

- 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( $Q, \tilde{\Delta}^\circ$ ). Introducing experimental facilities

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

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

Lecture 14 - Correlation function to resolution and accessible( $Q, \tilde{\Delta}^\circ$ ). 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 \(Continued...\)](#)

[Lecture 37 - Operational Amplifiers](#)

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

[Lecture 39 - Summing Amplifiers](#)

[Lecture 40 - Frequency response of an integration](#)

[Lecture 41 - Filters](#)

[Lecture 42 - Specification of OP Amplifiers](#)



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](#)

[Lecture 39 - Diffusion in magnetized plasma](#)

[Lecture 40 - Surface plasma wave](#)

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

[Lecture 42 - Current trends and epilogue](#)

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](#)

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](#)



- Lecture 1 - Context, Scope and Contents of the Course
- 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
- Lecture 12 - Strained-Layer Epitaxy and Quantum Well Structures
- Lecture 13 - Bandgap Engineering
- Lecture 14 - Heterostructure p-n junctions
- Lecture 15 - Schottky Junctions and Ohmic Contacts
- Lecture 16 - Fabrication of Heterostructure Devices
- Lecture 17 - Interaction of Photons with Electrons and Holes in a Semiconductor
- Lecture 18 - Optical Joint Density of States, and Probabilities of Emission and Absorption
- Lecture 19 - Rates of Emission and Absorption
- Lecture 20 - Amplification by Stimulated Emission
- Lecture 21 - The Semiconductor (Laser) Amplifier
- Lecture 22 - Absorption Spectrum of Semiconductors
- Lecture 23 - Gain and Absorption Spectrum of Quantum Well Structures
- Lecture 24 - Electro-absorption Modulator-I Principle of Operation
- Lecture 25 - Electro-absorption Modulator-II Device Configuration
- Lecture 26 - Injection Electroluminescence
- Lecture 27 - Light emitting diode-I Device structure and parameters
- Lecture 28 - Light emitting diode-II Device Characteristics
- Lecture 29 - Light emitting diode-III Output Characteristics
- Lecture 30 - Light emitting diode-IV Modulation Bandwidth
- Lecture 31 - Light emitting diode-V Material and Applications

[Lecture 32 - Laser Basics](#)

[Lecture 33 - Semiconductor Laser-I Device Structure](#)

[Lecture 34 - Semiconductor Laser-II Output Characteristics](#)

[Lecture 35 - Semiconductor Laser-III Single Frequency Lasers](#)

[Lecture 36 - Vertical cavity Surface Emitting Laser \(VCSEL\)](#)

[Lecture 37 - Quantum Well Laser](#)

[Lecture 38 - Practical Laser Diodes and Handling](#)

[Lecture 39 - General Characteristics of Photodetectors](#)

[Lecture 40 - Responsivity and Impulse Response](#)

[Lecture 41 - Photoconductors](#)

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

[Lecture 43 - Semiconductor Photo-Diodes-II: APD](#)

[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

[Lecture 32 - Methods of Mode Locking](#)

[Lecture 33 - Some Common Lasers](#)

[Lecture 34 - Fiber Lasers](#)

[Lecture 35 - Semiconductor Lasers](#)

[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](#)

[Lecture 34 - Interacting charged fermions - 2](#)

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

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

[Lecture 37 - Scattering Cross Section Revisited - 2](#)

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

[Lecture 39 - Weak Interactions - 2](#)

[Lecture 40 - Lagrangian Framework](#)

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

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

[Lecture 43 - Electroweak Theory - 2](#)

[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](#)

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
- Lecture 28 - Pure dephasing and Dissipative Bloch Equations
- Lecture 29 - Derivation of Fermi-Golden Rule
- Lecture 30 - Introduction to Cavity Optomechanics;Fabry-Perot Cavity
- Lecture 31 - Cavity Optomechanics: Basic Physics - I

[Lecture 32 - Problem Solving Session - 7](#)

[Lecture 33 - Cavity Optomechanics: Basic Physics - II](#)

[Lecture 34 - Classical Regime - I](#)

[Lecture 35 - Classical Regime - II; Classical Langevin Equation](#)

[Lecture 36 - Problem Solving Session - 8](#)

[Lecture 37 - Langevin Equation](#)

[Lecture 38 - Quantum Langevin Noise](#)

[Lecture 39 - Problem Solving Session - 9](#)

[Lecture 40 - Input-Output Relation](#)

[Lecture 41 - Cavity Quantum Optomechanics](#)

[Lecture 42 - Linearized Cavity Optomechanics; Ground state cooling](#)

[Lecture 43 - Normal-Mode Splitting](#)

[Lecture 44 - Quantum Optomechanics: Squeezed States](#)

- Lecture 1 - Introduction
- Lecture 2 - Lagrangian Formalism
- Lecture 3 - Hamiltonian Mechanics
- Lecture 4 - Flows and Symmetries
- Lecture 5 - Examples of Continuum Systems
- Lecture 6 - Symmetries and Noether's Theorem
- Lecture 7 - Dynamical Symmetries
- Lecture 8 - Symmetries in Field Theories
- Lecture 9 - The Relativistic Electromagnetic Field
- Lecture 10 - Stress-Energy (Energy-Momentum) Tensor
- Lecture 11 - Green's Theorem and Green's Functions
- Lecture 12 - Diffraction Theory
- Lecture 13 - Introduction to Elasticity Theory
- Lecture 14 - Solution of the rubber band problem
- Lecture 15 - The Stress Function Method
- Lecture 16 - Strain Energy
- Lecture 17 - The Euler Equation
- Lecture 18 - Bernoulli's Principle
- Lecture 19 - Matter, Momentum and Energy Transport
- Lecture 20 - Stokes' Drag - I
- Lecture 21 - Stokes' Drag - II
- Lecture 22 - Towards Quantum Fields
- Lecture 23 - Right and Left Movers
- Lecture 24 - Functional Integration - I
- Lecture 25 - Functional Integration - II
- Lecture 26 - Perturbation theory
- Lecture 27 - Quantum Mechanics using Lagrangians
- Lecture 28 - Path Integrals - Formalism
- Lecture 29 - Path Integrals - Free particles
- Lecture 30 - Path Integrals - Harmonic oscillator
- Lecture 31 - Creation and annihilation operators - Excitations

[Lecture 32 - Creation and annihilation operators - Photons](#)

[Lecture 33 - Creation and annihilation operators - Many-body physics](#)

[Lecture 34 - Particle and Hole Green functions](#)

[Lecture 35 - Current Algebra](#)

[Lecture 36 - Tight Binding Models - I](#)

[Lecture 37 - Tight Binding Models - II](#)

[Lecture 38 - Order Parameters](#)

[Lecture 39 - Schrieffer Wolff Transformation](#)

[Lecture 40 - Matsubara Green functions - I](#)

[Lecture 41 - Matsubara Green functions - II](#)

[Lecture 42 - Self Energy and Spectral Functions](#)

[Lecture 43 - S-Matrix Perturbation Theory](#)

[Lecture 44 - Keldysh Contour](#)

[Lecture 45 - Bosonic Coherent States](#)

[Lecture 46 - Fermionic Coherent States](#)

[Lecture 47 - Nonlocal particle hole operators - Bosons](#)

[Lecture 48 - Nonlocal particle hole operators - Fermions](#)

Lecture 1 - Conductance in Nanostructures

Lecture 2 - S-Matrix, Reflection and Transmission

Lecture 3 - Introduction to Classical and Quantum Hall Effect

Lecture 4 - Quantum Hall Effect

Lecture 5 - Landau Levels

Lecture 6 - Degenracy of Landau levels

Lecture 7 - Shubnikov de Haas Oscillations

Lecture 8 - Kubo Formula

Lecture 9 - Symmetric gauge

Lecture 10 - Tight binding model, Hofstadter Butterfly

Lecture 11 - Topological Invariant, Chern number

Lecture 12 - Electronic structure of Graphene

Lecture 13 - Low energy Dispersion

Lecture 14 - Dirac Hamiltonian, Hofstadter Butterfly

Lecture 15 - QHE, Landau Levels

Lecture 16 - Properties of Spin angular Momentum, Spin Hall Effect

Lecture 17 - Quantum spin Hall insulator, Kene-Mele Model

Lecture 18 - Kene-Mele Model

Lecture 19 - Landau gauge in fractional quantum Hall effect

Lecture 20 - Laughlin States, Properties

Lecture 21 - Plasma analogy

Lecture 22 - Composite Fermions, Hierarchy

[Lecture 1 - Brief Overview of the course](#)

[Lecture 2 - Nuclear Size](#)

[Lecture 3 - Nuclear Size \(Continued...\)](#)

[Lecture 4 - Nuclear Size \(Continued...\)](#)

[Lecture 5 - Semi empirical Mass Formula](#)

[Lecture 6 - Semi empirical Mass Formula \(Continued...\)](#)

[Lecture 7 - Semi empirical Mass Formula \(Continued...\)](#)

[Lecture 8 - Semi empirical Mass Formula \(Continued...\)](#)

[Lecture 9 - Semi empirical Mass Formula \(Continued...\)](#)

[Lecture 10 - How are Neutron stars bound](#)

[Lecture 11 - Deuteron](#)

[Lecture 12 - Deuteron \(Continued...\)](#)

[Lecture 13 - Deuteron \(Continued...\)](#)

[Lecture 14 - Scattering of nucleons](#)

[Lecture 15 - Low energy n-p scattering](#)

[Lecture 16 - Theories of nuclear forces](#)

[Lecture 17 - Shell model](#)

[Lecture 18 - Shell model \(Continued...\)](#)

[Lecture 19 - Shell model \(Continued...\)](#)

[Lecture 20 - Shell model \(Continued...\)](#)

[Lecture 21 - Shell model \(Continued...\)](#)

[Lecture 22 - Collective models](#)

[Lecture 23 - Vibrational and Rotational levels](#)

[Lecture 24 - Radioactivity, Alpha Decay](#)

[Lecture 25 - Alpha decay \(Continued...\)](#)

[Lecture 26 - Beta decay](#)

[Lecture 27 - Beta decay \(Continued...\)](#)

[Lecture 28 - Beta decay \(Continued...\)](#)

[Lecture 29 - Gamma decay](#)

[Lecture 30 - Nuclear Reactions](#)

[Lecture 31 - Nuclear reaction \(Continued...\)](#)

[Lecture 32 - Nuclear reaction \(Continued...\)](#)

[Lecture 33 - Nuclear Fission basics](#)

[Lecture 34 - Nuclear fission of uranium](#)

[Lecture 35 - Nuclear Fission Reactor](#)

[Lecture 36 - Nuclear Energy Programme of India](#)

[Lecture 37 - Nuclear Fusion](#)

[Lecture 38 - Nuclear fusion \(Continued...\)](#)

[Lecture 39 - Thermonuclear fusion reactors](#)

[Lecture 40 - Fusion reactions in Stars and stellar neutrinos](#)

[Lecture 41 - Nucleosynthesis of elements in Stars](#)

[Lecture 42 - Mossbauer Spectroscopy](#)

[Lecture 43 - RBS, PIXE, NAA, Summary](#)

Lecture 1 - Coloumb's Law

Lecture 2 - Coloumb's Force due to several Point charges

Lecture 3 - Force due to distribution of Charges

Lecture 4 - What is an Electric Field?

Lecture 5 - Electric Field due to a Charged Distribution

Lecture 6 - Helmholtz's Theorem for Electric Field

Lecture 7 - Divergence of a Field

Lecture 8 - Divergence of Electric Field & Gauss's Law

Lecture 9 - Curl Of a Field - I

Lecture 10 - Curl of a Field - II & Stokes' Theorem

Lecture 11 - Line surface area & volume elements in Cartesian & Cylindrical Coordinates

Lecture 12 - Line surface area & volume elements in Spherical Polar Coordinates

Lecture 13 - Examples of application of the divergence and stokes' theorems

Lecture 14 - Electrostatic Potential

Lecture 15 - Electric field as the gradient of electrostatic potential

Lecture 16 - Laplace's and Poisson's equations for electrostatic potential

Lecture 17 - Electrostatic potential due to a charge distribution - I; a line charge of finite length

Lecture 18 - Electrostatic potential due to a charge distribution - II;a ring and a spherical shell of charge

Lecture 19 - Uniqueness of the solution of Laplace's and Poisson's equations

Lecture 20 - Method of images I: point charge in front of a grounded metallic plane - I

Lecture 21 - Method of imagesII: point charge in front of a grounded metallic plane and grounded metal sphere

Lecture 22 - Laplaces equations in some other physical phenomena

Lecture 23 - Energy of a charge distribution - I

Lecture 24 - Energy of a charge distribution - II An example

Lecture 25 - Energy of a charge distribution - III Energy density in terms of electric field

Lecture 26 - Electric field and potential in a conductor

Lecture 27 - Reciprocity theorem for conductors - I

Lecture 28 - Reciprocity theorem for conductors - II

Lecture 29 - Electric polarization and bound charges - I

Lecture 30 - Electric polarization and bound charges - II

Lecture 31 - Electric Displacement



Lecture 32 - Electrostatics in presence of Dielectric Materials - I

Lecture 33 - Electrostatics in presence of Dielectric Materials - II

Lecture 34 - Introduction to Magnetostatics; The BiO-Savart law

Lecture 35 - Divergence and curl of Magnetic Field

Lecture 36 - Amperes law for Magnetic Fields

Lecture 37 - Vector Potential for Magnetic Fields

Lecture 38 - Calculation of Vector Potential for a given magnetic field

Lecture 39 - Equation for the Vector Potential in terms of current density

Lecture 40 - Vector potential from Current Densities - I

Lecture 41 - Vector potential from Current Densities - II

Lecture 42 - Magnetic Materials - I

Lecture 43 - Magnetic Materials - II Bound Current Densities

Lecture 44 - The Auxiliary Field - H

Lecture 45 - Solving for Magnetic Field of a magnet - I

Lecture 46 - Solving for Magnetic Field of a magnet in presence of Magnetic Materials

Lecture 47 - Faradays Law

Lecture 48 - Induced Electric field due to changing Magnetic Field

Lecture 49 - Demonstrations on faradays law, Lenzs law and Nonconservative nature of Induced electric field

Lecture 50 - Energy stored in a magnetic Field-I

Lecture 51 - Energy stored in a magnetic Field-I;solved examples

Lecture 52 - Displacement Current

Lecture 53 - Quasistatic approximation

Lecture 54 - Energy transport by electromagnetic fields; The Poynting Vector

Lecture 55 - The Poynting Vector;solved examples

Lecture 56 - Linear Momentum and Angular Momentum carried by Electromagnetic Fields

Lecture 57

Lecture 58

Lecture 59

Lecture 60

Lecture 61

Lecture 62

Lecture 63

Lecture 64

[Lecture 65](#)

[Lecture 66 - Solution Assignment 1 - Problems 1 to 3](#)

[Lecture 67 - Solution Assignment 1 - Problems 4 to 9](#)

[Lecture 68 - Solution Assignment 2 - Problems 1 to 4](#)

[Lecture 69 - Solution Assignment 2 - Problems 5 to 11](#)

[Lecture 70 - Solution Assignment 3 - Problems 1 to 5](#)

[Lecture 71 - Solution Assignment 3 - Problems 6 to 10](#)

[Lecture 72 - Solution Assignment 4- Problems 1 to 5](#)

[Lecture 73 - Solution Assignment 4- Problems 6 to 10](#)

[Lecture 74 - Solution Assignment 5- Problems 6 to 11](#)

[Lecture 75 - Solution Assignment 5- Problems 1to 5](#)

[Lecture 76 - Solution Assignment 6- Problems 1 to 4](#)

[Lecture 77 - Solution Assignment 6- Problems 5 to 8](#)

[Lecture 78 - Solution Problem Set 7](#)

Lecture 1 - Introduction to Vectors

Lecture 2 - Addition and subtraction of vectors

Lecture 3 - Multiplying vectors

Lecture 4 - Introduction to vectors: solved examples - I

Lecture 5 - Transformation of vectors under rotation

Lecture 6 - Vector products and their geometric interpretation

Lecture 7 - Vector Product: Kronecker Delta and Levi-Civita symbols - I

Lecture 8 - Vector Product: Kronecker Delta and Levi-Civita symbols - II

Lecture 9 - Introduction to vectors: solved examples - II

Lecture 10 - Equilibrium of rigid bodies  $\hat{A}$ – Forces and torques

Lecture 11 - Calculating torques and couple moments - I

Lecture 12 - Calculating torques and couple moments - II

Lecture 13 - Finding a force and a couple equivalent to an applied force

Lecture 14 - Different elements and associated forces and torques - I

Lecture 15 - Different elements and associated forces and torques - II

Lecture 16 - Solved examples; equilibrium of bodies  $\hat{A}$ – I

Lecture 17 - Solved examples; equilibrium of bodies  $\hat{A}$ – II

Lecture 18 - Forces in different geometric configuration

Lecture 19 - Plane trusses I - building a truss and condition for it to be statically determinate

