## University of Kerala

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| Discipline | **PHYSICS** | | | | |
| Course Code | **UK3DSEPHY202** | | | | |
| Course Title | **BASICS OF NANOSCIENCE AND NANOTECHNOLOGY** | | | | |
| Type of Course | **DSE** | | | | |
| Semester | **III** | | | | |
| Academic Level | **200 - 299** | | | | |
| Course Details | Credit | Lecture per week | Tutorial per week | Practical per week | Total Hours/Week |
| | 4 | 4 Hrs | - | - | 4 Hrs |
| Pre-requisites | - | | | | |
| Course Summary | Materials Structure and Bonding. Crystals and Imperfections in Solids, Electrical and Optical Properties of Materials, Generation of Nanoscience and Nanotechnology, Applications of Nanoscience and Nanotechnology for a Sustainable Future: Addressing Global Challenges | | | | |

**BOOKS FOR STUDY**:


1. Materials Science and Engineering: An Introduction, 10th Edition by William D. Callister Jr, David G. Rethwisc, Wiley (2018)
2. Textbook Of Nanoscience And Nanotechnology, B.S Murthy, P.Shankar. Baldev Raj,B.B.Rath , James Murday, Orient Blackswan, (2021)
3. Nanotechnology: Principles and Practices, Third Edition, by Sulabha K. Kulkarn (2014)
4. Introduction To Nanoscience And Nanotechnology By Chattopadhyay, PHI ,India

**BOOKS FOR REFERENCE:**

1. Fundamentals of Nanotechnology, CRC press, by G.L. Hornyak, J.J. Moone, H.F. Tihhale, J. Dutta
2. Nanotechnology Technology Revolution of 21st Century by Rakesh Rathi, published by S.Chand
3. Nanomaterials by A.K. Bandyopadhyay; New Age International Publishers.
4. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education.
5. Nano Essentials- T.Pradeep, TMH

**WEB REFERENCE**

1. https://nptel.ac.in/courses/113/104/113104076/

**DETAILED SYLLABUS: THEORY**

| Module | Unit | Content | Hrs | CO No |
|---|---|---|---|---|
| I | | **Materials Structure and Bonding** | **12** | |
| | 1 | Why Study Materials Science and Engineering? (Book1: Chapter 1) | 1 | 1 |
| | 2 | Arrangement of Atoms, Two-Dimensional Crystal Structures, Three-Dimensional Crystal Structures, Elementary ideas and examples of Three-Dimensional Crystals (Book1: Chapter 3) | 3 | 1 |
| | 3 | Planes in the Crystals, Crystallographic Directions, Reciprocal Lattice (Book1: Chapter 3) | 3 | 1 |
| | 4 | Atomic bonding in solids - bonding forces and energies (Book1: Chapter 2) | 3 | 1 |
| | 5 | Primary bonding - Ionic bonding, Covalent bonding (Book1: Chapter 2) | 1 | 1 |
| | 6 | Metallic bonding, Secondary bonding- van der Waals bonding (Book1: Chapter 2) | 1 | 1 |
| II | | **Crystals and Imperfections in Solids** | **12** | |
| | 7 | Crystalline and non-crystalline materials -Single crystals, Polycrystals (Book1: Chapter 3) | 2 | 2,3 |
| | 8 | Atomic packing factors of FCC, BCC, Hexagonal close packed crystal structure (Book1: Chapter 3) | 4 | 2,3 |
| | 9 | Imperfection in solids – Point and line defects-Frenkel defect (Book1: Ch 4) | 3 | 2,3 |
| | 10 | Schottky defect-Burger vectors Vacancies, Interstitial (Book1: Ch 12) | 3 | 2,3 |

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| **III** | **Electrical and Optical Properties of Materials** | | **12** | |
| | 11 | Electrical Conductivity, Electronic and Ionic Conduction(Book1: Chapter 18) | 2 | 4 |
| | 12 | Energy Band Structures in Solids, Conduction in Terms of Band and Atomic Bonding Models, Electron Mobility (Book1: Chapter 18) | 3 | 4 |
| | 13 | Semiconductivity-Intrinsic Semiconduction, Extrinsic Semiconduction, Temperature Dependence of Carrier Concentration, Factors affect Carrier Mobility (Book1: Chapter 18) | 3 | 4 |
| | 14 | Optical Properties, Electromagnetic Radiation, Light Interactions with Solids (Book1: Chapter 21) | 2 | 4 |
| | 15 | Refraction , Reflection, Absorption, Transmission, Colour (Book1: Chapter 21) | 2 | 4 |
| **IV** | **Generation of Nanoscience and Nanotechnology** | | **12** | |
| | 16 | Nano and Nature, Nanoscopic colours (Butterfly wings), Bioluminescence (Fireflies) | 2 | 5 |
| | 17 | Tribology in nature - Geckos Sticky feet, lotus-leaf effect. (Book3: Chapter 11) | 2 | 5 |
| | 18 | The development of nanoscale science: Size scale, Nanotechnology timeline, pre-18th Century; 19 th Century, 20th Century, 21 th Century | 2 | 5 |
| | 19 | Carbon age-New form of Carbon- Fullerenes, Bucky balls, Carbon Nanotubes (CNTs) , Multi walled CNTs (Book3: Chapter 11) | 3 | 5 |
| | 20 | Influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties, mechanical-physical-chemical properties, | 3 | 5 |
| **V*** | **Applications of Nanoscience and Nanotechnology for a Sustainable Future: Addressing Global Challenges (Book2: Ch**apter **4)** | | **12** | |
| | 21 | Food and Agricultural Industry, Cosmetic and Consumer Goods, | 4 | 6 |
| | 22 | Energy ,Water treatment and Environment, Nano Medical Applications | 4 | 6 |
| | 23 | Textiles, Paints, Defence and Space Applications | 4 | 6 |

