Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara

(Autonomous)

Undergraduate Programme

B. Sc. in Physics

Syllabi of the Papers

Materials Science

Choice based credit system syllabus

(To be implemented from academic year 2021- 22)

Department of Physics

Preamble:

This syllabus is framed to focus on the fundamental aspects of materials science which every materials scientists is supposed to be familiar with. The course discusses the fundamental properties of materials, classification of materials based on their elastic, electrical, optical, magnetic properties. Property based technological applications of materials.

Students learn materials science as a separate subject from B.Sc. I. The goal of the syllabus is to make the study of materials interesting, curious, encouraging and popular to the students for higher studies including research.

The new syllabus is based on fundamental (physical and chemical) properties of materials with vigor and depth. At the same time precaution is taken to make the syllabus comparable to the syllabi of other universities and the needs of industries and research.

The syllabus is prepared after discussion at length with number of faculty members of the subject and experts from industries and research fields.

The units of the syllabus are well defined, taking into consideration the level and capacity of students. This syllabus is framed to give sound knowledge with understanding of materials science to undergraduate students as one of the subject at first and second year.

Program Objectives of the Course:

The course discusses the basic properties of materials, classification of materials based on the properties and applications. The evolution of new eras in science and technology, based on the properties of the novel materials. The objective of the course is to provide the students with basic knowledge of materials science, so that they would be able to

1. understand and distinguish between variety of materials based on their properties.
2. acquire the measurement skills for different properties of materials.
3. aware with present status of materials development in the respective field of application
4. to develop the power of appreciations, the achievements in science and role in nature and society.
5. to enhance student sense of enthusiasm for developments in materials science and to involve them in an intellectually stimulating experience of Course in a supportive environment.

Program Specific Outcomes:

After successful completion of B.Sc. Materials Science Course student will be able to:

Course Outcomes:

1. students will get to know the different classes of materials used in engineering applications.
2. choose the right materials for specific applications.
3. develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in materials science.
4. identify their area of interest in academic, Research and Development.
5. perform job in various fields' like science, engineering, education, business and public service, etc. or be an entrepreneur with precision, analytical mind, innovative thinking, clarity of thought , expression, and systematic approach.

B. Sc. Part I

1. **Title:** Materials Science
2. **Year of Implementation:** The syllabus will be implemented from September, 2021 onwards.
3. **Duration:** The course shall be a full time.
4. **Pattern: S**emester examination.
5. **Medium of Instruction:** English.

6. Structure of Course:

B.Sc.-I Semester-I

Sr. No.	Paper Title	Theory			Practical		
		Paper Code	Lectures per week	Credits	Paper Title	Lectures per week	Credits
1	Properties of Materials	BMST101	5	2	Practical Paper-I : BMP103	4	2
2	Structure of Materials	BMT102		2			

B.Sc.-I Semester-II

Sr. No.	Paper Title	Theory			Practical		
		Paper Code	Lectures Per week	Credits	Paper Title	Lectures Per week	Credits
1	Special Materials	BMT201	5	2	Practical Paper – II : BMP203	4	2
2	Polymers and Applications	BMT202		2			

B: B.Sc. P: Physics T: Theory, P: Practical

3. Titles of papers of B.Sc. course:

B.Sc.-I Semester-I

Theory: 36 lectures, 30 hours (for each paper)

Paper – I : BMT101: **PROPERTIES OF MATERIALS**

Paper – II: BMT102: **STRUCTURE OF MATERIALS**

Practical : 40 lectures, 32 hours

Practical : BPP103: **Materials Science-I**

B.Sc. – I Semester – II

Theory: 36 lectures, 30 hours (for each paper)

Paper – III : BPT201: **SPECIAL MATERIALS**

Paper – IV : BPT202: **POLYMERS AND APPLICATIONS**

Practical : 40 lectures, 32 hours

Practical : BPP203: **Materials Science-II**

B. Sc. Part-I Semester-I

BMT101: Properties of Materials (Credits:02)

Course Objectives: Students should

- understand the different elastic properties of materials and the ways to determine moduli of elasticity and applications.
- learn the thermal and dielectric properties of materials, their measurements and applications.
- understand concept of of band structure based classification of materials and to deduce the properties of semiconducting materials
- understand the of origin of magnetism in materials, classification of magnetic materials and their applications.
- be promoted for the basic understanding of optical properties of materials.

