Syllabus of

M.Sc. Second Year (Semester Pattern) (Choice Based Credit System)

SUBJECT - PHYSICS

Semester III & Semester IV
### Syllabus for M. Sc. Physics

Choice Based Credit System (Semester Pattern)
Gondwana University, Gadchiroli
Effective from 2016-2017

**Scheme of teaching and examination under semester pattern Choice Based Credit System (CBCS) for M.Sc. Program in subjects Physics**

**Semester III:**

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<tr>
<td>Core 9 (PSCPH YT09)</td>
<td>Paper 9 Quantum Mechanics II</td>
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<td>Foundation Course I (PSCPH YT12)</td>
<td>Paper 12 Fundamental of Spectroscopy OR Fundamental of Nanoscience and Nanotechnology</td>
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<td>Practical 5 (Based on Core 9 &amp; 10)</td>
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<td>Practical</td>
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Seminar
Guidelines for Students, Supervisors and Examiners

In each semester, the student will have to deliver a seminar on any topic relevant to the syllabus / subject encompassing the recent trends and development in that field / subject. The topic of the seminar will be decided at the beginning of each semester in consultation with the supervising teachers. The student has to deliver the seminar which will be followed by discussion. The seminar will be open to all the teachers of the department, invitees, and students.

The students should submit the seminar report typed and properly bound in one copy to the head of the department. The said shall be evaluated by the concerned supervisor / head of the department. The marks of the seminar shall be forwarded to the university within due period through head of the Department. The record of the seminar should be preserved till the declaration of the final result.

Internal Assessment:

1. The internal assessment marks shall be awarded by the concerned teacher.
2. The internal assessment marks shall be sent to the University after the Assessment in the prescribed format.
3. For the purpose of internal assessment the University Department / College shall conduct any three assignments described below. Best two scores of a student in these tests shall be considered to obtain the internal assessment score of that student.
4. If the student does not appear for the Practical Exam he shall be declared failed in Practical Examination irrespective of marks obtained in Internal Practical Assessment. However the Internal Practical Assessment marks will be carried forward for his next supplementary Practical Exam.
5. General guidelines for Internal Assessment are:
   a) The internal assessment marks assigned to each theory paper as mentioned in Appendix 1 shall be awarded on the basis of assignments like class test, attendance, home assignments, study tour, industrial visits, visit to educational institutions and research organizations, field work, group discussions or any other innovative practice / activity.
   b) There shall be three assignments (as described above) per course.
   c) There shall be no separate / extra allotment of work load to the teacher concerned. He/ She shall conduct the internal assessment activity during the regular teaching days / periods as a part of regular teaching activity.
   d) The concerned teacher / department / college shall have to keep the record of all the above activities until six months after the declaration of the results of that semester.
   e) **At the beginning of each semester, every teacher / department / college shall inform his / her students unambiguously the method he / she propose to adopt and the scheme of marking for internal assessment. (Prescribed in syllabus of respective Subjects).
   f) Teacher shall announce the schedule of activity for internal assessment in advance in consultation with HOD / Principal.

Practical Examination

1. Each practical carries 100(80 Pr+20 Int) marks. The scheme of marking shall be as per given in the syllabi of respective subjects.
2. Practical performance shall be jointly evaluated by the External and Internal Examiner. In case of discrepancy, the External Examiner’s decision shall be final.
3. Duration of practical examination will be as per given in the syllabi of respective subjects.
4. The Practical Record of every student shall carry a certificate as shown below, duly signed by the teacher-in-charge and the Head of the Department. If the student fails to submit his / her certified Practical Record duly signed by the Teacher-In-Charge and the Head of the Department, he / she shall not be allowed to appear for the Practical Examination and no Marks shall be allotted to the student.
5. The certificate template shall be as follows:

**CERTIFICATE**

Name of the college / institution ____________________________

Name of the Department: ____________________________

This is to certify that this Practical Record contains the bonafide record of the Practical work of Shri / Shrimati / Kumari ____________________________ of M. Sc. ____________________________

Semester ____________________________ during the academic year ____________________________ The candidate has satisfactorily completed the experiments prescribed by Gondwana University Gadchiroli for the subject ____________________________

Dated __/__/________

Signature of the teacher who taught the examinee

1. ____________________________

2. ____________________________

Head of the Department

General Rules and Regulations regarding pattern of question paper for the semester end examination:

**A) Pattern of Question Paper**

1. There will be four units in each paper.

2. Maximum marks of each theory paper will be 80.

3. Question paper will consist of five questions, each of 16 marks.

4. Four questions will be on four units with internal choice (One question on each unit).

5. Fifth question will be compulsory with questions from each of the four units having equal weightage and there will be no internal choice.
M.Sc. Physics Semester III
1. (Core 9) Paper 9: Quantum Mechanics-II
2. (Core 10) Paper 10: Solid State Physics and Spectroscopy
3. Any one of the Elective papers from the following list. Paper 11 (Core Elective 1)
   E1.1 Materials Science I
   E1.2 Nanoscience and Nanotechnology I
   E1.3. Atomic and Molecular Physics I
   E1.4 Applied Electronics I

