

- Lecture 1 - Scalar field and its Gradient
- Lecture 2 - Line and Surface Integrals
- Lecture 3 - Divergence and Curl of Vector Fields
- Lecture 4 - Conservative Field, Stoke's Theorem
- Lecture 5 - Laplacian
- Lecture 6 - Electric Field Potential
- Lecture 7 - Gauss's Law, Potential
- Lecture 8 - Electric Field and Potential
- Lecture 9 - Potential and Potential Energy - I
- Lecture 10 - Potential and Potential Energy - II
- Lecture 11 - Potential and Potential Energy - III
- Lecture 12 - Coefficients of Potential and Capacitance
- Lecture 13 - Poission and Laplace Equation
- Lecture 14 - Solutions of Laplace Equation - I
- Lecture 15 - Solutions of Laplace Equation - II
- Lecture 16 - Solutions of Laplace Equation - III
- Lecture 17 - Special Techniques - I
- Lecture 18 - Special Techniques - II
- Lecture 19 - Special Techniques - III
- Lecture 20 - Dielectrics - I
- Lecture 21 - Dielectrics - II
- Lecture 22 - Dielectrics - III
- Lecture 23 - Equation of Continuity
- Lecture 24 - a) Force between current loops b) Magnetic Vector Potential
- Lecture 25 - Magnetic Vector Potential
- Lecture 26 - Boundary Conditions
- Lecture 27 - Magnetized Material
- Lecture 28 - Magentostatics (Continued...), Time Varying Field (Introduction)
- Lecture 29 - Faraday's Law and Inductance
- Lecture 30 - Maxwell's Equations
- Lecture 31 - Maxwell's Equations and Conservation Laws

[Lecture 32 - Conservation Laws](#)

[Lecture 33 - a\) Angular Momentum Conservation b\) Electromagnetic Waves](#)

[Lecture 34 - Electromagnetic Waves](#)

[Lecture 35 - Propagation of Electromagnetic Waves in a metal](#)

[Lecture 36 - Waveguides - I](#)

[Lecture 37 - Waveguides - II](#)

[Lecture 38 - Resonating Cavity](#)

[Lecture 39 - Radiation - I](#)

[Lecture 40 - Radiation - II](#)

NPTEL : Special Theory of Relativity (Physics)

Co-ordinators : Prof. Shiva Prasad

Lecture 1 - Problem with Classical Physics

Lecture 2 - Michelson-Morley Experiment

Lecture 3 - Postulates of Special Theory of Relativity and Galilean Transformation

Lecture 4 - Look out for a New Transformation

Lecture 5 - Lorentz Transformation

Lecture 6 - Length Contraction and Time Dilation

Lecture 7 - Examples of Length Contraction and Time Dilation

Lecture 8 - Velocity Transformation and Examples

Lecture 9 - A Three Event Problem

Lecture 10 - A Problem involving Light and Concept of Casuality

Lecture 11 - Problems involving Casuality and Need to Redefine Momentum

Lecture 12 - Minikowski Space and Four Vectors

Lecture 13 - Proper Time a Four Scalar

Lecture 14 - Velocity Four Vector

Lecture 15 - Momentum Energy Four Vector

Lecture 16 - Relook at Collision Problems

Lecture 17 - Zero Rest Mass Particle and Photon

Lecture 18 - Doppler Effect in Light

Lecture 19 - Example in C-Frame

Lecture 20 - Force in Relativity

Lecture 21 - Force Four-Vector

Lecture 22 - Electric & Magnetic Field Transformation

Lecture 23 - Example of EM Field Transformation

Lecture 24 - Current Density Four Vector and Maxwell Equation

- Lecture 1 - Why Quantum Computing?
- Lecture 2 - Postulates of Quantum Mechanics - I
- Lecture 3 - Postulates of Quantum Mechanics - II
- Lecture 4 - Qubit - The smallest unit
- Lecture 5 - Qubit - Bloch sphere representation
- Lecture 6 - Multiple Qubit States and Quantum Gates
- Lecture 7 - Quantum Gates
- Lecture 8 - Quantum Circuits
- Lecture 9 - No-Cloning Theorem and Quantum Teleportation
- Lecture 10 - Super Dense Coding
- Lecture 11 - Density Matrix - I
- Lecture 12 - Density Matrix - II
- Lecture 13 - Bloch Sphere and Density Matrix
- Lecture 14 - Measurement Postulates - I
- Lecture 15 - Measurement Postulates - II
- Lecture 16 - Simple Algorithms-Deutsch Algorithm
- Lecture 17 - Deutsch-Josza and Bernstein - Vazirani Algorithms
- Lecture 18 - Simon Problem
- Lecture 19 - Grover's Search Algorithm - I
- Lecture 20 - Grover's Search Algorithm - II
- Lecture 21 - Grover's Search Algorithm - III
- Lecture 22 - Grover's Search Algorithm - IV
- Lecture 23 - Quantum Fourier Transform
- Lecture 24 - Period Finding and QFT
- Lecture 25 - Implementing QFT
- Lecture 26 - Implementing QFT-3 qubits (and more)
- Lecture 27 - Shor's Factorization Algorithm
- Lecture 28 - Shor's Factorization Algorithm-Implementation
- Lecture 29 - Shor's Algorithm-Continued Fraction
- Lecture 30 - Quantum Error Correction - I
- Lecture 31 - Quantum Error Correction - II Three Qubit Code

[Lecture 32 - Quantum Error Correction - III Shor's 9 Qubit Code - I](#)

[Lecture 33 - Quantum Error Correction - IV Shor's 9 Qubit Code - II](#)

[Lecture 34 - Classical Information Theory](#)

[Lecture 35 - Shannon Entropy](#)

[Lecture 36 - Shannon's Noiseless Coding Theorem](#)

[Lecture 37 - Von Neumann Entropy](#)

[Lecture 38 - EPR and Bell's Inequalities - I](#)

[Lecture 39 - EPR and Bell's Inequalities - II](#)

[Lecture 40 - EPR and Bell's Inequalities - III](#)

[Lecture 41 - Cryptography-RSA Algorithm - I](#)

[Lecture 42 - Cryptography-RSA Algorithm - II](#)

[Lecture 43 - Quantum Cryptography - I](#)

[Lecture 44 - Quantum Cryptography - II](#)

[Lecture 45 - Experimental Aspects of Quantum Computing - I](#)

[Lecture 46 - Experimental Aspects of Quantum Computing - II](#)

Lecture 1 - Introduction

Lecture 2 - Algebraic Preliminaries

Lecture 3 - Basic Group Concepts and Low Order Groups - I

Lecture 4 - Basic Group Concepts and Low Order Groups - II

Lecture 5 - Lagrange's Theorem and Cayley's Theorem - I

Lecture 6 - Lagrange's Theorem and Cayley's Theorem - II

Lecture 7 - Factor Group Conjugacy Classes - I

Lecture 8 - Factor Group Conjugacy Classes - II

Lecture 9 - Cycle Structures and Molecular Notation - I

Lecture 10 - Cycle Structures and Molecular Notation - II

Lecture 11 - Cycle Structures and Classification - I

Lecture 12 - Cycle Structures and Classification - II

Lecture 13 - Point Group Notation and Factor Group - I

Lecture 14 - Point Group Notation and Factor Group - II

Lecture 15 - Representation Theory - I

Lecture 16 - Representation Theory - II

Lecture 17 - Representation Theory - III

Lecture 18 - Representation Theory - IV

Lecture 19 - Schur's Lemma and Orthogonality Theorem - I

Lecture 20 - Schur's Lemma and Orthogonality Theorem - II

Lecture 21 - Orthogonality For Characters - I

Lecture 22 - Orthogonality For Characters - II

Lecture 23 - Character Tables and Molecular Applications - I

Lecture 24 - Character Tables and Molecular Applications - II

Lecture 25 - Preliminaries About The Continuum - I

Lecture 26 - Preliminaries About The Continuum - II

Lecture 27 - Classical Groups - I

Lecture 28 - Classical Groups - II

Lecture 29 - Classical Groups-Topology - I

Lecture 30 - Classical Groups-Topology - II

Lecture 31 - SO(3) And Matrix Exponent - I

- Lecture 32 - $SO(3)$ And Matrix Exponent - II
- Lecture 33 - Generators, Discussion Of Lie's Theorems - I
- Lecture 34 - Generators, Discussion Of Lie's Theorems - II
- Lecture 35 - Group Algebras; $SO(3)$ - $SU(2)$ Correspondence - I
- Lecture 36 - Group Algebras; $SO(3)$ - $SU(2)$ Correspondence - II
- Lecture 37 - $SO(3)$, $SU(2)$ Representations - I
- Lecture 38 - $SO(3)$, $SU(2)$ Representations - II
- Lecture 39 - Representation On Function Spaces - I
- Lecture 40 - Representation On Function Spaces - II
- Lecture 41 - Lorentz Boosts, $SO(3,1)$ Algebra - I
- Lecture 42 - Lorentz Boosts, $SO(3,1)$ Algebra - II
- Lecture 43 - Representation Of Lorentz Group And Clifford Algebra - I
- Lecture 44 - Representation Of Lorentz Group And Clifford Algebra - II
- Lecture 45 - $SU(3)$ And Lie's Classification - I
- Lecture 46 - $SU(3)$ And Lie's Classification - II
- Lecture 47 - Fundamental Symmetries Of Physics - I
- Lecture 48 - Fundamental Symmetries Of Physics - II

Lecture 1 - Introduction to Quantum Mechanics - I

Lecture 2 - Introduction to Quantum Mechanics - II

Lecture 3 - Review of Particle in Box, Potential Well, Barrier, Harmonic Oscillator - I

Lecture 4 - Review of Particle in Box, Potential Well, Barrier, Harmonic Oscillator - II

Lecture 5 - Tutorial 1 - Part I

Lecture 6 - Tutorial 1 - Part II

Lecture 7 - Bound States - I

Lecture 8 - Bound States - II

Lecture 9 - Conditions and Solutions for one Dimensional Bound States - I

Lecture 10 - Conditions and Solutions for one Dimensional Bound States - II

Lecture 11 - Tutorial 2

Lecture 12 - Linear Vector Space (LVS) - I

Lecture 13 - Linear Vector Space (LVS) - II

Lecture 14 - Linear Vector Space (LVS) - III

Lecture 15 - Basis for Operators and States in LVS - I

Lecture 16 - Basis for Operators and States in LVS - II

Lecture 17 - Tutorial 3 - Part I

Lecture 18 - Tutorial 3 - Part II

Lecture 19 - Function Spaces - I

Lecture 20 - Function Spaces - II

Lecture 21 - Postulates of Quantum Mechanics - I

Lecture 22 - Postulates of Quantum Mechanics - II

Lecture 23 - Tutorial 4 - Part I

Lecture 24 - Tutorial 4 - Part II

Lecture 25 - Classical vs Quantum Mechanics - I

Lecture 26 - Classical vs Quantum Mechanics - II

Lecture 27 - Compatible vs Incompatible Observable - I

Lecture 28 - Compatible vs Incompatible Observable - II

Lecture 29 - Tutorial 5 - Part I

Lecture 30 - Tutorial 5 - Part II

Lecture 31 - Tutorial 5 - Part III

[Lecture 32 - Schrodinger and Heisenberg Pictures - I](#)

[Lecture 33 - Schrodinger and Heisenberg Pictures - II](#)

[Lecture 34 - Solutions to other Coupled Potential Energies - I](#)

[Lecture 35 - Solutions to other Coupled Potential Energies - II](#)

[Lecture 36 - Tutorial 6 - Part I](#)

[Lecture 37 - Tutorial 6 - Part II](#)

[Lecture 38 - Hydrogen Atom and Wave Functions, Angular Momentum Operators, Identical Particles - I](#)

[Lecture 39 - Hydrogen Atom and Wave Functions, Angular Momentum Operators, Identical Particles - II](#)

[Lecture 40 - Identical Particles and Quantum Computer - I](#)

[Lecture 41 - Identical Particles and Quantum Computer - II](#)

[Lecture 42 - Tutorial 7 - Part I](#)

[Lecture 43 - Tutorial 7 - Part II](#)

[Lecture 44 - Harmonic Oscillator - I](#)

[Lecture 45 - Harmonic Oscillator - II](#)

[Lecture 46 - Ladder Operators - I](#)

[Lecture 47 - Ladder Operators - II](#)

[Lecture 48 - Tutorial 8 - Part I](#)

[Lecture 49 - Tutorial 8 - Part II](#)

[Lecture 50 - Stern-Gerlach Experiment - I](#)

[Lecture 51 - Stern-Gerlach Experiment - II](#)

[Lecture 52 - Oscillator Algebra](#)

[Lecture 53 - Tutorial 9 - Part I](#)

[Lecture 54 - Tutorial 9 - Part II](#)

[Lecture 55 - Angular Momentum - I](#)

[Lecture 56 - Angular Momentum - II](#)

[Lecture 57 - Rotations Groups - I](#)

[Lecture 58 - Rotations Groups - II](#)

[Lecture 59 - Tutorial 10 - Part I](#)

[Lecture 60 - Tutorial 10 - Part II](#)

[Lecture 61 - Addition of Angular Momentum - I](#)

[Lecture 62 - Addition of Angular Momentum - II](#)

[Lecture 63 - Clebsch-Gordan Coefficients - I](#)

[Lecture 64 - Clebsch-Gordan Coefficients - II](#)

[Lecture 65 - Tutorial 11 - Part I](#)

[Lecture 66 - Tutorial 11 - Part II](#)

[Lecture 67 - Clebsch-Gordan Coefficients - III](#)

[Lecture 68 - Tensor Operators and Wigner-Eckart Theorem - I](#)

[Lecture 69 - Tensor Operators and Wigner-Eckart Theorem - II](#)

[Lecture 70 - Tensor Operators and Wigner-Eckart Theorem - III](#)

[Lecture 71 - Tutorial 12](#)

- Lecture 1 - Quantum Theory Fundamental Quantisation - I
- Lecture 2 - Quantum Theory Fundamental Quantisation - II
- Lecture 3 - Path Integral Formulation - I
- Lecture 4 - Path Integral Formulation - II
- Lecture 5 - Path Integral Formulation - III
- Lecture 6 - Path Integral Formulation - IV
- Lecture 7 - Correlation Functions - I
- Lecture 8 - Correlation Functions - II
- Lecture 9 - Generating Functional, Forced Harmonic Oscillator - I
- Lecture 10 - Generating Functional, Forced Harmonic Oscillator - II
- Lecture 11 - Generating Function in Field Theory - I
- Lecture 12 - Generating Function in Field Theory - II
- Lecture 13 - Effective Potential - I
- Lecture 14 - Effective Potential - II
- Lecture 15 - Effective Potential - III
- Lecture 16 - Effective Potential - IV
- Lecture 17 - Asymptotic Theory - I
- Lecture 18 - Asymptotic Theory - II
- Lecture 19 - Asymptotic Condition Kallen-Lehmann representation - I
- Lecture 20 - Asymptotic Condition Kallen-Lehmann representation - II
- Lecture 21 - Gauge Invariance - Minimal Coupling
- Lecture 22 - Gauge Invariance - Geometric Picture
- Lecture 23 - Gauge Invariance - Abelian Case
- Lecture 24 - Gauge Invariance - Non-abelian case
- Lecture 25 - Yang Mills Theory - Coupling to Matter
- Lecture 26 - Yang Mills Theory - Physical Content
- Lecture 27 - Yang Mills Theory Constraint Dynamics - I
- Lecture 28 - Yang Mills Theory Constraint Dynamics - II
- Lecture 29 - Gauge Fixing and Faddeev Popov Ghosts - I
- Lecture 30 - Gauge Fixing and Faddeev Popov Ghosts - II
- Lecture 31 - Topological Vacuum of Yang Mills Theories - I

Lecture 32 - Topological Vacuum of Yang Mills Theories - II

Lecture 1 - Introduction

Lecture 2 - DNA packing and structure

Lecture 3 - Shape and function

Lecture 4 - Numbers and sizes

Lecture 5 - Spatial scales and System variation

Lecture 6 - Timescales in Biology

Lecture 7 - Random walks and Passive diffusion

Lecture 8 - Random walks to model Biology

Lecture 9 - Derivation of FRAP equations

Lecture 10 - Drift-diffusion equations

Lecture 11 - Solutions of the drift-diffusion equations

Lecture 12 - The cell signaling problem

Lecture 13 - Cell Signalling and Capture Probability of absorbing sphere

Lecture 14 - Capture probability of reflecting sphere

Lecture 15 - Mean capture time

Lecture 16 - Introduction to fluids, viscosity and reynolds number

Lecture 17 - Introduction to the navier stokes equation

Lecture 18 - Understanding reynolds number

Lecture 19 - Life at low reynolds number

Lecture 20 - Various phenomena at low reynolds number

Lecture 21 - Bacterial flagellar motion

Lecture 22 - Rotating flagellum

Lecture 23 - Energy and equilibrium

Lecture 24 - Binding problems

Lecture 25 - Transcription and translation

Lecture 26 - Internal states of macromolecules

Lecture 27 - Protein modification problem

Lecture 28 - Haemoglobin-Oxygen binding problem

Lecture 29 - Freely jointed polymer model

Lecture 30 - Entropic springs and persistence length

Lecture 31 - Freely rotating chain model and radius of gyration

- Lecture 32 - The hierarchical chromatin packing model
- Lecture 33 - FISH and DNA looping
- Lecture 34 - Nucleosomes as barriers, Hi-C, and contact probabilities
- Lecture 35 - Deriving the full force extension curve
- Lecture 36 - Random walk models for proteins
- Lecture 37 - Hydrophobic polar protein model
- Lecture 38 - Diffusion in crowded environments
- Lecture 39 - Depletion interactions
- Lecture 40 - Examples and implications of depletion interactions
- Lecture 41 - Introduction to Biological dynamics
- Lecture 42 - Introduction to rate equations
- Lecture 43 - Separation of timescales in enzyme kinetics
- Lecture 44 - Structure and treadmilling of actins and microtubules
- Lecture 45 - Average length of polymers in equilibrium
- Lecture 46 - Growth rate of polymers
- Lecture 47 - Dynamic treadmilling in microtubules
- Lecture 48 - Introduction to molecular motors
- Lecture 49 - Force generation by molecular motors
- Lecture 50 - Models of motor motion
- Lecture 51 - molecular motors
- Lecture 52 - Free energies of motor for stepping
- Lecture 53 - Two state models
- Lecture 54 - cooperative transport of cargo
- Lecture 55 - Cytoskeleton as a motor
- Lecture 56 - translocation ratchet
- Lecture 57 - Spatial pattern in biology
- Lecture 58 - Some common spatial patterns in biology
- Lecture 59 - reaction diffusion and spatial pattern
- Lecture 60 - Pattern formation in reaction diffusion system with stability
- Lecture 61 - Condition for destabilization in pattern formation
- Lecture 62 - Schnakenberg kinetics

Lecture 1 - Introduction - I

Lecture 2 - Introduction - II

Lecture 3 - Normal subgroup, Coset, Conjugate group

Lecture 4 - Factor group, Homomorphism, Isomorphism

Lecture 5 - Factor group, Homomorphism, Isomorphism

Lecture 6 - Conjugacy Classes

Lecture 7 - Permutation Groups

Lecture 8 - Cycle Structure

Lecture 9 - Cycle Structure (Continued...)

Lecture 10 - Young Diagram and Molecular Symmetry

Lecture 11 - Point Groups

Lecture 12 - Symmetries of Molecules, Schoenflies Notation

Lecture 13 - Symmetries of Molecules, Stereographic Projection

Lecture 14 - Examples of Molecular Symmetries and Proof of Cayley Theorem

Lecture 15 - Matrix Representation of Groups - I

Lecture 16 - Matrix Representation of Groups - II

Lecture 17 - Reducible and Irreducible Representation - I

Lecture 18 - Reducible and Irreducible Representation - II

Lecture 19 - Great Orthogonality Theorem and Character Table - I

Lecture 20 - Great Orthogonality Theorem and Character Table - II

Lecture 21 - Mulliken Notation, Character Table and Basis

Lecture 22 - Tensor Product of Representation

Lecture 23 - Tensor Product and Projection Operator - I

Lecture 24 - Tensor Product and Projection Operator - II

Lecture 25 - Tensor Product and Projection Operator with an example

Lecture 26 - Binary Basis and Observables

Lecture 27 - Selection Rules

Lecture 28 - Selection Rules and Molecular Vibrations

Lecture 29 - Molecular vibration normal modes: Classical Mechanics approach

Lecture 30 - Molecular vibration normal modes: Group Theory approach

Lecture 31 - Molecular vibration modes using projection operator

- Lecture 32 - Vibrational representation of character
- Lecture 33 - Infrared Spectra and Raman Spectra
- Lecture 34 - Introduction to continuous group
- Lecture 35 - Generators of translational and rotational transformation
- Lecture 36 - Generators of Lorentz transformation
- Lecture 37 - Introduction to $O(3)$ and $SO(3)$ group
- Lecture 38 - $SO(n)$ and Lorentz group
- Lecture 39 - Generalised orthogonal group and Lie algebra
- Lecture 40 - Subalgebra of Lie algebra
- Lecture 41 - $gl(2,C)$ and $sl(2,C)$ group
- Lecture 42 - $U(n)$ and $SU(n)$ group
- Lecture 43 - Symplectic group
- Lecture 44 - $SU(2)$ and $SU(3)$ groups
- Lecture 45 - Rank, weight and weight vector
- Lecture 46 - Weight vector, root vector, comparison between $SU(2)$ and $SU(3)$ algebra
- Lecture 47 - Root diagram, simple roots, adjoint representation
- Lecture 48 - $SU(2)$ sub-algebra, Dynkin diagrams
- Lecture 49 - Fundamental weights, Young diagrams, dimension of irreducible representation
- Lecture 50 - Young diagrams and tensor products
- Lecture 51 - Tensor product, Wigner - Eckart theorem
- Lecture 52 - Tensor product of irreducible representation 1: Composite objects from fundamental particles
- Lecture 53 - Tensor product of irreducible representation 2: Decimet and octet diagrams in the Quark Model
- Lecture 54 - Clebsch - Gordan coefficients
- Lecture 55 - 1) Quadrupole moment tensor (Wigner-Eckart theorem) 2) Decimet Baryon wavefunction
- Lecture 56 - Higher dimensional multiplets in the quark model
- Lecture 57 - Symmetry breaking in continuous groups
- Lecture 58 - Dynamical symmetry in hydrogen atom: $SO(4)$ algebra
- Lecture 59 - Hydrogen atom energy spectrum and degeneracy using Runge-Lenz vector

Lecture 1 - Neutrons as Probe of Condensed Matter

Lecture 2 - Sources for thermal neutrons used in neutron scattering

Lecture 3

Lecture 4 - Calculating Neutron Scattering cross-section

Lecture 5

Lecture 6 - Scattering theory and introducing dynamics in the formalism

Lecture 7 - Scattering theory and introducing dynamics in the formalism

Lecture 8 - Scattering theory and introducing dynamics in the formalism

Lecture 9 - Scattering law's correlation with double-Fourier transform of real space correlation function

Lecture 10 - Scattering law's correlation with double-Fourier transform of real space correlation function

Lecture 11 - Correlation function to resolution and accessible($Q, \tilde{\omega}$). Introducing experimental facilities

Lecture 12 - Correlation function to resolution and accessible($Q, \tilde{\omega}$). Introducing experimental facilities

Lecture 13 - Correlation function to resolution and accessible($Q, \tilde{\omega}$). Introducing experimental facilities

Lecture 14 - Correlation function to resolution and accessible($Q, \tilde{\omega}$). Introducing experimental facilities

Lecture 15 - Introducing resolution and components of neutron scattering facilities.