Lecture 20 - Plane trusses II - calculating forces in a simple truss and different types of trusses

Lecture 21 - Plane trusses III - calculating forces in a simple truss by method of joints

Lecture 22 - Plane trusses IV- Solved examples for calculating forces in a simple truss by method of joints

Lecture 23 - Plane trusses V - Solved examples for calculating forces in a simple truss by method of joints

Lecture 24 - Plane trusses VI - method of sections for calculating forces in a simple truss

Lecture 25 - Dry friction I - introduction with an example

Lecture 26 - Dry friction II - a solved example

Lecture 27 - Dry friction III - Dry thrust bearing and belt friction with demonstration

Lecture 28 - Dry friction IV - Screw friction and rolling friction

Lecture 29 - Dry friction V - Solved examples

Lecture 30 - Properties of plane surfaces I - First moment and centroid of an area

Lecture 31 - Properties of plane surfaces II - Centroid of an area made by joining several plane surfaces

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- Lecture 32 - Properties of plane surfaces III - Centroid of a distributed force and its relation with centre of gravity
- Lecture 33 - Properties of plane surfaces IV - solved examples of calculation of first moment and centroid of distributed forces
- Lecture 34 - Properties of plane surfaces V- Second moment and product of an area and radius of gyration
- Lecture 35 - Properties of plane surfaces VI - Parallel axis transfer theorem for second moment and product of an area
- Lecture 36 - Properties of plane surfaces VII - transformation of second moment and product of an area under rotation of coordinate axes
- Lecture 37 - Properties of plane surfaces VIII - second moment and product of an area, solved examples
- Lecture 38 - Method of virtual work I - degrees of freedom, constraints and constraint forces
- Lecture 39 - Method of virtual work II - virtual displacement, virtual work and equilibrium condition in terms of virtual work
- Lecture 40 - Method of virtual work III - solved examples
- Lecture 41 - Motion of a particle in a plane in terms of planar polar coordinates
- Lecture 42 - Planar polar coordinates: solved examples
- Lecture 43 - Description of motion in cylindrical and spherical coordinate systems
- Lecture 44 - Using planar polar, cylindrical and spherical coordinate systems: solved examples
- Lecture 45 - Motion with constraints, constraint forces and free body diagram
- Lecture 46 - Motion with constraints  $\hat{A}$ - solved examples
- Lecture 47 - Motion with dry friction  $\hat{A}$ - solved examples
- Lecture 48 - Motion with drag  $\hat{A}$ - solved examples
- Lecture 49 - Equation of motion in terms of linear momentum and the principle of conservation of linear momentum
- Lecture 50 - Linear momentum and centre of mass
- Lecture 51 - Momentum transfer, impulse and force due to a stream of particles hitting an object
- Lecture 52 - Momentum and the variable mass problem
- Lecture 53 - Linear momentum  $\hat{A}$ - solved examples
- Lecture 54 - Work and energy I - work energy theorem; conservative and non-conservative force fields
- Lecture 55 - Work and energy II - Definition of potential energy for conservative forces; total mechanical energy and the principle of conservation of energy
- Lecture 56 - Work and energy III - Two solved examples using conservation principles
- Lecture 57 - Work and energy IV  $\hat{A}$ - Further discussion on potential energy
- Lecture 58 - Work and energy V - Solved examples
- Lecture 59 - Work and energy VI  $\hat{A}$ - Applying conservation principles to solve a collision problem
- Lecture 60 - Work and energy VII - Solved examples
- Lecture 61 - Rigid body motion I - degrees of freedom and number of variables required to describe motion of a rigid body
- Lecture 62 - Rigid body motion II - Equation of motion for a single particle in terms of angular momentum and torque; motion of a conical pendulum

# DIGIMAT - The No.1 Autonomous Learning Platform for Creative Learning

Lecture 63 - Rigid body motion III - Conservation of angular momentum; angular momentum for a collection of particles

Lecture 64 - Rigid body motion IV - applying angular momentum conservation, a solved example

Lecture 65 - Rigid body motion V (fixed axis rotation) - some demonstrations of conservation of angular momentum about fixed axis

Lecture 66 - Rigid body motion VI (fixed axis rotation) - Some more demonstrations and related problems

Lecture 67 - Rigid body motion VII (fixed axis rotation) - Kinetic energy and moment of inertia for fixed axis rotation and some solved examples

Lecture 68 - Rigid body motion VIII (fixed axis rotation) - solved examples for calculating moment of inertia and conservation of angular momentum

Lecture 69 - Rigid body motion IX (fixed axis rotation) - solved examples

Lecture 70 - Rigid body motion X - rotation and translation with axis moving parallel to itself

Lecture 71 - Rigid body motion XI - solved examples for rotation and translation with axis moving parallel to itself

Lecture 72 - Rigid-body dynamics XII - Some demonstrations on general motion of rigid bodies

Lecture 73 - Rigid-body dynamics XIII - Infinitesimal angles as vector quantities and change of a vector when rotated by an infinitesimal angle

Lecture 74 - Rigid-body dynamics XIV - Angular velocity and the rate of change of a rotating vector; relating change in angular velocity to an applied torque

Lecture 75 - Rigid-body dynamics XV - Relationship between angular momentum and angular velocity  $\hat{A}$ – the moment of inertia tensor and the principal axes

Lecture 76 - Rigid-body dynamics XVI - Solved examples

Lecture 77 - Rigid body motion XVII  $\hat{A}$ – A review of the relation between angular momentum and angular velocity, moment of inertia tensor and the principal axes Edit Lesson

Lecture 78 - Rigid body motion XVIII- Solved examples for calculating rate of change of angular momentum and torque when angular velocity and angular momentum are not parallel

Lecture 79 - Rigid body dynamics XIX - understanding demonstrations shown earlier using equation of motion

Lecture 80 - Rigid body dynamics XX - understanding demonstrations shown earlier using equation of motion (Euler equations)

Lecture 81 - Rigid body dynamics XXI - Euler equations, solved examples

Lecture 82 - Simple harmonic motion I - expanding potential energy about the equilibrium point and the corresponding force

Lecture 83 - Simple harmonic motion II - solving the equation of motion with given initial conditions

Lecture 84 - Simple harmonic motion III - solved examples

Lecture 85 - Simple harmonic motion IV - representing simple harmonic motion on a phasor diagram; energy of an oscillator

Lecture 86 - Simple harmonic motion V - solved examples

Lecture 87 - Simple harmonic motion VI - solving the equation of motion with constant friction in the system

Lecture 88 - Simple harmonic motion VII - harmonic oscillator with velocity-dependent damping (heavy damping)

Lecture 89 - Simple harmonic motion VIII - harmonic oscillator with velocity-dependent damping (critical damping)

Lecture 90 - Simple harmonic motion IX - solved examples

Lecture 91 - Simple harmonic motion X - harmonic oscillator with velocity-dependent damping (light damping)

Lecture 92 - Simple harmonic motion XI - solved examples

[Lecture 93 - Simple harmonic motion XII - oscillations of an un-damped harmonic oscillator subjected to an oscillatory force](#)

[Lecture 94 - Simple harmonic motion XIII - oscillations of a forced damped harmonic oscillator - I](#)

[Lecture 95 - Simple harmonic oscillator XIV - oscillations of a forced damped harmonic oscillator - II](#)

[Lecture 96 - Simple harmonic oscillator XV - Energy and power in a forced damped harmonic oscillator](#)

[Lecture 97 - Simple harmonic oscillator XVI - Solved examples](#)

[Lecture 98 - Equation of motion in a uniformly accelerating frame](#)

[Lecture 99 - Motion described in a uniformly accelerating frame; solved examples - I](#)

[Lecture 100 - Motion described in a uniformly accelerating frame; solved examples - II](#)

Lecture 1 - Lecture 1 - About Computers

Lecture 2 - Lecture 2 - Python: Variables and Assignments

Lecture 3 - Lecture 3 - Python: Numpy arrays

Lecture 4 - Lecture 4 - Python: Control structures

Lecture 5 - Lecture 5A - Python packages; Programming

Lecture 6 - Lecture 5B - Some suggestions on programming

Lecture 7 - Lecture 6 - Plotting in Python

Lecture 8 - Lecture 7 - Errors and Nondimensionalization

Lecture 9 - Lecture 8 - Data I/O and Mayavi

Lecture 10 - Lecture 9 - Lagrange interpolation

Lecture 11 - Lecture 10 - Interpolation II: 2D, splines

Lecture 12 - Lecture 11 - Integration I: Newton-Cotes

Lecture 13 - Lecture 12 - Integration II: Gaussian quadrature

Lecture 14 - Lecture 13 - Gaussian quadrature continued

Lecture 15 - Lecture 14 - Numerical Differentiation

Lecture 16 - Lecture 15 - ODE solvers

Lecture 17 - Lecture 16 - ODE solvers continued

Lecture 18 - Lecture 17 - Fourier transform

Lecture 19 - Lecture 18 - PDE solver: Diffusion equation in spectral method

Lecture 20 - Lecture 19A - PDE solver: Diffusion equation using finite difference

Lecture 21 - Lecture 19B - PDE solver: Wave equation using finite difference

Lecture 22 - Lecture 20 - Linear algebra:  $Ax = b$  solver

Lecture 23 - Lecture 21 - Summary

Lecture 1 - Black Body Radiation I - Relevant Definitions and Black Body as cavity

Lecture 2 - Black Body Radiation II - Intensity of radiation in terms of energy density

Lecture 3 - Black Body Radiation III - Spectral energy density and radiation pressure inside a black body radiation

Lecture 4 - Black Body Radiation IV - Stephen's Boltzman law

Lecture 5 - Black Body Radiation V - Wein's Displacement law and analysis for spectral density

Lecture 6 - Black Body Radiation VI - Wein's distribution law and rayleigh - Jeans distribution law

Lecture 7 - Black Body Radiation VII - Quantum Hypothesis and plank's distribution Formula

Lecture 8 - Radiation as a collection of particles called photons

Lecture 9 - Quantum Hypothesis and specific heat of solids

Lecture 10 - Bohr's Model of hydrogen spectrum

Lecture 11 - Wilson Sommerfeld quantum condition I - Harmonic oscillator and particle in a box

Lecture 12 - Wilson Sommerfeld quantum condition II - Particle moving in a coulomb potential in a plane and related quantum numbers

Lecture 13 - Wilson Sommerfeld quantum condition III - Particle moving in a coulomb potential in 3D and related quantum numbers

Lecture 14 - Quantum conditions and atomic structure, electron spin and Pauli exclusion principle

Lecture 15 - Interaction of atoms with radiation : Eienstien's A and B coefficients

Lecture 16 - Stimulated emmission and amplification of light in a LASER

Lecture 17 - Brief description of a LASER

Lecture 18 - Introduction to the correspondence principle

Lecture 19 - General nature of the correspondence principle

Lecture 20 - Selection rules (for transitions) through the correspondence principle

Lecture 21 - Applications of the correspondence principle : Einstiens A coefficient for the harmonic oscillator and the selection rules for atomic transitions

Lecture 22 - Heisenberg's formulations of quantum mechanics : expressing kinetic variables as matrices

Lecture 23 - Heisenberg's formulation of quantum mechanics : the quantum condition

Lecture 24 - Heisenberg's formulation of the quantum mechanics : Application to harmonic oscillator

Lecture 25 - Brief introduction to matrix mechanics and the quantum condition in matrix form

Lecture 26 - Introduction to waves and wave equation

Lecture 27 - Sationary waves eigen values and eigen functions

Lecture 28 - Matter waves and their experimental detection

Lecture 29 - Represenating a moving paticle by a wave packet

Lecture 30 - Stationary-state Schrodinger equation and its solution for a particle in a box



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Lecture 31 - Solution of the stationary-state Schrodinger equation for a simple harmonic oscillator

Lecture 32 - Equivalence of Heisenberg and the Schrodinger formulations : Mathematical preliminaries

Lecture 33 - Equivalence of Heisenberg and Schrodinger formulations : The x and p operators and the quantum condition

Lecture 34 - Born interpretation of the wavefunction and expectation values of x and p operators

Lecture 35 - Uncertainty principle and its simple applications

Lecture 36 - Time dependent Schrodinger equation the probability current density and the continuity equation for the probability density

Lecture 37 - Ehrenfest theorem for the expectation values of x and p operators

Lecture 38 - Solution of Schrodinger equation for a particle in one and two delta function potentials

Lecture 39 - Solution of Schrodinger equation for a particle in a finite well

Lecture 40 - Numerical solution of a one dimensional Schrodinger equation for bound states - I

Lecture 41 - Numerical solution of a one dimensional Schrodinger equation for bound states - II

Lecture 42 - Reflection and transmission of particles across a potential barrier

Lecture 43 - Quantum-tunneling and its examples

Lecture 44 - Solution of the Schrodinger for free particles and periodic boundary conditions

Lecture 45 - Electrons in a metal : Density of states and Fermi energy

Lecture 46 - Schrodinger equation for particles in spherically symmetric potential, angular momentum operator

Lecture 47 - Angular momentum operator and its eigenfunctions

Lecture 48 - Equation for radial component of the wavefunction in spherically symmetric potentials and general properties of its solution

Lecture 49 - Solution for radial component of the wavefunction for the hydrogen atom

Lecture 50 - Numerical solution for the radial component of wavefunction for spherically symmetric potentials

Lecture 51 - Solution of the Schrodinger equation for one dimensional periodic potential : Bloch's theorem

Lecture 52 - Kroning-Penny model and energy bands

Lecture 53 - Kroning-Penny model with periodic Dirac delta function and energy bands

Lecture 54 - Discussion on bands

Lecture 55 - Summary of the course

Lecture 1 - Introduction to Drude's theory of electrons in a metal - Part 1

Lecture 2 - Introduction to Drude's theory of electrons in a metal - Part 2

Lecture 3 - Postulates of Drude's theory

Lecture 4 - Calculating electrical conductivity of metal using Drude's theory of electrons in metal - Part 1

Lecture 5 - Calculating the electrical conductivity of metal using Drude's Model - Part 2

Lecture 6 - Introduction to Hall effect in Metals - Part 1

Lecture 7 - Introduction to Hall effect in metals - Part 2

Lecture 8 - Introduction to Hall effect in metals - Part 3

Lecture 9 - Understanding thermal conductivity of a metal using Drude's model - Part 1

Lecture 10 - Understanding thermal conductivity of a metal using Drude's model - Part 2

Lecture 11 - Introduction to Sommerfeld's Theory of electrons in a metal - Part 1

Lecture 12 - Introduction to Sommerfeld's Theory of electrons in a metal - Part 2

Lecture 13 - Introduction to Sommerfeld's Theory of electrons in a metal - Part 3

Lecture 14

Lecture 15

Lecture 16

Lecture 17

Lecture 18

Lecture 19 - Electronic Contribution to the Specific heat of a Solid - Part 1

Lecture 20 - Electronic Contribution to the Specific heat of a Solid - Part 2

Lecture 21 - Electronic Contribution to the Specific heat of a Solid - Part 3

Lecture 22 - Electronic Contribution to the Specific heat of a Solid - Part 4

Lecture 23 - Understanding Thermal conductivity of Metals

Lecture 24 - Introduction to Magnetism in Metal - Part 1

Lecture 25 - Introduction to Magnetism in Metal - Part 2

Lecture 26

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  $\omega$  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

- 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



[Lecture 1](#)

[Lecture 2](#)

[Lecture 3](#)

[Lecture 4](#)

[Lecture 5](#)

[Lecture 6](#)

[Lecture 7](#)

[Lecture 8](#)

[Lecture 9](#)

[Lecture 10](#)

[Lecture 11](#)

[Lecture 12](#)

[Lecture 13](#)

[Lecture 14](#)

[Lecture 15](#)

[Lecture 16](#)

[Lecture 17](#)

[Lecture 18](#)

[Lecture 19](#)

[Lecture 20](#)

[Lecture 21](#)

[Lecture 22](#)

[Lecture 23](#)

[Lecture 24](#)

[Lecture 25](#)

[Lecture 26](#)

[Lecture 27](#)

[Lecture 28](#)

[Lecture 29](#)

[Lecture 30](#)

[Lecture 31](#)

[Lecture 32](#)

[Lecture 33](#)

[Lecture 34](#)

[Lecture 35](#)

[Lecture 36](#)

[Lecture 37](#)

[Lecture 38](#)

[Lecture 39](#)

[Lecture 40](#)

[Lecture 41](#)

[Lecture 42](#)

[Lecture 43](#)

[Lecture 44](#)

[Lecture 45](#)

[Lecture 46](#)

[Lecture 47](#)

[Lecture 48](#)

[Lecture 49](#)

[Lecture 50](#)

[Lecture 51](#)

[Lecture 52](#)

[Lecture 53](#)

[Lecture 1](#)

[Lecture 2](#)

[Lecture 3](#)

[Lecture 4](#)

[Lecture 5](#)

[Lecture 6](#)

[Lecture 7](#)

[Lecture 8](#)

[Lecture 9](#)

[Lecture 10](#)

[Lecture 11](#)

[Lecture 12](#)

[Lecture 13](#)

[Lecture 14](#)

[Lecture 15](#)

[Lecture 16](#)

[Lecture 17](#)

[Lecture 18](#)

[Lecture 19](#)

[Lecture 20](#)

[Lecture 21](#)

[Lecture 22](#)

[Lecture 23](#)

[Lecture 24](#)

[Lecture 25](#)

[Lecture 26](#)

[Lecture 27](#)

[Lecture 28](#)

[Lecture 29](#)

[Lecture 30](#)

[Lecture 31](#)

[Lecture 32](#)

[Lecture 33](#)

[Lecture 34](#)

[Lecture 35](#)

[Lecture 36](#)

[Lecture 37](#)

[Lecture 38](#)

[Lecture 39](#)

[Lecture 40](#)

[Lecture 41](#)

[Lecture 42](#)

[Lecture 43](#)

[Lecture 44](#)

[Lecture 45](#)

[Lecture 46](#)

[Lecture 47](#)

[Lecture 48](#)

[Lecture 49](#)

[Lecture 50](#)

[Lecture 51](#)

[Lecture 52](#)

[Lecture 53](#)

[Lecture 54](#)

[Lecture 55](#)

[Lecture 56](#)

[Lecture 57](#)

[Lecture 58](#)

[Lecture 59](#)

[Lecture 60](#)

[Lecture 61](#)

[Lecture 62](#)

[Lecture 63](#)

[Lecture 64](#)

[Lecture 65](#)

[Lecture 66](#)

[Lecture 67](#)

[Lecture 68](#)

[Lecture 69](#)

[Lecture 70](#)

[Lecture 71](#)

- 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 \(Continued...1\)](#)

[Lecture 36 - CMBR and Thermal History \(Continued...2\)](#)

[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...)

