

## **FISI 4041-01: INTRODUCTORY APPLIED NUCLEAR PHYSICS**

Special Topic in Nuclear Science- CREDITS-3

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**Prerequisites:** FISI3012/QUIM 3002/BIOL3102

### **I. SYLLABUS:**

#### **1. INTRODUCTION TO QUANTUM MECHANICS**

Experimental basis of quantum physics: photoelectric effect, Compton scattering, photons, Franck-Hertz experiment, the Bohr atom, electron diffraction, de Broglie waves, and wave-particle duality of matter and light. Introduction to wave mechanics: Schroedinger's equation, wave functions, wave packets, quantum statistics, probability amplitudes, stationary states, the Heisenberg uncertainty principle, and zero-point energies.

#### **2. ATOMIC & NUCLEAR STRUCTURES**

General description of atomic & nuclear structure, nuclear radius and binding energy, nuclear electromagnetic moments, nuclear excited states, characteristics of nuclear forces, standard model of fundamental particles & interactions, nuclear structure model, exchange force model, shell model.

#### **3. RADIOACTIVITY**

Nuclear radiation, source of nuclear radiation, radioactivity, radioactive decay law, half-Life & statistics, radioactive process and conservation laws, Alpha decay, Beta decay, double Beta decay, Gamma decay, radioactive dating.

#### **4. Detection & measurement of Nuclear radiation**

Interaction of radiation with matter, G.M. Counter, calculating dead time of GM tube, scintillation detectors, semiconductor detectors, measuring background radiation, shielding - Alpha, Beta, and Gamma Radiation, Inverse Square Law.

#### **5. NUCLEAR REACTIONS: FISSION & FUSION**

Types of reactions and conservation laws, energetic nuclear reactions, isospin, reaction cross section, Coulomb scattering, nuclear scattering, nuclear fission, characteristics of fission, energy in fission, fission and nuclear structure, controlled fission reactions, fission reactors, nuclear fusion processes, characteristics of fusion, solar fusion, controlled fusion reactors, thermonuclear weapons, accelerators, electrostatic accelerators, cyclotron accelerators, linear accelerators, synchrotrons.

#### **6. NUCLEAR MEDICINE:**

Biological Half-Life, Effective Half-Life, background radiation, production of radionuclides, Radiopharmaceuticals, Radiation dosimetry, emission computed tomography (CT), single-photon emission computed tomography (SPECT), positron emission tomography (PET), biological effects of radiation & risk evaluation.

## Textbooks:

- Krane, Kenneth S. *Introductory Nuclear Physics*. 3rd ed. John Wiley & Sons, 1987. ISBN: 9780471805533.
- Griffiths, David J. *Introduction to Quantum Mechanics*. 2nd ed. Addison-Wesley, 2004. ISBN: 9780131118928.
- DoE Fundamentals Handbook: Nuclear Physics & Reactor Theory Vol. 1 & 2, U. S. Department of Energy, D.C. 20585 ISBN: 978-1-304-14988-6 & 978-1-304-06494-3
- Principles of Nuclear Radiation Detection, G.G. Eichholz, J. W. Poston, 2018, CRC Press, ISBN: 0-87371-062-2
- Clinical Nuclear Medicine, H. Ahmadzadehfar, H-J. Biersack, L. M. Freeman, L.S. Zucker (Eds), 2<sup>nd</sup> Edition, 2020, Springer, ISBN: 978-30030-39455-4
- Nuclear Medicine Physics-The Basics, R. Chandra, 7<sup>th</sup> Edition, Wolter Kluwer, 2012, ISBN: 978-1-4511-0941-2

