

GUJARAT TECHNOLOGICAL UNIVERSITY

NANO TECHNOLOGY (39)
PHYSICS OF NANOMATERIAL
SUBJECT CODE: 2143902
B.E. 4th Semester

Type of course: Physical science and Technology

Prerequisite: Solid state physics, crystal physics, mathematics (differentiation and integration), material chemistry (inorganic chemistry) and some physical properties of materials from 12th science level syllabus.

Rationale: The purpose of this course is to develop basic concepts of properties of materials, and how its modified with nano scale materials, and understanding of some basic physical properties of nano materials

Teaching and Examination Scheme:

| Teaching Scheme | | | Credits C | Examination Marks | | | | | | Total Marks |
|-----------------|---|---|--------------|-------------------|--------|-----|-----------------|-----|-----------|----------------|
| L | T | P | | Theory Marks | | | Practical Marks | | | |
| | | | | ESE (E) | PA (M) | | PA (V) | | PA (I) | |
| | | | | | PA | ALA | ESE | OEP | | |
| 3 | 0 | 0 | 3 | 70 | 20 | 10 | 0 | 0 | 0 | 100 |

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment

Contents:

| Sr. No. | Topics | Teaching Hrs. | Module Weightage |
|---------|--|---------------|------------------|
| 1 | INTRODUCTION :- An overview of quantum mechanical concepts related to low-dimensional systems | 5 | 10% |
| 2 | CONCEPTS RELATED TO ELECTRONIC STRUCTURE: Direct lattice, Reciprocal lattice, Energy bands, Direct-and Indirect-gap semiconductors, Variation of energy bands with alloy composition and its exploitation for devices, Lattice matching, Effective mass, Electron statistics, carrier concentration and Fermi level. | 6 | 15% |
| 3 | QUANTUM CONFINED SYSTEMS: Hetero junctions, Type I and Type II hetero structures, Classification of Quantum confined systems, Electrons and holes in Quantum wells. Surface to volume ratio in quantum confined systems, Spherical cluster approximation, Exterior surface area, Interior surface area. | 5 | 10% |
| 4 | ELECTRON STATES IN HETERO STRUCTURES: | 6 | 15% |

| | | | |
|---|--|---|-----|
| | Electronic wave functions, energy sub bands and density of electronic states in Quantum wells, Quantum wires, and Quantum dots, Effective mass mismatch in hetero structures. | | |
| 5 | INTERACTING QUANTUM WELLS: Coupling between Quantum wells, Super lattices, Wave functions and Density of States for super lattices, Unit cell for quantum well, for quantum wire and for quantum dot. | 5 | 10% |
| 6 | EXCITONS: Excitons in bulk, in Quantum structures and in hetero structures. | 5 | 10% |
| 7 | NANOCLUSTERS AND NANOPARTICLES:- Introduction, Metal nano clusters- Magic numbers, Geometric structures, Electronic structure, Bulk to nanotransition, Magnetic clusters; Semiconducting nanoparticles; Rare-gas and Molecular clusters. | 5 | 10% |
| 8 | CARBON NANOTUBES - Chiral vector, Chiral angle and the Unit cell for the Carbon nanotubes. | 5 | 10% |
| 9 | BULK NANOSTRUCTURED MATERIALS - Solid disordered nanostructures, Nanostructured crystals, Photonic structure. | 6 | 10% |

Suggested Specification table with Marks (Theory):

| Distribution of Theory Marks | | | | |
|------------------------------|---------|---------|---------|---------|
| R Level | U Level | A Level | N Level | E Level |
| 16 | 20 | 27 | 7 | |

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table

Course Outcome:

The Syllabus of Physics of Nanomaterials helps student to improve their knowledge of some fundamental physical properties of materials and how this properties get change by varying particle size in nano scale. As well as they learn some important nanomaterials and their physical properties and their applications in Nanotechnology.

Reference Books:

1. V.V. Mitin, V.A. Kochelap, and M.A. Stroscio, "Quantum Heterostructures: Microelectronics
2. Optoelectronics", Cambridge University Press, 1999.2. C.P. Poole, Jr. and F.J. Owens, "Introduction to Nanotechnology", Wiley India. 2006.
3. T. Pradeep, "Nano: The essentials", Tata McGraw-Hill, 2007.
4. P. Harrison, "Quantum Wells, Wires, and Dots: Theoretical and Computational
a. Physics", John Wiley, 2000.
5. G. Streetman and S. Banerjee, "Solid State Electronic Devices", Prentice Hall of India, 2001.
6. A. Shik, "Quantum Wells: Physics and Electronics of two-dimensional systems", World Scientific, 1999.
7. G.L. Hornyak, J. Dutta, H.F. Tibbals and A.K. Rao, "Introduction to Nanoscience", CRC Press, 2008.

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.