[Lecture 1](#)

[Lecture 2](#)

[Lecture 3](#)

[Lecture 4](#)

[Lecture 5](#)

[Lecture 6 - Systems with variable mass - 3](#)

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

[Lecture 8 - Central force - 1](#)

[Lecture 9 - Central force - 2](#)

[Lecture 10 - Central force - 3](#)

[Lecture 11 - Central force - 4](#)

[Lecture 12 - Central force - 5](#)

[Lecture 13 - Central force - 6](#)

[Lecture 14 - Central force - 7](#)

[Lecture 15 - Central force - 8](#)

[Lecture 16 - Central force - 9](#)

[Lecture 17 - Central force - 10](#)

[Lecture 18 - Central force - 11](#)

[Lecture 19 - Central force - 12](#)

[Lecture 20 - Central force - 13](#)

[Lecture 21 - Central force - 14](#)

[Lecture 22 - Central force - 15](#)

[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](#)

[Lecture 27 - Rigid body dynamics - 1](#)

[Lecture 28 - Rigid body dynamics - 2](#)

[Lecture 29 - Rigid body dynamics - 3](#)

[Lecture 30 - Rigid body dynamics - 4](#)

[Lecture 31 - Rigid body dynamics - 5](#)

Lecture 32 - Rigid body dynamics - 6

Lecture 33 - Rigid body dynamics - 7

Lecture 34 - Rigid body dynamics - 8

Lecture 35 - Rigid body dynamics - 9

Lecture 36 - Rigid body dynamics - 10

Lecture 37 - Rigid body dynamics - 11

Lecture 38 - Rigid body dynamics - 12

Lecture 39 - Rigid body dynamics - 13

Lecture 40 - Rigid body dynamics - 14

Lecture 41 - Rigid body dynamics - 15

Lecture 42 - Rigid body dynamics - 16

Lecture 43 - Lagrangian Formulation - 1

Lecture 44 - Lagrangian Formulation - 2

Lecture 45 - Lagrangian Formulation - 3

Lecture 46 - Lagrangian Formulation - 4

Lecture 47 - Lagrangian Formulation - 5

Lecture 48 - Lagrangian Formulation - 6

Lecture 49 - Lagrangian Formulation - 7

Lecture 50 - Lagrangian Formulation - 8

Lecture 51 - Lagrangian Formulation - 9

Lecture 52 - Lagrangian Formulation - 10

Lecture 53 - Small oscillation - 1

Lecture 54 - Small oscillation - 2

Lecture 55 - Small oscillation - 3

Lecture 56 - Small oscillation - 4

Lecture 57 - Small oscillation - 5

Lecture 58 - Small oscillation - 6

Lecture 59 - Small oscillation - 7

Lecture 60 - Small oscillation - 8

- Lecture 1 - Atom to Solid Structure
- Lecture 2 - Atom to Solid Structure (Continued...)
- Lecture 3 - Structure of Solid
- Lecture 4 - Structure of Solid (Continued...)
- Lecture 5 - Crystal Structure
- Lecture 6 - Crystal Structure (Continued...)
- Lecture 7 - Crystal Structure (Continued...)
- Lecture 8 - Crystal Structure (Continued...)
- Lecture 9 - Crystal Structure (Continued...)
- Lecture 10 - Crystal Structure (Continued...)
- Lecture 11 - Crystal Structure (Continued...)
- Lecture 12 - Crystal Structure (Continued...)
- Lecture 13 - Crystal Structure (Continued...)
- Lecture 14 - Crystal Structure (Continued...)
- Lecture 15 - Crystal Structure (Continued...)
- Lecture 16 - Crystal Structure (Continued...)
- Lecture 17 - Crystal Structure (Continued...)
- Lecture 18 - X-ray Diffraction from Crystal
- Lecture 19 - X-ray Diffraction from Crystal (Continued...)
- Lecture 20 - X-ray Diffraction from Crystal (Continued...)
- Lecture 21 - X-ray Diffraction from Crystal (Continued...)
- Lecture 22 - X-ray Diffraction from Crystal (Continued...)
- Lecture 23 - X-ray Diffraction from Crystal (Continued...)
- Lecture 24 - X-ray Diffraction from Crystal (Continued...)
- Lecture 25 - Reciprocal Lattice
- Lecture 26 - Reciprocal Lattice (Continued...)
- Lecture 27 - Reciprocal Lattice (Continued...)
- Lecture 28 - Reciprocal Lattice (Continued...)
- Lecture 29 - Reciprocal Lattice (Continued...)
- Lecture 30 - Intensity of Bragg Diffraction
- Lecture 31 - Intensity of Bragg Diffraction (Continued...)

- Lecture 32 - Electrical Properties of Metal
- Lecture 33 - Electrical Properties of Metal (Continued...)
- Lecture 34 - Electrical Properties of Metal (Continued...)
- Lecture 35 - Electrical Properties of Metal (Continued...)
- Lecture 36 - Electrical Properties of Metal (Continued...)
- Lecture 37 - Electrical Properties of Metal (Continued...)
- Lecture 38 - Electrical Properties of Metal (Continued...)
- Lecture 39 - Electrical Properties of Metal (Continued...)
- Lecture 40 - Band Theory of Solids
- Lecture 41 - Band Theory of Solids (Continued...)
- Lecture 42 - Band Theory of Solids (Continued...)
- Lecture 43 - Band Theory of Solids (Continued...)
- Lecture 44 - Band Theory of Solids (Continued...)
- Lecture 45 - Band Theory of Solids (Continued...)
- Lecture 46 - Band Theory of Solids (Continued...)
- Lecture 47 - Physics of Semiconductor
- Lecture 48 - Physics of Semiconductor (Continued...)
- Lecture 49 - Physics of Semiconductor
- Lecture 50 - Electrical Conduction
- Lecture 51 - Electrical Conduction
- Lecture 52
- Lecture 53
- Lecture 54 - Thermal Properties of Solid (Continued...)
- Lecture 55 - Thermal Properties of Solid (Continued...)
- Lecture 56 - Thermal Properties of Solid (Continued...)
- Lecture 57 - Thermal Properties of Solid (Continued...)
- Lecture 58 - Magnetic Property of Solid
- Lecture 59 - Magnetic Property of Solid (Continued...)
- Lecture 60 - Magnetic Property of Solid (Continued...)
- Lecture 61 - Magnetic Property of Solid (Continued...)
- Lecture 62 - Magnetic Property of Solid (Continued...)
- Lecture 63 - Magnetic Property of Solid (Continued...)
- Lecture 64 - Magnetic Property of Solid (Continued...)

[Lecture 65 - Magnetic Property of Solid \(Continued...\)](#)

[Lecture 66 - Magnetic Property of Solid \(Continued...\)](#)

[Lecture 67 - Magnetic Property of Solid \(Continued...\)](#)

[Lecture 68 - Magnetic Property of Solid \(Continued...\)](#)

[Lecture 69 - Magnetic Property of Solid \(Continued...\)](#)

[Lecture 70 - Magnetic Property of Solid \(Continued...\)](#)

[Lecture 71 - Magnetic Property of Solids \(Continued...\)](#)

[Lecture 72 - Dielectric Properties of Solid](#)

[Lecture 73 - Dielectric Properties of Solid \(Continued...\)](#)

[Lecture 74 - Dielectric Properties of Solid \(Continued...\)](#)

[Lecture 75 - Superconductivity](#)

- Lecture 1 - Experimental observations and theoretical development in discovery of constituents of an atom
- Lecture 2 - Experimental observations and theoretical development in discovery of constituents of an atom (Continued...)
- Lecture 3 - Experimental observations and theoretical development in discovery of constituents of an atom (Continued...)
- Lecture 4 - Experimental observations and theoretical development in discovery of constituents of an atom (Continued...)
- Lecture 5 - Experimental observations and theoretical development in discovery of constituents of an atom (Continued...)
- Lecture 6 - Structure of an atom
- Lecture 7 - Structure of an atom
- Lecture 8 - Structure of an atom (Continued...)
- Lecture 9 - Atomic structure of an atom
- Lecture 10 - Atomic structure of an atom
- Lecture 11 - Structure of an atom
- Lecture 12 - Atomic structure of an atom
- Lecture 13 - Atomic structure of an atom
- Lecture 14 - Structure of an atom
- Lecture 15 - Structure of an atom
- Lecture 16 - Structure of an atom
- Lecture 17 - Structure of an atom
- Lecture 18 - Structure of an atom
- Lecture 19 - Structure of an atom
- Lecture 20 - Structure of an atom
- Lecture 21 - Atomic spectra
- Lecture 22 - Atomic spectra
- Lecture 23 - Multielectron atoms
- Lecture 24 - Multielectron atoms (Continued...)
- Lecture 25 - Multielectron atoms (Continued...)
- Lecture 26 - Multielectron atoms (Continued...)
- Lecture 27 - Quantum mechanical treatment
- Lecture 28 - Quantum mechanical treatment (Continued...)
- Lecture 29 - Quantum mechanical treatment of H-like atom
- Lecture 30 - Quantum mechanical treatment of H-like atom (Continued...)
- Lecture 31 - Quantum mechanical treatment of Hydrogen like atom

[Lecture 32 - Quantum mechanical treatment of Hydrogen like atom \(Continued...\)](#)

[Lecture 33 - Quantum mechanical treatment of hydrogen like atom \(Continued...\)](#)

[Lecture 34 - Quantum mechanical treatment of hydrogen like atom \(Continued...\)](#)

[Lecture 35 - Quantum mechanical treatment of hydrogen like atom \(Continued...\)](#)

[Lecture 36 - Quantum Mechanical treatment of Hydrogen like atom \(Continued...\)](#)

[Lecture 37 - Quantum Mechanical treatment of Hydrogen like atom \(Continued...\)](#)

[Lecture 38 - Hydrogen like atom in magnetic field](#)

[Lecture 39 - Hydrogen like atom in magnetic field \(Continued...\)](#)

[Lecture 40 - Hydrogen like atom in electric field](#)

[Lecture 41 - Physics of molecules](#)

[Lecture 42 - Rotation of a molecule](#)

[Lecture 43 - Rotation of a molecule \(Continued...\)](#)

[Lecture 44 - Rotation of a molecule \(Continued...\)](#)

[Lecture 45 - Rotation of a molecule \(Continued...\)](#)

[Lecture 46 - Vibration of a molecule](#)

[Lecture 47 - Vibration of a molecule \(Continued...\)](#)

[Lecture 48 - Vibration of a molecule \(Continued...\)](#)

[Lecture 49 - Vibration of a molecule \(Continued...\)](#)

[Lecture 50 - Vibration of a molecule \(Continued...\)](#)

[Lecture 51 - Electronic spectra of a molecule](#)

[Lecture 52 - Electronic spectra of a molecule \(Continued...\)](#)

[Lecture 53 - Electronic structure of molecules](#)

[Lecture 54 - Electronic structure of molecules \(Continued...\)](#)

[Lecture 55 - Electronic structure of a molecule](#)

[Lecture 56 - Atomic and Molecular Spectroscopy](#)

[Lecture 57 - Raman Spectroscopy](#)

[Lecture 58 - Raman Spectroscopy \(Continued...\)](#)

[Lecture 59 - Raman Spectroscopy \(Continued...\)](#)

[Lecture 60 - Resonance spectroscopy](#)



- Lecture 1 - Maxwells equations and electromagnetic waves
- Lecture 2 - Maxwells equations and electromagnetic waves (Continued...)
- Lecture 3 - Maxwells equations and electromagnetic waves (Continued...)
- Lecture 4 - Maxwells equations and electromagnetic waves (Continued...)
- Lecture 5 - Maxwells equations and electromagnetic waves (Continued...)
- Lecture 6 - Maxwells equations and electromagnetic waves (Continued...)
- Lecture 7 - Maxwells equations and electromagnetic waves (Continued...)
- Lecture 8 - Wave propagation in anisotropic media
- Lecture 9 - Wave propagation in anisotropic media (Continued...)
- Lecture 10 - Wave propagation in anisotropic media (Continued...)
- Lecture 11 - Wave propagation in anisotropic media (Continued...)
- Lecture 12 - Wave propagation in anisotropic media (Continued...)
- Lecture 13 - Wave propagation in layered structures
- Lecture 14 - Wave propagation in layered structures (Continued...)
- Lecture 15 - Wave propagation in layered structures (Continued...)
- Lecture 16 - Wave propagation in layered structures (Continued...)
- Lecture 17 - Wave propagation in layered structures (Continued...)
- Lecture 18 - Waves in guided structures and modes
- Lecture 19 - Waves in guided structures and modes (Continued...)
- Lecture 20 - Waves in guided structures and modes (Continued...)
- Lecture 21 - Waves in guided structures and modes (Continued...)
- Lecture 22 - Waves in guided structures and modes (Continued...)
- Lecture 23 - Waves in guided structures and modes (Continued...)
- Lecture 24 - Coupling of waves and optical couplers
- Lecture 25 - Coupling of waves and optical couplers (Continued...)
- Lecture 26 - Coupling of waves and optical couplers (Continued...)
- Lecture 27 - Coupling of waves and optical couplers (Continued...)
- Lecture 28 - Coupling of waves and optical couplers (Continued...)
- Lecture 29 - Electro-optic Effect
- Lecture 30 - Electro-optic Effect (Continued...)
- Lecture 31 - Electro-optic Effect (Continued...)

[Lecture 32 - Electro-optic Effect \(Continued...\)](#)

[Lecture 33 - Electro-optic Effect \(Continued...\)](#)

[Lecture 34 - Electro-optic Modulators and Devices](#)

[Lecture 35 - Electro-optic Modulators and Devices \(Continued...\)](#)

[Lecture 36 - Electro-optic Modulators and Devices \(Continued...\)](#)

[Lecture 37 - Electro-optic Modulators and Devices \(Continued...\)](#)

[Lecture 38 - Electro-optic Modulators and Devices \(Continued...\)](#)

[Lecture 39 - Electro-optic Modulators and Devices \(Continued...\)](#)

[Lecture 40 - Electro-optic Modulators and Devices \(Continued...\)](#)

[Lecture 41 - Acousto-optic Effect](#)

[Lecture 42 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 43 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 44 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 45 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 46 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 47 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 48 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 49 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 50 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 51 - Acousto-optic Effect \(Continued...\)](#)

[Lecture 52 - Acousto-optic Effect \(Continued...\)](#)

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

[Lecture 54 - Acousto-optic Modulators and Devices](#)

[Lecture 55 - Acousto-optic Modulators and Devices \(Continued...\)](#)

[Lecture 56 - Acousto-optic Modulators and Devices \(Continued...\)](#)

[Lecture 57 - Acousto-optic Modulators and Devices \(Continued...\)](#)

[Lecture 58 - Magneto-optic Effect](#)

[Lecture 59 - Magneto-optic Effect \(Continued...\)](#)

Lecture 1 - Basic Linear Optics

Lecture 2 - Basic Linear Optics (Continued...)

Lecture 3 - Basic Linear Optics (Continued...)

Lecture 4 - Basic Linear Optics (Continued...)

Lecture 5 - Basic Linear Optics (Continued...)

