NPRE-447/521: Radiation Interaction with Matter II

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Instructor: Prof. Yang Zhang (Z)
zhyang@illinois.edu — 111A Talbot Laboratory, MC-234
(217) 300-0452 — 104 South Wright Street
http://zhang.npre.illinois.edu — Urbana, IL 61801

Teaching Assistant: Guanfeng Gao ggao5@illinois.edu
Jinsheng Wang jwang278@illinois.edu

Schedule:
Lectures (447 and 521): MWF, 11:00 – 11:50, 101 Transportation Building
Lectures (521): F, 12:00 – 12:50, 101 Transportation Building
Recitation: M, 5:00-6:00pm, 100H Talbot Laboratory
Office Hours: R, 4:00-5:00pm, 100H Talbot Laboratory

Course Website: http://zhang.npre.illinois.edu/teaching.html

Credit: 3 undergraduate hours (447), 4 graduate hours (521)

Prerequisite: NPRE 446 or equivalent.

Grading:

1) Homework (40%). Late homework is accepted, but 10% of the score will be deducted *per day* until 50% is reached.

2) Quizzes (10%). Quizzes will be given in class randomly. No make-ups are allowed.

3) Mid-term exam (25%), Final exam (25%). A *letter size hand-written only cheat sheet* (otherwise half of the score will be deducted) is allowed during the exam. The cheat sheet will be collected at the end of the exam, but will not be graded.

Academic dishonesty and plagiarism of any kind on a homework, project, quiz, or exam will result in at least an "F" for that assignment, and maybe, depending on the severity of the case, an "F" for the entire course. Furthermore, they may be subject to appropriate referral to the university for further action.

Description:

The classical and quantum theories of the interaction of radiation (heavy and light charged particles, electromagnetic waves, photons, and neutrons) with matter are the core components of nuclear science and engineering. At UIUC, we offer a sequence of four courses at different progressive levels on this subject:

Part 1. (Undergraduate, Required) *NPRE-446 Radiation Interaction with Matter I*, covers classical mechanics, classical electrodynamics, and quantum mechanics.

Part 2. (Undergraduate, Required) *NPRE-447 Radiation Interaction with Matter II*, covers nuclear physics including nuclear properties, nuclear structure, radioactive decay, interactions of radiation with matter, and nuclear reactions.

Part 3. (Graduate, Required) *NPRE-521 Interaction of Radiation with Matter*, covers quantitative treatments of single interaction event in atomic and nuclear physics.

Part 4. (Graduate, Elected) *NPRE-529/CSE-529 Interaction of Radiation with Matter II: Multiple Events and Computational Methods*, covers equilibrium and non-equilibrium statistical mechanics, liquid theories, and atomistic simulations.

The sequence, in the aggregate, aims to provide the students with solid trainings on essential physical principles, mathematical competence, and computational skills.

Topical Outline:

1. Nuclear Properties: terminology, size, distributions of charge and mass, abundance, binding energy, Q-value, separation energy, semi-empirical mass formula, liquid drop model, mass parabola, spin, parity, electromagnetic moments

2. Nuclear Force and Nuclear Structure: properties of nuclear force, deuteron structure, neutron-proton scattering, phase shift, partial wave approximation, scattering length, differential cross section, exchange force model, nuclear shell model, nuclear magic numbers
3. Interaction of Radiation with Matter: heavy and light charged particle (stopping power, Bragg curve, range, ionization loss and radiation loss), gamma (attenuation, photoelectric effect, Compton scattering, pair production), neutron (neutron-proton scattering, energy dependence of cross section, moderation)

Recommended Texts:

Essential Physics (Basic Level):

1. J. R. Taylor, *Classical Mechanics,* University Science Books (2005).
2. D. J. Griffiths, *Introduction to Electrodynamics,* 4th edition, Pearson (2012).
3. D. J. Griffiths, *Introduction to Quantum Mechanics,* 2nd edition, Pearson (2004).

Essential Physics (Advanced Level):

4. H. Goldstein, C. Poole and J. Safko, *Classical Mechanics,* 3rd edition, Addison-Wesley (2001).
5. J. D. Jackson, *Classical Electrodynamics,* 3rd edition, Wiley (2001).
6. J. J. Sakurai, *Modern Quantum Mechanics,* 2nd edition, Addison-Wesley (2010).

Nuclear Physics:

7. (*Required) K. S. Krane, *Introductory Nuclear Physics,* 3rd edition, Wiley (1987).
8. W. E. Meyerhof, *Elements of Nuclear Physics,* McGraw-Hill (1967).
9. R. D. Evans, *The Atomic Nucleus,* McGraw-Hill (1955).
10. S. Yip, *Nuclear Radiation Interactions,* World Scientific (2014).
11. D. J. Griffiths, *Introduction to Elementary Particles,* 2nd edition, Wiley (2008).