Unit I: Mechanical Properties: (9)

Stress, strain, elastic properties, modulus of elasticity Poisson's ratio and relationship between moduli (qualitative), yield strength, stress-strain diagram for ductile and brittle materials, uses - factors affecting elastic modulus and tensile strength, toughness, elongation, plastic deformation, hardness, impact strength, creep, fatigue, ductile and brittle fracture.

Unit II: Thermal and Dielectric properties: (9)

Specific heat, thermal conductivity, thermal expansion. thermal shock resistance, thermoelectric effect, Applications of thermoelectrics. ***Dielectric properties:*** Dielectric polarization. AC response. Breakdown strength, Measurement of dielectric constant. Applications of dielectrics.

Unit III: Electronic Properties: (9)

Concept of energy band diagram for materials - conductors, semiconductors and insulators, Intrinsic Semiconductors, direct and indirect band gap semiconductors, Carrier concentration in intrinsic semiconductors, extrinsic semiconductors, Carrier concentration in N-type & P-type semiconductors, Variation of carrier concentration with temperature electrical conductivity effect of temperature on conductivity.

Unit IV: Magnetic and Optical properties: (9)

Origin of magnetism in materials, paramagnetism, diamagnetism, antiferromagnetism, ferromagnetism, ferrimagnetism, magnetic hysteresis. ferromagnetic domains. Soft and hard magnetic materials. Measurement of magnetic susceptibility. Applications of magnetic materials. Optical Properties: Reflection, refraction, absorption and transmission of electromagnetic radiation in solids. photoelectric emission, photoconductivity and photoluminescence. Lasers.

Reference Books:

1) Physical metallurgy. – R. W. Cahn, II Edition, North Holland, Amsterdam (1970)
2) Modern physical metallurgy – R.E. Smallman, Butterworths, London (1970)
3) Physical properties of glass - D. G. Holloway Wykeham publications, London (1973)
4) An introduction to metallurgy – A.H. Cottrell, Edward Arnold, London (1967)
5) M. A. Wahab; Solid State Physics, A. S. International (2005)
6) K. H. J. Buschow& F. R. de Boer: Physics of Magnetism and Magnetic Materials.
7) S.O. Pillai; Solid State Physics, 6th Ed., New Age International (p) Ltd publishers, (2005
8) Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley & Sons

Course Outcomes:

- The students will understand different strengths of materials, moduli of elasticity, their determination and applications.
- The students will acquire sound knowledge on thermal expansion and thermal conductivity of materials. Further they will gain an idea of dielectric properties and their measurements.
- The students will gain knowledge on semiconductor materials, their types and charge carrier concentration.
- The students will secure knowledge on different types of magnetic materials and optical properties of materials.

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B. Sc. Part-I Semester-I

BMT102: Structure of Materials (Credits:02)

Course Objectives: Students should

- understand the atomic structure and properties of elements as per organized in periodic table.
- understand different types of bonds their strengths in materials and theories of hybridization..
- learn concept of coordination chemistry.
- understand co-ordination chemistry of materials and their properties.
- be able to explore the electronic and magnetic properties dependence on co-ordination.

Unit I: Atomic Structure and Periodic Properties of Elements (9)

Introduction to atomic structure, isotope, isobar and isotones, electronic configuration, introduction to periodic table, atomic radius, electonegativity, ionization enthalphy, oxidation states, metal, metalloids and non metals.

Unit II: Introduction to Bonding (9)

Types of bond, covalent bond, concept of hybridization, types of hybridization, valence bond theory (VBT), Valence Shell Electron Pair Repulsion (VSEPR) theory.

Unit III: Co-ordination Compounds (9)

Coordinate Bond, double salts and complex salts, ligands and its types, complex formation and chelation, crystal field theory (CFT), Molacular Orbital theory (MOT).

Unit IV: Electronic and Magnetic Properties of Co-ordination Compounds (9)

Electronic spectra of coordination compounds, d-d transition, charge transfer spectra, diamagnetic, paramagnetic, ferromagnetic properties of coordination complex.

Reference Books:

1. Concise Inorganic Chemistry- J. D. Lee's .
2. Inorganic Chemistry: Principles of Structure and Reactivity by J. E. Huheey, E. A. Keiter and R. L. Keiter, 4th ed. Harper Collins 1993
3. Concepts and Models of Inorganic Chemistry by B. E. Douglas, D. H. McDaniel and J. J. Alexander, John Wiley, 1993, 3rd ed.