Lecture 16 - Introducing resolution and components of neutron scattering facilities.

Lecture 17 - Continue with neutron scattering set up and its components like collimators, filters, detectors etc

Lecture 18 - Continue with neutron scattering set up and its components like collimators, filters, detectors etc

Lecture 19 - Describe the operation of various kinds of neutron detectors

Lecture 20 - Describe the operation of various kinds of neutron detectors

Lecture 21 - Introducing neutron choppers, velocity selectors and polarizers, some important components of beam tailoring devices

Lecture 22 - Introducing neutron choppers, velocity selectors and polarizers, some important components of beam tailoring devices

Lecture 23 - Neutron polarizers and spin-flippers

Lecture 24 - Neutron polarizers and spin-flippers

Lecture 25 - Diffraction at various length scales at a reactor and at a spallation neutron source

Lecture 26 - Diffraction at various length scales at a reactor and at a spallation neutron source

Lecture 27 - Application of neutron crystallography

Lecture 28 - Application of neutron crystallography

Lecture 29 - Magnetism in solids

Lecture 30 - Magnetism in solids

Lecture 31 - Magnetic interaction in solids and magnetic neutron diffraction

Lecture 32 - Magnetic interaction in solids and magnetic neutron diffraction

Lecture 33 - Magnetic interaction in solids and magnetic neutron diffraction

Lecture 34 - Magnetic neutron diffraction

Lecture 35 - Magnetic neutron diffraction

Lecture 36 - Neutron diffraction from liquid and amorphous systems

Lecture 37 - Neutron diffraction from liquid and amorphous systems

Lecture 38 - Small Angle Neutron Scattering (SANS) for mesoscopic structure

Lecture 39 - Small Angle Neutron Scattering (SANS) for mesoscopic structure

Lecture 40 - Small Angle Neutron Scattering (SANS) for mesoscopic structure

Lecture 41 - Small Angle Neutron Scattering (SANS) for mesoscopic structure

Lecture 42 - SANS for soft condensed matter

Lecture 43 - SANS for soft condensed matter

Lecture 44 - SANS for polymers, biological systems, nanoparticle aggregates, rocks, Superconducting vortex lattice

Lecture 45 - SANS for polymers, biological systems, nanoparticle aggregates, rocks, Superconducting vortex lattice

Lecture 46 - Neutron reflectometry for thin films

Lecture 47 - Neutron reflectometry for thin films

Lecture 48 - Neutron reflectometry for thin films

Lecture 49 - Details formalism to evaluate specular neutron reflectivity and comparison with x-ray reflectometry

Lecture 50 - Details formalism to evaluate specular neutron reflectivity and comparison with x-ray reflectometry

Lecture 51 - Neutron reflectometry data analysis and reflectometers at various sources

Lecture 52 - Neutron reflectometry data analysis and reflectometers at various sources

Lecture 53 - Neutron reflectometry data analysis and reflectometers at various sources

Lecture 54 - Examples of PNR with and without spin analysis and introduction to off-specular reflectometry

Lecture 55 - Examples of PNR with and without spin analysis and introduction to off-specular reflectometry

Lecture 56 - Examples of PNR with and without spin analysis and introduction to off-specular reflectometry

Lecture 57 - Off-specular neutron reflectometry and introduction to inelastic neutron scattering

Lecture 58 - Off-specular neutron reflectometry and introduction to inelastic neutron scattering

Lecture 59 - Off-specular neutron reflectometry and introduction to inelastic neutron scattering

Lecture 60 - Phonon measurements with neutrons

Lecture 61 - Phonon measurements with neutrons

Lecture 62 - Phonon measurements; single crystals

Lecture 63

Lecture 64 - Phonon: Density of States measurements

[Lecture 65 - Stochastic dynamics with neutrons](#)

[Lecture 66 - Stochastic motion and various types of diffusion](#)

[Lecture 67 - Stochastic motion and various types of diffusion](#)

[Lecture 68 - Spin echo spectrometer, Summary of the course](#)

[Lecture 69 - Spin echo spectrometer, Summary of the course](#)

Lecture 1 - Why accelerators

Lecture 2 - Accelerator as a microscope

Lecture 3 - Charging and Discharging of capacitors

Lecture 4 - Charging and Discharging of capacitors (Continued...)

Lecture 5 - Introduction to DC accelerators

Lecture 6 - Cockcroft Walton Accelerator (1929)

Lecture 7 - Van-de-Graaff accelerator and Tandem and Pelletron accelerators

Lecture 8 - Van-de-Graaff accelerator and Tandem and Pelletron accelerators

Lecture 9 - Voltage measurement and stabilisation

Lecture 10 - Voltage measurement and stabilisation

Lecture 11 - Beam energy calibration/measurement

Lecture 12 - Beam energy calibration/measurement

Lecture 13 - Beam focussing using electrostatic and magnetic lenses and beam optics

Lecture 14 - Beam focussing using electrostatic and magnetic lenses and beam optics

Lecture 15 - Beam focussing using electrostatic and magnetic lenses and beam optics

Lecture 16 - Ion Sources

Lecture 17 - Ion Sources

Lecture 18 - Introduction and Basic concepts of linear accelerators

Lecture 19 - Introduction and Basic concepts of linear accelerators

Lecture 20 - RF Acceleration - 1

Lecture 21 - RF Acceleration - 1

Lecture 22 - RF Acceleration - 2

Lecture 23 - RF Acceleration - 2

Lecture 24 - RF Acceleration - 3 - Waveguides and cavities

Lecture 25 - RF Acceleration - 3 - Waveguides and cavities

Lecture 26 - Accelerating structures - Pillbox cavity and DTL

Lecture 27 - Accelerating structures - Pillbox cavity and DTL

Lecture 28 - Accelerating structures - Travelling wave linacs and periodic accelerating structures

Lecture 29 - Accelerating structures - Travelling wave linacs and periodic accelerating structures

Lecture 30 - Superconducting cavities

Lecture 31 - Superconducting cavities

Lecture 32 - Transverse Dynamics - 1
Lecture 33 - Transverse Dynamics - 1
Lecture 34 - Transverse Dynamics - 2
Lecture 35 - Transverse Dynamics - 2
Lecture 36 - Transverse Dynamics - 3
Lecture 37 - Transverse Dynamics - 3
Lecture 38 - Longitudinal Dynamics - 1
Lecture 39 - Longitudinal Dynamics - 1
Lecture 40 - Longitudinal Dynamics - 2
Lecture 41 - Longitudinal Dynamics - 2
Lecture 42 - Radio Frequency Quadrupole
Lecture 43 - Radio Frequency Quadrupole
Lecture 44 - Cyclic accelerators: Some basic principles
Lecture 45 - Cyclic accelerators: Some basic principles
Lecture 46 - About the cyclotron
Lecture 47 - About the cyclotron
Lecture 48 - Microtron
Lecture 49 - Equation of motion, Focusing
Lecture 50 - Equation of motion, Focusing
Lecture 51 - Strong focusing, Edge focusing, AG principle
Lecture 52 - Strong focusing, Edge focusing, AG principle
Lecture 53 - Matrix methods
Lecture 54 - Matrix methods
Lecture 55 - Hill's equation and parameterization - 1
Lecture 56 - Hill's equation and parameterization - 1
Lecture 57 - Hill's equation and parameterization - 2
Lecture 58 - Hill's equation and parameterization - 2
Lecture 59 - Hill's equation and parameterization - 3
Lecture 60 - Hill's equation and parameterization - 3
Lecture 61
Lecture 62
Lecture 63
Lecture 64

[Lecture 65](#)

[Lecture 66](#)

[Lecture 67 - Proton synchrotron for spallation source](#)

[Lecture 68 - Proton synchrotron for spallation source](#)

[Lecture 69 - Colliders](#)

[Lecture 70 - Colliders](#)

[Lecture 71 - Laser Plasma accelerators and Accelerator Driven Systems \(ADS\)](#)

[Lecture 72 - Laser Plasma accelerators and Accelerator Driven Systems \(ADS\)](#)

Lecture 1 - p-n diode

Lecture 2 - p-n Junction/Diode (Continued...)

Lecture 3 - p-n diode (Continued...)

Lecture 4 - Diode Application

Lecture 5 - Transistors

Lecture 6 - Reverse - bias (Continued...)

Lecture 7 - Transistors (Continued...)

Lecture 8 - Transistors (Continued...)

Lecture 9 - Biasing a transistor unit 2 (Continued...)

Lecture 10 - Biasing of transistor

Lecture 11 - H and R Parameters and their use in small amplifiers

Lecture 12 - Small signal amplifiers analysis using H - Parameters

Lecture 13 - Small signal amplifiers analysis using R - Parameters

Lecture 14 - R - analysis (Continued...)

Lecture 15 - Common Collector(CC) amplifier (Continued...)

Lecture 16 - Feedback in amplifiers, Feedback Configurations and multi stage amplifiers

Lecture 17 - Reduction in non-linear distortion

Lecture 18 - Input/Output impedances in negative feedback amplifiers (Continued...)

Lecture 19 - RC Coupled Amplifiers

Lecture 20 - RC Coupled Amplifiers (Continued...)

Lecture 21 - RC Coupled Amplifiers (Continued...)

Lecture 22 - FETs ans MOSFET

Lecture 23 - FETs ans MOSFET (Continued...)

Lecture 24 - Depletion - MOSFET

Lecture 25 - Drain and transfer characteristic of E - MOSFET

Lecture 26 - Self Bias (Continued...) Design Procedure

Lecture 27 - FET/MOSFET Amplifiers and their Analysis

Lecture 28 - CMOS Inverter

Lecture 29 - CMOS Inverter (Continued...)

Lecture 30 - Power Amplifier

Lecture 31 - Power Amplifier (Continued...)

[Lecture 32 - Power Amplifier \(Continued...\)](#)

[Lecture 33 - Power Amplifier \(Continued...\)](#)

[Lecture 34 - Differential and Operational Amplifier](#)

[Lecture 35 - Differential and Operational Amplifier \(Continued...\) dc and ac analysis](#)

[Lecture 36 - Differential and Operational Amplifier dc and ac analysis \(Continued...\)](#)

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[Lecture 38 - Operational amplifiers in open loop \(Continued...\)](#)

[Lecture 39 - Summing Amplifiers](#)

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Lecture 1 - Introduction to Plasmas

Lecture 2 - Plasma Response to fields: Fluid Equations

Lecture 3 - DC Conductivity and Negative Differential Conductivity

Lecture 4 - RF Conductivity of Plasma

Lecture 5 - RF Conductivity of Plasma (Continued...)

Lecture 6 - Hall Effect, Cowling Effect and Cyclotron Resonance Heating

Lecture 7 - Electromagnetic Wave Propagation in Plasma

Lecture 8 - Electromagnetic Wave Propagation in Plasma (Continued...)

Lecture 9 - Electromagnetic Wave Propagation Inhomogeneous Plasma

Lecture 10 - Electrostatic Waves in Plasmas

Lecture 11 - Energy Flow with an Electrostatic Wave

Lecture 12 - Two Stream Instability

Lecture 13 - Relativistic electron Beam- Plasma Interaction

Lecture 14 - Cerenkov Free Electron Laser

Lecture 15 - Free Electron Laser

Lecture 16 - Free Electron Laser: Energy gain

Lecture 17 - Free Electron Laser: Wiggler Tapering and Compton Regime Operation

Lecture 18 - Weibel Instability

Lecture 19 - Rayleigh Taylor Instability

Lecture 20 - Single Particle Motion in Static Magnetic and Electric Fields

Lecture 21 - Plasma Physics Grad B and Curvature Drifts

Lecture 22 - Adiabatic Invariance of Magnetic Moment and Mirror confinement

Lecture 23 - Mirror machine

Lecture 24 - Thermonuclear fusion

Lecture 25 - Tokamak

Lecture 26 - Tokamak operation

Lecture 27 - Auxiliary heating and current drive in tokamak

Lecture 28 - Electromagnetic waves propagation in magnetised plasma

Lecture 29 - Longitudinal electromagnetic wave propagation cutoffs, resonances and Faraday rotation

Lecture 30 - Electromagnetic propagation at oblique angles to magnetic field in a plasma

Lecture 31 - Low frequency EM waves magnetized plasma

[Lecture 32 - Electrostatic waves in magnetized plasma](#)

[Lecture 33 - Ion acoustic, ion cyclotron and magneto sonic waves in magnetized plasma](#)

[Lecture 34 - Vlasov theory of plasma waves](#)

[Lecture 35 - Landau damping and growth of waves](#)

[Lecture 36 - Landau damping and growth of waves \(Continued...\)](#)

[Lecture 37 - Anomalous resistivity in a plasma](#)

[Lecture 38 - Diffusion in plasma](#)

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[Lecture 40 - Surface plasma wave](#)

[Lecture 41 - Laser interaction with plasmas embedded with clusters](#)

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Lecture 1 - Introduction

Lecture 2 - Anisotropic Media

Lecture 3 - Anisotropic Media (Continued...)

Lecture 4 - Anisotropic Media (Continued...)

Lecture 5 - Nonlinear optical effects and nonlinear polarization

Lecture 6 - Non - Linear Optics (Continued...)

Lecture 7 - Non - Linear Optics (Continued...)

Lecture 8 - Non - Linear Optics (Continued...)

Lecture 9 - Non - Linear Optics (Continued...)

Lecture 10 - Non - Linear Optics - Quasi Phase Matching

Lecture 11 - Non - Linear Optics

Lecture 12 - Non Linear Optics (Continued...)

Lecture 13 - Non Linear Optics (Continued...)

Lecture 14 - Non Linear Optics (Continued...)

Lecture 15 - Non Linear Optics (Continued...)

Lecture 16 - Non Linear Optics (Continued...)

Lecture 17 - Non Linear Optics (Continued...)

Lecture 18 - Non Linear Optics (Continued...)

Lecture 19 - Non Linear Optics (Continued...)

Lecture 20 - Third Order Non - Linear Effects

Lecture 21 - Third Order Non - Linear Effects (Continued...)

Lecture 22 - Third Order Non - Linear Effects (Continued...)

Lecture 23 - Third Order Non - Linear Effects (Continued...)

Lecture 24 - Review of Quantum Mechanics

Lecture 25 - Review of Quantum Mechanics (Continued...)

Lecture 26 - Review of Quantum Mechanics (Continued...)

Lecture 27 - Quantization of EM Field

Lecture 28 - Quantization of EM Field (Continued...)

Lecture 29 - Quantization of EM Field (Continued...)

Lecture 30 - Quantum States of EM Field

Lecture 31 - Quantum States of EM Field (Continued...)

[Lecture 32 - Quantization of EM Field \(Continued...\)](#)

[Lecture 33 - Quantization of EM Field \(Continued...\)](#)

[Lecture 34 - Quantization of EM Field \(Continued...\)](#)

[Lecture 35 - Quantization of EM Field \(Continued...\)](#)

[Lecture 36 - Quantization of EM Field \(Continued...\)](#)

[Lecture 37 - Beam Splitter](#)

[Lecture 38 - Beam Splitter \(Continued...\)](#)

[Lecture 39 - Beam Splitter and Balanced Homodyning](#)

[Lecture 40 - Balanced Homodyning](#)

[Lecture 41 - Quantum Picture of Parametric Down Conversion](#)

[Lecture 42 - Questions](#)

NPTEL : Quantum Mechanics and Applications (Physics)

Co-ordinators : Prof. Ajoy Ghatak

Lecture 1 - Basic Quantum Mechanics I: Wave Particle Duality

Lecture 2 - Basic Quantum Mechanics II: The Schrodinger Equation and The Dirac Delta Function

Lecture 3 - Dirac Delta Function & Fourier Transforms

Lecture 4 - The Free Particle

Lecture 5 - Physical Interpretation of The Wave Function

Lecture 6 - Expectation Values & The Uncertainty Principle

Lecture 7 - The Free Particle (Continued...)

Lecture 8 - Interference Experiment & The Particle in a Box Problem

Lecture 9 - On Eigen Values and Eigen Functions of the 1 Dimensional Schrodinger Equation

Lecture 10 - Linear Harmonic Oscillator

Lecture 11 - Linear Harmonic Oscillator (Continued...1)

Lecture 12 - Linear Harmonic Oscillator (Continued...2)

Lecture 13 - Linear Harmonic Oscillator (Continued...3)

Lecture 14 - Tunneling through a Barrier

Lecture 15 - The 1-Dimensional Potential Wall & Particle in a Box

Lecture 16 - Particle in a Box and Density of States

Lecture 17 - The Angular Momentum Problem

Lecture 18 - The Angular Momentum Problem (Continued...)

Lecture 19 - The Hydrogen Atom Problem

Lecture 20 - The Two Body Problem

Lecture 21 - The Two Body Problem: The Hydrogen atom, The Deuteron and The Diatomic Molecule

Lecture 22 - Two Body Problem: The Diatomic molecule (Continued...) and the 3 Dimensional Oscillator

Lecture 23 - 3d Oscillator & Dirac's Bra and Ket Algebra

Lecture 24 - Dirac's Bra and Ket Algebra

Lecture 25 - Dirac's Bra and Ket Algebra : The Linear Harmonic Oscillator

Lecture 26 - The Linear Harmonic Oscillator using Bra and Ket Algebra (Continued...)

Lecture 27 - The Linear Harmonic Oscillator: Coherent State and Relationship with the Classical Oscillator

Lecture 28 - Coherent State and Relationship with the Classical Oscillator

Lecture 29 - Angular Momentum Problem using Operator Algebra

Lecture 30 - Angular Momentum Problem (Continued...)

Lecture 31 - Pauli Spin Matrices and The Stern Gerlach Experiment

Lecture 32 - The Larmor Precession and NMR Spherical Harmonics using Operator Algebra

Lecture 33 - Addition of Angular Momentum: Clebsch Gordon Coefficient

Lecture 34 - Clebsch Gordon Coefficients

Lecture 35 - The JWKB Approximation

Lecture 36 - The JWKB Approximation: Use of Connection Formulae to solve Eigen value Problems.

Lecture 37 - The JWKB Approximation: Use of Connection Formulae to calculate Tunneling Probability.

Lecture 38 - The JWKB Approximation: Tunneling Probability Calculations and Applications.

Lecture 39 - The JWKB Approximation: Justification of the Connection Formulae

Lecture 40 - Time Independent Perturbation Theory

Lecture 41 - Time Independent Perturbation Theory (Continued...1)

Lecture 42 - Time Independent Perturbation Theory (Continued...2)

NPTEL : Semiconductor Optoelectronics (Physics)

Co-ordinators : Prof. M.R. Shenoy

Lecture 1 - Context and Scope of the Course

Lecture 2 - Energy Bands in Solids

Lecture 3 - E-K Diagram

Lecture 4 - The Density of States

Lecture 5 - The Density of States (Continued...)

