Dr. Babasaheb Ambedkar Marathwada University,

Aurangabad – 431004 (MS)

Department of Physics

Course Structure and Curriculum

for

M. Sc. Physics

(Effective from June 2013 onwards)

Syllabus for M.Sc. (Physics) Academic Autonomy
(Choice Based Credit System)

The M.Sc. (Physics) programme is divided into four semesters having 104 credits. There are 16 theory courses subdivided into 11 core courses, 4 specialized courses and 1 elective course. Besides there are 7 laboratory courses, a final semester project and seminar / tutorials. This programme offers four specializations viz. Electronics, Condensed Matter Physics, Nuclear Physics and Spectroscopy.

Eligibility:

Those who have completed B. Sc. with Physics as an optional subject from any recognized University/ Institution are eligible for registration subject to the rules and regulations laid down by Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. Preference will be given to the candidates who have completed their B. Sc. with Physics and Mathematics.

Admission / Promotion Process:

In response to the advertisement for registration, interested students will have to register themselves. Admission will be done on the basis of performance of students at their qualifying graduate level examination. Once the student is admitted he / she will be promoted to the next semester with full carryon, however students have to register themselves for every consecutive semester. Dropout students will be allowed to register for respective semester as and when the concerned courses are offered by the department, however he / she should not exceed more than twice the duration of the course from the date of first registration at parent department. The admission of the concern student will be automatically cancelled if he / she fails to complete the course within a period of maximum four years / eight semesters.

Choice Based Credit System (CBCS) :

The choice based credit system has been adopted by this department. This provides flexibility to make the system more responsive to the changing needs of our students, the professionals and society. It gives greater freedom to students to determine their own pace of study. The credit based system also facilitates the transfer of credits.

- Students will have to earn 104 credits for the award of M.Sc. degree.
- Out of 104 credits, students will have to earn 100 credits (Core courses worth 44 credits, specialized courses worth 16 credits, elective course worth 4 credits, laboratory courses worth 20 and seminar / tutorials worth 16 credits) from physics department.
- Remaining 04 credits can be earned through opting service course either from the parent department (inter specialization) or other departments of the University (Subject to approval by the Departmental Committee of Physics Department). If the course opted by the students from other department is having less / more than 4 credits, it will be converted into 4 equivalent credits.
- If the service course from other university departments is not available, student will have to opt service course from other specialization from the physics department. (Choice of service course from the same specialization will not be allowed)

Credit-to- contact hour Mapping:

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

Course Structure:

Semester I

Course	Course Title	Teaching time/week	Marks	Credit
PHY-401	Mathematical Methods in Physics	4 hours	100	4
PHY-402	Classical Mechanics	4 hours	100	4
PHY-403	Quantum Mechanics-I	4 hours	100	4
PHY-404	Linear And Digital Electronics	4 hours	100	4
PHY-451	Lab course 1 (General Physics + Nuclear Physics)	4 hours	50	2
PHY-452	Lab course 2 (Condensed Matter Physics + Electronics)	4 hours	50	2
PHY-453	Seminars / Tutorials	5 hours	100	4

Semester II

Course	Course Title	Teaching time/week	Marks	Credit
PHY-405	Quantum Mechanics - II	4 hours	100	4
PHY-406	Statistical Mechanics	4 hours	100	4
PHY-407	Electrodynamics and Plasma Physics	4 hours	100	4
PHY-408	Atomic and Molecular Physics	4 hours	100	4
PHY-454	Lab Course 3 (General Physics + Nuclear Physics)	4 hours	50	2
PHY- 455	Lab Course 4 (Condensed Matter Physics + Electronics)	4 hours	50	2
PHY- 456	Seminars / Tutorials	5 hours	100	4

Semester III

Course	Title	Teaching time/week	Marks	Credit
PHY- 409	General Condensed Matter Physics	4 hours	100	4
PHY- 410	General Nuclear Physics	4 hours	100	4
PHY- 411	Special paper – 1 : A1-Electronics/B1- Spectroscopy/ C1- Nuclear Physics/D1- Condensed Matter Physics	4 hours	100	4
PHY- 412	Special paper – 2: A2-Electronics/B2- Spectroscopy/ C2- Nuclear Physics/D2- Condensed Matter Physics	4 hours	100	4
PHY- 457	Lab course 5 (A1/B1/C1/D1)	6 hours	50	3
PHY- 458	Lab course 6 (A2/B2/C2/D2)	6 hours	50	3
PHY- 459	Seminars / Tutorials	5 hours	100	4

Semester IV

Course	Title	Teaching time/week	Marks	Credit
PHY- 413	Numerical Methods in Physics	4 hours	100	4
PHY- 421	Elective Paper	4 hours	100	4
PHY- 414	**Special Paper – 3:** A3-Electronics/B3- Spectroscopy/ C3- Nuclear Physics/D3- Condensed Matter Physics	4 hours	100	4
PHY- 415	**Special Paper – 4:** A4-Electronics/B4- Spectroscopy/ C4- Nuclear Physics/D4- Condensed Matter Physics	4 hours	100	4
PHY- 460	Lab course 7 (A3/B3/C3/D3)	6 hours	50	3
PHY- 461	Project	6 hours	50	3
PHY- 462	Seminars / Tutorials	5 hours	100	4

List of Elective papers (Any one of the following)

Course	Title	Teaching time/week	Marks	Credit
PHY- 421 E1	Communication and Industrial Electronics	4 hours	100	4
PHY- 421 E2	Advanced Communication Electronics	4 hours	100	4
PHY- 421 E3	Industrial Instrumentation	4 hours	100	4
PHY- 421 E4	Modern Trends in Spectroscopy	4 hours	100	4
PHY- 421 E5	Quantum Theory of Solids	4 hours	100	4
PHY- 421 E6	Reactor Physics	4 hours	100	4
PHY- 421 E7	Physics of Nanomaterials	4 hours	100	4
PHY- 421 E8	Renewable Energy	4 hours	100	4

Following courses will be offered to other departments (as well to the students of other specialization in the physics department) as service courses (subject to approval by the Departmental Committee). The time table for these service courses will be arranged on Friday and Saturday (every week).

PHY- 441: Modern Trends in Spectroscopy
PHY- 442: Reactor Physics
PHY- 443: Physics of Nanomaterials
PHY- 444: Renewable Energy
PHY -445: Advanced Sensor Technology

Notes: (1) Tutorials consists of conceptual as well as numerical problems / questions based the respective theory courses in the semester covering all five (05) units. Total marks assigned for tutorials will be 80 (20 for each theory course). Remaining 20 marks are assigned for seminar based on laboratory course.

(2) Each course / paper should be taught for 40 to 45 contact hours.

(3) Teaching duration for LAB COURSES in first and second semesters should be of 4 hours and for those in third and fourth semesters and project should be 06 hours per week per batch

(4) Each of the courses is divided into five units.

(5) 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.

Attendance:

Students must have 75 % of attendance in each core, specialized, elective and laboratory course for appearing examination otherwise he / she will not be strictly allowed for appearing the examination of each course. However, students having 65 % attendance with medical certificate may request Head of the Department for the condonation of attendance. Monthly attendance of the students for each course will be displayed on the notice board.

Registration for Service Course:

- Students will have to register themselves for the service course of his / her interest after the start of semester in the department on official registration form. The teacher in-charge of the respective course will keep the record of the students registered. Maximum fifteen days period will be given from the date of admission for completion of registration procedure. The departmental committee shall follow a selection procedure after counseling to the students to avoid the overcrowding to a particular course at the expense of some other courses.
- No student shall be permitted to opt more than one service course in a semester.
- Normally no service course shall be offered unless a minimum of 10 students are registered.
- Students will have to pay the prescribed fees per course per semester / year for the registration as decided by the university.

Departmental Committee:

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

Results Grievances / Redressal Committee

Grievances / redressal committee will be constituted in the department to solve all grievances relating to the evaluation. The committee shall consist of Head of the department and the concerned teacher of a particular course.

Evaluation Methods:

- The grades for courses will be based on 20: 80 ratio of continuous internal assessment (CIA) and semester end examination (SEE).

Internal Evaluation Method:

- There will be two mid semester examinations (20 marks each) as a part of continuous internal assessment (CIA), first based on 40 percent of the syllabus taught and second based on 60 percent of the syllabus taught. The setting of the question paper and the assessment will be done by the concerned teacher who has taught the course. Average score obtained out of two mid semester examinations will be considered for the preparation of final sessional marks / grades.

Term end Examination and Evaluation:

- Semester end examination (SEE) time table will be declared by the departmental committee and accordingly the concern course teacher will have to set question paper, conduct theory examination, conduct practical examination with external expert, evaluate, satisfy the objection / query of the students (if any) and submit the result to DC in one week time from the date of examination of that particular course / paper.

- The semester end theory examination in each theory course / paper will be of 80 marks. The total marks shall be 100 for each theory course / paper (80 marks semester end exam + 20 marks internal tests) and this is equivalent to 4 credits.
- Pattern of semester end question paper will be as below:

    - The semester end examination of theory course / paper will have two parts (20+60 = 80 Marks)
    - Part A will carry short questions of 2-3 marks (fill in the blanks/ answer in sentence / multiple choice questions) as compulsory question and it should cover entire syllabus (20 Marks)
    - Part B will carry 7 questions (12 marks each) out of which there shall be at least one question from each unit. Students will have to attempt any five questions (60 Marks).
    - 20 to 30% weightage can be given to problems 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 practical examination will be of 50 marks each (semester end examination only). Student must perform at least six experiments from each lab course. The final practical / project examination will be conducted at the end of each semester along with the theory examination. Students will be examined by one external and one internal examiner.

- At the end of each semester the Departmental Committee will assign grades to the students. The result sheet will be prepared in duplicate.

- Every student shall have the right to scrutinize answer scripts of mid semester / semester end examinations and seek clarifications from the teacher regarding evaluation of the scripts immediately thereafter or within 3 days of receiving the evaluated scripts.

- The Head of the Department shall display the grade points and grades for the notice of the students.

- The Head of the Department shall send all records of evaluation for safekeeping to the Controller of Examination in two week time after declaration of results.

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 4^{th} 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

Sr No	Marks Obtained (%)	Grade Point	Grade	Description
1	90-100	9.00- 10	O	Outstanding
2	80-89	8.00-8.90	A^{++}	Excellent
3	70-79	7.00-7.90	A^{+}	Exceptional
4	60-69	6.00-6.90	A	Very Good
5	55-59	5.50-5.90	B^{+}	Good
6	50-54	5.00-5.40	B	Fair
7	45-49	4.50-4.90	C^{+}	Average
8	41-44	4.1-4.40	C	Below Average
9	40	4.0	D	Pass
10	< 40	0.0	F	Fail (Unsatisfactory

- Non appearance in any examination / assessment shall be treated as the students have secured zero marks in that subject examination / assessment.
- Minimum D 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 has to clear the course by appearing in the next successive semester examinations. There will be no revaluation or recounting under this system.
- 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 Physics Department 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 IVth 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 issued by the University at the end of IVth semester.