**COURSE OUTCOMES**

| No. | Upon completion of the course the graduate will be able to | Cognitive Level | PSO addressed |
|---|---|---|---|
| CO-1 | Explain the fundamentals of nanoscale systems and its physical, chemical, and electrical properties | U | PSO-1,2 |
| CO-2 | List and classify the fundamental crystal structure of the materials | R, U | PSO-2,3 |
| CO-3 | Outline the various defects occurs in materials | U | PSO-1,3 |
| CO-4 | Illustrate the electrical and optical properties of materials | Ap | PSO-3,4 |
| CO-5 | Illustrate the surface effects on mechanical-physical-chemical properties of materials | Ap | PSO-5 |
| CO-6 | Define and analyse the fundamental applications of nanotechnology and point out how it supports for a sustainable future in modern era | R, An | PSO-6,7 |

**R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

**Name of the Course: BASICS OF NANOSCIENCE AND NANOTECHNOLOGY**

**Credits: 4:0:0 (Lecture: Tutorial: Practical)**

| CO No. | CO | PO / PSO | Cognitive Level | Knowledge Category | Lecture (L)/ Tutorial (T) | Practical (P) |
|---|---|---|---|---|---|---|
| CO-1 | Explain the fundamentals of nanoscale systems and its physical, chemical, and electrical properties | PO1,3,4,5 ,6,8/ PSO-1,2 | U | F, C | L | - |
| CO-2 | List and classify the fundamental crystal structure of the materials | PO1,2,3,4 ,5,8/ PSO-2,3 | R, U | F, C | L | - |
| CO-3 | Outline the various defects occurs in | PO1,2,3,4 ,6/ PSO- | U | F, C | L | - |

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|---|---|---|---|---|---|---|
| | materials | 1,3 | | | | |
| CO-4 | Illustrate the electrical and optical properties of materials | PO1,2,3,4 ,6/ PSO-3,4 | Ap | F, C | L | |
| CO-5 | Illustrate the surface effects on mechanical-physical-chemical properties of materials | PO1,2,3,7 /PSO-5 | Ap | F, C | L | - |
| CO-6 | Define and analyse the fundamental applications of nanotechnology and point out how it supports for a sustainable future in modern era | PO1,3,4,5 ,7,8/PSO-6,7 | R, An | F, C | L | - |

**F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

**Mapping of COs with PSOs and POs :**

| | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 2 | - | - | - | - | - | 2 | - | 1 | 1 | 2 | 2 | - | 1 |
| CO-2 | - | 2 | 1 | - | - | - | - | 1 | 2 | 2 | 1 | 2 | - | - | 2 |
| CO-3 | 2 | - | 1 | - | - | - | - | 1 | 2 | 2 | 1 | - | 1 | - | - |
| CO-4 | - | - | 3 | 2 | - | - | - | 2 | 2 | 1 | 1 | - | 1 | - | - |
| CO-5 | - | - | - | - | 3 | - | - | 1 | 2 | 2 | - | - | - | 2 | - |
| CO-6 | - | - | - | - | - | 2 | 2 | 1 | - | 2 | 2 | 2 | - | 1 | 1 |

**Correlation Levels:**

| **Level** | - | 1 | 2 | 3 |
|---|---|---|---|---|
| **Correlation** | Nil | Slightly / Low | Moderate / Medium | Substantial / High |

**Assessment Rubrics:**

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

**Mapping of COs to Assessment Rubrics :**

| CO No | Internal Exam | Assignment | Project Evaluation | End Semester Examinations |
|---|---|---|---|---|
| CO-1 | ✓ | - | - | ✓ |
| CO-2 | ✓ | - | - | ✓ |
| CO-3 | - | ✓ | - | ✓ |
| CO-4 | - | ✓ | - | ✓ |
| CO-5 | - | ✓ | - | ✓ |
| CO-6 | ✓ | - | - | - |