HSNC UNIVERSITY, MUMBAI

SYLLABUS FOR SEM - V & VI

Program: B.Sc

Subject: Physics (Compulsory Elective Course)

(Under the Choice Based Credit System (CBCS) w. e. f the Academic Year 2022-2023)

Preamble:
This syllabus is a part of the B. Sc Program of the Hyderabad and Sind National Collegiate University to be taught in Semesters 5 and 6 in the subject of Physics from the academic year 2022-23 onwards.

The syllabus introduces the Learner to various aspects of the study of Materials such types, properties, characterization, synthesis, processing and structure-property relation with applications.

In the course of both the theory and practical course the Learner will learn about several instruments and techniques associated with study of materials.

Objectives:

1. The primary objective of the syllabus is to culminate six semesters of study of core Physics into a field of contemporary research. This led to the design of the syllabus on Materials Science.
2. The syllabus is also made such that it brings out the interdisciplinary aspect of the Course.
3. The Learner will also get a training in the use of certain instruments and techniques which will prove helpful into his future forays into research.

The Scheme of Teaching and Examination is as under:

Third Year - Semester – V

Summary

Sr. No.	Choice Based Credit System	Course Codes	Remarks
1	Compulsory Elective Course 1	US-TPH-CE-501 US-TPH-CE-P01	

Detail Scheme

Sr. No.	Course Code	Course Title	Periods Per Week					Credit	Seasonal Evaluation Scheme					Total Marks
			Units	S. L.	L	T	P		SLE	CT	TA	Attendance	SEE	
1	US-TPH-CE-501	Materials Science 1	4	20% *	4	0	0	02	10	15	10	05	60	100
2	US-TPH-CE-P01	Physics Compulsory Elective Practical Course 1	-	-	0	0	4	02	-	-	-	-	100	100
Total Hours / Credit								04	Total Marks					200

***One to two lectures to be taken for CONTINUOUS self –learning Evaluation.**

III Year - Semester – V - Units – Topics – Teaching Hours

S. No	Course Code	Course Unit		Lectures	Total No. of lectures	Credit	Total Marks
		No	Title				
1	US-TPH-CE-501	I	Introduction to Materials	15	60	2	100 (60+40)
		II	Chemical Bonding, Defect, Dislocations and Diffusion in Materials	15			
		III	Phase Diagram	15			
		IV	Synthesis, Processing and Measurements	15			
2	US-TPH-CE-P01	Practical Course of US-TPH-CE-501		4 lectures per week	32	2	100 (60 + 20 + 20)

- **Lecture Duration = 50 mins**
- **1 credit = 24 lectures**

Curriculum topics with Self-Learning topics - to be covered through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT.

Course Name: Materials Science -1
Course Code: US-TPH-CE-501

Learning Outcomes:

- Learner will be introduced to material science and its importance, classes of materials, different areas of materials and special materials, chemical bonding, defects, dislocations and diffusion in materials, to phase diagrams, to synthesis, processing and related measurements.

Unit	Content	No. of Lectures
I	**Introduction to Materials:** 1.1 Materials science and its importance: an interdisciplinary area that covers the design and discovery of new materials, Relation to development of human civilization 1.2 Classification of materials: structural and functional: Crystalline and nanocrystalline, polycrystalline/amorphous, Inorganic solids, ionic Solids, polymers, metals and alloys., 1.3 Different areas of materials: Optical materials, display materials, acoustic materials/SAW devices, dielectric and magnetic materials, superconducting materials, biomaterials, high temperature superconductors, energy materials 1.4 Special Materials: Advanced materials (for nuclear, space and defence applications), ferrous alloys, non- ferrous alloys, metallic glasses, glass-ceramics, fiber reinforced plastics/glass, metal matrix composites. Futuristic materials (smart materials and nano-materials, biodegradable and bio-renewable Polymers)	**15**
II.	**Chemical Bonding, Defect, Dislocations and Diffusion in Materials:** 2.1 Chemical Bonding: Bond energy and bond length, ionic bonding, covalent bonding, metallic bonding, secondary bonding, variation in bonding character and properties, structure (nano, micro and macro) 2.2 Rules of solid solubility, Imperfections (defects) in solids: (i) Point defects: vacancies, Frenkel defect, Schottky defect, (ii) Line	**15**