PHY-401 : Mathematical Methods in Physics : Credits 4

1. Matrices: Special matrices and their properties: Hermitian, anti Hermitian, symmetric, antisymmetric, unitary, orthogonal, rotation matrix in two and three dimensions, trace of a matrix, rank of a matrix, inverse of matrix and its application for solution of systems of linear simultaneous equations. Eigen values and eigen vectors, Cayley Hamilton's theorem, diagonalization of matrices,

Elementary complex analysis: Complex numbers and their representations, complex algebra, Euler formula, De Moivre's theorem, powers and roots of a complex number, elementary functions. Analytic functions of a complex variable, Cauchy-Riemann conditions, singular points, poles, harmonic functions,

2. Differential equations: Second order differential equations with variable coefficients, ordinary and singular points of an ODE, series solution about an ordinary point, series solution about singular point. Solutions of the following differential equations by series expansions: Legendre, Bessel, Hermite and Laguerre differential equations.

3. Special Functions: Legendre polynomials: Rodrigue's formula, generating function and recurrence relations, orthogonality.
Bessel functions of the first kind: recurrence relations, orthogonality.
Hermite Polynomials: generating function, recurrence relations, and orthogonality.
Lauguerre Polynomials: recurrence relations, orthogonality.

4. Fourier series: Definition, Evaluation of coefficients, Derichlet's conditions, Derichlet's theorem (without proof), extension of the interval. Fourier series representation of even and odd functions, complex representation of a Fourier series, Applications of Fourier series to half wave rectifier, full wave rectifier.
Fourier transforms: Definition, Fourier transform of elementary functions, Fourier transform of rectangular aperture (Diffraction due to rectangular slit). Fourier transform of derivatives, Fourier transform of Dirac delta function, Fourier sine and cosine transforms, convolution theorem. Applications for solving integrals.

5. Laplace transform: Definition and properties, Laplace transform of elementary functions, Laplace transform of derivative and integral of a function, Laplace transform of Dirac delta function, convolution theorem,
Inverse Laplace transform by partial fraction expansion: linear unrepeated and repeated factors, quadratic repeated and unrepeated factors,
Applications of Laplace transform for solution of differential equations and problems in physics

Books:

1. Mathematical methods in the Physical Sciences , by Mary L. Boas, John Wiley and Sons Inc., N.Y.
2. Introduction to Mathematical Physics, by Charlie Harper, Prentice-Hall of India Pvt. Ltd.
3. Mathematical Methods for Physicists (4ht Ed), by George Arfken and H.J. Weber, Academic Press, San Diago (1995)
4. Laplace Transforms and Control Systems Theory for Technology, by Theodore F. Bogrt Jr., PE, John Wiley and Sons, N.Y.
5. Mathematical Methods of Physics ,by Jon Mathew and R. L. Walker, Pearson Education,(2nd Ed.).
6. Mathematical Methods for Physics and Engineering, by K.F. Riley, M.P. Hobson and S. J. Bence, Cambridge U.P.
7. Theory and Problems of Laplace Transforms- Schaum's outline series- , by Murray R. Spigel- Mc Graw Hill Bok Company, International Ed.
8. Theory and Problems of Fourier analysis with applications to boundary value problems -- ,Schaum's outline series- Murray R. Spigel- Mc Graw Hill Bok Company
9. Mathematical methods, by M C Potter and Jack Goldber, Prentice Hall of India
10. Mathematical Physics, by B.S. Rajput, Pragati prakashan, Meerut,
11. Mathematical Physics, by Gupta, and R.P.S. Yadav

PHY-402 : Classical Mechanics : Credits 4

1. Mechanics of a particle:

Mechanics of a particle, Mechanics of a system of particles, Constraints; their classification, D'Alembert's principle and Lagrange's equations, Simple application of the Lagrangian formulation. Hamilton's principle, Techniques of calculus of variations, Some applications of calculus of variations, Derivation of Lagrange's equations from Hamilton's principle, Extension of Hamilton's principle to nonholonomic systems, Conservation theorem and symmetry properties, Energy function and conservation of energy.

2. The two body central force problem:

Reduction to the equivalent one-body problem, the equation of motion and first integrals, the equivalent one dimensional problem and classification of orbits, The differential equation for the orbit, and integrable power law potentials, the Kepler problem: inverse square law of force, scattering in a central force field for Rutherford's scattering.

3. Hamiltonian mechanics:

Hamiltonian canonical equations, Cyclic co-ordinates, canonical transformations, generating functions, Examples of canonical transformations, Poisson brackets and its invariance under canonical transformations, Equations of motion in Poisson bracket notation, Jacobi,s identity, Examples, Hamiltonian –Jacobi equation for Hamiltonian characteristic function, Action and angle variables.

4. Rigid body motion:

Eulerian angles, Equations of motion in rotating frame, Coriolis force, Inertia tensor, Euler equations, Symmetric top.

5. Theory of small vibrations:

Small oscillations, Normal co-ordinates and applications to vibrations of linear in triatomic molecules.

Test Book:

1. *Classical Mechanics*, by H. Goldstein, 2 nd Edition (Narosa Pub.House Pvt. Ltd)
2. Classical Mechanics, by H. Goldstein, Charles Poole, J. L. Safco, 3 rd Edition (Pearson Education Asia)

Reference books:

1. *Classical Mechanics*, by N.C. Rana and P.S. Joag (TataMcgraw-Hill, 1991)
2. *Mechanics*, by A. Sommerfeld (Academic Press, 1952)
3. *Introduction to Dynamics*, by I. Perceival and D Richards(Cambridge Univ. Press. 1982).
4 *Classical Mechanics*, P. V. Panat (Narosa Pub. House Pvt.Ltd)
5. Classical Mechanics, by Gupta, Kumar and Sharma, Pragati Prakashan, Meerut.
6. Classical Mechanics, by J C Upadhyaya (Himalaya Publication, Nagpur)

PHY-403 : Quantum Mechanics – I : Credits 4

1. Origin of quantum mechanics, particle aspects of radiation, wave aspect of radiation, particles versus waves, intermediate nature of microphysical world, quatizations rules, wave packets

2. Wave function, Operators, Schrodinger equation, continuity equation, expectation values. Ehrenfest's theorem stationary states, boundary and continuity conditions, degeneracy orthogonality and parity. Simple one-dimensional problems, particle in a box, step potential, tunneling through a barrier, potential well, harmonic oscillator

3. Spherically symmetric potentials, Hydrogen atom conversion to spherical polar coordinates, separation and solutions of θ, φ and r parts. Wave functions of Hydrogen atom. Angular momentum operators and L_+, L_- operators in spherical polar coordinates, spherical harmonics.

4. Dirac's bra and ket algebra, linear operators, observables, completeness condition. Linear harmonic oscillator using creation and annihilation operators, wave function, matrices of creation and annihilation operators and of x and p. Unitary transformations. Evolution of system with time. Hisenberg, Schrodinger and Interaction pictures.

5. Angular momentum, commutation relations between L_x, L_y, L_z, p_x, p_y, p_z , L^2, r^2 etc. Angular momentum and rotations. Orbital and Spin angular momentum. Ladder operators J_+ and J_- eigen values of J^2 and J_z. Lower and upper bounds. Angular momentum matrices for $j = {}^1/_2$ or j =1, Pauli spin matrices. Addition of angular momenta. Possible values of j, Clebsch Gordan coefficients for $j_1 = j_2 = {}^1/_2$

Tutorial: Simple problems given in the books related to the topics.

Books:

1. *Quantum Mechanics, Theory and applications* 4^{th} edition by Ajoy Ghatak and S Loknathan. Macmillan India Limited
2. *Introductory* Quantum *Mechanics* by Richard L Liboff 4^{th} edition Pearson education Ltd.
3. *Quantum Mechanics* by G. Aruldhas, Prentice-Hall India Private Ltd.
4. *Quantum Mechanics- Concepts and Applications* by Nouredine Zettili, John Wiley

PHY-404 : Linear And Digital Electronics : Credits 4

1. **Operational amplifier** 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,
2. **Applications of Operational Amplifier**: Adder, Subtractor, Integrator, differentiator, Comparator & Schmitt's trigger; Wave form generators: Astable Multivibrator, Monostable Multivibrator, and Wien Bridge Oscillator.
3. **Timing Circuits, Numbers systems, and Codes**: Integrated circuit timer**:** Block diagram of IC – 555, Monostable, Astable Multivibrator using IC-555.Decimal, Binary, & Hexadecimal numbers systems, and its arithmetic's. BCD and Gray code. AND, OR, NOT operations, NAND and NOR operations, NAND and NOR as building blocks, Exclusive – OR operation.
4. **Combinational Logic:** Boolean algebra, Standard Representation for Logical Functions, Karnaugh-map. Half & Full adder, Parallel 4-bit adder, encoder (decimal to binary), Decoder (BCD to decimal), BCD to seven segment decoder, Multiplexer: (4:1) and (8:1), Demultiplexer: (1:8) and (1:16) and their applications.
5. **Sequential Logic:** 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. Semiconductors Memories: Read only memory, Programmable ROMs(PROMs & EROMs), Read/Write Random Access Memories.

Books:

1. Electronic Devices**,** by Thomas L Floyd, Charles E. Merrill Publishing company.
2. Operational amplifier with Linear integrated circuits**,** by William D Stanev Fourth Edition, LPE PEARSON Education.
3. Op-Amp and Linear Integrated Circuits, R. A. Gaikwad 4th. Ed, Prentice Hall of India, 2002, ISBN 81 –203–2058–1.
4. Modern Digital Electronics , by R P Jain, 3'rd Edition, Tata McGraw – Hill Publishing Company Ltd.
5. Digital Fundamentals , by Thomas L Floyd, 2nd Edition Charles E. Merrill Publishing Company.

PHY-451 : Lab course 1 (General Physics + Nuclear Physics) : Credits 2

1. To determine Planck's constant using a photocell.
2. Measurement of thickness of thin wire using He-Ne laser
3. To determine Determination of e/m by helical method
4. To determine λ and dλ for sodium light using Michelson interferometer
5. Determination of operating voltage of G.M. tube and dead time of a G.M. tube by double source method.
6. Mass absorption coefficient of β particles for Al
7. Solution of algebraic equations by bisection method
8. Method of least squares to fit a straight to the given data
9. Study of coil in A.C. circuit

PHY-452 : Lab course 2 (Condensed Matter Physics + Electronics): Credits 2

1. Determination of magnetic susceptibility by Quinke's method
2. Determination of velocity and wavelength of ultrasonic waves in liquids.
3. OP-AMP as (a) inverting and (b) non inverting amplifier
4. MOD 16 ripple counter
5. OP-AMP as Wein bridge oscillator
6. Astable multivibrator using IC 555
7. OP-AMP as (a)Basic comparator (b) Schmitt trigger: U.T.P., L.T.P. hysteresis
8. Study of CE amplifier (Input impedance, Output impedance, frequency response and 3 dB gain)
9. Study of characteristic x-rays of copper

PHY- 453 : Tutorials and Seminars : Credits 4

PHY- 405 : Quantum Mechanics – II : Credits 4

1. The WKB approximation. Application to bound states connecting formulae Bohr sommerfield Quantization rules, WKB application to transmission problem, Variational method, H_2^+ ion.
2. Time independent Perturbation theory, non-degenerate and degenerate case. Application to anharmonic potentials of the form x^3 and x^4.
3. Time dependent perturbation theory, Fermi's rule, Harmonic perturbation, adiabatic and sudden approximations.
4. Scattering: Scattering cross section, scattering amplitude. Partial wave analysis. Phase shifts. Center of mass frame. Born approximation. Scattering by a hard sphere, attractive potential
5. The Klein-Gordon equation, Its interpretation and limitations, Dirac equation for free particle, Dirac matrices, plane wave solutions, electron in an electromagnetic field, spin of Dirac particle, magnetic moment of electron, spin-orbit interaction

Tutorial:. Simple problems given in the books related to the topics.