Course Outcomes:

- The students will understand atomic structure of elements, ordering of elements in periodic table as per their properties.
- The students will acquire sound knowledge on bonding in materials and concept of hybridization during formation of materials and compounds.
- The students will gain knowledge on co-ordination chemistry of compounds, theories of co-ordination.
- The students will secure knowledge on different magnetic properties of materials based on co-ordination chemistry.

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Practical Paper-I: BMP103

Materials Science-I (Credits:2)

Course Objectives: Students should acquire experimental skills

- to test elastic properties of materials of materials,
- thermal properties of materials of materials
- optical properties of materials of materials.
- **Experiments:**

1. Torsional pendulum - Determination of rigidity modulus of wire and moment of inertia of disc.
2. Young's modulus of material of bar by vibration.
3. Y & n of wire by Searle's method.
4. Poisson's ratio for rubber using rubber tube.
5. Determination of specific heat of Graphite.
6. Lee's Method- Determination of thermal conductivity of a bad conductor.
7. Potentiometer-Determination of thermo e.m.f. of a thermocouple.
8. Laser- Determination of the wave length of the laser using grating.
9. Determination of thermal conductivity of graphite and steel.
10. Determination of Band gap of a semiconductor.

REFERENCE BOOKS:

1. Advanced Practical Physics for Students : B. L. Worsnop and H. T. Flint , 1971 Asia Publ. House.
2. Practical Physics: S. L. Gupta and V. Kumar, Pragati Prakashan, 27th Edition, 2010.
3. An Advanced course in Practical Physics: D. Chattopadhyay and P. C. Rakshit, 7th edition, 2005, New Central Book Agency Pvt. Ltd.
4. Experimental College Physics: White and manning, McGRAW-HILL Book Company. 3rd edition.

OUTCOMES:

After completion of the unit, Students are able to:

- learn measuring skills in practical.
- understand theoretical concepts by performing experiments.
- develop awareness of minimizing experimental errors.
- handle various instruments.
- determine various moduli of elasticity.
- determine thermal and optical properties of materials.
- band gap determination and to measure of viscosity of liquids.

B. Sc. Part-I Semester-II

BMT201: Special Materials (Credits:02)

Course Objectives: Students should

- understand different composite materials and their engineered properties for different application.
- learn the types of glasses, their optical, electrical properties.
- understand ceramic materials and polymers with their enormous properties.
- understand origin of magnetism, classification of magnetic materials and their applications.
- learn phenomenological understanding of Ferroelectrics, Piezoelectrics and Pyroelectrics and their advanced applications.

Unit I: Composite materials (9)

Introduction, Fundamentals of composites - need for composites – enhancement of properties - classification of composites – Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) Reinforcing materials for fibrous composites, Manufacture of fiber composites, Elastic properties of a composite, Strength of a fiber composite, Specific stiffness and specific strength, Toughness of fiber composites.

Unit II: Glasses (6)

Glasses: Types of glasses, role of oxides in glasses, glass transition temperature, optical properties of glasses, electrical properties of glasses, electronically conducting glasses, special glasses, metallic glasses.

Unit III: Functional Materials (6)

Advanced Ceramics: Introduction, Classification of Ceramics, Structure of the Ceramics, Ceramic Processing, Properties of Ceramics, Applications. Polymer Materials: Introduction to commercial polymers-vizpolyethylene. Polyvinylchloride, Polystyrene, Nylon, Polyesters, Silicones etc.

Unit IV: Dielectric Properties of Materials (15)

Ferroelectrics: Ferroelectric phenomena, Representative crystal, types of ferroelectrics: Properties of Rochelle salt, BaTiO3, Theory of ferroelectric displacive transitions, Applications of ferroelectric materials, ***Piezoelectrics***: Piezoelectric phenomena, Phenomenological approach to piezoelectric effects, Piezoelectric parameters and their measurements, Piezoelectric materials and their applications. ***Pyroelectrics***: Pyroelectric phenomena, Phenomenological approach to pyroelectric effects, Pyroelectric parameters and their measurements, Pyroelectric and thermally sensitive materials, NTC and PTC materials, Applications of pyroelectric materials.

