Savitribai Phule Pune University

(Formerly University of Pune)

Faculty of Science

Structure of Syllabus

B. Sc.(Nanoscience)

From Academic Year 2016-2017

Savitribai Phule Pune University

Proposed Structure of B.Sc. (Nanoscience) Syllabus

1) Preamble:

The systematic and planned curricula from first year to the third year shall motivate and encourage the students for pursuing higher studies and research in Nanoscience and for becoming an entrepreneur.

Aim:

To provide working knowledge of nanoscience and nanotechnology to the students, this can be useful to blend them efficiently in the development of scientific and technological applications for the betterment of society.

Objectives

1. To provide in depth knowledge of scientific and technological aspects of nanoscience.
2. To make aware students with technology issues which are impeding the adoption of nanoscience and nanotechnology.
3. To apply key concepts in Physics, Chemistry, biology and engineer to the nanoscience and nanotechnology
4. To explain the nanoscale paradigm in terms of dimensions.
5. To make aware of various types of nanostructures and their basic properties.
6. To familiarize with current and recent scientific and technological developments in nanotechnology.
7. To train students in skills related to research, education, industry and market of nanotechnology.
8. To create foundation for research and development in nanoscience and technology.
9. To help students build-up a progressive and successful career in nanotechnology.
10. To make aware the students with potential growth over the next 25 year.

1) Eligibility:

1 **First Year B.Sc.:** Higher Secondary School Certificate (10+2) Science stream or its equivalent Examination as per the Savitribai Phule Pune University eligibility norms.

2 **Second Year B.Sc.:** Keeping terms of First Year of B. Sc. with nanoscience as one of the subjects. Other students if they fulfill the conditions approved by the equivalence committee of Faculty of Science of the Savitribai Phule Pune University are also eligible.

3 **Third Year B. Sc.:** Student shall pass all First Year B. Sc. courses and satisfactorily keeping terms of Second Year of B. Sc. with Nanoscience as one of the subjects.

Note: Admissions will be given as per the selection procedure / policies adopted by the respective college, in accordance with conditions laid down by the Savitribai Phule Pune University. Reservation and relaxation will be as per the Government rules.

F.Y. B. Sc.
(From Academic Year 2016-2017)
(To be implemented from Academic Year 2016-17

Paper	Title
Paper I	Section I (For Term 1): Fundamentals of Nanoscience
	Section II (For Term 2):Chemical and Biological Techniques for synthesis of nanomaterials.
Paper II	Section I (For Term 1): Materials Science
	Section II (For Term 2): Basic Characterization Techniques
Paper III	(For Term1 and Term 2): Practical

For each theory course: 36 Lectures per term/2 Credits per term

For practical course: 20 practicals/4Credits

S. Y. B. Sc.
(Semester Pattern)
(From Academic Year 2017-2018)

Semester I

Paper	Title
Paper I (NS 211)	Physical Techniques for synthesis of Nanomaterials
Paper II (NS 212)	Properties of Nanomaterials (Physical, chemical, Optical and Magnetic)

Semester II

Paper	Title
Paper I (NS 221)	Organic and polymer science of nanomaterials
Paper II (NS 222)	Advanced Techniques for Characterization of Nanomaterials

Practical Course (Annual)

Paper III (NS 223) (Annual)	Practical

T. Y. B. Sc. (Nanoscience)
(Semester Pattern)

(From Academic Year 2018-2019)

Theory Courses (Semester)	
Semester III	**Semester IV**
NS 331: Mathematical Methods of Physics(T.Y.B.Sc. Physics)	NS 341: Quantum Material (T.Y.B.Sc.)
NS 332: Biological Chemistry (T.Y.Zoology)	NS 342: Solid State Physics(T.Y.B.Sc. Physics)
NS 333: Inorganic Chemistry (T.Y.Chemistry)	NS 343: Molecular Biology(T.Y.B.Sc. Zoology)
NS 334: Functional Nanomaterials	NS 344: Nanobiology and Nanomedicine
NS 335: Nanoelectronics and Applications	NS 345: Catalysis and Sensor Applications