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

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

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

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

Lecture 10 - Nonlinear Optics : An Introduction

Lecture 11 - Classical origin of optical nonlinearity

Lecture 12 - Miller's Rule

Lecture 13 - Second Harmonic Generation (SHG)

Lecture 14 - Optical Rectification, Linear electro-optic effect

Lecture 15 - Sum and Difference frequency generation

Lecture 16 - Nonlinear Maxwell's equation

Lecture 17 - Theory of SHG

Lecture 18 - Phase matching

Lecture 19 - Phase matching of SHG, Gain band width calculation

Lecture 20 - Manley-Rowe Relation, Energy conservation in SHG,

Lecture 21 - Birefringence phase-matching (BPM), Type I and Type II phase matching

Lecture 22 - Type II phase matching, Symmetry in nonlinear susceptibility

Lecture 23 - Kleinman's Symmetry, Neumann's Principle

Lecture 24 - Neumann's Principle (Continued...) Centrosymmetric system

Lecture 25 - Matrix form : SHG, SFG, DFG , SHG in KDP Crystal

Lecture 26 - SHG in KDP crystal, Calculation of deff

Lecture 27 - SHG in LiNbO<sub>3</sub>

Lecture 28 - Quasi phase matching (QPM)

Lecture 29 - Quasi phase matching (QPM) (Continued...), Periodic d function

Lecture 30 - 1st, 2nd, 3rd order QPM, SHG under depleted pump

Lecture 31 - Realistic calculation of SHG, 3 wave interaction

- Lecture 32 - 3 wave interaction, Equation for pump, signal and idler wave, Non-collinear phase matching
- Lecture 33 - Manley-Rowe Relation (3 wave mixing), Parametric down conversion
- Lecture 34 - Parametric down conversion (Continued...), Optical Parametric Amplification (OPA)
- Lecture 35 - Optical Parametric Amplification (OPA), Difference frequency generation under OPA
- Lecture 36 - Sum frequency generation under OPA
- Lecture 37 - OPA under non-phase matching condition, Expression of gain
- Lecture 38 - Optical parametric Oscillator (OPO), Singly resonant oscillator
- Lecture 39 - Doubly Resonant Oscillator (DRO)
- Lecture 40 - Doubly Resonant Oscillator (DRO) (Continued...)
- Lecture 41 - 3rd order nonlinear effect
- Lecture 42 - Optical Kerr effect and Self-focusing, Symmetry in 3rd order susceptibility
- Lecture 43 - Symmetry in 3rd order susceptibility (Continued...), Self Phase Modulation (SPM)
- Lecture 44 - Self Phase Modulation (Continued...), Frequency Shift
- Lecture 45 - Third Harmonic Generation(3HG), Energy conservation
- Lecture 46 - Third Harmonic Generation (Continued...)
- Lecture 47 - Third Harmonic Generation (Continued...), Cross Phase Modulation (XPM)
- Lecture 48 - Cross Phase Modulation (Continued...), Nonlinear Absorption
- Lecture 49 - Four Wave Mixing
- Lecture 50 - Four Wave mixing (Continued...)
- Lecture 51 - Parametric Amplification under FWM
- Lecture 52 - Parametric Amplification under FWM (Continued...)
- Lecture 53 - Optical Phase Conjugation
- Lecture 54 - Raman Scattering
- Lecture 55 - Stimulated Raman Scattering
- Lecture 56 - Raman Amplification
- Lecture 57 - Raman Amplification (Continued...)
- Lecture 58 - Linear pulse propagation
- Lecture 59 - Nonlinear Pulse propagation
- Lecture 60 - Optical Soliton

Lecture 1 - Introduction

Lecture 2 - Concentration

Lecture 3 - Sources and Process Overview of Natural Gas

Lecture 4 - Pure Component Phase Behavior

Lecture 5 - Mixture Phase Behavior

Lecture 6 - Phase Behaviour of Natural Gas

Lecture 7 - Dew Point and Bubble Point Calculations

Lecture 8 - Vapor Liquid Equilibrium

Lecture 9 - Problems on Vapor Pressure, Gibb's Phase Rule, Dew Point Bubble Point Temperatures

Lecture 10 - Thermophysical Properties of Natural Gas - I

Lecture 11 - Thermophysical Properties of Natural Gas - II

Lecture 12 - Thermodynamic and Chemical Properties

Lecture 13 - Combustion Properties

Lecture 14 - Flow in Natural Gas Systems

Lecture 15 - Flow Measurement In Natural Gas - I

Lecture 16 - Flow Measurement In Natural Gas - II

Lecture 17 - Temperature and Quality Measurement in Natural Gas Systems

Lecture 18 - Pressure measurement in natural gas systems

Lecture 19 - Tutorial on the estimation of thermophysical properties

Lecture 20 - Tutorial on the combustion and thermodynamic properties of natural gas

Lecture 21 - Tutorial on fluid mechanics

Lecture 22 - Tutorial on flow and pressure measurement in natural gas systems

Lecture 23 - Tutorial on temperature and quality measurement in natural gas

Lecture 24 - Heat transfer in natural gas systems

Lecture 25 - Tutorial on heat transfer in natural gas systems

Lecture 26 - Heat exchangers in natural gas systems

Lecture 27 - Analysis of heat exchangers in natural gas systems

Lecture 28 - Tutorial on heat exchanger analysis

Lecture 29 - Equilibrium vapour-liquid separation

Lecture 30 - Equilibrium in multicomponent systems

Lecture 31 - Separation by distillation

- Lecture 32 - Design of distillation column
- Lecture 33 - Equilibrium fluid solid separation
- Lecture 34 - Membrane separation in natural gas systems
- Lecture 35 - Estimation of water content in natural gas
- Lecture 36 - Multistage single component equilibrium separation
- Lecture 37 - Tutorial on vapour liquid separation
- Lecture 38 - Tutorial on ideal binary distillation
- Lecture 39 - Tutorial on equilibrium gas- solid separation
- Lecture 40 - Tutorial on membrane gas separation
- Lecture 41 - Dehydration of natural gas
- Lecture 42 - Natural gas Processing - hydrate removal
- Lecture 43 - Acid gas removal in natural gas system - I
- Lecture 44 - Acid gas removal in natural gas system - II
- Lecture 45 - Nitrogen removal in natural gas system - I
- Lecture 46 - Nitrogen removal in natural gas system - II
- Lecture 47 - Compression in natural gas systems
- Lecture 48 - Compressors used in natural gas systems
- Lecture 49 - Tutorial on hydrate removal
- Lecture 50 - Multicomponent distillation column design: Approximate method
- Lecture 51 - Sulfur recovery in natural gas systems - I
- Lecture 52 - Tutorial on compression
- Lecture 53 - Pigging
- Lecture 54 - Sulfur recovery in natural gas systems - II
- Lecture 55 - Trace components in natural gas
- Lecture 56 - Helium recovery, upgradation and purification
- Lecture 57 - Fundamentals of absorption and stripping for natural gas processing
- Lecture 58 - Tutorial on absorption and stripping
- Lecture 59 - Gas liquid separation in natural gas systems - I
- Lecture 60 - Gas liquid separation in natural gas systems - II
- Lecture 61 - Tutorial on equilibrium in multicomponent systems
- Lecture 62 - Tutorial on multicomponent distillation - I
- Lecture 63 - Tutorial on multicomponent distillation - II
- Lecture 64 - Pumps in natural gas systems - I

- Lecture 65 - Pumps in natural gas systems - II
- Lecture 66 - Pumps in natural gas systems - III
- Lecture 67 - Tutorial on pumps - I
- Lecture 68 - Tutorial on pumps - II
- Lecture 69 - Cryogenic refrigeration and liquefaction in natural gas systems - I
- Lecture 70 - Cryogenic refrigeration and liquefaction in natural gas systems - II
- Lecture 71 - Tutorial on refrigeration - I
- Lecture 72 - Tutorial on refrigeration - II
- Lecture 73 - Cryogenic refrigeration and liquefaction in natural gas systems - III
- Lecture 74 - Cryogenic refrigeration and liquefaction in natural gas systems - IV
- Lecture 75 - Cryogenic refrigeration and liquefaction in natural gas systems - V
- Lecture 76 - Tutorial on refrigeration - III
- Lecture 77 - Tutorial on refrigeration and liquefaction - IV
- Lecture 78 - Tutorial on refrigeration and liquefaction - V
- Lecture 79 - Hydrocarbon recovery in natural gas system - I
- Lecture 80 - Hydrocarbon recovery in natural gas system - II
- Lecture 81 - Hydrocarbon recovery in natural gas system - III
- Lecture 82 - Tutorial on hydrocarbon recovery in natural gas
- Lecture 83 - Piping in natural gas systems - I
- Lecture 84 - Piping in natural gas systems - II
- Lecture 85 - Tutorial on piping in natural gas systems - I
- Lecture 86 - Tutorial on piping in natural gas systems - II

Lecture 1 - Introduction

Lecture 2 - Basic tools and apparatus

Lecture 3 - Basic tools and apparatus (Continued...)

Lecture 4 - Basic tools and apparatus (Continued...)

Lecture 5 - Basic tools and apparatus (Continued...)

Lecture 6 - Basic tools and apparatus (Continued...)

Lecture 7 - Basic components

Lecture 8 - Basic apparatus

Lecture 9 - Basic apparatus (Continued...)

Lecture 10 - Basic analysis

Lecture 11 - Basics analysis (Continued...)

Lecture 12 - Basics analysis (Continued...)

Lecture 13 - Basics analysis (Continued...)

Lecture 14 - Basics analysis (Continued...)

Lecture 15 - Basics analysis (Continued...)

Lecture 16 - Basics analysis (Continued...)

Lecture 17 - Basics analysis (Continued...)

Lecture 18 - Basics analysis (Continued...)

Lecture 19 - Basics analysis (Continued...)

Lecture 20 - Determination of Young's modulus

Lecture 21 - Demonstration on the experiment of Young's modulus of mettalic bar and data collection

Lecture 22 - Calculate the value of young's modulus of given metallic bar form the recorded datas

Lecture 23 - Experimental demonstration to calculate the spring constant of a given spring

Lecture 24 - Calculate the value of calculate the spring constant of a given spring form the recorded datas

Lecture 25 - Theory regarding Moment of inertia of a flywheel

Lecture 26 - Experimental demonstration to calculate the moment of inertia of a given flywheel

Lecture 27 - How to calculate the value of moment of inertia of a flywheelform the recorded data

Lecture 28 - Theory regarding surface tension of the liquid

Lecture 29 - Demonstration on the experiment of surface tension and data collection

Lecture 30 - How to calculate the value of surface tension of water from the recorded data

Lecture 31 - Theory regarding viscosity of liquid



Lecture 32 - Demonstration on the experiment of viscosity

Lecture 33 - Data analysis of recorded data on viscosity

Lecture 34 - Forced Oscillations Pohls pendulum

Lecture 35 - Coupled Pendulum

Lecture 36 - Demonstration on the experiment of compound pendulum

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.

Lecture 39 - Linear expansion of metal

Lecture 40 - Expt. to study linear expansion

Lecture 41 - Determine the coefficient of thermal conductivity of a bad conductor

Lecture 42 - Determination of electrical equivalent of heat

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

Lecture 44 - Determination of the calibration curve of a given (Type K chromel- $\alpha$ alumel) thermocouple and hence determination of Seebeck coefficient

Lecture 45 - Theory and Demonstration Platinum Resistance thermometer

Lecture 46 - Experiment on Platinum Resistance thermometer

Lecture 47 - To study the current-voltage relationship of an L-R circuit

Lecture 48 - To study the variation in current and voltage in a series LCR circuit

Lecture 49 - Sensitivity of Blastic Galvanometer

Lecture 50 - Expt. for Sensitivity of Blastic Galvanometer

Lecture 51 - Theory on RC Circuit

Lecture 52 - Expt. on RC Circuit

Lecture 53 - Theory regarding the magnetic field along the axis of a circular coil

Lecture 54 - Experiment regarding the magnetic field along the axis of a circular coil

Lecture 55 - Study the induced e.m.f of inductance coil

Lecture 56 - Mutual inductance

Lecture 57 - Theory regarding permeability of air

Lecture 58 - Experiment to determination the permeability of air

Lecture 59 - Devices around us

Lecture 60 - Devices around us (Continued...)

Lecture 1 - Introduction

Lecture 2 - Summary of Experimental Physics - I

Lecture 3 - Summary of Experimental Physics - I (Continued...)

Lecture 4 - Summary of Experimental Physics - I (Continued...)

Lecture 5 - Summary of Experimental Physics - I (Continued...)

Lecture 6 - Basic analysis

Lecture 7 - Basic analysis (Continued...)

Lecture 8 - Basic components

Lecture 9 - Basic components (Continued...)

Lecture 10 - Basic components (Continued...)

Lecture 11 - Basic idea on mirrors and lenses and their applications

Lecture 12 - Determination of focal length of concave mirror

Lecture 13 - Determination of focal length of concave mirror (Continued...)

Lecture 14 - Determination of focal length of convex mirror

Lecture 15 - Determination of focal length of convex lens

Lecture 16 - Determination of focal length of concave lens

Lecture 17 - Determination of focal length of convex lens by displacement method

Lecture 18 - Applications of mirrors and lenses

Lecture 19 - Determination of refractive index of liquid using travelling microscope

Lecture 20 - Basic discussion on spectrometer and prism

Lecture 21 - Basic discussion on spectrometer and prism (Continued...)

Lecture 22 - Basic discussion on spectrometer and prism (Continued...)

Lecture 23 - Schuster's method

Lecture 24 - Discussion on angle of the prism, angular dispersion and dispersive power of given prism

Lecture 25 - Determination of the angle of prism

Lecture 26 - Determination of the angle of minimum deviation for a given prism and hence to determine the refractive index of the given prism

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.

Lecture 29 - Determination of the calibration plot of deviation versus wavelength for a given prism and hence determination of the wavelength of the unknown light source using the calibration plot

Lecture 30 - Determination of the dispersive power, Cauchy constant and resolving power of a given prism.

Lecture 31 - Interference Phenomena

Lecture 32 - Interference Phenomena (Continued...)

Lecture 33 - Interference Phenomena (Continued...)

Lecture 34 - Bi-prism

Lecture 35 - Bi-prism (Continued...)

Lecture 36 - Interference phenomena by Newton ring (Theory)

Lecture 37 - Interference phenomena by Newton ring (Experiment)

Lecture 38 - Michelson interferometer (Theory)

Lecture 39 - Michelson interferometer (Experiment)

Lecture 40 - Theory of diffraction

Lecture 41 - Theory of diffraction (Continued...)

Lecture 42 - Theory of diffraction (Continued...)

Lecture 43 - Single slit diffraction

Lecture 44 - Double slit diffraction

Lecture 45 - Plane transmission grating

Lecture 46 - Plane transmission grating (Continued...)

Lecture 47 - Theory of polarization

Lecture 48 - Theory of polarization (Continued...)

Lecture 49 - Experiment for Verification of Malus law

Lecture 50 - Experiment for Brewster

Lecture 51 - Experiment for Brewster angle

Lecture 52 - Experiment on e-ray and o-ray

Lecture 53 - Polarimeter

Lecture 54 - Zone-plate Theory

Lecture 55 - Zone-plate Experiment

Lecture 56 - Theory of Photoelectric Effect

Lecture 57 - Experiment on Photoelectric Effect

Lecture 58 - Thomson experiment to determine the specific charge of an electron ( $e/m$ )

Lecture 59 - Frank-Hertz Experiment

Lecture 60 - Experiment on Rydberg constant

Lecture 61 - Experiment on Rydberg constant (Continued...)

Lecture 1 - Basic Tools and Instruments in the Laboratory

Lecture 2 - Basic Tools and Instruments in the Laboratory (Continued...)

Lecture 3 - Cathode Ray Oscilloscope (CRO)

Lecture 4 - Cathode Ray Oscilloscope (CRO) (Continued...)

Lecture 5 - Electro Magnet and Constant Current Power Supply

Lecture 6 - Electro Magnet and Constant Current Power Supply (Continued...)

Lecture 7 - Electro Magnet and Constant Current Power Supply (Continued...)

Lecture 8 - Gaussmeter/Teslameter

Lecture 9 - Gaussmeter/Teslameter (Continued...)

Lecture 10 - Lock in Amplifier

Lecture 11 - Lock in Amplifier (Continued...)

Lecture 12 - Measurement of magneto resistance

Lecture 13 - Magneto resistance for Semiconductor

Lecture 14 - Hall Effect

Lecture 15 - Hall Effect as a function of magnetic Field

Lecture 16 - Hall Effect as a function of temperature

Lecture 17 - To study the variation of resistivity of metal and semiconductor at low temperature region (Continued...)

Lecture 18 - To study the variation of resistivity of metal and semiconductor at low temperature region (Continued...)

Lecture 19 - Measurement of magnetisation of ferromagnetic material

Lecture 20 - Measurement of magnetisation of ferromagnetic material (Continued...)

Lecture 21 - Susceptibility of paramagnetic substance by Quincke's tube method

Lecture 22 - Experiment of Quincke's Tube Method

Lecture 23 - Susceptibility of paramagnetic substance by Gouy's method

Lecture 24 - Dielectric constant of solid

Lecture 25 - Dielectric constant of non-conducting liquid

Lecture 26 - P-E Loop of Ferroelectric Material

Lecture 27 - Measurement of Ionic Conductivity

Lecture 28 - Measurement of Ionic Conductivity (Continued...)