Books:

1. *Quantum Mechanics, Theory and applications* 4th edition by Ajoy Ghatak and S Loknathan. Macmillan India Limited
2. *Introductory* Quantum *Mechanics* by Richard L Liboff 4th edition Pearson education Ltd.
3. *Quantum Mechanics* by G. Aruldhas, Prentice-Hall India Private Ltd.
4. *Quantum Mechanics- Concepts and Applications* by Nouredine Zettili, John Wiley

PHY- 406 : Statistical Mechanics : Credits 4

1. **The Statistical Basis of Thermodynamics**
   Postulates of classical statistical Mechanics. Macroscopic and microscopic states. Phase space.Ensemble-microcanonical, canonical and grand canonical, Statistical equilibrium, density distribution of phase point, Liouville's theorem.
2. **Ideal classical gas**
   Partition function of a classical ideal gas, Thermodynamical potentials in terms of partition function for an ideal monoatomic gas in microcanonical and grand canonical ensembles, entropy of mixing and Gibbs paradox, Maxwell-Boltzmann distribution law, Entropy of a monoatomic gas.
3. **Quantum Statistical Mechanics**
   Postulate of Quantum Statistical Mechanics. Density matrix, statistics of indistinguishable particles, MB statistics, FD statistics, BE statistics, Thermal properties of Bose Einstein gas, Statistical photon gas, Bose Einstein condensation .
4. **Cluster Expansion and Co-operative phenomenon**
   Cluster Expansion of classical gas, virial equation of state, first order phase transition, co-operative phenomenon, Ising model in one and two dimensions. Landau's theory of phase transitions.
5. **Fluctuations**
   Fluctuation and transport Phenomenon, Brownian motion, transport equation,Langevin theory of Brownian motion, Einstein's theory of Brownian motion, Fokker-Plank equation, fluctuation dissipation theorem.

Books:

1. Statistical Mechanics; B.K.Agrawal, Melvin Eisner, New Age International Pvt.Ltd.New Delhi.
2. Fundamental of Stastical Mechanics; B.B.Laud, New Age International Pvt.Ltd.New Delhi.
3. Statistical Mechanics;R.K.Patharia, Butterworth-Heinmann Published By Elsevier a division of Reed Elsevier India Pvt.Ltd.New Delhi.
4. Statistical Mechanics; Gupta, Kumar, Pragati prakashan Meerut.
5. Introduction to Statistical Mechanics,S.K. Sinha, Narosa publishing house Pvt.Ltd New Delhi-110002

PHY: 407 : Electrodynamics and Plasma Physics : Credits 4

1. **Electromagnetic wave equation and field vectors**: Maxwell's equations in free space, 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, concept of Retarded potentials, Lienard Wiechert potential.

2. **Reflection and Transmission of electromagnetic waves -I:** Laws of reflection and refraction, Incident wave polarized with its **E** vector normal to the plane of incidence, oblique incidence: Incident wave polarized with its **E** vector parallel to the plane of incidence, Reflection and Refraction at the interface between two non-magnetic dielectrics (loss-less).
3. **Reflection and Transmission of electromagnetic waves -II:** concept of Brewster's angle, derivation of Brewster's angle in terms of media parameters, total reflection, Reflection and refraction at the surface of good conductor, oblique incidence of uniform plane waves on a perfectly conducting surface: E wave parallel to the plane of incidence.
4. **Relativistic Electrodynamics:** Four vectors, field tensor, electrodynamics in tensor notation, relativistic potentials. Motion of charged particles in uniform static magnetic field, motion in combined uniform static electric and magnetic fields, particle drifts in nonuniform magnetic fields.
5. **Plasma Physics:** Elementary concepts of plasma, derivation of moment equations from Boltzman equation. Plasma oscillation, Debye shielding, plasma confinement, magneto plasma.
   Fundamental equations, hydromagnetic waves: magnetosonic waves, Alfven waves, wave propagation parallel and perpendicular to magnetic field.

Books :

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, Inc.
5. Electromagnetism Theory and Applications, Ashutosh Pramanik, PHI publication.
6. Electrodynamics, Gupta ,Kumar,Singh, Pragati Prakashan
7. Electromagnetics, B. B. Laud, 2nd Edition, Wiley Eastern Ltd

PHY- 408 : Atomic and Molecular Physics : Credits 4

1. 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.
2. 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)
3. **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[Scope *Spectra of diatomic molecules* G. Herzberg, , chapter 3 + Molecular structure and spectroscopy by G Aruldhas, chapter 6. Rotation of molecules + Spectroscopy volume 2, Edited by B.P. Straughan and S. Walker, chapter 4. Infrared and Raman Spectroscopy)
4. **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, [Scope *Spectra of diatomic molecules* G. Herzberg, chapter 3 + Molecular structure and spectroscopy by G Aruldhas, Chapter 7. Infrared spectroscopy + Spectroscopy volume 2, Edited by B.P. Straughan and S. Walker, chapter 4. Infrared and Raman Spectroscopy)
5. **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 lasers [Scope: *Physics of atoms and molecules* B. H. Bransden and C. J. Joachain + *Laser Spectroscopy, Basic Concepts and Instrumentation* by W. Demtroder, chapter 5. Lasers as Spectroscopic Light Sources]

Tutorial: Problems given in the books on related topics.

Books:

1. Introduction to Atomic Spectra H E White McGraw Hill
2. Atomic Physics by Christopher J. Foot, Oxford University Press 2005.
3. Fundamentals of Molecular Spectroscopy C.N Banwell & Elaine M. McCash. Tata McGraw Hill
4. Spectra of diatomic molecules G. Herzberg, Krieger Malbar Florida
5. Molecular structure and spectroscopy by G Aruldhas Prentice Hall of India

6. Spectroscopy volume 2, Edited by B.P. Straughan and S. Walker, London Chapman and Hall
7. Laser & Non linear Optics B B Laud. Wiley Eastern Limited.
8. Laser Spectroscopy, Basic Concepts and Instrumentation by W. Demtroder, Springer
9. Physics of atoms and molecules B. H. Bransden and C. J. Joachain Pearson Education

PHY-454 : Lab course 3 (General Physics + Nuclear Physics): Credits 2

1. Determination of h/e of electron by photocell
2. Calibration of platinum resistance thermometer as a function of temperature and to determine unknown temperature
3. Determination of temperature of a flame by sodium line reversal method.
4. Study of capacitor in A.C. circuit
5. To study random nature of radioactive disintegration by G M counter
6. Determination of range of β particles from Radium and Sr in Al
7. Inversion of matrix using Gaussian elimination method (In EXCEL)
8. Integration of mathematical equation by using Simpson's 1/3 rule with error analysis (In EXCEL)
9. Study of interference of microwaves

PHY-455: Lab course 4 (Condensed Matter Physics + Electronics): Credits 2

1. Study of band gap of semiconductor using 4 probe method
2. Determination of magnetic susceptibility by Gouy's method
3. Measurement of Hall coefficient of given semiconductor, identification of semiconductor and estimation of charge carrier concentration
4. Study the dielectric constant of solids as a function of temperature and verification of the Curie law
5. Decimal to BCD encoder using diode matrix array.
6. MOD 12 and MOD 10 ripple counters
7. Monostable multivibrator using IC- 555
8. Study of diode matrix ROM for given Boolean equations

PHY- 456 : Tutorials and Seminars : Credits 4

PHY- 409: General Condensed Matter Physics : Credits 4

1. **Crystal Structure :** Lattice translation vectors and lattices, basis crystal structure, primitive and non-primitive cell, 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., f.c.c, sodium chloride, liquid crystals.
2. **Crystal diffraction and reciprocal lattice :** Interaction of X-rays with matter, absorption of X-rays, Braggs law, reciprocal lattice vectors, diffraction conditions, Laue equations, Brillion zones, atomic form factor, experimental methods in X – rays : Laue method, Rotating crystal method, Powder photograph method, structure form factor for s.c., b.c.c., and f.c.c, reciprocal lattice , reciprocal lattice of (s.c., b.c.c., and f.c.c).
3. **Lattice vibration and thermal properties :** Vibrations of one –dimensional monoatomic and diatomic lattice, properties of lattice waves, phonons, Einstein's theory of specific heat, Debye models of lattice heat capacity, anharmonicity, thermal expansion and thermal conductivity, inelastic scattering of neutron by phonons, lattice thermal conductivity.
4. **Free electron model of metals :** 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.
5. **Energy bands in solids :** 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.

Books:

1. Introduction to solid state physics – C. Kittel, Willey Eastern Pvt. Ltd.
2. Elementary Solid State Physics – M. A. Omar, Addition Wesley Pvt. Ltd.

3. Solid State Physics – A. J. Dekker, Mcmillan India Ltd.
4. Solid State Physics - Aschroft and Mermen, Saunders College Publishing New York.
5. Introduction to Solids – L. V. Azaroff McGraw Hill, New York
6. Solid State Physics – S. O. Pillai, New age International Pvt. Ltd.
7. Solid State Physics – M. A. Wahab
8. Concept in Solid State Physics – J. P. Shrivastava, Prentice Hall Ltd.
9. Solid State Physics – Saxena, Gupta, Saxena

PHY- 410 : General Nuclear Physics : Credits 4

1. **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.
2. **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.
3. **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.
4. **Nuclear Models:** 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.
5. **Acceleration of Charged particles:** Cascade generators, Cockroft and Walton voltage multiplier, Vande Graff machine, tandem accelerators, linear multipole accelerator, wave-guide accelerator, cyclotron, synchro 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.

PHY-411 - A1 (Special paper 1) : 8086 Microprocessor and Interfacing : Credits 4

1. **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, out put 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.