NS336: Elective I (Select any One)	NS346: Elective II (Select any One)
A: Environmental Nanotechnology	F: Nano-toxicology
B: Nanocomposites	G: Photonics and Spintronics
C: Agricultural Nanotechnology	H: Nano-biotechnology
D: Nanostructural Solar Cells	I: Supercapacitors and Batteries

Practical Courses (Annual)

NS347: Laboratory Course I

NS348: Laboratory Course II

NS349: Laboratory Course III (Project)

Examination:

A) Pattern of Examination:

i) F. Y. B. Sc.

(a) There shall be university examination at the end of the academic year for 80 marks for each theory paper.

(b) 20 marks for each paper are allotted to the comprehensive internal assessment of the student by the respective teacher, teaching the course. The teacher shall evaluate the performance of the student for 10 marks in each term; on the basis of written tests. Ordinarily written tests shall consist of (i) multiple choice questions, (ii) True/False, (iii) basic definitions, (iv) tricky computational problems involving minimal calculations. Student is asked to answer 20 questions in 40 minutes. Each question will be of ½ marks. In the same classroom setup, different set of equivalent sets of question papers may be experimented. It will be preferred to have two such tests in each term, per course(one at the middle of the term and one at the end of the term) and average (or best of the two tests) be considered as internal marks out of 10 for that term. Internal Test shall cover the entire syllabus. If teacher prefers to have one test only, it shall be at the end of the term covering the entire syllabus).

(c) Practical examination be conducted by respective colleges at the end of the academic year 80 marks be assigned to practicals and 20 marks for internal examination, journal attendance (Journal 10 marks, Oral 10 marks).

ii) S. Y. B. Sc. and T. Y. B. Sc.

(a) There shall be university examination at the end of semester for 40 marks for each theory paper.

(b) 10 marks for each paper are allotted to the comprehensive internal assessment of the student by the respective teacher, teaching the course. Pattern of internal assessment shall be on the lines of F.Y.B. Sc.

(c) University Practical examination be conducted at the end of the academic year 80 marks be assigned to practicals and 20 marks for internal examination, journal attendance (Journal 10 marks, Oral 10 marks).

For practical examination:

(1) At least one examiner should be external

(2) Certified journals be compulsory

(3) There shall be two experts for all subjects.

(4) (a) At T. Y. B. Sc. level, it is preferred to have project work in lien of one of the practical course.

(b) Blue print for Model Question Paper: Each Board of Studies shall frame at least 5 sets of model theory papers and 10 sets of model question set for internal assessment.

II) Pattern of the Question paper:

For theory paper (University examination) shall be as follows.

F. Y. B. Sc. (80 Marks) (Time Allotted: 3 hrs)

Q1. 16 marks for 8 sub-questions, each sub-question for two marks. Sub-questions shall be answerable in two to four lines and shall be based on complete syllabus.

Q2. and Q3. Student shall attempt four out of six questions. Each short answer type question shall carry four marks and be answerable in 6 to 8 lines.

Q4. Student shall attempt 2 out of 4 long answer type questions. Each question will be for 8 marks and be answerable in 12 to 16 lines.

Q5. Long easy type question for 16 marks. Student shall attempt one out of two questions.

OR

Q5. Shall be on the pattern of question 4.

(Question paper of a particular course should contain minimum of 30% weightage to problems)

S. Y. B. Sc. and T. Y. B. Sc. (Theory) University Question Paper Pattern:

(40 marks, Time allotted: 2 hrs)

Q1. 10 sub-question each for 1 mark. Sub-questions be answerable within 2 to 4 lines and shall be based on complete syllabus. All sub-questions are compulsory.

Q2 and Q3: (10 Marks for each questions) Three sub questions. Students have to attempt any two questions.

Q4. Long Essay type question for 8 marks and one question of two marks.

B) Standard of Passing: 40 % marks

C) ATKT Rules

(i) Students shall clear 8 heads of passing (out of 12 such heads) while going from F. Y. B. Sc. to S.Y.B.Sc. However he must pass in all F. Y. B. Sc. subjects while going to T. Y. B. Sc.