Lecture 6 - The Density of states in a Quantum well Structure

Lecture 7 - Occupation Probability and Carrier Concentration

Lecture 8 - Carrier Concentration and Fermi Level

Lecture 9 - Quasi Fermi Levels

Lecture 10 - Semiconductor Materials

Lecture 11 - Semiconductor Hetrostructures-Lattice-Matched Layers

Lecture 12 - Strained -Layer Epitaxy and Quantum Well Structures

Lecture 13 - Bandgap Engineering

Lecture 14 - Hetrostructure p-n junctions

Lecture 15 - Schottky Junction and Ohmic Contacts

Lecture 16 - Fabrication of Heterostructure Devices

Lecture 17 - Interaction od Photons with Electrons and Holes in a Semiconductor

Lecture 18 - Optical Joint Density of States

Lecture 19 - Rates of Emission and Absorption

Lecture 20 - Amplication by Stimulated Emission

Lecture 21 - The Semiconductor (Laser) Amplifier

Lecture 22 - Absorption Spectrum of Semiconductor

Lecture 23 - Gain and Absorption Spectrum of Quantum Well Structures

Lecture 24 - Electro-absorption Modulator

Lecture 25 - Electro-absorption Modulator - II Device Configuration

Lecture 26 - Mid-Term Revision Question and Discussion

Lecture 27 - Part - III Semiconductor Light Sources

Lecture 28 - Light Emitting Diode-I Device Structure and Parameters

Lecture 29 - Light Emitting Diode-II Device Chraacteristics

Lecture 30 - Light Emitting Diode-III Output Characteristics

Lecture 31 - Light Emitting Diode-IV Modulation Bandwidth

[Lecture 32 - Light Emitting Diode-V materials and Applications](#)

[Lecture 33 - Laser Basics](#)

[Lecture 34 - Semiconductor Laser-I Device Structure](#)

[Lecture 35 - Semiconductor Laser-II Output Characteristics](#)

[Lecture 36 - Semiconductor Laser-III Single Frequency Lasers](#)

[Lecture 37 - Vertical Cavity Surface Emitting Laser \(VCSEL\)](#)

[Lecture 38 - Quantum Well Laser](#)

[Lecture 39 - Practical Laser Diodes and Handling](#)

[Lecture 40 - General Characteristics of Photodetectors](#)

[Lecture 41 - Responsivity and Impulse Response](#)

[Lecture 42 - Photoconductors](#)

[Lecture 43 - Semiconductor Photo-Diodes](#)

[Lecture 44 - Semiconductor Photo-Diodes-II : APD](#)

[Lecture 45 - Other Photodectors](#)

[Lecture 46 - Photonic Integrated Circuits](#)

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- Lecture 2 - Energy Bands in Solids
- Lecture 3 - E-k Diagram - The Band Structure
- Lecture 4 - The Density of States
- Lecture 5 - The Density of States $\tilde{I}(k)$, $\tilde{I}(E)$
- Lecture 6 - Density of States in a Quantum Well Structure
- Lecture 7 - Occupation Probability and Carrier Concentration
- Lecture 8 - Carrier Concentration and Fermi Level
- Lecture 9 - Quasi Fermi Levels
- Lecture 10 - Semiconductor Materials
- Lecture 11 - Semiconductor Heterostructures-Lattice-Matched Layers
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- Lecture 24 - Electro-absorption Modulator-I Principle of Operation
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- Lecture 26 - Injection Electroluminescence
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- Lecture 28 - Light emitting diode-II Device Characteristics
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- Lecture 30 - Light emitting diode-IV Modulation Bandwidth
- Lecture 31 - Light emitting diode-V Material and Applications

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[Lecture 42 - Semiconductor Photo-Diodes-I: PIN Diode](#)

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[Lecture 44 - Other Photodetectors](#)

[Lecture 45 - Photonic Integrated Circuits](#)

Lecture 1 - General Introduction, Scope and Contents

Lecture 2 - Interaction of Radiation with Matter

Lecture 3 - The Einstein Coefficients

Lecture 4 - Atomic Lineshape Function, $g(\hat{\nu})$

Lecture 5 - Amplification by Stimulated Emission

Lecture 6 - Line Broadening Mechanisms - 1

Lecture 7 - Line Broadening Mechanisms - 2

Lecture 8 - Laser Rate Equations: 2-Level System

Lecture 9 - Laser Rate Equations: 3-Level System

Lecture 10 - Laser Rate Equations: 4-Level System

Lecture 11 - Laser Amplifiers

Lecture 12 - Er-Doped Fiber Amplifier

Lecture 13 - Resonance Frequencies

Lecture 14 - Spectral Response of an Optical Resonator

Lecture 15 - Resonator Loss and Cavity Lifetime

Lecture 16 - Spherical Mirror Resonators

Lecture 17 - Resonator Stability Condition

Lecture 18 - Ray Paths in Spherical Mirror Resonators

Lecture 19 - Transverse Modes of a Spherical Mirror Resonator

Lecture 20 - Gaussian Mode of the Spherical Mirror Resonator

Lecture 21 - Longitudinal Modes of a Spherical Mirror Resonator

Lecture 22 - Laser Oscillations and The Threshold Condition

Lecture 23 - Spectral Hole Burning

Lecture 24 - Variation of Laser Power around Threshold

Lecture 25 - Optimum Output Coupling

Lecture 26 - Laser Output Characteristics

Lecture 27 - Laser Beam Properties

Lecture 28 - Ultimate Linewidth of a Laser

Lecture 29 - Pulsed Lasers

Lecture 30 - Q-Switching

Lecture 31 - Mode Locking

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[Lecture 36 - Lasers and Laser Amplifiers in Optical Fiber Communication](#)

[Lecture 37 - Lasers in Nonlinear Optics](#)

[Lecture 38 - Laser Safety](#)

Lecture 1 - Introduction

Lecture 2 - Nuclear Properties

Lecture 3 - Properties of Nuclear Force

Lecture 4 - Deuteron

Lecture 5 - Nucleons Scattering

Lecture 6 - Nuclear Models - I

Lecture 7 - Nuclear Models - II

Lecture 8 - Radioactive Decay - General Properties

Lecture 9 - Nuclear Alpha Decay

Lecture 10 - Nuclear Beta decay

Lecture 11 - Beta-decay details

Lecture 12 - Gamma decay

Lecture 13 - Nuclear Scattering - Preliminaries

Lecture 14 - Types of Reactions

Lecture 15 - Particle Accelerators - I

Lecture 16 - Particle Accelerators - II

Lecture 17 - Detectors

Lecture 18 - Elementary Particles - Introduction and Overview

Lecture 19 - Quark Model - I

Lecture 20 - Quark Model - II

Lecture 21 - Quark Model - III

Lecture 22 - Structure of the Hadron - Nucleus

Lecture 23 - Structure of the Hadron - Proton

Lecture 24 - Deep Inelastic Scattering

Lecture 25 - Relativistic Kinematics

Lecture 26 - Klein-Gordon Equation

Lecture 27 - Interaction of charged scalar with EM field

Lecture 28 - Relativistic Electrodynamics

Lecture 29 - Quantum Electrodynamics

Lecture 30 - Interaction between charged scalars

Lecture 31 - Dirac Equation - 1

[Lecture 32 - Dirac Equation - 2](#)

[Lecture 33 - Interacting charged fermions - 1](#)

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[Lecture 35 - Interacting charged fermions - 3](#)

[Lecture 36 - Scattering Cross Section Revisited - 1](#)

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[Lecture 38 - Weak Interactions - 1](#)

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[Lecture 40 - Lagrangian Framework](#)

[Lecture 41 - Gauge Symmetry - U\(1\)](#)

[Lecture 42 - Electroweak Theory - 1](#)

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[Lecture 44 - SSB and the Higgs Mechanism](#)

Lecture 1 - Propagators - I

Lecture 2 - Propagators - II

Lecture 3 - Second quantization - I

Lecture 4 - Second quantization - II

Lecture 5 - Second quantized Hamiltonian

Lecture 6 - Tight Binding Hamiltonian, Hubbard model

Lecture 7 - Magnetism

Lecture 8 - Singlet and Triplet State: Magnetic Hamiltonian

Lecture 9 - Antiferromagnetism in Hubbard model

Lecture 10 - Green's function and representations in quantum mechanics

Lecture 11 - S matrix and free electron Green's function

Lecture 12 - Wick's theorem and normal ordering

Lecture 13 - Green's function and Feynman diagrams

Lecture 14 - Feynman diagram

Lecture 15 - phonon Green' function and Hartree Fock approximation

Lecture 16 - Finite temperature Green's function and Matsubara frequencies

Lecture 17 - Dyson's equation and disorder in electronic systems

Lecture 18 - Introduction to electrodynamics, Meissner effect

Lecture 19 - London penetration depth, Type I and II superconductors

Lecture 20 - Cooper's problem, BCS gap equation

Lecture 21 - BCS theory, Transition temperature

Lecture 22 - Ginzburg Landau Theory, Coherence length and penetration depth

Lecture 23 - Quantum Hall Effect

Lecture 24 - Spin Hall effect, 2D topological insulator

Lecture 25 - Bose-Einstein condensation

Lecture 1 - Introduction, Postulates of Quantum Mechanics

Lecture 2 - Stern Gerlach Experiment, Spin Quantization, Young's Double Slit Experiment

Lecture 3 - The Mathematical Formalism of Quantum Mechanics, Uncertainty Principle

Lecture 4 - The Density Matrix Formalism, Expectation values of Operators

Lecture 5 - Quantum Harmonic Oscillator, Creation and annihilation Operators

Lecture 6 - Coherent States and their Properties

Lecture 7 - Applications of Coherent States, squeezed states

Lecture 8 - Symmetries and Conservation Principles in Quantum Mechanics

Lecture 9 - Rotation Operator and Invariance of Angular Momentum, Parity

Lecture 10 - Spherically Symmetric System and Applications to quantum dots

Lecture 11 - Spin Angular Momentum, Addition of Angular Momentum, Clebsch gordan coefficients

Lecture 12 - Magnetic Hamiltonian, Heisenberg Model

Lecture 13 - Nuclear Magnetic Resonance (NMR)

Lecture 14 - Applications of NMR, time evolution of Magnetic Moments

Lecture 15 - Introduction to Quantum Computing

Lecture 16 - Qubits,EPR Paradox

Lecture 17 - Quantum Entanglement (QE)

Lecture 18 - Teleportation, Quantum Teleportation for one spin

Lecture 19 - Entangled state for two spins

Lecture 20 - Quantum Gates, Walsh Hadamard Transformation, No cloning theorem

Lecture 21 - Perturbation Theory

Lecture 22 - Stark Effect: First order in ground state

Lecture 23 - Stark Effect: Second order in ground state

Lecture 24 - Variational method, Variation of constants, Upper bound on ground state energy

Lecture 25 - Application of Variational method,Hydrogen,Helium atom,Comparison with perturbation theory

Lecture 26 - WKB Approximation, Bohr Sommerfeld quantization condition

Lecture 27 - Summary of Approximation methods, Time dependent Perturbation Theory

Lecture 28 - Time dependent Perturbation Theory, Fermi's Golden rule, Einstein's A and B coefficients

Lecture 29 - Scattering Theory

Lecture 30 - Linear Response Theory: Derivation of Kubo formula

Lecture 31 - Quantum Dynamics: Two level system

[Lecture 32 - Examples](#)

[Lecture 33 - Interaction of Radiation with matter, Landau levels](#)

NPTEL : NOC:A Brief Course on Superconductivity (Physics)

Co-ordinators : Dr. Saurabh Basu

Lecture 1 - Historical introduction of superconductivity

Lecture 2 - Meissner effect, Electrodynamics of Superconductors, coherence length and penetration depth

Lecture 3 - Electron Pairing, Basics of BCS Theory

Lecture 4 - BCS ground state, variational calculation, expression for T_c

Lecture 5 - Order parameter, Free energy functional, Ginzburg-Landau (GL) Theory, GL equations

Lecture 6 - London Equations, Flux quantization

Lecture 7 - Thermodynamic properties of superconductors, specific heat

Lecture 8 - Experimental determination of Superconducting properties

Lecture 9 - Unconventional Superconductivity, Uemura plot, High- T_c superconductivity, d-wave pairing, ARPES

Lecture 10 - Singlet and triplet states of two $s=1/2$, magnetic Hamiltonian

Lecture 11 - t-J model, discrete symmetry groups, example square lattice

Lecture 12 - Cuprate Superconductors, electron vs hole doped superconductors

Lecture 13 - Non-Fermi Liquid Theory, Adiabatic continuity

Lecture 14 - Quasiparticle lifetime, breakdown of Fermi Liquid Theory in cuprate superconductors

Lecture 15 - Josephson junctions, Josephson equations

Lecture 16 - Numerical Differentiation

Lecture 17 - Richardson's extrapolation

Lecture 1 - Prerequisites and Introduction

Lecture 2 - Combinatorics and Entropy

Lecture 3 - Method of steepest descent

Lecture 4 - Bose and Fermi gases

Lecture 5 - Maxwell Boltzmann distribution

Lecture 6 - Thermodynamic potentials

Lecture 7 - Legendre transformation

Lecture 8 - Specific heats of quantum gases

Lecture 9 - Low and high temperature equations of state

Lecture 10 - Chandrasekhar Limit

Lecture 11 - Radiation thermodynamics

Lecture 12 - Thermodynamics of black holes

Lecture 13 - Van der Waals fluid

Lecture 14 - Landau Diamagnetism

Lecture 15 - Relations between ensembles and Pauli paramagnetism

Lecture 16 - Ferromagnetism

Lecture 17 - Correlations and Mean Field

Lecture 18 - Theories of Specific Heat of Solids

Lecture 19 - Tutorial - I

Lecture 20 - Tutorial - II

Lecture 21 - Tutorial - III

Lecture 22 - Tutorial - IV

Lecture 23 - Tutorial - V

Lecture 24 - RG method Ising model

Lecture 25 - Introduction to Second Quantisation: Harmonic Oscillator

Lecture 26 - Quantum Theory of EM Field - I

Lecture 27 - Quantum Theory of EM Field - II

Lecture 28 - Creation and Annihilation in Fock Space - I

Lecture 29 - Creation and Annihilation in Fock Space - II

Lecture 30 - Green functions in many particle systems

Lecture 31 - Second quantised hamiltonians

Lecture 32 - Current algebra

Lecture 1 - Error analysis and estimates, significant digits, convergence

Lecture 2 - Roots of Non-linear equations, Bisection method

Lecture 3 - Newton Raphson method, Secant method

Lecture 4 - Newton Raphson Method

Lecture 5 - Newton Raphson Method (example), Curve fitting and interpolation of data

Lecture 6 - Newton's interpolation formula, statistical interpolation of data

Lecture 7 - Linear and Polynomial regression

Lecture 8 - Numerical differentiation

Lecture 9 - Numerical differentiation, Error analysis

Lecture 10 - Numerical integration, Trapezoidal rule

Lecture 11 - Simpson's 1/3rd rule

Lecture 12 - Simpson's 1/3rd rule, Gaussian integration

Lecture 13 - Ordinary Differential equations

Lecture 14 - Solution of differential equation, Taylor series and Euler method

Lecture 15 - Heun's method

Lecture 16 - Runge Kutta method

Lecture 17 - Examples of differential equation: Heat conduction equation

Lecture 18 - Introduction to Monte Carlo technique

Lecture 19 - Details of the Monte Carlo method

Lecture 20 - Importance sampling

Lecture 21 - Applications: Ising model

Lecture 22 - Introduction to Molecular Dynamics

Lecture 23 - Verlet algorithm

Lecture 24 - Applications of Molecular dynamics

- Lecture 1 - Introduction, Constraints
- Lecture 2 - Generalized Coordinates, Configuration Space
- Lecture 3 - Principle of Virtual Work
- Lecture 4 - D'Alembert's Principle
- Lecture 5 - Lagrange's Equations
- Lecture 6 - Hamilton's Principle
- Lecture 7 - Variational Calculus, Lagrange's Equations
- Lecture 8 - Conservation Laws and Symmetries
- Lecture 9 - Velocity Dependent Potentials, Non-holonomic Constraints
- Lecture 10 - An Example: Hoop on a ramp
- Lecture 11 - Phase Space
- Lecture 12 - Legendre Transforms
- Lecture 13 - Hamilton's Equations
- Lecture 14 - Conservation Laws, Routh's procedure
- Lecture 15 - An Example: Bead on Spinning Ring
- Lecture 16 - Canonical Transformations
- Lecture 17 - Symplectic Condition
- Lecture 18 - Canonical Invariants, Harmonic Oscillator
- Lecture 19 - Poisson Bracket Formulation
- Lecture 20 - Infinitesimal Canonical Transformations
- Lecture 21 - Symmetry Groups of Mechanical Systems
- Lecture 22 - Hamilton Jacobi Theory
- Lecture 23 - Action-Angle Variables
- Lecture 24 - Separation of Variables and Examples
- Lecture 25 - Continuous Systems and Fields
- Lecture 26 - The Stress-Energy Tensor
- Lecture 27 - Hamiltonian Formulation

Lecture 1 - Energy Scenarios

Lecture 2 - Overview of solar energy conversion devices and applications

Lecture 3 - Physics of propagation of solar radiation from the sun to the earth

Lecture 4 - Solar radiation and sunshine measuring instruments

Lecture 5 - Geometry, angles and measurement - I

Lecture 6 - Geometry, angles and measurement - II

Lecture 7 - Estimation of radiation under different climatic conditions

Lecture 8 - Estimation of radiation in horizontal and inclined surface

Lecture 9 - Fundamentals of PV cells

Lecture 10 - Semiconductor physics

Lecture 11 - Performance characterization of PV cells

Lecture 12 - Photovoltaic modules and arrays

Lecture 13 - Components of standalone PV system

Lecture 14 - Design of standalone PV system

Lecture 15 - Functioning and components of PV system

Lecture 16 - Design of a grid connected PV system

Lecture 17 - Performance analysis of a grid connected PV system

Lecture 18 - Basics of thermal collectors

Lecture 19 - Basics of heat transfer

Lecture 20 - Solar collector losses and loss estimation

Lecture 21 - Analysis of flat plate collector

Lecture 22 - Influence of various parameters on the performance of LFPC

Lecture 23 - Testing and application of LFPC

Lecture 24 - Basics and performance analysis of solar air heaters

Lecture 25 - Testing and application of solar air heaters

Lecture 26 - Fundamentals of concentrating collectors

Lecture 27 - Concentrating collector technologies and working principle

Lecture 28 - Tutorial: Concentrating Collector

Lecture 29 - Sensible heat, latent heat and thermochemical energy storage

Lecture 30 - Solar pond

Lecture 31 - Tutorial: Solar pond power plant design

[Lecture 32 - Emerging technologies](#)

[Lecture 33 - Solar energy applications in cooking, desalination, refrigeration and electricity generation](#)

[Lecture 34 - Tutorial: COP of VARS and performance analysis of PVT collector](#)

- Lecture 1 - Introduction and Basic Quantum Mechanics
- Lecture 2 - Problem Solving Session - 1
- Lecture 3 - Two-level System - I
- Lecture 4 - Bloch Sphere: Supplementary Lectuer - I
- Lecture 5 - Two-level Systems - II
- Lecture 6 - Two-level Systems - III
- Lecture 7 - Dressed States;Introduction to Density Matrix
- Lecture 8 - Problem Solving Session - 2
- Lecture 9 - Density-matrix formalism
- Lecture 10 - Quantum Harmonic Oscillators
- Lecture 11 - Quantization of Electromagnetic Radiation
- Lecture 12 - Quantization of Standing EM Waves;Quantum States of Radiation Fields - I
- Lecture 13 - Problem Solving Session - 3
- Lecture 14 - Quantum States of Radiation Fields-II: Squeezed States
- Lecture 15 - Problem Solving Session - 4
- Lecture 16 - Introduction and Basics of Superconductivity
- Lecture 17 - Cooper Pair Box as TLS;Introduction to Transmission Line
- Lecture 18 - Quantization of Transmission Line - I
- Lecture 19 - Quantization of Transmission Line - II
- Lecture 20 - The Jaynes Cummings Model - I
- Lecture 21 - Problem Solving Session - 5
- Lecture 22 - The Jaynes Cummings Model - II
- Lecture 23 - Josephson Junctions - I
- Lecture 24 - Josephson Junctions - II
- Lecture 25 - Problem Solving Session - 6
- Lecture 26 - Transmon;Introduction to Dissipation in Quantum Systems
- Lecture 27 - Quantum Master Equation
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NPTEL : NOC:Introductory Quantum Mechanics (Physics)

Co-ordinators : Prof. Manoj K Harbola

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Lecture 27 - Introduction to crystals and bonding in crystals

Lecture 28 - Understanding crystal structure using Bravais Lattice

Lecture 29 - Bravais Lattice Types - Part 1

Lecture 30 - Bravais Lattice Types - Part 2

Lecture 31 - Introduction to different crystal types - Part 1

Lecture 32 - Introduction to different crystal types - Part 2

Lecture 33 - Indexing crystal planes

Lecture 34 - Scattering of X rays from crystals - Part 1

Lecture 35 - Scattering of X rays from crystals - Part 2

Lecture 36 - Reciprocal lattice vectors - Part 1

Lecture 37 - Reciprocal lattice vectors - Part 2

Lecture 38 - Reciprocal lattice vectors and Laue's condition for diffraction of waves in crystals - Part 1

Lecture 39 - Reciprocal lattice vectors and Laue's condition for diffraction of waves in crystals - Part 2

Lecture 40 - Reciprocal lattice vectors, Laue's condition and Bragg's law for diffraction of waves by a crystal

Lecture 41 - Wave equation in a continuous medium and generalization to a discrete medium

Lecture 42 - Derivation of wave equation for motion of atoms in a crystal

Lecture 43 - Solution of the wave equation for a crystal and the relation between frequency ω and wavevector k

Lecture 44 - Group velocity of waves and speed of sound in a crystal

Lecture 45 - Waves in a crystal considering interaction among atoms beyond their nearest neighbours

Lecture 46 - Normal modes in a crystal : Phonons and their momenta and energy

Lecture 47 - Experimental determination of Phonon dispersion curves

Lecture 48 - Lattice with two atom basis: Optical Phonons

Lecture 49 - Displacement of the atoms for the acoustic and optical Phonons

Lecture 50 - Density of states of phonons

Lecture 51 - Calculating the density of states of Phonons: The Einstein's and the Debye's Models

