagram of IC - 555, Monostable, Astable Multivibrator using IC555.

Unit III: Numbers systems, Codes and Combinational Logic: (12 Contact Hours)
Decimal, Binary, & Hexadecimal numbers systems, and its arithmetic's. BCD code. AND, OR, NOT operations, NAND and NOR operations, NAND and NOR as building blocks, Exclusive - OR operation. Boolean algebra, Standard Representation for Logical Functions, Half & Full adder, Parallel 4-bit adder, encoder (decimal to binary), Decoder (Decimal to BCD), BCD to seven segment decoder, Multiplexer: (4:1) and (8:1), Demultiplexer: (1:8) and (1:16) and their applications.

Unit IV: Sequential Logic: (12 Contact Hours)
Flip-Flops: S-R, D- type, T-type, J-K and J-K master-slave. Shift registers: Serial in Serial out, Serial in parallel out, Parallel in Parallel out, Parallel in Serial out. Ripple counters: Mod-16, Mod - 12 and Mod- 10. Synchronous counters: Mod-8 and Mod-16.

Unit V: Tutorials, assignments and seminar presentations based on unit I, II, III and IV **(12 Contact Hours)**

Text Books, Reference books and Websites

1. Operational amplifier with Linear integrated circuits, by William D Staney Fourth Edition, LPE PEARSON Education, 2004, ISBN 81-297-0463-3.
2. Op-Amp and Linear Integrated Circuits, R. A. Gaikwad 4th. Ed, Prentice Hall of India, 2002, ISBN 81 -203-2058-1.
3. Operational amplifier & Linear integrated circuits, 6/e Robert F. Coughlin, Frederick F. Driscoll Modern Digital Electronics , by R P Jain, 3rrd Edition, Tata McGraw - Hill Publishing Company Ltd. 2003, ISBN 0-07-049492-4.
4. Digital Electronics, Second Edition, Tokheim, 1985, ISBN 0-07-064980-4.
5. Principles of Electronics, V. K. Metha , Rohit Mehta, S. Chand and Company Ltd. 2012, ISBN: 81-219-2450-2.
6. Digital Fundamentals, by Thomas L Floyd, 2nd Edition Charles E. Merrill Publishing Company.
7. Electronic Devices, by Thomas L Floyd, Charles E. Merrill Publishing company

PHYF-212: Foundation Course in Spectroscopy

(Atomic and Molecular Physics)

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials:12

Course Objectives: The themes dealt with in this paper:

1 > The atom, the nucleus, the electron and the photon - four necessary steps for the development of quantum physics

2 > The structure of the atom. Atoms in electric and magnetic fields. Fine and hyperfine structure. X-ray spectroscopy. Molecular structure

3 > Rotation-, vibration- and electronic spectra. Chemical bonds. Optical spectroscopy.

4 > Applying laser spectroscopic methods as well as other modern tools in atomic and molecular physics, special efforts will be made in laboratory work.

Course Outcomes (COs): The present unit attempts to achieve the following learning outcomes: **At the end of the course the student should be able to;**

CO-1 The course is a continuation of the Atomic and Molecular Physics course.

CO-2 Introductory Atomic- and Molecular Physics will be discussed more in detail.

CO-3 A big part of the course will give a view of the modern experimental tools of Atomic- and Molecular Physics job prospects.

Learning objectives:

> The atom, the nucleus, the electron and the photon - four necessary steps for the development of quantum physics.

> The structure of the atom. Atoms in electric and magnetic fields. Fine and hyperfine structure. X-ray spectroscopy. Molecular structure. Rotation-, vibration- and electronic spectra.

> Chemical bonds. Optical spectroscopy. Applying laser spectroscopic methods as well as other modern tools in atomic and molecular physics, special efforts will be made in laboratory work.

Leaning Outcome:

> The course is a continuation of the Atomic and Molecular Physics course.

> Introductory Atomic- and Molecular Physics will be discussed more in detail.

> A big part of the course will give a view of the modern experimental tools of Atomic- and Molecular Physics job prospects.

Course Contents:

Unit I: Introduction

Stern Gerlach experiment, Quantum states of an electron. Quantum numbers. Spectra of Hydrogen atom. Spin angular momentum, orbital angular momentum. Coupling of spin and orbit. Fine structure, spectroscopic terms, selection rules. Spectra of the alkali elements. Interaction energy in L-S and j-j coupling, Hund's rule and term reversal. Zeeman effect in one valence electron atoms, interaction energy, selection rules, Zeeman patterns. Paschen- Back effect, Pauli principle. Hyper fine structure (Qualitative)

Unit II: Rotational spectroscopy:

Classification of molecules, Interaction of radiation with rotating molecule, IR spectra of diatomic molecules, Rigid rotator, energy levels, eigen functions and spectrum of rigid rotator, non-rigid rotator, isotopic substitution, effect of vibration on rotation, Intensities of rotational lines, information derived from rotational spectra..

Unit III: Vibrational spectroscopy:

Vibrational course structure, Deslandres table, Diatomic molecule as a harmonic oscillator, energy levels, eigen functions and spectrum of harmonic oscillator, Morse potential, anharmonic oscillator, vibrating rotator with & without Born Oppenheimer approximation.

Unit IV: Laser Fundamentals:

Masers and lasers, methods of obtaining population inversion, Ammonia maser, Spontaneous and induced emission, Einstein's A and B coefficients, Properties of lasers, Principle & working of He-Ne, Ruby, semiconductor and color center.

References

1. Introduction to Atomic Spectra H. E. White McGraw Hill, First Edition ISBN-10: 0070697205 / ISBN-13: 978-0070697201.
2. Atomic Physics by Christopher J. Foot, Oxford University Press 2005. ISBN 10: 0198506961 / ISBN 13: 9780198506966
3. Fundamentals of Molecular Spectroscopy C.N Banwell & Elaine M. McCash. Tata McGraw Hill. ISBN 10: 0077079760 ISBN 13: 9780077079765
4. Spectra of diatomic molecules G. Herzberg, Krieger Malbar Florida (2015). ISBN 10: 5458354060 ISBN 13: 9785458354066.
5. Molecular structure and spectroscopy by G Aruldhas Prentice Hall of India (2009) ISBN 10: 8120332156 ISBN 13: 9788120332157.
6. Spectroscopy volume 2, Edited by B.P. Straughan and S. Walker, London Chapman and Hall. ISBN 10: 0470150319 ISBN 13: 9780470150313.
7. Laser & Non linear Optics B. B. Laud. Wiley Eastern Limited (2011). ISBN 10: 8122430562 ISBN 13: 9788122430561
8. Laser Spectroscopy, Basic Concepts and Instrumentation by W. Demtroder, Springer. ISBN 10: 0387103430 ISBN 13: 9780387103433

Physics of atoms and molecules B. H. Bransden and C. J. Joachain Pearson Education. ISBN 10: 0306410494 ISBN 13: 9780306410499

PHYF-213: Foundation Course in Nuclear Physics

(General Nuclear Physics)

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objective: The themes dealt with in this paper:

- This course will introduce students to the fundamentals of General Nuclear Physics.
- It aims to provide a coherent and concise coverage of traditional nuclear physics.
- Important topics of current research interest will be also discussed, such as radioactivity, radiation detector and accelerators which plays an important role in the realization of this course.
- A General Nuclear Physics is a foundation course as it is a preparatory course for university-level art and design education.

Learning Outcomes: The present unit attempts to achieve the following learning outcomes:

- On successful completion of the course, students should be able to illustrate general considerations of Nuclear physics to atomic and nuclear system; make general orders of magnitude of estimation of physical effects.
- Explain how interaction of gamma radiation with matter; the working principle of accelerators and radiation detector.

Pre-requisite - This general nuclear physics is a pre-requisite for certain other courses.

- One can starts an entrepreneurship after the completion of this general nuclear physics foundation course.

Course Contents:

Unit I : General Properties of Nucleus:
Nuclear size and its determination, nuclear radii by electron scattering and mirror nuclei methods. Binding energy, mass defect, Packing fraction. Semi-empirical mass formula and its applications. Quantum numbers of nuclei, nuclear angular momentum, nuclear magnetic dipole moment, electric quadrupole moment.

Unit II : Radioactivity (Natural and Artificial):
The basis of the theory of radioactive disintegration, the disintegration constant, half life and the mean life. Successive radioactive transformation, radioactive equilibrium, the natural radioactive series, units of radioactivity. The discovery of artificial radioactivity, the artificial radio nucleids, electron and positron emission, orbital electron capture, the artificial radio nucleids: alpha emitters.

Unit III : Nuclear Radiation detectors:
Types of detectors, ionization chamber, G.M. Counters, proportional counter, semiconductor

detector, counting errors, counting efficiency, scintillation counter, energy decapitation in phosphor, photoemission from phosphor.

Unit IV : Nuclear Models and Acceleration of Charged particles:
Liquid drop model, single particle levels and magic numbers, evidence of shell effects, Bhor-wheeler theory of fission. Shell model, single particle shell model, deformed nuclei and collective model, nuclear wave function for even-even nuclei, energy spectrum and wave function for odd - A nuclei. Acceleration of Charged particles: Cascade generators, Cockroft and Walton voltage multiplier, Vande Graff machine, tandem accelerators, linear multipole accelerator, wave-guide accelerator, cyclotron.

Books:

1. Introduction to Nuclear Physics; H.A. Enge, Addison- Wesley, 1975.
2. Nuclear Physics; I. Kaplan, 2nd edition, Narosa, 1989.
3. The atomic Nucleus; R.D. Evans, Mc Graw- Hill, New York 1955.
4. Nuclear Physics; R.R. Roy and B.P. Nigam, Wiley - Eastern Ltd, 1983.
5. Basic Nuclear physics; B. N. Shrivastava, Pragati prakashan, Meerut.
6. Theory of Nuclear Structure; M. K. Pal, East - weast press Ltd. 1982.
7. Nuclear Physics; D.C. Tayal, Himalaya Publishing House, Bombay.
8. Experimental Nuclear Physics; E.Serge, John Wiley and sons, New York, 1959.
9. Encyclopaedia of nuclear Physics 3 : M.Chandrabhanu first edition : 2011.
10. Atomic and Nuclear Physics: N Subrahmanyam Brijlal. first edition : 1984.
11.. Atomic and Nuclear Physics : Shatendra Sharma 2008.
12. Nuclear Physics An Introduction: S B Patel 2011.
13. Nuclear Physics : Rajkumar First Edition 2010.
14. Fundamentals of Nuclear Physics : Prof Jahan Singh, Pragati Prakashan First Edition 2012.
15. Radiation Physics For Medical Physicists E.B Podgor Second,Enlarged Edition Springer 2009.
16. Physics and Engineering of Radiation Detection Syed Naeem Ahmed Queen's University, Kingston, Ontario Academic Press Inc. Published by Elsevier First edition 2007
17. Radiation, Ionization, and Detection in Nuclear Medicine: Tapan K.Gupta ISBN978-3-642-34076- 5(eBook) Springer-Verlag Berlin Heidelberg 2013

PHYF-214: Foundation Course in Condensed Matter Physics

(General Condensed Matter Physics)

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives: This course deals with crystalline solids and is projected to make available students with the basic physical concept and mathematical tools used to portray solids. The course deals with groups of materials, as in the periodic table, in terms of their structure, electronic, optical, and thermal properties. Specific objectives are: To show how crystal symmetry leads to substantial mathematical simplifications when dealing with solids. To describe basic experimental measurements, to show typical data sets and to compare these with theory.

Learning Outcomes: The field of General Condensed Matter Physics investigates different classes of materials -metals, ceramics, electronic materials with an emphasis on the relationships between the underlying structure and the processing, properties, and performance of the materials. Research opportunities are offered as scientists and technologists, etc in national and international institutions.

Course Contents:

Unit I : Crystal Structure: (13 Contact hours)

Lattice translation vectors and lattices, basis and crystal structure, primitive, non-primitive Wigner- Seiz cells, fundamental types of lattices, 2d & 3d Bravais lattices, characteristics of cubic lattices, miller indices, symmetry elements, point group and space groups, different crystal structures: hexagonal close packed structure, s.c., b.c.c., fc.c, sodium chloride, diamond, Expermental method on the basis of Ewald Construction, Electron and Neutron diffraction by crystals, Atomic and geometric structure factors, Reciprocal lattice and Brillouin Zone.

Unit II : Lattice Dynamic and Specific Heat: (13 Contact hours)

Vibrations of one-dimensional monoatomic lattices: Firs Brillouin zone, Group velocity, long wavelentha and force constant, Diatomic lattices, quantization of lattice vibrations, phonons, inelastic scattering of neutron by phonons, models of Einstein, Debye of lattice heat capacity, comparison with electronic heat capacity, anharmonicity, thermal expansion and thermal conductivity: thermal resistivity, Umklapp processes and problems: zero point lattice, Grunsissen constant, density of modes of square lattice.

Unit III: Free electron model of metals: (11 Contact hours)

Free electron gas in three dimensions, Fermi - Dirac distribution, heat capacity of electron gas, hall effect, Matthiessen rule, fermi surface, de Hass von Alfen effect, magnetoresistance, tight binding method, pseudopotentials.

Unit IV: Energy bands in solids: (11 Contact hours)

Origin of energy band gap, Bloch function, Kronig-Penny Model, number of states in a band, distinction between metals, insulators and semiconductors, concept of holes, equation of motion for electron and holes, effective mass of electron and holes.

References

1. Solid State Physics: An Introduction- Philip Hofmann, 2nd Edition, Willey-VCH (2015) ISBN: 978-3-527-41282-2, E-Book978-3-527-68206-5.
2. Introduction to solid state physics - C. Kittel, Willey Eastern Pvt. Ltd. (2015) ISBN 10: 8126535180 ISBN 13: 9788126535187.
3. Elementary Solid State Physics - M. A. Omar, Addition Wesley Pvt. Ltd. ISBN 10: 0201607336 ISBN 13: 9780201607338.