Reference Books:

1. Modern composite materials - L. J. Broutman and R H Krock Addition-Wesley Pub. Co., Massachusetts (1967)
2. Glass science - R H Doremus, John Wiley and sons, N. Y. (1973)
3. Physical properties of glass - D. G. Holloway Wykeham publications, London (1973)
4. Introduction to ceramics - W. D. Kingery, John Wiley and sons, N. Y. (1960)

5. Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley & Sons
6. M.A. Wahab; Solid State Physics: Structure and Properties of Materials, Alpha Science International (2005)
7. Materials Science & Engineering: Raghavan, Tata MC Graw Hill
8. Materials Science: Arumugam
9. Materials Science & Metallurgy: O. P. Khanna
10. Materials Science and Engineering: Callister S.

Course Outcomes:

- The students will understand composite materials, their types and applications.
- The students learn types of glasses their optical and electrical properties.
- The students will gain knowledge about ceramics and polymers for industrial applications.
- The students will learn about of Ferroelectrics, Piezoelectrics and Pyroelectrics materials and their applications.

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B. Sc. Part-I Semester-II

BMT202: Polymers and Their Applications (Credits: 02)

Course Objectives: Students should

- understand the polymer materials and their engineered properties for application.
- learn methods for preparation of polymers.
- understand advanced applications of polymers.

UNIT I: Introduction to Polymers: (9)

Fundamentals of polymers, Classification of polymers, natural and synthetic, monomer functionality, thermoplastic and thermosetting, polymerization-its types and techniques,

UNIT II: Molecular Weights of Polymers: (9)

Number average and weight average molecular weights, degree of polymerization, molecular weight distribution, polydispersity, molecular weight determination, different methods, Gel Permeation Chromatography.

UNIT III: Preparation of polymers: **(9)**

Petroleum based, plant products and synthetic routes. ***Polymers in fiber industry***: Fiber forming polymers. Synthesis, structure and properties of fibers. Application of fibers. ***Polymers for paints and coatings:*** Basics of paint technology. Polymeric binders, pigments, extenders and additives. Essential concepts of paint formulations. Properties of paints. ***Polymers as adhesives:*** Polymer based adhesives. Adhesion improvers. Thermal and mechanical behaviour of adhesives. Mechanism of adhesion.

UNIT IV: **Polymers in Electronic and Information technology**: **(9)**

Polymers used in electronic industries. Physical, chemical and morphological properties of electronic polymers and their applications. Piezo and pyroelectric polymers. Electric and dielectric properties of polymers. Polymers in optical media data storage devices. Various types of polymers used in information technology, their synthesis and properties. Fabrication of CD substrates. Polymers in tyre industries

Reference Books:

- Raw Materials for Industrial Polymers by H Ulrich, Hanser Publication1989.
- Principles of Polymer Science, by Bahadur and Sastry, Narosa Publishing House 2002.
- Polymer Science by Gowarikar, Johan wiley and Sons 1986.
- Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
- Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
- Petrochemicals The Rise of an Industry by Peter H. Spitz, Johan Wiley and sons 1988.
- Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.
- Polymer Science and Technology by J. R. Fried, Prentice-Hall, Inc 1995.

Course Outcomes:

- The students will types of polymers.
- The students learn basics of polymerization process.
- The students will learn polymer properties and their industrial applications.
- The students will learn about of electronic and IT applications of polymers.

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B. Sc. Part-I Semester-II
Practical Paper-II: BMT203

Materials Science-II (Credits: 02)

Course Objectives: Students should acquire experimental skills

- to prepare the standard solutions of chemicals.
- to determine the hardness of water.
- to determine molecular weight of polymers.

List of Experiments

1. Determination of wavelength of LASER using grating.
2. Determination of co-efficient of viscosity of a liquid by Poiseuille‟s flow.
3. Optical fibre -Determination of Numerical Aperture and acceptance angle
4. Impact test on metal specimen (Charpy).
5. Hardness test on metals (Rockwell and Brinell Hardness Tests).
6. Preparation of standard solution of K2Cr2O7 and to determine it s strength.
7. Preparation of tetramminecopper(II)sulphate.
8. Preparation of sodium cuprous thiosulphate.
9. To determine the hardness of water.
10. Estimation of copper content of the given solution by iodometry.
11. Determination of molecular weight of poly vinyl alcohol using Ostwald viscometer.

OUTCOMES:

After completion of the unit, Students are able to:

- learn measuring skills in practical.
- learn to handle mechanical test instruments.
- learn to prepare standard solutions in chemistry.
- learn to calculate molecular weight of polymers.

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