Lecture 52 - Average energy of Phonons at Temperature T

Lecture 53 - Debye's Model of specific heat of crystals

Lecture 54 - Anharmonic effects in crystals: thermal expansion and Umklapp processes

Lecture 55 - Going beyond free electron model: Periodic crystal potential and Bloch's theorem for the wavefunction

Lecture 56 - Applying perturbation theory to free electron wavefunctions and nearly free electron model

Lecture 57 - Applying perturbation theory to free electron wavefunctions and creation of energy gap at zone boundaries

Lecture 58 - Mixing of plane waves to get Bloch Wavefunction - I

Lecture 59 - Mixing of plane waves to get Bloch Wavefunction - II

Lecture 60 - Equivalence of wave vectors k and $k+G$ and reduced zone scheme

Lecture 61 - Applying periodic boundary condition to Bloch wavefunction and counting the number of states

Lecture 62 - Band theory of metals, insulators and semiconductors

Lecture 63 - Kronig- Penney model

Lecture 64 - Bloch wavefunction as a linear combination of atomic orbitals: Tight Binding Model- I

Lecture 65 - Tight Binding Model - II

Lecture 66 - Semiclassical dynamics of a particle in a band and Bloch oscillations

Lecture 67 - Experimental observations of Bloch oscillations

Lecture 68 - Concept of hole as a current carrier in semiconductors - I

Lecture 69 - Concept of hole as a current carrier in semiconductors - II

Lecture 70 - Calculating carrier density in semiconductors - I

Lecture 71 - Calculating carrier density in semiconductors - II

Lecture 72 - Donor and acceptor energy levels in a semiconductor

Lecture 73 - charge carrier density in n-type and p-type semiconductors

Lecture 74 - Electrical conductivity and hall coefficient in semiconductors

Lecture 75 - Paramagnetism in solids I - Magnetic moment and Lande g factor for atoms

Lecture 76 - Paramagnetism in solids II - temperature dependence of paramagnetic susceptibility and Curie's Law

Lecture 77 - Hund's rule for calculating the total angular momentum J, orbital angular momentum L and spin angular momentum S for an atom

Lecture 78 - Examples of performing paramagnetic susceptibility calculations

Lecture 79 - Diamagnetism in Solids

Lecture 80 - Understanding quenching of orbital angular momentum in transition metal ions

Lecture 81 - Ferromagnetism in solids

Lecture 82 - Introduction to Meissner state of superconductors and levitation

Lecture 83 - Superconducting materials and Type-I and Type-II superconductors

Lecture 84 - London's equation for superconductors

Lecture 85 - Application of London's equation, behavior

Lecture 86 - A qualitative introduction to BCS theory of superconductivity

Lecture 87 - Josephson's effect in superconductors and tunneling current across barriers

NPTEL : NOC:Physics of Turbulence (Physics)

Co-ordinators : Prof. Mahendra Verma

Lecture 1 - The turbulence problem

Lecture 2 - Basic hydrodynamics - Governing equations

Lecture 3 - Basic hydrodynamics - Vorticity

Lecture 4 - Basic hydrodynamics - Quadratic quantities

Lecture 5 - Basic hydrodynamics - Example problems

Lecture 6 - Fourier space representation - Definitions

Lecture 7 - Fourier space representation - Flow equations

Lecture 8 - Fourier space representation - Kinetic energy

Lecture 9 - Fourier space representation - Vorticity, Kinetic Helicity, and Enstrophy

Lecture 10 - Fourier space representation - Examples

Lecture 11 - Fourier space representation - Examples (Continued...)

Lecture 12 - Craya-Herring Basis: Definitions

Lecture 13 - Craya-Herring Basis: Equations of Motion for a Triad

Lecture 14 - Craya-Herring Basis: Equations of Motion for an Anticlockwise Triad

Lecture 15 - Thermal Instability

Lecture 16 - Thermal Instabilities (Continued...)

Lecture 17 - Rotating Convection: Instability and Patterns

Lecture 18 - Magnetoconvection: Instability and Patterns

Lecture 19 - Nonlinear Saturation: Lorenz Equation

Lecture 20 - Patterns, Chaos, and Turbulence

Lecture 21 - Energy Transfers: Mode-to-mode Energy Transfers

Lecture 22 - Energy Transfers: Mode-to-mode Energy Transfers (Continued...)

Lecture 23 - Energy Transfers: Examples

Lecture 24 - Energy Transfers: Spectral Energy Flux and Shell-to-Shell Energy Transfer

Lecture 25 - Energy Transfers: Fluid Simulations using Spectral Method

Lecture 26 - Energy Transfers: Fluid Simulations - Dealiasing

Lecture 27 - Kolmogorov's Theory: Energy Spectrum and Flux

Lecture 28 - Kolmogorov's Theory: Insights and its Verification with Direct Numerical Simulation

Lecture 29 - Kolmogorov's Theory: Spectrum and Flux in inertial-dissipation range

Lecture 30 - Kolmogorov's four-fifth law: Isotropic Tensor and Correlations

Lecture 31 - Kolmogorov's four-fifth law: Derivation

[Lecture 32 - Kolmogorov's four-fifth law: Derivation \(Final steps\)](#)

[Lecture 33 - Enstrophy Spectrum and Flux](#)

[Lecture 34 - Two-dimensional Turbulence](#)

[Lecture 35 - Helical turbulence](#)

[Lecture 36 - Flow with a scalar](#)

[Lecture 37 - Passive scalar turbulence](#)

[Lecture 38 - Stably stratified turbulence](#)

[Lecture 39 - Turbulent thermal convection](#)

[Lecture 40 - Flow with a vector](#)

[Lecture 41 - MHD Turbulence: Formalism](#)

[Lecture 42 - MHD Turbulence: Energy Transfers](#)

[Lecture 43 - MHD Turbulence: Turbulence Models](#)

[Lecture 44 - MHD Turbulence: Dynamo](#)

Lecture 1 - General introduction

Lecture 2 - Phase space and Liouville's theorem

Lecture 3 - Collisionless Boltzmann equation

Lecture 4 - Boltzmann equation for collisional system - I

Lecture 5 - Boltzmann equation for collisional system - II

Lecture 6 - Equilibrium distribution function - I

Lecture 7 - Equilibrium distribution function - II

Lecture 8 - Derivation of moment equations - I

Lecture 9 - Derivation of moment equations - II

Lecture 10 - Application of moment equations in collisionless systems

Lecture 11 - Derivation of ideal fluid equations

Lecture 12 - Macroscopic forces on an ideal fluid

Lecture 13 - Properties of ideal fluid

Lecture 14 - Kelvin's vorticity theorem

Lecture 15 - Conservative form and invariants in ideal fluids

Lecture 16 - Steady flow, streamlines and stream function

Lecture 17 - Departure from Maxwellian distribution

Lecture 18 - Derivation of real fluid equations

Lecture 19 - Hydrostatics: Model of solar corona

Lecture 20 - Stellar/solar wind

Lecture 21 - Accretion disks - I

Lecture 22 - A small digression: Newtonian fluids

Lecture 23 - Accretion disk - II

Lecture 24 - Weak perturbation in a compressible fluid: sound wave

Lecture 25 - Effect of nonlinearity: shocks

Lecture 26 - Supernova explosion and spherical blast waves - I

Lecture 27 - Supernova explosion and spherical blast waves - II

Lecture 28 - de Laval nozzle and extragalactic jets

Lecture 29 - Convective instability and Schwarzschild stability criterion

Lecture 30 - Rayleigh Benard convection - I

Lecture 31 - Rayleigh Benard convection - II

- Lecture 32 - Jeans instability
- Lecture 33 - Waves and instabilities in a two-fluid interface - I
- Lecture 34 - Waves and instabilities in a two-fluid interface - II
- Lecture 35 - Oscillations of stars
- Lecture 36 - Oscillation of stars (Continued...)
- Lecture 37 - Rotation in astrofluids and Rayleigh criterion
- Lecture 38 - Fluid dynamics in a rotating frame of reference
- Lecture 39 - Vorticity theorem in rotating frame and Taylor-Proudman theorem
- Lecture 40 - Effect of rotation on a self gravitating mass
- Lecture 41 - Effect of rotation in stars
- Lecture 42 - Introduction to Plasmas
- Lecture 43 - Description of Plasma
- Lecture 44 - Kinetic to fluid picture of plasmas
- Lecture 45 - MHD fluids: magnetic pressure, magnetic tension and plasma beta
- Lecture 46 - Inviscid invariants in MHD
- Lecture 47 - Inviscid invariants in MHD (Continued...)
- Lecture 48 - Elsasser variables in MHD
- Lecture 49 - Linear wave modes in MHD
- Lecture 50 - MHD in space plasmas
- Lecture 51 - Introduction to turbulence in fluids
- Lecture 52 - Richardson-Kolmogorov phenomenology of turbulence
- Lecture 53 - Turbulent diffusion
- Lecture 54 - Turbulent viscosity
- Lecture 55 - Turbulence in MHD fluids
- Lecture 56 - Introduction to astrophysical dynamos
- Lecture 57 - Anti-dynamo theorem and turbulent dynamos

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NPTEL : NOC:Scientific Computing Using Python (Physics)

Co-ordinators : Prof. Mahendra K. Verma

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Lecture 1 - Introduction to Field Theory and Course

Lecture 2 - Integration using Complex Analysis

Lecture 3 - Cauchy Principal Value Theorem

Lecture 4 - Fourier Transform

Lecture 5 - Green's Function and Examples

Lecture 6 - Green's Function in Fourier Space

Lecture 7 - Fourier Transform, Time Frequency

Lecture 8 - Green's Function for Helmholtz Equation and Wave Equation

Lecture 9 - Green's Function for Diffusion and Schrodinger Equation

Lecture 10 - Dimensional Analysis

Lecture 11 - Functionals - Part 1

Lecture 12 - Lagrangian Formalism - Part 2

Lecture 13 - Relativistic Fields

Lecture 14 - Hamiltonian Formalism

Lecture 15 - Principle of Least Action

Lecture 16 - Relativistic Fields and Hamiltonian Formalism

Lecture 17 - Noether's Theorem and Symmetries

Lecture 18 - Review of Quantum Mechanics

Lecture 19 - Second Quantization

Lecture 20 - Field Operators

Lecture 21 - Fock Space and Vacuum Energy

Lecture 22 - Quantization of Bosons and Fermions

Lecture 23 - Examples

Lecture 24 - Free Fermi Gas

Lecture 25 - Propagators and Perturbations

Lecture 26 - Relativistic Quantum Field Theory

Lecture 27 - Feynman Propagator

Lecture 28 - Review of Statistical Mechanics (Partition Function)

Lecture 29 - Feynman Path Integral

Lecture 30 - Diagrammatic Field Theory (Wick's Theorem)

Lecture 31 - Wick's Theorem (Continued...)

Lecture 32 - Diagrammatic Perturbation Theory

Lecture 33 - Green's Function and Correlation Function

Lecture 34 - Feynman Diagrams

Lecture 35 - Phase Transition and Landau Theory

Lecture 36 - Failure of Landau's Theory

Lecture 37 - Scale Invariance

Lecture 38 - Renormalization Group - Preliminary

Lecture 39 - RG Steps

Lecture 40 - Perturbative Calculations

Lecture 41 - RG Fixed Points

Lecture 42 - Relevant and Irrelevant Variables

Lecture 43 - Behaviour Near Critical Points

Lecture 44 - Computing Critical Exponents

Lecture 45 - Mass and Charge Renormalization, Running Coupling const: $\hat{1}/4$ Theory

Lecture 46 - Charge and Mass Renormalization: QED and QCD

Lecture 47 - Breaking a Continuous Symmetry (Goldstone Mode)

Lecture 48 - Covariant Electrodynamics (Gauge Interactions)

Lecture 49 - Higgs Mechanism

Lecture 50 - Introduction to Non-Equilibrium Field Theory (Langevin Equation)

Lecture 51 - Fluctuation Dissipation Theorem

Lecture 52 - Kolmogorov's Theory of Turbulence

Lecture 53 - Equilibrium and Non Equilibrium Solution of Navier Stokes

Lecture 54 - Energy Flux in Navier Stokes Equation

Lecture 55 - RG Analysis of Field Theory of Turbulence

Lecture 56 - Renormalized Viscosity and Discussion

Lecture 57 - Renormalization of the Coupling Constant for the Shell Model

Lecture 58 - Flux Computation for the Shell Model of Turbulence

Lecture 59 - Renormalization Group Analysis of Navier Stokes Equation

Lecture 60 - Flux Computation for the Navier Stokes Equation

Lecture 61 - Functional Form of a Dynamical Equation

Lecture 62 - Surface Growth Phenomena: Introduction

Lecture 63 - Surface Growth Phenomena: EW Equation

Lecture 64 - Surface Growth Phenomena: KPZ Equation

[Lecture 65 - Surface Growth Phenomena: KPZ Equation \(Continued...\)](#)

[Lecture 66 - RG Procedure for KPZ Equation](#)

[Lecture 67 - Noise Renormalization](#)

[Lecture 68 - Fixed Point Solution](#)

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[Lecture 70 - Weak Turbulence Applications \(Rotating Turbulence, Internal and Surface Gravity Waves\)](#)

[Lecture 71 - Nonlinear Schrodinger Equation](#)

[Lecture 72 - Field Theory of Passive Scalar Turbulence](#)

[Lecture 73 - Course Summary](#)

- Lecture 1 - Main differences between classical and quantum mechanics
- Lecture 2 - Introduction to Coherence and Stochastic Processes
- Lecture 3 - The Joint Probability Function used in Classical Optics: The Correlation Functions
- Lecture 4 - Second-order Coherence Theory (Temporal)
- Lecture 5 - Quantifying the Temporal Correlations
- Lecture 6 - Second-order Coherence Theory (Spatial); Spatial Correlations
- Lecture 7 - Quantifying the Spatial Correlations
- Lecture 8 - Second-order Coherence Theory (Angular); Angular Correlations
- Lecture 9 - Second-order Coherence Theory (Polarization)
- Lecture 10 - Degree of Polarization
- Lecture 11 - Coherent Mode Representation of Optical Fields
- Lecture 12 - Review of Quantum Mechanics
- Lecture 13 - Quantum Mechanical Correlation Functions
- Lecture 14 - Basics of Nonlinear Optics
- Lecture 15 - Two-Photon State Produced by Parametric Down-Conversion
- Lecture 16 - Coherence and Quantum Entanglement
- Lecture 17 - Temporal Two-Photon Interference
- Lecture 18 - Some example of Two-Photon Interference Effects
- Lecture 19 - Spatial Two-Photon Interference
- Lecture 20 - Quantum Measurements
- Lecture 21 - Can the Quantum Mechanical Description of Physical Reality be Considered Complete ?
- Lecture 22 - Hidden Variable Interpretation of Quantum Mechanics
- Lecture 23 - Bell Inequalities
- Lecture 24 - Entanglement Verification
- Lecture 25 - Entanglement Quantification and Connection Between Coherence and Entanglement
- Lecture 26 - 84 Quantum Cryptography
- Lecture 27 - Quantum Teleportation

NPTEL : NOC:Classical Motion of a Single Particle (Physics)

Co-ordinators : Prof. Supratik Banerjee

- Lecture 1 - Introduction and Newton's laws of motion
- Lecture 2 - From dynamics to Kinematics
- Lecture 3 - Equations of dynamics and constants of motion
- Lecture 4 - Constants of motion (Continued...), Work-energy theorem and conservative forces
- Lecture 5 - Dynamics under constants and central forces
- Lecture 6 - Derivation of gradient form from zero curl condition
- Lecture 7 - Concept of equilibrium
- Lecture 8 - Terminal velocity, stable and unstable equilibria
- Lecture 9 - Stable and unstable equilibria in more than one dimensions
- Lecture 10 - Motion in one-dimensional potential
- Lecture 11 - Solving equations of motion in one dimension
- Lecture 12 - Calculation of Work Done in a Force Field
- Lecture 13 - Central forces, Velocity and Acceleration in Plane Polar Coordinates
- Lecture 14 - Dynamics and Trajectories Under a Central Force
- Lecture 15 - Equation For Trajectories Under a Central Force (Continued...) : Binet Equation
- Lecture 16 - Trajectory of a Particle Under Attractive Inverse-Square Force Law
- Lecture 17 - Energy Diagram in an Effective One-Dimensional Motion
- Lecture 18 - Two Interesting Problems On the motion Under Central Forces
- Lecture 19 - Motion Under an Attractive Inverse-Square Force
- Lecture 20 - Motion Under an Attractive Inverse-Square Force (Continued...)
- Lecture 21 - Trajectories Under Attractive Inverse-Square Force, Laws of Kepler
- Lecture 22 - Laplace Runge-Lenz Vector
- Lecture 23 - Simple harmonic oscillators
- Lecture 24 - Two examples of simple harmonic oscillation
- Lecture 25 - Forced harmonic oscillator
- Lecture 26 - Forced harmonic oscillator at resonance
- Lecture 27 - Damped harmonic oscillator
- Lecture 28 - Nature of motion under a harmonic potential
- Lecture 29 - Comparison among three types of damped oscillation
- Lecture 30 - Forced harmonic oscillator with damping
- Lecture 31 - A problem on damped harmonic oscillator

Lecture 32 - Beats

Lecture 33 - Motion of a particle in electric and magnetic fields

Lecture 34 - E X B drift

Lecture 35 - Inertial frames of reference, Galilean transformation

Lecture 36 - Non-inertial frames of reference, pseudo forces

Lecture 37 - Motion of a particle in a rotating frame of reference

Lecture 38 - Motion of a particle relative to an observer on earth

Lecture 39 - Motion of a particle under various constraints

Lecture 40 - Principle of Virtual work, D'Alembert's principle

Lecture 41 - Lagrange's equation of first kind

Lecture 42 - Solving problems using Lagrange's equation of first kind

Lecture 43 - Generalized Coordinates and Generalized Velocities

Lecture 44 - Kinetic Energy and Acceleration in Terms of Generalized Coordinates

Lecture 45 - Generalized Momentum and Generalized Force; Derivation of Euler-Lagrange Equation

Lecture 46 - Euler Lagrange Equation, Cyclic Coordinates and Other Properties

Lecture 47 - Properties of Euler-Lagrange equations (Continued...)

Lecture 48 - Lagrangian of various oscillating systems

Lecture 49 - Problem solving using Euler-Lagrange equations

Lecture 50 - Concept of Phase Space

Lecture 51 - Phase space trajectories and fixed points

Lecture 52 - Stability of fixed points

Lecture 53 - Different types of fixed points

Lecture 54 - Fixed points and their stability for mechanical systems

Lecture 55 - Linear two-dimensional phase space dynamics

Lecture 56 - Linear two-dimensional phase space dynamics (Continued...)

Lecture 57 - Concept of limit cycles

Lecture 58 - Lorenz equations and introduction to chaos

Lecture 1 - Introduction

Lecture 2 - Keplers Law

Lecture 3 - The Solar System

Lecture 4 - The Solar System (Continued...)

Lecture 5 - Binary Systems

Lecture 6 - Binary Systems (Continued...)

Lecture 7 - Tidal Forces and the Earth Moon System

Lecture 8 - Fluid Mechanics

Lecture 9 - Hydrostatics and the Solar Wind

Lecture 10 - Radiative Transfer

Lecture 11 - Radiative Transfer (Continued...)

Lecture 12 - Thermal Radiation

Lecture 13 - Thermal Radiation and the Sun

Lecture 14 - Virial Theorem and Its Application to Stars

Lecture 15 - Stars: Magnitudes and the H-R Diagram

Lecture 16 - Stellar Physics - I

Lecture 17 - Stellar Physics - II

Lecture 18 - Stellar Physics - III

Lecture 19 - Stellar Physics - IV

Lecture 20 - Stellar Physics - V

Lecture 21 - White Dwarfs

Lecture 22 - White Dwarfs and Neutron Stars

Lecture 23 - Galaxies

Lecture 24 - Galaxies and the Expanding Universe

Lecture 25 - The Expanding Universe

Lecture 26 - Dynamics of the Expanding Universe

Lecture 27 - Dynamics of the Expanding Universe (Continued...)

Lecture 28 - The Expanding Universe and the Cosmological Metric

Lecture 29 - The Cosmological Space - Time

Lecture 30 - Distances

Lecture 31 - Distances (Continued...)

[Lecture 32 - Distances and the Hubble Parameter](#)

[Lecture 33 - Distances, the Hubble Parameter and Dark Energy \(Continued...\)](#)

[Lecture 34 - CMBR and Thermal History](#)

[Lecture 35 - CMBR and Thermal History \(Continued...1\)](#)

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[Lecture 37 - Thermal History, Expansion Rate and Neutrino Mass](#)

[Lecture 38 - Thermal History: Neutrino Mass, Nucleosynthesis](#)

[Lecture 39 - Big Bang Nucleosynthesis](#)

[Lecture 40 - Big Bang Nucleosynthesis \(Continued...\)](#)

Lecture 1 - Set, Group, Field, Ring

Lecture 2 - Vector Space

Lecture 3 - Span, Linear combination of vectors

Lecture 4 - Linearly dependent and independent vector, Basis

Lecture 5 - Dual Space

Lecture 6 - Inner Product

Lecture 7 - Schwarz Inequality

Lecture 8 - Inner product space, Gram-Schmidt Ortho-normalization

Lecture 9 - Projection operator

Lecture 10 - Transformation of Basis

Lecture 11 - Transformation of Basis (Continued...)