4. Foundation course 1
   Any one of following courses: Paper 12
   F1.1 Fundamentals of Spectroscopy
   F1.2 Fundamentals of Nanoscience and Nanotechnology

M.Sc. Physics Semester IV
1. (Core 11) Paper 13: Nuclear and Particle Physics
2. (Core 12) Paper 14: Solid State Physics
3. One of the elective papers from list below Paper 15 (Core Elective 2)
   E2.1 Materials Science II
   E2.2 Nanoscience and Nanotechnology II
   E2.3 Atomic and Molecular Physics II
   E2.4 Applied Electronics II

4. Foundation course II
   Any one of the following courses: Paper 16
   F2.1 Spectroscopic Applications
   F2.2 Optics and Optical Instruments
Semester III  Paper 9 (Core 9) Quantum Mechanics II

Unit - I
Time independent perturbation theory, First order perturbation theory applied to non-degenerate states, second order perturbation extension to degenerate state, Application of perturbation theory to the ground state energy, He atom (calculation given in Pauling and Wilson), Normal and anomalous Zeeman effect, First order Stark effect in the ground and first excited states of H atom and second order Stark effect of H atom, and harmonic oscillator.

Unit II
Time dependent perturbation theory, transition state, Fermi Golden rule, constant perturbation harmonic in time, radiative transitions, absorption and induced emission, atomic radiation, dipole approximation, Einstein’s atomic radiation, Einstein’s A and b coefficients and their calculations.
Approximation methods: W. K. B. method and its application to barrier penetration.
Variational principle and its application to simple cases like ground state of He atom and deuteron in Yukawa potential.

Unit III
System of identical particles, exchange and transposition operators, totally symmetric and antisymmetric wave function and their expressions for a system of non-interacting particles, statistics of systems of identical particles, Relation of statistics with spin, Ortho and para states of the helium atom and their perturbation by Coulomb repulsion.
Scattering theory, scattering cross-section in laboratory and centre of mass system, scattering by a central potential, Partial wave method, phase shifts and their importance, scattering by a square well potential and a perfectly rigid sphere, resonance scattering.

Unit IV
Relativistic wave equation, the Klein-Gordon equation and initial difficulties in interpreting its solutions, Dirac’s relativistic equation, Dirac’s matrices, explanation of the spin of the electron, equation for an electron in an electromagnetic field and explanation of the magnetic moment due to the electron spin, spin-orbit interaction, solution for hydrogen atom in Dirac’s theory, negative energy states and their qualitative explanations.

Text and References Books:
1. E. Merzbacher, Quantum Mechanics (Wiley and Sons-Toppon)
2. J. L. Powell and B. Crasemann, Quantum mechanics (B I Publications)
3. L. I. Schiff, Quantum Mechanics (McGraw-Hill)
4. Quantum Mechanics: Aruldhas
5. Pauling and Wilson, Introduction to Quantum Mechanics
6. A.K. Ghatak and Lokanathan, Quantum Mechanics (Macmillan, India)
7. Quantum Mechanics: 500 problems with Solutions: Aruldhas (PHI)
**Semester III Paper 10 (Core 10) Solid State Physics and Spectroscopy**

**Unit I:** Order in Solids-Crystal classes and system, 2d and 3d lattices, Space groups, Concept of point group, bonding of common crystal structure; reciprocal lattice, diffraction and structure factor, Miller and Bravais indices, Bonding, diffraction and structure factor in solids, short and long range order in liquids and solids, liquid crystals, quasicrystals and glasses

**Unit II**
**Defects:** Vacancies, Point defects, line defects and stacking faults, Burgers vector and Burger circuit, presence of dislocation, dislocation motion, perfect and imperfect dislocations, slip planes and slip directions, dislocation reactions

**Dielectric Properties:** -Polarization mechanisms, Clausius-Mossotti equation, piezo, pyro and ferroelectricity

**Unit III**

**Unit IV**
**Molecular Structure and Molecular Spectra:** Types of molecules, Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Morse potential energy curve, Molecules as vibrating rotator, Vibration spectrum of diatomic molecule, PQR branches. Elementary discussion of Raman, ESR and NMR spectroscopy, chemical shift

**Reference Books:**
2. Introduction to Atomic Spectra: H.E. White.
3. Solid State Physics, Charles Kittel, John Willey & Sons
4. Molecular Spectra and Molecular Spectroscopy (Vol. 1), G. Herzberg
5. Introduction to Atomic Spectra: HG Kuhn
6. Fundamentals of molecular spectroscopy, C.B. Banwell
7. Introduction to molecular Spectroscopy , G. M. Barrow
8. Introduction to Solid State Physics: C. Kittle
9. Materials Science and Engineering: V. Raghavan
11. FerroelectricityJona and Shirane
Semester III  Practical 5