4. Solid State Physics - A. J. Dekker, Published by Macmillan India (2000) ISBN 10:0333918339/ISBN 13:9780333918333.
5. Solid State Physics - Aschroft and Mermen, New York, Holt, Rinehart and Winston (1976).
6. Introduction to Solids - L. V. Azaroff McGraw Hill, New York (1960)
7. Solid State Physics - S. O. Pillai, New age International Pvt. Ltd (2015). ISBN 10: 8122436978 ISBN 13: 9788122436976.
8. Solid State Physics - M. A. Wahab (2011). ISBN 10: 8184870566 ISBN 13: 9788184870565.
9. Concept in Solid State Physics - J. P. Shrivastava, Prentice Hall Ltd.
10. Fundamentals of Solid State Physics - Saxena, Gupta, Saxena, Pragati Prakashan, Publisher: Anu Books (2019) **ASIN:** B07YCMDBTT.
11. Dynamical stability and low-temperature lattice specific heat of one-dimensional fullerene polymers, Atsushi Shimizu, Shota Ono,Chemical Physics LettersVolume 694, 16 February 2018, Pages 14-17, https://doi.org/10.1016Zi.cplett.2018.01.037.
12. Photoswitching mechanism of a fluorescent protein revealed by time-resolved crystallography and transient absorption spectroscopy,Joyce Woodhouse, Gabriela NassKovacs, Martin Weik, Nature Communications**volume 11**, Article number: 741 (2020).
13. Structural, morphological, physical and dielectric properties of Mn doped ZnOnanocrystals synthesized by sol-gel method,VD Mote, Y Purushotham, **BN Dole**, Materials & Design 96 (2016) 99-105.

PHYL-221 Lab course 3 (Condensed Matter Physics + Nuclear Physics + Spectroscopy) Credits: 02

This course is based on **Foundation Courses: Condensed Matter Physics, Nuclear Physics and Spectroscopy**)

Learning Objectives: The themes dealt with in this paper:

- This course gives basic foundation to specialization in nuclear physics Condensed Matter Physics and Spectroscopy and applications.
- The course is an advanced course and requires special efforts. So, it can be taught in Semester II.
- The course will help the student to explain characteristics of Geiger Muller counter/tube: Operating voltage, Dead time and counting statistics.
- The course is most suitable in IInd semester, because this interpret the contents of the next following course PHYL-321-Lab course 5 (C1) Nuclear Physics to be covered as lab course in IIIrd semester.

Learning Outcomes: The present unit attempts to achieve the following learning outcomes:

- After completing this course the student will be prepare to explain the scope and possibilities of studies in nuclear physics for research career as well as in industry.
- The students able to explain the characteristics of Geiger Muller counter/tube: Operating voltage, Dead time and counting statistics.
- This course is prerequisite to the second lab course as mentioned above for IIIrd semester.

Course Contents:

1. Study of given XRD data for cubic and diamond type materials and determination of lattice parameters.
2. Study of given XRD data for hexagonal type materials and determination of lattice parameters.
3. Determination of characteristics of Geiger Muller counter/tube: Operating voltage and Dead time.
4. Determination of characteristics of Geiger Muller counter/tube: Counting Statistics.
5. Study of variation of resistivity of given specimen using 4-probe method and determination of its energy band gap.

6. Determination of magnetic Susceptibility of diamagnetic/paramagnetic samples using Guoy type balance method and determination of number of unpaired electron.
7. Study of variation of dielectric constant as a function of temperature and verification of the Curie law and determination of the Curie temperature.
8. Determination of magnetogyric ratio of 1H in glycerin sample
9. Continuous wave NMR experiment in rubber and glycerine
10. Continuous wave ESR experiment in TCNQ and DPPH
11. Determination of band structure of given specimen.
12. Study of Hall Effect and determination of type and number of charge carriers, Hall coefficient and drift mobility
13. Study of UV Vis Spectra of II-VI type semiconductors

A student is expected to perform at least 8 experiments.

PHYL-222; Lab course 4 (Electronics + Computational Physics) Credits: 02

This course is based on **Foundation Course: Electronics**. It also contains some experiments based on **Computational Physics**. Students will choose any four experiments from list of experiments below based on Electronics and four experiments from list of experiments below based on computational physics)

Course Contents:

1. Determination of Characteristics of Op -Amp 741: CMRR and Slew rate.
2. Determination of Characteristics of Op -Amp 741: input offset voltage and input bias current.
3. Study of Inverting and non-inverting amplifier using Op-amp 741.
4. Study of Astable multivibrator using Op-amp 741.
5. Op- amp as comparator and Schmitt Trigger using op-amp 741.
6. Study of Wien bridge oscillator using op-amp 741.
7. Study of Monostable multivibrator using IC-555.
8. Study of Decimal to BCD encoder.
9. Study of diode matrix ROM.
10. Study of Mod 16 ripple counter
11. Study of Mod 10 and Mod 12 ripple counter.

A student is expected to perform at least 8 experiments.

PHYR-231: Research Project Part I (Review of literature for Research Project and formulation of Topic of Research Project) : Credits 02

Students are expected to formulate the topic of research project

Semester - III

PHYF-311: Foundation course in Physics

Electrodynamics

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Outcomes: Students will have achieved the ability to:

1. Use Maxwell equations in analyzing the electromagnetic field due to time varying charge and current distribution.
2. Describe the nature of electromagnetic wave and its propagation through different media and interfaces.
3. Explain charged particle dynamics and radiation from localized time varying electromagnetic sources.

Learning Objectives:

To apprise the students regarding the concepts of electrodynamics and Maxwell equations and use them various situations.

Course content:

Unit I: Electromagnetic wave equation and field vectors: Plane waves in free space. Dispersion of electromagnetic waves. Poynting vector in free space. Polarization of electromagnetic waves, electric field vector in terms of scalar and vector potential. Wave equation in terms of scalar and vector potential. Retarded potentials, Lienard Wiechert potential.

Unit II: Reflection and Transmission of electromagnetic waves: Laws of reflection and refraction, Fresnel's reflection and refraction for vertically and horizontally polarized waves. Brewster or polarizing angle, total internal reflection, reflection and transmission from good conductors for both polarization.

Unit III: Guided waves, wave guide and cavities: Electromagnetic wave propagation between two parallel conducting planes, (TE and TM waves). Rectangular waveguide, Characterizations wave impedance of rectangular waveguide cavity resonator (rectangular and cylindrical).

Unit IV: Relativity and Formulation of Electrodynamics: The relativity of magnetic and electric fields. Transformation of E and B fields. Invariance of Maxwell's equations. Four vectors, Maxwell's equation in four vector form.

References:

1. Electromagnetic Waves and Fields, R. N. Singh, Tata Mc Graw Hill.
2. Classical Electromagnetic Radiation, J. B. Marion

3. Introduction to Electrodynamics, David J. Griffith PHI publications.
4. Classical Electrodynamics, Jackson. John Wiley & Sons, In
5. Electromagnetism Theory and Applications, Ashutosh Pramanik, PHI publication.
6. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat, Narosa
7. Electromagnetic, B. B. Laud, 2nd Edition, Wiley Eastern Ltd

PHYE-312 Generic Electives 1 (A1/ B1/ C1/ D1)

PHYE-312 - Elective 1 (A1): 8086 Microprocessor and Interfacing

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives:

1. To facilitate the students to understand
   a) the concepts of microprocessor and assembly language programming.
   b) the concept of interfacing devices at laboratory as well industrial level
2. To provide an opportunity to the students to enter into entrepreneurship.

Learning Outcome:

1. Students will be able to learn
   a) Microprocessor architecture, physical configuration of memory, logical configuration of memory, microprocessor programming and interfacing.
2. Students will be capable to perform following job
   a) Industrial automation using 8086 interfacing and programming.
   b) Start his / her own small scale industry for manufacturing microprocessor based automated devices.
3. Students will have option to start his / her teaching career either in science or engineering colleges / institutes as this course is included in science as well engineering discipline.

Course Contents:

Unit I: Introduction:

Overview of Microcomputer structure and operation, memory, input / output, CPU, address bus, data bus, control bus, 8086 microprocessor family overview, **8086 internal architecture:** execution unit, (flag register, general purpose register, ALU), Bus interface unit, segment register, stack pointer register, pointer and index register [Refer Douglas and Hall book for above articles], **Pin out and pin functions of 8086 :** The pin out, power supply requirements, DC characteristics, input characteristics, output characteristics, pin connections (common pins, maximum mode pins and minimum mode pins) **Addressing Modes**: Data addressing modes: Register addressing, Immediate addressing, Direct addressing, register indirect addressing, base plus index addressing, register relative addressing, base relative plus index addressing, Programme memory addressing modes:

Direct program memory addressing, relative program memory addressing, indirect program memory addressing; stack memory addressing modes.

Unit II: Data Movement, Arithmetic and Logical Instructions:

MOV revised: machine language, the opcode, MOD field, register assignments, R/M memory addressing, special addressing, **PUSH/POP :** PUSH, POP, initializing the stack; **Miscellaneous data transfer instructions:** XCHG, IN and OUT, **Arithmetic and Logic Instructions: Addition, subtraction and comparison: Addition:** Register addition, immediate addition, memory to register addition, array addition, increment addition, addition with carry; **Subtraction:** Register subtraction, immediate subtraction, decrement subtraction, subtraction with barrow; **Comparison, Multiplication and division**: **Multiplication**: 8 bit multiplication, 16 bit multiplication; **Division:** 8 bit division, 16 bit division; **Basic Logic Instructions:** AND, OR, Ex-OR, TEST, NOT, NEG; **Shift and Rotate: Shift:** left shift, right shift; **Rotate:** Rotate left, rotate right

Unit III: Program Control Instructions and Assembly Language Programming:

The Jump Group: **Unconditional jump:** short jump, near jump, far jump, indirect jumps using an index; **Conditional Jumps:** LOOP, conditional LOOPs; **Procedures**: CALL, near CALL, far CALL, indirect memory address, RET; **Machine Control and Miscellaneous Instructions:** Controlling the carry flag bit, wait, HLT, NOP ; **Assembly Language Programming: Assembler directives:** ASSUME, DB, DD, DQ, DT, DW, END, ENDP, ENDS, EQU, EVEN, EXTRN, GLOBAL, GROUP, INCLUDE, LABEL, LENGTH, NAME, OFFSET, ORG, PROC, PTR, PUBLIC, SEGMENT, SHORT, TYPE [Refer Douglas and Hall book for above articles **Assembly Language Programming:** Sum of an array, factorial, largest / smallest from given array, sorting of numeric array, square root.

Unit IV: Input / Out Interfacing (with reference to 8086 Microprocessor):

Introduction to I/O interface, I/O instructions, isolated and memory mapped I/O, basic input and output interfaces, handshaking, I/O port address decoding: decoding of 8-bit I/O addresses, decoding of 16 - bit I/O address; The programmable peripheral interface: basic description of 8255, programming the 8255, mode 0 operation, an LCD display interfaced to 8255, a stepper motor interfaced to 8255, Mode 1 strobed input, mode1 strobed output , Mode 2 bisectional operation

References:

1. The Intel Microprocessors, Architecture Programming and interfacing, Barry B Brey ; Sixth Edition ; Prentice Hall International, Publications, **(2002),** ISBN-10: 0130607142, ISBN-13: 978-0130607140
2. The Intel Microprocessors, Architecture Programming and interfacing, Barry B Brey ;Eighth Edition ; Prentice Hall International, Publications **(2009),** ISBN 0-13-502645-8
3. Microprocessors and Interfacing : Programming and Hardware, Douglas V Hall : II Edition ; Tata McGraw-Hill **(1990),** ISBN-10: 0070257426, ISBN-13: 978-0070257429.
4. Microcomputer Systems : The 8086 / 8088 Family; Architecture, Programming and Design, Yu-Cheng Liu and Glenn A. Gibson, Prentice Hall International, Publications **(1986),** ISBN-10: 013580499X, ISBN-13: 9780135804995.
5. The 8086/8088 Family: Design, Programming and Interfacing, John, Uffenbeck, Prentice

Hall International, Publications **(1986),** ISBN-10: 0132467526, ISBN-13: 978-0132467520

PHYE-312 - Elective 1 (B1): Atomic Spectroscopy:

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives:

a) The concept of the photon, however, emerged from experimentation with **thermal radiation**, electromagnetic radiation emitted as the result of a source's temperature, which produces a continuous spectrum of energies. More direct evidence was needed to verify the quantized nature of electromagnetic radiation. In this course, we describe how experimentation with visible light provided this evidence.
b) This course addresses various aspects of spectroscopic analysis relevant to research and industry.
c) Seeing that spectroscopy is a set of tools that can put be together in different ways to understand systems and solve chemical problems
d) Understanding basic concepts of instrumentation, data acquisition and data processing.

Learning Outcomes:

After completing this course the student will be able to use spectroscopic methods forqualitative and quantitative analysis.

Course Contents

1. **Reletivistic effect on Atomic Spectra**: Sommerfeld relativity correction, fine structure and spinning electrin, observed hydrogen fine structure, fine structure of ionized helium line X = 4686 A, the Dirac electron in hydrogen atom, Sommerfeld formula from Dirac's theory.
[Scope: Introduction to Atomic Spectra by H. E. White,Chapter IX] Lamb shift (qualitative) [Scope: Atomic Physics, Christopher J. Foot , page 40-41].

2. **Atoms in magnetic field**: Vector model of a one electron system in weak magnetic field, magnetic moment of bound electron, magnetic interaction energy, selection rules, intensity rules, Paschen Back effect, Paschen Back effect of a Principal series doublet, selection rules for Paschen Back effect, The Zeeman and Paschen Back effects for hydrohen, Quantum mechanical model of an atom in a strong magnetic field.
[Scope: Introduction to Atomic Spectra by H. E. White,Chapter X]

3. **Complex Spectra:** Regularities in atomic spectra of complex atom-The Rydberg Series

relationship, Hartley law of constant doublet separation, Displacement law, Law of alternation of multiplicities. Terms in many electron atom - Terms arising due to L-S coupling, Terms in j-j coupling non-equivalent electrons system, Terms in equivalent electron system - Two s-electrons, Two p-electrons, Three equivalent p-electrons, Four equivalent p-electrons, Five equivalent p-electrons, Six equivalent p-electrons, Two equivalent d-electrons, Equivalent electrons in j-j coupling, Lande interval rule. Application of Lande Interval rule, Hund's rules, Pauli exclusionprinciple for p^2, p^3, p^4, p^5, d^2 electrons.