Lecture 12 - Unitary transformation, Similarity Transformation

Lecture 13 - Eigen Value, Eigen Vectors

Lecture 14 - Normal Matrix

Lecture 15 - Diagonalization of a Matrix

Lecture 16 - Hermitian Matrix

Lecture 17 - Rank of a Matrix

Lecture 18 - Cayley - Hamilton Theorem, Function space

Lecture 19 - Metric Space, Linearly dependent - independent functions

Lecture 20 - Linearly dependent & independent functions (Continued...), Inner Product of functions

Lecture 21 - Orthogonal functions

Lecture 22 - Delta Function, Completeness

Lecture 23 - Fourier

Lecture 24 - Fourier Series (Continued...)

Lecture 25 - Parseval Theorem, Fourier Transform

Lecture 26 - Parseval Relation, Convolution Theorem

Lecture 27 - Polynomial space, Legendre Polynomial

Lecture 28 - Monomial Basis, Factorial Basis, Legendre Basis

Lecture 29 - Complex Numbers

Lecture 30 - Geometrical interpretation of complex numbers

Lecture 31 - de Moivre's Theorem

Lecture 32 - Roots of a complex number

Lecture 33 - Set of complex no, Stereographic projection

Lecture 34 - Complex Function, Concept of Limit

Lecture 35 - Derivative of Complex Function, Cauchy-Riemann Equation

Lecture 36 - Analytic Function

Lecture 37 - Harmonic Conjugate

Lecture 38 - Polar form of Cauchy-Riemann Equation

Lecture 39 - Multi-valued function and Branches

Lecture 40 - Complex Line Integration, Contour, Regions

Lecture 41 - Complex Line Integration (Continued...)

Lecture 42 - Cauchy-Goursat Theorem

Lecture 43 - Application of Cauchy-Goursat Theorem

Lecture 44 - Cauchy's Integral Formula

Lecture 45 - Cauchy's Integral Formula (Continued...)

Lecture 46 - Series and Sequence

Lecture 47 - Series and Sequence (Continued...)

Lecture 48 - Circle and radius of convergence

Lecture 49 - Taylor Series

Lecture 50 - Classification of singularity

Lecture 51 - Laurent Series, Singularity

Lecture 52 - Laurent series expansion

Lecture 53 - Laurent series expansion (Continued...), Concept of Residue

Lecture 54 - Classification of Residue

Lecture 55 - Calculation of Residue for quotient form

Lecture 56 - Cauchy's Residue Theorem

Lecture 57 - Cauchy's Residue Theorem (Continued...)

Lecture 58 - Real Integration using Cauchy's Residue Theorem

Lecture 59 - Real Integration using Cauchy's Residue Theorem (Continued...)

Lecture 60 - Real Integration using Cauchy's Residue Theorem (Continued...)

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[Lecture 7 - Systems with variable mass - 4](#)

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[Lecture 23 - Mooring Co-ordinate Systems - 1](#)

[Lecture 24 - Mooring Co-ordinate Systems - 2](#)

[Lecture 25 - Mooring Co-ordinate Systems - 3](#)

[Lecture 26 - Mooring Co-ordinate Systems - 4](#)

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Lecture 6 - Phase Behaviour of Natural Gas

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Lecture 37 - Theory regarding compound pendulum has been discussed

Lecture 38 - Experimental demonstration on the standing Waves on a String has been shown clearly how to determine the linear mass density of the string.

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Lecture 40 - Expt. to study linear expansion

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Lecture 42 - Determination of electrical equivalent of heat

Lecture 43 - Determination of specific heat of the given solid metals using Dulong-Petit's law

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Lecture 25 - Determination of the angle of prism

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Lecture 27 - Discussion on the angle of incidence and corresponding deviation of light through a prism and determination of the angle of minimum deviation for a given prism from the plot of the angle of incidence versus deviation.

Lecture 28 - Determination of the angle of minimum deviation from (i-D) plot for a given prism and hence to determine the refractive index of the given prism.

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[Lecture 48 - Determination of Wavelength of Spectral Lines using Constant Deviation Spectrometer \(Continued...\)](#)

[Lecture 49 - Photoelastic Property of Materials](#)

[Lecture 50 - Photoelastic Property of Materials \(Continued...\)](#)

[Lecture 51 - Photoelastic Property of Materials \(Continued...\)](#)

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[Lecture 53 - Faraday Effect \(Continued...\)](#)

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[Lecture 56 - Determination of Velocity of Light in Free Space](#)

[Lecture 57 - Determination of Velocity of Light in Free Space \(Continued...\)](#)

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[Lecture 59 - X-Ray Diffraction and Crystal Structure \(Continued...\)](#)

[Lecture 60 - X-Ray Diffraction and Crystal Structure \(Continued...\)](#)

[Lecture 61 - X-Ray Diffraction and Crystal Structure \(Continued...\)](#)

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Lecture 1 - Free electrons: Drude Theory

Lecture 2 - Weidemann Franz Law

Lecture 3 - Drude Model continued: Hall Effect

Lecture 4 - Schrodinger Equation: Boundary Conditions

Lecture 5 - Density of States

Lecture 6 - Properties of Degenerate Fermi Gas

Lecture 7 - Statistics Fermi-Dirac distribution and Maxwell-Boltzmann Distribution: comparison and Specific Heat

Lecture 8 - Sommerfeld Expansion and Band Formation: Temperature dependent densities, Chemical Potential, Specific Heat

Lecture 9 - Bonding and Band Formation: N=2 solid Molecular Orbitals, Linear combinations of Atomic Orbitals (LCAO)

Lecture 10 - Variational Method: Molecular Orbitals, Bonding and anti-bonding Orbitals

Lecture 11 - Bonding and Band Formation (LCAO)

Lecture 12 - Bonding and Band Formation (LCAO) (Continued...)

Lecture 13 - Bloch's Theorem

Lecture 14 - Proof of Bloch's Theorem

Lecture 15 - N atoms Solid

Lecture 16 - Brillouin Zones

Lecture 17 - Tight binding: lattice with a basis

Lecture 18 - Fermi Surfaces

Lecture 19 - Lattice with basis:Energy Spectrum

Lecture 20 - Energy spectrum (Continued...)

Lecture 21 - Graphene and Fermi Surfaces

Lecture 22 - Fermi Surfaces Instabilities

Lecture 23 - Low Dimensional Systems

Lecture 24 - Integer Quantum Hall Effect (IQHE)

Lecture 25 - Integer Quantum Hall Effect (Continued...)

Lecture 26 - Electron in a Strong Magnetic Field and IQHE

Lecture 27 - Spintronics: Introduction and Applications

Lecture 28 - Magnetism

Lecture 29 - Magnetism: Quantum Theory

Lecture 30 - Hund's Rule

Lecture 31 - Curie's Law and Van Vleck Paramagnetism

- Lecture 32 - Curie's law for any J, Susceptibility
- Lecture 33 - Susceptibility and Thermal Properties
- Lecture 34 - Adiabatic Demagnetisation
- Lecture 35 - Pauli Paramagnetism
- Lecture 36 - Paramagnetism of metals
- Lecture 37 - Exchange interaction for 2 electrons
- Lecture 38 - Exchange interactions of different types
- Lecture 39 - Magnetic Order
- Lecture 40 - Magnetic Order of different types and Heisenberg model
- Lecture 41 - Ising Model
- Lecture 42 - Mean Field Theory
- Lecture 43 - Spontaneous magnetisation and 1D Ising Model
- Lecture 44 - Symmetries of Ising model, Exact Solution
- Lecture 45 - Ferromagnetic Heisenberg Model
- Lecture 46 - Ground State and Magnons/Excitations
- Lecture 47 - Superconductivity
- Lecture 48 - London Equation
- Lecture 49 - Meisner Effect from London Equation
- Lecture 50 - Cooper problem
- Lecture 51 - Instability of the Fermi Surface
- Lecture 52 - BCS Theory Introduction
- Lecture 53 - BCS Theory, Excitation Spectrum
- Lecture 54 - BCS
- Lecture 55 - Tunneling and Ginzberg Landau Theory
- Lecture 56 - Electrodynamics of Superconductivity
- Lecture 57 - Type II superconductors
- Lecture 58 - Josephson junction
- Lecture 59 - Vortices, SQUID, Quantum Supremacy and Qubits
- Lecture 60 - Topological state of matter, XY Model, Topological Insulators

Lecture 1 - Wave Equation, Maxwell's equation, Plane wave

Lecture 2 - EM wave in vacuum, Poynting vector, Maxwell's equation in Dielectric Medium

Lecture 3 - Poynting Vector, Maxwell's equation in dielectric medium (Continued...)

Lecture 4 - Total Internal reflection, Evanescent wave

Lecture 5 - Step-index fiber (SIF), Light guidance in SIF

Lecture 6 - Light guidance in SIF (Skew Ray), V-Parameter, Discrete Ray

Lecture 7 - Cutoff wavelength, Fiber characteristics

Lecture 8 - Fiber Loss, dB units, Dispersion

Lecture 9 - Dispersion, Ray Path constant

Lecture 10 - Ray path constant, Ray equation

Lecture 11 - Ray equation (Continued...)

Lecture 12 - Ray transit time

Lecture 13 - Ray transit time (Continued...)

Lecture 14 - Material dispersion

Lecture 15 - Material dispersion (Continued...)

Lecture 16 - Material Dispersion (Continued...), Dispersion Coefficient

Lecture 17 - Pulse Broadening

Lecture 18 - Pulse Propagation in Dispersive Medium

Lecture 19 - Pulse Propagation in Dispersive Medium (Continued...)

Lecture 20 - Concept of Modes

Lecture 21 - TE and TM Modes

Lecture 22 - TE and TM Modes (Continued...)

Lecture 23 - Modes in Slab waveguide

Lecture 24 - Modes in Slab waveguide (Continued...)

Lecture 25 - Modes in Slab waveguide (Continued...)

Lecture 26 - Modes in Slab Waveguide (Continued...)

Lecture 27 - Waveguide Dispersion

Lecture 28 - Physical Understanding of Modes

Lecture 29 - Power Associated with a Modes

Lecture 30 - Modes in an Optical Fiber

Lecture 31 - Modes in an optical fiber (Continued...)

- [Lecture 32 - Modes in an optical fiber \(Continued...\)](#)
- [Lecture 33 - LP_{lm} mode structure](#)
- [Lecture 34 - Optical fiber mode morphology \(Continued...\)](#)
- [Lecture 35 - Effective area of mode, Fiber optics components](#)
- [Lecture 36 - Directional Coupler](#)
- [Lecture 37 - Coupled Mode Theory](#)
- [Lecture 38 - Coupled Mode Theory \(Continued...\)](#)
- [Lecture 39 - 3 dB power splitter](#)
- [Lecture 40 - Working principle of WDM coupler](#)
- [Lecture 41 - Fiber Bragg Grating](#)
- [Lecture 42 - Fiber Bragg Grating \(Continued...\)](#)
- [Lecture 43 - Reflectivity Calculation](#)
- [Lecture 44 - Reflectivity Calculation \(Continued...\)](#)
- [Lecture 45 - Reflectivity calculation of FBG \(Continued...\)](#)
- [Lecture 46 - Reflectivity calculation of FBG \(Continued...\)](#)
- [Lecture 47 - Reflectivity calculation of FBG \(Continued...\)](#)
- [Lecture 48 - Bandwidth of reflectivity](#)
- [Lecture 49 - Basic nonlinear optics](#)
- [Lecture 50 - Frequency mixing, Optical Kerr effect](#)
- [Lecture 51 - Optical Kerr effect \(Continued...\)](#)
- [Lecture 52 - Self Phase Modulation](#)
- [Lecture 53 - Self Phase Modulation \(Continued...\)](#)
- [Lecture 54 - Self Phase Modulation \(Continued...\)](#)
- [Lecture 55 - Pulse propagation in nonlinear waveguide](#)
- [Lecture 56 - Pulse propagation in nonlinear waveguide \(Continued...\)](#)
- [Lecture 57 - Pulse propagation in nonlinear dispersive waveguide](#)
- [Lecture 58 - Pulse propagation in nonlinear dispersive waveguide \(Continued...\)](#)
- [Lecture 59 - Concept of optical soliton](#)
- [Lecture 60 - Concept of optical soliton \(Continued...\)](#)

- Lecture 1 - Introduction and relevance of the course
- Lecture 2 - Energy sources
- Lecture 3 - Solar Radiation
- Lecture 4 - Solar Photovoltaic Systems
- Lecture 5 - Origin of Band Structure and Energy Band Gap
- Lecture 6 - Basics of Semiconductors
- Lecture 7 - Construction of Solar Cells
- Lecture 8 - Characterization of Solar Cells and Future Direction
- Lecture 9 - Solar Heaters
- Lecture 10 - Introduction to Wind Energy
- Lecture 11 - Continuity Equation and its applications
- Lecture 12 - Betz Criteria for extracting wind power
- Lecture 13 - Wind turbines and their operation
- Lecture 14 - Materials Aspects and future direction
- Lecture 15 - Introduction to Hydroelectric Power
- Lecture 16 - Hydroelectric Power Station and Turbines
- Lecture 17 - Wave power and converters
- Lecture 18 - Introduction to Tidal Power
- Lecture 19 - Tidal Power and Geothermal Energy
- Lecture 20 - Introduction to Energy Storage Systems
- Lecture 21 - Thermal Energy Storage
- Lecture 22 - Basics of Mechanical Energy Storage
- Lecture 23 - Pumped Hydroelectric to Flywheels (Mechanical Energy Storage Systems)
- Lecture 24 - Introduction to Li-ion battery
- Lecture 25 - Characteristics and Parameters of Li-ion batteries
- Lecture 26 - Cathode Materials for Li-ion batteries
- Lecture 27 - Anode Materials for Li-ion batteries
- Lecture 28 - Electrolytes and Separators for Li-batteries
- Lecture 29 - From battery to supercapacitors
- Lecture 30 - Construction, development and classification of Supercapacitors
- Lecture 31 - Electric double layer capacitors (EDLCs)

[Lecture 32 - Pseudocapacitors](#)

[Lecture 33 - Electrochemical Techniques for Supercapacitors and Batteries](#)

[Lecture 34 - From material to a supercapacitor device](#)

[Lecture 35 - Effect of temperature on supercapacitor performance](#)

[Lecture 36 - Effect of external magnetic field and frequency on supercapacitors](#)

[Lecture 37 - Introduction to Fuel Cells](#)

[Lecture 38 - Explanation of Fuel cell systems](#)

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[Lecture 40 - Nanotechnology and Nanomaterials for Energy Applications](#)

[Lecture 41 - Synthesis of nanomaterials](#)

[Lecture 42 - Carbon- and metal-oxide based nanomaterials](#)

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[Lecture 44 - Characterization techniques for solid materials](#)

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[Lecture 49 - Particle size and zeta potential analysis](#)

[Lecture 50 - BET analysis](#)

[Lecture 51 - Electrochemical Impedance Spectroscopy](#)

- Lecture 1 - Foundation of kinetic theory of gasses
- Lecture 2 - Maxwell's law for speed distribution of gas molecules
- Lecture 3 - Average speeds in an ideal gas assembly
- Lecture 4 - Principle of equipartition of energy
- Lecture 5 - Maxwell's law for energy distribution of gas molecules
- Lecture 6 - The mean free path of a gas assembly
- Lecture 7 - Expression for mean free path
- Lecture 8 - Experimental determination of mean free path
- Lecture 9 - Pressure and molecular flux from mean free path
- Lecture 10 - Problems on mean free path
- Lecture 11 - Transport in fluids: introduction
- Lecture 12 - Viscosity: transport of momentum
- Lecture 13 - Thermal conductivity: transport of thermal energy
- Lecture 14 - Diffusion coefficient: transport of mass
- Lecture 15 - Molecular effusion: theory and applications
- Lecture 16 - Brownian motion: concept, features, theory of fluctuation
- Lecture 17 - Brownian motion: mean square displacement and vertical distribution of particles
- Lecture 18 - Perrin's experiment on Brownian motion - Part 1
- Lecture 19 - Perrin's experiment on Brownian motion - Part 2
- Lecture 20 - Problems on Brownian motion, Rotational brownian motion
- Lecture 21 - Specific heat of solids: Dulong-Petit law and Einstein theory
- Lecture 22 - Limitation of Einstein theory of specific heat
- Lecture 23 - Debye theory of specific heat
- Lecture 24 - Behavior of real gasses
- Lecture 25 - Van der Waals equation of state
- Lecture 26 - Critical parameters from Van der Waal's equation
- Lecture 27 - Determination of Van der Waals' constants and Boyle temperature
- Lecture 28 - Other equations of state
- Lecture 29 - Measurement of temperature: Celsius scale, ideal gas scale, absolute zero
- Lecture 30 - The platinum resistance thermometer
- Lecture 31 - Basic concepts of classical thermodynamics

Lecture 32 - Basic concepts of classical thermodynamics (Continued...)

Lecture 33 - First law of thermodynamics

Lecture 34 - General description of work done and specific heat

Lecture 35 - General discussion on Heat conduction and elastic properties

Lecture 36 - Cyclic processes

Lecture 37 - The reversible heat engine: Carnot cycle

Lecture 38 - Refrigerator and Carnot Theorem

Lecture 39 - 2nd law and Clausius theorem

Lecture 40 - Concept of Entropy and mathematical form of 2nd law

Lecture 41 - The entropy principle

Lecture 42 - Efficiency of a cycle from T-S diagram

Lecture 43 - The Otto cycle

Lecture 44 - The Diesel cycle

Lecture 45 - Entropy and available energy

Lecture 46 - Thermodynamic relations

Lecture 47 - Application of thermodynamic relation

Lecture 48 - The free energy functions

Lecture 49 - Condition for thermodynamic equilibri

Lecture 50 - Thermodynamics of chemical reaction

Lecture 51 - Equilibrium between phases: The Clapeyron equation

Lecture 52 - 1st order phase transition along liquid-vapor equilibrium

Lecture 53 - Phase diagram and triple point

Lecture 54 - The 2nd latent heat equation

Lecture 55 - Gibbs phase rule and basics of second order phase transition

Lecture 56 - Basic concepts of radiation

Lecture 57 - Diffused radiation and Kirchhoff's law

Lecture 58 - Cavity radiation as a thermodynamic system: Stefan-Boltzmann law

Lecture 59 - Thermodynamics of cavity radiation

Lecture 60 - 3rd law of thermodynamics

Lecture 1 - Introduction: Magnetism and superconductivity as macroscopic quantum phenomena

Lecture 2 - Bohr magneton, BvL theorem

Lecture 3 - An electron in a magnetic field, magnetism of isolated atoms

Lecture 4 - Magnetism of isolated atoms (Continued...), Diamagnetism

Lecture 5 - Magnetism of atoms-dia and paramagnetic susceptibilities. Hund's rules, Van Vleck paramagnetism

Lecture 6 - Van Vleck paramagnetism (Continued...), Paramagnetism

Lecture 7 - Curie's law for arbitrary J, adiabatic demagnetization

Lecture 8 - Paramagnetism of conduction electrons - Pauli paramagnetism

Lecture 9 - Ions in a solid: crystal field, orbital quenching, Jahn-Teller effect

Lecture 10 - Jahn-Teller effect (Continued...), Magnetic resonance techniques NMR, ESR

Lecture 11 - Resonance techniques (Continued...), Recapitulation and overview

Lecture 12 - Recapitulation, interacting moments and long range order, dipolar exchange

Lecture 13 - Interacting moments, 2-electron system, origin of exchange and spin Hamiltonian

Lecture 14 - Spin Hamiltonian, Heisenberg model, Exchange interactions: direct

Lecture 15 - GMR, spin model and mean-field theory, Ising model

Lecture 16 - Ising model and its properties

Lecture 17 - Ising model and its properties (Continued...), absence of LRO in $d=1$, mean-field theory

Lecture 18 - Ising model recap, applications, exact solutions

Lecture 19 - Exact solution of Ising model in $d=1$, exact results in $d=2$. Mermin-Wagner theorem

Lecture 20 - Recap - Exact solution of Ising model. Mermin-Wagner theorem on the absence

Lecture 21 - Ferromagnetic Heisenberg model ground state

Lecture 22 - Ferromagnetic Heisenberg model, spin-waves and magnons

Lecture 23 - Antiferromagnetic Heisenberg model, AF magnetic structures

Lecture 24 - AF magnetic structures, susceptibility and excitations

Lecture 25 - Antiferromagnets and frustration, spin glass

Lecture 26 - Superconductivity: discovery, properties

Lecture 27 - Superconductivity: Meissner effect, London Equation

Lecture 28 - Electron-phonon interaction, Cooper problem

Lecture 29 - Cooper problem, setting up the BCS theory

Lecture 30 - BCS wave function, the Superconducting state and calculations of various properties

Lecture 31 - BCS theory (Continued...), energy gap, transition temperature

[Lecture 32 - Consequences of BCS theory, gap vs T, Transition temperature, specific heat, tunnelling](#)

[Lecture 33 - Transition temperature, specific heat, tunnelling](#)

[Lecture 34 - Andreev reflection, Ginzburg-Landau Theory and electrodynamics of superconductors](#)

[Lecture 35 - Ginzburg-Landau theory, coherence length and Type I and II superconductors](#)

[Lecture 36 - Flux lattice, Flux quantization, Josephson junctions](#)

[Lecture 37 - Josephson effect and Josephson junctions](#)

[Lecture 38 - SQUID, Quantum computers and Josephson junction Qubits](#)

[Lecture 39 - High-Temperature Superconductivity: an enduring enigma](#)

[Lecture 40 - Overview and conclusion](#)