**Practical 5 (Core 9 and Core 10)**

1. Determination of ionization potential of lithium
2. X-ray diffraction by TELEXOMETER.
3. Study of emission spectra of iron (Iron arc).
4. Determination of Dissociation Energy of Iodine Molecule by photography of the absorption band of Iodine in the visible region.
5. Study of Stark effect
6. Study of Molecular Spectra
7. Determination of Rydberg’s constant
8. Determination of Plank’s constant
9. Study of Crystals
10. Study of line spectra

Note: Instructor can introduce new and relevant experiments which are not in the list.
Semester III  Paper 11 (Core Elective E1.1) Materials Science I

Unit- I

**Equilibrium and kinetics:** Stability and metastability, Basic thermodynamic functions, Statistical nature of entropy, Kinetics of thermally activated process.

**Phase diagrams:** The phase rule, free energy composition diagram, correlation between free energy and phase diagram, calculation of phase boundaries, thermodynamics of solutions, single component system (water), two component system containing two phases and three phases, Binary phase diagrams having intermediate phases, Binary phase diagrams with eutectic system. Lever principle, maximum, minimum, super lattice, miscibility gap, microstructure changes during cooling, application to zone refining.

Unit – II

**Phase transformations:** Time scale for phase changes, peritectic reaction, eutectoid and eutectic transformations, order disorder transformation, transformation diagrams, dendritic structure in alloys, transformation on heating and cooling, grain size effect on rate of transformation at constant temperature and on continuous cooling, grain size effect on rate of transformation, nucleation kinetics, growth kinetics, interface kinetics leading to the crystal growth.

Unit-III

**Diffusion in solids:** Fick’s laws and their solutions, the Kirkendall effect, mechanism of diffusion, temperature dependence of diffusion coefficient, self diffusion, interstitial diffusion, the Snoek effect in diffusion, diffusion in ionic crystals, diffusion path other than the crystal lattice, thermal vibrations and activation energy, diffusion of carbon in iron.

**Solid State Ionics:** Definition, classification and characteristic properties of solid electrolytes. Complex impedance spectroscopy, Arrhenius theory of ionic conductivity. Chemical sensors: Nernst equation, potentiometer and amperometric sensors for various gases, electrochemical redox-reaction, advantages of electrochemical sensors.

UNIT-IV

**Solid state energy devices:** Fundamental of Solar cells, Primary and secondary solid state cells, advantages of lithium batteries, ion intercalation compounds for secondary cell, open circuit voltage and short circuit current, intercalation compounds for secondary cell, open circuit voltage and short circuit current, Energy density, power density. Fuel cells – advantages and disadvantages, classification, efficiency- emf of fuel cells, hydrogen/oxygen fuel cell, criteria for the selection electrode and electrolyte, methanol fuel cell, solid oxide fuel cells, phosphoric acid fuel cells, molten carbonate fuel cell, proton exchange membrane fuel cell, biochemical fuel cell.
Text and Reference books:
2. V. Raghvan: Materials Science.
7. Kelly and Groves: Crystal and defects.
9. M. A. Azaroff: Elements of crystallography
9. Introduction to solid state theory: Modelung.
Semester III  Paper 11 (Core Elective E1.2) Nanoscience and Nanotechnology I

Unit I:
Introduction to Nanoscience:
Free electron theory (qualitative idea) and its features, Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size, Structure property relation, Size dependence properties. Determination of particle size, Increase in width of XRD peaks of nano-particles, Shift in photoluminescence peaks, Variation on Raman spectra of nano-materials.

Unit II:
Synthesis of Nanomaterials:
Physical methods: High energy Ball Milling, Melt mixing, Physical vapour deposition, Ionised cluster beam deposition, Laser ablation, Laser pyrolysis, Sputter deposition, Electric arc deposition, Photolithography.

Unit III:
Nanomaterials Characterizations:

Unit IV:
Special Nanomaterials and Properties:
Carbon nanotubes, Porous silicon, Aerogels, Core shell structures. Self assembled nanomaterials. Metal and semiconductor nanoclusters
Mechanical, Thermal, Electrical, Optical, Magnetic, Structural properties of nanomaterials

Text and Reference books:
7. Hand Book of Nanotechnology, Bhushan
Semester III  Paper 11 (Core Elective E1.3) Atomic and Molecular Physics I

Unit I
Quantum states of an electron in an atomic Electron spin, spectrum of hydrogen, Helium and alkali atoms, Relativistic corrections for energy levels of hydrogen; Basic principles of interaction of spin and applied magnetic field.
Concepts of NMR spectroscopy concepts of spin-spin and spin-lattice relaxation, chemical shift; spin-spin coupling between two and more nuclei; chemical analysis using NMR.
Mossbauer effect-Recoil less emission of gamma rays, chemical shieft, magnetic hyperfine interaction,