4. **X-ray Spectra**: Mosley's law, Absorption spectra, energy levels, selection and intensity rules (Burger - Dorgelo - Ornstein rules), regular and irregular doublet law, predicted structure in x-rays, x-ray satellites, explanation of x-ray absorption spectra.
   [Scope: Introduction to Atomic Spectra by H. E. White, Chapter XIV]

Books:

1. Introduction to Atomic spectra by H E White McGraw Hill. McGraw-Hill Inc.,New York, US, **ISBN-10:** 0070697205, **ISBN-13:** 978-0070697201, (1934 & 1954)
2. Atomic Physics by Christopher J. Foot, ISBN: 9780198506959 Published by Oxford University Press, New York 2005-02-10 (2005) Oxford University Press.
3. Laser Spectroscopy, Volume 1: Basic Principles, Fourth Edition by Wolfgang Demtroder, Springer,
   ISBN 978-3-540-73415-4 e-ISBN 978-3-540-73418-5 , DOI 10.1007/978-3-540-734185
   Library of Congress Control Number: 2007939486, © 2008, 2003, 1996, 1981 Springer-Verlag Berlin Heidelberg.
4. Atom, laser and spectroscopy by S. N. Thakur and D. K. Rai, ISBN: 9788120339569 Published by A. K. Ghosh Prentice Hall India Learning Private Limited, New Delhi (2010) First Edition. Second Edition ISBN: 9788120348325, Published Prentice Hall India Learning Private Limited, New Delhi (2011).
5. Modern Spectroscopy by J. M. Hollas, ISBN: 9780470844167, Published by John Wiley & Sons Ltd. (2004) Fourth Edition.

PHYE-312 - Elective 1 (C1): Radioactivity and Nuclear Decay:

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials:12

Learning Objectives: Nuclear physics is one of the most important topic of physics. This course is necessary as it gives the idea of important phenomenon of Radioactivity and various nuclear decays, the course will help the student for preparation of NET/SET and other competitive examinations. It should be taught as an Elective.

Learning Outcomes: This course is beneficial to students because it can help to understand the uses of radioactivity in determining age of earth, mountains, etc. The understanding of various nuclear decay is beneficial in radio physics / Chemistry and in the field of medical (Treating the cancer patients). The students can get job in medical diagnostic centers as well as they can do research in BARC and other institutions.

Course Contents:

Unit I: Radioactivity
Introduction, Basic parameters of radioactivity, radioactive series, Induced radioactivity (Artificial radioactivity), radioactivity dating, The age of earth, Units of radioactivity, Radiation dosimetry.

Unit II: Alpha Decay
Introduction, Properties of alpha particle, Disintegration energy of alpha decay, Alpha Spectrum, Range of alpha-particles and Geiger-Nuttal law, Long range alpha-particles, Experimental methods for range of alpha-particles (Bragg and Kleeman method, Geiger-Nuttal method), Conservation laws in alpha decay, Gammows theory of alpha decay.

Unit III: Beta Decay
Introduction, Properties of beta-ray, Types of beta decay processes, Energetics of beta decay, Bucherer's method for e/m, Beta ray spectra, Pauli's Neutrino hypothesis, Fermi's theory of beta decay, Selection rules in beta decay, Energy levels and decay schemes.

Unit IV: Gamma Decay
Introduction, Properties of gamma-ray, Selection rule, Multipolarity in gamma transitions, Life time of gamma active nuclei, Gamma rays spectra, Conservation laws in gamma emission, Internal conversion, Nuclear isomerism, Mossbauer effect, Interaction of gamma rays with matter.

References:

1. **Nuclear Physics,** R. C. Sharma, 1st edition, K. Nath & Co. Meerut- (2007) (ISBN-EBK0036746).
2. **Fundamentals of Nuclear Physics,** Jahan Singh, 1st edition, Pragati Prakashan, Meerut- (2012) (ISBN-978-93-5006-593-8)
3. **Radioactive Materials,** Dr. B. M. Rao, 1st edition, Himalaya Publishing House, Mumbai- (2002).
4. **Nuclear Physics,** S. B. Patil, 1st edition, New Age International Publishers, New Delhi- (1991) (ISBN-978-81-224-0125-7).
5. **Nuclear Physics,** D. C. Tayal, 10th edition, Himalaya Publishing House, Mumbai- (2005) (ISBN-81-8318-281-x).
6. **Basic Nuclear Physics,** B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
7. **Nuclear Physics,** Satya Prakash, 2nd edition, Pragati Prakashan, Meerut (2011) (ISBN-81-7556-915-8).
8. **Nuclear Physics,** K. P. Das, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-517-3).

PHYE-312 - Elective 1 (D1) : Crystallography:

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning objectives: The objective of this course is to present the basic concepts needed to understand the crystal structure of materials. Fundamental concepts including lattices, symmetries, point groups, and space groups will be discussed and the relationship between crystal symmetries and physical properties will be addressed. The theory of X-ray diffraction by crystalline matter along with the experimental X-ray methods used to determine the crystal structure of materials will be covered. Application of X-ray diffraction electron diffraction and neutron diffraction will be briefly discussed.

Students will be able to: i) Describe what can be detected with X-ray crystallography ii) explain the impact of temperature iii) atom size, and impurities on the tests.

Learning Outcomes: Acquisition of the following skills: i) Ability to explain basic/fundamental crystallographic concepts ii) Ability to extort the relevant information from a crystallographic paper.iii) Ability to find specific tools for solution of a given crystallographic problems.

iv) An ability to relate their broad tutoring toward the understanding of the impact of engineering solutions in a global and societal context.

Course Contents:

Unit I: Crystal Binding: (12 Contact Hours)

Crystal of inert gases, Van der Waals - London interaction, repulsive interaction, cohesive energy, ionic crystals, Madelung energy, Born-Mayer model, evaluation of Madelung constant for an infinite line of ions, binding in covalent, metal and Hydrogen bonded crystals, Atomic radii.

Unit II: Crystallography and Crystal Physics: (12 Contact Hours)

Principle of powder diffraction method, interpretation of powder photographs, indexing of powder patterns, accurate determination of lattice parameters, least square method, Synchrotron X-ray diffraction (SCXRD), applications of powder method, Diffraction by an ideal crystal, The Debye - Waller factor. External symmetry elements of crystals, influence of symmetry on physical properties, derivation of equivalent point position, experimental determination of space groups;

Unit III: Defects and Alloys: (12 Contact Hours)

Classification of defects, Point defects: Vacancy, Schottky, Frenkel Defects, Color Centres, Line Defects: Edge Dislocation, Screw Dislocation, Burger Vector, Alloys: diffusion, magnetic alloys and Kondo effect, Dislocation in Crystals: slip and plastic deformation, shear strength of single crystals, stress fields of dislocations, dislocation multiplication and slip, short and low range order in liquids and solids, liquid crystals, quasi crystals and glasses, low angle grain boundaries, dislocation densities, dislocation and crystal growth, whiskers.

Unit IV: Semiconductor Devices: (12 Contact Hours)

Intrinsic and extrinsic semiconductors, intrinsic and extrinsic carriers concentration, electrical conductivity and mobility and their temperature dependence, thermal electron power transport in semiconductors, Hall effect, Experimental determination of Hall coefficient, Semiconductor Devices: p-n junction, forward and reverse biasing, volt-ampere characteristic of p-n junction, Zener diodes, Tunnel Diode, Photodiode, Solar cells, Light emitting diode (LED), Thermistors and Batteries, Field effect Transistor(FET), Metal Oxide Semiconductor Field Effect Transistor (MOSFET), Quantum Dots (QDs), applications of semiconductors, Problems.

Unit V: Tutorials, assignments and seminar presentations based on unit I, II, III and IV
(12 Contact Hours)

References:

1. Introduction to Solid State Physics, Charles Kittel, Willey India Edition, (8th Edition), ISBN - 978-0-471-41526-8, 1 January 2019.
2. Elementary Solid State Physics - M. A. Omar, Addition Wesley Publishing Company 1993, Digitized 21/11/2007, ISBN: 0201607336.
3. Solid State Physics - A. J. Dekker, Published by Macmillan India (2000) ISBN 10:0333918339/ ISBN 13:9780333918333.
4. Solid State Physics - N. W. Aschroft and N. D. Mermin, Publisher Cengage Learning, 2011, ISBN: 8131500527.
5. Introduction to Solids - L. V. Azaroff, McGraw Hill, New York, 2001, ISBN: 10:0070992193.
6. Solid State Physics - S. O. Pillai, Publisher Kent: New Age Science, 2010,
7. Solid State Physics - M. A. Wahab, Narosa Publishinng House, ISBN: 81-7319-266-9.
8. Concept in Solid State Physics - J. P. Shrivastava, Prentice Hall Ltd.
9. Solid State Physics - Saxena, Gupta, Saxena, Pragati Prakashan Eleventh Edition, 2007, ISBN: 81-8398-135-6.
10. Crystallography of Quasicrystals- Walter Steurer; Sofa Deloudi, Springer 2009, e-Book.
11. Crystallography- E.J.W. Whittaker, Elsevier Science 2013, e-Book.
12. Point Defects in Solids- James H.Crawford; Lawrence M. Slifkin, Springer US 2012, e-Book
13. Alloy Physics- Wolfgang Pfeiler, Wiley 2008, e-Book
14. The Physics of Dilute Magnetic Alloys- Jun Kondo; Shigeru Koikegami; Kosuke Odagiri; Kunihiko Yamaji; Takashi Yanagisawa, Cambridge University Press 2012, eBook.
15. Dislocations in Solids-John P. Hirth, Elsevier Science 2011, e-Book.
16. Crystal Growth Technology: Semiconductors and Dielectrics (Kindle Edn.) -Hans J. Scheel (Editor),Peter Capper(Editor),Peter Rudolph(Editor) 2011, Amazon Inc. eBook.
17. Dislocation Models of Crystal Grain Boundaries, W. T. Read and W. Shockley,APSJournals, Physical Review Letters, Phys. Rev. 78, 275 - Published 1 May 1950.
18. Defect engineering using crystal symmetry, Ramamoorthy Ramesh, | PNAS | September 18, 2018 | vol. 115 | no. 38, pp 9344-9346.
19. Interstitial Point Defect Scattering Contributing to High Thermoelectric Performance in SnTe, Pei, Y. et al., Adv. Electron. Mater. 2, (2016) 1600019.
20. Irradiation responses and defect behavior of single-phase concentrated solid solution alloys, T. Yang et al., J. Mater. Res., 2018, pp1-15.

21. Native Point Defect Measurement and Manipulation in ZnO Nanostructures, Leonard Brillson, Jonathan Cox, Hantian Gao, Geoffrey Foster, William Ruane, Alexander Aarjour, Martin Allen, David Look, Holger von Wenckstern and Marius Grundmann, Materials (2019), 12, pp 2242.
22. A study of the 160 MeV Ni 7+ swift heavy ion irradiation effect of defect creation andshifting of the phonon modes on MnxZn1-xO thin films, H A Khawal, **B N Dole**, RSC Advances 7 (55), (2017) 34736-34745.

PHYE-313 Generic Electives 2 (A2/ B2/ C2/ D2)

PHYE-313 - Elective 2 (A2) : Microwaves

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives: The themes dealt with in this paper:

1. Gain knowledge of microwaves, its features, different bands and its applications.
2. Analyze transmission line, their associated problems and applications. Also gain knowledge of the Smith chart for solving transmission-line problems
3. To Analysis and study characteristics of microwave tube Generators, Amplifiers and microwave Semiconductor of devices.
4. Obtain knowledge of microwave components such as tees, couplers, hybrid junctions, ferrite devices and different microwave antennas.
5. Impart knowledge of different microwave measurements like power, frequency, impedance, S-parameters and VSWR.

Learning Outcomes (COs): At the end of the course the student should be able to:

1. Able to design impedance matching network for any transmission line or system.
2. Able to analyze and find applications and limitations of microwave tube Generators, Amplifiers and semiconductor devices.
3. Able to discriminate different microwave components find applications and use it in supporting systems.
4. Able to Conduct experiments and interpret the data accordingly.
5. Able to apply theory and practical knowledge of microwaves for various microwave

engineering in specific area.

Course content:

Unit I: Introduction of Microwaves and Transmission line theory (12 Contact Hours)
Microwave frequency, features, applications and bands. Distributed parameters, Basic transmission line equations and solution, Determination of alpha and beta for a transmission line. Distortion on a transmission line, conditions for distortion less line. Standing waves, standing waves ratio, quarter & half wavelength lines, Properties of lines of various lengths, Impedance matching by use of stubs, matched lines, Smith chart.

Unit II: Microwaves Generators: (12 Contact Hours)
Tubes: Two cavity Klystron, velocity modulation, mathematical analysis, performance and applications. Multi cavity klystron. Reflex klystron, operation, transit time, Relation between repeller voltage and frequency, Modes, Applications. Magnetrons, crossed electric and magnetic fields, RF structure of magnetron, oscillation mechanism in magnetron, travelling wave tube amplifier, backward wave oscillator.
Microwave solid state devices: MESFET, principle of operation, Gunn diode, background, Gunn effect, Mode of operations, Gunn oscillator modes, Transit time mode, Quenched and delayed domain modes, LSA mode. Gunn oscillator circuits, coaxial cavity waveguide cavity circuits.

Unit III: Microwave Components and antennas: (12 Contact Hours)
Waveguide tees, E- plane tee and H-plane tee, Hybrid junction. Directional coupler, two hole directional coupler, loop directional coupler, Isolators, Faraday's rotational isolator, applications, Circulator, Microwave network representations, S- Matrix theory of E, H, Directional coupler and magic tee.
Microwave antennas: Horn antenna, microwave dish antenna, lens antenna, slot antenna, broadband antenna.