- Lecture 1 - Vector analysis, Scalar and vector fields, vector identities
- Lecture 2 - Vector Analysis (Continued...)
- Lecture 3 - Use of Levi-Civita Symbol, Coordinate system
- Lecture 4 - Coordinate system, Orthogonal Transformation
- Lecture 5 - Spherical Coordinate system, Line, surface and volume element
- Lecture 6 - Line, surface and volume element (Continued...)
- Lecture 7 - Line, surface and volume integral
- Lecture 8 - Differential calculus, Gradient
- Lecture 9 - Gradient operator, Concept of divergence
- Lecture 10 - Divergence operator, Divergence Theorem
- Lecture 11 - Curl operator, Stokes Theorem
- Lecture 12 - Gradient, Divergence and Curl (A recap), Vector identities
- Lecture 13 - Curvilinear coordinate system
- Lecture 14 - Curvilinear coordinate system (Continued...)
- Lecture 15 - Curvilinear coordinate system (Continued...)
- Lecture 16 - Delta Function
- Lecture 17 - Delta Function (Continued...)
- Lecture 18 - Helmholtz's Theorem
- Lecture 19 - Helmholtz's Theorem(Recap), Tutorial
- Lecture 20 - Tutorial (Continued...)
- Lecture 21 - Concept of charge, Charge density
- Lecture 22 - Coulomb's Law
- Lecture 23 - Coulomb's Law (Continued...), Charge distribution
- Lecture 24 - Charge distribution problem, Gauss's Law
- Lecture 25 - Topics More on Gauss's Law
- Lecture 26 - Application of Gauss's Law
- Lecture 27 - Electrostatic potential
- Lecture 28 - Electrostatic potential (Continued...)
- Lecture 29 - Electrostatic energy
- Lecture 30 - Electrostatic energy (Continued...)
- Lecture 31 - Electrostatic energy calculation

- Lecture 32 - Electrostatic dipole
- Lecture 33 - Electric dipole (Continued...)
- Lecture 34 - Multipole expansion
- Lecture 35 - Monopole and Dipole moment
- Lecture 36 - Quadrupole moment
- Lecture 37 - Dipole and Quadrupole moment (Continued...)
- Lecture 38 - Conductor
- Lecture 39 - Conductor (Continued...)
- Lecture 40 - Boundary condition
- Lecture 41 - Electrostatic pressure, Capacitor
- Lecture 42 - Energy of the Capacitor, Dielectric
- Lecture 43 - Dielectric (Continued...)
- Lecture 44 - Displacement Vector
- Lecture 45 - Electrostatic boundary value problem
- Lecture 46 - Electrostatic boundary value problem (Continued...)
- Lecture 47 - Electrostatic boundary value problem (Continued...), Image method
- Lecture 48 - Image method (Continued...)
- Lecture 49 - Charge particle in magnetic field
- Lecture 50 - Biot-Savart Law
- Lecture 51 - Application of Biot-Savart Law
- Lecture 52 - Ampere's Law
- Lecture 53 - Application of Ampere's Law
- Lecture 54 - Magnetic vector potential
- Lecture 55 - Magnetic vector potential (Continued...)
- Lecture 56 - Magnetic dipole moment
- Lecture 57 - Magnetic dipole moment (Continued...)
- Lecture 58 - Torque and potential energy of magnetic dipole, Magnetization
- Lecture 59 - Bound Current
- Lecture 60 - Magnetic materials
- Lecture 61 - Electromagnetic Induction
- Lecture 62 - Self and mutual inductance
- Lecture 63 - Wave equation, Maxwell's Equation
- Lecture 64 - Maxwells Equation (Continued...)

[Lecture 65 - Maxwells Equation: a complete overview](#)

[Lecture 66 - Maxwells Equation: a complete overview \(Continued...\)](#)

[Lecture 67 - Lorentz Gauge, Maxwell's wave equation](#)

[Lecture 68 - Maxwell's wave equation \(Coninued...\)](#)

[Lecture 69 - Maxwell's Equation in matter](#)

[Lecture 70 - Maxwell's Equation in matter \(Continued...\)](#)

[Lecture 71 - Tutorial 2 \(Electrostatic\)](#)

[Lecture 72 - Tutorial 3 \(Magnetostatic\)](#)

[Lecture 73 - Tutorial 4 \(Magnetostatic and EM Wave\)](#)

Lecture 1 - Introduction to solid state materials - From conventional to functional

Lecture 2 - Ceramics and Composites - I

Lecture 3 - Ceramics and Composites - II

Lecture 4 - Polymers

Lecture 5 - Introduction to Nanomaterials and functionality

Lecture 6 - Synthesis protocols - I

Lecture 7 - Synthesis protocols - II

Lecture 8 - Synthesis protocols - III

Lecture 9 - Crystal structure - I

Lecture 10 - Crystal structure - II

Lecture 11 - Crystal structure - III

Lecture 12 - Crystal imperfections

Lecture 13 - Alloys and Melts

Lecture 14 - Theory of Solids

Lecture 15 - Nearly free electron model

Lecture 16 - Bonds in molecules and solids

Lecture 17 - Transformations kinetics and reaction rates

Lecture 18 - Thermodynamics

Lecture 19 - Phase and phase transitions

Lecture 20 - Diffusion and various properties

Lecture 21 - Mechanical properties of solids

Lecture 22 - Thermal Properties of Solids

Lecture 23 - Negative and Zero Expansion Ceramics

Lecture 24 - Heat Capacity

Lecture 25 - Thermogravimetric (TGA) analysis

Lecture 26 - Introduction to magnetism and Magnetic properties of solids

Lecture 27 - From magnetic to multiferroic materials

Lecture 28 - Magnetic materials and their applications

Lecture 29 - Magnetism at nanoscale

Lecture 30 - GMR materials

Lecture 31 - CMR materials

[Lecture 32 - Ferrofluids](#)

[Lecture 33 - Spintronics and devices](#)

[Lecture 34 - Introduction to the basic properties of liquids and melts](#)

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[Lecture 36 - Viscosity, electric and thermal conduction of liquids and melts](#)

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[Lecture 39 - Introduction to energy storage devices and basics of supercapacitors](#)

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[Lecture 50 - Summary](#)

Lecture 1 - Introduction to waves, 1D wave equation and its solutions

Lecture 2 - 1D Light waves

Lecture 3 - Characteristics of light waves - amplitude, absolute phase, wavelength and frequency

Lecture 4 - Phase, Phase velocity and Phase delay

Lecture 5 - Complex notation for the description light waves and superposition

Lecture 6 - Maxwell's equations to the 3D wave equation and its solutions

Lecture 7 - Recap of Week 1

Lecture 8 - 3D wave equation and plane waves

Lecture 9 - Complex notation for Electric fields, Superposition and interference

Lecture 10 - Fabry-Perot interferometer and its transmittance

Lecture 11 - Physical interpretation of FP transmittance

Lecture 12 - Recap of Fabry-Perot modes

Lecture 13 - Free spectral range of a Fabry-Perot etalon

Lecture 14 - Resonator modes and optical pulses - insight

Lecture 15 - Table - Top Coherent and Incoherent Imaging

Lecture 16 - Recap of Etalon free spectral range

Lecture 17 - Line width and finesse of an etalon

Lecture 18 - Actual resonator modes

Lecture 19 - Resonator configurations and stability

Lecture 20 - Recap of optical resonators

Lecture 21 - Introduction of light pulses

Lecture 22 - Complex amplitude, Gaussian pulse

Lecture 23 - Recap of light pulses

Lecture 24 - Introduction of Fourier Transforms

Lecture 25 - Tutorial 1

Lecture 26 - Motivating Fourier Transforms

Lecture 27 - Fourier Transform Properties

Lecture 28 - Frequency domain electric field

Lecture 29 - Recap of Fourier transform properties

Lecture 30 - Frequency domain description of pulses

Lecture 31 - Spectral Phase

- Lecture 32 - Recap of spectral phase
- Lecture 33 - Instantaneous Frequency and group delay
- Lecture 34 - Phase wrapping, blanking, and Taylor series expansion
- Lecture 35 - Recap of instantaneous frequency, phase wrapping, and phase blanking
- Lecture 36 - Frequency domain phase expansion, group delay dispersion
- Lecture 37 - Absolute Phase
- Lecture 38 - Recap of concepts + discussion
- Lecture 39 - Absolute Phase (revisited)
- Lecture 40 - Carrier envelope phase, frequency comb
- Lecture 41 - Discussion
- Lecture 42 - Recap of concepts
- Lecture 43 - First order phase
- Lecture 44 - Second order phase
- Lecture 45 - Recap of first order and second order phase
- Lecture 46 - Chirped pulse: Instantaneous frequency and Fourier transform
- Lecture 47 - Group delay, nonlinearly chirped pulse
- Lecture 48 - Recap of chirped pulses
- Lecture 49 - Quadratic chirp pulses
- Lecture 50 - Higher order spectral phase
- Lecture 51 - Recap and discussion on higher order phase
- Lecture 52 - Relative importance of intensity and phase
- Lecture 53 - Pulse propagation through a medium
- Lecture 54 - Recap of pulse propagation and pulse length
- Lecture 55 - Discussion of RMS pulse width and uncertainty principle
- Lecture 56 - Time-bandwidth product
- Lecture 57 - Recap of previous module
- Lecture 58 - Introduction of Lorentz Oscillator Model
- Lecture 59 - Effect of matter on light
- Lecture 60 - Recap of Lorentz oscillator, Polarization tensor
- Lecture 61 - Dynamics of electrons in the Lorentz oscillator
- Lecture 62 - Solving the inhomogeneous wave equation
- Lecture 63 - Inhomogeneous wave equation, absorption coefficient, refractive index
- Lecture 64 - Nonlinear response of matter

[Lecture 65 - Origin of nonlinear optical effects](#)

[Lecture 66 - Wave equation in an inert gas](#)

[Lecture 67 - Perturbation theory and second harmonics](#)

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[Lecture 69 - Atoms in the presence of fields](#)

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[Lecture 71 - Attosecond pulse generation and metrology](#)

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[Lecture 73 - Nonlinear response of matter to light](#)

[Lecture 74 - Sum and difference frequency generation](#)

[Lecture 75 - Recap of sum and difference frequency generation, second harmonic generation](#)

[Lecture 76 - Generalized nonlinear effects, conservation laws in SHG](#)

[Lecture 77 - Phase matching in SHG, polarization dependent refractive index](#)

Lecture 1 - Introduction

Lecture 2 - Introduction (Continued...)

Lecture 3 - Concept of wave, Wave Equation

Lecture 4 - Plane wave, Spherical wave

Lecture 5 - Maxwell's wave equation, Poynting Vector

Lecture 6 - Superposition of waves

Lecture 7 - Superposition of wave (Complex method)

Lecture 8 - Random and coherent source, standing wave formation

Lecture 9 - Group and Phase velocity

Lecture 10 - Material Dispersion

Lecture 11 - Material Dispersion (Continued...)

Lecture 12 - Concept of Coherence

Lecture 13 - Concept of Coherence (Continued...)

Lecture 14 - Concept of Coherence (Continued...)

Lecture 15 - Concept of Coherence (Continued...)

Lecture 16 - Two beam interference

Lecture 17 - Young's double slit experiment

Lecture 18 - Young's double slit experiment (Continued...)

Lecture 19 - Interference by division of amplitude

Lecture 20 - Interference by division of amplitude (Continued...)

Lecture 21 - Newton's Ring

Lecture 22 - Newton's Ring (Continued...)

Lecture 23 - Newton's Ring (Continued...)

Lecture 24 - Optical Interferometers

Lecture 25 - Michelson Interferometer

Lecture 26 - Multiple beam interference

Lecture 27 - Fabry-Perot Interferometer

Lecture 28 - Fabry-Perot Interferometer (Continued...)

Lecture 29 - Resolving power of Fabry-Perot interferometer

Lecture 30 - Diffraction of Light

Lecture 31 - Huygen's Theory

- Lecture 32 - Fraunhofer Diffraction
- Lecture 33 - Single-slit Diffraction
- Lecture 34 - Single-slit Diffraction (Continued...)
- Lecture 35 - Double-slit Diffraction
- Lecture 36 - Multi-slit Diffraction
- Lecture 37 - Multi-Slit Diffraction (Continued...)
- Lecture 38 - Grating spectra
- Lecture 39 - Grating spectra (Continued...)
- Lecture 40 - Resolving power of grating
- Lecture 41 - Fraunhofer diffraction for a circular aperture
- Lecture 42 - Fraunhofer diffraction for a rectangular aperture
- Lecture 43 - Fresnel Diffraction
- Lecture 44 - Fresnel's half period zone
- Lecture 45 - Fresnel's half period zone (Continued...)
- Lecture 46 - Zone Plate
- Lecture 47 - Fresnel's diffraction from an aperture
- Lecture 48 - Fresnel's diffraction for a circular aperture
- Lecture 49 - Fresnel's diffraction for a rectangular aperture
- Lecture 50 - Fresnel's diffraction for a rectangular aperture (Continued...)
- Lecture 51 - Fresnel's diffraction for semi-infinite opaque screen
- Lecture 52 - Polarization of light (Basic concept)
- Lecture 53 - Circularly polarized light
- Lecture 54 - Matrix treatment of polarization
- Lecture 55 - Jones Matrix for polarization
- Lecture 56 - Jones Matrix for polarization (Continued...)
- Lecture 57 - Jones Matrix for polarization (Continued...)
- Lecture 58 - Jones Matrix for polarization (Continued...)
- Lecture 59 - Jones matrix for polarization (Continued...)
- Lecture 60 - Production of polarized light
- Lecture 61 - Production of polarized light (Continued...)
- Lecture 62 - Birefringent Crystal
- Lecture 63 - Birefringent Crystal (Continued...)
- Lecture 64 - Index Ellipsoid

[Lecture 65 - Analyzing Polarised Light](#)

[Lecture 66 - Babinet Compensator](#)

NPTEL : Special Topics in Atomic Physics (Physics)

Co-ordinators : Prof. P.C. Deshmukh

Lecture 1 - Introductory lecture about this course

Lecture 2 - Quantum Mechanics and Symmetry of the Hydrogen Atom

Lecture 3 - Hydrogen atom: Rotational and Dynamical Symmetry of the $1/r$ Potential

Lecture 4 - Hydrogen atom: Dynamical Symmetry of the $1/r$ Potential

Lecture 5 - Degeneracy of the Hydrogen Atom: $SO(4)$

Lecture 6 - Wavefunctions of the Hydrogen Atom

Lecture 7 - Angular Momentum in Quantum Mechanics

Lecture 8 - Angular Momentum in Quantum Mechanics: half-odd-integer and integer quantum numbers: $SU(2)$ & $SO(3)$

Lecture 9 - Angular Momentum in Quantum Mechanics: Addition Theorem for Spherical Harmonics - Coupling of Angular Momenta

Lecture 10 - Angular Momentum in Quantum Mechanics Dimensionality of the Direct-Product (Composite) Vector Space CGC recursion relations

Lecture 11 - Angular Momentum in Quantum Mechanics CGC matrix, Wigner D Rotation Matrix, Irreducible Tensor Operators

Lecture 12 - Angular Momentum in Quantum Mechanics - more on ITO, and the Wigner-Eckart Theorem

Lecture 13 - Angular Momentum in Quantum Mechanics Wigner-Eckart Theorem - 2

Lecture 14 - Relativistic Quantum Mechanics of the Hydrogen Atom - 1

Lecture 15 - Relativistic Quantum Mechanics of the Hydrogen Atom - 2

Lecture 16 - Relativistic Quantum Mechanics of the Hydrogen Atom - PAULI Equation - Foldy - Wouthysen Transformations - 1

Lecture 17 - Relativistic Quantum Mechanics of the Hydrogen Atom - Foldy - Wouthysen Transformations - 2

Lecture 18 - Relativistic Quantum Mechanics of the Hydrogen Atom - Foldy - Wouthysen Transformations - 3

Lecture 19 - Relativistic Quantum Mechanics of the Hydrogen Atom - Spherical Symmetry of the Coulomb Potential

Lecture 20 - Hartree-Fock Self-Consistent Field formalism - 1

Lecture 21 - Hartree-Fock Self-Consistent Field formalism - 2

Lecture 22 - Hartree-Fock Self-Consistent Field formalism - 3

Lecture 23 - Hartree-Fock Self-Consistent Field formalism - 4

Lecture 24 - Hartree-Fock Self-Consistent Field formalism - 5

Lecture 25 - Perturbative treatment of relativistic effects | Schrodinger's and Dirac QM

Lecture 26 - Perturbative treatment of relativistic effects | Schrodinger's and Dirac QM

Lecture 27 - Probing the atom - Collisions and Spectroscopy - boundary conditions - 1

Lecture 28 - Atomic Probes - Collisions and Spectroscopy - boundary conditions - 2

Lecture 29 - Atomic Probes - Collisions and Spectroscopy - Scattering phase shifts and boundary conditions

Lecture 30 - Atomic Probes - Time reversal symmetry - applications in atomic collisions and photoionization processes

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[Lecture 31 - Atomic Photoionization cross sections, angular distributions of photoelectrons - 1](#)

[Lecture 32 - Atomic Photoionization cross sections, angular distributions of photoelectrons - 2](#)

[Lecture 33 - Atomic Photoionization cross sections, angular distributions of photoelectrons - 3](#)

[Lecture 34 - Atomic Photoionization cross sections, angular distributions of photoelectrons - 4](#)

[Lecture 35 - Atomic Photoionization cross sections, angular distributions of photoelectrons Cooper Zare Formula](#)

[Lecture 36 - Stark- Zeeman Spectroscopy - Stark effect](#)

[Lecture 37 - Stark- Zeeman Spectroscopy - Stark effect on \$n=2\$ excited state of the H atom Zeeman effect](#)

[Lecture 38 - Stark- Zeeman Spectroscopy - Normal, Anomalous Zeeman effect; Paschen- Back effect](#)

[Lecture 39 - Stark- Zeeman Spectroscopy - Anomalous Zeeman effect](#)

[Lecture 40 - Zeeman effect Fine structure, Hyperfine structure - Elemental, rudimentary introduction to Laser Cooling, BEC, Atomic Clock / Attosecond metrology](#)

Lecture 1 - What is Classical Field Theory?

Lecture 2 - Symmetries and Invariances - I

Lecture 3 - Symmetries and Invariances - II

Lecture 4 - Group Theory in Physics - I

Lecture 5 - Group Theory in Physics - II

Lecture 6 - Finite Groups - I

Lecture 7 - Finite Groups - II

Lecture 8 - Basics of CFT - I

Lecture 9 - Basics of CFT - II

Lecture 10 - Basics of CFT - III

Lecture 11 - Green Functions - I

Lecture 12 - Green Functions - II

Lecture 13 - Noether's Theorem - I

Lecture 14 - Noether's Theorem - II

Lecture 15 - Kink Soliton

Lecture 16 - Hidden Symmetry

Lecture 17 - Local Symmetries

Lecture 18 - The Abelian Higgs model

Lecture 19 - Lie Algebras - I

Lecture 20 - Lie Algebras - II

Lecture 21 - Magnetic Vortices - I

Lecture 22 - Magnetic Vortices - II

Lecture 23 - Non-abelian gauge theories - I

Lecture 24 - Non-abelian gauge theories - II

Lecture 25 - Irreps of Lie algebras - I

Lecture 26 - Irreps of Lie algebras - II

Lecture 27 - The Standard Model - I

Lecture 28 - The Standard Model - II

Lecture 29 - Irreps of the Lorentz/Poincare algebras

Lecture 30 - The Dirac monopole

Lecture 31 - The 't Hooft-Polyakov monopole

[Lecture 32 - Revisiting Derrick's Theorem](#)

[Lecture 33 - The Julia-Zee dyon](#)

[Lecture 34 - Instantons - I](#)

[Lecture 35 - Instantons - II](#)

[Lecture 36 - Instantons - III](#)

[Lecture 37 - Instantons - IV](#)

[Lecture 38 - Dualities](#)

[Lecture 39 - Geometrization of Field Theory](#)

NPTEL : Topics in Nonlinear Dynamics (Physics)

Co-ordinators : Prof. V. Balakrishnan

Lecture 1 - Overview

Lecture 2 - Critical points of a dynamical system

Lecture 3 - Two-dimensional flows

Lecture 4 - Stable and unstable manifolds

Lecture 5 - Hamiltonian dynamics - Part I

Lecture 6 - Hamiltonian dynamics - Part II

Lecture 7 - Hamiltonian dynamics - Part III

Lecture 8 - Hamiltonian dynamics - Part IV

Lecture 9 - Hamiltonian dynamics - Part V

Lecture 10 - Elementary bifurcations

Lecture 11 - Limit cycles

Lecture 12 - Poincaré index

Lecture 13 - Illustrative examples

Lecture 14 - Quiz 1. Questions and answers

Lecture 15 - Bead on a rotating hoop

Lecture 16 - Types of dynamical behaviour

Lecture 17 - Discrete time dynamics - Part I

Lecture 18 - Discrete time dynamics - Part II

Lecture 19 - Discrete time dynamics - Part III

Lecture 20 - Discrete time dynamics - Part IV

Lecture 21 - Coarse-grained dynamics in phase space - Part I

Lecture 22 - Coarse-grained dynamics in phase space - Part II & Stochastic dynamics - Part I

Lecture 23 - Stochastic dynamics - Part II

Lecture 24 - Stochastic dynamics - Part III

Lecture 25 - Coarse-grained dynamics in phase space - Part IV & Stochastic dynamics - Part IV

Lecture 26 - Discrete time dynamics - Part V

Lecture 27 - Quiz 2. Questions and answers

Lecture 28 - Stochastic dynamics - Part V

Lecture 29 - Stochastic dynamics - Part VI

NPTEL : Condensed Matter Physics (Physics)

Co-ordinators : Prof. G. Rangarajan

Lecture 1 - Principles of Condensed Matter Physics

Lecture 2 - Symmetry in Perfect Solids

Lecture 3 - Symmetry in Perfect Solids (Continued...)