2. **Data Movement 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

3. **Program Control Instructions: 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

4. **Memory Interfacing (with reference to 8086 Microprocessor): Memory devices:** Memory pin connections, ROM memory, static RAM devices, Dynamic RAM memory, Address Decoding**:** simple NAND gate decoder, the 3 to 8 line decoder**,** the dual 2 to 4 line decoder, PROM decoder, 8086 memory interface **;**

5. **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

Books :

1. The Intel Microprocessors, Architecture Programming and interfacing, Barry B Brey ; Sixth Edition ; PHI
2. Microprocessors and Interfacing : Programming and Hardware, Douglas V Hall : II Edition ; Tata McGraw-Hill
3. Microcomputer Systems : The 8086 / 8088 Family; Architecture, Programming and Design, Yu-Cheng Liu and Glenn A. Gibson ; PHI
4. The 8086/8088 Family:Design, Programming and Interfacing, John Uffenbeck, PHI

PHY- 411 - B1 (Special paper 1) : Atomic Spectroscopy : Credits 4

1. **Relativistic effect on Atomic Spectra**: Sommerfeld relativity correction, fine structure and spinning electrin, observed hydrogen fine structure, fine structure of ionized helium line = 4686 Å, 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 aBack 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**: Displacement law, Law of alternation of multiplicities. Terms arising due to three or more valence electrons, Lande interval rule. Hund's rules, Pauli exclusion principle for p^2, p^3, p^4, p^5, d^2 electrons [Scope: Introduction to Atomic Spectra by H. E. White, Chapter XIV]
4. **X- ray Spectra**: Characteristic and continuous 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 (EXAFS) [Scope: Introduction to Atomic Spectra by H. E. White, Chapter XVI]
5. **Widths and Profiles of Spectral Lines** :Natural Linewidth, Lorentzian Line Profile of the Emitted Radiation, Relation Between Linewidth and Lifetime ,Natural Linewidth of Absorbing Transitions ,Doppler Width ,Collisional Broadening of Spectral Lines, Phenomenological Description, Relations Between Interaction Potential, Line Broadening, and Shifts , Collisional Narrowing of Lines , Transit-Time Broadening ,Homogeneous and Inhomogeneous Line Broadening ,Saturation and Power Broadening ,Saturation of Level Population by Optical Pumping, Saturation Broadening of Homogeneous Line Profiles , Power Broadening, Spectral Line Profiles in Liquids and Solids [Scope: Laser Spectroscopy by W. Demtröder, chapter 3]

Tutorial: Problems given in the books on related topics

Books:

1. Introduction to Atomic spectra by H E White McGraw Hill.
2. Atomic Physics, Christopher J. Foot ,Oxford University Press
3. Laser Spectroscopy by W. Demtröder , Springer
4. Atom, laser and spectroscopy, by S. N. Thakur and D. K. Rai, Prentice Hall India New Delhi.
5. Modern Spectroscopy by J. M. Hollas John Wiley & Sons, Ltd.

PHY-411 - C1 (Special paper 1) : Decay processes and Elementary particle : Credits 4

1. **Alpha Decay:** Introduction, Velocity and energy of alpha particles, range velocity and range half life relations, alpha decay and alpha ray spectra, Fine structure of alpha ray spectra, emission of alpha particles, Gammow's theory of alpha decay, Geiger - Nuttel relations.
2. **Beta Decay:** Introduction, velocity and energy of beta particles, range of beta particles, range –energy relation for beta particles,conservation of energy in beta decay, Fermi's theory of beta decay, life time of beta decay, selection rules, general theory of beta decay, electron capture, Neutrino hypothesis.
3. **Gamma Decay:** Introduction, measurement of gamma ray energies, internal conversion, internal peer creation, nuclear isomerism, coloumb excitation, angular distribution and directional correlation, measurement of life times of nuclear states, nuclear resonance fluroscence, the attenuation of electromagnetic radiation in matter, photo electric absorbtion, Compton scattering, pair production, selection rules, decay scheme of Co^{60} .
4. **Elementary particles:** Introduction , Types of interactions, classification of elementary particles, conservation laws, iso spin formalism, hypercharge, strangeness, invariance principles and symmetries, conservation and parity, meson theory of nuclear forces.
5. **Quark theory:** Elementary particle symmetries, Quarks, isospins of quarks, quark wave function of baryons, magnetic dipole moment of the baryon octet, quantum cryodynamics, electroweak interaction theory.

Books:

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. Experimental Nuclear Physics,E. Serge, John Wiley and sons, New York, 1959.

PHY-411 - D1 (Special paper 1): Crystallography: Credits 4

1. **Crystal binding:** 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 and infinite line of ions, binding in covalent, metal and Hydrogen bonded crystals
2. **Crystal physics and X-ray crystallography :** External symmetry elements of crystals, concept of point groups and space groups, influence of symmetry on physical properties, derivation of equivalent point position, experimental determination of space groups ; Principle of powder diffraction method, interpretation of powder photographs, indexing of powder patterns, accurate determination of lattice parameters, least square method, applications of powder method.
3. **Point Defects and Alloys:** Classification of defects, Point defects, lattice vacancies, alloys, diffusion, magnetic alloys and Kondo effect, Colour centers.
4. **Dislocation in Crystals:** slip and plastic deformation, shear strength of single crystals, edge and screw dislocation, Burgers vectors, 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.
5. **Semiconductor Crystals:** 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 in semiconductor, law of mass action, impurity levels, applications of semiconductors.

Books :

1. Introduction to solid state physics – C. Kittel, Willey Eastern Pvt. Ltd.
2. Elementary Solid State Physics – M. A. Omar, Addition Wesley Pvt. Ltd.
3. Solid State Physics – A. J. Dekker, Mcmillan India Ltd.
4. Solid State Physics - Aschroft and Mermen, Saunders College Publishing New York.
5. Introduction to Solids – L. V. Azaroff McGraw Hill, New York
6. Solid State Physics – S. O. Pillai, New age International Pvt. Ltd.
7. Solid State Physics – M. A. Wahab
8. Concept in Solid State Physics – J. P. Shrivastava, Prentice Hall Ltd.
9. Solid State Physics – Saxena, Gupta, Saxena

PHY-412- A2 (Special paper 2): Microwaves: Credits 4

1. **Introduction of microwaves and Transmission Line Theory:** Microwave frequency, characteristic 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 studs, matched lines, Smith chart.
2. **Microwaves Generators:** Tubes: Two cavity Klystron, Mathematical analysis, velocity modulation, Power output at catcher grid, 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. Traveling wave tube amplifier. Backward wave oscillator.
3. **Microwaves solid state sources:** Gunn effect diode, GaAs diode, background. Gunn effect. Mode of operations, Gunn oscillation modes, LSA, Stable amplification mode, IMPATT and TRAPATT diodes, physical structures, principle of operation, power output and efficiency, Tunnel diodes, Schottky- Barriers diode, backward diode.
4. **Microwave Components:** 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, Traveling detectors, Microwave network representations, S- Matrix theory of E, H, Directional coupler, and magic tee.
5. **Microwave Measurements:** Measurement of power by bolometer, 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. Q-measurement of microwave cavities transmission method, VSWR method.

Books:

1. Microwave Devices and Circuits, by Samuel, Liao, Third Edn PHI. (For chap. 3)
2. Microwaves, by K.C. Gupta, Wiley Estern Ltd. (For Chap. 1 and 2, 4 and 5)
3. Microwave Engineering, by Sanjeev Gupta, Khanna Publishers. (For Chap. 1 and 2 and 4)
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

PHY-412- B2 (Special paper 2) : Molecular Spectroscopy : Credits 4

1. **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, Deslandres table, progressions and sequences, evaluation of vibrational constants, Information derived from vibrational analysis, Rotational structure of electronic bands. Band head formation and shading of bands, the Fortrat parabolae. Combination relation and evaluation of rotational constant for bands without and with Q branches.

Band origin determination, Dissociation. Problems. [Scope: Spectra of Diatomic Molecules by G. Herzberg, chapter 4 +Molecular Structure and Spectroscopy by G. Aruldhas, Chapter 9]

2. **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: Λ type doubling, Spin Uncoupling. Symmetry properties of rotational levels. Types of electronic transitions, selection rules, Study of $^1\Sigma$- $^1\Sigma$, $^2\Sigma$ – $^2\Sigma$ and $^1\Pi$- $^1\Sigma$ transitions. [Scope: Spectra of Diatomic Molecules by G. Herzberg, chapter 5]
3. **Determination of term manifold**: Separated atoms. (like and unlike at oms) Term manifold from electronic configuration. Pauli principle. Term of non-equivalent electrons. Molecular configurations of CO, C_2, N_2, AlO, BeO, BeH etc molecules. Types of binding. Homopolar, Heteropolar and Van der Waal. [Scope: Spectra of Diatomic Molecules by G. Herzberg, chapter 6]
4. **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. Problems. [Scope: Molecular Structure and Spectroscopy by G Aruldhas, Chapter 8]
5. **Intensities in electronic bands:** Intensity distribution in the vibrational structure: observed intensity distribution in absorption, the Franck-Condon principle: absorption, the Franck Condon principal: emission (Condon parabola), Wave mechanical formulation of the Franck-Condon principle, vibrational sum rule and vibrational temperature. Intensity distribution in the rotational structure: $11^1\Sigma$ - $^1\Sigma$ transitions, other transitions, Intensity alternation. [Scope: Spectra of Diatomic Molecules by G. Herzberg, chapter 4-.4]

Tutorial: Problems given in the books on related topics

Books:

1. Spectra of Diatomic Molecules by G. Herzberg, Krieger Malbar Florida
2. Molecular Structure and Spectroscopy by G Aruldhas, Prentice Hall India
3. Spectroscopy volume 3 by B. P. Straughan and S.Walkar, London Chapman and Hall.
4. Fundamentals of Molecular Spectroscopy, C. N. Bannwell and E. M. McCash, Tata-McGraw Hill

PHY- 412 - C2 (Special paper 2): Nuclear Reactions: Credits 4

1. **Nuclear Reactions :** Introduction, Types of nuclear reactions, conservation laws, nuclear reaction kinematics, reaction dynamics (Q-equation), nuclear transmutation, charge particle reaction spectroscopy, neutron spectroscopy, level width in nuclear reaction.
2. **Theories of Nuclear Reactions**
   Nuclear reaction cross-section and partial wave analysis, theories of nuclear reactions, compound nucleus, energy levels of compound nucleus and resonance, resonance scattering and reactions, the optical model, theory of stripping and pickup reactions and photonuclear reactions.
3. **Nuclear Fission**
   Introduction, discovery of fission, types of fission reactions, the energy released in fission, energy distribution of fission fragments, mass distribution of fission products, emission of neutrons in fission, theory of fission, fission potential energy barrier, nuclear fission as a source of energy, fission chain reactions.
4. **Nuclear Fusion :** Sources of stellar energy, carbon – Nitrogen Cycle, Nuclear reaction in stars, controlled thermonuclear reactions, condition of controlled fusion, controlled thermonuclear devices, fusion induced by µ-mesons.
5. **Cosmic rays :** Introduction, secondary cosmic rays, geomagnetic effect, interpretation of geomagnetic effect, absorption of cosmic rays, cosmic ray showers, cosmic ray primaries, extensive air showers, origin of cosmic rays.

Books:

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. **Experimental Nuclear Physics,**E.Serge, John Wiley and sons, New York, 1959.

PHY-412 – D2 (Special paper 2) : Material Properties and Superconductivity : Credits 4

1. **Structure determination methods**
   Oscillation and Burger precision method, determination of relative structure amplitudes from measured intensities, Fourier representation of electron density.
2. **Dielectric properties**
   Polarization, local electric field at an atom, Lorentz's relation, dielectric constant and polarizability, Claussius – Mossotti relation, sources of polarizability, electronic polarizability, ionic polarizability, orientation polarizability, Langevin Debye equation, Dielectric relaxation and losses.
3. **Ferroelectric properties**
   General properties of ferroelectric materials, classification of ferroelectric crystals, the polarization catastrophe, the dipolar theory of ferroelectricity, the theory of ferroelectricity in $BaTiO_3$, ferroelectric domain, piezoelectricity, pyroelectricity
4. **Superconductivity:**
   Basic phenomenology, Meissners effect, heat capacity, energy gap, type I and type II superconductors, persistent currents, penetration depth, superconducting ring.
5. **Josephson effect,** Vortex state, London equation, Coherence length, , critical fields and critical currents, qualitative ideas of BCS theory, thermodynamics of superconducting transition.

