

# *PH 107 (2021)*

## *Quantum Physics and Applications*

### Instructors:

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# You already know...

## Class 12 Physics Book Part-1

Chapter 1 – Electric Charges and Fields

Chapter 2- Electrostatic Potential and Capacitance

Chapter 3- Current Electricity

Chapter 4- Moving Charges and Magnetism

Chapter 5- Magnetism and Matter

Chapter 6- Electromagnetic Induction

Chapter 7- Alternating Current

Chapter 8- Electromagnetic Waves

## Class 12 Physics Book Part 2

Chapter 9- Ray Optics and Optical Instruments

Chapter 10- Wave Optics

Chapter 11- Dual Nature of Radiation and Matter

Chapter 12- Atoms

Chapter 13- Nuclei

Chapter 14- Semiconductor Electronics: Materials, Devices and Simple Circuits

 **PH108**

 **PH107**

# Why learn Quantum mechanics?

- Quantum mechanics is considered the most important discovery of the 20th century.
- Quantum theory made it possible to understand atoms. Atoms make molecules and there by understand Chemistry --- the chemical bond. Chemistry is the basis of Biology.
- Quantum mechanics permits us to understand solid bodies and there by conduction of electricity in solids.
- Quantum theory is the basis of semi-conductors. Semiconductor devices made possible miniaturized electronics, including the laptop/tab/mobile phone you are seeing this slide with!
- Many technological inventions of the last 60 years are based on principles of quantum mechanics.

# Quantum theory in the real world

## *Practical Applications*

- LASERs
- Semiconductors
- Transistors
- LED
- Night Vision Goggles
- CCD
- Magnetic Resonance Imaging
- GPS

## *Explanation of Phenomena*

- Tunnelling
- Radioactive decay
- Periodic table

(Pauli Exclusion Principle  
explanation to Mendeleev's  
chart)

# Quantum theory in the future

- Dot LASERs
- Logic gates
- Computing
- Cryptography / Encryption
- Cloning
- Teleportation

# Syllabus : PH 107 (Quantum Physics and Applications)

## Introduction

Compton Scattering, de-Broglie hypothesis, Electron interference (double slit experiment) and Electron Diffraction (Davison - Germer experiment)

## Concept of Wave packets

Phase velocity, group velocity

## Mathematical interlude

Introduction to Fourier Transforms; Few examples (Step potentials, Gaussian wave packet), leading to concept of Uncertainty relation.

## Quantum Physics

Heuristic derivation of Schrodinger Equation. Concept of free particle, particle in a box problem. Finite Square well. Bound vs. unbound states. Superposition principle of eigenstates. Concept of collapse of wave function. Scattering problem. Reflection and Transmission coefficients. A few examples Concept of quantum tunnelling. Few realistic examples of tunnelling, e.g. alpha decay, Scanning Tunnelling Microscope.