Lecture 29 - Electron Spin Resonance (ESR)

Lecture 30 - Electron Spin Resonance (ESR) Experiment

Lecture 31 - Superconductivity

[Lecture 32 - Superconductivity \(Continued...\)](#)

[Lecture 33 - Superconductivity \(Continued...\)](#)

[Lecture 34 - Nuclear g-factor](#)

[Lecture 35 - Nuclear g-factor \(Continued...\)](#)

[Lecture 36 - P-N Junction](#)

[Lecture 37 - P-N Junction \(Continued...\)](#)

[Lecture 38 - P-N Junction \(Continued...\)](#)

[Lecture 39 - Zeeman Effect](#)

[Lecture 40 - Zeeman Effect \(Continued...\)](#)

[Lecture 41 - Zeeman Effect \(Continued...\)](#)

[Lecture 42 - Sodium Yellow Doublet](#)

[Lecture 43 - Sodium Yellow Doublet \(Continued...\)](#)

[Lecture 44 - Study of Absorption Spectrum of Iodine Vapour](#)

[Lecture 45 - Study of Absorption Spectrum of Iodine Vapour \(Continued...\)](#)

[Lecture 46 - Study of Absorption Spectrum of Iodine Vapour \(Continued...\)](#)

[Lecture 47 - Determination of Wavelength of Spectral Lines using Constant Deviation Spectrometer](#)

[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 \(Continued...\)](#)

[Lecture 52 - Faraday Effect](#)

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

[Lecture 54 - Electron Diffraction](#)

[Lecture 55 - Electron Diffraction \(Continued...\)](#)

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

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

[Lecture 58 - X-Ray Diffraction and Crystal Structure](#)

[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 \(Continued...\)](#)

[Lecture 62](#)

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<sub>lm</sub> 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](#)

[Lecture 39 - Microbial Fuel Cells](#)

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

[Lecture 41 - Synthesis of nanomaterials](#)

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

[Lecture 43 - Nanocatalysts](#)

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

[Lecture 45 - X-ray diffraction method](#)

[Lecture 46 - UV-Visible Spectroscopy](#)

[Lecture 47 - Fourier Transform Infrared Spectroscopy](#)

[Lecture 48 - SEM, TEM and XPS](#)

[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](#)

[Lecture 35 - Heat capacity and diffusion of liquids and melts](#)

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

[Lecture 37 - Sensors](#)

[Lecture 38 - Electrochemical Sensors](#)

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

[Lecture 40 - Supercapacitors - II](#)

[Lecture 41 - Magnetic supercapacitors](#)

[Lecture 42 - Battery - I](#)

[Lecture 43 - Battery - II](#)

[Lecture 44 - Solar Cells - I](#)

[Lecture 45 - Solar Cells - II](#)

[Lecture 46 - X-ray Diffraction \(XRD\)](#)

[Lecture 47 - Fourier Transform Infrared Spectroscopy](#)

[Lecture 48 - UV- Vis Spectroscopy](#)

[Lecture 49 - Scanning and Transmission Electron Microscopy](#)

[Lecture 50 - Summary](#)

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

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

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](#)

- 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...)

- 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 \(standard Brownian motion\)](#)

Lecture 1 - Discrete Probability

Lecture 2 - Continuous Probability

Lecture 3 - Characteristic Function

Lecture 4 - Gaussian Distribution

Lecture 5 - Binomial Distribution

Lecture 6 - Poisson Distribution

Lecture 7 - Central Limit Theorem

Lecture 8 - Many Random Variables

Lecture 9 - Entropy and Probability

Lecture 10 - Entropy Maximization

Lecture 11 - Transformation of Random Variables

Lecture 12 - Tutorial

Lecture 13 - Mathematical Preliminaries - 1

Lecture 14 - Microcanonical Ensemble

Lecture 15 - Two Level System (Microcanonical Ensemble)

Lecture 16 - Classical Ideal Gas (Microcanonical Ensemble)

Lecture 17 - Entropy of Mixing

Lecture 18 - Canonical Ensemble

Lecture 19 - Two Level System (Canonical Ensemble)

Lecture 20 - Classical Ideal Gas (Canonical Ensemble)

Lecture 21 - Gibbs Canonical Ensemble

Lecture 22 - Classical Ideal Gas (Gibbs Canonical Ensemble)

Lecture 23 - N Spins in a Uniform Magnetic Field

Lecture 24 - Grand Canonical Ensemble

Lecture 25 - Ideal Gas (Grand Canonical Ensemble)

Lecture 26 - N Non - Interacting Spins in Constant Magnetic Field

Lecture 27 - Quantum Statistical Mechanics

Lecture 28 - Statistics of Fermions and Bosons

Lecture 29 - Quantum to Classical Correspondance

Lecture 30 - Vibrations of Solid (Low Temperature)

Lecture 31 - Vibrations of Solid (Continuation)

[Lecture 32 - Free Electrons\(Fermi Gas\) in a Metal](#)

[Lecture 33 - Free Electrons\(Fermi Gas\) in a Metal \(Continuation\)](#)

[Lecture 34 - Problem solving demo - Part 1](#)

[Lecture 35 - Problem solving demo - Part 2](#)

Lecture 1 - Introduction to Fortran - Part 1

Lecture 2 - Introduction to Fortran - Part 2

Lecture 3 - Introduction to Fortran - Part 3

Lecture 4 - Introduction to Fortran - Part 4

Lecture 5 - Introduction to Fortran - Part 5

Lecture 6 - Numerical Integration - Part 1

Lecture 7 - Numerical Integration - Part 2

Lecture 8 - Numerical Integration - Part 3

Lecture 9 - Numerical Integration - Part 4

Lecture 10 - Numerical Integration - Part 5

Lecture 11 - Numerical Integration - Part 6

Lecture 12 - Numerical Integration - Part 7

Lecture 13 - Numerical Integration - Part 8

Lecture 14 - Numerical Integration - Part 9

Lecture 15 - Numerical Integration - Part 10

Lecture 16 - Monte Carlo Simulation Introduction - Part 1

Lecture 17 - Monte Carlo Simulation Introduction - Part 2

Lecture 18 - Implementing the Ising model on computer

Lecture 19 - Periodic Boundary conditions and the Metropolis scheme

Lecture 20 - Testing the simulation and relaxation to equilibrium, finite size effects

Lecture 21 - Monte Carlo Simulation Analysis - Part 1

Lecture 22 - Monte Carlo Simulation Analysis - Part 2

Lecture 23 - Monte Carlo Simulation Analysis: Thermodynamic Quantities - Part 1

Lecture 24 - Monte Carlo Simulation Analysis: Thermodynamic Quantities - Part 2

Lecture 25 - Calculating  $T_c$  using Binder's cumulant; Principle of detailed balance

Lecture 26 - Differential Equations Euler and Runge Kutta - Part 1

Lecture 27 - Differential Equations Euler and Runge Kutta - Part 2

Lecture 28 - Differential Coupled Equation Non Linear Equation - Part 1

Lecture 29 - Differential Coupled Equation Non Linear Equation - Part 2

Lecture 30 - Coupled Differential Equation Visualisation and Making Movie

Lecture 31 - Differential Equations With Specified Boundary Conditions - Part 1

- Lecture 32 - Differential Equations With Specified Boundary Conditions - Part 2
- Lecture 33 - Partial Differential equations - 1
- Lecture 34 - Partial Differential equations - 2
- Lecture 35 - Partial Differential equations - 3
- Lecture 36 - Differential Equation for Quantum Mechanical Problems: Numerov Algorithm - 1
- Lecture 37 - Differential Equation for Quantum Mechanical Problems: Numerov Algorithm - 2
- Lecture 38 - Differential Equation for Quantum Mechanical Problems: Numerov Algorithm - 3
- Lecture 39 - Differential Equation for Quantum Mechanical Problems: Numerov Algorithm - 4
- Lecture 40 - Differential Equation for Quantum Mechanical Problems: Numerov Algorithm - 5
- Lecture 41 - Differential Equation for Quantum Mechanical Problems: Variational principle - 1
- Lecture 42 - Differential Equation for Quantum Mechanical Problems: Variational principle - 2
- Lecture 43 - Differential Equation for Quantum Mechanical Problems: Variational principle - 3
- Lecture 44 - Differential Equation for Quantum Mechanical Problems: Variational principle - 4
- Lecture 45 - Differential Equation for Quantum Mechanical Problems: Variational principle - 5
- Lecture 46 - Molecular Dynamics Introduction - Part 1
- Lecture 47 - Molecular Dynamics Introduction - Part 2
- Lecture 48 - Molecular Dynamics Details and Algorithm - Part 1
- Lecture 49 - Molecular Dynamics Details and Algorithm - Part 2
- Lecture 50 - Molecular Dynamics Details and Algorithm - Part 3
- Lecture 51 - Molecular Dynamics Analysis - Part 1
- Lecture 52 - Molecular Dynamics Analysis - Part 2
- Lecture 53 - Molecular Dynamics Neighbours Lists - Part 1
- Lecture 54 - Molecular Dynamics Neighbours Lists - Part 2
- Lecture 55 - Molecular Dynamics: Calculation Of Thermodynamics Quantities
- Lecture 56 - Molecular Dynamics Diffusion Constant Calculation - Part 1
- Lecture 57 - Molecular Dynamics Diffusion Constant Calculation - Part 2
- Lecture 58 - Molecular Dynamics Diffusion Constant Calculation - Part 3

- Lecture 1 - Simple Harmonic Motion
- Lecture 2 - Superposition of Oscillations : Beats
- Lecture 3 - Superposition of Oscillations : Beats
- Lecture 4 - Superposition of Oscillations : Lissajous Figures
- Lecture 5 - Simple Harmonic Motion : Problems
- Lecture 6 - Damped oscillator - Part 1
- Lecture 7 - Damped oscillator - Part 2
- Lecture 8 - Damped oscillator and Q-factor
- Lecture 9 - Damped oscillator : Problems
- Lecture 10 - Forced oscillator - Part 1
- Lecture 11 - Forced oscillator - Part 2
- Lecture 12 - Resonances
- Lecture 13 - Q-factor of forced oscillator
- Lecture 14 - Applications of forced oscillator
- Lecture 15 - Forced Oscillator : Problems
- Lecture 16 - Coupled Oscillations - Part 1
- Lecture 17 - Coupled Oscillations - Part 2
- Lecture 18 - Solving for normal modes
- Lecture 19 - Coupled oscillations - More examples
- Lecture 20 - Coupled oscillator : Problems
- Lecture 21 - Coupled Oscillations of Loaded String
- Lecture 22 - Solutions for Loaded String
- Lecture 23 - Oscillations of Loaded String
- Lecture 24 - Continuum Limit of Loaded String
- Lecture 25 - Wave equation and its solutions
- Lecture 26 - Wave equation - impedance and velocities
- Lecture 27 - Standing waves
- Lecture 28 - Transverse waves in periodic structures
- Lecture 29 - Wave equation : Problems
- Lecture 30 - Reflection and transmission of waves
- Lecture 31 - Impedance matching



- Lecture 32 - Energy of vibrating string
- Lecture 33 - Dispersion of waves
- Lecture 34 - Bandwidth theorem and problems
- Lecture 35 - Longitudnal Waves and Speed of Sound
- Lecture 36 - Longitudnal Standing Waves
- Lecture 37 - Sound Intensity
- Lecture 38 - Longitudnal Waves: Problems
- Lecture 39 - Fourier Series - Part 1
- Lecture 40 - Fourier Series - Part 2
- Lecture 41 - Fourier Series and Energy of Vibrating String
- Lecture 42 - Frequency Spectrum and Fourier Transforms
- Lecture 43 - Fourier Series : Problems
- Lecture 44 - Waves in Optical Systems
- Lecture 45 - Waves in Optical Systems: Applying Fermat's Principle
- Lecture 46 - Waves in Optical Systems: Thin Lens
- Lecture 47 - Waves in Optical Systems: Matrix Method
- Lecture 48 - Waves in Optical Systems: Problems
- Lecture 49 - Interference: Part 1
- Lecture 50 - Interference: Newton's rings
- Lecture 51 - Michelson and Fabry-Perot Interferometers
- Lecture 52 - Young's Double Slit Experiment
- Lecture 53 - Diffraction
- Lecture 54 - Beyond Linear Oscillators: Non-linear Pendulum
- Lecture 55 - Beyond Linear Oscillators: Forced Oscillator
- Lecture 56 - Beyond Linear Oscillators: Chaotic Oscillator
- Lecture 57 - Beyond Linear Waves: Solitary Waves
- Lecture 58 - Waves in Quantum Mechanics and Summary

Lecture 1 - Introduction to Mathematica, Wolfram language and Wolfram Cloud

Lecture 2 - Technical Prelim 1

Lecture 3 - Plotting Simple Functions

Lecture 4 - Function Behaviour near Extrema

Lecture 5 - Radicals and Logarithms

Lecture 6 - Properties of Functions

Lecture 7 - Vector Fields, Vector and Streamline Plots and Contour Plots

Lecture 8 - Introduction to Non-dimensionalisation

Lecture 9 - Non-dimensionalization and visual thinking

Lecture 10 - Non-dimensionalisation and Parametric Plot

Lecture 11 - Technical Prelim 2: Loops

Lecture 12 - Introduction to Simple Harmonic Oscillator

Lecture 13 - Simple Harmonic Oscillator with a spring mass system

Lecture 14 - More Examples of Simple Harmonic Oscillator

Lecture 15 - Anharmonic Oscillator

Lecture 16 - Introduction to Data Analysis - 1

Lecture 17 - Introduction to Data Analysis - 2

Lecture 18 - Curve fitting

Lecture 19 - Linear superposition of oscillations

Lecture 20 - Technical Prelim 3: Introduction to Calculus Tools

Lecture 21 - Damped Harmonic Oscillator: LCR Circuit

Lecture 22 - Solving Initial Value Problem with Mathematica

Lecture 23 - Damped Harmonic Oscillator: Spring-mass System with Friction

Lecture 24 - Technical Prelim 4: Manipulation of Lists using @, @@, /@ operators

Lecture 25 - Introduction to Euler's Method for Solving Differential Equation

Lecture 26 - Technical Prelim 5: Writing Custom Functions

Lecture 27 - Writing Euler's Method as a custom function

Lecture 28 - Mean Global Error in Euler's method and Application of Euler's method to damped oscillator

Lecture 29 - Improved Euler (RK2) and RK4 Methods for solving ODEs

Lecture 30 - Driven oscillations

Lecture 31 - Driven oscillations using the Improved Euler method

[Lecture 32 - Falling Bodies](#)

[Lecture 33 - Escape velocity](#)

[Lecture 34 - Driven oscillations: Variations](#)

[Lecture 35 - Linear systems: Insights from the phase space picture - 1](#)

[Lecture 36 - Linear systems: Insights from the phase space picture - 2](#)

[Lecture 37 - Linearization - 1](#)

[Lecture 38 - Linearization - 2](#)

[Lecture 39 - The Monte Carlo Method - 1](#)

[Lecture 40 - The Monte Carlo Method - 2](#)

[Lecture 41 - The Monte Carlo Method - 3](#)

[Lecture 42 - The Monte Carlo Method - 4](#)

[Lecture 43 - The Monte Carlo Method - 5](#)

[Lecture 44 - Random Walks - 1](#)

[Lecture 45 - Random Walks - 2](#)

[Lecture 46 - Random Walks - 3](#)

[Lecture 47 - Random Walks - 4](#)

[Lecture 48 - Random Walks - 5](#)

[Lecture 49 - Random Walks - 6](#)

[Lecture 50 - Random Walks - 7](#)

Lecture 1 - Vector algebra

Lecture 2 - Vector algebra in component form

Lecture 3 - Vector triple products

Lecture 4 - Vector differential calculus: Gradient

Lecture 5 - Divergence

Lecture 6 - Curl

Lecture 7 - Tutorial on differential vector calculus

Lecture 8 - More problems on vector differential calculus

Lecture 9 - Vector integral calculus: Line integral

Lecture 10 - Surface integral

Lecture 11 - Volume integral

Lecture 12 - Fundamental theorems of vector calculus: The gradient theorem

Lecture 13 - The divergence theorem (Gauss's theorem)

Lecture 14 - The curl theorem (Stokes' theorem)