Unit IV: Microwave Measurements: (12 Contact Hours)
Measurement of power by bolometer, bridge method, calorimeter, VSWR Measurement (High & low), Detector diodes and detector mounts, Detector output indicator, Impedance measurement by slot line and probe, Network analyzer, Measurement of scattering parameters, Frequency measurement by wave meter, Electronics techniques for frequency measurement, transfer oscillator and direct reading microwave counters.

Unit V: Tutorials, assignments and seminar presentations based on unit I, II, III and IV **(12 Contact Hours)**

References:

1. Microwave Devices and Circuits, by Samuel, Liao, Fourteenth impression PHI. ISBN 81-978-81-7758 (2012)
2. Microwaves, by K.C. Gupta, Wiley Estern Ltd. ISBN 0 85226 346 5
3. Microwave Engineering, by Sanjeev Gupta, Khanna Publishers.
4. Electronics Communications, by Sanjeeva Gupta, Khanna Publishers Delhi- 6. (For Chap. 3 and 5)
5. Electronics Communication systems By George Kennedy third Edn

6. Networks Lines and Filters by John D. Ryder, PHI second Edn.
7. Microwave Engineering by Annapurna Das & Sisir K. Das (TMH Publication) 2000.
8. Introduction to Microwaves, by G. I Wheelers, PHI
9. Microwave and Radar Engineering, by M. Kulkarni, 3rd Edition , Umesh Publications Delhi 110006
10. Antenna and wave propagation by G S N Raju
11. Microwave Engineering, by Monojit Mitra, II Edition,

PHYE-313 - Elective 2 (B2): Molecular Spectroscopy

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives:

- Introduction to electronic spectroscopy of diatomic molecules
- study of vibrational course structure of electronic spectra of diatomic molecules; analysis of vibrational spectra of diatomic molecules and estimation of moment of inertia, force constant and bond length
- To understand the electronic structure, coarse and fine structure of energies of electronic states, of diatomic molecules
- To understand the vibrational, rotational motions and coupling of these motions by evaluating the vibrational and rotational constants of the electronic states
- To understand various coupling schemes
- To understand uncoupling phenomena like A type doubling and spin uncoupling
- Determination of term manifold of homonuclear and heteronuclear diatomic molecules
- To understand the symmetry properties of the electronic wavefunctions,he selection rules and allowed electronic transitions
- To understand the basic physics of Raman scattering of diatomic/polyatomic molecules; experimental techniques of Raman spectroscopy; analysis of Raman spectra for investigating the molecular structure

Learning Outcomes:

The student will be able to:

CO1	arrange the wavenumbers of band heads and band origin in the Deslandres table;identify various sequences and progressions in the band spectrum;analyze the electronic spectra of diatomic molecules, and estimate vibrational constants and vibrational energies; able to calculate: harmonicity and anharmonicity constants of the upper and lower electronic states, force constants the upper and lower electronic states
CO2	explain various coupling schemes and uncoupling phenomena
CO3	calculate the term manifold of homonuclear and heteronuclear diatomic molecules
CO4	explain the symmetry properties of rotational levels of upper and lower electronic state
CO5	explain the symmetry properties of rotational levels of lower electronic state
CO6	explain the selection rules for electronic transitions ; draw the allowed electronic

transitions

CO7 describe the role of various parts of Raman spectrometer,analyze the Raman spectra of molecules, and determine their structure

Course Contents:

Unit I: Electronic Spectra of Diatomic Molecules:

Electronic energy and total energy, electronic energy and potential curves; stable and unstable molecular states, resolution of total eigen functions, resolution of total energy, Vibrational structure of electronic transitions: general formulae, examples; graphical representation, Deslanders table, progressions and sequences, evaluation of vibrational constants, Rotational structure of electronic bands. Band head formation and shading of bands. Combination relation and evaluation of rotational constant for bands without and with Q branches. Band origin determination. Isotope effect in electronic spectra

Unit II: Coupling of rotation and electronic motion:

Classification of electronic states; multiplet structure, orbital angular momentum, spin, total angular momentum of the electrons; multiplets, symmetry properties of the electronic eigen functions, Hunds cases a, b and c, Uncoupling phenomena: A type doubling, Spin Uncoupling. Symmetry properties of rotational levels. Types of

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electronic transitions, selection rules, Study of ^- and n- transitions.

Unit III: Determination of term manifold:

Separated atoms. (like and unlike atoms) Term manifold from electronic configuration. Pauli principle. Term of non-equivalent electrons. Molecular configurations of CO, C2, N2, AlO, BeO, BeH etc molecules. Types of binding. Homopolar, Heteropolar and Van der Waal.

Unit IV: Raman Spectroscopy:

Classical theory and quantum theory of Raman effect, Pure rotational Raman Spectra, Raman spectra of linear, symmetric top and asymmetric top molecules. Raman activity of vibrations, vibrational Raman Spectra. Rotational fine structure, polarization of light and Raman effect, degree of polarization, Vibration of spherical top molecules.

Structure determination from Raman and IR spectra,

Instrumentation: Raman spectrometer

References:

1. Spectra of Diatomic Molecules by G. Herzberg, Krieger Malbar Florida,1950, ISBN-10: 1406738530, ISBN-13: 978-1406738537

2. MOLECULAR STRUCTURE AND SPECTROSCOPY, by ARULDHAS, G. , Second Edition ,2004; ISBN: 978-81-203-3215-7, PHI Learning

PHYE-314 - Electives 2 (C2): Reactor Physics

(Credits: 04; Contact Hours: 60)

Lectures: 48 ;Tutorials: 12

Learning Objectives: The themes dealt with in this paper:

- Outline and brief description, including fundamentals of the different reactors like swimming pool (Apsara) type reactor, Zerlina type reactor etc.
- To enable the students to study the basic and advance concepts of Reactor Physics

Learning Outcomes: The present unit attempts to achieve the following learning outcomes:

- To explain the basic properties of neutrons and their sources.
- Able to define the different types of detectors.
- To explain the strengths and weakness of different types of detectors.
- To describe Neutron Diffraction.
- Students will be able to study the basic and advance concepts of Reactor Physics will be able have job opportunities in BARC.

- **Course contents:**

Unit I: The Neutron

Discovery of neutron, neutron sources, basic properties of neutrons, wavelength of neutrons, high energy neutrons, measurements of energy of neutrons, time of flight method.

Unit II: Neutron Detections

Detection of neutrons, detection of slow neutrons- foil- activation method, ionization chambers and counter tubes for the detection of slow neutrons, Scintillatiors for the detection of slow neutrons, fission chambers for detection of thermal neutrons, detection of fast neutrons.

Unit III: Neutron Diffraction

Neutron diffraction from crystal, reflection for slow neutrons from mirrors, mechanical velocity selectors, measurement of neutron cross-section as a function of energy, cold neutrons and their isolations, neuton electron interaction, decay of neutrons.

Unit IV: Physics of Nuclear Reactors

Thermalization of neutrons, dynamics of elastic scattering of neutrons, angular distribution of neutons, diffusion of thermal neutron ,Fermi age equation, condition of criticality of a reactor, critical equation of a reactor, rectangular parallelepiped reactor.

Types of Nuclear reactors : Spherical reactor, reactor in the shape of a cylinder, Physical processes in a reactor, control of reactors, nuclear fuel conversion, nuclear materials employed in reactors, moderators, some important reactors, Swimming pool (Apsara) type reactor, Zerlina type reactor.

References:

1. Nuclear Physics, R. C. Sharma.
2. Nuclear Physics, I. Kaplan, 2nd edition, Narosa, 1989.
3. Basic Nuclear physics, B. N. Shrivastava, Pragati prakashan, Meerut.
4. Nuclear Physics, D.C. Tayal, Himalaya Publishing House, Bombay.
5. The elements of nuclear reactor theory, Glastone and Edund.
6. Introduction to Nuclear Engineering, Murry.

PHYE-313 - Elective 2 (D2) : Electrical Properties of Solids and Superconductivity

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives: The course aims at giving the students,

- In depth knowledge and know-how within the theory of superconductivity in order to understand and describe the principles behind various superconducting applications.
- Distinguish between perfect conduction and perfect diamagnetism, and give a qualitative description of the Meissner effect, describe different theories of superconductivity and their ranges of validity.
- Get familiarized with the types of polarization of dielectrics in static and alternating electric fields.
- Acquiring of knowledge concerning the electrical behaviour of dielectric and ferroelectric materials. Will be able to experimentally investigate ferroelectric and dielectric materials.

Learning Outcome: At the end of the course the student will be able to

- Describe different theories of superconductivity and basic properties of superconductors.
- Explain type-I and type-II superconductivity based on thermodynamic calculations of the Gibbs free energy for a superconductor.
- Will learn to understand the relationship between material structure and electrical properties of materials.
- Will acquire knowledge about different types of dielectric and ferroelectric materials.
- A student can develop research/teaching career in the field of Superconductivity/ Dielectrics.

Course Contents:

Unit I: Dielectric Properties of Solids

Fundamental definitions, Local field, Clausius- Mossotti relation, Polarization mechanisms in dielectrics: induced, orientational, electronic, ionic, interfacial and lattice polarizations; combined mechanisms, frequency and temperature effects on polarization, Classical theory of electronic polarizability, dipolar polarizability. Langevin's theory of dipolar polarizability dielectric loss, dielectric breakdown, determination of dielectric constant, properties and different types of insulating materials, Debye theory, Onsager equation, Applications.

Unit II: Ferroelectric properties of Solids

Fundamentals, Curie-Weiss law, Classification of ferroelectric materials, Theory of spontaneous polarization of $BaTiO_3$, antiferroelectricity and ferrielectricity, Ferroelectric domains, Piezoelectricity, Pyroelectricity, Applications

Unit III: Basic properties of Superconductors

Some fundamental Phenomena associated with Superconductivity (Zero resistance, persistent currents, superconducting transition temperature T_c, isotope effect, perfect diamagnetism and

Meissner effect, penetration depth and critical field, Characteristics Length,). Type-I and Type-II Superconductors, Intermediate states, mixed states, Supercurrents and Critical Currents., Quantization of Magnetic Flux. Thermodynamics of superconducting transition: First order and second order transition, specific heat above and below Tc, thermal conductivity;

Unit IV: Theories of Superconductivity

London Equations, BCS theory: Coherence of the BCS Ground State and the Meissner- Ochsenfeld Effect ,Electron -Electron Interaction via Lattice Cooper Pairs, BCS Wave function; Tunneling phenomenon, energy level diagram, ac And dc Josephson Effects, quantum interference. Novel High Temperature superconductors, Applications.

References:

1. Introduction to Solid State Physics, C.kittl;7th Edition; Wiley Eastern Pvt. Ltd.(2011); ISBN-978-81-265-1045-0.
2. Solid State Physics, A.J.Dekker; Macmillan Publishers India Ltd.; (2012); ISBN-10: 0333-91833-9; ISBN-13: 978-0333-91833-3.
3. Introduction to Solids, L.V.Azaroff; TMH Edition; 33rd reprint (2009); TATA McGraw Hill; ISBN-13: 978-0-07-099-219-1; ISBN-10: 0-07-099-219-3
4. Solid State Physics, M.A.Wahab; 2nd Edition; 3rd reprint (2008); Narosa Publishing House Pvt. Ltd; ISBN: 978-81-7319-603-4.
5. Solid state physics, S.O.Pillai; 6th Edition; New Age international Pvt. Ltd.; (2005); ISBN:81-224-1682-9.
6. Solid State Physics, Vimal Kumar Jain; Ane Books Pvt. Ltc; (2013); ISBN:978-93-8116-297-2.
7. Modern Physics and Solid State Physics (Problems and Solutions), S.O.Pillai; Revised 3rd Edition; New Age International Publishers; ISBN:81-224-1704-3.
8. Elementary Solid State Physics, M. Ali Omar; 5th Impression (2009); Pearson Education.inc; ISBN:978-81-7758-377-9.
9. Fundamentals of Solid State Physics, Saxena, Gupta, Saxena,; 50th Edition; Pragati Prakashan; (2012); ISBN:978-93-5006-539-6.
10. Solid State Physics, Neil W. Ashcroft, N. Devid Mermin; 9th Indian Reprint (2010); CENGAGE Learning India Pvt. Ltd. (India Edition); ISBN-13: 978-81-315-0052-1.

PHYE-314 - Electives 3 (A3/ B3/ C3/ D3/E3/F3/G3/H3/I3/J3) (Any One)

PHYE-314 - Electives 3 (A3): Industrial Electronics

(Credits: 04; Contact Hours: 60)

Lectures: 48 ;Tutorials: 12

Learning Objectives:

- To get an overview of different types power semiconductor devices and their switching characteristics.
- To learn about types of operations.
- To learn about types of power converters.
- To learn about dc converters.

Learning Outcomes (COs): At the end of the course, students will be able to:

CO-1	Explain the operation of SCR, UGT, PUT and its related circuits.
CO-2	analysis of UGT, PUT oscillators
CO-3	discuss working of controlled half wave and full wave rectifiers with different types of load
CO-4	discuss principle and working of different types of chopper circuits
CO-5	design the different types of circuits using SCR, UGT and PUT for various applications
CO-6	discuss the need for parallel and series operations of power devices

Course content:

Unit I: Thyristor: Principles and Characteristics: (12 Contact Hours)

Thyristor family, Principle of operation of SCR, Two transistor model of SCR, Thyristor Construction, Turn on methods of Thyristor, Dynamic turn on switching characteristics, Turn off mechanism.Gate Triggering Circuits: Resistance firing circuit, Resistance and capacitance firing circuit, Resistance capacitance full wave trigger circuit, Unijunction transistor, Basic operation, UJT relaxation oscillator, UJT as an SCR trigger, Synchronized UJT triggering. Programmable Unijunction transistor, PUT as an SCR trigger.

Unit II: Series and Parallel operation of Thyristors : (12 Contact Hours)
Series operation of Thyristors, Need for equalizing Network, equalizing network design, Triggering of series connected Thyristors, Parallel operation of Thyristors, Methods of ensuring proper current sharing, triggering of Thyristors in parallel .