Unit II
electron spin resonance, experimental setup, hyperfine structure and isotopic shift,width of spectral lines, LS & JJ coupling, Zeeman, Paschen Back & Stark effect. Spontaneous and Stimulated emission, Einstein A & B Coefficients; LASERS, optical pumping, population inversion, rate equation, modes of resonators and coherence length, Role of resonant cavity, three and four level systems, Ammonia MASER, ruby, He-Ne, CO2, dye and diode lasers, Lasers applications

Unit III
Rotational, vibrational and Raman spectra of diatomic molecules, Quantum theory, Molecular polarizability, Intensity alteration in Raman spectra of diatomic molecules, Experimental setup for Raman spectroscopy in the structure determination of simple molecules. polyatomic molecules, symmetric top asymmetric top molecules. Hunds rule.

Unit IV

Text Book and References:
5. Introduction to Atomic Spectra – H. E. White.
8. Introduction to Molecular Spectroscopy – G. M. Barrow.
14. Laser spectroscopy and instrumentation- Demtroder
Semester III  Paper 11 (Core Elective E1.4) Applied Electronics I

Unit – I
Operational Amplifiers, Block diagram of a typical operational amplifier, analysis, open loop configuration, inverting and non-inverting amplifiers, operational amplifier with negative feedback, voltage series feedback, effect of feedback on close loop gain, input resistance output resistance bandwidth and output offset voltage, voltage follower. Practical operational amplifier, input offset voltage, input bias current, input off set current, total output off set voltage, CMRR, frequency response, dc and ac amplifier, summing, scaling and averaging amplifier, instrumentation amplifier, integrator and differentiator. Application of Op-Amp as fixed and variable voltage regulator. Oscillators principles- Barkhausen criterion for oscillations, The phase shift oscillator, Weinbridge oscillator, LC tunable oscillator, multi-vibrators, mono-stable and astable, comparators, square wave and triangular wave generators

UNIT II
Communication electronics: Amplitude modulation, generation of AM waves, demodulation of AM waves, DS BSC modulation, generation of DSBSC waves, coherent detection DSBSC wave, SSB modulation, generation and detection of SSB waves, Vestigial sideband modulation, frequency division multiplexing (FDM).
Microwave communication: Advantage and disadvantage of microwave transmission, loss in free space propagation of microwaves, atmospheric effect on propagation, Fresnel zone problem, ground reflection, fading sources, detector components, antennas used in microwave communication systems

Unit – III
Microprocessor: Introduction to microcomputers, Memory. Input-output devices, interfacing devices. 8085 CPU, architecture, bus timing, de-multiplexing, the address bus, generating control signals, instruction set, addressing modes, illustrative programmes, assembly language programmes, looping, counting and indexing, counters and timing delay, stack and sub routings, read only memory (ROM) and applications. Random access memory (RAM) and applications, Digital to analogue converters. Ladder and weighted register types, analog to digital converters, successive approximations and dual slope converters, application of DAC and ADC,

Unit – IV
Microwave devices: Klystrons, magnetrons, and travelling wave tubes, velocity modulation, basic principle of two cavity klystrons and reflex klystrons, principle of operation of magnetrons, Helix travelling wave tubes, wave modes, transferred electron devices, gun effect, principle of operation, modes of operation, read diode, IMPATT diode, TRAPATT diode.

Text and Reference Books:
2. OP-Amps and linear integrated circuits: Ramakanth A. Gayakwad (PHI 2nd Edn).
8. Advanced electronics communication systems: Wayne Tomasi (Phi Edn).
Semester III  Practical 6 and 7 for elective papers

Practical 6 and 7 (elective)

Materials Science
1. Crystal structure determination by powder diffraction.
2. Study of microstructures of metal alloys.
3. Dislocation in alkali halide crystals.
4. Crystal growth from slow cooling of the melt.
5. Thermal analysis of binary alloy.
7. To study electrochemical method of corrosion control.
8. Dielectric behaviour of LiNbO$_3$ and BaTiO$_3$ in crystals and ceramics.
10. To test hardness of a material by Brinell hardness tester.
11. Photo elasticity study.
12. Multiple beam interferrometric study of surfaces.
15. Study of transport property in solid electrolytes.
17. Determination of Thermoelectricity Power.

Nanoscience and Nanotechnology
1. Synthesis of metal oxide nanoparticles by wet chemical method.
2. Deposition of thin films by spray pyrolysis technique.
5. Synthesis of conducting polymer nanofibres by chemical oxidation method.
7. Determination of particle size of nanomaterials from x-ray diffraction.
8. Study of photoluminescence of well known luminescent nanoparticles.
10. Thermoluminescence study of nanomaterials.
11. Deposition of thin films by dip coating technique.
12. Study of particle size effect on luminescence.
13. Electrical characterisation of nanostructured materials.
15. Deposition of thin film in vacuum.
16. Electrical resistivity of nanomaterials using four probe method
17. Photoluminescence study of prepared red/blue/green luminescent nanomaterials.
18. Characterization of nanomaterials using SEM/TEM.