Books :

1. Introduction to solid state physics – C. Kittel, Willey Eastern Pvt. Ltd.
2. Basic courses in crystallography, Jak Tareen, TRN Kutty
3. Solid State Physics – A. J. Dekker, Mcmillan India Ltd.
4. Solid State Physics - Aschroft and Mermen, Saunders College Publishing New York.
5. Introduction to Solids – L. V. Azaroff McGraw Hill, New York
6. Solid State Physics – S. O. Pillai, New age International Pvt. Ltd.
7. Solid State Physics – M. A. Wahab

PHY- 457– A1: Microwave and communication Electronics (Lab Course 5): Credits 3

1. Demonstrate the relationship between frequency (f), wavelength (λ_0) in free space and wavelength in waveguide (λ_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 its detection
14. Study of PLL
15. Study of PWM and its detection

Note: Students must perform at least **six** experiments from above list.

PHY- 457 – B1 : Atomic Spectroscopy (Lab course 5): Credits 03

1. Simulation of wave function for a particle in a box
2. Simulation of Barrier penetration – Calculation of transition probability and graphical display of wave functions
3. Record the spectrum of Hydrogen using HR 4000 spectrometer and determine Rydberg constant
4. Record the spectra of Hg sing HR 4000 spectrometer –

5. Record the spectra of Cd using HR 4000 spectrometer
6. Record the spectra of Ne using HR 4000 spectrometer
7. Record the spectra of He using HR 4000 spectrometer
8. Record the spectra of copper (DC arc) using HR 4000 spectrometer
9. Record the spectra of iron (DC arc) using HR 4000 spectrometer
10. Record the spectra of zinc (DC arc) and brass using HR 4000 spectrometer
11. Record the spectra of brass (DC arc) using HR 4000 spectrometer
12. To verify the line spectra of calcium and to verify the Lande interval rule
13. To verify the Lande interval rule for the sharp series lines of Zinc
14. Record the absorption spectrum of the Sun using HR 4000 spectrometer and identify the elements in the spectrum
15. Study of hyperfine structure of mercury green line
16. Study of normal Zeeman effect and calculation of *e/m*
17. Determination of magnetogyric ratio for proton
18. Determining earth's magnetic field with ESR

PHY- 457 – C1 : Nuclear Physics (Lab course 5): Credits 3

1. Dead time of G.M. counter by double source method.
2. Dead time of G.M. Counter by various area method.
3. Verification of Inverse Square law.
4. To measure the efficiency and energy resolution of Hp-Ge detector.
5. Energy calibration of Scintillation counter
6. Study of Mossbauer spectra of pure iron.
7. Design, fabrication and study of circuit, which gives an output pulse independent of size and shape of input pulse.
8. Design, fabrication and study of Linear pulse amplifier

PHY- 457 – D1 : Condensed Matter Physics (Lab course 5): Credits 3

1. Determination of energy band gap of semiconducting material (Thermistor) by Bridge method.
2. Resistivity by four probe method
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. Measurement of dielectric constant and its variation with temperature.
9. Variation of residual magnetization of carbon steel rod as a function of temperature.
10. Study of magnetic susceptibility in liquids
11. Determination of bulk density of different materials using immersion technique

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

PHY- 458 – A2 : 8086 Microprocessor and interfacing (Lab course 6) : Credits 3

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 six experiments.

PHY- 458 – B2 : Molecular Spectroscopy (Lab course 6) : Credits 3

1. Vibrational analysis AlO : 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, force constants, Morse parameters and dissociation energies 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 HR4000 spectrometer. Construct the Deslandre's table by using known wavelengths and calculate vibrational constants, force constants, Morse parameters and dissociation energies 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, force constants, Morse parameters and dissociation energies of upper and lower electronic states
4. Record the spectrum of Iodine using HR 4000 spectrometer and determine dissociation energy of I_2 molecule
5. Studies of IR spectra of organic molecules containing various functional groups using IR/FTIR spectrometers.
6. Study of NMR spectra of various samples using NMR spectrometer
7. Study of ESR spectra of various samples using ESR spectrometer
8. Calculation of Morse potential energy curves for molecular X and B states of AlO
9. Calculation of Morse potential energy curves for molecular states of Swan system of C_2
10. Calculation of Morse potential energy curves for molecular states of visible system of BeO
11. Comparing STO's and GTO's for 1s orbital of hydrogen: Lab procedure.
12. Calculations of Basis sets, Functions : Lab procedure

PHY-458 – C2: Nuclear Physics (Lab course 6): Credits 3

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 aluminium.
4. Alpha spectroscopy with surface barrier detector- energy analysis of an unknown gamma source.
5. Determination of range of beta particles in aluminium.
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.

PHY-458 – D2 : Condensed Matter Physics (Lab course 6): Credits 3

1. Magnetic susceptibility of solids by Gouy's method
2. Paramagnetic susceptibility temperature variation
3. Study of Hall effect
4. To determine the magneto resistance of Bismuth crystal / Bismuth compound thin film as a function of magnetic field
5. Determination of Curie temperature of a ferromagnetic material
6. 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)
7. Interpretation of transmission Buare photograph
8. Determination of orientation of crystal by back reflection Laue method
9. Rotation / Oscillation photograph and their interpretation
10. Determination of particle size using X-ray powder method
11. Characteristics of solar cell

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

PHY- 459 : Tutorials and Seminars : Credits 4

PHY- 413 : Numerical Methods in Physics: Credits 4

1. **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
2. **Curve fitting**: Linear regression, polynomial regression, nonlinear regression using exponential functions. Fitting curves of the form $y=ax^b$, $y=ae^{bx}$ Numerical Integration: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Newton - Cotes Formulae, Gaussian Quadrature formula.
3. **Finite differences**: Forward difference, backward difference, central difference, Interpolation with equally spaced points: Newton forward interpolation, Newton backward interpolation, Central difference interpolation, Gauss forward interpolation, Gauss backward interpolation, Numerical differentiation: using derivative of Newton forward, backward and central difference interpolation formulae
4. **Numerical solution of 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 equations, initial value problem, boundary value problem**,** Euler method, Modified Euler method, Runge-Kutta second order method, Runge-Kutta fourth order method, Predictor-Corrector method: Adam's-Moulton's method, Milne's method**,** Elementary ideas of partial differential equation: introduction, classification.
5. **The Finite Element Method**: Introduction, functionals, Methods of approximation: The Rayleigh-Ritz method, The Galerkin method; the finite element method, application to two-dimensional problems.

Books:-

1. *Numerical Methods* ; E. Balgurusamy , Tata McGrow Hill
2. *Introdictory methods of numerical analysis*; S.S. Sastry , Prentice Hall of India
3. *Numerical methods with programs in BASIC, FORTRAN, Pascal and C++*; S. Balchandra Rao, C K Shantha, Universities Press (India)Pvt. Ltd.
4. *Numerical Methods for Scientists*; Chhapra
5. *Applications of Numerical methods*; Jain M K, Iyengar S R K, and Jain R K, Addison-Wesley, 1972
6. *Theory and problems of numerical analysis*; Schield F. Schaum's outline series, Mc Graw Hill
7. *Mathematical methods*; M C Potter and Jack Goldberg, Prentice Hall of India

PHY- 421 E1 : Communication and Industrial Electronics : Credits 4

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.

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.

2. **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
3. **Thyristor: Principles and Characteristics** : 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
4. **Phase Controlled Rectifiers:** Phase angle control, Single-phase half-wave controlled rectifier, Single-phase full-wave controlled rectifier: Mid point converter (M-2 connection)

   Inverters: Thyristor inverter classification, Series inverters, Basic series inverters, Basic Parallel inverter.
5. **Choppers**: Introduction, Principle of chopper operation, Control strategies: Time-Ratio Control, Current-limit Control; Step-Up Choppers, Step-Up/down Chopper, Jones chopper (design not expected)

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).
5. Power Electronics M D Singh and K B Khanchandani (TMH).
6. Power Electronics M H Rashid (PHI).
7. Power Electronics P S Bimbhra Khanna Publishers.

PHY- 421 E2 : Advanced Communication Electronics : Credits 4

1. **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).
2. **Broad-band communications:** Time division multiplexing, Frequency division multiplexing, Microwave links, line of sight links, tropospheric links, satellite communication, Choice of orbit, Multiple Access, FDMA, TDMA, SPADE and Communication package, Propagation of waves, Ground or surface wave, The space wave, Tropospheric waves,, Sky waves and The ionosphere waves, Fresnel zone problem, Fading.
3. **Cellular Telephone Concepts:** Introduction, Mobile telephone service, Evolution of cellular telephone, cellular telephone, Frequency reuse, Interference, Cell splitting, Sectoring, Segmentation, and Dualization, Cellular system topology, Roaming and handoffs, Cellular telephone network components, cellular telephone call processing.
4. **Satellite Communication:** Introduction, Satellite orbits, Satellite elevation categories, Satellite orbital patterns, Geosyncronous satellites, satellite velocity, Round trip time delay of geosyncronous satellite, Clarke orbit, Advantages and disadvantages, Antenna look angles, Angle of elevation, Azimuth angle, Limits of visibility.
5. **Satellite classifications,** Spacing and Frequency allocation, Satellite antenna radiation patterns: Footprints, Spot and zonal beams, Hemispherical beams, Earth beams, Satellite system link models, Uplink model, Transponder, Downlink model Satellite system parameters, Back-of loss, Transit power and bit energy, Equivalent noise temperature.