Unit III: Phase Controlled Rectifiers: (12 Contact Hours)
Phase angle control, Single-phase half-wave controlled rectifier: with restive load, with inductive load, effect of freewheeling diode, Single-phase full-wave controlled rectifier: Mid point converter (M-2 connection): with restive load, with inductive load, effect of freewheeling diode.

Unit IV: Choppers: (12 Contact Hours)
Introduction, Principle of chopper operation, Control strategies: Time-Ratio Control, constant frequency system, variable frequency system, Current-limit Control; Step-Up Choppers, Step-Up/down chopper, Jones chopper (design not expected).

Unit V: Tutorials, assignments and seminar presentation based on unit I to IV.
(12 Contact Hours)

Text Books, Reference books and Websites

1. Power Electronics, M D Singh and K B Khanchandani (TMH), 2004, ISBN0-07- 463369-4.
2. Power Electronics, M.S.Jamil Asghar, PHI, 2006, ISBN :81-203-2396-3.
3. Principles of Electronics, V.K.Metha , Rohit Mehta, S. Chand and Company Ltd. 2012, ISBN: 81-219-2450-2.
4. Power Electronics P S Bimbhra Khanna Publishers 1998, ISBN 81 -7409-020-7.
5. Electrical circuits and Basic Semiconductor Electroics, Pragati Prakashan Meerut, 2010, ISBN 978-93-5006-302-6.
6. Industrial Electronics, G.K. mithal, Khanna Publishers, Delhi, 1987.
7. Industrial Electronics, S.N.Biswas, Dhanpat rai and Sons, 1996.

PHYE- 314 - Electives 3 (B3) : Modern Trends in Spectroscopy

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives:

a) Acquiring of knowledge concerning the electrical behavior of dielectric materials.
b) The students become accustomed with the nuclear magnetic resonance (NMR) methods.
c) The student will develop their abilities to investigate polyatomic molecules by NMR spectroscopy.
d) Imparting knowledge based on fundamentals of physical principles and measurement methods used for characterization.

Learning Outcomes:

a) The student will be able to analyze the molecular spectra.
b) The student will be able to analyze the FTIR spectra of thin film and molecules and determine their structure.
c) The student will be able to analyze the NMR spectra of molecules, and determine their structure.
d) The student will be able to get the information about a particular substance using ESR, NMR, Raman and FTIR.

Course Contents

1. **ELECTRONS SPIN RESONANCE SPECTROSCOPY:**
Principle of ESR, ESR Spectrometer, Total Hamiltonian, Hyperfine Structure, ESR Spectrum of Hydrogen Atom, ESR Spectra of Free Radicals in Solution- Energies of Radicals with One Unpaired Electron, CH3 Radical, Benzene Anion ($C_6H_6^-$), etc.
[Scope: Molecular structure and spectroscopy by G Aruldhas, Prentice Hall of India, Chapter 11].

2. **NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY:** Introduction, Magnetic Properties of Nuclei, Resonance Condition, NMR Spectrometer, Relaxation Processes and their Mechanism. Bloch Equation, Fourier Transformation, Dipolar Interaction, Chemical Shift. Indirect Spin Interaction. Spectrum of Spin 1/2 AB System. Interpretation of Few NMR Spectra.
[Scope: Molecular structure and spectroscopy by G Aruldhas, Prentice Hall of India, Chapter 10].

3. **FOURIER TRANSFORM INFRARED SPECTROSCOPY:**
Introduction, Historical Background, FT-IR Spectroscopy, Basic Integral Equation, Attenuated Total Reflectance, Experimental Setup, Advantages, Other Aspects,

Applications, Surface Studies, Characterization of Optical Fibers, Vibrational Analysis of Molecules, Study of Biological Molecules, Study of Polymers.
[**Scope**: Handbook of Applied Solid State Spectroscopy, by D. R. Vij, Springer, chapter 9].

4. **NONLINEAR SPECTROSCOPIC PHENOMENA:** Nonlinear Raman Phenomena (Preliminaries), Hyper Raman Effect, Stimulated Raman Scattering, Inverse Raman Effect, Coherent Anti-Stokes Taman Scattering, Photo-acoustic Raman Scattering, Multiphoton Spectroscopy.
[Scope: Molecular structure and spectroscopy by G Aruldhas, Prentice Hall of India, Chapter 15].

Books:

1. Dielectric Properties and Molecular Behaviour, by Nora E. Hill, A. H. Price and Mansel Davies, ISBN 10:0442034113ISBN 13:9780442034115Published by Van Nostrand Reinhold Company (1969) London.
2. Handbook of Applied Solid State Spectroscopy, by D. R. Vij, ISBN: 978-0-387-32497-5 (Print) 978-0-387-37590-8 (Online) **DOI** 10.1007/0-387-37590-2, 2006 Springer.
3. MOLECULAR STRUCTURE AND SPECTROSCOPY, by ARULDHAS, G. , Second Edition ,2004. ISBN: 978-81-203-3215-7, PHI Learning.

PHYE-313 - Elective 3 (C3) : Nuclear Reactions and Nuclear Energy

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives: The themes dealt with in this paper:

> This course gives basic foundation to specialization in nuclear physics and applications, including power production through fission and fusion reactors.

> The course is an advanced course and requires special efforts. So, it can be taught as an elective course only.

> The course will help the student for preparation of NET/SET and other competitive examinations.

> The course is most suitable in IIIrd semester, because this knowledge is essential for understanding the contents of the next following course "radiation measurements and Nuclear dosimetry" to be covered as elective course in IVth semester.

Learning Outcomes: The present unit attempts to achieve the following learning outcomes:

- After completing this course the student will be to prepare to understand the scope and possibilities of studies in nuclear physics for research career as well as in industry.
- This course is prerequisite to the second elective course as mentioned above for IVth semester.

Course Contents :

Unit I: General Features of Nuclear Reaction
Introduction, Conservation laws in nuclear reactions, Energetics and Q-Value of nuclear reaction, Nuclear transmutation, Nuclear reaction cross-section, Partial cross-section, Determination of cross-section, partial wave analysis for reaction cross-section, Breit-Wigner dispersion formula, Level width.

Unit II: Nuclear Reaction Mechanism
Types of nuclear reaction, Compound Nucleus, Theory of nuclear reaction, Characteristics of pre-equilibrium reaction, Direct reaction, Theory of Stripping and Pick-up reaction, Continuum theory of nuclear reaction, Statistical theory of nuclear reaction.

Unit III: Nuclear Fission
Introduction, Nuclear fission, Types of fission, Emission of nuclear fission, fission of fertile material, Distribution of mass of fission products, Energy released in fission, Distribution of energy of fragments, Neutrons released in fission, Prompt and delayed neutrons, Spontaneous fission, Theory of fission (Liquid drop model), Nuclear chain reaction, Four factor formula, Nuclear Reactor, Breeding of fuel, Classification of Nuclear Reactor.

Unit IV: Nuclear Fussion
Introduction, The plasma, Fussion reaction in the plasma, Conditions for maintain fussion reaction, Stellar energy, Sources of stellar energy, Carbon-Nitrogen cycle, Controlled thermal nuclear reactions, The eight synthesizing processes.

References :

1. **Nuclear Physics,** D. C. Tayal, 10th edition, Himalaya Publishing House, Mumbai- (2005) (ISBN-81-8318-281-x).
2. **Nuclear Physics,** R. C. Sharma, 1st edition, K. Nath & Co. Meerut- (2007) (ISBN-EBK0036746).
3. **Fundamentals of Nuclear Physics,** Jahan Singh, 1st edition, Pragati Prakashan, Meerut- (2012) (ISBN-978-93-5006-593-8)
4. **Nuclear Physics,** S. B. Patil, 1st edition, New Age International Publishers, New Delhi- (1991) (ISBN-978-81-224-0125-7).
5. **Nuclear Measurement Techniques,** K. Sri Ram, 1st edition, Affiliated East-West Press, Madras(1986) (ISBN-81-85095-56-6).
6. **Basic Nuclear Physics,** B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
7. **Nuclear Physics,** Satya Prakash, 2nd edition, Pragati Prakashan, Meerut (2011) (ISBN-81-7556-915-8).
8. **Nuclear Physics,** K. P. Das, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-517-3).
9. **Radioactive Materials,** Dr. B. M. Rao, 1st edition, Himalaya Publishing House, Mumbai- (2002).
10. **Nuclear Energy,** R. K. Taneja, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-516-6).

PHYE-314 - Electives 3 (D3); Physics of Nanomaterials

(Credits: 04; Contact Hours: 60)

Lectures: 48 Tutorials: 12

Course objectives: Students should be capable to,

- Student should be able to apply basic knowledge of physics and materials science to develop proficient understanding of how nanoscale properties affect macroscale performance and enable new technologies.
- Expand basic knowledge in the synthesis of nanomaterials, their properties and characterization.
- Portray the physical properties of nanomaterials resulting from constraints on their nanoscale organization.
- Confer how to analyze structure-function relationships and understand nanoscale features of materials.

Course outcomes: At the end of the course the student will acquire,

- Insight into how macroscopic properties can be changed via molecular level engineering and nanoscale manipulation.
- Knowledge about the techniques of how to synthesize nanomaterials and will understand their nanoscale properties.
- Adequate knowledge of important characterization techniques and will able to analyze obtained data.
- fundamental knowledge of nanotechnology principles and applications
- A student can develop research career in the field of Nano technology.

Course Contents:

Unit I: Quantum Tunneling and Confinement Free particle: Concepts of nanosized particles, Size and Dimensionality Effects, Energy levels of a particle - Infinite square well in one- two- and three dimensions - Density of states, Quantum confinement - Penetration of a barrier -Tunnel effect. Quantum wells- Quantum wires and Quantum dots. Carbon clusters & Fullerenes; Carbon Nanotubes: Structures & Electronic Properties, Application of carbon Nanotubes.

Unit II: Synthesis of nanomaterials: Top down and Bottom up concepts, Growth techniques of nanomaterials: Plasma Arc discharge, Sputtering, Evaporation, physical vapor deposition, Chemical vapor deposition, Pulsed Laser deposition, Molecular beam epitaxy, Sol-gel process, Co-precipitation process.

Unit III: Characterization techniques: XRD, Scanning Probe Microscopy (SPM), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), Electron Microscopy: Scanning Electron Microscopy (SEM & FESEM), Transmission Electron Microscopy (TEM).

Unit IV: Properties and applications of nanomaterials: Physical Properties of Nanomaterials; i) Electrical ii) Thermal. iii) Magnetic. iv) Optical. v) Mechanical. Applications in medicine and electronics.

References:

1. Nanotechnology: Principles and Practices, Sulbha K. kulkarni; (2009), Revised Reprint; Capital

Publishing Company; ISBN:81-85589-29-1.
2. Introduction to Nanoscience, Charles P. Poole, Jr., Frank J. Owens; Reprint (2011); Wiley India Edition; ISBN: 978-81-265-1099-3. 3. The physics and Chemistry of Nanotechnology, Frank j. Owens, Charles P. Poole Jr.; John Wiley & Sons. Inc. Hoboken, New Jersey; (2008); ISBN: 978-0-470-06740-6 (cloth).
4. Nano Materials, Nanotechnologies and Design, Michael F. Ashby. Paulo J. Ferreira, Daniel L. Shodek; © 2009 First Printed in India (2011); Butterworth-Heinemann, An imprint of Elsevier; ISBN: 978-93-80931-77-7. 5. Introduction to Nanoscience, S.M.Lindsay; Indian Edition; Oxford University Press; (2010); ISBN-13: 978-0-19-959129-9
6. Nanostructures and Nanomaterials: synthesis, properties and applications, Guozhong Cao, zying Wang; 2nd Edition; World Scientific Publishing; (2011); ISBN-13:978-981-4322-50-8; ISBN-10:9814-4322-50-4; ISBN-13:978-981-4324-55-7(pbk) ; ISBN-10:981-4324-55-8(pbk)
7. Introduction to Nanoscience, Gabor L. Hornyak, Joydeep Dutta, Harry F. Tibbals, Anil Rao; CRC Press, Taylor & Francis Group; © (2008); ISBN-978-1-4200-4805-6.

PHYE-314 - Electives 3 (E3); X ray Diffraction

(Credits: 04; Contact Hours: 60)

Lectures: 48 Tutorials: 12

Learning Objectives:
- To understand the most powerful source of plane and circularly polarized x rays.
- To have a prior training before research activities on INDUS 2 or any SR in the world.

Learning Outcomes:
- Understanding research activities at SR INDUS
- The practice of x ray data analyses

Course Contents:

Unit I - X ray Diffraction-1: Limitations of x rays from tubes as regards x ray diffraction studies, synchrotron radiation as source of x rays: Production and properties of radiation from storage rings, wigglers and undulators, Insertion devices. types of polarized x rays using SR, INDUS I and INDUS II, Diffraction using SR: using plane polarized x rays and using circularly and elliptically polarized x rays (X ray Circular Magnetic Dichroism XCMD): methods of obtaining monochromatic x rays, polarized x rays; Detectors: high flux (> 108photons/sr/sec), very low time structure (~ 10-9 sec or less)

Unit II- X ray Diffraction-2: X ray diffraction data analysis of various types of samples : cubic, tetragonal, hexagonal, etc, determination of various parameters like lattice parameters, near neighbor distances, strain, etc. Pair distribution Function (PDF) analysis

Unit III- Emission Spectroscopy: Continuous and characteristic X-ray spectra, Energy level diagram. Dipole, forbidden and satellite lines. Regular and irregular doublets. Relative intensity of X-ray lines. Chemical effects in X-ray spectra; Experimental techniques of wavelength and energy dispersive Xray spectroscopy: Bragg and double crystal spectrometers. Focussing spectrographs: Cauchois, Johann and Johanson types. Tangential incidence grating spectrographs.

