Physics 682 **Fall 2019**

Electronic Transport and Optical Phenomena in Semiconductors

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Web: http://physics.oregonstate.edu/~grahamat/COURSES/ph682/

Preparation: graduate standing.

Recommended: completion of 1-yr QM & 1-term E&M.

Prior intro solid state physics at the level of PH 575 or PH 427 is needed (e.g. basic aspects of electronic band structure).

Intro to AMO, PH 585 is helpful but not assumed.

Rec Textbook: Optical Properties of Solids, Mark Fox, Oxford Press (2010).

Band Theory and Electronic Properties of Solids, John Singleton, Oxford Press (2010)

A combination of the below free online reference collectively contain similar material, further text info provided in-class.

Related content texts available "free online"

1) **Solid State Physics, Part II: Optical Properties of Solids,** Mildred S. Dresselhuas MIT Class Notes [m. advanced than Fox]

http://web.mit.edu/6.732/www/opt.pdf

2) **Optical Properties of Solids,** Frederick Wooten, (1972) [solid state focus]

http://www.phys.ufl.edu/~tanner/Wooten-OpticalPropertiesOfSolids-2up.pdf

Semiconductor Optics - Focused References:

1) "Optical Processes in Semiconductors" by Pankove
2) Undergraduate solid state physics text (Ashcroft & Mermin, Kittel or Sutton)

Office hours: Weniger 375, Wed, Fri 1 – 2 PM

Meeting Times: M W F in Weniger 304, 2-3:30 pm

Problem Sets:

Problem sets will be handed out every week. Solutions should be turned in the beginning of the lecture on the due date, unless specified otherwise. 4 problem sets are anticipated.

Independent Study Project: Please select ONE comprehensive review article published in the last decade in a high-impact journal. Complete the following:

(1) 2-5 page summary notes of the review article.

Convince me that you read & understood most of the review article. This can be your hand-written point-form notes [but please hand me a neat, condensed 2nd draft]. Focus on equations and explanation of 3-6 figures copied into your notes. Keep words to a minimum.

(2) 4-5 min 'elevator-pitch' class talk. [no more than two equations per talk; 3-4 content slides]

Briefly explain what your chosen topic is, and why it is important?

Do not lecture on the physics. Your job is to convince us that your topic is the most exciting.

(3) 1-page class handout. *In your own words*, write a new 1 paragraph abstract for the review paper. Fill the remainder of the page with anything that you think will help the class appreciate your topic. This could be a figure, some equations; the most important part of #1.

(4) you will be given a problem specific to your chosen topic on the final exam.

[*Optional alternative to #1-3*: instead write a 4-6 page Wikipedia-style article on your topic including figures.]

List of example review articles will be provided. You can choose any topical optical sciences review article (i.e. one that closely related to your research!). Your review article must have a strong AMO theme (e.g. light-matter interactions) and have some ties to a condensed matter system. Reviews of a condensed matter system are NOT appropriate (e.g. carbon nanotube review, OPV materials, 2D materials).

Please discuss your paper with me by beginning of week 2.

Exam:

We will have either in an in-class or take-home final exam due during exam week. It will include 1 student specific question related to your independent study project.

Grading Policy:

Homework (total)	40%
Independent Study	(Score on Item #4) x (Score on Items #1-3): 25%
Final	35%

Proposed Topics:
Electronic Transport
- Fundamentals of band structure – free electron gas, Bloch theorem
-Boltzmann transport – Drude model, diffusion, phonon scattering
-Quantum transport – scattering, 1D wire, Coulomb blockade
-Quantum to classical crossover – transmission, tunneling, localization

EM Field-Matter Interactions

- **Classical:** Polarizability, Lorentz model, complex dielectric function.
- Kramers-Kronig relations, reflectivity and linear spectroscopy
- Microscopic description of polarizability
- Birefringence, Kerr rotation, Faraday effects
- The electron gas plasma resonance & linear spectroscopy

Interband excitations and emissions

- Band-to-band transitions, radiative non-radiative transitions
- Absorption cross-section
- Exciton models (Wannier and Frenkel)
- Exction phonon coupling & spectral lineshape broadening
- Excitons in low-dimensional systems
- Polaritonics: exciton-, plasmon-, phonon- and magnon-polaritons

Optical Semiconductor Interfaces & Light Harvesting

- pn junctions
- Purcell effect
- Optimal bandgap and Shockley–Queisser limit

Nonlinear Optics & Advanced Spectroscopic Techniques

Students with Special Needs: Students with documented disabilities who may need accommodation, who have any medical information which the instructor should know of, or who need special arrangements in the event of evacuation, should make an appointment to discuss their needs with the instructor as early as possible, and no later than the first 3 days of the class.