Introduction to Physics of Nanoparticles and Nanostructures - Web course

COURSE OUTLINE

The course is a one semester course on Physics of Nanoparticles and Nanostructures in two distinct parts to give a flavor of the subject at an advanced level for M. Sc. Physics. The first part consists of interaction of EM radiation with matter and begins with basic concepts of EM radiations ending with the Absorption and Scattering of radiation by Nanoparticles.

The second part is related to electron transport in semiconductor device structures, and starting with the basic concepts of electron states in semiconductors, develops the electron transport in semiconductor device structures within effective mass theory, without going into the details of actual devices.

Both courses require basic knowledge of Solid State Physics. At the end of this course, a student is expected to be familiar with the importance of both the Nanoparticles and Nanostructures and their possible applications for taking up more challenging advanced level research problems.

COURSE DETAIL

S.No	Section	Topics and contents	Number of Lectures
1.	Part I NanoParticles	Absorption and scattering of EM waves from Nanoparticles based on b u l k properties: Brush up : Maxwell's equations, constitutive relations, propagation of homogeneous plane waves, Kramer Kronig relations, sum rules.	4
2.		Reflection and Transmission through slab, Absorbance, Ripple structures, analogy between slab and a particle.	3
3.		Single and multiple oscillator models for bulk dielectric function of insulators, semiconductors with electronic and vibrational contributions, metals, polar and glassy materials, magnetic materials.	4
4.		Polarization of EM waves and Stokes parameters, Mueller matrices.	2
5.		Absorption and scattering by a	4

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Physics

Pre-requisites:

Introductory Solid State Physics at the level of "Introduction to Solid State physics by C. Kittel, 7th Edition, John Wiley (2004)".

Additional Reading:

1. Wooten F, Optical Properties of Solids, Academic Press, 1972.
2. Kerker M, The Scattering of Light and Other Electromagnetic Radiation, Academic Press, 1969.
3. Yu Y U and Cardona M, Fundamentals of Semiconductors : Physics and Materials Properties, Springer-Verlag, 1996.
4. Gaponenko S V, Optical properties of semiconductor Nanocrystals, Cambridge University Press, 1998.
5. Datta S, Electronic Transport in Mesoscopic Systems, Cambridge University Press, 1997.

Coordinators:

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	Nanoparticles	particle: boundary conditions, amplitude and phase scattering matrices, Stokes parameters of scattered waves. Extinction, scattering and absorption cross section for a single particle and slab of particles.	
6.		Mie theory for Scattering and absorption by a sphere, field patterns and normal modes, extinction and scattering cross sections.	3
7.		Small particles, size parameter, quasi-static approach to polarizability of uncoated and multiply coated ellipsoidal particles, surface modes for various materials, scattering cross sections. Maxwell-Garnett theory for collection of particles, size distribution effect.	4
8.		Applications: Surface Enhanced Raman Scattering (SERS) from small particles. Dielectrophoresis of small particles.	2
9.	Part II Nanostuctures	Electronic Phenomena in Nanostructures: Brush up: Electronic structures and effective mass theory for bulk Si, Ge, GaAs; Excitons. Boltzmann electron transport in bulk.	4
10.		Electron energy states in quantum confined systems, semiconductor heterojunctions, 2-DEG systems, Quantum Wires, Quantum dots.	4
11.		Transmision in nanostructures: Tunneling in planar barrier, Resonant Tunnel diodes.	4
12.		Ballistic transport, Landauer formula, electron transport in Quantum wave-guide structures.	4
13.		Single electron phenomena: electronic states in quantum dots, without and with magnetic fields, single electron tunneling and Coulomb blockade, single electron transistor.	4
		Total number of lectures	46

References:

1. Bohren C F and Huffman D R, Absorption and Scattering of Light by Small

Particles, Wiley Interscience, Paperback Series, 1998.

2. Ferry D K and Goodnick S M, Transport in Nano-Structures, Cambridge University Press, 1997.