Books:

1. Advanced Electronic Communication Systems, Wayne Tomasi. (For Chap.4 and 5) Sixth Edition
2. Data and Computer Communication, William stalling. 6th Edition, EEE
3. Electronic Communications; Dennis Roddy and John Coolen. Fourth Edition. (For Chap.1)
4. Principle of Communication Engineering; Anoke Singh (S. Chand & Company) 1994.(For Chap.2, 3)
5. Communication Systems (Analog and Digital); R.P.Singh and S.D.Sapre. (TMH Publication) 1995. (For Chap.2)
6. Electronic Communication Technology By Edward A. Wilson, Prentice- Hall International editions. (For Chap.2, i.e.
7. for digital communications systems)

PHY- 421 E3 : Industrial Instrumentation : Credits 4

1. **Introduction to Instruments and their representation:** Functional elements of a measurement system, Bourdan tube pressure gauge as an example. Brief description of the functional elements of the instruments : Transducer element, signal conditioning element and data representation element. Standards and Calibration :Standars of measurements : International standards, Primary standards, Secondary standards, Working standards. Calibration : Primary calibration, Secondary Calibration, Direct Calibration with known Input Source, Indirect Calibration and Routine Calibration. Static Performance Characteristics of Instruments :
2. **Types of Errors** : Systematic or Cumulative Errors, Accidental or Random Errors, Miscellaneous type of Gross Errors. Static Performance Parameters :Accuracy, Precision, Accuracy versus Precision, Resolution or Deiscrimination, Threshold, Static sensitivity, Linearity, Range and Span, Hysteresis, Dead band, Backflash, Drift, Impedance Loading and Matching. Temperature Transducer : Metallic Resistance Thermometer or Resistance Temperature Detector (RTD), Thermister, Thermocouple, Thermal switches (bimetallic). Magnetic Transducers : Magnetic pick-up, Inductive pick-up, Proximative switches (Inductive and capacitive).
3. **Mechanical Sensors :** Strain Guage, Load-cell, Piezo sensors Light Sensors : LDR, IRLED, Optocoupler, Opto-transistor Gas Sensor : Fuel cells. Sound Sensors : Microphones Displacement Sensor : LVDT Speed Sensor : Digital Transducers, Shaft encoder and Decoder Flow Sensors : Turbine, Electromagnetic turbine sensor Mirco Sensors : Silicon Microsensors, Hall Effect Sensors
4. **Intermediate Elements :** Amplifiers, Mechanical Amplifier, Hydraulic Amplifier, Pneumatic Amplifier, Optical Amplifier, Electrical Amplifier, Operational Amplifier : Inverting Amplifier, Non-inverting Amplifier, Summing Amplifier, Differential Amplifier, CMRR, Charge Amplifier. Instrumentation Amplifier : Block diagram of Instrumentation Amplifier, Instrumentation Amplifier using Transducer bridge (Refer R.A. Gaikwad book for this article). Linearising Capacitance Transducer using Operational Amplifier, Differentiating and Integrating elements, Filters, Classification of filters. A/D Convertors, D/A Convertors, **Data Transmission Elements :** Electrical type data transmission elements, Pneumatic type data transmission elements, Position type data transmission elements, Radio frequency transmission system.
5. **Indicating, Recording, Display and Terminal Devices:** Galvanometric Recorders, SERVO Type Potentiometric Recorders, Magnetic Type Recorders, Digital Recorders of Memory Type, Data-Acquisition System. Alarms, buzzers, beepers, solenoid relays, actuators, relays, 7 segment displays, LCD displays. DC motor (6V, 9V, 12V) Stepper Motor (construction, working, principle and driver circuits)

Books:

1. Instrumentation measurement and analysis Nakra & Choudhary, Tata McGraw Hill.
2. Transducers and Instrumentation, D.V.S. Muthy,PHI.
3. Principles of Industrial Instrumentation, Patranabis, Tata McGraw Hill.
4. Electrical & Electronics Measurement & Instrumentation, A.K. Sawhney, Dhanpat Rai & Sons.
5. Instrumentation, Rangan & Sharma, Tata McGraw Hill.
6. Integrated Circuits & Semiconductor Devices Deboo & Burrus, Tata McGraw Hill.
7. Instrumentation Handbook, vol. I & II, Liptek Butterworth Heinmann, 1995.
8. 8051 Microcontroller, Architecture, Programming and Applications, Kenneth J. Ayala,Second Edition, Penram International Publishing (India).

PHY- 421 E4 : Modern Trends in Spectroscopy : Credits 4

1. **FOURIER TRANSFORM INFRARED SPECTROSCOPY:** Introduction, Historical Background, FT-IR Spectroscopy, Basic Integral Equation, 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].

2. **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, CH_3 Radical, Benzene Anion ($C_6H_6^-$), etc. [**Scope**: Molecular Structure and Spectroscopy, by G. Aruldhas, Prentice Hall of India pvt, chapter 11].

3. **MOSSBAUER SPECTROSCOPY:** Recoilless Emission and Absorption, Experimental Techniques, Isomer Shift, Quadrupole Interaction, Magnetic Hyperfine Interaction, Applications – Electronic Structure, Molecular Structure, Surface Studies, Biological Applications, Crystal Symmetry and Magnetic Structure, etc.
   [**Scope**: Molecular Structure and Spectroscopy, by G. Aruldhas, Prentice Hall of India pvt, chapter 13].

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.
   [**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].

5. **MOLECULAR SYMMETRY AND THE SYMMETRY GROUPS:** Molecular Point Groups, Matrix Representation of Symmetry Operations, Reducible and Irreducible Representations, The Great Orthogonality Theorem, 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 3 & 4].

Tutorial: Problems given in the book.

Books:

1. Handbook of Applied Solid State Spectroscopy, by D. R. Vij, Springer.
2. Molecular Structure and Spectroscopy, by G. Aruldhas, Prentice Hall of India pvt.
3. Chemical Applications of Group Theory (Third Edition), by F. Albert Cotton, John Wiley & Sons.
4. Elements of Group Theory for Physicists by A. W. Joshi, Wiley Eastern Ltd, New Delhi.
5. Group Theory and Quantum Mechanics by M. Tibkham, Tata Mc-Graw Hill, New Delhi.

PHY-421 E5 : Quantum Theory of Solids : Credits 4

1. **Introductory Quantum mechanics**: Schrodinger equation, expectation values and momentum operator, finite square well, variational method and its application to infinite and finite square well
2. **Bonding in molecules and solids**: Double square well potential, LiH molecule, Tetrahedral bonding in Si crystal, Bonding in GaAs, Trends in semiconductors,
3. **Band Structure of Solids:** Bloch theorem, K-P model, T-B model, NFE model, Band structure of tetrahedral semiconductors, use of pseudopotentials.
4. **Band structure and defects in bulk semiconductors:** k.p theory for semiconductors, effective masses for electrons and holes, trends in semiconductors, impurities in semiconductors, amorphous semiconductors.
5. **Physics of low dimensional semiconductor structures:** Confined states in quantum systems with zero, one and two dimensions, DoS in these structures, Modulation doping, heterojunctions, Quantum Hall effect, Semiconductor laser actions, strained layer lasers, Tunneling structures and devices.

Tutorials : Problems based on the text books mentioned below. Stress be given on problems involving numbers.

1. Quantum Theory of Solids, Eoin O’ Reilly, Taylor & Francis, NY, 2002 0-7484-0628-X
2. Quantum Mechanics : Fundamentals and Application to Technology, Jasprit Singh, John Wiley 1997 ISBN: 0-471-15758-9
3. Physics of Semiconductors and their heterostructures, Jasprit Singh, McGraw Hill, Inc. (1993) ISBN: 0-07-057607-06.

PHY- 421 E6 : Reactor Physics: Credits 4

1. **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.
2. **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.
3. **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.
4. **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.
5. **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.

Books:

1.**Nuclear Physics,** R. C. Sharma.
2**. Nuclear Physics**, I. Kaplan, 2^{nd} 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.

PHY- 421 E7 : Physics of Nanomaterials: Credits 4

1. **Introduction:** Low dimensional materials, particle in a box, electron states in potential well, spherically symmetric potential, Coulomb potential, periodic potential, tunneling though potential barrier, concept of exciton, concept of energy band gap, idea of surface to volume ratio, confinement of electron in one and two dimensional infinitely deep square well.
2. **Cluster:** Semiconductor and metal clusters, cluster stability, fullerene (structure, synthesis, properties). Carbon nanotubes (structure, synthesis, properties), quantum well structure, quantum dots, quantum wires.
3. **Synthesis of Nanomaterials (bottom up approach):** Physical techniques-physical vapor deposition, electron beam evaporation, sputter deposition, laser ablation, ion beam mixing.
4. **Properties of Nanomaterials:** Mechanical, thermal, structural, optical, electrical, magnetic properties of nanomaterials.
5. **Characterization techniques and applications of Nanomaterials:** X-rays diffraction, Electron microscopes (SEM, TEM), Atomic Force Microscopes (AFM), application of nanomaterials in electronics communication, medicine.

Books:

1. *Nanotchnolgy, molecularly designed materials*
   Gan-Moog Chow, Kenneth E. Gonsalves, American Chemical Society
2. *Nano technology: Molecular Speculations on global abundance*
   B.C. Crandall, MIT press1996
3. *Physics* of *Semiconductor nanosutructers*
   K.P.Jain, Narosa,1997
4. *Nano particles and nano structured films preparation characterization and applications*
   J.H. Fendler, John Wiley and Sons 1998
5. *Physics of low dimensional semiconductors*
   John H. Davies Cambridge university press1997
6. Introduction to Nanoscience
   Gabor L. Hornyak, Joydeep Dutta, Hary f Tibbals, Anil K Rao, CRC Press, Taylor & Francis group, 2008.
7. The physics and Chemistry of Nanosolids.
   Frank J Owens, Charles P Poole Jr, Wiley-Interscience, A John Wiley & sons, 2008.
8. Nanomaterials, an Introduction to synthesis, properties and applications.
   Dieter Vollath, wiley-VCH, Verlag GmbH & co, 2008.

PHY- 421 E8 : Renewable Energy

1. **Solar energy and its conversion:** Importance of Solar energy: Nature of Solar radiation, sun as a fusion reactor, spectral distribution of extraterrestrial radiation, Estimation of extra terrestrial solar radiation, Radiation on horizontal and tilted surfaces. Beam diffuse, Available solar radiation, measurement of beam, Various ways to convert solar energy into different forms, Sunshine duration recorder Angstron relations.
2. **Solar Photovoltaics (SPV):** Solar photovoltaics conversion: basic principle of solar photo-valtaics conversion, types of solar cell materials, fabrication of solar photovoltaic cells, solar cell parameters and characteristics.
   Solar Photovoltaic conversion system: Block diagram of general SPV conversion system and their characteristics, solar photovoltaic conversion system components and their characteristics, Application (such as street lights, water pumps, small capacity power generation).
3. **Photothermal applications of Solar Energy:** selective Coatings: ideal characteristics of selective coating for various applications. Types of selective coatings, material and techniques for selective coatings, Effect of selective coating on the efficiency of solar collectors.
   Solar thermal devices and Systems: Differential types of collectors, Flat collector (Basic principle, Energy balance equation of steady state, Testing, methods to reduce losses, solar cooker's, Domestic hot water system, solar dryers, solar furnace, solar refrigeration.
4. **Solar Hydrogen Energy:** Hydrogen Fuel: Importance of hydrogen as a future fuel, Sources of hydrogen, fuel of vechicles.Hydrogen Production: Production of hydrogen by photoelectrolysis and Photo-catalytic process.
   Hydrogen Storage: Gaseous, cryogenics and metal hybride.
   Utilization of hydrogen: fuel cell-principle, construction and applications.
5. **Wind energy:** Introduction, the wind: energy and power in the wind, wind turbines, wind turbines types, horizontal and vertical axes wind turbines, aerodynamics of wind turbines: aerodynamic forces, horizontal and vertical axes wind turbines, production of power and energy from wind turbines, estimating wind speed characteristics of a site,, electricity generation by wind energy, planning & wind energy, calculating the costs of wind energy, small scale wind turbines, wind energy potential, off shore wind energy.