Atomic and Molecular Physics
1. Study of line spectra on photographed plates/films and calculation of plate factor.
2. Verification of Hartman's dispersion formula.
4. Determination of metallic element in a given inorganic salt.
5. To record the spectrum of CN violet bands and to perform vibrational analysis.
6. To record the visible bands of ALO and to perform vibrational analysis.
7. To photograph and analyse the reddish glow discharge in air under moderate pressure.
8. To photograph and analyse the whitish glow discharge in air under reduced pressure.
9. To perform vibrational analysis of a band system of N2.
10. To perform vibrational analysis of a band system of C2.
11. To photograph and analyse the line spectrum of Calcium atom.
12. To record/analyse the fluorescence spectrum of a sample.
13. To record/analyse the Raman spectrum of a sample.
15. To photograph the (O, O) band of CuH and to perform rotational analysis.
17. E/m of electron.
22. Analysis of ESR Spectra of transition metals.
24. Measurements of dielectric constant of polymer sheet at low frequency.
25. E.S.R. of DPPH.
26. To measure the dielectric constant and polarisation of unknown liquid.
27. To measure the dielectric constant of unknown wood at microwave frequency.
28. To measure the ultrasonic velocity in unknown liquid.
29. He-Ne Layer
30. To study polarisation of sodium light
31. To study polarisation of light using Babinet compensator.

Applied Electronic
1. Pulse amplitude modulation/demodulation
2. Pulse position/Pulse width modulation/demodulation
3. FSK modulation/demodulation using Timer/PPL
4. Microwave characterization and measurements.
5. PLL circuit and application.
7. Design of active filters.
8. BCD to seven segment display.
10. Experiments using various type of memory elements.
11. Addition, Subtraction, Multiplication and Division using 8085/8086.
12. Wave form generation and storage Oscilloscope.
13. Frequency Temperature voltage measurements.
15. Trouble shooting using signature analyzer.
16. Assembly language programming on PC.
17. Experiment based on Computer aided design.
18. OPAMP as a integrator and differentiator.
19. OPAMP as a Schmitt trigger generator.
20. Construction and study of astable, monostable and bistable multivibrator.
21. Study of OPAMP as fixed and variable voltage regulator.

Note: Instructor can introduce new and relevant experiments which are not in the list.
Semester III  Paper 12 (Foundation course F1.1) Fundamentals of Spectroscopy

Unit I

Unit II
Molecular Spectra: Microwave Spectra: Rotational spectra of rigid diatomic molecules - effect of isotopic substitution. Non–rigid rotor – rotational spectra of polyatomic molecules

Unit III
Raman Spectroscopy: Pure rotational Raman spectra - linear and symmetric top molecules - vibrational Raman spectra – Raman activity of vibrations - structure determination from Raman and IR spectroscopy.

Unit IV

Reference Books:
1. Introduction of Atomic Spectra, H.E. White, McGraw Hill
4. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill
6. Elements of Spectroscopy, Gupta, Kumar & Sharma, PragathiPrakshan
8. Laser Spectroscopy techniques and applications, E.R. Menzel, CRCPress, India
Semester III  Paper 12 (Foundation course F1.2) Fundamentals of Nanoscience and Nanotechnology

Unit-I Basics of Nanoscience
Introduction to quantum physics, electron as waves, wave mechanics, Schrödinger equation and particle in a box, Heisenberg’s uncertainty principle, exclusion principal, Free electron theory (qualitative idea) and its features, Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size
The p-n-junction and bipolar transistor, Metal semiconductor and metal insulator, semiconductor junction, field effect transistor.

Unit-II Properties of Nanomaterials
Mechanical, Thermal, Electrical, Optical, Magnetic and Structural. Carbon nanostructures- Fabrication, structure, electrical properties and mechanical properties.

Unit-III Synthesis of Nonmaterial’s
Physical methods: Bottom up-Ball Milling, Melt mixing, Physical vapour deposition, Ionised cluster beam deposition, Laser pyrolysis, Sputter deposition, Electric arc deposition, Gas evaporation.
Chemical methods: Hydrothermal combustion, bath deposition with capping techniques and top down, Chemical vapour deposition, Synthesis of metal & semiconductor nanoparticles by colloidal route, Microemulsions, Sol-gel method, Combustion method, Wet chemical method

Unit-IV Bionanotechnology
Biological building blocks, nanostructure, protein nanoparticles, DNA double nanowire. Bionanostructures- Micelles, vesicles, multilayer films, biological interactions, bilayers, bioelectronics and biosensors.