Unit IV- Absorption Spectroscopy: Absorption of X-rays. Physical process of X ray absorption. Measurement of X-ray absorption coefficients. Units of dose and intensity, X-ray fluorescence. Auger effect. Fluorescence yield. Auger electron spectroscopy, Photoelectron spectroscopy, Chemical effects in X-ray absorption spectra. White line, Chemical shifts of absorption edges, Fine structures (XANES and EXAFS) associated with the absorption edges and their applications. Soft X-ray spectroscopy of metals and alloys, Applications to semiconductors and insulators

References:

(1) X-rays in Theory and Experiment , A.H. Compton and S.K. Allison, 1935,(New York: D. Van Nostrand Company, Inc. 1935)

(2) Elements of Modern X-ray Physics, Jens Als-Nielsen and Des McMorrow (ISBN 0471498580, 9780471498582, Wiley 2001)

(3) X-Ray Science and Technology, A. G. Michette and C. J. Buckley (ISBN-13: 9780750302333 ISBN-10: 075030233X CRC Press 1993)

(4) Principles and Practice of X-ray Spectrometric Analysis, E.P. Bertin (ISBN 1461344166, 9781461344162 Springer Science & Business Media 2012)

PHYE-314 - Electives 3 (F3) : Thin film and Vacuum Technology

(Credits: 04; Contact Hours: 60)

Lectures: 48 ; Tutorials: 12

Learning Objectives:

> This program will help prepare students to work as technicians in industries which rely on vacuum-based processes to create and manufacture products.

> Individuals studying vacuum technology will learn skills in building, validating, operating, maintaining, and troubleshooting vacuum-based equipment as well as providing advice on the use of this equipment and the processes supported by this technology. Positions may include responsibilities associated with research and design, operations, quality control, technical writing, and technical sales.

Learning Outcome:

> Employment opportunities span a variety of industries such as semiconductor, micro electromechanical systems (MEMS), glass, optics, light-emitting diodes (LEDS), solar cells, vacuum-based equipment and other industries which used thin film coating processes.

> The duties of a technician include building, validating, operating, maintaining, and troubleshooting vacuum-based equipment as well as providing advice on the use of this equipment and processes supported by this technology.

> The Vacuum and Thin Film Technology program prepares a student to work as a technician in industries which rely on vacuum-based processes to create and manufacture products.

> Employment opportunities span a variety of industries such as:Semiconductor, Microelectromechanical systems (MEMS), Glass, Optics, Light-emitting diodes (LEDS), Solar cells, Vacuum-based equipment, Other industries which use thin film coating

processes

Course contents:

Unit I:
Thermodynamics and Thin Film growth, Vacuum Technology: Gas Laws, Kinetic Theory of Gases, Conductance and Throughput, Gas Sources in a Vacuum Chamber, Vacuum Pumps.

Unit II:
Physical Vapor Deposition: Sputtering (Plasma Physics (DC Diode), rf Plasmas, Magnetic Fields in Plasmas, Sputtering Mechanisms) and Evaporation.

Unit III:
Chemical Vapor Deposition: Mechanisms, Materials, Chemistries, Systems. Module-V Etching: Wet Chemical Etching (Mechanisms, Materials and Chemistries), Dry Plasma Etching/Reactive Ion Etching (Mechanisms, Materials and Chemistries).

Unit IV:
FILM Formation and Structure: Capillarity Theory, Atomistic Nucleation processes, Cluster Coalescence, Grain Structure of Films. Thin Film Characterization: Structural, optical, electrical and magnetic

References

1. R. K. Waits, Thin Film Deposition and Patterning, American Vacuum Society, 1998. M. Ohring, ISBN 10: 156396872X ISBN 13: 9781563968723
2. The Materials Science of Thin Films, Academic Press, Boston, 1991. Ludmila Eckertova, Physics of Thin Films, 2nd Plenum Press New York, 1986 (QC 176.83.E2613 1986) ISBN 10: 0123418240 ISBN 13: 9780123418241
3. Kasturi L. Chopra, Thin Film Phenomena (McGraw-Hill, 1969). ISBN 10: 0070107998 ISBN 13: 9780070107991
4. Handbook of Thin Film : Maissel and Glang (1970). ISBN 10: 0070397422 ISBN 13: 9780070397422

PHYE-314 - Electives 3 (G3): Methods in Theoretical Physics

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12 hours

Learning Objective: The themes dealt with in this paper:

- To provide a high quality education which prepares students for further study and research in physics and for a wide range of career opportunities in industry .
- To provide a high quality mathematical models and abstractions of physical objects and systems to

rationalize, explain and predict natural phenomena.

- To provide students with a training in the mathematical techniques which underpin physics, and to offer them the opportunity to develop related skills and knowledge to a high level.
- To provide students with knowledge and skills this will equip them to start a doctorate.

Learning outcomes:

- Demonstrate enhanced ability to address appropriate physical problems using theoretical analysis and computational skills.
- To provide opportunities for scientific study and creativity within a global context that will stimulate and challenges students.
- To provide body of knowledge, methods and techniques that characterizes science and technology.
- To develop an ability to analyze, evaluate and synthesize scientific information.

Course content:

Unit I: Methods for obtaining solutions of linear and nonlinear equations and their convergence:
Graphical method, interval bisection method, Newton Raphson method, secant method, method of false position, Solution of simultaneous equations: Gauss elimination, pivoting, Gauss-seidel Iterative method, LU decomposition. **(12 Lectures)**

Unit II: Curve fitting: Linear regression, polynomial regression, nonlinear regression using exponential functions. Fitting curve of the form y= aebx .
Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Newton-Cotes formulae, Gaussian Quadratic formula. **(12 Lectures)**

Unit III: Finite differences: Forward Difference, backward difference, central difference, Interpolation with equally spaced point: Newton forward interpolation, Newton backward Interpolation, central difference interpolation, Gauss forward interpolation, Numerical differentiation: using derivative of Newton forward, backward and central difference interpolation formulae. **(12 Lectures)**

Unit IV: Numerical solution by ordinary differential equations: Preliminaries and classification: General form of ordinary differential equation(ODE), solution of an ODE, Order and degree of ODE, linear and nonlinear differential equation, Initial value problem, boundary value problem, Euler method, Runge-Kutta second order method, Runge-Kutta fourth order method, Predictor -Corrector method: Adams-Moulton's method, Milnes method. Finite Element method : Application to two dimensional problems. **(12 Lectures)**

References:

1. Numerical Methods in Engineering & Science (with Programs in C,C++ &MATLAB) by B.S. Grewal
2. Numerical methods; E. Balguruswamy, Tata McGrow Hill.
3. Introductory methods of numerical analysis; S.S. Shatry, Prentice Hall of India.
4. Application of Numerical methods; Jain M.K. Iyengar S R K and Jain R. K.Addison-Wesley.

5. Numerical methods with programs in BASIC, FORTRAN, Pascal and C++; S Bhalchandra Rao,C K Shantha, Universities Presss (India) pvt lLtd.
6. Theory and problems of numerical analysis; Scield F. Schaum's Outline series Mc Graw Hill

PHYE-314 - Electives 3 (H3): Communication Electronics

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives:

1. The fundamentals of basic communication system, detailed about the amplitude modulation.
2. Need of modulation, modulation processes and different amplitude modulation schemes.
3. Different frequency, phase and pulse modulation schemes.
4. Different demodulation methods.
5. Need of sampling and different sampling techniques.
6. Generation and detection of pulse modulation techniques and multiplexing

Learning Outcomes:

After successful completion of the course students will able to

1. Understand different blocks in communication system and how noise affects communication using different parameters.
2. Distinguish between different amplitude and frequency modulation schemes with their advantages, disadvantages and applications.
3. Analyze detection of AM and FM signal.
4. Identify different pulse modulation systems and use of their circuits in communication.
5. Able to understand how to sample analog signal and recover original signal.

Course Contents

1. **Modulation:** Amplitude modulation: Power in AM Wave, Current relation, Vector Representations. Amplitude modulator circuits, Non-linear Modulation, Linear Modulators Circuits, Collector modulation, Double Side band Suppressed Carrier System, Balanced Modulator, Ring Modulator, Single Side band Suppressed Carrier, Vestigial Side-band Systems.

2. **Frequency Modulation**: Frequency Spectrum of an FM wave, Vector Representations, Narrow Band FM, Wide Band FM, F.M. circuits: Varactor Diode Modulation, Reactance Tube Modulator, Transistor Reactance Modulator. Phase Modulation: Phase Modulation Circuit, Interference in AM and FM Systems. Pulse Modulation: Pulse amplitude Modulation, Pulse Width Modulation, Pulse position Modulation.
3. **Demodulation:** AM Detectors: Envelop Detection, Practical Diode Detectors, Input Resistance of a Diode Detector, V.S.B. Demodulators, Synchronous Detector, Phase - Locked Loop (PLL), FM Discriminators, Foster-Seeley Discriminator, Phase - Locked Loop (PLL) frequency Discriminator, Demodulation of Phase modulated waves
4. **Pulse and Digital Communication:** Sampling theorem, Pulse Amplitude modulation, Natural sampling, Flat-top sampling, Spectrum of flat top sampling,, A PAM modulator circuit, Demodulation of PAM signals, A PAM demodulator circuit, A pulse time modulation, Generation of PTM signals, Demodulation of PTM signal., bandwidth of PTM signals, PCM, Bandwidth of PCM system, Delta modulation and Adaptive delta modulation and detection. Digital modulation techniques: ASK, FSK, PSK or BPSK, QPSK, DPSK, MSK. Telephone: Telephone Instruments, Transmitters, receivers, Telephone set, Exchanges (Local, Central and Electronic).

Books:

1. Principle of Communication Engineering Anokh Singh and A K Chhabra (S. Chand & Company).
2. Electronic Communications Dennis Roddy and John Coolen (Pearson).
3. Communication Systems (Analog and Digital) R P Singh and S D Sapre. (TMH).
4. Electronic Communication Systems Kennedy and Davis (TMH)

PHYL-321: Lab course 5 (Based on Electives A1/ B1/ C1/ D1)

PHYL-321 - Lab course 5 (A1): 8086 Microprocessor and interfacing : Credits 3

Learning Objectives:

1. To facilitate the students to understand
   a) The concepts of microprocessor and assembly language programming.
   b) The concept of interfacing devices at laboratory as well industrial level

2. To provide an opportunity to the students to enter into entrepreneurship.

Learning Outcome: Students will be able to learn

a) Microprocessor architecture, physical configuration of memory, logical configuration of memory, microprocessor programming and interfacing.

1. Students will be capable to perform following job

a) Industrial automation using 8086 interfacing and programming.
b) Start his / her own small scale industry for manufacturing microprocessor based automated devices.

2. Students will have option to start his / her teaching career either in science or engineering colleges / institutes as this course is included in science as well engineering discipline.

Experiments using 8086 Kit

1. Data transfer, addition, subtraction, multiplication, division and sum of series
2. Factorial and square of the number
3. Sorting of data (ascending / descending), square root of a number
4. Arithmetic mean of N- numbers and sum of square of Numbers
5. Interfacing of SPDT switches and 7 segment display as a position encoder / decoder
6. Interfacing of stepper motor
7. Interfacing of DC motor
8. Interfacing of DAC to generate ramp wave, triangular wave and square wave.
9. Interfacing of 8-bit ADC
10. Interfacing of LCD display

Experiments Using 8086 Assembler

11. Data transfer, addition, subtraction, multiplication, division and sum of series
12. Factorial and square of the number
13. Sorting of data (ascending / descending), square root of a Number
14. Arithmetic mean of N- numbers and sum of square of Numbers

Note: Students should perform any eight experiments.

PHYL-321 - Lab course 5 (B1) : Atomic Spectroscopy : Credits 3

Learning Objectives:

a) Knowledge of absorption and emission spectra
b) Study of various types of excitation mechanisms and excitation sources
The student will get a training for using state of the art computer interfaced data acquisition system in spectroscopy laboratory for recording the atomic emission spectra
c) Analysis of recorded atomic spectra
e) Study the effect of external electromagnetic fields on the atomic spectra
f) Application of ESR spectroscopy

Learning Outcomes: The student will be able to:

CO1	perform DCarc excitation of Fe
CO2	perform DCarc excitation of Cu
CO3	perform DCarc excitation of Zn
CO4	perform DCarc excitation Brass
CO5	record the spectra of elements using HR4000 spectrometer
CO6	excite the emission spectra using gas discharges
CO7	excite the inert gases
CO8	record the absorption spectrum of the Sun
CO9	arrange the Zeeman effect setup and record the splitting

CO10 use ESR spectrometer for determining earth's magnetic field

Course Contents:

1. Record the spectrum of Hydrogen using HR 4000 spectrometer and determine Rydberg constant
2. Record the spectra of (arc sourcesiron using HR 4000 Spectrometer
3. Record the spectra of (arc sources) copper using HR 4000spectrometer
4. Record the spectra of (arc sources) zinc using HR 4000spectrometer
5. Record the spectra of (arc sources brass using HR 4000spectrometer
6. Record the spectra of (gas discharge sources) Hg using HR 4000 spectrometer
7. Record the spectra of (gas discharge sources) Cd using HR 4000 spectrometer
8. Record the spectra of (inert gases) Ne using HR 4000 spectrometer
9. Record the spectra of (inert gases) He using HR 4000 spectrometer
10. To verify the line spectra of calcium and to verify the Landed interval rule
11. To verify the Landed interval rule for the sharp series lines of Zinc
12. Record the absorption spectrum of the Sun using HR 4000 spectrometer and identify the elements in the spectrum
13. Study of hyperfine structure using Zeeman effect
14. Study of normal Zeeman effect and calculation of e/m.

References:

1. ATOM, LASER AND SPECTROSCOPY by THAKUR, S. N. , RAI, D. K. , SECOND EDITION , 2010 ; ISBN: 978-81-203-4832-5.

Note: Students should perform any eight experiment

PHYL-321 - Lab course 5 (C1) Nuclear Physics ;Credits 3

Learning Objectives:

a) Recording the pulse height spectra using latest gamma ray spectroscopy system.
b) Analysis of recorded pulse height spectra.
c) Study of various types of gamma ray sources.
d) Study the characteristics of Geiger-Muller (G-M) counter .

Learning Outcomes:

a) The student will get a training for using state of the art data acquisition system in Nuclear Physics laboratory
b) The student will get a training for analysis of recorded pulse height spectra.
c) The student will be able to perform various kinds of experiments using GM and Scintillation counter.
d)

Course Contents:

1. To study characteristics of Geiger-Muller (G-M) counter.
2. Determination of dead time of Geiger-Muller G-M) counter (Two source method).
3. Determination of dead time of Geiger-Muller (G-M) counter (Absorber

method).