Books :

1. World Energy Resources, Charles E. Brown (Springer Publication, 2002).
2. Principles of solar Engineering, F. Kreith and J. F. Kreider (McGraw Hill, 1978).
3. Energy Policy for India. B. V. Desai (Weiley Eastern Publication).
4. Solar Energy Termal Processes. J. A. Duffie and W.A. Beckman (John Wiley and Sons, 1980).
5. Principle of Solar Energy Conversion, A. W. Culp (McGraw Hill International Publication).
6. Heat and thermodynamics, M. W. Zemansky (McGraw Hill International Publication).
7. Solar Energy- Principles of thermal Collection and Storage, S. P. Sukhatme (2nd edition, Tata McGraw Hill Publication, 1976)
8. Handbook of solar Radiation, A. Mani (Appied Publishers, 1980)
9. Solar energy Fundamentals and applications, H. P. Garg and satya Prakash (Tata McGraw Hill, 1997)
10. Solar Thermal Engineering, J. A.Duffie (Academic Press)
11. TEDDY Year Book (Tata Energy Research Institute TERI Publication, 2002)
12. Treatise on Solar Energy, H. P. Garg, Vol. 1,2 and 3 (John Wiely and sons, 1982)
13. Solar Energy Utilization, G. D. Rai (Khanna Publishers, 1996).
14. Climatological and Solar data for India, Seshadri (Sarita Prakashan, 1969)
15. Energy Technology, S, Rao and B. B. Parulekar (Khanna Publishers, 1995)
16. Terrestrial Solar Photovotics, Tapan Bhattacharya (Namsa Publication House, New Delhi, 1998)
17. Solar Celle-operating principles, Technology and system applications, Martin A. Green (Prentice Inc. U.S.A.)
18. Fundamentals of solar Cells, F. A. Faherenbruch and R. H. Bube (Academic Press).
19. Thin Film Solar Cells, K. L. Chopra And S. R. Das (Plenum Press, 1983).
20. Solar Hydrogen Energy Systrems, T. Onta (Pergamon Press, 1979).
21. Hydrogen Technology for Energy, D. A. Maths (Noyes Data Corp.976).
22. Hydrogen as an Energy Carrier Tecchnologies, Systems Economy, Winter and Nitch (Eds).
23. Photoelectrichemical Solar Cells, Chandra
24. Handbook – Batteries Sources and Fuel, Linden (McGraw Hill, 1984).
25. Handbook – Batteries Sources and Conversion Technology, N. K. Bansal, M. Kleeman and S. N. Srinivas (Tata Energy Research Institute, New Delhi, 1996)
26. Wind Energy Conversion System, L. L. Feris (Prentice Hall, 1990)
27. Biomass Energy Systems, Venkata Ramla and S. N. Srinivas (Tata Energy Research Institute, New Delhi, 1996)
28. Renewable energy, Godfrey Boyle, Oxford University Press

PHY- 414 A3 (Special paper 3): Advanced Sensor Technology: Credits 4

1. **Sensor and Sensor Characteristics:**

   Sensors, Signals, and Systems; Ideal sensor curve, ideal sensor requisite, Sensor Classification ; Transfer Function ; Span (Full-Scale Input) ; Full-Scale Output ; Accuracy ; Calibration ; Calibration Error ; Hysteresis; Nonlinearity ; Saturation ; Repeatability ; Dead Band ; Resolution

2. **Sensor Materials and Technologies:**

   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; Thin film / nanostructure synthesis for sensor development by various techniques viz. electrochemical technique, Chemical Vapour Deposition ; chemical bath deposition, vacuum evaporation, spin coating etc

3. **Physical Principles of Sensing and Interface Electronic Circuits:**

   Electric Charges, Fields, and Potentials; Capacitance: Capacitor, Dielectric Constant; Resistance: Specific Resistivity, Temperature Sensitivity; Temperature and Thermal Properties of Materials; **Input Characteristics of Interface Circuits:** Amplifiers: Operational Amplifiers , Voltage Follower, Instrumentation Amplifier, Charge Amplifiers.

4. **Physical Sensors:**

   Potentiometric Sensors ; Gravitational Sensors ; Capacitive Sensors ; Inductive and Magnetic Sensors: LVDT and RVDT , Eddy Current Sensors , Introduction of light detectors: Photodiodes, Phototransistor , Photoresistors ; photovoltaic cell; Optical fibre Sensors: Principle of optical fibres; types of optical fibres; losses in optical fibre; types of optical fibre sensors; Thermal Detectors : Golay Cells, Thermopile Sensors ; Pyroelectric Sensors ; Active Far-Infrared Sensors.

5. **Chemical Sensors:**

   Chemical Sensor Characteristics ; Specific Difficulties ; Classification of Chemical-Sensing Mechanisms ; Direct Sensors : Metal-Oxide Chemical Sensors, ChemFET, Electrochemical Sensors, Potentiometric Sensors, Conductometric Sensors , Amperometric Sensors, Enhanced Catalytic Gas Sensors, Elastomer Chemiresistors ; Complex Sensors: Optical Chemical Sensors , Biochemical Sensors, Enzyme Sensors ; Chemical Sensors Versus Instruments: Chemometrics, Multisensor Arrays, Electronic Noses (Olfactory Sensors), “Smart” Chemical Sensors.

Books :

1. Hand Book of Modern Sensors : Physics, Designs and Applications By Jacob Fraden
   T h i r d E d i t i o n (Springer)
2. Understanding Smart Sensors By Randy Frank; Second Edition (Artech House
   Boston . London)
3. Sensors and Transducers By Ian R. Sinclair (Newnes : Third Edition)
4. Preface To Chemical Sensors : Fundamentals of Sensing Materials; M. Z. Atashbar, S. Krishnamurthy, G. Korotcenkov; Vol 1; Momentum Press
5. **Chemical Sensors: An Introduction for Scientists and Engineers : Grundler, Peter; Springer**
6. Principles of Chemical Sensors : Janata, Jiri 2nd Edition ; Springer
7. Optoelectronics by R. A. Barapate (Tech-Max Publication)
8. Optoelectronics Devices and System by S. C. Gupta (PHI)
9. Optical Fibers and fiber optic communication Systems by Subir Kumar Sarkar (S Chand & Company Ltd).
10. Lasers and Optical Fiber Communications by P Sarah (I.K. International Publishing House Pvt Ltd, New Delhi)

PHY- 414- B3 (Special paper 3) : Applied Spectroscopy : Credits 4

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. **FLUORESCENCE SPECTROSCOPY**: Fluorescence. Joblanski Diagram, Resonance Fluorescence and Normal Fluorescence. Intensity of Transitions. Non Radiative Decay of Fluorescent Molecules, Effects of Medium on Fluorescence Spectra. [Scope: Spectroscopy Vol. 3 by B. P. Straughan and S.Walkar, London Chapman and Hall, Chapter 5].

4. **PHOSPHORESCENCE SPECTROSCOPY:** Population of Triplet States, Phosphorescence Intensity, Solvent Effect, Delayed Fluorescence. Excitation 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].

5. **NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY:** 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].

   Tutorial: Problems given in the book.

   Books:

   1. Spectroscopy Vol. 1, 2 and 3 by B. P. Straughan and S.Walkar, London Chapman and Hall
   2. Molecular structure and spectroscopy by G Aruldhas Prentice Hall of India
   3. Laser spectroscopy by W. Demtroder Springer.
   4. Modern Spectroscopy by J. M. Hollas John Wiley & sons, Ltd

PHY- 414- C3 (Special paper 3) : Two Body Nuclear Interactions and Nuclear cross sections : Credits 4

1. **The Deuteron**: The deuteron, ground state of deuteron, root mean square radius of deuteron, singlet and triplet states in deuteron, ground and excited states of deuteron, angular momentum of deuteron.
2. **Two Body Nuclear Interactions** : n-p Scattering below 10 MeV, scattering from spherical potential, scattering lengths, effective range measurements, p-p scattering, partial wave analysis of n-p scattering, singlet and triplet state potentials.
3. **Nuclear Forces** : Effective range of nuclear forces, distinction between p-p and n-p scattering, similarility between n-n and p-p scattering, equivalence of n-p and p-p forces, tensor forces, exchange forces, high energy nucleon-nucleon forces, Meson theory of nuclear forces.
4. **Particle Interactions :**Nuclear forces characteristics, classification of particle interactions, response of particle of strong, weak, and electromagnetic interactions, cross sections, difference between geometric and cross section of nuclear event, scattering cross section.
5. **Nuclear Cross-sections :** Differential cross- section, total cross-section and partial cross-section, angular distribution, angular correlation, geometric and absolute cross section, cross section referred to electrons and atoms, classical elastic coulomb scattering cross section (Rutherford formula), Coulomb scattering cross section for like particles (Nott formula).

Books:

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. **Theory of Nuclear Structure**,M. K. Pal, East – weast press Ltd. 1982.
5. **Nuclear Physics**, D.C. Tayal, Himalaya Publishing House, Bombay.
6. **Physics of Nuclei and particles Vol. 1**,P. Norminer and Eric Sheldon, Academic press, Inc, ii, 5th Avenue, New York.

PHY- 414- D3 (Special paper 3) : Magnetism and Superfluidity : Credits 4

1. **Diamagnetism and Paramagnetism:**
   Langevin theory of diamagnetism, Langevin theory of Para magnetism, Curie law, quantum theory of paramagnetism, Curie law, magnetism of rare earth ions, iron group Ions, crystal field splitting, quenching of orbital angular momentum, Hund's rule, paramagnetic susceptibility of conduction electrons.
2. **Ferromagnetism :**
   Ferromagnetic ordering, mean field theory, Curie – Weiss law, Heisenberg exchange interaction, magnon and dispersion relation for magnons, origin of domains, domain walls, coercive force, hystersis, motion of domain walls, experimental methods to determine the magnetic susceptibility, thickness and energy of Bloch wall, anisotropy energy.
3. **Antiferromagnetism:**
   Antiferromagnetc order, the two sublattice model, susceptibility below the Neel temperature, the dispersion relation for magnons in an antiferromagnet, super exchange interaction,
4. **Ferrimagnetism:**
   Ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, ferrimagnetic compounds, properties of ferromagnetic substances, the structure of ferrites, the saturation magnetization, Neel's theory.
5. **Superfludity :**
   Phenomenology, two fluid model, Bose - Einstein condensation, Landau theory, super fluid velocity, super fluid flow, excited state, Ginzberg – Landau equations, second order critical fields, Abrikosov vortex lattices.

Books :

1. Introduction to Solid State Physics, C. Kittel
2. Superfluidity and Superconductivity, David R. riley and John tilley, Van Nostrand Reinhold company Ltd.
3. Solid State Physics, S. O. Pillai, New Age International Pvt. Ltd.
4. Solid State Physics, M. A. Wahab
5. Solid State Physics, A. J. Dekker
6. Introduction to Solid, L.V.Azaroff, McGraw Hill, New York
7. Quantum theory of Solids, C. Kittel

PHY- 415- A4 (Special paper 4) : 8051- Microcontroller : Credits 4

1. **8051 Microcontroller:** An Introduction: Microprocessors and Microcontrollers, comparing microprocessors and Microcontrollers, a Microcontrollers survey, development system for Microcontrollers, 8051 Microcontroller hardware: Block diagram, Programming model, pin diagram, the 8051 oscillator and clock, program counter and data pointer, A and B CPU registers, flags and program status word, internal memory, internal RAM, the stack and the stack pointer, special function registers, internal ROM; Input / output pins, ports and circuits: port pin circuits, port 0, port 1, port 2, port 3; external memory, counters and timers, serial data input / outputs, interrupts.
2. **Moving data and logical operations:** Move Operations**:** Introduction, addressing modes, external data moves, code memory read only data moves, push and pop op-codes, data exchange, simple programs, Logical operations: Introduction, byte level logical operations, bit level logical operation, rotate and swap operations, examples programs.
3. **Arithmetic Operations :** Introduction, flags, instructions affecting flags, incrementing and decrementing, addition: unsigned and signed , multiple byte signed arithmetic, subtraction : Unsigned and signed substraction, multiplication and division, decimal arithmetic, examples programs;
4. **Jump and call Instructions**: introduction, the jump and call program range, relative range, Short absolute range, long absolute range. Jumps, bit jumps, byte jumps, unconditional jumps, Calls and subroutine, subroutines, Calls and the stacks, Calls and returns. Interrupts and returns, examples problems.
5. **Application of 8051 Microcontroller:** Simple programmes using 8051 Microcontroller, Display, generation of waves, Pulse measurements, D/A and A/D conversion, Stepper motor.

