**PHY524A: Atomic, Molecular and Optical Physics**

**2015/2016**

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**Schedule:** All lectures and tutorials are in FB: 482. We will request for a LH room.

**Lectures:** Monday 12:00 - 13:30

Tuesday 09:00 - 10:30

**Tutorial:** Friday 014:00 - 15:00

**Course Evaluation:**

30 % Homework Assignments

10 % Class Participation (Teaser Questions)

20% Quiz /Paper presentation

*Teaser questions:* Before every class, you will get a handout which will also have a question to answer. These teaser questions should be discussed in groups and then you return the sheets in next class. *We will make groups of three (you get to choose your group first: whoever remaining will be then grouped together).* You should discuss among your group members to come up with an answer. Each group returns one answer sheet. 10% of your evalutation will depend on these answers (normalized over each group). Since a large part of this exercise is to initiate an atmosphere of collaboration and debate, each group member bears the added responsibility of tracking down and working together with an inactive member.

Also, whoever misses the class (a group member) gets no credit for that day.

*Homework Assignments:* For homework assignments, you are supposed to return the assigned problems on a specific date and time, once every two weeks.

*Plagiarism of any kind, in these assignments, will be dealt with utmost seriousness: we follow a zero tolerance policy on any plagiarism, with a straight F awarded for the course, if caught.*

For this course you will soon notice that you really do not need to take any such crazy, unfair means. There are enough bits and pieces to score, and if you do fine in some of these, you will be ok in terms of grades. Of course if you discuss with your friends regarding the assignments, that is absolutely fine and most welcome: you should just mention on top of the assignment shit whom all you have collaborated with.

We will either have two quizzes or paper presentation by groups, depending on what you vote for.

**Exams:**

15 % Mid-semester Examination,

25 % End-semester Examination,

**Office Hour:**

There will not be any designated office hour. Office hours are to be scheduled through request over email. You can write to either me directly or discuss with either of the TAs. You are free to discuss with the TAs for the teaser questions or homework assignments.

An important theme for this course is to learn physics through problem solving, discussions and debates. So please discuss the class materials with your group members, friends, TAs and the instructor.

If you have a problem with English or the way it is used in class, please contact me.

**Academic Integrity:**

As stated already, we will follow a zero-tolerance policy for academic dishonesty in examinations, assignments and class conduct.

**Course Contents:**

Below is an exhaustive list of topics we intend to cover, in that order. But not necessarily every topic will be discussed and a large part of the actual material will be planned on progress and will largely depend on the available time.

1. ***Optical Physics*** (1/3)

Statistical mechanics of photons, Interaction of light with atoms, Field Quantization,

Atom-photon interactions: Interaction Hamiltonian, Rabi flop, spontaneous emission

Few representative(“must know”) quantum states of light: Fock states, coherent states, squeezed states, thermal states, state of radiation emitted from a classical dipole and state from a laser

1. ***Atomic Physics*** (1/3)

Atomic bound and continuum states, scaling laws, Hamiltonian with nuclear spin, relativistic and screening corrections: periodic table and its idiosyncrasies.

Interaction of atoms with dc electric and magnetic fields: Atom and ion traps, single atom in a dipole trap

Opto-mechanical forces: Radiative pressure, scattering theory, optical molasses, laser cooling, estimation of temperature scales.

1. ***Molecular Physics*** (1/3)

Molecular levels, selection rules and symmetry. Spectroscopy of molecules in biology.

Cooling and trapping of molecules, double-slit experiment with C60 molecules, molecular computation

Macro-states: Bose-Einstein condensation of neutral atoms, states of optical lattices (Mott-insulator transitions), AMO expands its horizon: simulation of quantum Hamiltonians, quantum information and computation, precision metrology.

***Reference Materials:***

I will try to either give copies of my lecture notes or supplement the lecture material from pages of a book/notes.

After trying out several references, I feel the best notes on AMO around is that of Prof. ***Mikhail Lukin***’s lecture notes. Accordingly, this will be our primary reference and it is available online:

<https://www.openrev.org/paper/lily-notes-285b-mikhail-lukin>

Another important reference for this course is:

“***The quantum theory of light***” by ***Rodney Loudon***.

It is an excellent reference for understanding photons in particular but for atoms as well.

I will keep mailing you materials to read, including recent or classic,old papers. There are few other “must reads” in AMO. The first and foremost is the gigantic classic by *Cohen-Tanoudji*: “***Atom-Photon Interactions***”. If you can get hold of an e-copy, keep it on your mobile for this course.

Also, “***Quantum Optics***” by ***Scully and Zubairy*** is a good reference: a bit advanced, but deals with simple understandable formulation and language. A well-written “hard” book.

*More references:*

1. Standard Reference: “Atomic Physics”, Christopher J. Foot
2. Most important Quantum Mechanics References: “Quantum Mechanics” R. Shankar

3. Elementary Atomic Structure : G.K. Woodgate, H. Friderich

1. For experiments: “Atoms, Molecules and Photons”, Wolfgang Demtroder