4. To study absorption of beta particles in matter.
5. Verification of the Inverse Square Law.
6. Window thickness of a Geiger-Muller (G-M) counter.
7. Window thickness of a Geiger-Muller (G-M) counter (Inverse Square Law).
8. Shelf ratios of a sample holder.
9. Determination of Efficiency of a Geiger-Muller (G-M) counter.
10. Energy dependence of Geiger-Muller (G-M) counter efficiency.
11. Determination of beta decay energy.
12. Relationship between thickness of absorber and backscattering
13. Shielding effect of radiation penetrability
14. Strength of a beta-source
15. Determination of Half-Life of unknown sample
16. Half-life of ^{40}K.
17. Statistics of radioactive measurements.
18. Poisson distribution of radioactive measurements.
19. Gaussian distribution of radioactive measurements.
20. Chi-Square test of Geiger-Muller (G-M) counter.
21. Study of Mossbauer spectra of magnetic materials.
22. Statistical aspects of radioactivity measurements.
23. Beta backscattering as a function of atomic number.
24. Determination of the air borne activity.
25. Secular equilibrium.
26. Transient equilibrium.

Note: Students should perform any eight experiments.

PHYL-321 - Lab course 5 (D1) : CRYSTALLOGRAPHY: Credits 3

Experiments on Crystallography:

Learning Objectives:

a) To facilitate the students to understand the concepts of structure of the materials
b) identification of materials using Energy band gap concept
c) To provide an opportunity to the students to enter into entrepreneurship.

Learning Outcomes:

a) Students will be able to learn

i) Hall coefficient of the given semiconducting materials.
ii) Specific heat of graphite
iii) Crystallogrpaic parameters, analysis of the obtained XRD data

iv) Grain Size, thickness of the materials

c) Students will be capable to perform following job

i) Students will have option to start his / her teaching career either in science or engineering colleges / institutes as this course is included in science as well engineering discipline.

Course Contents:

1. Determination of energy band gap of semiconducting material (Thermister) by Bridge method.
2. Measurement of Hall coefficient of a given sample..
3. Energy band gap of a P-N junction
4. To measure the ionic conductivity of ionic solids and to determine activation energy
5. Variation of specific heat of solid with temperature
6. To determine the coefficient of thermal conductivity
7. Determination of velocity and wavelength of ultrasonic waves.
8. Study of crystal structure by Powder method front reflection, back reflection (measurement of lattice parameter and indexing of powder photograph / X ray powder diffractometer data cubic, tetragonal, orthorhombic)
9. Interpretation of transmission Buare photograph
10. Determination of orientation of crystal by back reflection Laue method
11. Rotation / Oscillation photograph and their interpretation
12. Determination of particle size using X-ray powder method
13. Porosity determination of semiconducting material.
14. Structural analysis of thin film by XRD
15. Study the dispersion relation for monoatomic Lattice.
16. Study the dispersion relation for diatomic Lattice.

Note: 1) Other experiments may be added as per the availability of instruments.
2) Students should perform any eight experiments.

PHYL-322: Lab course 6 (Based on Electives A2/ B2/ C2/ D2)

PHYL-322 - Lab course 6 (A2) : Microwave and communication Electronics: Credits 3

Learning Objectives: The themes dealt with in this paper:

1 6. Gain knowledge of microwaves, microwave components and verify the relationship between frequency and wavelength experimentally.

2 7. Experimental verification of the characteristics of Gunn and Klystron oscillators as microwave generators.

3 8. Determine the plane pattern and beam width of microwave horn antenna and study the inverse square law with the same.

4 9. Measure voltage standing wave ratio, S-parameters, Detector law, dielectric constant of solid and liquid with microwave bench setup.

5 10. Gain knowledge of communication and verify how the signal is transmitted and detected with different electronic circuits like PAM, PWM, PPM, FSK, and PL

Learning Outcomes (COs): At the end of the course the student should be able to;

CO-1 Understand the working use of all microwave components that may be used in a microwave X-band setup.

CO-2 Assemble the bench as per the experimental requirement.

CO-3 Obtain output power and perform experiment satisfactorily.

CO-4 Conduct experiments smoothly, safely and interpret the data accordingly.

CO-5 Apply practical knowledge of microwaves for other applications and research for finding basic properties of materials at microwave frequency.

Course contents:

1. Demonstrate the relationship between frequency (f), wavelength (1 o) in free space and Wavelength in waveguide (1 g)
2. Reflex Klystron Characteristics - Mode diagrams, ETR and ETS
3. Gunn Diode Characteristics; I-V Characteristics, Power versus bias characteristics and Power-frequency characteristics
4. Microwave Horn Antenna E-H Plane pattern and Beam width
5. Study of square law behavior of microwave crystal detector and hence to determine Operating range and detection frequency
6. Study of high and low VSWR and impedance measurements using Smith chart.
7. Measurement of S- parameters of a) E-Tee b) Magic Tee c) Directional coupler.
8. Determination of dielectric constant of solids - Two point method
9. Determination of dielectric constant of liquids - Robert-Von Hipple method
10. Study of Faraday's rotational principle
10. Study of PAM and its detection
11. Study of Balance modulator using IC 1596
12. Study of FSK modulation and detection
13. Study of PPM and detection
14. Study of PLL
15. Study of PWM and detection
16. Reflection and refraction in microwaves.
17. Interference and diffraction in microwaves.

Note: Students should perform any eight experiments.

References:

1. Microwave Devices and Circuits, by Samuel, Liao, Fourteenth impression PHI. ISBN 81-978-81-7758 (2012)
2. Microwaves, by K.C. Gupta, Wiley Estern Ltd. ISBN 0 85226 346 5
3. Microwave Engineering, by Sanjeev Gupta, Khanna Publishers.
4. Electronics Communications, by Sanjeeva Gupta, Khanna Publishers Delhi- 6. (For Chap. 3 and 5)
5. Electronics Communication systems By George Kennedy third Edn
6. Networks Lines and Filters by John D. Ryder, PHI second Edn.
7. Microwave Engineering by Annapurna Das & Sisir K. Das (TMH Publication) 2000.
8. Introduction to Microwaves, by G. I Wheelers, PHI
9. Microwave and Radar Engineering, by M. Kulkarni, 3rd Edition , Umesh Publications Delhi 110006
10. .Microwave Engineering, by Monojit Mitra, II Edition,
11. Basic microwave techniques and Laboratory manual, by M. L. Sisodia and G.S. Raghuvanshi.

PHYL-322 - Lab course 6 (B2) : Molecular Spectroscopy:
Credits 3

Learning Course Objectives:

- Thermal and DC electric field excitation of molecular spectra
- Recording the molecular spectra using latest computer interfaced instruments
- Vibrational analysis of the recorded molecular spectra and calculation of vibrational constants of upper and lower electronic states and estimation of force constants
- Rotational analysis of the recorded molecular spectra and calculation of rotational constants of upper and lower electronic states and estimation of bond lengths
- Understanding of Morse potentials of diatomic molecules
- Estimation of dissociation energy of I_2.
- Understanding the fundamentals and instrumentation of NMR spectrometer; analysis of NMR spectrum

Course Outcomes:

The student will be able to:

CO1	Record the molecular spectrum using HR4000 spectrometer by DC arc excitation
CO2	identify various sequences in the band spectrum and arrange the wavenumbers of band heads in the Deslandres table
CO3	Perform vibrational analysis and calculate vibrational constants of the upper and lower electronic states. Calculate force constants the upper and lower electronic states
CO4	Perform rotational analysis and calculate rotational constants of the upper and lower

electronic states. Estimate bond lengths in upper and lower electronic states.

CO5 able to explain the role of Morse parameter an to plot Morse potential curve for a given diatomic molecule

CO6 Able to explain various parts and their role in recording NMR spectrum using NMR spectrometer

CO7 Able to record and analyze the NMR spectrum

Course contents:

Experiments based on Molecular Spectroscopy

1. Record the spectrum of Al arc in air using HR4000 spectrometer. Construct the Deslandre's table by using known wavelengths and calculate the vibrational constants and force constants of upper and lower electronic states
2. Vibrational analysis C_2 Swan system: Record the spectrum of gas flame (C_2 Swan system) in air using high resolution monochromator. Construct the Deslandre's table by using known wavelengths and calculate vibrational constants and force constants of upper and lower electronic states
3. Recording the high resolution spectra of BeO using high resolution spectrometer with CCD camera and calculate vibrational constants and force constants of upper and lower electronic states
4. Rotational analysis of spectra of diatomic molecules (High resolution spectroscopy) for bands with Q-branches
5. Rotational analysis of spectra of diatomic molecules (High resolution spectroscopy) for bands without Q-branches
6. Studies of IR spectra of organic molecules containing various functional groups using IR/FTIR spectrometers.
7. Spectroscopic investigations of molecules using Raman Spectrometer.
8. Record the spectrum of Iodine and determine dissociation energy of I_2 molecule by Brige-Spooner method
9. Calculation of Morse potential energy curves for molecular X and B states of AlO, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states
10. Calculation of Morse potential energy curves for molecular states of Swan system of C_2, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states.
11. Calculation of Morse potential energy curves for molecular states of visible system of BeO, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states.

Note: Students should perform any eight experiments.

PHYL-322 - Lab course 6 (C2) : Nuclear Physics: Credits 3 Learning

Objectives:

d) Recording the pulse height spectra using latest gamma ray spectroscopy system.
e) Analysis of recorded pulse height spectra.
f) Study of various types of gamma ray sources.
g) Study the NaI(Tl) detector..

Learning Outcomes:

e) The student will get a training for using state of the art data acquisition system in Nuclear Physics laboratory
f) The student will get a training for analysis of recorded pulse height spectra.
g) The student will be able to perform various kinds of experiments using GM and Scintillation counter.

Experiments based on Nuclear Physics

1. Study of gamma ray spectrum using scintillation counter using single channel analyzer.
2. Absorption of gamma rays in lead.
3. Absorption of gamma rays in aluminum.
4. Alpha spectroscopy with surface barrier detector- energy analysis of an unknown gamma source.
5. Determination of range of beta particles in aluminum.
6. X-ray fluorescence with proportional counter.
7. Determination of range of beta particles from unknown source by feather analysis.
8. Design, fabrication and study of Linear pulse amplifier.
9. Excitation ofK-X-rays in different material by beta radiation (verification of Mosley's law).
10. Kinematics of Compton scattering. Compton scattering process.

Note: Students should perform any eight experiments.

PHYL-322 - Lab course 6 (D2) : Electrical Properties of solids and Superconductivity: Credits3

Experiments based on Electrical Properties of solids and Superconductivity

Learning objectives: i) This activity introduces the fundamental principles of four probe resistivity ii) ferroelectricity iii) measurement of dielectric constant of different solid samples

Students will be able to: i) Describe what can be detected by four probe resistivity technique ii) explain the impact of temperature iii) atom size, and impurities on the tests.**Learning Outcomes:** Acquisition of the following skills: i) Ability to explain basic/fundamental dielectric concepts ii) Ability to extort the relevant information from four probe resistivity papers.iii) Ability to find specific tools for solution of a given ferroelectric, superconducting problem.

Course Contents:

1. Resistivity Measurement of a given sample by four probe method.
2. Measurement of dielectric constant and its variation with temperature.
3. Determination of bulk density of different materials using immersion technique.
4. Measurement of dielectric constant of liquids.
5. Measurement of electrical conductivity of Graphite at room temperature.
6. Determination of specific heat of Graphite at different temperatures.
7. Measurement of dielectric constant of solids.
8. Porosity determination of Superconducting materials.
9. Determination of Bulk density of ferroelectric materials.
10. To measure ferroelectric hysteresis curves
11. Determination of Curie Temperature of Ferroelectrics.

Note: 1) Other experiments may be added as per the availability of instruments.2)

Students should perform any eight experiments.

PHYR-331: (Experimental work): Research Project Part II: Credit 3

Students are expected to do experimental work as per the formulation of topic of research project selected during 2nd semester.

Semester - IV

Semester - IV

(Elective Courses)

Generic Electives 4 (A4): Advanced Sensor Technology

(Credits: 04 ; Contact Hours : 60)

Lectures: 48; Tutorials: 12

Learning Objectives:

1. To facilitate the students to understand
   a) the concepts of sensor science and technology
   b) the concept of Sensor materials and different principles of sensing technology which are used at laboratory as well industrial level
2. To provide an opportunity to the students to enter into sensor research and develop smart sensor devices.
3. To create enthusiasm among the students to undertake research in sensors

Learning Outcome:

1. Students will be able to -
   a) learn sensor materials and technologies,
   b) Develop sensor devices and sensor networks.

2. Students will be capable to undertake the job in sensor industries.
3. Students will have option to start his / her teaching career either in science or engineering colleges / institutes as this course is included in science as well engineering discipline OR do research in sensor science.