	defects (dislocation): edge dislocation, screw dislocation, (iii) Surface defects or interfacial defects and (iv) Volume defect. 2.3 Formation and removal of defects: Deformation- irradiation- quenching- annealing- recovery, recrystallisation and grain growth. 2.4.Diffusion in solids: Fick's law- Inter diffusion and Kirkendall effect.	
III	**Phase Diagram:** 3.1 Phase equilibria, Construction of phase diagram, Gibb's phase rule 3.2 Classification of phase diagram (unary phase diagram, binary phase diagram), Binary phase diagram for: i) sugar-water, ii) NaCl-water. 3.3 Construction of phase diagram, Eutectic reaction, Lever rule, Pb-Sn phase diagram. 3.4 The kinetics of phase transformations, Metastable versus equilibrium states, transformation diagrams, Continuous-cooling transformation diagrams	**15**
IV	**Synthesis, Processing and Measurements:** 4.1 Nucleation and growth**:** Nucleation kinetics, The growth and the overall transformation kinetics, 4.2 Techniques of single crystal growth: General introduction to various growth method: **(Solution,** vapour, melt**),** **4**.3 Techniques of thin film preparation (physical vapor deposition, chemical vapour deposition, gel method etc) 4.4 Importance of processing and structure property correlation.	**15**

Self-Learning topics (Unit wise)

Unit	Topics
I	Crystalline and nanocrystalline, polycrystalline/amorphous, dielectric and magnetic materials, Ferrous alloys, Non- ferrous alloys,

II	Bond Energy and Bond Length, Ionic Bonding, Covalent Bonding
III	Classification of phase diagram (unary phase diagram, binary phase diagram), Binary phase diagram for: i) sugar-water, ii) NaCl-water.
IV	Solution growth of crystal and vapor deposition of thin film

Reference Books:

1. Elements of Materials Science and Engineering I. H. Vanvlach (4th Edition)
2. Materials Science and Engineering V.Raghavan Printice Hall India Ed. V 2004. New Delhi
3. William D. Callister, Jr., "Materials Science and Engineering an Introduction", 2/e Edition, John Wiley & Sons, Inc., 2007.
4. Materials Science by M.Arumugam, Anuradha Publishers. 1990 Vidayalkaruppur, Kumbakonam..
5. V.R. Gowariker, N.V. Viswanathan and Jayadev Sreedhar, "Polymer Science" New Age International (p) Ltd., New Delhi (2010). 2. F.W. Bill Mayer, "Text book of polymer science" 3rd Edition – John Wiley & sons, Inc., New York (2011).
6. Palanisamy, P.K., "Materials Science", Scitech (2013).
7. Balasubramaniam, R. "Callister's Materials Science and Engineering" Wiley India Pvt. Ltd. (2014).
8. Donald Askeland, "Materials Science and Engineering", Cengage Learning India Pvt Ltd (2010).
9. Foundation of Materials Science and Engineering –Kakani and Kakani
10. Foundations of Materials Science and Engineering - William F.Smith

Additional Reference Books:

1. Hibbeler, R.C., Mechanics of Materials, Pearson Education, Low Price Edition, 2007 4. Ferdinand P. Been, Russell Johnson, J.r. and John J. Dewole Mechanics of Materials, Tata Mc Graw Hill publishing 'co. Ltd., New Delhi.
2. G.S. Misra, "Introductory Polymer Chemistry "New age International Publishers, India (2005)
3. M.S. Bhatnagar, A Textbook of Polymers, Volume 1: Chemistry and Technology of Polymers (Basic Concepts), S. Chand & Company Ltd. (2010)
4. Materials Research: Current Scenerio and future projections by R Chidambram and S

Banerjee, Allied Publishers pvt Ltd, 2003 (Advanced Reading)

Course Name: Physics Compulsory Elective Practical Course 1

Course Code: US-TPH-CE-P01

Learning Outcomes:

- Learner will learn about FTIR spectroscopy, determine yield point, break point of an elastic material, specific heat of graphite and many other properties of materials, use deposition methods to prepare thin films etc.