(ii) Student shall clear 12 heads of passing (out of 20 such heads) while going from S. Y. B. Sc. to T. Y. B. Sc. (Practical course of S. Y. B. Sc. will be equivalent to 2 heads of passing)

D) Award of Class: As per University norms.

E) External Students: Not applicable

F) Setting of question paper/Pattern of Question paper: As mentioned above

6) Structure of the Course:

a) Compulsory paper: a) At F.Y.B.Sc. and S.Y.B.Sc. all papers are compulsory and at T.Y.B.Sc. 8 papers are compulsory and one paper is optional.

b) Optional papers: At T.Y.B.Sc. one paper per semester is optional.

c) Question papers and papers etc.: As mentioned above

d) Medium of Instructions: English

7) Equivalence of previous syllabus along with propose syllabus: The papers are similar so no equivalence is required at B. Sc. level.

8) University terms: 6 terms

9) Subject-wise detailed syllabus: Attached with this format.

10) Recommended books: Given in the syllabus at the end of each course.

11) Qualification of teachers: As per UGC regulations.

F. Y. B. Sc.
Term -I

Physics Paper I: Section I: Mechanics

Lectures: 36 **Credits: 2**

Learning Outcomes:

On successful completion of this course students will be able to do the following:

1. Demonstrate an understanding of Newton's laws and applying them in calculations of the motion of simple systems.
2. Use the free body diagrams to analyse the forces on the object.
3. Understand the concepts of energy, work, power, the concepts of conservation of energy and be able to perform calculations using them.
4. Understand the concepts of elasticity and be able to perform calculations using them.
5. Understand the concepts of surface tension and viscosity and be able to perform calculations using them.
6. Use of Bernoulli's theorem in real life problems.
7. Demonstrate quantitative problem solving skills in all the topics covered.

Syllabus:

1. Newton's laws of motion **(6 Lectures)**

1.1 Newton's First and Second Law and their explanation
1.2 Working with Newton's First and Second Law
1.3 Newton's Third Law of motion and its explanation
1.4 Various types of forces in nature (explanation) and concept of field
1.5 Frame of reference (Inertial, Non-inertial)
1.6 Pseudo Forces (e.g. Centrifugal Force)

2. Work and Energy **(8 Lectures)**

2.1 Kinetic Energy
2.2 Work and Work-Energy Theorem
2.3 Calculation of Work done with
i) Constant Force
ii) Variable Force
Illustration
2.4 Conservative and Non-conservative Forces
2.5 Potential energy and conservation of Mechanical energy
2.6 Change in potential energy in rigid body motion
Mass-energy equivalence

3. Elasticity **(8 Lectures)**

3.1 Hook's law and coefficient of elasticity
3.2 Young's modulus, Bulk modulus and Modulus of rigidity
3.3 Work done during longitudinal strain, volume strain, and shearing strain
3.4 Poisson's ratio
3.5 Relation between three elastic moduli (Y, η, K)
3.6 Determination of Y of rectangular thin bar loaded at the centre
3.7 Torsional oscillations
Torsional rigidity of a wire, to determine η by torsional oscillations

4. Surface Tension **(5 Lectures)**

4.1 Surface Tension, Angle of Contact, Capillary Rise Method
4.2 Rise of liquid in a conical capillary tube
4.3 Energy required to raise a liquid in capillary tube

4.4 Factors affecting surface tension
4.5 Jeager's Method for Determination of surface tension
4.6 Applications of Surface Tension

5. Viscosity and Fluid Mechanics (9 Lectures)

5.1 Concept of Viscous Forces and Viscosity
5.2 Pressure in a fluid and buoyancy
5.3 Pascal's law
5.4 Atmospheric Pressure and Barometer
5.5 Pressure difference and Buoyant Force in accelerating fluids
5.6 Steady and Turbulent Flow, Reynolds's number
5.8 Equation of continuity
5.9 Bernoulli's Principle
5.10 Application of Bernoulli's equation
i) Speed of Efflux
ii) Ventury meter
iii) Aspirator Pump
iv) Change of plane of motion of a spinning ball.