## Electronic references

- <https://www.iaea.org/newscenter/news/what-is-radiation>
- <https://world-nuclear.org/focus/fukushima-daiichi-accident/nuclear-radiation-and-health-effects.aspx>
- [https://www.cdc.gov/nceh/radiation/nuclear\\_medicine.htm](https://www.cdc.gov/nceh/radiation/nuclear_medicine.htm)
- <https://www.nrc.gov/about-nrc/radiation/health-effects/radiation-basics.html>
- <https://www.epa.gov/radtown/radioactive-fallout-nuclear-weapons-testing>
- [https://chem.libretexts.org/Bookshelves/Introductory\\_Chemistry/Chemistry\\_for\\_Allied\\_Health\\_\(Soult\)/10%3A\\_Nuclear\\_and\\_Chemical\\_Reactions/10.01%3A\\_Nuclear\\_Radiation](https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Chemistry_for_Allied_Health_(Soult)/10%3A_Nuclear_and_Chemical_Reactions/10.01%3A_Nuclear_Radiation)
- <https://www.ans.org/nuclear/radiation/>
- <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/nuclear-radiation>
- <https://www.imagesco.com/geiger/pdf/geiger-counter-experiments-book.pdf>

## I. Course Grading:

The final grade will be assigned by adding all the points up obtained in all the three sections.

Grade Scale out of 100 points	
Total points	Letter Grade
≥ 90	A
≥ 80	B
≥ 70	C
≥ 60	D
< 50	F

## II. Instructional Strategy

The class will be fully presential (in person/face-to-face). The main instructional tool in this class is lecturing, homework, assignment, class reflection, presentation, class test/quiz, and examinations.

## III. Course requirements and evaluations:

The student needs to take exams, give presentations, and submit assignments and review reports/reflections to complete the course. You are required to submit all the assignments before the deadline through “UPR Moodle”. **The Moodle will NOT allow to submit after the deadline.** Student presentation will be power point in person in the classroom. The students can also be asked to make a presentation in the class on a chosen topic using audiovisual aids

if necessary, which may be counted as one of the assignments. Class reflections need to be submitted hardcopy in the class. There will be two exams: Midterm & Final (cumulative).

#### **IV. Rights of Students with Disabilities:**

UPR complies with all Federal and State Laws and regulations regarding discrimination, including the Americans with Disabilities Act 1990 (ADA) and the Commonwealth of Puerto Rico Law 51. Students receiving services through Rehabilitation Vocational must contact the professor at the beginning of the semester in order to plan for a reasonable accommodation and any required support equipment according to the recommendations given by the Oficina de Asuntos para Personas con Impedimentos (OAPI) of the Dean of Students. Likewise, students with special need that require some type of accommodation must contact the professor at the beginning of the semester.

#### **V. Reasonable Accommodation:**

The University of Puerto Rico complies with all federal, state and regulations concerning discrimination, including "The American Disabilities Act" (Law ADA) and Law 51 of the Commonwealth of Puerto Rico. Students receiving vocational rehabilitation services should contact the teacher at the beginning of the semester to plan for reasonable accommodation and necessary support equipment in accordance with the recommendations of the Office of Matters for Persons with Disabilities (OAPI) of the Dean of Students. A request for reasonable accommodation does not exempt the student from meeting the academic requirements of the course.

#### **VI. Academic Integrity:**

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR General Student Regulations (Certification Num. 13, 2009-2010, of the Board of Trustees) states that "academic dishonesty includes, but is not limited to: fraudulent actions, obtaining grades or grades academics using false or fraudulent simulations, copying all or part of another person's academic work, plagiarizing all or part of another person's work, totally or partially copying another person's answers to the questions of an exam, making or getting another take in your name any oral or written test or exam, as well as help or facilitation for another person to incur such conduct. "

#### **VIX. Harassment:**

The University of Puerto Rico prohibits discrimination based on sex and gender in all its forms, including sexual harassment. According to the Institutional Policy against Sexual Harassment at the University of Puerto Rico, Certification No. 130, 2014-2015 of the Governing Board, if a student is being or was affected by behaviors related to sexual harassment, he can go to the Office of the Student Prosecutor's Office, the Office of the Dean of Students or the Compliance Coordinator with Title IX for guidance and / or filing a complaint.