Text and Reference Books:
2. Carbon nanotechnology..recent developments in Chemistry, Physics, materials science and device applications, -Elsevier Science
4. Physics, Chemistry and Application of Nanostructures, world scientific co.
10. Hand Book of Nanotechnology, Bhushan
Semester IV  Paper 13 (Core 11) Nuclear and Particle Physics

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:

Text-books recommended:
2) Nuclear and Particle Physics: Brian Martin.
3) Atomic and Nuclear Physics: S.N. Ghoshal.
4) Introduction to Particle Physics : D. Griffiths.
5) Introduction to Nuclear Physics: F. A. Enge, Addison Wesley (1975)
6) Introductory Nuclear Physics: Burcham
Semester IV Paper 14 (Core 12) Solid State Physics

**Unit I: Band Theory:** Bloch theorem, the Kronig-Penney model, construction of Brillouin zones, extended and reduced zone schemes, effective mass of an electron, tight binding approximation. Fermi surface.

**Magnetic Properties:**
Quantum theory of paramagnetism, magnetism of iron group and rare earth ions, exchange interactions. Pauli paramagnetic susceptibility

**Unit II**

**Lattice Dynamics:** Energy of atomic motions, adiabatic principle, harmonic approximation, cyclic boundary condition. Lattice vibrations of linear monoatomic and diatomic chains. Dispersion relations, acoustic and optical phonons. Theories of lattice specific heat, Dulong and Petit's law, Einstein and Debye models, $T^3$ law, Born procedure, anharmonicity and thermal expansion.

**Unit III: Free Electron Theory:** Electrons moving in one and three dimensional potential wells, quantum state and degeneracy, density of states, electrical and thermal conductivity of metals, relaxation time and mean free path, the electrical resistivity of metals, thermonic emission. Seebeck effect, thermoelectric power.

**Semiconductors:** Free carrier concentration in semiconductors, Fermi level and carrier concentration in semiconductors, effect of temperature on mobility, electrical conductivity of semiconductors, Hall effect in conductors and semiconductors.

**Unit IV**

**Text and Reference books:**
4. Feynman Lectures: Vol. III.
5. Board and Huano: Dynamical Theory of Crystal Lattice.
Semester IV  Practical 7 for core papers

Practicals based on core 11 and core 12

1. Measurement of resistivity of a semiconductor by four probe method at two different temperatures and determination of band gap energy.
3. Determination of Hall life of ‘In’.
4. Determination of range of Beta-rays from Ra and Cs.
5. G-M counter
6. Magnetoresistance by Hall effect
7. Determination of Dielectric constant
8. Random decay of nuclear disintegration using dice (or simulation)

In all 7 practicals, instructor can introduce new and relevant experiments which are not in the list.
Unit –I
**Mechanical response of Materials:** Elasticity, model of elastic response, inelasticity, viscoelasticity, stress-strain curves, concept of various mechanical properties such as hardness, yield strength, toughness, ductility, yield toughness, ductility, brittleness, stiffness, young modulus, shear modulus, shear strength, Frenkel model, Peierls-Nabarro relation, Plastic deformation,

**Corrosion and degradation of materials** – electrochemical considerations – passivity forms of corrosion – corrosion inhibition.

**Spintronics and Photonics:** Spin glass, magnetic bubbles, domain walls, magnetic multilayers, magnenites, GMR and CMR, DMS materials. Photonic band gap materials.

Unit –II
**Concept of Synthesis:** Concept of equilibrium and nonequilibrium processing and their importance in materials science.


Unit –III
**Processing of materials:** Metallic and non metalic, Ceramics and other materials. Only basic elements of powder technologies, compaction, sintering calcination, vitrification reactions, with different example, phenomenon of particle coalescence, porosity. Quenching: concept, glass formation

**Structural characterization:**

Unit –IV

**Microscopic techniques** – TEM, SEM & STEM, AFM, EDX and XPS.

**Text and Reference Books:**
Semester IV  Paper 15 (Core Elective E2.3) NanoScience and Nanotechnology II

Unit – I:
**Nanophotonics:**
Fundamentals of photonics and photonic devices, Lasers, CFLs, LEDs, OLEDs, Wall paper lighting, Display devices, X-ray imaging nanophosphors, Photo therapy lamps and its applications, Nanomaterials for radiation, Dosimetry special for thermoluminescence. Optical stimulated luminescence, Luminescence solar concentration.

Unit – II:
**Nanomagnetics:**
Basics of Ferromagnetism, effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets, nanopore containment, giant and colossal magnetoresistance, applications in data storage, ferrofluids, Superparamagnetism, effect of grain size, magneto-transport, Magneto-electronics, magneto-optics, spintronics.