Books:

1. The 8051 Micorcontroller, Architecture, Programming and applications by Kenneth J Ayala ; Second Edition
2. Microprocessors and Interfacing : Programming and Hardware by Douglas V Hall : II Edition ; Tata McGraw-Hill Edition
3. The 8051 Microcontroller and embedded Systems by Muhammad Ali Mazidi and Janice Gillspie Mazidi; Pearson Education

PHY- 415- B4 (Special Paper 4) : Lasers, Nonlinear Optical mixing and Spectroscopic phenomena : Credits 4

1. **Basic Concepts**: Absorption, induced and spontaneous emission. Discrete and continuous absorption and emission spectra, transition probabilities, life times, spontaneous and radiationless transitions, Semiclassical description, Basic equations. Dipole approximation, Coherence properties of radiation fields, temporal, spatial coherence [Scope: *Laser Spectroscopy, W. Demtröder* , Springer, chapter 2].
2. **Lasers**: Fundamentals, basic elements, threshold condition, rate equations, laser resonators, open optical resonator, stability of resonators. Spectral characteristics of laser emission, active resonators and laser modes, gain saturation, spatial hole burning. Multimode lasers and gain competition, mode pulling [Scope: *Laser Spectroscopy, W. Demtröder* , Springer, chapter 5: 5.2,5.3]
3. **Tunable lasers**: Basic concepts, semiconductor-diode laser,Tunable solid state lasers, Dye lasers: flashlamp pumped dye lasers, Pulsed-laser pumped dye laser, continuous wave dye laser [Scope: *Laser Spectroscopy, W. Demtröder* , Springer, chapter 5: 5.7]
4. **Non liner optical mixing**: Physical Background , Phase Matching, Second harmonic generation, Quasi Phase Matching Sum frequency & higher harmonic generation. X ray laser. Optical parametric oscillator, Difference-Frequency Spectrometer [Scope: *Laser Spectroscopy, W. Demtröder* , Springer, chapter 5:5.8]
5. **Nonlinear Spectroscopic phenomena**: Nonlinear Raman phenomena-preliminaries, Hyper Raman effect, Stimulated Raman scattering, Inverse Raman effect, Coherent Anti-Stokes Raman Scattering, Photo-acaustic Raman Scattering, Multiphoton spectroscopy [Scope: Molecular Structure and Spectroscopy by G. Aruldhas, PHI, chapter 15]

Tutorial: Problems given in the books on related topics.

Books:

1. Laser spectroscopy by W. Demtroder, Springer.
2. High resolution spectroscopy by J.M. Hollas, Wiley.
3. Molecular Structure and Spectroscopy by G. Aruldhas, PHI

PHY- 415 - C4 (Special Paper 4): Radiation Measurements And Nuclear Dosimetry : Credits 4

1. **Nuclear radiation measurements** : Crystal conduction counters, energy resolution of the counter, surface barrier counters, cloud chamber, diffusion cloud chamber, bubble chamber, Spark chamber.
2. **Interaction of Nuclear Radiations with matter**: Stopping power of charged nuclear particles, range and straggling, stopping power and range for electrons, absorbtion of gamma rays , photoelectric effect, Compton effect, pair production.
3. **Radiation Protections** : Harms of radiation to body, radiation safety standards, radiation dosimetry measuring instruments, film dosimetry principles, experimental techniques, applications, solid state nuclear track dosimetry, track processing methods, canting procedure and applications, safe working methods of nuclear radiation.
4. **Measurement techniques of Ionising events**: Pulse Shaping, Pulse amplifier, the univibrator, scaling unit, Dekatron, coincidence circuit, pulse height analyzer, voltage discriminator, single channel pulse height analyzer, Multichannel pulse height analyzer.
5. **Applications of Nuclear irradiations** : Introduction, The technique of NMR, seed oil mass screening by NMR technique, Mossbauer effect, some experiments using Mossbauer effects, Radiaion effects, Mutation by irradiation.

Books:

1. **Basic Nuclear physics** ; B. N. Shrivastava, Pragati prakashan, Meerut.
2. **Nuclear Physics**; D.C. Tayal, Himalaya Publishing House, Bombay.
3. **Principles of radioisotope Methodology**; G.D. Ghose, Burgess Publishing Company, Minneota.
4. **Experimental Nuclear Chemistry;** G.R. Choppin, prentice hall Inc. Englewood Clifs N. J.
5. **Fundamentals of Nuclear Science;** P.N. Tiwari, Wiley eastern Pvt. Ltd. New Delhi, 1974.

PHY- 415 - D4 (Special Paper 4) : Material Synthesis and Characterization : Credits 4

1. **Independent Electron Approximation**
   The Hartree equations, Thomas- Fermi and Lindhard Theory, the Hartree Fock approximation, the tight binding approximation, the Wigner and Seitz method, energy band calculations Fermi-Liquid theory, Lindhard theory.
2. **Synthesis and Characterization of Ferrites :**
   Synthesis : successive ionic layer adsorption and reaction (SILAR), solid state reaction route (SSRR), co-precipitation route (CR), properties : Electrical, Mechanical & magnetic, characterization: X-ray diffraction (XRD), Thermal electron microscopy (TEM).
3. **Thin Film Deposition Techniques**
   Vacuum pumps: Mechanical pumps-oil sealed Rotary pumps, roots pumps, molecular-drag pumps, cryogenic pumps, vacuum seals, vacuum measurement- thin film nucleation- the capillarity model, the critical Nucleus.
   Particle size determination techniques, physical vacuum deposition, MBE,CVD, MOCVD, PVD, sputtering, electrochemical deposition, plasma assisted techniques, Thickness measurement of films, electrical conductivity of thin films, Boltzmann transport equation of thin films.
4. **Synthesis of Superconducting Materials**
   Synthesis : solid state reaction route (SSRR), Chemical Route, Melt Grown Route, Melt Grown and Infiltration route, Co-precipitation Route, Sol-Gel Route.
5. **Properties and characterization of HTSC Materials**
   Properties: mechanical, electrical and magnetic, characterization: X-ray diffraction (XRD), determination of lattice parameters from XRD data, estimation of volume, density, scanning electron microscopy (SEM), Scanning tunneling microscopy (STM). Superconducting quantum interference devices system (SQUIDs).

Books :

1. Handbook of Thin Film : Maissel and Glang
2. Superfluidity and Superconductivity – D. R. Tilley and J. Tilley
3. Sperconductivity – T. V. Ramakrishan and C. N. R. Rao
4. Physical and magnetic properties of High Temerature Superconductors – S. K. Malik and S. S. Shah (Nova Science publishers. Inc.)

PHY- 460 : A3 : Electronics (Lab Course 7) : Credits 3

Unit-I : 8051 –Microcontroller

1. Write programs for addition using 8051 microcontroller.
2. Write programs for subtraction using 8051 microcontroller.
3. Write programs for multiplication using 8051 microcontroller.
4. Write programs for division using 8051 microcontroller.
5. Write program for Ascending and descending numbers using 8051 microcontroller.
6. Write program to find Square root of given number using 8051 microcontroller.
7. Write program to find Maximum and minimum numbers using 8051 microcontroller.
8. Write program for temperature control interface using 8051 Microcontroller.
9. Write program for analog to digital converter using 8051 microcontroller.
10. Write program to generate ramp, triangular and square waves using DAC through 8255 of 8051 microcontroller.
11. Write program for stepper motor interface using 8051 microcontroller.

Unit II: Advanced Sensor Technology

1. Determination of Numerical Aperture of PMMA optical fiber
2. Losses in Optical fiber.
3. Study of Optical to Electrical (O-E) characteristics of fiber optic Phototransistor converter.
4. Optical fiber chemical sensor.
5. Study of Displacement Sensor.
6. Study of Potentiometric Sensor
7. Study of Characteristics of photovoltaic cell
8. Gas Sensor based on OCP (organic Conducting Polymers)
9. Gas Sensor based on Single Walled carbon nanotubes (SWNTs)

Note: Students should perform at least six experiments (at least three experiments from each Unit)

PHY- 460 : B3: Spectroscopy (Lab Course 7) : Credits 3

Advanced Optics experiments using lasers

1. Determine the thickness of Fabry-Perrot interferometer using He-Ne laser/Na lamp
2. Fabry-Perot Interferometer: Determination of wavelength
3. Measure the divergence of a LASER beam.
4. Determine the wedge angle of a glass plate by Double spot technique
5. Measure the refractive index of a liquid (Water) using hollow prism.
6. Measure the grating element of transmission grating.
7. Measure the numerical aperture of an optical fiber.
8. Measure the attenuation in an optical fiber.
9. Verify the Malu's law.
10. Setup and study the electro-optic Kerr effect.
11. Setup and study the Faraday effect.
12. Measure the Brewster angle and hence the refractive index of a glass.
13. To verify Beer and Lamberts law using spectrophotometer
14. Michelson interferometer
15. Twyman-Green Interferometer

PHY – 460 : C3: Nuclear physics (Lab Course 7) : Credits 3

1. Mass attenuation coefficient of gamma rays in lead.
2. Mass attenuation coefficient of gamma rays in aluminium.
3. The proportional counter and low-energy X-ray measurements.
4. Gamma- gamma coincidence studies.
5. Spectrum analysis of Fe by using Mossbauer.
6. Study of Multichannel analyzer.
7. Study of absorption of nuclear radiation using proportional counter.
8. To study the Compton scattering using gamma rays of suitable energy.
9. Measurement of activity of alpha, beta and gamma sources.

PHY- 460 : D3: Condensed matter physics (Lab Course 7) : Credits 3

1. Thin film deposition by Chemical Bath Deposition (CBD) and measure its thickness.
2. Structural analysis of thin film by XRD
3. Variation of conductivity with temperature and frequency
4. Thin film deposition by chemical route (Electrodeposition)
5. To study the vacuum system (production and measurement)
6. Synthesis of semiconductor nanoparticles by SILAR
7. Wind energy
8. Determination of size and position of nanoparticles using nano kit
9. Porosity determination of semiconducting material.
10. Estimation of core loss and coercive force for a ferromagnetic core material of a transformer
11. Measurement of dielectric constant of liquids.

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

PHY- 461 : A4 / B4/ C4/ D4 : Project for all specializations (Lab Course 8) : Credits 3

PHY- 452 : Tutorials and Seminars : Credits 4

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