CONTENTS **(Practical course based on US-TPH-CE-501)**	**No. of Lectures**
1. Determination of Hydrogen Bond-Length using Fourier Transform Infrared spectral (FTIR) profile of given sample 2. Determination of the yield point and the breaking point of an elastic material 3. Study of vibration band - Using Fourier Transform Infrared Spectroscopy. 4. To determine the specific heat of graphite. 5. Chromatography analysis using Column chromatography. 6. Determination of absorption and transmittance percentage and study the graphical relation between absorption and wavelength of the given sample 7. Determination of resistivity and band gap energy of a semiconductor by four probe method. 8. Deposition of a aluminum or silver on a glass plate by vapor deposition 9. Deposition of a film on glass by chemical deposition	4 lectures per Experiment

Reference Books:

1. Instrumental Methods of Analysis, Sharma, B.K. Goel Publishing House,1995
2. Spectroscopy of organic compounds, P.S. Kalsi 6th Edition, New Age International

Publishers,2006

3. Elements of X‑ray diffraction, Cullity, B. D Addison‑Wesley Publishing Company, Inc.

Note:

1. Minimum 8 experiments are to be performed by the Learner in the Practical Course
2. A record of experiments performed by the Learner must be maintained and be regularly checked by the Teacher-in-Charge.

The Scheme of Teaching and Examination is as under:

Third Year - Semester – VI
Summary

Sr. No.	Choice Based Credit System	Course Code	Remarks
1	Compulsory Elective Course 2	US-TPH-CE-501 US-TPH-CE-P01	

Detail Scheme

Sr. No.	Course Code	Course Title	Periods Per Week					Credit	Seasonal Evaluation Scheme					Total Marks
			Units	S. L.	L	T	P		SLE	CT	TA	Attendance	SEE	
1	US-TPH-CE-601	Materials Science 2	4	20% *	4	0	0	2	10	15	10	05	60	100
2	US-TPH-CE-P02	Physics Compulsory Elective Practical Course 2	-	-	0	0	4	2	-	-	-	-	100	100
Total Hours / Credit								04	Total Marks					200

***One to two lectures to be taken for CONTINUOUS self -learning Evaluation.**

III Year - Semester – VI - Units – Topics – Teaching Hours

S. No	Course Code	Course Unit		Hours/ Lectures	Total No. of hours/ lectures	Credit	Total Marks
		No	Title				
1	US-TPH-CE-601	I	Material Characterization Techniques-I: Instrumentation and Principles of Techniques	15	60	2	100 (60+40)
		II	Material Characterization Techniques – II: Instrumentation and Principles of Techniques	15			
		III	Measurements and Interpretations of Materials Properties	15			
		IV	Structure Property Relation and Application: Some Examples	15			
2	US-TPH-CE-P02	Practical Course of US-TPH-CE-601		4 lectures per week	32	2	100 (60 + 20 + 20)

- **Lecture Duration = 50 mins**
- **1 credit = 24 lectures**

Curriculum topics with Self-Learning topics - to be covered through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT.

Course Name: Materials Science -2
Course Code: US-TPH-CE-601
Learning Outcomes:

- Learner will learn about material characterization techniques, to measure and interpret material properties, about structure property relation and its application with some examples.

Unit	Content	No. of Lectures
I	**Material Characterization Techniques-I: Instrumentation and Principles of Techniques:** 1.1 Thermal analysis: TGA, DTA, DSC, Thermomechanical analyzer (TMA) 1.2 X-ray diffraction: X-ray diffraction and analysis and interpretations. 1.3 Electrical measurements set up: Four probe method, Temperature dependence of conductivity.	**15**
II	**Material Characterization Techniques – II: Instrumentation and Principles of Techniques:** 2.1 Transmission/absorption/reflection: UV Visible spectroscopy, fluorescence, phosphorescence and chemiluminescence-Beer-Lambert law: qualitative and quantitative analyses 2.2 FTIR and RAMAN Spectroscopy: Theory of FTIR spectroscopy, Instrumentation (sources, optical path and detectors used in different regions), sample preparation techniques, Differences between IR and Raman spectroscopy. 2.3 Structural analysis: Principle and measurement of optical microscopy, Transmission electron microscopy (TEM), Scanning electron microscopy (SEM): instrumentation and	**15**