Lecture 15 - Curvilinear coordinates: Cartesian vs. Polar

Lecture 16 - Generic curvilinear coordinate systems: Unit vectors and components

Lecture 17 - Differential vector calculus in curvilinear coordinate systems

Lecture 18 - Special curvilinear coordinate systems: Cylindrical and spherical

Lecture 19 - Vector calculus in spherical coordinate system

Lecture 20 - Vector calculus in cylindrical coordinate system

Lecture 21 - Introduction to Dirac delta function

Lecture 22 - Tutorial on vector calculus and curvilinear coordinates

Lecture 23 - Introduction to electrostatics

Lecture 24 - Continuous charge distribution: Line charge

Lecture 25 - Electric field due to a line charge distribution

Lecture 26 - Electric field lines, Flux, Gauss law

Lecture 27 - Application of Gauss law with cylindrical symmetry

Lecture 28 - Application of Gauss law on a flat 2D surface

Lecture 29 - Tutorial on Dirac delta function and electrostatics

Lecture 30 - Tutorial on electrostatics

Lecture 31 - The curl of an electric field

Lecture 32 - Scalar potential

Lecture 33 - Calculation of electric potential from different approaches

Lecture 34 - Boundary conditions on electric field and potential

Lecture 35 - Work and energy of an assembly of point charges

Lecture 36 - General idea of energy in electrostatics

Lecture 37 - Electrostatics with conductors

Lecture 38 - Capacitors

Lecture 39 - Laplace equation

Lecture 40 - Boundary conditions and the uniqueness theorems

Lecture 41 - The method of images

Lecture 42 - Induced charge

Lecture 43 - Force and energy

Lecture 44 - Another example of the method of images

Lecture 45 - Electric dipoles

Lecture 46 - Multipole expansion, continuous charge distribution, and assembly of point charges

Lecture 47 - Electric field due to a dipole

Lecture 48 - Introduction to electric polarization in matter

Lecture 49 - Electric polarization and bound charges

Lecture 50 - Electric displacement vector and Gauss law

Lecture 51 - Boundary conditions on the displacement vector and linear dielectric materials

Lecture 52 - Parallel plate capacitors

Lecture 53 - Energy in dielectric materials

Lecture 54 - Force on dielectric materials

Lecture 55 - Motion of a charged particle in electromagnetic field

Lecture 56 - Work done by a magnetic field

Lecture 57 - Electric current

Lecture 58 - Surface and volume current

Lecture 59 - Biot Savart law

Lecture 60 - Biot Savart law with surface and volume currents

Lecture 61 - A tutorial on currents and magnetic field

Lecture 62 - Straight line current: Curl of the magnetic field

Lecture 63 - Divergence and curl of a generic magnetic field

Lecture 64 - Ampere's law in integral form and its applications

- [Lecture 65 - Magnetic field in a long solenoid](#)
- [Lecture 66 - A comparison between electrostatics and magnetostatics](#)
- [Lecture 67 - Magnetic vector potential](#)
- [Lecture 68 - Tutorial on magnetic fields](#)
- [Lecture 69 - Calculation of vector potential](#)
- [Lecture 70 - Boundary conditions on magnetic field](#)
- [Lecture 71 - Magnetic dipole](#)
- [Lecture 72 - Multipole expansion of the vector potential](#)
- [Lecture 73 - Magnetism, force and torque on magnetic dipole](#)
- [Lecture 74 - Fringing magnetic field](#)
- [Lecture 75 - Magnetization](#)
- [Lecture 76 - A tutorial on the magnetic dipole moment](#)
- [Lecture 77 - Ampere's law in magnetized materials](#)
- [Lecture 78 - Electrodynamics](#)
- [Lecture 79 - Electromagnetic induction](#)
- [Lecture 80 - Laws of electromagnetism so far](#)
- [Lecture 81 - Maxwell's correction to electromagnetism](#)
- [Lecture 82 - Fictitious discussion about symmetry](#)
- [Lecture 83 - Maxwell's equations in matter and the boundary conditions](#)

Lecture 1 - Introduction. Symmetries of space and time

Lecture 2 - Generalized coordinates and degrees of freedom

Lecture 3 - Virtual Work

Lecture 4 - Virtual Work (rigid body)

Lecture 5 - d'Alembert Principle

Lecture 6 - Euler Lagrange Equation for a holonomic system

Lecture 7 - Euler Lagrange Equations. Examples

Lecture 8 - Euler Lagrange Equations. Examples (Continued...)

Lecture 9 - Properties of Lagrangian

Lecture 10 - Kinetic term in generalized coordinates

Lecture 11 - Cyclic coordinates

Lecture 12 - Conservation laws - Conservation of Energy

Lecture 13 - Energy Function, Jacobi's Integral

Lecture 14 - Momentum conservation

Lecture 15 - Matrices and all that

Lecture 16 - Matrices, Forms, and all that

Lecture 17 - Principal axis transformation

Lecture 18 - Small Oscillations

Lecture 19 - Oscillations, Normal Coordinates

Lecture 20 - Oscillations, Triatomic molecule

Lecture 21 - Triatomic molecule normal coordinates

Lecture 22 - Coupled pendulums, normal modes

Lecture 23 - Coupled pendulums, Beats

Lecture 24 - Oscillations, General solution

Lecture 25 - Forced oscillations

Lecture 26 - Damped oscillations

Lecture 27 - Forced Damped oscillations

Lecture 28 - one dimensional systems

Lecture 29 - Two-body problem

Lecture 30 - Two-body problem, Kepler's second law

Lecture 31 - Two-body problem, Kepler problem

- Lecture 32 - Two-body problem, Conic Sections in Polar Coordinates
- Lecture 33 - Two-body problem, Ellipse in polar coordinates
- Lecture 34 - Orbits in Kepler Problem
- Lecture 35 - Apsidal distances, eccentricity of orbits
- Lecture 36 - Kepler's Third law; Laplace-Runge-Lenz vector
- Lecture 37 - Rigid Body, degrees of freedom
- Lecture 38 - Rigid Body, Transformation matrix
- Lecture 39 - Rigid Body, Euler Angles
- Lecture 40 - Parameterization using Euler Angles
- Lecture 41 - Rigid Body, Euler's Theorem
- Lecture 42 - General motion of a rigid body
- Lecture 43 - Moment of Inertia Tensor
- Lecture 44 - Principal Moments
- Lecture 45 - Lagrangian of a rigid body
- Lecture 46 - Motion of a free symmetric top
- Lecture 47 - Angular velocity using Euler angles
- Lecture 48 - Lagrangian of a heavy symmetric top
- Lecture 49 - First integrals of a heavy symmetric top
- Lecture 50 - Nutation and Precession of a heavy symmetric top
- Lecture 51 - Sleeping Top
- Lecture 52 - Rotating Frames. Euler Equations
- Lecture 53 - Calculus of Variations: Functionals
- Lecture 54 - Method of Lagrange Multipliers
- Lecture 55 - Calculus of Variations: Condition for extremum
- Lecture 56 - Calculus of Variations: Several variables
- Lecture 57 - Cartesian Tensors
- Lecture 58 - Hamiltonian Mechanics: Hamilton's equations of motion
- Lecture 59 - Hamiltonian Mechanics: Liouville's theorem
- Lecture 60 - Hamiltonian Mechanics: Poisson Bracket
- Lecture 61 - Hamiltonian Mechanics: Canonical Coordinates
- Lecture 62 - Hamiltonian Mechanics: Generating Function of Canonical Transformations
- Lecture 63 - Hamiltonian Mechanics: Generating functions of the 4 kinds
- Lecture 64 - Examples of Generating Functions



[Lecture 65 - Harmonic Oscillator \(Canonical Transformations\)](#)

[Lecture 66 - Invariance of Poisson Brackets](#)

[Lecture 67 - Normal modes of triatomic molecule using Mathematica](#)

Lecture 1 - Introduction to the course

Lecture 2 - Continuum hypothesis, distribution function and stress-viscosity relation

Lecture 3 - Continuum hypothesis, distribution function and stress-viscosity relation - Recap

Lecture 4 - Fluid Kinematics

Lecture 5 - Fluid Kinematics - Recap

Lecture 6 - Conservation laws: Mass conservation and incompressibility

Lecture 7 - Conservation laws: Momentum conservation and Euler equation

Lecture 8 - Conservation laws - Recap

Lecture 9 - Potential flows

Lecture 10 - Bernoulli constant, its applications and vorticity equation

Lecture 11 - Recap - Potential flows, Bernoulli constant and its applications

Lecture 12 - Vorticity dynamics -- Kelvin's vorticity theorem and Magnus effect

Lecture 13 - Navier-Stokes equation

Lecture 14 - Navier-Stokes equation (Continued...) and energy equation

Lecture 15 - Energy equation in a conservative form

Lecture 16 - Boundary conditions in Navier-Stokes equation, d'Alembert's paradox

Lecture 17 - Poiseuille flow, deriving viscosity from microscopies

Lecture 18 - Dimensionless numbers -- Mach number, Reynolds number

Lecture 19 - Dimensionless numbers (Continued...) -- plasma beta, magnetic Reynolds number, Alfvén Mach number, Prandtl number, dimensionless numbers -- Mach number, Reynolds number

Lecture 20 - Reynolds number and dynamic similarity

Lecture 21 - Reynolds number recap, Low Re flows, and drag on a sphere (Stokes law)

Lecture 22 - High Re flows -- turbulent drag law, vortex shedding and drag crisis

Lecture 23 - Lift on a body, introduction to compressible flows

Lecture 24 - Compressible flows -- derivation of sound speed and dispersion relation

Lecture 25 - Subsonic and supersonic flows

Lecture 26 - Propagation of sonic information, shock tube problem and piston problem

Lecture 27 - Criterion for neglect of compressibility, method of characteristics

Lecture 28 - Shock thickness

Lecture 29 - Shock thickness recap, shock jump conditions

Lecture 30 - Shock jump conditions (Continued...), transonic 1D flows, converging/diverging channels

- Lecture 31 - Coverging/diverging channels, de Laval nozzle and its application to astrophysical jets
- Lecture 32 - Spherically symmetric transonic flows
- Lecture 33 - Spherically symmetric transonic flows (Continued...)
- Lecture 34 - Solar wind : Parker's solution
- Lecture 35 - Solar wind : Modifications in Parker's solution
- Lecture 36 - Spherical accretion onto a compact object : Eddington luminosity and accretion rate
- Lecture 37 - Spherical accretion onto a compact object : Solutions for flow properties
- Lecture 38 - Spherical accretion (Continued...), disk accretion--Roche lobe overflow
- Lecture 39 - Disk accretion : Mass conservation and vertical hydrostatic equilibrium
- Lecture 40 - Disk accretion : Removal of angular momentum, Shakura-Sunyaev viscosity parameter
- Lecture 41 - Disk accretion : Viscous dissipation and the energy equation, two-temperature criterion
- Lecture 42 - Particle acceleration in astrophysical settings : Shocks and non-thermal energy distribution
- Lecture 43 - Particle acceleration in astrophysical settings : Diffusive shock acceleration
- Lecture 44 - Spherical blast waves : Bomb explosion and supernova explosion
- Lecture 45 - Spherical blast waves : Sedov-Taylor solution
- Lecture 46 - Spherical blast waves : Sedov-Taylor solution (Continued....)
- Lecture 47 - Magnetohydrodynamics (MHD) : Introduction
- Lecture 48 - Magnetohydrodynamics (MHD) : The induction equation
- Lecture 49 - Magnetohydrodynamics (MHD) : Currents in MHD, momentum equation and magnetic stress tensor
- Lecture 50 - Magnetohydrodynamics (MHD) : Magnetic stresses and magnetic buoyancy
- Lecture 51 - Magnetohydrodynamics (MHD) : Plasma beta, force-free fields and potential configurations
- Lecture 52 - Magnetohydrodynamics (MHD) : Magnetic flux-freezing
- Lecture 53 - Magnetohydrodynamics (MHD) : Magnetic flux-freezing (Continued....), magnetic dynamos
- Lecture 54 - Magnetohydrodynamics (MHD) : Dynamo theory
- Lecture 55 - Magnetohydrodynamics (MHD) : Waves in MHD - Alfvén waves
- Lecture 56 - Magnetohydrodynamics (MHD) : Waves in MHD - Alfvén waves and magnetosonic waves
- Lecture 57 - Magnetohydrodynamics (MHD) : Waves in MHD - Magnetosonic waves
- Lecture 58 - Magnetohydrodynamics (MHD) : Shocks in MHD
- Lecture 59 - Magnetohydrodynamics (MHD) : Shocks in MHD - Shock jump conditions
- Lecture 60 - Non-ideal MHD : Introduction to magnetic reconnection
- Lecture 61 - Non-ideal MHD : Magnetic reconnection - The Sweet-Parker model
- Lecture 62 - Non-ideal MHD : Magnetic reconnection - The Petscheck model
- Lecture 63 - Sun's atmosphere : Solar corona and the coronal heating problem



Lecture 1 - Introduction

Lecture 2 - Classical and Semi-classical Transport: Overview

Lecture 3 - Quantum Transport Regimes

Lecture 4 - Band-bending and Metal semiconductor Interfaces

Lecture 5 - Semiconductor Heterostructures

Lecture 6 - 2DEG and Electrostatic Gating

Lecture 7 - Device Fabrication - Photolithography

Lecture 8 - Device Fabrication - Electron-beam Lithography

Lecture 9 - Quantum hall Effect - Overview

Lecture 10 - Quantum Hall Effect: Quantization of electron orbitals, Landau levels and Flux quantization

Lecture 11 - Quantum Hall Effect: Landau level, filling factor and Shubnikov-de-Haas effect

Lecture 12 - Quantum Hall Effect: Edge states and Resistance Quantization

Lecture 13 - Weak Localization

Lecture 14 - Aharonov-Bohm Effect

Lecture 15 - Ballistic 1D transport-Quantum Point contacts

Lecture 16 - Ballistic 1D transport-Current from transmission

Lecture 17 - Ballistic 1D transport-Where is the power dissipation?

Lecture 18 - 0D Transport - Single Electron Tunneling

Lecture 19 - Single Electron Transistors, Coulomb Blockade

Lecture 20 - Quantum Dots, Shell filling, Artificial Atoms

Lecture 21 - Transport on Double Quantum Dots - I

Lecture 22 - Transport on Double Quantum Dots - II

Lecture 23 - Superconductivity-Introduction

Lecture 24 - Superconducting tunnel junctions-Josephson effect - 1

Lecture 25 - Superconducting tunnel junctions-Josephson effect - 2

Lecture 26 - Charge sensing with quantum point contacts

Lecture 27 - Charge sensing with single electron transistors

Lecture 28 - Real-time charge sensing

Lecture 29 - Quantum Electrical Metrology - I

Lecture 30 - Quantum Electrical Metrology - II

Lecture 31 - Qubits - Overview

[Lecture 32 - Superconducting qubits](#)

[Lecture 33 - Quantum dot qubits](#)

Lecture 1 - Introduction to Thermodynamics

Lecture 2 - Laws of Thermodynamics

Lecture 3 - Second Law of Thermodynamics and Heat Engines

Lecture 4 - Entropy, Clausius Inequality, Thermodynamic Processes and Systems

Lecture 5 - Extensivity of Entropy and Internal Energy, Gibbs Duhem relation

Lecture 6 - Exact and Inexact differentials, Legendre Transformation

Lecture 7 - Free Energy in Thermodynamics

Lecture 8 - Maxwell's relations - Part I

Lecture 9 - Maxwell's relations - Part II

Lecture 10 - Maxwell's relations - Part III

Lecture 11 - Response Functions and manipulating Partial Derivatives

Lecture 12 - Working With Thermodynamics

Lecture 13 - Joule Expansion and Joule Thomson Effect

Lecture 14 - Stability of Thermodynamic Potentials

Lecture 15 - Consequences of Stability of Thermodynamic Potentials

Lecture 16 - Conditions of Equilibrium and Gibbs Phase Rule

Lecture 17 - Introduction to Probability

Lecture 18 - Discrete and Continuous Distributions

Lecture 19 - Central Limit Theorem and Statistical Entropy

Lecture 20 - Classical Probability Density and Liouville Equation

Lecture 21 - Classical Probability Density, Ergodicity and Microcanonical Ensemble

Lecture 22 - Microcanonical Ensemble

Lecture 23 - Examples of Microcanonical Ensemble - Two Level System

Lecture 24 - Examples of Microcanonical Ensemble - Magnetic System and Ideal Gas - Part I

Lecture 25 - Examples of Microcanonical Ensemble - Magnetic System and Ideal Gas - Part II

Lecture 26 - Examples of Microcanonical Ensemble - Ultra-Relativistic Gas

Lecture 27 - Microcanonical Ultrarelativistic Gas and Quantum Solid

Lecture 28 - Microcanonical Excluded Volume

Lecture 29 - Canonical Ensemble

Lecture 30 - Canonical Ensemble Paramagnet

Lecture 31 - Canonical Ensemble Ideal Gas

- Lecture 32 - Canonical Ensemble Einstein Solid
- Lecture 33 - Grand Canonical Ensemble
- Lecture 34 - Grand Canonical Ensemble Ideal Gas - Part I
- Lecture 35 - Grand Canonical Ensemble Ideal Gas - Part II
- Lecture 36 - MicroCanonical to Canonical - Part I
- Lecture 37 - MicroCanonical to Canonical - Part II
- Lecture 38 - Interacting System - Part I
- Lecture 39 - Interacting System - Part II
- Lecture 40 - Van-Der Waals Equation of State
- Lecture 41 - Quantum Statistical Mechanics Density Matrix
- Lecture 42 - Density Matrix in different Ensembles
- Lecture 43 - Free Particle Quantum Canonical Partition Function Free
- Lecture 44 - Single Particle Quantum Partition Function Harmonic Oscillator - Part I
- Lecture 45 - Single Particle Quantum Partition Function Harmonic Oscillator - Part II
- Lecture 46 - Wigner Transformation
- Lecture 47 - N-Particle partition function
- Lecture 48 - Canonical Formulation of Ideal Gas
- Lecture 49 - Grand Canonical Formulation of Ideal Gas
- Lecture 50 - High Temperature Expansion
- Lecture 51 - Degenerate Fermi Gas
- Lecture 52 - Ideal Fermi Gas close to  $T=0$ , Chemical Potential and Specific Heat
- Lecture 53 - Relativistic Fermi Gas at  $T=0$
- Lecture 54 - Ideal Bose Gas
- Lecture 55 - Bose-Einstein Condensation
- Lecture 56 - Pressure of an Ideal Bose Gas
- Lecture 57 - Specific Heat of an Ideal Bose Gas - Part 1
- Lecture 58 - Specific Heat of an Ideal Bose Gas - Part 2
- Lecture 59 - Bose-Einstein Condensation in a Harmonically Trapped Bose Gas
- Lecture 60 - Specific Heat of a Harmonically Trapped Bose Gas
- Lecture 61 - General Treatment of a Bose gas - Part 1
- Lecture 62 - General Treatment of a Bose gas - Part 2
- Lecture 63 - Discontinuity in the Specific Heat of a Bose Gas - Part 1
- Lecture 64 - Discontinuity in the Specific Heat of a Bose Gas - Part 2





Lecture 1 - What is solid?