Unit – III:
**Nanoelectronics:**
Top down and bottom up approach, CMOS Scaling, Nanoscale MOSFETs, Limits to Scaling, System Integration, Interconnects;
NanoDevices: Nanowire Field Effect Transistors, FINFETs, Vertical MOSFETs, Other Nanowire Applications, Tunneling Devices, Single Electron Transistors, Carbon nanotube transistors, Memory Devices,

Unit – IV:
**Nanocomposites:**
Classification of nanocomposites, Metallic, ceramic and polymer nanocomposites, Tribology of polymeric nanocomposites, Nano ceramic for ultra high temperature MEMS, Optimizing nanofiller performance in polymers, Preparation techniques, Graphene/Fullerene/Carbon nanotube (CNT) polymer nanocomposites, One dimensional conducting polymer nanocomposites and their applications

Text and reference books:
2. C.P.Poole Jr., F.J.Owens; Introduction to Nanotechnology, John Wiley and sons, 2003
3. C. Furetta; Hand book of thermoluminescence; World Scientific Publ.
4. S.W.S. McKEEVER; Thermoluminescence in solids; Cambridge Univ. Press.
5. Alex Ryer; Light measurement hand book; Int. light Publ.
7. T.J.Deming; Nanotechnology; Springer Verlag, Berlin, 1999
9. Gusev; Nanocrystalline Materials
10. C. Delereue, M.Lannoo; Nanostructures theory and Modelling
11. Fausto, Fiorillo ; Measurement and Characterization of Magnetic materials
12. Bhushan; Hand Book of Nanotechnology
13. Janos H., Fendler; Nanoparticles and Nanostructured Films
14. T.Pradip; Nano: The Essentials
15. Liu; Hand Book of Advanced Magnetic Materials (4 Vol.)
16. Lakhtakia; Nanometer Structure
17. Banwong, Anurag Mittal; Nano CMOS Circuit and Physical Design
18. G.W.Hanson: Fundamental of Nanoelectronics
20. S. Sakka; Sol-gel science and technology processing, characterization and applications; Kluwer Acad. Publ.
22. Supriyo Datta, “From Atom to Transistor”
Unit I
Time dependence in quantum mechanics, Time dependent perturbation theory, rate expression for emission, perturbation theory, calculation of polarizability. Quantum mechanical expression for emission rate. Time correlation function and spectral Fourier transform pair, properties of time correlation functions and spectral time shape. Fluctuation dissipation theorem rotational correlation function and pure rotational spectra, Re-orientational spectroscopy of liquids.

Unit II
Saturation spectroscopy, Burning and detection of holes in Doppler broadened two level systems, Experimental methods of saturation spectroscopy in laser, Ramsey fringes, Saturation techniques for condensed matter application, Laser optogalvanicspectroscopy. Two photon absorption spectroscopy, Selection rules, Expression for TPA cross section – photo acoustic spectroscopy, PAS in gaseous medium, Roseneweig and Greshow theory, Thermally thin, thick samples, Typical experimental set up, Application in Spectroscopy.

Unit III
Stimulated Raman scattering, Quantum mechanical treatment, Raman Oscillation Parametric instabilities, Electromagnetic theory of SRS. Vibronic interaction, Herzberg Teller theory, Fluorescence spectroscopy, Kasha’s rule, Quantum yield, Non-radioactive transitions, Jablonski diagram, Time resolved fluorescence and determination of excited state lifetime. Light detectors, Single photon counting technique, Phase sensitive detectors.

Unit IV
Matrix isolation spectroscopy, Fourier transforms spectroscopy, Laser cooling. Molecular symmetry and group theory, Matrix representation of symmetry elements of a point group, Reducible and irreducible representations, and character tables specially for C2v and C3 point group molecules, Normal coordinates normal modes, Application of group theory to molecular vibrations.

Text Book and References:
5. J. M. Hollas, High resolution spectroscopy.
7. Herzberg, Molecular spectra and molecular structure II and III.
9. King, Molecular spectroscopy.
Semester IV  Paper 15 (Core Elective E2.5) Applied Electronics II

Unit – I:
An Overview of Electronic Communication system; block diagram of an digital electronic Communication system, Pulse modulation systems, sampling theorem, lowpass and band-pass signals, PAM channel bandwidth for a PAM signal, Natural sampling, flat top sampling, signal recovery throughholding, quantization of signals, quantization, differential PCM delta modulation, adaptive delta modulation CVSD. Digital modulation techniques: BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK. Mathematical representation of noise, sources of noise, frequency domain representation of noise, Noise in Pulse Code and Delta modulation system, PCM transmission, calculation of quantization of noise, output signal power effect of thermal noise, output signal to noise ratio in PCM, DM, quantization noise in DM, output signal power, DM output, signal to quantization noise ratio, effect of thermal noise in delta modulation, output signal to noise ratio in DM.

Unit – II
Computer communication systems: Types of networks, design features of communication network, examples, TYMNET, ARPANET, ISDN, LAN. Mobile radio and satellite - time division multiplex access (TDMA) frequency division multiplex access (FDMA) ALOHA, Slotted ALOHA, Carrier sense multiple access (CSMA) Poisson distribution protocols.

