

**FISI 8992-013: APPLIED NUCLEAR PHYSICS
(Special Topic in Nuclear Science)**

CREDITS-3

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I. Course Objective:

The applications of nuclear science and technology have become ubiquitous in our modern societies, well beyond our imagination, but at the same time, there exist an irrational fear in our mind about the nuclear radiations due to recent nuclear accidents in Fukusima, Japan. This is significantly affecting the development of nuclear power plants. Nuclear power is cable of low emission heat and hydrogen for sustainable future. More efforts are needed to get nuclear power on track with the Net Zero Emissions by 2050 scenario.

The main motivation of study Nuclear Physics is to understand the science of radiation and applications in a safe & effective way. The other important fundamental science motivation is the radioactive ion beams for exploring the structure of matter and the rapid development of astrophysics where stars, both during their lifetime and at their death, offer unique laboratories to nuclear physics with condition of temperature and density that cannot be reproduced on Earth. Nuclear radiations have significant impact on diagnosis & treatment of several heath issues. Nuclear medicine uses radioactive material inside the body to see how organs or tissues are functioning (for diagnosis) or to target and destroy damaged or diseased organs or tissue (for treatment). Common uses of PET scans include diagnosing heart disease, Alzheimer's disease, and brain disorders. The course will discuss about the nuclear structure and standard model and application of nuclear radiation in health care, nuclear technology in power generation, and radiation detections.

II. SYLLABUS:

1. REVIEW OF ATOMIC & NUCLEAR STRUCTURES

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

2. RADIOACTIVITY

Radioactivity, Radioactive decay law, Nuclear radiation, half-Life & statistics, Radioactive process and conservation laws, alpha decay, Beta decay, double beta decay, Gamma decay, radioactive dating.

3. Detection & measurement of Nuclear radiation

Interaction of radiation with matter, Geiger Counter, scintillation detectors, semiconductor detectors, measuring background radiation, Poisson distribution, shielding - Alpha, Beta, and Gamma Radiation, Inverse Square Law experiment, Detecting Low Level Radioactivity in Food, Capturing and Detecting Radon in the Environment, Calculating Dead Time of GM Tube,

Backscattering experiment, Magnetic Deflection of Beta Particles Experiment, Half-Life Experiment, detection of high energy radiation.

4. 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.

5. NUCLEAR MEDICINE:

Half-Life, average half-Life, Biological Half-Life, Effective Half-Life, Statistics of radioactive decay, 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.
- 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), 2nd Edition, 2020, Springer, ISBN: 978-30030-39455-4
- Nuclear Medicine Physics-The Basics, R. Chandra, 7th 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.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>

III. 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

IV. Instructional Strategy

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

V. Course requirements and evaluations:

The student need to take exams, give presentations, and submit assignments and review reports 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 exams.

VI. 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.

VII. 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.

VIII. 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.