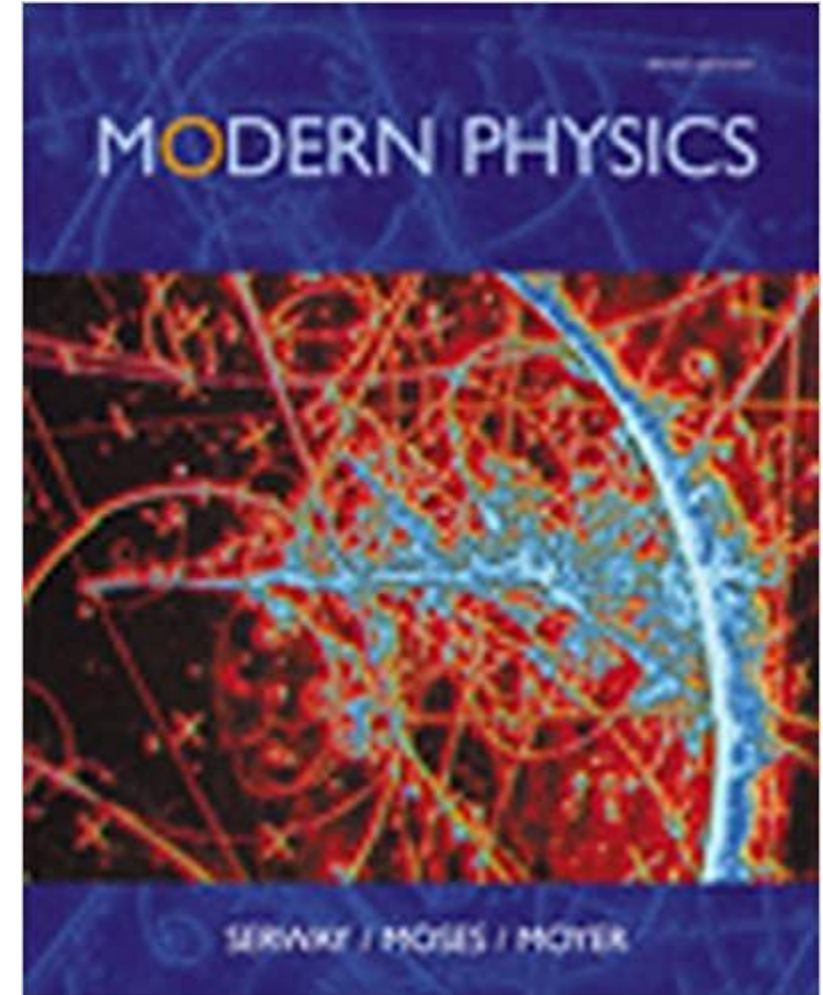
## Introduction to Statistical Physics

Basic intro to classical and quantum particles. Pauli's exclusion principle. Microstates and macro-states. A few examples. Classical (Maxwell-Boltzmann) and Quantum statistics,[Bose Einstein (BE)and Fermi Dirac (FD)]. Derivation of classical statistics and give hints to derive BE and FD. Planck's distribution.

# PH-107: Reference Book

**Modern Physics (3<sup>rd</sup> Edition):** R. A. Serway, C. J. Moses, C. A. Moyer,  
Thomson Learning Inc. 2005

There is not enough time in lectures to cover all the material thoroughly. You will gain a much better understanding of the topics by reading the material outside of class. Ideally you will read the relevant chapter before coming to class.



# PH-107: Learning objectives

- Some insights paved way to our understanding of microscopic systems.
  - evidence of the wave nature of electrons and describe how their wavelength depends on speed
  - explain how quantum theory differs from classical physics
- solve simple physical problems to understand
  - Quantization of energy
  - Tunneling of particles
- Extend the ideas of Avogadro number of particles
- Statistical mechanics
- Applications to solid state physics to exploit new technologies.



# PH-107: Schedule

Lectures for D1 and D2	Tuesday	2:30 – 3:25 PM
Lectures for D1 and D2	Friday	2:30 – 3:25 PM
Tutorials for D1 and D2	Wednesday	3:00 – 3:55 PM
Lectures for D3 and D4	Tuesday	9:30 – 10:25 AM
Lectures for D3 and D4	Thursday	10:35 – 11:30 AM
Tutorials for D3 and D4	Wednesday	4:00 – 4:55 PM

In the first week, i.e., on 1<sup>st</sup> December (Wednesday) there will be **NO tutorials**.

# PH-107-D3: Schedule

- Thursday's lecture (02-12-2021) – video upload on Tuesday (30-11-2021)
- Answer the quizzes by 10:25 am on 02-12-2021 on Moodle.
- Tuesday's lecture (07-12-2021) – video upload on Friday (03-12-2021).
- Answer the quizzes by 9:25 am on 07-12-2021 on Moodle.
- **NO LECTURE ON 09-12-2021 only for D3.**

# PH-107: Tutorials

- Each Division has 8 tutorial batches.
- Each division will have an additional tutorial batch (T9).  
This will be exclusively for HINDI as a medium for tutorials.
- Students will be informed of their Teaching Assistants (TAs) by 30<sup>th</sup> November.
- Students who want to attend the HINDI tutorials should register, by sending an email to [ph107@phy.iitb.ac.in](mailto:ph107@phy.iitb.ac.in) by 3<sup>rd</sup> December 2021.
- Once a student registers for T9 batch, she/he has to continue in the same tutorial batch for the whole semester.
- Once the students are comfortable with English, tutor will change over to English.

# Evaluation Scheme

Your final grade will be determined using the following weights:

Category	Number of Times	Weightage	Best of	Percentage
Video Quizzes*	20	1	14	14 %
Class Participation*	20	0.25	5	5 %
Tutorials**	10	2	8	16 %
Mid-Semester	1	-	-	25 %
End-Semester	1	-	-	40 %

\* Details will be given by Instructors

\*\* Details will be given by Tutors

# Video Quizzes and Class participation evaluation

- To enhance your comprehension of a particular subject to be covered, videos related to the week's lecture will be posted on MS-Teams and Moodle.
- It is mandatory for the students to listen to these video lectures.
- Some questions will be embedded in the video lectures.
- Students have to upload the answers to the questions in the video lectures on SAFE.
- For Tuesday's lecture the time slot to upload the answer is Monday 8:00 PM – 11:00 PM (every week).
- For Thursday/Friday's lecture the time slot to upload the answer is Wednesday 8:00 PM – 11:00 PM (every week).

# Video Quizzes and Class participation evaluation

- During the class, some students will be called to answer some questions from the video.
- Both will be used for a cumulative evaluation at the end of the semester.
- The class participation marks are entirely up to the Instructor and no questions can be asked about it.

# Online classes and tutorials : MS Teams

- Classes as well as Tutorials will be conducted on MS Teams platform.
- Recorded video Lectures and Tutorial sheets will be available on MS teams well before the class timings. Recorded lectures and Tutorial sheets will ALSO be available on Moodle.
- During the class hours, there will be ONLY a review of the recorded lectures and the remaining time will be used for interaction (question and answer).
- Tutorials will be conducted online; no recorded proceedings.
- Students have to attend the classes for their division. If you are in D1, you have to attend D1 classes.
- Attendance will be downloaded 5 min after the scheduled start of the class. If anybody joins the class after that, attendance will not be considered.

All the best