Reference Books:

1. University Physics: Sears and Zeemansky, XIth edition, Pearson education
2. Concepts of Physics: H.C. Varma, Bharati Bhavan Publishers
3. Problems in Physics: P.K. Srivastava, Wiley Eastern Ltd.
4. Applied Fluid Mechanics: Mott Robert, Pearson Benjamin Cummir, VI Edition, Pearson Education/Prentice Hall International, New Delhi
5. Properties of Matter: D. S. Mathur, Shamlal Chritable Trust New Delhi
6. Mechanics: D.S Mathur, S Chand and Company New Delhi-5.

F. Y. B. Sc.
Term –II

Physics Paper I: Section II: Heat and Thermodynamics
Lectures: 36 Credits: 2 Learning Outcomes:

After successfully completing this course, the student will be able to do the following:

1. Describe the properties of and relationships between the thermodynamic properties of a pure substance.
2. Describe the ideal gas equation and its limitations.
3. Describe the real gas equation.
4. Apply the laws of thermodynamics to formulate the relations necessary to analyze a thermodynamic process.
5. Analyse the heat engines and calculate thermal efficiency.
6. Analyze the refrigerators, heat pumps and calculate coefficient of performance.
7. Understand property 'entropy' and derive some thermo dynamical relations using entropy concept.
8. Understand the types of thermometers and their usage.

Syllabus

1. Equation of state **(8 lectures)**

1.1 Equations of state
1.2 Andrew's experiment
1.3 Amagat's experiment
1.4 Van der Waals' equation of state
1.5 Critical constants
1.6 Reduced equation of state
1.7 Joule-Thomson porous plug experiment

2. Concepts of Thermodynamics **(8 lectures)**

2.1 Thermodynamic state of a system and Zeroth law of Thermodynamics
2.2 Thermodynamic Equilibrium
2.3 Adiabatic and isothermal changes
2.4 Work done during isothermal changes
2.5 Adiabatic relations for perfect gas
2.6 Work done during adiabatic change
2.7 Indicator Diagram
2.8 First law of Thermodynamics
2.9 Reversible and Irreversible processes

3. Applied Thermodynamics **(8 lectures)**

3.1 Conversion of Heat into Work and its converse
3.2 Carnot's Cycle and Carnot's Heat Engine and its efficiency
3.3 Second law of Thermodynamics
3.4 Concept of Entropy
3.5 Temperature-Entropy Diagram
3.6 T-dS Equation
3.7 Clausius-Clapeyron Latent heat equations

4. Heat Transfer Mechanisms **(8 lectures)**

4.1 Heat Engines
   i. Otto cycle and its efficiency
   ii. Diesel cycle and its efficiency

4.2 Refrigerators:

i. General Principle and Coefficient of performance of refrigerator
ii. The Carnot Refrigerator
iii. Simple structure of vapour compression refrigerator

4.3 Air conditioning: principle and its applications

5. Thermometry (4 lectures)

5.1 Temperature Scales: Centigrade, Fahrenheit and Kelvin scale

5.2 Principle, construction and working of following thermometers

i. Liquid and Gas Thermometers
ii. Resistive Type Thermometer
iii. Thermocouple as thermometer
iv. Pyre heliometer

Reference Books:

1. Physics: 4th Edition, Volume I, Resnick/Halliday/Krane JOHN WILEY & SONS (SEA) PTE LTD
2. Concept of Physics: H.C. Verma, Bharati Bhavan Publishers
3. Heat and Thermodynamics: Brijlal, N. Subrahmanyam, S. Chand & Company Ltd, New Delhi
4. Heat and Thermodynamics: Mark. W. Zemansky, Richard H. Dittman, Seventh Edition, McGraw-Hill International Editions
5. Thermodynamics and Statistical Physics: J.K. Sharma, K.K. Sarkar, Himalaya Publishing House
6. Thermal Physics (Heat & Thermodynamics): A.B. Gupta, H.P. Roy Books and Allied (P) Ltd, Calcutta.