	preliminary interpretation of data 2.4 Hardness tester/microhardness tester/ nano-indenter: Mechanical strength, bending, fracture etc.	
III	**Measurements and Interpretations of Materials Properties:** 3.1 Structural properties: macro-, micro- and nano- structures 3.2 Thermal Properties: Heat capacity, Thermal expansion, Thermal conductivity, Crystallization temperature, Glass transition temperature etc. 3.3 Electrical Properties: Conductivity (metal, semiconductor, insulators), Resistivity, Dielectric strength, Temperature dependence of conductivity and activation energy, Piezoelectricity. 3.4 Optical and optoelectronic Properties: Linear and non-linear refractive indices, Transmission/absorption, Photoconductivity, Band gap, Luminescence (photoluminescence, light emission), stimulated emission (laser properties), Birefringence, Second harmonic generation (SHG) **3.5** Mechanical Properties: Stress, Strain (tensile, compressive and shear), Strength, Elasticity, Plasticity, Ductility, Malleability, Hardness, Toughness, Creep, Fatigue, Stiffness, Isotropy, Anisotropy, factors affecting the mechanical properties, (grain size, temperature, exposure to atmosphere/corrosion effect, Heat treatment and carbon content).	**1 5**
IV	**Structure Property Relation and Application: Some Examples** **4**.1. Study of effect of compositional variation of Ge-Si single/ polycrystalline semiconductor material on band gap and wavelength cut off, Development of a photodetectors by tailoring of band gap. 4.2 Structural dependence on optical property (transmission / absorption, color) of a glass-ceramics - effect of change from micro to nano crystal size, Making of an optical filter. 4.3 Change in thermal expansion coefficient of a material with	**15**

	composition and structure: Development of materials with desired expansion coefficient such as zero expansion coefficient blank for telescope mirror. 4.4 Effect of processing/composition/crystal size/structure on mechanical strength for making a soft/hard material	

Self-Learning topics (Unit wise)

Unit	Topics
I	Four probe method
II	Beer-Lambert law, Differences between IR and Raman spectroscopy.
III	Thermal expansion, Conductivity (metal, semiconductor, insulators), resistivity, Stress, strain
IV	Change in thermal expansion coefficient of a material with composition

Reference Books:

1. Introduction to Materials science and engineering – Ralls Cartney and Wolf (Wiley)
2. Instrumental methods of analysis, Willard, H.H., Merritt.l.l., Dean J.a., and Settle,F.A.,Sixth edition, CBS publishers,1986.
3. "Principles and Practice of Analytical Chemistry, F.W. Fifield and D. Kealey, 1st Indian Reprint, Blackwell Pub., 2004.
4. Qualitative Inorganic analysis (A. I. Vogel), Day R.A Underwood A.L. V Edition, Prentice- Hall of India (P) Ltd, New Delhi
5. "Analytical Chemistry", G.D Christian, 6th Edn., John Wiley Press (2006).
6. Instrumental Methods of Analysis, Sharma, B.K. Goel publishing House,1995
7. Spectroscopy of organic compounds, Kalsi .P.S. 6th Edition, New Age International Publishers,2006
8. Organic Spectroscopy, William Kemp,3rd Edition, Palgrave publishers, 2007
9. An Introduction to Materials Characterization, Khangaonkar P. R., Penram International Publishin
10. Elements of X-ray diffraction, Cullity, B. D Addison-Wesley Publishing Company, Inc.
11. "Principles of Instrumental Analysis", D. A. Skoog, F. James Leary and T. A. Nieman, Fifth Edition, Saunders Publishing Co., 1998 2. D.A. Skoog, F.J. Holler and S.R. Crouch, "Principles of Instrumental Analysis" 6 th Edition, Thomas Brookes/Cole,

2007

12. ASM Handbook, Volume 10, Materials Characterisation, Whan R E (Ed),Nineth edition, ASM international, USA, 1986.
13. “Principles of Thermal Analysis and Calorimetry”, Haines, P.J.Royal Society of Chemistry (RSC), Cambridge, 2002. 6. D. A. Skoog, F. James Leary and T. A. Nieman, “Principles of Instrumental Analysis”, Fifth Edition, Saunders Publishing Co., 1998