Unit – III
Microprocessor and Micro-computers: Microprocessor and architecture, Pin out and pin functions of 8086/8088 Internal microprocessor architecture, bus buffering and latching, Bus timings, ready and wait states, minimum mode versus and maximum mode. Real and protected mode of memory addressing, memory paging, addressing modes, data addressing modes, programme memory addressing mode, stack memory addressing modes, instruction sets, data movement instruction, arithmetic and logic instruction, programme control instruction, clock generator (8284A).

Unit – IV
Memory and I/O Interface: Memory devices, ROM, RAM, DRAM, SRAM, Address decoding, 3 to 8 line decoder 74LS138, 8086, and 80386(16 bits) Memory interface, Introduction to I/O interface, Interfacing using 8255, Introduction to PIT 8254, Basic Communication device (UART) pin diagram and functioning of 16550 Interrupts: Basic interrupt processing, Hardware interrupt, expanding the interrupt structure, 8259A PIC.

Text and Reference books.
1. Principles of communication systems: Taub and Schilling (ii Edn THM, 1994)
3. Communication systems: Simon Haykin (iii Edn John Wiley & Sons)
4. The intel microprocessors 8086/80188, 80386, 80486, Pentium and Pentium processor architecture, programming and interfacing: Barry B. Brey (PHI iv Edn, 1999)
Semester IV  Paper 16 (Foundation course F2.1) Spectroscopic applications

Unit-I

Principle of spectroscopic instruments, UV-VIS visible: Absorption of light, radiation sources, sample holder, monochromator, radiation detectors, samples holder, monochromator, radiation detector, single and double beam experiment.

Infrared and Raman spectroscopy, predicting number of active modes of vibration, analysis of representative spectra of metal complexes with various functional groups at the coordination sites, organic and inorganic functional group identification through IR spectroscopy.

Unit-II

NMR phenomenon, spin ½ nuclei, (¹H, ¹³C, ³¹P and ¹⁹F), ¹H NMR, Zeeman splitting, effect of magnetic field strength on sensitivity and resolution, chemical shift, chemical and magnetic equivalence of spins, spin-spin coupling constant J.

Electronic spectroscopy, basic principle, electronic transitions in organic, inorganic and organometallic molecules and application to structure elucidation.

Unit-III

Electron paramagnetic resonance (EPR) spectroscopy of inorganic and organic compounds with unpaired electrons, determination of electronic structure, Zeeman splitting, g values hyperfine and superhyperfine coupling constant.

Mossebauer spectroscopy-Mossebauer effect, recoilless emission and absorption, hyperfine interaction, chemical isomer shift, magnetic hyperfine and quadrupole interaction and interpretation of spectra.

Unit-IV

Mass spectroscopy, basic principles, ionization techniques, isotope abundance, molecular ion, high resolution MS, soft ionization methods, ESI-MS and MALDI-MS, illustrative example from macromolecules and supramolecules studies of inorganic/coordination and organometallic representative compounds.

Text books
Semester IV  Paper 16 (Foundation course F2.2) Optics and Optical Instruments

Unit-1
General theory of image formation, Cardinal points of an optical system, thick lens and lens combination, telephoto combinations, telephoto lens and eyepieces, Aberration in images; chromatic aberration, monochromatic aberration and their reductions, aspherical mirrors and correction plates, meniscus lens, entrance and exit pupil, need for multiple eyepiece, Ramsden and Huygens eyepiece, microscope and telescope, astronomical telescope.

Unit-2
Principal of superposition, coherence optical path retardation, fringes in thin film, localized fringes, two slit interference, Newton’s rings and applications, Michelson interferometer and its applications, Diffraction; Fresenel type- half period zone, rectilinear propagation, straight edge, Fraunhofer type-Diffraction at a slit, half period zone, circular aperture, plane transmission, reflection, blazed and concave grating, resolving power of grating, Raileigh criterion of resolution, resolving power of prism and grating.
Refraction- refraction in uniaxial crystal, double image prism, plane, circular and elliptical polarized light, Nicols prism, optical rotation in liquid crystals.

Unit-3
Optical instruments- magnifying glass, principal of photo camera, pinhole, lens and SLR camera, video camera, angular magnification, aperture, camera lucida, collimator and compound microscope, lens, periscope, binocular, field glass, jeweler’s glass, projector, eyeglasses and its principal, prism spectroscope.

Unit-4
Holography: Importance of coherence, Principle of holography and characteristics, Recording and reconstruction, classification of hologram and application, non-destructive testing, optical fibre waveguides (step index, graded index, single mode), attenuation in fibre, couplers and connectors, LED,
X-ray –Principal and process of X-ray image (radiographs) production, factors affecting radiographs, Computed Tomography, principal and working of fluoroscopy, principal and working of CT-scanning, Ultrasound, working principal, imaging by us waves, Doppler ultrasound, magnetic resonance imaging, its working principal.

References;
1. Optics by Ajay Ghatak
2. Fundamental of optics by Jetkins and white
3.Optics and spectroscopy by R. Murugeshan, kiruthignsivaprakash.
5.Collaborative radiology by Chales De Kahn, 2013