F. Y. B. Sc.

Term I

Physics Paper II: Section I: Physics Principles and Applications

Lectures: 36 **Credits: 2**

Learning Outcomes:

On successful completion of this course students will be able to do the following:

1. To demonstrate an understanding of electromagnetic waves and its spectrum.
2. Understand the types and sources of electromagnetic waves and applications.
3. To understand the general structure of atom, spectrum of hydrogen atom.
4. To understand the atomic excitation and LASER principles.
5. To understand the bonding mechanism in molecules and rotational and vibrational energy levels of diatomic molecules.
6. To demonstrate quantitative problem solving skills in all the topics covered.

Syllabus:

1. Physics of Atoms (12Lectures)

1. The concept of atom (Atomic Models: Thompson and Rutherford)
2. Atomic Spectra
3. Bohr Theory
4. Hydrogen atom Spectra
5. Frank Hertz experiment
6. The LASER
   Absorption, Spontaneous Emission, and Stimulated Emission, Population Inversion and Laser Action, Applications of Lasers

2. Physics of Molecules (10 Lectures)

1. Bonding Mechanisms: A Survey
   i. Ionic Bonds
   ii. Covalent Bonds
   iii. Van der Waals Bonds
   iv. The Hydrogen Bond
   v. Metallic Bond
2. Variation of potential energy with inter-atomic distance
3. Concept of Rotational and vibrational energy levels of diatomic molecule

3. Electromagnetic Waves (14 Lectures)

1. Historical Perspective of Electromagnetic Waves
2. Production of electromagnetic waves : Hertz experiment
3. Electromagnetic spectrum
4. Planck hypothesis of photons (Concept only)
5. Sources of electromagnetic waves : Radio waves, Microwaves, Infrared, Visible light, Ultraviolet, X-rays, Gamma rays
6. Applications
   i. microwave oven
   ii. RADAR
   iii. Pyro electric thermometer
   iv. X-ray radiography and CT Scan
   v. Solar cell

References

1. Concepts of Modern Physics: A Beiser (6th ed., McGraw Hill, 2003
2. Modern Physics: Raymond A. Serway, Clement J. Moses, Curt A. Moyer
3. Sears and Zemansky's University Physics: H.D. Young R. A. Freedman, Sandin (11th Ed. Pearson Education)
4. Nanotechnology : Principles and Practices: S. K. Kulkarni, Capital Publishing Company.

F. Y. B. Sc.
Term II

Physics Paper II: Section II: Electromagnetics

Lectures: 36 **Credits: 2**

Learning Outcomes:

On successful completion of this course students will be able to do the following:

1. Demonstrate an understanding of the electric force, field and potential, and related concepts, for stationary charges.
2. Calculate electrostatic field and potential of simple charge distributions using Coulomb's law and Gauss's law.
3. Demonstrate an understanding of the dielectric and effect on dielectric due to electric field.
4. Demonstrate an understanding of the magnetic field for steady currents using Biot-Savart and Ampere's laws.
5. Demonstrate an understanding of magnetization of materials.
6. Demonstrate quantitative problem solving skills in all the topics covered.

Syllabus

1. Electrostatics **(9 Lectures)**

1. Revision of Coulomb's law
2. Superposition principle
3. Electric field due to an electric dipole, line and disc
4. Revision of Gauss's law
5. Coulomb's law from Gauss's law
6. Gauss's law applications in Cylindrical, planar and spherical symmetry

2. Dielectrics **(9 Lectures)**

1. Electric Dipole
2. Electric dipole and dipole moment
3. Electric potential and intensity at any point due to dipole
4. Torque on a dipole placed in an electric field
5. Polar and non-polar molecules
6. Electric polarization of dielectric material
7. Gauss' law in dielectric
8. Electric vectors and relation between them

