Week 1

PHY 106 Quantum Physics

Instructor: Sebastian Wüster, IISER Bhopal, 2018

These notes are provided for the students of the class above only.
There is no warranty for correctness, please contact me if you spot a mistake.

0) Administrative Affairs

(i) Office: AB1 - 014
Phone: 1213
Email: sebastian@iiserb.ac.in
Office hours: Wed 2 p.m - 5 p.m.
webpage: http://home.iiserb.ac.in/~sebastian/teaching.html

(ii) Literature:

- **Beiser, *Concepts of Modern Physics*.**
- **French, *Vibrations and waves***
- Eisberg and Resnick, *Quantum Physics of atoms and etc.*
- H. C. Verma, *Quantum Physics*.
- R. P. Feynman, *et al.*, *The Feynman Lecture of Physics* Vol 3.
- H. S. Mani and G. K. Mehta: *Introduction to Modern Physics*.
- R. Shankar, *Fundamentals of Physics* II

(iii) Assessment:

- 20% Online Quizzes after each one/two weeks using "Examineer:" https://examineer.in/quiz/#/, provided by our CREATES
- 30% Mid-Sem Exam
- 50% End-Sem Exam

The purpose of the Quizzes is to motivate you to follow the material continuously, not only for exam revision. You should have no problem answering the questions, while referring to the book or the notes.

(iv) Tutorials:

- In the tutorial class, please form team of 3-6 students to work together on the questions provided. There will be TA's to assist.
- The **exams** will be designed such that you **will not be able to score high in them** without regular attendance of the tutorials, and active participation in your team.

(v) Assignments:

- Assignment sheets will be provided online each week. These are meant for your self assessment and exam preparation, but they will **not be graded.**
- You **will not be able to score high in the exam** without regularly working through the assignment sheets **yourself**.
- There will be too many assignment question for you to try to work through all of them in the last moment before the exams.
- Solutions will be provided online after some time.

(1) ASK QUESTIONS!!!!

(2) ASK ME TO TALK
S. L. O. W. L. Y. !!!!

(3) ASK QUESTIONS!!!!

(iii) Tentative course outline:

Further reading

(1) Motivation: The dawn of Quantum Physics

week 1: Motivation movies on YouTube

How was quantum mechanics invented? Why does it challenge our everyday intuition?

week 2: Dawn of Quantum Physics, problems with classical theory

What is “quantum physics” / “modern physics” as opposed to classical physics?
Where is quantum mechanics at work around us?

Mechanics/ oscillator: French, chapter 4, or textbook PHY101

(2) Waves and Particles

week 3: *Introduction to wave mechanics* ***French, chapter 7***

What are waves? How do we describe them mathematically?

week 4: *Particle properties of waves:* ***[longer than a week (;]*** ***Beiser, chapter 2***

Where does classical wave theory reach its limitations?

French, chapter 7

week 5: *Wave packets* ***Beiser, section 3.4***

What if we combine multiple different waves? How fast does the combination move?

week 6: Wave properties of particles: ***[longer than a week (;]*** ***Beiser, chapter 3***

Where does classical particle theory reach its limitations?

(3) Atomic Physics and quantum mechanics

week 7: Structure of the atom

Why can the atom not be explained classically?

week 8 : Introduction to Quantum Mechanics

Brief historical overview. How can we work with QM mathematically?

(roughly here: mid-term exam)

week 9 : Quantum problems in one dimension

What does a quantum atom do, if we trap it in a box?

week 10: Hydrogen atom

Our first really important quantum mechanical calculation.
And one of very few that can be done exactly.

(4) Many Particle Quantum Problems

week 11: Many electron systems

Why do two electrons not like each other?

week 12: Molecules and Chemistry

Why is quantum mechanics essential for chemistry?

(5) Current Research Frontier in Quantum Physics

week 13: Outlook on advanced topics (time permitting)

How come everything around us “looks classical”? How can quantum physics provide technologies that look like magic? Is quantum physics even important for biology?

1) Motivation: the dawn of quantum physics

1.1) Motivation

Please watch these movies online, in this order:

Powers of 10, 9 min:
https://www.youtube.com/watch?v=0fKBhvDjuy0
The Secrets Of Quantum Physics, 59 min:
https://www.youtube.com/watch?v=lSdBAf-ysI0
Quantum Theory Made Easy, part 1, 31 min:
https://www.youtube.com/watch?v=e5_V78SWGF0
Quantum Theory Made Easy, part 2, 35 min:
https://www.youtube.com/watch?v=FIIrgE5T_g0

Many explanations in these movies are too fast and others too basic. However they communicate that quantum physics is exciting and mind-boggling. We will go through all effects discussed in the movies in much more detail.

The first online quiz regarding these movies will be open the first week of the semester (31.12.2018 - 6.1.2019). You can login and out multiple times, and thus answer questions “while” watching. *(The most efficient method will be to watch only after having read the quiz questions !)*