Lecture 4 - Symmetry in Perfect Solids - Worked Examples

Lecture 5 - Diffraction Methods For Crystal Structures

Lecture 6 - Diffraction Methods For Crystal Structures (Continued...)

Lecture 7 - Diffraction Methods For Crystal Structures - Worked Examples

Lecture 8 - Physical Properties of Crystals

Lecture 9 - Physical Properties of Crystals (Continued...)

Lecture 10 - Physical Properties of Crystals - Worked Examples

Lecture 11 - Cohesion in Solids

Lecture 12 - Cohesion in Solids - Worked Examples

Lecture 13 - The Free Electron Theory of Metals

Lecture 14 - The Free Electron Theory of Metals - Worked Examples

Lecture 15 - The Free Electron Theory of Metals - Electrical Conductivity

Lecture 16 - The Free Electron Theory of Metals - Electrical Conductivity - Worked Examples

Lecture 17 - Thermal Conductivity of Metals

Lecture 18 - Thermal Conductivity of Metals - Worked Examples

Lecture 19 - The Concept of Phonons

Lecture 20 - Debye Theory of Specific Heat, Lattice Vibrations

Lecture 21 - Debye Theory of Specific Heat, Lattice Vibrations - Worked Examples

Lecture 22 - Lattice Vibrations (Continued) Phonon thermal conductivity

Lecture 23 - Lattice Vibrations (Continued) Phonon Thermal Conductivity - Worked Examples

Lecture 24 - Anharmonicity and Thermal Expansion

Lecture 25 - Dielectric (Insulating) Solids

Lecture 26 - Dispersion and Absorption of Electromagnetic Waves in Dielectric Media, Ferro-and Antiferroelectrics

Lecture 27 - Optical Properties of Metals; Ionic Polarization in Alkali Halides; Piezoelectricity

Lecture 28 - Dielectric Solids - Worked Examples

Lecture 29 - Dia - and Paramagnetism

Lecture 30 - Paramagnetism of Transition Metal and Rare Earth Ions

Lecture 31 - Quenching of Orbital Angular Momentum; Ferromagnetism

- Lecture 32 - Exchange Interactions, Magnetic Order, Neutron Diffraction
- Lecture 33 - Hysteresis and Magnetic Domains; Spin Waves and Magnons
- Lecture 34 - Magnetic Resonance
- Lecture 35 - Magnetism and Magnetic Resonance - Worked Examples
- Lecture 36 - Magnetism - Worked Examples (Continued...)
- Lecture 37 - Pauli Paramagnetism and Landau Diamagnetism
- Lecture 38 - Band Magnetism; Itinerant Electrons; Stoner Model
- Lecture 39 - Superconductivity - Perfect Electrical Conductivity and Perfect Diamagnetism
- Lecture 40 - Type I and Type II Superconductors
- Lecture 41 - Ginsburg - Landau Theory, Flux Quantization
- Lecture 42 - Cooper Pairs
- Lecture 43 - Microscopic (BCS) Theory of Superconductivity
- Lecture 44 - BCS Theory (Continued...): Josephson Tunneling: Quantum Interference
- Lecture 45 - Josephson Effect (Continued...); High Temperature Superconductors
- Lecture 46 - Superconductors - Worked Examples
- Lecture 47 - Energy Bands in Solids
- Lecture 48 - Electron Dynamics in a Periodic Solid
- Lecture 49 - Semiconductors
- Lecture 50 - Semiconductors (Continued...)
- Lecture 51 - Semiconductors - Worked Examples
- Lecture 52 - Defects in Solids - Point Defects
- Lecture 53 - Point Defects in Solids - Worked Examples
- Lecture 54 - Defects in Solids - Line and Surface Defects
- Lecture 55 - Dislocations in Solids - Worked Examples
- Lecture 56 - Quantum Fluids and Quantum Solids
- Lecture 57 - Quantum Liquids and Quantum Solids - Worked Examples
- Lecture 58 - Epilogue

NPTEL : Quantum Field Theory (Physics)

Co-ordinators : Dr. Prasanta Tripathy

Lecture 1 - Introduction

Lecture 2 - Introduction to Classical Field Theory

Lecture 3 - Quantization of Real Scalar Field - I

Lecture 4 - Quantization of Real Scalar Field - II

Lecture 5 - Quantization of Real Scalar Field - III

Lecture 6 - Quantization of Real Scalar Field - IV

Lecture 7 - Quantization of Complex Scalar Field

Lecture 8 - Interacting Field Theory - I

Lecture 9 - Interacting Field Theory - II

Lecture 10 - Interacting Field Theory - III

Lecture 11 - Interacting Field Theory - IV

Lecture 12 - Interacting Field Theory - V

Lecture 13 - Interacting Field Theory - VI

Lecture 14 - Interacting Field Theory - VII

Lecture 15 - Quantization of Electromagnetic Field - I

Lecture 16 - Quantization of Electromagnetic Field - II

Lecture 17 - Fermion Quantization - I

Lecture 18 - Fermion Quantization - II

Lecture 19 - Fermion Quantization - III

Lecture 20 - Fermion Quantization - IV

Lecture 21 - Fermion Quantization - V

Lecture 22 - Fermion Quantization - VI

Lecture 23 - The S-Matrix Expansion in QED - I

Lecture 24 - The S-Matrix Expansion in QED - II

Lecture 25 - Feynman Rules in QED - I

Lecture 26 - Feynman Rules in QED - II

Lecture 27 - Compton Scattering - I

Lecture 28 - Compton Scattering - II

Lecture 29 - Compton Scattering - III

Lecture 30 - Moller Scattering - I

Lecture 31 - Moller Scattering - II

[Lecture 32 - Vertex Correction - I](#)

[Lecture 33 - Vertex Correction - II](#)

[Lecture 34 - Vertex Correction - III](#)

[Lecture 35 - Vertex Correction - IV](#)

[Lecture 36 - Electron Selfenergy](#)

[Lecture 37 - Photon Selfenergy - I](#)

[Lecture 38 - Photon Selfenergy - II](#)

NPTEL : Quantum Mechanics I (Physics)

Co-ordinators : Prof. S. Lakshmi Bala

- Lecture 1 - Quantum Mechanics " An Introduction
- Lecture 2 - Linear Vector Spaces - I
- Lecture 3 - Linear Vector Spaces - II: The two-level atom
- Lecture 4 - Linear Vector Spaces - III: The three-level atom
- Lecture 5 - Postulates of Quantum Mechanics - I
- Lecture 6 - Postulates of Quantum Mechanics - II
- Lecture 7 - The Uncertainty Principle
- Lecture 8 - The Linear Harmonic Oscillator
- Lecture 9 - Introducing Quantum Optics
- Lecture 10 - An Interesting Quantum Superposition: The Coherent State
- Lecture 11 - The Displacement and Squeezing Operators
- Lecture 12 - Exercises in Finite Dimensional Linear Vector Spaces
- Lecture 13 - Exercises on Angular Momentum Operators and their algebra
- Lecture 14 - Exercises on Quantum Expectation Values
- Lecture 15 - Composite Systems
- Lecture 16 - The Quantum Beam Splitter
- Lecture 17 - Addition of Angular Momenta - I
- Lecture 18 - Addition of Angular Momenta - II
- Lecture 19 - Addition of Angular Momenta - III
- Lecture 20 - Infinite Dimensional Linear Vector Spaces
- Lecture 21 - Square-Integrable Functions
- Lecture 22 - Ingredients of Wave Mechanics
- Lecture 23 - The Schrodinger equation
- Lecture 24 - Wave Mechanics of the Simple Harmonic Oscillator
- Lecture 25 - One-Dimensional Square Well Potential: The Bound State Problem
- Lecture 26 - The Square Well and the Square Potential Barrier
- Lecture 27 - The Particle in a one-dimensional Box
- Lecture 28 - A Charged Particle in a Uniform Magnetic Field
- Lecture 29 - The Wavefunction: Its Single-valuedness and its Phase
- Lecture 30 - The Central Potential
- Lecture 31 - The Spherical Harmonics

[Lecture 32 - Central Potential: The Radial Equation](#)

[Lecture 33 - Illustrative Exercises - I](#)

[Lecture 34 - Illustrative Exercises - II](#)

[Lecture 35 - Ehrenfest's Theorem](#)

[Lecture 36 - Perturbation Theory - I](#)

[Lecture 37 - Perturbation Theory - II](#)

[Lecture 38 - Perturbation Theory - III](#)

[Lecture 39 - Perturbation Theory - IV](#)

[Lecture 40 - Time-dependent Hamiltonians](#)

[Lecture 41 - The Jaynes-Cummings model](#)

Lecture 1 - Course Overview

Lecture 2 - Equations of Motion (i)

Lecture 3 - Equations of Motion (ii)

Lecture 4 - Equations of Motion (iii)

Lecture 5 - Equations of Motion (iv)

Lecture 6 - Equations of Motion (v)

Lecture 7 - Oscillators, Resonances, Waves (i)

Lecture 8 - Oscillators, Resonances, Waves (ii)

Lecture 9 - Oscillators, Resonances, Waves (iii)

Lecture 10 - Oscillators, Resonances, Waves (iv)

Lecture 11 - Polar Coordinates (i)

Lecture 12 - Polar Coordinates (ii)

Lecture 13 - Dynamical Symmetry in the Kepler Problem (i)

Lecture 14 - Dynamical Symmetry in the Kepler Problem (ii)

Lecture 15 - Real Effects of Pseudo-Forces (i)

Lecture 16 - Real Effects of Pseudo-Forces (ii)

Lecture 17 - Real Effects of Pseudo-Forces (iii)

Lecture 18 - Real Effects of Pseudo-Forces (iv)

Lecture 19 - Special Theory of Relativity (i)

Lecture 20 - Special Theory of Relativity (ii)

Lecture 21 - Special Theory of Relativity (iii)

Lecture 22 - Special Theory of Relativity (iv)

Lecture 23 - Potentials Gradients Fields (i)

Lecture 24 - Potentials Gradients Fields (ii)

Lecture 25 - Potentials Gradients Fields (iii)

Lecture 26 - Gauss Law Eq of continuity (i)

Lecture 27 - Gauss Law Eq of continuity (ii)

Lecture 28 - Gauss Law Eq of continuity (iii)

Lecture 29 - Fluid Flow Bernoulli Principle (i)

Lecture 30 - Fluid Flow Bernoulli Principle (ii)

Lecture 31 - Classical Electrodynamics (i)

[Lecture 32 - Classical Electrodynamics \(ii\)](#)

[Lecture 33 - Classical Electrodynamics \(iii\)](#)

[Lecture 34 - Classical Electrodynamics \(iv\)](#)

[Lecture 35 - Chaotic Dynamical Systems \(i\)](#)

[Lecture 36 - Chaotic Dynamical Systems \(ii\)](#)

[Lecture 37 - Chaotic Dynamical Systems \(iii\)](#)

[Lecture 38 - Chaotic Dynamical Systems \(iv\)](#)

[Lecture 39 - Chaotic Dynamical Systems \(v\)](#)

[Lecture 40 - The Scope and Limitations of Classical Mechanics](#)

Lecture 1 - Introduction to the STiTACS course

Lecture 2 - Quantum Theory of collisions

Lecture 3 - Quantum Theory of collisions: optical Theorem

Lecture 4 - Quantum Theory of collisions: Optical Theorem (Continued...)

Lecture 5 - Quantum Theory of collisions: Differential scattering cross section

Lecture 6 - Quantum Theory of collisions: Differential scattering cross section, Partial wave analysis

Lecture 7 - Quantum Theory of collisions: Optical Theorem \hat{A} – Unitarity of the Scattering Operator

Lecture 8 - Quantum Theory of collisions: Reciprocity Theorem, Phase shift analysis

Lecture 9 - Quantum Theory of collisions: More on Phase shift analysis

Lecture 10 - Quantum Theory of collisions: resonant condition in the l th partial wave.

Lecture 11 - Quantum Theory of collisions: Levinson's theorem

Lecture 12 - Quantum Theory of collisions: Levinson's theorem (Continued...)

Lecture 13 - Many body theory, electron correlations

Lecture 14 - Second Quantization Creation, Destruction and Number operators

Lecture 15 - Many-particle Hamiltonian & Schrodinger Equation in 2nd Quantization

Lecture 16 - Many-electron problem in quantum mechanics

Lecture 17 - Hartree-Fock Self-Consistent-Field

Lecture 18 - Exchange, Statistical, Fermi-Dirac correlations

Lecture 19 - Limitations of the Hartree-Fock Self-Consistent-Field formalism

Lecture 20 - Many-Body formalism, II Quantization

Lecture 21 - Density fluctuations in an electron gas

Lecture 22 - Bohm-Pines approach to Random Phase Approximation

Lecture 23 - Bohm-Pines approach to Random Phase Approximation (Continued...)

Lecture 24 - Bohm-Pines approach to Random Phase Approximation (Continued...)

Lecture 25 - Schrodinger, Heisenberg and Dirac \hat{A} “pictures” of QM

Lecture 26 - Dyson's chronological operator

Lecture 27 - Gell-Mann-Low Theorem

Lecture 28 - Reyleigh-Schrodinger perturbation methods and adiabatic switching

Lecture 29 - Feynman Diagrams

Lecture 30 - I Order Feynman Diagrams

Lecture 31 - II and higher order Feynman Diagrams

[Lecture 32 - Linear response of electron correlations](#)

[Lecture 33 - Lippman Schwinger equation of potential scattering](#)

[Lecture 34 - Born Approximation](#)

[Lecture 35 - Coulomb scattering](#)

[Lecture 36 - Scattering of partial waves](#)

[Lecture 37 - Scattering at high energy](#)

[Lecture 38 - Resonances in Quantum Collisions](#)

[Lecture 39 - Breit-Wigner Resonances](#)

[Lecture 40 - Fano parameterization of Breit-Wigner formula](#)

[Lecture 41 - Discrete state embedded in the continuum](#)

[Lecture 42 - Resonance life times](#)

[Lecture 43 - Wigner-Eisenbud formalism of time-delay in scattering](#)

[Lecture 44 - Photoionization and Photoelectron Angular Distributions](#)

[Lecture 45 - Ionization and Excitation of Atoms by Fast Charged Particles](#)

[Lecture 46 - Photo-absorption by Free and Confined Atoms and Ions: Recent Developments](#)

- Lecture 1 - Analytic functions of a complex variable - Part I
- Lecture 2 - Analytic functions of a complex variable - Part II
- Lecture 3 - Calculus of residues - Part I
- Lecture 4 - Calculus of residues - Part II
- Lecture 5 - Calculus of residues - Part III
- Lecture 6 - Calculus of residues - Part IV
- Lecture 7 - Linear response; dispersion relations - Part I
- Lecture 8 - Linear response; dispersion relations - Part II
- Lecture 9 - Analytic continuation and the gamma function - Part I
- Lecture 10 - Analytic continuation and the gamma function - Part II
- Lecture 11 - Möbius transformations - Part I
- Lecture 12 - Möbius transformations - Part II
- Lecture 13 - Möbius transformations - Part III
- Lecture 14 - Multivalued functions; integral representations - Part I
- Lecture 15 - Multivalued functions; integral representations - Part II
- Lecture 16 - Multivalued functions; integral representations - Part III
- Lecture 17 - Multivalued functions; integral representations - Part IV
- Lecture 18 - Laplace transforms - Part I
- Lecture 19 - Laplace transforms - Part II
- Lecture 20 - Fourier transforms - Part I
- Lecture 21 - Fourier transforms - Part II
- Lecture 22 - Fourier transforms - Part III
- Lecture 23 - Fundamental Green function for \hat{p}^2 - Part I
- Lecture 24 - Fundamental Green function for \hat{p}^2 - Part II
- Lecture 25 - The diffusion equation - Part I
- Lecture 26 - The diffusion equation - Part II
- Lecture 27 - The diffusion equation - Part III
- Lecture 28 - The diffusion equation - Part IV
- Lecture 29 - Green function for $(\hat{p}^2 + k^2)$; nonrelativistic scattering - Part I
- Lecture 30 - Green function for $(\hat{p}^2 + k^2)$; nonrelativistic scattering - Part II
- Lecture 31 - Green function for $(\hat{p}^2 + k^2)$; nonrelativistic scattering - Part III

[Lecture 32 - The wave equation - Part I](#)

[Lecture 33 - The wave equation - Part II](#)

[Lecture 34 - The rotation group and all that - Part I](#)

[Lecture 35 - The rotation group and all that - Part II](#)

[Lecture 36 - The rotation group and all that - Part III](#)

NPTEL : Nuclear Reactors and Safety - An Introduction (Physics)

Co-ordinators : Dr.G.Vaidyanathan

- Lecture 1 - Energy Sources
- Lecture 2 - Nuclear Power Production Cycle
- Lecture 3 - Basic Physics of Nuclear Fission
- Lecture 4 - Basic Physics of Nuclear Fission (Continued...)
- Lecture 5 - Nuclear Reactors
- Lecture 6 - Reactors Generation
- Lecture 7 - Radiation Sources and Protection
- Lecture 8 - Biological Effects of Radiation
- Lecture 9 - Safety Principles
- Lecture 10 - Safety Principles (Continued...)
- Lecture 11 - Safety Approach
- Lecture 12 - Risk and Probabilistic safety analysis (PSA)
- Lecture 13 - History of Events in Nuclear Power Plants and Radiation facilities
- Lecture 14 - Other Events
- Lecture 15 - Validation and Dynamic Analysis
- Lecture 16 - Validation and Dynamic Analysis (Continued...)
- Lecture 17 - Quality Assurance
- Lecture 18 - Siting of Nuclear Plants
- Lecture 19 - Siting of Nuclear Plants (Continued...)
- Lecture 20 - Engineered Safety Systems
- Lecture 21 - Engineered Safety Systems (Continued...)
- Lecture 22 - Assessment of Radiological Consequences of Incidents
- Lecture 23 - Safety Regulation in India
- Lecture 24 - Safety Regulation in India (Continued...)
- Lecture 25 - Safety Regulation in India (Continued...)
- Lecture 26 - Safety Practices in Indian NPPs
- Lecture 27 - Safety Practices in Indian NPPs (Continued...)
- Lecture 28 - Safety Practices in Indian NPPs (Continued...)
- Lecture 29 - Passive Safety
- Lecture 30 - Passive Safety (Continued...)

NPTEL : Physical Applications of Stochastic Processes (Physics)

Co-ordinators : Prof. V. Balakrishnan

- Lecture 1 - Discrete probability distributions - Part 1
- Lecture 2 - Discrete probability distributions - Part 2
- Lecture 3 - Continuous random variables
- Lecture 4 - Central Limit Theorem
- Lecture 5 - Stable distributions
- Lecture 6 - Stochastic processes
- Lecture 7 - Markov processes - Part 1
- Lecture 8 - Markov processes - Part 2
- Lecture 9 - Markov processes - Part 3
- Lecture 10 - Birth-and-death processes
- Lecture 11 - Continuous Markov processes
- Lecture 12 - Langevin dynamics - Part 1
- Lecture 13 - Langevin dynamics - Part 2
- Lecture 14 - Langevin dynamics - Part 3
- Lecture 15 - Langevin dynamics - Part 4
- Lecture 16 - Itô and Fokker-Planck equations for diffusion processes
- Lecture 17 - Level-crossing statistics of a continuous random process
- Lecture 18 - Diffusion of a charged particle in a magnetic field
- Lecture 19 - Power spectrum of noise
- Lecture 20 - Elements of linear response theory
- Lecture 21 - Random pulse sequences
- Lecture 22 - Dichotomous diffusion
- Lecture 23 - First passage time (Part 1)
- Lecture 24 - First passage time (Part 2)
- Lecture 25 - First passage and recurrence in Markov chains
- Lecture 26 - Recurrent and transient random walks
- Lecture 27 - Non-Markovian random walks
- Lecture 28 - Statistical aspects of deterministic dynamics (Part 1)
- Lecture 29 - Statistical aspects of deterministic dynamics (Part 2)

Lecture 1 - The Nature of Physical Laws

Lecture 2 - Fundamental Constants and Dimensional Analysis

Lecture 3 - Dimensional analysis and scaling

Lecture 4 - sketching Elementary Functions

Lecture 5 - The fundamental forces of nature

Lecture 6 - Scalars, Vectors and All That

Lecture 7 - Plane Polar Coordinates

Lecture 8 - Vectors In a Plane, Scalars and Pseudoscalars

Lecture 9 - Kinematics In a Plane

Lecture 10 - Vectors in 3-Dimensional Space

Lecture 11 - Vectors in 3-Dimensional space (Continued...)