3. Magneto statics **(9 Lectures)**

1. Revision of Biot-Savart's law with examples
2. Amperes' law, e.g. Solenoid and Toroid
3. Gauss law for magnetism

4. Magnetic properties of materials **(9 Lectures)**

1. Magnetic materials and Bohr magneton
2. Magnetization (M), magnetic intensity (H), magnetic induction (B), magnetic susceptibility and permeability
3. Relation between B, M and H
4. Hysteresis

References:

1. Fundamentals of Physics: 8th Edition, Halliday Resnik and Walkar
2. Electromagnetics: B. B. Laud

F. Y. B. Sc.
Term I and II

Physics paper III: Practical

Total Practicals: 20 **Credits: 4**

Learning Outcomes:

After successfully completing this laboratory course, the students will be able to do the following:

1. Acquire technical and manipulative skills in using laboratory equipment, tools, and materials.
2. Demonstrate an ability to collect data through observation and/or experimentation and interpreting data.
3. Demonstrate an understanding of laboratory procedures including safety, and scientific methods.
4. Demonstrate a deeper understanding of abstract concepts and theories gained by experiencing and visualizing them as authentic phenomena.
5. Acquire the complementary skills of collaborative learning and teamwork in laboratory settings.

Syllabus:

1. Mechanics

1. Range and Least Count of Instruments, Measurements using various instruments and error analysis (Vernier caliper, screw gauge, travelling microscope, spectrometer etc.)
2. Determination MI of disc using ring
3. MI of Flywheel
4. Determination of coefficient of viscosity by Poiseulli's method
5. Determination of Y and n by flat spiral spring
6. Determination of Y by bending
7. Surface Tension by Jeager's method.

2. Heat and Thermodynamics

1. Interpretation of isothermal and adiabatic curves on PV diagrams (Theoretical). Theoretical study of Carnot's cycle by drawing graphs of isothermal and adiabatic curves.
2. Temperature coefficient of resistance
3. Study of thermocouple and determination of inversion temperature
4. Thermal conductivity by Lee's method
5. Specific heat of graphite

3. Light

1. Study of spectrometer and determination of angle of prism
2. Spectrometer calibration. Determination of refractive indices of different colours and plotting the graph of refractive index vs wavelength.
3. Study of total internal reflection using LASER
4. Study of polarization of light by reflection
5. Determination of wavelength of LASER light by plane diffraction grating or cylindrical obstacle.

4. Electricity and magnetism

1. Charging and discharging of a capacitor

2. Study of LR circuit
3. Study of LCR series circuit
4. Study of Kirchhoff's laws
5. Diode characteristics
6. Study of millimetres (all AC, DC ranges, Least Count)
7. Determination of frequency of AC mains

Students have to perform minimum three experiments from each section and total sixteen experiments. Students can perform any two experiments from Computer Aided experiments in place of any two experiments in above four sections.

Additional Activities

1. Demonstrations (Any four demonstrations equivalent to two experiments)
    1. Magnet –magnet interaction
    2. Collision by using balls
    3. Study of Signal generator using CRO (Sine, square wave signal, measurement of AC voltage, frequency)
    4. Demonstration of action potential
    5. Measurement of sound pressure level
2. Computer aided demonstrations (Using computer simulations or animations)
    (Any two demonstrations equivalent to two experiments)
    1. Coulomb's law
    2. Vectors : visualization of vectors
    3. Bohr's model
    4. Carnot engine, diesel engine
    5. Graphs and their slopes, and Kinematics graphs (using computer simulations)
3. Mini projects/Hand on activities
    (Any one equivalent to two experiments)
    1. Students should collect the information of at least five Physicists with their work.
    2. Students should carry out mini projects
4. Study tour (Equivalent to two experiments)
    Students participated in study tour must submit a study tour report.

Students have to perform at least two additional activities out of four activities in addition to sixteen experiments mentioned above. Total Laboratory work with additional activities should be equivalent to twenty experiments.