Lecture 2 - Bravais lattice

Lecture 3 - Indexing of crystal planes

Lecture 4 - Simple crystal structures

Lecture 5 - Diffraction of waves by crystals

Lecture 6 - Fourier analysis of diffraction

Lecture 7 - Diffraction condition

Lecture 8 - Laue equations and Ewald construction

Lecture 9 - Introduction to Brillouin zone

Lecture 10 - Brillouin zones for bcc and fcc lattice

Lecture 11 - Fourier analysis of the basis and structure factor

Lecture 12 - Atomic form factor

Lecture 13 - Van der Waals attraction

Lecture 14 - Repulsive interaction

Lecture 15 - Equilibrium lattice constant and cohesive energy

Lecture 16 - Ionic crystals

Lecture 17 - Evaluation of the Madelung constant

Lecture 18 - Covalent crystals: Linear combination of atomic orbitals

Lecture 19 - Electron tunneling in covalent bonds

Lecture 20 - Metallic bonds

Lecture 21 - The Drude theory of metals

Lecture 22 - Hall effect and magnetoresistance

Lecture 23 - AC electrical conductivity

Lecture 24 - Thermal conductivity

Lecture 25 - Introduction to Sommerfeld theory - I

Lecture 26 - Introduction to Sommerfeld theory - II

Lecture 27 - Electronic states at finite temperature

Lecture 28 - Fermi-Dirac distribution

Lecture 29 - Thermal properties of the free electron gas

Lecture 30 - The Sommerfeld theory for conduction in metals

Lecture 31 - Thermal conductivity

- Lecture 32 - One dimensional chain of atoms
- Lecture 33 - One dimensional chain of atoms
- Lecture 34 - Periodic boundary condition
- Lecture 35 - Energy levels in periodic array of quantum wells
- Lecture 36 - Tunneling of electrons
- Lecture 37 - Reflection and transmission amplitudes and coefficients
- Lecture 38 - Transfer matrix for a rectangular barrier
- Lecture 39 - Electron tunneling through a periodic potential
- Lecture 40 - The tight-binding approximation
- Lecture 41 - Tridiagonal matrices and continued fraction
- Lecture 42 - Plane-wave basis for nearly free electrons
- Lecture 43 - Nearly free electron approximation
- Lecture 44 - Dynamical aspects of electrons in band theory
- Lecture 45 - Semiconductor crystals
- Lecture 46 - Effective mass
- Lecture 47 - Carrier concentration
- Lecture 48 - Mobility, impurity conductivity, and Fermi surface
- Lecture 49 - Vibration of crystals with monatomic basis
- Lecture 50 - Analyzing the dispersion relation
- Lecture 51 - Phonons with diatomic basis
- Lecture 52 - Quantization of elastic waves
- Lecture 53 - Phonon heat capacity
- Lecture 54 - Phonon density of states
- Lecture 55 - Introduction to diamagnetism
- Lecture 56 - Issues with the classical theory of diamagnetism
- Lecture 57 - Quantum theory of diamagnetism
- Lecture 58 - The quantum theory of paramagnetism
- Lecture 59 - Rare earth atoms, Hund's rule
- Lecture 60 - Crystal field splitting
- Lecture 61 - Quenching of orbital angular momentum
- Lecture 62 - Paramagnetic susceptibility of conduction electrons
- Lecture 63 - Ferromagnetism
- Lecture 64 - Antiferromagnetism and ferrimagnetism

[Lecture 65 - Introduction to superconductivity](#)

[Lecture 66 - Thermodynamics of superconducting transition, London equation](#)

[Lecture 67 - BCS theory of superconductivity](#)

[Lecture 68 - Flux quantization in a superconducting ring](#)

[Lecture 69 - Single particle tunneling and Josephson effect](#)

[Lecture 70 - AC Josephson effect and microscopic quantum interference](#)

Lecture 1 - Quantum Field Theory

Lecture 2 - Quantizing Schrodinger Field

Lecture 3 - Quantizing Schrodinger Field (Continued...)

Lecture 4 - Symmetry and normalization of the states

Lecture 5 - A multiparticle system of Bosons

Lecture 6 - Klein-Gordon Equation

Lecture 7 - Quantization of Klein-Gordon Theory

Lecture 8 - Quantization of Klein-Gordon Theory (Continued...)

Lecture 9 - Quantization of Klein-Gordon Theory (Continued...)

Lecture 10 - Quantization of Klein-Gordon Theory (Continued...)

Lecture 11 - Quantization of Klein-Gordon Theory (Continued...)

Lecture 12 - Quantization of Klein-Gordon Theory (Continued...)

Lecture 13 - Quantization of Klein-Gordon Theory (Continued...)

Lecture 14 - Feynman propagator - 2

Lecture 15 - Feynman propagator - 3

Lecture 16 - Symmetries

Lecture 17 - Lorentz transformations

Lecture 18 - Lorentz transformations (Continued...)

Lecture 19 - Lorentz Group

Lecture 20 - Groups and Generators

Lecture 21 - SU(3) Generators

Lecture 22 - Representation of groups. Poincare group

Lecture 23 - Poincare Algebra

Lecture 24 - Symmetries in Classical Field Theories

Lecture 25 - Symmetries (Continued...)

Lecture 26 - Symmetries (Continued...)

Lecture 27 - Symmetries (Continued...)

Lecture 28 - Noether's theorem: The Proof

Lecture 29 - Noether's theorem (Continued...)

Lecture 30 - Momentum in KG Theory

Lecture 31 - Noether Currents corresponding to Lorentz symmetry

[Lecture 32 - Conserved currents and charges due to Lorentz symmetry](#)

[Lecture 33 - Conserved charges as symmetry generators](#)

[Lecture 34 - Consequences of symmetry](#)

[Lecture 35 - A boring world: Scattering in a free theory](#)

[Lecture 36 - Phi-4 Theory](#)

[Lecture 37 - Phi-4 Theory: Manipulating the ground state](#)

[Lecture 38 - Phi-4 Theory: Interaction picture - 1](#)

[Lecture 39 - Phi-4 Theory: Interaction picture - 2](#)

[Lecture 40 - Phi-4 Theory: Interaction picture \(Continued...\)](#)

[Lecture 41 - Phi-4 Theory: Interaction picture \(Continued...\)](#)

[Lecture 42 - Wick's Theorem](#)

[Lecture 43 - Wick's Theorem \(Continued...\)](#)

[Lecture 44 - Feynman Diagrams](#)

[Lecture 45 - Feynman Diagrams \(Continued...\)](#)

[Lecture 46 - Momentum space Feynman rules for  \$G\(x\_1, \dots, x\_N\)\$](#)

[Lecture 47 - Feynman rules for  \$G\(p\_1, p\_2, \dots, p\_N\)\$](#)

[Lecture 48 - Feynman rules for  \$G\(p\_1, p\_2, \dots, p\_N\)\$  \(Continued...\)](#)

[Lecture 49 - Cancellation of Bubble diagrams](#)

[Lecture 50 - Examples of Feynman Diagrams](#)

[Lecture 51 - Survey](#)

Lecture 1 - Scattering Matrix

Lecture 2 - Scattering Matrix (Continued...)

Lecture 3 - Scattering Matrix (Continued...)

Lecture 4 - Creating single particle states - 1

Lecture 5 - Creating single particle states - 2

Lecture 6 - Annihilating single particle states

Lecture 7 - Creating Multiparticle States

Lecture 8 - LSZ reduction

Lecture 9 - LSZ reduction (Continued...)

Lecture 10 - S matrix

Lecture 11 - S matrix (Continued...)

Lecture 12 - S matrix (Continued...)

Lecture 13 - Pole and residue of the propagator

Lecture 14 - Kallen-Lehmann spectral representation

Lecture 15 - Kallen-Lehmann spectral representation (Continued...)

Lecture 16 - High Energy Experiment Setup - 1

Lecture 17 - High Energy Experiment Setup - 2

Lecture 18 - Scattering cross-section

Lecture 19 - Differential cross-section

Lecture 20 - 2-2 scattering cross-section

Lecture 21 - Loop diagrams - 1

Lecture 22 - Wick rotated Green's functions

Lecture 23 - UV divergences - Part 1

Lecture 24 - UV divergences - Part 2

Lecture 25 - UV divergences - Part 3

Lecture 26 - Explicit evaluation of Feynman integrals

Lecture 27 - Few more Feynman integrals

Lecture 28 - UV Singularity structure in dimensional regularization

Lecture 29 - Renormalization - Part 1

Lecture 30 - Renormalization - Part 2

Lecture 31 - Renormalization - Part 3

[Lecture 32 - Renormalization - Part 4](#)

[Lecture 33 - Renormalization - Part 5](#)

[Lecture 34 - Renormalization Group Equation - 1](#)

[Lecture 35 - Renormalization Group Equation - 2](#)

[Lecture 36 - Renormalization Group Equation - 3](#)

[Lecture 37 - Solution of Callan Symanzik Equation](#)

[Lecture 38 - UV and IR fixed points and Asymptotic Freedom](#)

[Lecture 39 - Behaviour near fixed point](#)



- Lecture 1 - Introduction to Radio Astronomy
- Lecture 2 - Review of Electromagnetism - Part 1
- Lecture 3 - Review of Electromagnetism - Part 2
- Lecture 4 - Radio Astronomy - Tutorial 1
- Lecture 5 - Milestones in Radio Astronomy
- Lecture 6 - Radio Astronomy Fundamentals - Part 1
- Lecture 7 - Radio Astronomy Fundamentals - Part 2
- Lecture 8 - Radiative Transfer - Tutorial 1
- Lecture 9 - Fundamentals of Antenna
- Lecture 10 - Fundamental of Antenna Theory - Part 1
- Lecture 11 - Fundamental of Antenna Theory - Part 2
- Lecture 12 - Fundamental of Antenna Theory - Part 3
- Lecture 13 - Signal Processing and Receivers
- Lecture 14 - Signal Proceeding and Receivers - Part 2
- Lecture 15 - Radio Telescopes
- Lecture 16 - Single Dish Observations
- Lecture 17 - Demonstration of Antenna Design and Simulation - Part 1
- Lecture 18 - Demonstration Of Antenna Design and Simulation - Part 2
- Lecture 19 - What Have we Learnt so Far? - A Review
- Lecture 20 - Demonstration of Antenna Design and Simulation - Part 3
- Lecture 21 - Co-ordinate System
- Lecture 22 - Radio Interferometers
- Lecture 23 - Example Questions
- Lecture 24 - Python Crash Course
- Lecture 25 - Few Concepts with the help of python as a computational tool
- Lecture 26 - Live session
- Lecture 27 - Example Questions
- Lecture 28 - Radio Interferometry and Aperture Synthesis
- Lecture 29 - Introduction to CASA
- Lecture 30 - Examples
- Lecture 31

[Lecture 32](#)

[Lecture 33 - Revision](#)

[Lecture 34 - Revision](#)

- Lecture 1 - Introduction
- Lecture 2 - Need for Optical Communication
- Lecture 3 - Salient Features of Optical Fiber - I
- Lecture 4 - Salient Features of Optical Fiber - II
- Lecture 5 - Optical Fiber Fabrication
- Lecture 6 - Transmission Characteristics - I
- Lecture 7 - Transmission Characteristics - II
- Lecture 8 - Transmission Characteristics - III
- Lecture 9 - Propagation in Infinitely Extended Dielectric
- Lecture 10 - EM Waves in Dielectrics
- Lecture 11 - Electromagnetic Analysis of Waveguides - I
- Lecture 12 - Electromagnetic Analysis of Waveguides - II
- Lecture 13 - Electromagnetic Analysis of Waveguides - III
- Lecture 14 - Electromagnetic Analysis of Waveguides - IV
- Lecture 15 - Electromagnetic Analysis of Waveguides - V
- Lecture 16 - Electromagnetic Analysis of Waveguides - VI
- Lecture 17 - Electromagnetic Analysis of Waveguides - VII
- Lecture 18 - Electromagnetic Analysis of Waveguides - VIII
- Lecture 19 - Optical Fiber Waveguide - I
- Lecture 20 - Optical Fiber Waveguide - II
- Lecture 21 - Optical Fiber Waveguide - III
- Lecture 22 - Optical Fiber Waveguide - IV
- Lecture 23 - Optical Fiber Waveguide - V
- Lecture 24 - Splice Loss
- Lecture 25 - Waveguide Dispersion - I
- Lecture 26 - Waveguide Dispersion - II
- Lecture 27 - Recap: Propagation Characteristics
- Lecture 28 - Optical Fiber Components and Devices - I
- Lecture 29 - Optical Fiber Components and Devices - II
- Lecture 30 - Optical Fiber Components and Devices - III
- Lecture 31 - Optical Fiber Components and Devices - IV

[Lecture 32 - Optical Fiber Components and Devices - V](#)

[Lecture 33 - Optical Sources and Detectors - I](#)

[Lecture 34 - Optical Sources and Detectors - II](#)

[Lecture 35 - Optical Sources and Detectors - III](#)

[Lecture 36 - Optical Sources and Detectors - IV](#)

[Lecture 37 - Optical Sources and Detectors - V](#)

[Lecture 38 - System Design Aspects](#)

[Lecture 39 - Optical Fiber Measurements](#)

[Lecture 40 - Summary and Recent Advances](#)

Lecture 1 - Energy and its Sources

Lecture 2 - Introduction to Solar Energy

Lecture 3 - Introduction of Quantum Mechanics in Solar Photovoltaics - I

Lecture 4 - Introduction of Quantum Mechanics in Solar Photovoltaics - II

Lecture 5 - Introduction of Quantum Mechanics in Solar Photovoltaics - III

Lecture 6 - Band Theory

Lecture 7 - Energy Band Diagram

Lecture 8 - Charge Carrier Dynamics in Semiconductor

Lecture 9 - P-N junction model and Diode working principle

Lecture 10 - Current-Voltage Characteristics of Solar Cell

Lecture 11 - Equivalent Circuits of Solar Cells, Fill Factor

Lecture 12 - Fabrication Process of Semiconductor Grade Silicon

Lecture 13 - Fabrication Process of Single crystalline Silicon

Lecture 14 - Thin Film deposition Techniques

Lecture 15 - Thin Film Solar Cells: Amorphous Silicon

Lecture 16 - Photo Physics of Dye Sensitized Solar Cells

Lecture 17 - Fabrication of Dye Sensitized Solar Cells

Lecture 18 - Design of Novel dyes

Lecture 19 - Design of Electrolytes

Lecture 20 - Quantum Dot Solar Cells

Lecture 21 - Fabrication of Organic Solar Cells

Lecture 22 - Physics of Bulk Hetero Junction (BHJ) Solar Cells

Lecture 23 - Photo Physics of Organic Solar Cells

Lecture 24 - Morphology Optimization of Organic Solar Cells

Lecture 25 - Perovskite Solar Cells

Lecture 26 - Fabrication of Perovskite Solar Cells

Lecture 27 - Photo Physics of Perovskite Solar Cells

Lecture 28 - Stability in Perovskite Solar Cells

Lecture 29 - Morphology Optimization of Perovskite Solar Cells

Lecture 30 - Perovskite Single Crystal Solar Cells

Lecture 31 - Photophysics in Perovskite Single Crystal Solar Cells

[Lecture 32 - Applications of Perovskite Single Crystal Solar Cells](#)

[Lecture 33 - Organic Nano Particles Based Solar Cells](#)