Course Contents:

Unit I : Sensor Materials and Sensor Matrix

Materials : Material selection criteria, fulfilment of ideal sensor requisite, importance of 1 -D materials in sensors, importance of surface area enhancement and enhancement in surface activity, Importance of size dependent Properties for sensing applications; Promising sensing materials: Carbon Nanotubes, Organic Conducting Polymers, Porphyrins and metal nanoparticles, Sensor Fabrication Technologies : AC Dielectrophoretic alignment of SWNTs and surface modification of SWNTs by OCP by charge controlled potentiostatic deposition and porphyrins by solid casting, for SWNTs, confirmation of coating by I-V measurements and electrochemical measurements;

Unit II : Chemical Sensors

Chemical Sensor Characteristics ; Specific Difficulties ; Classification of Chemical-Sensing Mechanisms ; Direct Sensors : Metal-Oxide Chemical Sensors, Chemiresistive and ChemFET sensors, Electrochemical Sensors, Potentiometric Sensors, Conductometric Sensors, Amperometric Sensors, Complex Sensors: Optical Chemical Sensors Biosensor, Multisensor Arrays, Electronic Noses (Olfactory Sensors),

Unit III : Integrated circuit manufacturing techniques for Sensors

Introduction, **Photolithography:** Masks, Mask alignment, Spinning resist; **Exposure and development;** *Exposure, Development,* Resist tone, Critical dimension (CD) and resolution *(R)* , **Resist stripping***; Wet stripping, Dry stripping;* **Subtractive techniques**: Overview, **Dry etching:** *Physical etching: sputtering or ion etching, Etching profiles for physical etching, Dry chemical etching, Physical-chemical etching;* **Wet etching:** *Anisotropic and isotropic etching, Etch stop techniques,* Comparison of dry- and wet-etch techniques**;**

Unit IV : Sensors Technology (Techniques for Sensor Fabrication)

Chemical Methods for preparation of sensor matrix: Chemical bath deposition, SILAR, **Physical vapor deposition ;** *Evaporation, Sputtering, Molecular beam epitaxy, Laser ablation deposition;* **Chemical vapor deposition:** ***AP** CVD and LP CVD, PE CVD, Spray pyrolysis;* **Electrodeposition and electroless deposition***: Electroless deposition , Electrodeposition, Potentiostatic, Galvanostatic, Cyclic voltammetry* : **Chemical sensor fabrication technology** : screen printing, spin coating, dip coating, casting

References:

1. Modern Sensors Handbook, Edited by Pavel Ripka and Alois Tipek; ISTE Ltd, USA **(2007)**, ISBN 978-1-905209-66-8.
2. Handbook of Chemical and Biological Sensors; Edited by Richard F Taylor, Arthur D Little Inc., Jerome S Schultz, University of Pittsburgh ; Institute of Physics Publishing Bristol and Philadelphia; **(1996)** ISBN 0 7503 0323 9
3. Hand Book of Modern Sensors : Physics, Designs and Applications By Jacob Fraden Third Edition (Springer-Verlag New York, Inc.) **(2004)**, ISBN 0-387-00750-4.
4. Understanding Smart Sensors By Randy Frank; Second Edition; Artech House Boston . London **(2000),** ISBN 1-58053-398-1.

5. Sensors and Transducers, Third Edition By Ian R. Sinclair; Butterworth-Heinemann publication, Woburn **(2001),** ISBN 0 7506 4932 1
6. Chemical Sensors: An Introduction for Scientists and Engineers : Grundler, Peter; Springer Berlin Heidelberg New York **(2007),** ISBN 978-3-540-45742-8
7. Principles of Chemical Sensors : Janata, Jiri 2nd Edition ; Springer Dordrecht Heidelberg London, New York **(2009),** ISBN 978-0-387-69930-1 e-ISBN 978-0-387-69931-8
8. Optoelectronics Devices and System SECOND EDITION by S. C. Gupta;Prentice HallInternational**(2011)** ISBN: 978-81-203-5065-6
9. Optical Fibers and fiber optic communication Systems by Subir Kumar Sarkar; S Chand & Company Ltd **(2000),** ISBN: 9788121914598
10. Lasers and Optical Fiber Communications by P Sarah; I.K. International Publishing House Pvt Ltd, New Delhi **(2008),** ISBN : 9788189866587 / 8189866583
11. Optoelectronics by R. A. Barapate (Tech-Max Publication) **(2003)**

PHYE-411 - Generic Electives 4 (B4): Applied Spectroscopy

(Credits: 04; Contact Hours: 60)

Lectures: 48; Tutorials: 12

Learning Objectives:

a) Describe the basic principles of physics as related to the field of photonics.
b) Integrate the concepts of light, geometric and wave optics and their practical applications in photonics.
c) Theory and practice of instrumental methods for the separation, identification and quantitative analysis of chemical substances.
d) To understand how structure and bonding influence the physical properties and reactivity of molecules.
e) To be able to use crystal field theory to understand the electronic and magnetic properties of transition metal complexes.
f) To be able to use symmetry to predict molecular orbital diagrams and explain electronic spectra

Learning Outcomes:

a) After completing this course the student will be able to use spectroscopic methods for qualitative and quantitative analysis.

Course Contents

1. **SPECTROSCOPIC INSTRUMENTATION:** Spectrographs and Monochromators, Speed of Spectrometer, Spectral Transmission Range, Spectral Resolving Power, Free Spectral Range, Prism Spectrometer, Basic Considerations and Spectral Resolving Power of Grating Spectrometers, Multiple Beam Interferometry: Basic Concepts, Comparison between

Spectrometer and Interferometer: Spectral Resolving Power, Light Gathering Power, Accurate Wavelength Measurement. [Scope: Laser spectroscopy by W. Demtroder, Springer, chapter 4].

2. **DETECTION OF LIGHT**: Thermal Detectors, Photodiodes, Photoconductive Diodes, Photovoltaic Detectors, Fast Photodiodes, Photodiode Arrays, Photoemissive Detectors, Photocathodes, Photomultipliers, Detection Techniques and Electronic Equipment, photon counting. [Scope: Laser spectroscopy by W. Demtroder, Springer, chapter 4. Spectroscopic Instrumentation].

3. **LUMINESCENCE SPECTROSCOPY:** Introduction, Joblanski Diagram, Phosphorescence, Fluorescence, Resonance Fluorescence and Normal Fluorescence.

   Intensity of Transitions. Non Radiative Decay of Fluorescent Molecules, Effects of Medium on Fluorescence Spectra. Population of Triplet States, Phosphorescence Intensity, Solvent Effect, Delayed Fluorescence. Excitation Spectra, Emission spectra, Experimental Methods, Emission Life Time Measurement. Application of Fluorescence and Phosphorescence.
   [Scope: Spectroscopy Vol. 3 by B. P. Straughan and S.Walkar, London Chapman and Hall, Chapter 5].

4. **MOLECULAR SYMMETRY AND GROUP THEORY:** The Defining Properties of a Group, Some Examples of Groups, Subgroups, Classes, Symmetry Operations, Symmetry Elements, Algebra of Symmetry Operations, Multiplication Table. Molecular Point Groups, Matrix Representation of Symmetry Operations, Reducible and Irreducible Representations, Character Table for C_{2v} and C_{3v} Point Groups, Symmetry Species of Point Groups, Complete Character Table for Point Group, Distribution of Fundamentals among the Symmetry Species, Infrared Activity, Raman Activity.

   [**Scope**: **1)** Molecular Structure and Spectroscopy, by G. Aruldhas, Prentice Hall of India pvt, chapter 5.
   2) Chemical Applications of Group Theory (Third Edition), by F. Albert Cotton, John Wiley & Sons, Chapter 2,3 & 4].

Tutorials, assignments, seminars based on Units 1 - 4.

Books:

1. Laser Spectroscopy, Volume 1: Basic Principles, Fourth Edition by Wolfgang Demtroder, Springer,
   ISBN: 978-3-540-73415-4 e-ISBN 978-3-540-73418-5, DOI 10.1007/978-3-540-73418-5 Library of Congress Control Number: 2007939486, © 2008, 2003, 1996, 1981 Springer-Verlag Berlin Heidelberg.
2. Modern Spectroscopy by J. M. Hollas, ISBN: 9780470844167, Published by John Wiley &

Sons Ltd. (2004) Fourth Edition.

3. Spectroscopy by B. P. Straughan& S. Walker, ISBN: 0470150319 (v.1, Halsted Press), ISBN: 0470150327 (v.2), ISBN: 0412133806 (v.3, Cased Ed.) London: Chapman & Hall, New York, Vol. 1,2 & 3 (1976)
4. MOLECULAR STRUCTURE AND SPECTROSCOPY, by ARULDHAS, G. , Second Edition ,2004. ISBN: 978-81-203-3215-7, PHI Learning
5. Chemical Applications of Group Theory by F. Albert Cotton, ISBN: 9780471510949, John wiley& Sons (Wiley - Interscience) (1990) Third Edition.
6. Elements of Group Theory for Physicists by A. W. Joshi, ISBN: 812240975X, New Age International Private Limited publishers, New Delhi, (1997) Revised Fourth Edition.
7. Group Theory and Quantum Mechanics by M. Tinkham, ISBN: 9780486432472, McGraw Hill Book Company, New Delhi (1964).

PHYE-411 - Generic Electives 4 (C4) : Particle Physics, Nuclear forces and Cosmic rays:

(Credits: 04; Contact Hours: 60)

Lectures: 48 ;Tutorials: 12

Learning Objectives: The themes dealt with in this paper:

11. This course is necessary for the students to make aware to various elementary particles apart from proton, neutron and electron.
12. The knowledge of elementary particles is helpful to classify the nuclear structure, their interactions,
13. The course should be taught as an elective and it should be taught at Semester-IV as it requires understanding of interactions of those particles with other particles (elementary particles) which is a very involved topic and requires knowledge of other aspects of nuclear physics covered in IIIrd semester.
14. The course will help the student for preparation of NET/SET and other competitive examinations.

Learning Outcomes: The present unit attempts to achieve the following learning outcomes:

- The course is useful to students as it provides knowledge of various elementary particles, their properties etc and the nature of strongest force i.e. Nuclear force.
- The students can get job and opportunity of research in nuclear energy sector and accelerator center.
- The course is extremely important for carrying out theoretical research leading to more and more elementary particles and ultimately vision of universe.
- The origin of universe is a hot topic these days, for which studies in cosmic rays in also necessary.
- In short, the course is the basis for front-line research in physics in present times.

Course Contents:

Unit I: Elementary Particles physics-I
Concept of elementary particle, Fundamental properties of elementary particles, Classification of elementary particles, Particle Interactions, Coupling constant, Quantum numbers of elementary particles, Conservation laws of elementary particles, Relationship between particle and antiparticle.

Unit II: Elementary Particle Physics-II
Properties of massless and Lepton Particles, Properties of mesons (Pions, Neutral n-meson, K-mesons, ^-meson), Properties of Baryons (Nucleons, Hyperons, resonant particle), Description of strange particles (K-mesons and Hyperons, Violation of parity, Strangeness and hypercharge, Properties of strange particles), Quarks and Gluons, Inversions in elementary particles (Time-reversal, Parity, Charge conjugation), Elementary particle symmetries (SU (3)-symmetry, Gell-Mann-Okubo mass formula).

Unit III: Nuclear Forces
Introduction, Characteristics of nuclear forces, The deuteron, The ground state of deuteron, Radius of deuteron, n-n and n-p scattering, p-p scattering below 10MeV, Distinction between p- p and n-p scattering, Similarity between n-n and p-p forces, Meson theory of nuclear forces.

Unit IV: Cosmic rays
Introduction, Types of cosmic rays, Properties of primary cosmic rays, Geomagnetic effect, Interpretation of geomagnetic effect, Properties of secondary cosmic rays, Absorption of cosmic rays, cosmic ray showers, Extensive air showers, origin of cosmic rays.

References:

1. **Fundamentals of Nuclear Physics,** Jahan Singh, 1st edition, Pragati Prakashan, Meerut-(2012) (ISBN-978-93-5006-593-8)
2. **Nuclear Physics,** D. C. Tayal, 10th edition, Himalaya Publishing House, Mumbai- (2005) (ISBN-81-8318-281-x).
3. **Nuclear Physics,** Satya Prakash, 2nd edition, Pragati Prakashan, Meerut (2011) (ISBN-81-7556-915-8).
4. **Nuclear Physics,** S. B. Patil, 1st edition, New Age International Publishers, New Delhi-(1991) (ISBN-978-81-224-0125-7).
5. **Nuclear Measurement Techniques,** K. Sri Ram, 1st edition, Affiliated East-West Press, Madras(1986) (ISBN-81-85095-56-6).
6. **Basic Nuclear Physics,** B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
7. **Nuclear Physics,** R. C. Sharma, 1st edition, K. Nath & Co. Meerut- (2007) (ISBN-EBK0036746).
8. **Nuclear Physics,** K. P. Das, 1st edition, Cyber Tech Publications, New Delhi- (2009)

DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD.(M.S.)

Syllabus of Bridge Course for M.Sc.Physics(CBCS Pattern)
(Effect from the Academic Year 2021-22)
(Hours- 20)

Module 1.English for Science: Career Goals, Listening Skills,Reading Skills, Report Writing, Study Skills, Interpreting skills, Presentation Skills, Problem Solving Skills. (**Hours -02)**

Module 2. Introductory Mathematical Physics, Concept of Mathematical co-ordinat system. **(Hours -03)**

Module 3. Introductory Modern Physics: Special theory of relativity, Quantum theory of light. **(Hours -02)**

Module 4. Journey of Mechanics: (Newtonians - Classical -Quantum) **(Hours -01)**

Module 5. Analogue & Digital Electronics. **(Hours -03)**

Module 6. Lab course -1 : Introduction to basic measuring instruments : CRO, Function generators, power supplies, multi-meters etc. **(Hours -03)**

Module 7. Lab course -2 : Active and Passive components : Identification of electronic components, specifications, testing and etc. **(Hours -03)**

Module 8. Lab course -3 : Introduction to Algorithms and fundamentals of C, Experimental data processing on Excel sheet, graphics interpretations etc. **(Hours -03)**

Reference Book :-

1.Mathematical Physics by B.S.Rajput, Pragati Prakashan.

2.Introduction to Modern Physics by H.S.Mani and G.K.Mehta.

3.Foundations of Classical Mechanics by P.C.Deshmukh, Cambridge University Press.

4.Classical Mechanics by Gupta, Kumar and Sharma, Pragati Prakashan.

5.Introduction to Mechanics by R.B.Singh, New Age International Publications.

6.Analogue and Digital Electronics by Sonver Singh and Sanjay Agrawal, WILEY publiacations.

7.Linear integrated circuits and its applications by K.R.Bothkar.

8.Digital Electonics by Malvino Leach, Tata Macgrea Publishers.+..+

9.Electical Measuring instruments by A.K.Sawany. Tata Macgrew Publishers.

10.Basic Computational Techniques for Data Analysis An Exploration in MS-Excel 2021 Edition by D.Narayana, Sharad Ranjan, Nupur Tyagi, Sage D.Narayana, Sharad Ranjan, Nupur Tyagi. Sage Publisher.

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