Savitribai Phule Pune University

(Formerly University of Pune)

F. Y. B.Sc. Nanoscience

Paper Code: Paper-I (Section I)

Paper Title: Introduction to Nanoscience

Unit-1: Introduction (9 L)

Nano and Nature, Nanoscopiccolours (Butterfly wings), Bioluminescence (Fireflies), Tribology (Geckos Sticky feet, lotus-leaf effect etc.) in nature, the development of nanoscale science: Size scale, Nanotechnology timeline, pre-18th Century; 19th Century, 20th Century, 21th Century.

Unit-2: Generation of Nanotechnology (9 L)

Classification of Nanomaterials, OD, 1D, 2D and 3D types of nanomaterials (Quantum dots, Quantum wires, Carbon Nano Tubes, Bucky balls, Quantum confinement (Quantum size effect), Fullerences etc.)

Unit-3: Nanometrology (9 L)

Background to Nanometrology, Background to nanomanufacturing, the nano perspective, The Quantum triangle, Nanomechanical tools, Standards for Nanotechnology, IEEE Road map for Nanoelectronics, Introduction to MEMS & NEMS

Unit-4: Electromagnetic Nanoengineering (9 L)

Electronics and Nanoelectronics, Microelectronics, Nanoscale electronics, The Surface Plasmon resonance, Colour generation from Nanoparticles and nanostructures, Application of nanoplasmonics, Introduction to Nanophotonics, Introduction to Nanobiotechnology

Reference:

Fundamentals of Nanotechnology, CRC press, by G.L. Hornyak, J.J. Moone, H.F. Tihhale, J. Dutta

F.Y.B.Sc.
Nanotechnology
Paper-I (Section-II)

Paper Title:
Chemical and Biological technique for synthesis of nanomaterial

Unit-1: Synthesis of Nanomaterial (Chemical Method) (9L)
Colloids and colloids in solution, Nucleation and growth of nanoparticles, Synthesis of metal and semiconductor nanoparticle by colloidal routes, Langmuis-Blodgett (L-B) method, sol-gel method.

Unit-2: Synthesis of nanomaterial (chemical Methods) (9L)
Hydrothermal synthesis, Solvothermal synthesis, Sonochemical Synthesis, Solvothermal synthesis, Sonochemical Synthesis methods, Microwave synthesis, Synthesis using micro-reactor or Lab-or-chip spray pyrolysis, successive ionic Layer adsorption and reaction(SILAR), Electrodeposition,

Unit-3: Synthesis of nanomaterial (Chemical Methods) (9L)
chemical vapour deposition, Metallorganic chemical vapour deposition (MOCVD), Plasma enhanced chemical vapour deposition(PECVD), Vapour-Liquid-Solid(ULS) method, Metal Oxide frameworks(MoF), Kirkindall effect and method.

Unit-4: Synthesis of nanomaterial (Biological methods) (9L)
Introduction, Synthesis using microorganisms, Synthesis using plant extract, Use of proteins, Templates like DNA, S-tayer synthesis of nanoparticles using DNA.

Reference Books:

1. Nanotechnology :Technology Revolution of 21st Century by Rakesh Rathi, published by S.Chand.
2. Introduction to Nanoscience, by Stuart Lindsay.
3. Introduction to Nanomaterials and nanotechnology by VladimirPokropivny, RynnoLohmus, Irina Hussainova, Alex Pokropivny and Sergey Vlassov
4. Nanomaterials by A.K. Bandyopadhyay; New Age International Publishers.
5. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education.
6. Nano Essentials- T.Pradeep/TMH
7. Bharat Bhusan, “Springer Handbook of Nanotechnology”, springer, Newyork, 2007

8. Hari Singh Nalwa, “Encyclopedia of Nanotechnology”, USA 2011
9. James A. Schwarz, Cristian I. Contescu, Karol Putyera, “Dekker encyclopedia of nanoscience and nanotechnology” CRC Press, 2004.
10. Introduction to Nanoscience and Nanotechnology, CRC Press, G. L. Hornyak, H. F. Tibbals, J. Dutta, J. J. Moore
11. Nanotechnology: Principles and practices, 3rd Edition, Sulabha K. Kulkarni, Capital Publishing Company

Paper-II (Section-I)

Paper Title: Materials Science

Unit-1: Structure and Bonding: (9L)

Arrangements of atoms in solids, two dimension crystal structure, three dimension crystal structure, Bonding in solids, Bonding and antiboding states, Electronic structure of solids.