Lecture 12 - The Finite Rotation Formula, Polar Coordinates in 3-dimensions

Lecture 13 - Cylindrical and Spherical polar coordinates

Lecture 14 - Motion in a circle - Acceleration

Lecture 15 - Newtons laws of motion

Lecture 16 - Conservation Laws and Newtons Equations

Lecture 17 - Conservation of Angular Momentum

Lecture 18 - Two-Body Scattering

Lecture 19 - Two-Body Collision Kinematics

Lecture 20 - Conservative Forces - The Concept of a Potential

Lecture 21 - Central Potential and Central Force

Lecture 22 - The 2-Body Central Force Problem

Lecture 23 - Keplers Laws of Planetary Motion

Lecture 24 - Non-Inertial Forces (Pseudo-forces)

Lecture 25 - More on the Kepler problem; Satellite motion

Lecture 26 - Linear Elasticity of Solids

Lecture 27 - Simple Harmonic Motion

Lecture 28 - Some Physical Examples of Simple Harmonic Motion

Lecture 29 - More on Simple Harmonic Motion

Lecture 30 - Damped Simple Harmonic Motion

Lecture 31 - Wave Motion - Travelling and Standing Waves

[Lecture 32 - Wave Motion - Wave Equation, General Solution](#)

[Lecture 33 - Fluid Dynamics - Hydrostatic Equilibrium](#)

[Lecture 34 - Fluid Dynamics - Equation of Continuity](#)

[Lecture 35 - Fluid Flow - Bernoulli's Principle](#)

[Lecture 36 - Circulation and Vorticity](#)

[Lecture 37 - What is Thermodynamics?](#)

[Lecture 38 - The Classical Ideal Gas](#)

[Lecture 39 - The Laws of Thermodynamics](#)

[Lecture 40 - Specific Heat of an Ideal Gas](#)

[Lecture 41 - Van der Waals Equation](#)

[Lecture 42 - Phase Transitions](#)

[Lecture 43 - Summary](#)

Lecture 1 - Recapitulation of equilibrium statistical mechanics

Lecture 2 - The Langevin model (Part 1)

Lecture 3 - The Langevin model (Part 2)

Lecture 4 - The Langevin model (Part 3)

Lecture 5 - The Langevin model (Part 4)

Lecture 6 - Linear response theory (Part 1)

Lecture 7 - Linear response theory (Part 2)

Lecture 8 - Linear response (Part 3)

Lecture 9 - Linear response(Part 4)

Lecture 10 - Linear response (Part 5)

Lecture 11 - Linear response (Part 6)

Lecture 12 - Linear response theory (Part 7)

Lecture 13 - Quiz 1 - Questions and answers

Lecture 14 - Linear response theory (Part 8)

Lecture 15 - Linear response theory (Part 9)

Lecture 16 - The dynamic mobility

Lecture 17 - Fokker-Planck equations (Part 1)

Lecture 18 - Fokker-Planck equations (Part 2)

Lecture 19 - Fokker-Planck equations (Part 3)

Lecture 20 - The generalized Langevin equation (Part 1)

Lecture 21 - The generalized Langevin equation (Part 2)

Lecture 22 - Diffusion in a magnetic field

Lecture 23 - The Boltzmann equation for a dilute gas (Part 1)

Lecture 24 - The Boltzmann equation for a dilute gas (Part 2)

Lecture 25 - The Boltzmann equation for a dilute gas (Part 3)

Lecture 26 - The Boltzmann equation for a dilute gas (Part 4)

Lecture 27 - The Boltzmann equation for a dilute gas (Part 5)

Lecture 28 - Quiz 2 - Questions and answers

Lecture 29 - Critical phenomena (Part 1)

Lecture 30 - Critical phenomena (Part 2)

Lecture 31 - Critical phenomena (Part 3)

[Lecture 32 - Critical phenomena \(Part 4\)](#)

[Lecture 33 - Critical phenomena \(Part 5\)](#)

[Lecture 34 - Critical phenomena \(Part 6\)](#)

[Lecture 35 - Critical phenomena \(Part 7\)](#)

[Lecture 36 - The Wiener process \(standard Brownian motion\)](#)

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Lecture 2 - Continuous Probability

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Lecture 32 - Collisions in daily life - application of energy and momentum balance principles

Lecture 33 - Collision at micro-meter, atomic and sub-atomic scales - Brownian motion, Compton effect

Lecture 34 - Concepts necessary for translation and rotation of rigid bodies - centre of mass

Lecture 35 - Centre of mass of composite objects

Lecture 36 - Concepts necessary for translation and rotation of rigid bodies - moment of inertia

Lecture 37 - More on moment of inertia - 3D objects, composite objects, engineering applications

Lecture 38 - Symmetry of mass distribution - product of inertia

Lecture 39 - Determining the principal axes of rotation and moment of inertia about them

Lecture 40 - Example of finding principal axes, introduction to rotation, the angular velocity vector

Lecture 41 - Rotation of rigid bodies - the angular momentum vector

Lecture 42 - Rotation of rigid bodies - torque

Lecture 43 - Translation and rotation of rigid bodies - computing rules

Lecture 44 - Translation and rotation of rigid bodies - examples (rolling, collision with rotation)

- Lecture 1 - Introduction to Plasma - I
- Lecture 2 - Introduction to Plasma - II
- Lecture 3 - Plasma Oscillations
- Lecture 4 - Debye Shielding
- Lecture 5 - Debye Potential - I
- Lecture 6 - Debye Potential - II
- Lecture 7 - Debye Length and Plasma Criteria
- Lecture 8 - More Aspects of Debye Shielding
- Lecture 9 - Numerical Problems on Debye Shielding - I
- Lecture 10 - Plasma as a Gas and Distribution of Velocities
- Lecture 11 - Numerical Problems on Debye Shielding - II
- Lecture 12 - Single-Particle Motion in Uniform Electric Field
- Lecture 13 - Single-Particle Motion in Uniform Magnetic Field - I
- Lecture 14 - Single-Particle Motion in Uniform Magnetic Field - II
- Lecture 15 - Single-Particle Motion in Uniform Magnetic Field - III
- Lecture 16 - Single-Particle Motion Under Uniform Magnetic field - IV
- Lecture 17 - Motion in Perpendicular Electric and Magnetic fields - I
- Lecture 18 - Motion in Perpendicular Electric and Magnetic fields - II
- Lecture 19 - Gradient Drift
- Lecture 20 - Gradient and Curvature Drifts
- Lecture 21 - Vacuum Drift
- Lecture 22 - Numerical Problems on Drifts
- Lecture 23 - Magnetic Mirroring - I
- Lecture 24 - Magnetic Mirroring - II
- Lecture 25 - Magnetic Mirroring - III
- Lecture 26 - Magnetic Mirroring - IV
- Lecture 27 - Motion in Time Varying Magnetic Field - I
- Lecture 28 - Motion in Time Varying Magnetic Field - II
- Lecture 29 - Motion in Time Varying Electric field - I
- Lecture 30 - Motion in Time Varying Electric field - II
- Lecture 31 - Plasma as a Fluid: Equation of Continuity

- Lecture 32 - Plasma as a Fluid: Fluid Equation - I
- Lecture 33 - Plasma as a Fluid: Fluid Equation - II
- Lecture 34 - Plasma as a fluid: Governing Equations
- Lecture 35 - MHD Approximation - I
- Lecture 36 - MHD Approximation - II
- Lecture 37 - Plasma as a fluid: Electric and Magnetic Properties - I
- Lecture 38 - Plasma as a fluid: Electric and Magnetic Properties - II
- Lecture 39 - Plasma as a fluid: Fluid Drift - I
- Lecture 40 - Plasma as a fluid: Fluid Drift - II
- Lecture 41 - Magnetic Pressure
- Lecture 42 - Wave in Plasma: Perturbation Theory
- Lecture 43 - Wave in Plasma: Plasma Oscillation
- Lecture 44 - Wave in Plasma: Dispersion Relation
- Lecture 45 - Ion Acoustic Wave - I
- Lecture 46 - Ion Acoustic Wave - II
- Lecture 47 - Ion Acoustic Wave - III
- Lecture 48 - Invalidity of Plasma Approximation - I
- Lecture 49 - Invalidity of Plasma Approximation - II
- Lecture 50 - Electromagnetic Waves in Plasma
- Lecture 51 - Collisions and Diffusion in Plasma - I
- Lecture 52 - Collisions and Diffusion in Plasma - II
- Lecture 53 - Ambipolar Diffusion - I
- Lecture 54 - Ambipolar Diffusion - II
- Lecture 55 - Diffusion Equation
- Lecture 56 - Diffusion in Presence of B - I
- Lecture 57 - Diffusion in Presence of B - II
- Lecture 58 - Instabilities in Plasma
- Lecture 59 - Laser Produced Plasma and Pulsed Laser Deposited (PLD) Thin Film - I
- Lecture 60 - Laser Produced Plasma and Pulsed Laser Deposited (PLD) Thin Film - II
- Lecture 61 - Surface Modification of Metallic Components by Plasma Nitriding - I
- Lecture 62 - Surface Modification of Metallic Components by Plasma Nitriding - II

NPTEL : Relativistic Quantum Mechanics (Physics)

Co-ordinators : Prof. Apoorva D Patel

Lecture 1 - Introduction, The Klein-Gordon equation

Lecture 2 - Particles and antiparticles, Two component framework

Lecture 3 - Coupling to electromagnetism, Solution of the Coulomb problem

Lecture 4 - Bohr-Sommerfeld semiclassical solution of the Coulomb problem, The Dirac equation and the Clifford algebra

Lecture 5 - Dirac matrices, Covariant form of the Dirac equation, Equations of motion, Spin, Free particle solutions

Lecture 6 - Electromagnetic interactions, Gyromagnetic ratio

Lecture 7 - The Hydrogen atom problem, Symmetries, Parity, Separation of variables

Lecture 8 - The Frobenius method solution, Energy levels and wavefunctions

Lecture 9 - Non-relativistic reduction, The Foldy-Wouthuysen transformation

Lecture 10 - Interpretation of relativistic corrections, Reflection from a potential barrier

Lecture 11 - The Klein paradox, Pair creation process and examples

Lecture 12 - Zitterbewegung, Hole theory and antiparticles

Lecture 13 - Charge conjugation symmetry, Chirality, Projection operators, The Weyl equation

Lecture 14 - Weyl and Majorana representations of the Dirac equation, Unitary and antiunitary symmetries

Lecture 15 - Time reversal symmetry, The PCT invariance

Lecture 16 - Arrow of time and particle-antiparticle asymmetry, Band theory for graphene

Lecture 17 - Dirac equation structure of low energy graphene states, Relativistic signatures in graphene properties

Lecture 18 - Groups and symmetries, The Lorentz and Poincare groups

Lecture 19 - Group representations, generators and algebra, Translations, rotations and boosts

Lecture 20 - The spinor representation of $SL(2,C)$, The spin-statistics theorem

Lecture 21 - Finite dimensional representations of the Lorentz group, Euclidean and Galilean groups

Lecture 22 - Classification of one particle states, The little group, Mass, spin and helicity

Lecture 23 - Massive and massless one particle states

Lecture 24 - P and T transformations, Lorentz covariance of spinors

Lecture 25 - Lorentz group classification of Dirac operators, Orthogonality and completeness of Dirac spinors, Projection operators

Lecture 26 - Propagator theory, Non-relativistic case and causality

Lecture 27 - Relativistic case, Particle and antiparticle contributions, Feynman prescription and the propagator

Lecture 28 - Interactions and formal perturbative theory, The S-matrix and Feynman diagrams

Lecture 29 - Trace theorems for products of Dirac matrices

Lecture 30 - Photons and the gauge symmetry

Lecture 31 - Abelian local gauge symmetry, The covariant derivative and invariants

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Lecture 32 - Charge quantisation, Photon propagator, Current conservation and polarisations

Lecture 33 - Feynman rules for Quantum Electrodynamics, Nature of perturbative expansion

Lecture 34 - Dyson's analysis of the perturbation series, Singularities of the S-matrix, Elementary QED processes

Lecture 35 - The T-matrix, Coulomb scattering

Lecture 36 - Mott cross-section, Compton scattering

Lecture 37 - Klein-Nishina result for cross-section

Lecture 38 - Photon polarisation sums, Pair production through annihilation

Lecture 39 - Unpolarised and polarised cross-sections

Lecture 40 - Helicity properties, Bound state formation

Lecture 41 - Bound state decay, Non-relativistic potentials

Lecture 42 - Lagrangian formulation of QED, Divergences in Green's functions, Superficially divergent 1-loop diagrams and regularisation

Lecture 43 - Infrared divergences due to massless particles, Renormalisation and finite physical results

Lecture 44 - Symmetry constraints on Green's functions, Furry's theorem, Ward-Takahashi identity, Spontaneous breaking of gauge symmetry and superconductivity

Lecture 45 - Status of QED, Organisation of perturbative expansion, Precision tests

Lecture 1 - Introduction

Lecture 2 - Linear Systems

Lecture 3 - Homogeneous linear time invariant ordinary differential equations

Lecture 4 - In-homogeneous linear time invariant ordinary differential equations

Lecture 5 - Fourier transforms - Part 1

Lecture 6 - Fourier transforms - Part 2

Lecture 7 - Laplace transforms - Part 1

Lecture 8 - Laplace transforms - Part 2

Lecture 9 - Introduction to feedback control - Part 1

Lecture 10 - Introduction to feedback control - Part 2

Lecture 11 - Nyquist stability theory - Part 1

Lecture 12 - Nyquist stability theory - Part 2

Lecture 13 - Nyquist stability theory - Part 3

Lecture 14 - Bode plots

Lecture 15 - Steps for performing control design - Part 1

Lecture 16 - Steps for performing control design - Part 2

Lecture 17 - General controllers - Part 1

Lecture 18 - General controllers - Part 2

Lecture 19 - General controllers - Part 3

Lecture 20 - Bode plot-based control design - Part 1

Lecture 21 - Bode plot-based control design - Part 2

Lecture 22 - Introduction to root-locus

Lecture 23 - Control system design using root-locus

Lecture 24 - Control of systems with some known parameters - Part 1

Lecture 25 - Control of systems with some known parameters - Part 2

Lecture 26 - Limitations of 1-degree of freedom control

Lecture 27 - Introduction to 2-degree of freedom control

Lecture 28 - 2-Degree of freedom robust control design for plants with gain uncertainty - Part 1

Lecture 29 - 2-Degree of freedom robust control design for plants with uncertain gain - Part 2

Lecture 30 - 2-Degree of freedom robust control design for plants with uncertain pole

Lecture 31 - 2-Degree of freedom robust control design for plants with multiple uncertainties in their structure

Lecture 32 - Issues connected with 2-Degree of freedom control design using root-locus

Lecture 33 - Introduction to Nichols plot

Lecture 34 - Feedback control design using Nichols plot

Lecture 35 - Robust control design using Quantitative feedback theory - Part 1

Lecture 36 - Robust control design using Quantitative feedback theory - Part 2

Lecture 37 - Tutorial on QFT Toolbox software - Part 1

Lecture 38 - Tutorial on QFT Toolbox software - Part 2

Lecture 39 - Tutorial on QFT Toolbox software - Part 3

Lecture 40 - Fundamental properties of the loop gain - Part 1

Lecture 41 - Fundamental properties of the loop gain - Part 2

Lecture 42 - Ideal Bode Characteristic - Part 1

Lecture 43 - Ideal Bode Characteristic - Part 2

Lecture 44 - Introduction to nonminimum phase systems

Lecture 45 - Fundamental properties of nonminimum phase systems - Part 1

Lecture 46 - Fundamental properties of nonminimum phase systems - Part 2

Lecture 47 - Fundamental properties of unstable systems

Lecture 48 - Consequences of actuator bandwidth limitations while controlling unstable systems

Lecture 49 - Describing functions - Part 1

Lecture 50 - Describing functions - Part 2

- Lecture 1 - Born-Oppenheimer approximation
- Lecture 2 - Self-consistent field (SCF) method
- Lecture 3 - Simple MO Theory of Hydrogen Molecule
- Lecture 4 - Bloch's theorem
- Lecture 5 - Tight binding approximation
- Lecture 6 - Energy band theory - 1
- Lecture 7 - Energy band theory - 2
- Lecture 8 - Density of states
- Lecture 9 - Energy band theory - 3
- Lecture 10 - Energy band theory - 4
- Lecture 11 - Drude's classical free electron model - 1
- Lecture 12 - Drude's classical free electron model - 2
- Lecture 13 - Drude's classical free electron model - 3
- Lecture 14 - Drude's classical free electron model - 4
- Lecture 15 - Sommerfeld's quantum free electron model
- Lecture 16 - Specific heat of Fermi gas
- Lecture 17 - Energy dispersion relation in a periodic potential - 1
- Lecture 18 - Energy dispersion relation in a periodic potential - 2
- Lecture 19 - Brief overview of space groups and constant energy surface in 2D
- Lecture 20 - Energy band and effective mass
- Lecture 21 - Effective mass
- Lecture 22 - $k \cdot p$ perturbation method
- Lecture 23 - Revisiting Bloch's theorem and tight binding functions
- Lecture 24 - Symmetries in crystal Hamiltonian - 1
- Lecture 25 - Symmetries in crystal Hamiltonian - 2
- Lecture 26 - Tight binding method - 1
- Lecture 27 - Tight binding method - 2
- Lecture 28 - Tight binding method - 3
- Lecture 29 - Plane wave method
- Lecture 30 - Pseudo potential method
- Lecture 31 - Cellular method of energy band calculation

- Lecture 32 - Muffin tin potential and APW functions
- Lecture 33 - Augmented plane wave method of energy band calculation - 1
- Lecture 34 - Augmented plane wave method of energy band calculation - 2
- Lecture 35 - Greenâ€™s function method of energy band calculation - 1
- Lecture 36 - Greenâ€™s function method of energy band calculation - 2
- Lecture 37 - Cyclotron resonance technique
- Lecture 38 - De Haas-van Alphen effect
- Lecture 39 - De Haas-van Alphen effect conclusion.Introduction to point impurity effect on band structure
- Lecture 40 - Point impurity in crystal
- Lecture 41 - Friedel Oscillations
- Lecture 42 - Lindhard dielectric constant
- Lecture 43 - Dielectric anomaly. Crystal momentum
- Lecture 44 - Spatial and time reversal symmetries in crystals
- Lecture 45 - Time reversal symmetry (Continued...)
- Lecture 46 - Spin orbit interaction
- Lecture 47 - Disordered solids and transport in disordered solids
- Lecture 48 - Optical properties of semiconductors
- Lecture 49 - Excitonic states in semiconductors
- Lecture 50 - Excitonic states in semiconductors (Continued...)
- Lecture 51 - Molecular orbital calculation - I
- Lecture 52 - Mott-Hubbard transition
- Lecture 53 - Hubbard model
- Lecture 54 - Electron repulsion and magnetic exchange
- Lecture 55 - Beyond on-site electron repulsions;Pariser-Parr-Pople model
- Lecture 56 - Electron-hole symmetry and Pairing theorem. Solitons
- Lecture 57 - Density waves in 1-d systems and Lattice vibrations - I
- Lecture 58 - Lattice vibrations - II
- Lecture 59 - Lattice vibrations - III
- Lecture 60 - Lattice vibrations - IV

Lecture 1 - Introduction to NMR

Lecture 2 - NMR concepts and spin physics - I

Lecture 3 - NMR concepts and spin physics - II

Lecture 4 - Internal interaction parameters and chemical shifts

Lecture 5 - Chemical shifts

Lecture 6 - Scalar couplings

Lecture 7 - Multiplicity patterns of coupled spins and analysis of ^1H NMR spectrum

Lecture 8 - Multiplicity pattern and analysis of NMR spectra - II

Lecture 9 - Analysis of NMR spectra and their analysis

Lecture 10 - Heteronuclear NMR

Lecture 11 - Introduction to Fourier series

Lecture 12 - Complex form of Fourier series

Lecture 13 - Fourier theorems

Lecture 14 - Fourier transformation in NMR

Lecture 15 - Pople notation, construction of spin Hamiltonian

Lecture 16 - Quantum mechanical analysis of AX spectra

Lecture 17 - Quantum mechanical analysis of AB spin system

Lecture 18 - Quantum mechanical analysis of coupled spin systems

Lecture 19 - RF pulses and their phases

Lecture 20 - Receiver phase and phase cycling

Lecture 21 - Evolution of chemical shift

Lecture 22 - Evolution of J couplings: polarization transfer

Lecture 23 - selective saturation in homo and heteronuclear spin systems, coupled and decoupled INEPT

Lecture 24 - INEPT and DEPT

Lecture 25 - Coherence transfer pathway

Lecture 26 - Examples of coherence pathway selection

Lecture 27 - Pulse field gradients - I

Lecture 28 - Pulse field gradients - II

Lecture 29 - Selective excitation, selective inversion

Lecture 30 - Relaxation phenomenon

Lecture 31 - T1 relaxation concepts and measurements

- Lecture 32 - Spectral density function and relaxation mechanisms
- Lecture 33 - T1 Relaxation mechanisms
- Lecture 34 - T1 Relaxation mechanisms and T2 relaxation
- Lecture 35 - Measurement of T1 and T2
- Lecture 36 - Decoupling and NOE concepts
- Lecture 37 - DQ and ZQ relaxation pathways
- Lecture 38 - Positive and Negative NOE and spectral density functions
- Lecture 39 - NOE and correlation time
- Lecture 40 - Product operators
- Lecture 41 - Product operator analysis
- Lecture 42 - Product operator analysis of pulse sequences
- Lecture 43 - Product operators for two J coupled spins
- Lecture 44 - Spin echo sequences
- Lecture 45 - Introduction to 2D NMR
- Lecture 46 - 2D NMR concepts, 2D experiments
- Lecture 47 - 2D COSY experiment
- Lecture 48 - 2D COSY and its variants
- Lecture 49 - TOCSY Heteronuclear 2D experiments
- Lecture 50 - coupled and decoupled HSQC, HMBC, INADEQUATE, 2D Jresolved
- Lecture 51 - Introduction to multiple quantum NMR
- Lecture 52 - DQ and ZQ of coupled spins
- Lecture 53 - MQ and relative signs of couplings
- Lecture 54 - MQ and spin system filtering
- Lecture 55 - Introduction to solid state NMR
- Lecture 56 - CSA and dipolar couplings
- Lecture 57 - Magic Angle Spinning
- Lecture 58 - WAHUHA and Cross Polarization
- Lecture 59 - Cross Polarization
- Lecture 60 - CP at high speeds, Side band suppression, TOSS