[Lecture 34 - Morphology Optimization in Organic Nanoparticle Based Solar Cells](#)

[Lecture 35 - Multijunction Tandem Solar Cells](#)

[Lecture 36 - Introduction to Characterization Techniques](#)

[Lecture 37 - Vacuum Technology in Solar Photovoltaics](#)

[Lecture 38 - Introduction of Pressure Gauges](#)

[Lecture 39 - Electron Microscopy in Solar Photovoltaics](#)

[Lecture 40 - Impedance Spectroscopy](#)

Lecture 1 - An Introduction to the Earth's Atmosphere and Source of Energy - The Sun

Lecture 2 - Primary Source of Energy on the Earth - The Sun

Lecture 3 - Evolution of the Earth's Atmosphere

Lecture 4 - Earth's Second Atmosphere and Rise of Oxygen

Lecture 5 - Atmosphere of Other Planets in Solar System

Lecture 6 - Structure of Earth's Atmosphere

Lecture 7 - Vertical Structure of Atmosphere

Lecture 8 - Characterization of Atmosphere Based on Electrical Properties

Lecture 9 - Coupling of Solar Radiation with the Earth's Atmosphere

Lecture 10 - Forces and Their Classifications

Lecture 11 - Forces - Gravitational Force

Lecture 12 - Forces - Viscous Force

Lecture 13 - Forces - Coriolis Force

Lecture 14 - Coriolis Force and Curvature Effect

Lecture 15 - Hydrostatic Equation

Lecture 16 - Hypsometric Equation

Lecture 17 - Atmospheric Thermodynamics

Lecture 18 - Thermodynamics - Dry Air

Lecture 19 - Thermodynamics - Moist Air

Lecture 20 - Geopotential and Scale Height

Lecture 21 - Specific Heats

Lecture 22 - Air Parcel and Potential Temperature

Lecture 23 - Moisture Parameters

Lecture 24 - Saturation Mixing Ratio and Relative Humidity

Lecture 25 - Pseudo-Adiabatic Processes

Lecture 26 - Convection of Air

Lecture 27 - Atmospheric Stability and Cloud Formation

Lecture 28 - Cloud Formation

Lecture 29 - Cloud Formation and Lifting

Lecture 30 - Cloud Morphology

Lecture 31 - Secondary Cloud Classification and Fog

- Lecture 32 - Atmospheric Stability
- Lecture 33 - Atmospheric Stability Conditions
- Lecture 34 - Stable Unstable and Neutral Atmosphere
- Lecture 35 - Cloud Seeding and Precipitation
- Lecture 36 - Measuring Precipitation
- Lecture 37 - Droplet Growth and Curvature Effect
- Lecture 38 - Droplet Growth and Solute Effect
- Lecture 39 - Radial Growth of Droplets by Diffusion
- Lecture 40 - Radial Growth of Droplets by Diffusion (Continued...)
- Lecture 41 - Ionospheric Layers and Photochemistry
- Lecture 42 - Ionization Processes
- Lecture 43 - Ionospheric Chemical Reactions and Layers
- Lecture 44 - Chapman's Theory of Layer Production
- Lecture 45 - Chapman's Theory of Layer Production (Continued...)
- Lecture 46 - Chapman's Alpha Layer
- Lecture 47 - Hydrogen in Ionosphere
- Lecture 48 - Debye's Shielding
- Lecture 49 - Debye's Shielding and Debye's Potential
- Lecture 50 - Debye's Potential (Continued...)
- Lecture 51 - Particle Motion in Uniform Electric Field
- Lecture 52 - Particle Motion in Uniform Magnetic Field
- Lecture 53 - Particle Motion in Uniform Magnetic Field and Guiding Center
- Lecture 54 - Particle Motion in Uniform Electric and Magnetic Fields
- Lecture 55 - Gradient Magnetic Field
- Lecture 56 - Gradient Drift and Curvature Drift
- Lecture 57 - Vacuum Drift and Planetary Ring Current
- Lecture 58 - Magnetic Mirroring
- Lecture 59 - Magnetic Mirroring and Loss Cone
- Lecture 60 - Airglow and Aurora



Lecture 1 - Introduction

Lecture 2 - Sensor Fabrication and Characterization

Lecture 3 - Basic Optics for Optical Sensing - I

Lecture 4 - Basic Optics for Optical Sensing - II

Lecture 5 - Basic Optics for Optical Sensing - III

Lecture 6 - Basic Optics for Optical Sensing - IV

Lecture 7 - Basic Optics for Optical Sensing - V

Lecture 8 - Basic Optics for Optical Sensing - VI

Lecture 9 - Basic Optics for Optical Sensing - VII

Lecture 10 - Plasmons - I

Lecture 11 - Plasmons - II

Lecture 12 - Plasmons - III

Lecture 13 - Plasmons - IV

Lecture 14 - Plasmons - V

Lecture 15 - Plasmons - VI

Lecture 16 - Multiple Optical Sensors of Different Mechanisms

Lecture 17 - Interference based Sensors

Lecture 18 - Interference, Diffraction and Optical Fiber Sensors

Lecture 19 - Review of Biomaterial Optics

Lecture 20 - Terahertz Based Detection and Circular Dichroism

Lecture 1 - Atmospheric Forces and Dynamics - Part 1

Lecture 2 - Atmospheric Forces and Dynamics - Part 2

Lecture 3 - Total Derivative (Introduction)

Lecture 4 - Total Derivative of a Vector in a Rotating Frame of Reference

Lecture 5 - Momentum Equations and its Vectorial Form in Spherical Polar Coordinates - Part 1

Lecture 6 - Momentum Equations and its Vectorial Form in Spherical Polar Coordinates - Part 2

Lecture 7 - Momentum Equations and its Vectorial Form in Spherical Polar Coordinates - Part 3

Lecture 8 - Total Derivative and Lagrangian

Lecture 9 - Continuity Equation: Eulerian

Lecture 10 - Energy Equations - Part 1

Lecture 11 - Energy Equations - Part 2

Lecture 12 - Scaling analysis - Part 1

Lecture 13 - Scaling analysis - Part 2

Lecture 14 - Scaling Analysis of Governing Equations - Part 1

Lecture 15 - Scaling Analysis of Governing Equations - Part 2

Lecture 16 - Scaling Analysis - Part 3, A Tutorial

Lecture 17 - Scaling Analysis - Part 4, A Tutorial

Lecture 18 - Introduction of Atmospheric Waves - Part 1

Lecture 19 - Introduction of Atmospheric Waves - Part 2

Lecture 20 - Problems based on Total Derivative - Part 1

Lecture 21 - Problems based on Total Derivative - Part 2

Lecture 22 - Shallow Water Gravity Waves - Part 1

Lecture 23 - Shallow Water Gravity Waves - Part 2

Lecture 24 - Acoustic Waves

Lecture 25 - Internal Gravity Waves - Part 1

Lecture 26 - Internal Gravity Waves - Part 2

Lecture 27 - Internal Gravity Waves - Part 3

Lecture 28 - Pressure as a vertical coordinate - Part 1

Lecture 29 - Pressure as a vertical coordinate - Part 2

Lecture 30 - Pressure as a vertical coordinate - Part 3

Lecture 31 - General circulation and global winds

- Lecture 32 - Introduction to different types of Fronts
- Lecture 33 - Geostrophic winds
- Lecture 34 - Natural coordinate and Inertial flows
- Lecture 35 - Cyclostrophic winds and Rossby number
- Lecture 36 - Gradient winds
- Lecture 37 - Thermal winds
- Lecture 38 - Problems on thermal winds
- Lecture 39 - Ionosphere introduction (Basics)- Part 1
- Lecture 40 - Ionosphere introduction (Different layers) - Part 2
- Lecture 41 - Ionosphere introduction (Photochemistry) - Part 3
- Lecture 42 - Ionosphere introduction (Recombination) - Part 4
- Lecture 43 - Composite F layer - Part 1
- Lecture 44 - Composite F layer - Part 2
- Lecture 45 - Composite F layer H/He ions - Part 3
- Lecture 46 - The Sun - Earth Energetics and Aurora
- Lecture 47 - Airglows and Aurora
- Lecture 48 - Sun's magnetic field, Formation of Aurora, and Solar cycle
- Lecture 49 - Sun's internal structure, Prominences
- Lecture 50 - Solar wind - Magnetosphere interactions
- Lecture 51 - Solar wind interactions with different planets
- Lecture 52 - Solar wind properties and its interaction with different planets
- Lecture 53 - Static Model of Corona
- Lecture 54 - Parker's Theory of Solar Wind Acceleration - Part 1
- Lecture 55 - Parker's Theory of Solar Wind Acceleration - Part 2
- Lecture 56 - Parker's Theory of Solar Wind Acceleration - Part 3
- Lecture 57 - Parker's Theory of Solar Wind Acceleration - Part 4
- Lecture 58 - Introduction to Space Weather - Part 1
- Lecture 59 - Introduction to Space Weather - Part 2
- Lecture 60 - Introduction to Space Weather - Part 3

Lecture 1 - Historical Background, Observational Astronomy, Properties of Sun and of Stars

Lecture 2 - Properties of Galaxies and Universe

Lecture 3 - Background of elemental abundance curve

Lecture 4 - Evidences of Nucleosynthesis - I

Lecture 5 - Evidences of Nucleosynthesis - II

Lecture 6 - Evidences of Nucleosynthesis - III and Mass gaps

Lecture 7 - H-R Diagram

Lecture 8 - M-L relation, Hubble's Law and Echo of Big Bang

Lecture 9 - Thermonuclear reactions and Reaction cross-section

Lecture 10 - Reaction rate

Lecture 11 - Reaction rate and Neutron induced reactions

Lecture 12 - Gamma induced reactions and Inverse reactions

Lecture 13 - Inverse reactions

Lecture 14 - Inverse reactions and Mean life time of a nuclei

Lecture 15 - Mean life time of a nuclei and Time dependent abundance evolution

Lecture 16 - Non-resonant charged particle induced reactions

Lecture 17 - Astrophysical S-factor and Non-resonant charged particle induced reactions

Lecture 18 - Gamow peak and Electron screening effect

Lecture 19 - Resonant reactions

Lecture 20 - Resonant reactions

Lecture 21 - Neutron induced non-resonant reactions

Lecture 22 - Burning stages of stars and Hydrogen burning

Lecture 23 - pp chain

Lecture 24 - pp chain and CN cycle

Lecture 25 - CNO cycle, Shell model and Gamma decay

Lecture 26 - Formation of  $^{12}\text{C}$

Lecture 27 - Survival of  $^{12}\text{C}$

Lecture 28 - Carbon, Neon, Oxygen and Silicon burning

Lecture 29 - Nucleosynthesis beyond Iron

Lecture 30 - s-, r- and p-process

Lecture 31 - Charged particle and Neutron beams

[Lecture 32 - Accelerators and Targets](#)

[Lecture 33 - Backing materials and Target preparation](#)

[Lecture 34 - Contaminants and Radiation sources](#)

[Lecture 35 - Detectors - I](#)

[Lecture 36 - Detectors - II](#)

[Lecture 37 - Activity method](#)

[Lecture 38 - Kinematics - I](#)

[Lecture 39 - Kinematics - II](#)

[Lecture 40 - Time of flight method and Indirect methods](#)

Lecture 1 - Course Overview

Lecture 2 - Introduction to Geometrical Optics

Lecture 3 - Ray Theory, Fermat's Principle

Lecture 4 - Refraction from Single Interface

Lecture 5 - Refraction from double interface

Lecture 6 - Matrix method in paraxial optics - I

Lecture 7 - Matrix Method in Paraxial Optics - II

Lecture 8 - Thick and Thin Lenses, Unit Planes

Lecture 9 - Nodal Planes, System of Thin Lenses

Lecture 10 - Problems on Geometrical Optics

Lecture 11 - Concept of Wavefront, Huygens Principle - I

Lecture 12 - Concept of Wavefront, Huygens Principle - II

Lecture 13 - Superposition of Waves

Lecture 14 - Introduction to Polarization, Linear and Circular Polarization

Lecture 15 - Elliptical Polarization

Lecture 16 - Interference of Light Waves, Interference of Polarized Light - I

Lecture 17 - Interference of Light Waves, Interference of Polarized Light - II

Lecture 18 - Young's Double Slit Experiment - I

Lecture 19 - Young's Double Slit Experiment - II

Lecture 20 - Interference with White Light, Displacement of Fringes, Fresnel's Biprism

Lecture 21 - Interference by Division of Amplitude

Lecture 22 - Thin Parallel Films, Wedge Shaped Films

Lecture 23 - Newton's Rings

Lecture 24 - Michelson Interferometer and Its Applications - I

Lecture 25 - Michelson Interferometer and Its Applications - II

Lecture 26 - Multiple Beam Interference

Lecture 27 - Fabry-Perot Interferometer and Etalon - I

Lecture 28 - Fabry-Perot Interferometer and Etalon - II

Lecture 29 - Concept of Coherence - I

Lecture 30 - Concept of Coherence - II

Lecture 31 - Introduction to Diffraction

- Lecture 32 - Fraunhofer Diffraction
- Lecture 33 - Single Slit Diffraction
- Lecture 34 - Double Slit Diffraction
- Lecture 35 - Multiple Slit Diffraction
- Lecture 36 - Diffraction at a Rectangular Aperture
- Lecture 37 - Diffraction at a Circular Aperture
- Lecture 38 - Diffraction Grating
- Lecture 39 - Grating Spectrum and Resolving Power
- Lecture 40 - Fresnel Diffraction
- Lecture 41 - Fresnel Half Period Zones
- Lecture 42 - Vibration Curve
- Lecture 43 - Circular Obstacle, Zone Plates
- Lecture 44 - Rectangular Aperture
- Lecture 45 - Diffraction of a Plane Wave by a Long Narrow Slit
- Lecture 46 - Brewster's Law, Malus' Law
- Lecture 47 - Phenomenon of Double Refraction
- Lecture 48 - Normal and Oblique Incidence
- Lecture 49 - Production of Polarized Light
- Lecture 50 - Quarter and Half Wave Plates
- Lecture 51 - Analysis of Polarized Light and Optical Activity
- Lecture 52 - Plane Wave Propagation in Anisotropic Media - I
- Lecture 53 - Plane Wave Propagation in Anisotropic Media - II
- Lecture 54 - Antireflecting Coating
- Lecture 55 - Basic Concepts of Holography - I
- Lecture 56 - Basic Concepts of Holography - II
- Lecture 57 - Basic Concepts and Ray Optics Consideration of Optical Fiber
- Lecture 58 - Introduction to Lasers - I
- Lecture 59 - Introduction to Lasers - II
- Lecture 60 - Trifle

Lecture 1 - Scalars vectors, and tensors - basic definitions

Lecture 2 - Scalars, vectors and tensors - most general definition

Lecture 3 - Elementary vector algebra - I (unit vector, dot product)

Lecture 4 - Elementary vector algebra - II (cross product, triple product)

Lecture 5 - Review of Newton's laws of motion - tools for analysis

Lecture 6 - Newton's laws of motion - third and second law

Lecture 7 - Newton's laws of motion - first law

Lecture 8 - Solving mechanics problems - how to draw free body diagram correctly

Lecture 9 - Mechanical equilibrium (statics) using force and torque balance

Lecture 10 - Mechanical equilibrium (statics) using force and torque balance - more examples

Lecture 11 - Mechanical equilibrium of rope like structures, nature of tension force

Lecture 12 - Massless, flexible suspension cable in mechanical equilibrium

Lecture 13 - Massive flexible suspension cable in mechanical equilibrium

Lecture 14 - Mechanical equilibrium of truss (framework) - nature of internal forces

Lecture 15 - Mechanical equilibrium of truss (framework) - examples

Lecture 16 - Mechanical equilibrium of truss - uniqueness of solution, beam with distributed load

Lecture 17 - Mechanical equilibrium of truss - more on beam with distributed load

Lecture 18 - Mechanical equilibrium - more examples, principle of virtual work, constrained motion

Lecture 19 - Mechanical equilibrium: constraints, degrees of freedom, work done by constrained force

Lecture 20 - d'Alembert - Lagrange principle of virtual work - statement and examples

Lecture 21 - Equivalence of principles of force, torque balance and virtual work, stability analysis

Lecture 22 - Mechanical equilibrium: stability analysis, energy diagram technique

Lecture 23 - Friction between solids - Amonton-Coulomb laws, common misconceptions

Lecture 24 - Friction between solids - worked out examples

Lecture 25 - Friction between solid and fluid - drag force

Lecture 26 - Friction examples - projectile motion with drag force, tying a rope

Lecture 27 - Work-energy theorem in one dimension, importance of conservation laws

Lecture 28 - Work-energy theorem in higher dimensions, conservative forces

Lecture 29 - Momentum balance principle, critical review: projectile motion in real-life

Lecture 30 - Projectile motion - effect of lift and thrust force by examples

Lecture 31 - More on rocket motion - comparing effect of thrust in deep space and at lift off



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)

**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

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  $^1\text{H}$  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