Additional Reading:

1. Proceedings of National Workshop on Advanced Methods for Materials Characterization (NWMC-2004) organized by MRSI- Mumbai Chapter under the auspicious of Bord of Research in Nuclear Sciences (BRNS), Published by MRSI(Mumbai Chapter)

Course Name: Physics Compulsory Elective Practical Course 2

Course Code: US-TPH-CE-P02

Learning Outcomes:

- Learner will learn about UV spectroscopic techniques, to use TGA and DTA spectra, about X‑ray Powder Diffraction and many other techniques studied in the theory course

CONTENTS **(Practical course of US-TPH-CE-601)**	**No. of Lectures**
1. UV spectroscopic techniques- Validating Lambert-Beer's law using $KMnO_4$ 2. Comparative analysis of decomposition temperature using TGA and DTA spectra of given sample 3. Determination of Crystal Structure and Lattice Parameters of a Polycrystalline Material by Powder Diffraction (Debye Scherrer) Method. 4. X‑ray Powder Diffraction – (Graph plotting and grain size calculation using given data) 5. Determination of the optical power loss in attenuators. (Fiber Optics) 6. Determination of Optical Constants (n, k) of a given Sample using UV-VIS (Dual and Single beam) Spectrophotometer 7. Study of vibration band - Using Fourier Transform Infrared Spectroscopy. 8. Comparative analysis of Infrared spectroscopy and Raman Spectroscopy of biomaterial /or other sample.	4 lectures per Experiment

9. Determination of thermal expansion coefficient, crystallization temperature in glassy materials	

References:

1. Sharma, B.K., Instrumental Methods of Analysis, Goel publishing House,1995
2. Kalsi. P.S. Spectroscopy of organic compounds, 6th Edition, New Age International Publishers,2006
3. William Kemp, Organic Spectroscopy, 3rd Edition, Palgrave publishers, 2007

Note:

1. Minimum 8 experiments are to be performed by the Learner in the Practical Course
2. A record of experiments performed by the Learner must be maintained and be regularly checked by the Teacher-in-Charge.

Scheme of Examination:

Modality of Examination:

A) Internal Assessment:

1. Self-Learning Evaluation – Learner will make either a PowerPoint presentation or Video Presentation of the topics earmarked for self – study in each unit

2. Class Test – A Test containing 15 Multiple Choice Questions covering first two units of each theory course

3. Term Assignment – An assignment about all the SLE components for the given course

4. Class Attendance – To evaluate the participation of the learner in the classroom.

B) <u>Semester End Examination:</u>

i) Theory Assessment:

1. A Question Paper consisting of 5 questions as per the following pattern:

Q1 – pertaining to unit 1

Attempt ANY ONE:

(a) …. (8 marks)

Or

(b)

Attempt ANY ONE:

(c) … (4 marks)

Or

(d)

Q2 – pertaining to unit 2

Attempt ANY ONE:

(a) …. (8 marks)

Or

(b)

Attempt ANY ONE:

(c) … (4 marks)

Or

(d)

Q3 – pertaining to unit 3

Attempt ANY ONE:

(a) …. (8 marks)

Or

(b)

Attempt ANY ONE:

(c) … (4 marks)

Or

(d)

Q4 – pertaining to unit 4

Attempt ANY ONE:

(a) …. (8 marks)

Or

(b)

Attempt ANY ONE:

(c) … (4 marks)

Or

(d)

Q5 – pertaining to units 1, 2, 3 and 4

Attempt ANY FOUR: (12 marks)

(a) – (unit 1)

(b) – (unit 1)

(c) – (unit 2)

(d) – (unit 2)

(e) – (unit 3)

(f) – (unit 3)

(g) – (unit 4)

(h) – (unit 4)

ii) Practical Assessment:

The following rules shall apply to each Practical Course of the Semester:

1. A Learner will be allowed to appear for the Practical Examination of the Semester only if he submits a certified journal or a certificate from the Head of Department to the effect that he has completed the Practical Course with the minimum required experiments.

2. The Learner will have to appear for Practical Examination in each Practical Course of the Semester as per the below particulars:

Particulars	**Max Marks Allotted**
Experiment	60
Journal	20
Viva	20
Total	100