Unit-2: Different types of Solids: (9L)

Single phase alloys, Semiconductors, insulators and oxide materials, Composites, Polymers, Porous materials, Aerogels, Core-Shell particles.

Unit-3: Phase Diagram: (9L)

Basic term system, Surrounding, Component, Coordinates, Phase equilibrium, Phase diagram definition, Lever rule, Gibb’s Phase rule, Phase diagram of suger-water and NaCl-water. Types of Phase diagram, Pb-Sn phase diagram.

Unit-4: Crystal Structure: (9L)

Lattice, Basis, Crystallographic planes and directions. Simple, bcc and fcc crystal structure.

Reference Books:

1. Materials science and Engineering -V. Raghvan.
2. Elements of Materials science and Engineering - H. Vanvlach (4th Edition)
3. Nanotechnology - S.K. Kulkarni (3rd Edition)

Paper-II (Section-I)

Paper Title:Introduction to Characterization Techniques

Unit-1: Nonradiative and nonelectron characterization methods (9L)
Particle spectroscopy, Thermodynamic methods, Particle sizedetermination, Surface area and Porosity, Other important characterization methods.

Unit-2: Spectroscopic Methods (9L)
UV-Vis absorption and emission spectroscopy, Infra red, Photoluminescence and Electroluminescence methods.

Unit-3: Electron Probe Methods (9 L)
Types of characterization methods, Optics and Resolution, The nano perspectives, Electron interaction with matter, Scanning electron microscopy and electron probe microanalysis, Transmission electron microscopy, Other important electron probe methods.

Unit-4: Chemical Characterization (9 L)
Introduction to volumetric analysis, Methods of expressing concentrations, Primary and Secondary standard solution, Indicators, Acid base indicators, Acid-Base titration, Discuss titration with respect to newtralization and equivalence point of determination and limitation.

Reference Books:

1. Nanotechnology :Technology Revolution of 21st Century by Rakesh Rathi, published by S.Chand.
2. Introduction to Nanoscience, by Stuart Lindsay.
3. Introduction to Nanomaterials and nanotechnology by VladimirPokropivny, RynnoLohmus, Irina Hussainova, Alex Pokropivny and Sergey Vlassov
4. Nanomaterials by A.K. Bandyopadhyay; New Age International Publishers.
5. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education.
6. Nano Essentials- T.Pradeep/TMH
7. Bharat Bhusan, “Springer Handbook of Nanotechnology”, springer, Newyork, 2007

8. Hari Singh Nalwa, “Encyclopedia of Nanotechnology”, USA 2011
9. James A. Schwarz, Cristian I. Contescu, Karol Putyera, “Dekker encyclopedia of nanoscience and nanotechnology” CRC Press, 2004.
10. Analytical chemistry by G.D. Christian, 6th edition.
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Paper-III
Paper Title: Practical

1. Synthesis of TiO2 nanotubes by electrochemical anodization.
2. Synthesis of silver nanoparticles by chemical method
3. Synthesis of silver nanoparticles by using biological method
4. Synthesis of ZnO by hydrothermal method
5. Synthesis of Polyanilinenanofibers by CBD method
6. Synthesis of Fe2O3 by Sol-gel method
7. Preparation of CdS by chemical bath deposition
8. Electrodeposition of Cobalt thin films
9. Preparation of CdSe by Successive Ionic Layer, Adsorption and Reaction(SILAR) method
10. Synthesis of silver nanoparticle using microorganisms.
11. Synthesis of silver nanoparticles using plant extract
12. Cytotoxicity testing of nanoparticles.(antimicrobial Germination)
13.
14. Compulsory Research laboratory/Industry visit Report
15. submission by every Student
16.