THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE

Department of Physics

PHY 532 – Nuclear and Particle Physics II

COURSE PARTICULARS

Course Code: PHY 532
Course Title: Nuclear and Particle Physics II
No. of Units: 3
Course Duration: Two hours of theory and one hour of tutorial per week for 15 weeks.
Status: Compulsory
Course Email Address: oladelea970@gmail.com
Course Webpage: http://www.fwt.futa.edu.ng/courseschedule.php?coursecode=PHY20532
Prerequisite: PHY 401

COURSE INSTRUCTOR

Professor O. S. Ajayi
Room 32,
Dept. of Physics,
Federal University of Technology, Akure, Nigeria.
Phone: +23480 3502 7903
Email: osajayi@futa.edu.ng

COURSE DESCRIPTION

The course is the second part of a comprehensive course in nuclear and particle physics meant to train students in nuclear and health physics. It covers topics in radiation sources – natural and artificial sources. Charged and uncharged particles and their nature, properties and mechanisms of interaction with matter and dealt with. Nuclear instrumentation and radiation detection techniques are described. Closely following these are the descriptions of different types of nuclear radiation detectors and their applications. Nuclear spectroscopy such as gamma and alpha particle spectroscopy and their application in the analysis of mixed radiation sources are also taken care of in the course. The course also has a section on neutron physics – production, detection, uses, properties and interaction with matter. Nuclear reactor physics and application is a part of the course. Students taking the course will be trained in the production of nuclear energy through fission and fusion. The last part of the course is devoted to elementary particles – conservation laws, partial classification, strong electromagnetic and weak interactions.

COURSE OBJECTIVES

The objectives of this course are to:

- introduce students to nuclear instrumentations and nuclear radiation detection techniques;
- provide students with skills needed to explain how radiation detector function and use them to measure radioactivity; and
- intimate students with the different types of nuclear reactors in use and how they produce nuclear energy for useful purposes.

COURSE LEARNING OUTCOMES / COMPETENCIES

Upon completion of this course, students should be able to:

(Knowledge based)

- explain why nuclear radiations are emitted by radionuclides with very heavy atoms, and understand the nature and properties of the radiations;
- explain how charged and uncharged ionizing radiations interact with matter and the effects of the interactions on the material through which they traverse;
- explain how different radiation detectors function;
- classify and explain the function of different nuclear reactors;
- classify elementary particles and their possible decay modes;

(Skills)

- list the properties of the different nuclear radiations emitted by radioisotope when they decay.
- give examples of charged and uncharged particles with their characteristics
- tell the differences between the following modes of gamma ray interaction with matter
    - Photoelectric absorption
    - Compton scattering
    - Pair production
- categorise radiation detectors and their different areas of applications;
- calculate the amount of nuclear energy that will accompany the fission of one uranium atom and compare it with that resulting from burning one ton of coal or one kilogram of trinitro-toluene (TNT).

GRADING SYSTEM FOR THE COURSE

This course will be graded as follows:

Assignments	10%
Test(s)	20%
Final Examination	70%
TOTAL	**100%**

GENERAL INSTRUCTIONS

Attendance: Every student is expected to be in class for all lectures. Attendance records will be kept and used to determine each student's qualification to write the examination for the course at the end of the semester. In case of illness or other unavoidable cause of absence from lecture, affected student must communicate as soon as possible with course lecturer, indicating the reason for the absence.

Academic Integrity: Infringements of academic integrity, including lying and cheating in assignments, tests, examinations, or other academic performances are not allowed. Some cases of academic dishonesty may be reported to the University Management for appropriate punishment as spelt out in the Students' and University Handbooks.

Assignments and Group Work: Students are expected to honour deadlines on submission of assignments and group works. A student who fails to submit an assignment, as at when due, will be scored zero for the assignment. Late submission of assignments will only be tolerated when a student notifies the course lecturer latest on the deadline date/day.

Code of Conduct in Lecture Room: Students are expected to dress decently to the lecture room/hall. They should turn off their cell phones and shut down their laptops during lectures. Students are not allowed to engage in other activities such as texting, watching videos, discussion, and their likes during lectures. Eating, drinking and smoking are not allowed in the lecture rooms/halls.

READING LIST

[1]Littlefield and Thorley. (2004). *Introduction to Atomic and Nuclear Physics.* Special Edition. Que Publishing, Indianapolis, USA. 1231p.

[1]Irvine Kaplan (2010). *Nuclear Physicssing omputer Software Packages*. Published by Olasunkanmi, Nigeria. 304p.

[4]Tille (2012). *Computer Basics in Easy Steps*. 8th Edition. In Easy Steps Limited, Warwickshire, UK. 240p.

[1]STom Duncan(2010) *CPhysics: For Advanced Level Students*logy, Cengage Learning, Boston, USA. 760p.

Legend
1- Available in the University Library
2- Available in Departmental/School Libraries
3- Available on the Internet.
4- Available as Personal Collection
5- Available in local bookshops.

COURSE OUTLINE

Week	Topic	Remarks
1 & 2	Introduction and Course Overview Radiation sources – natural and artificial sources. Charged and uncharged particles, their nature and properties. Interaction of radiation with matter.	Students will be encouraged to build up and be determined to make the best of grade in the course. Information about sources of radiation will be made available to the students. The mechanisms of interaction of radiation with matter will be explained to the students
3 & 4	Nuclear instrumentation and radiation detection techniques. Radiation detectors and their applications. Scintillation detector, Semiconductor detectors, High Purity Germanium (HPGe), Thermoluminescent detector (TLD) and Solid State Nuclear Track Detectors (SSNTD).	The general principles of operation of radiation detectors will be exposed to students. Information about areas of applications, advantages and disadvantages of the different radiation detectors in use today will be given to the students. Students will be encouraged to familiarise themselves with the functions of the different components/parts of all radiation detectors.
5 & 6	Nuclear spectroscopy. Gamma and alpha particle spectroscopy and their applications in the analysis of mixed radionuclide sources.	When learning about nuclear spectroscopy, students will be made to know what a spectrometer system consists of. The functions of each of the components parts will be explained to the students. Student will the taught how to interpret and analyse gamma or alpha spectrum produced by a mixed radionuclide sample. Students will be taught how to calculate energy resolution, efficiency, detection limit and calibrate a detector.
7 & 8	Neutron physics – production, detection, uses, and properties of neutrons. Interaction with matter.	The production, detection, uses and properties of neutron will be taught to students. Students will be made to know the importance of neutron as an elementary particle especially in fission and nuclear reactions. The various mechanisms of interaction of neutron with matter – neutron or radiative capture, inelastic scattering and elastic

		scattering will be explained to the students.
9 & 10	Nuclear reactors and reactor physics. Applications.	At least ten (10) different types of reactor will be listed. Students will be requested submit descriptive write up on each type of nuclear reactor. Students will be taught the function of the very important parts of a typical nuclear reactor. Student will be made to know why and how reactor accidents occur with examples of Chenobyl and Fukushima nuclear accidents
		MID-SEMESTER TEST
11 & 12	Fission and Fusion. Production of nuclear energy through fission and fusion.	Students will be taught to differentiate between fission and fusion. The different conditions under which different radionuclides like uranium, thorium, proctoactinium, etc. undergo fission will be taught to students. The students will also be taught how to calculate energy from fission and fusion and compare them to see why fission is preferable to fusion with respect to production of nuclear energy.
13 & 14	Elementary particles – conservation laws, partial classification, strong electromagnetic and weak interactions.	Students will be shown the table of elementary particles. The different decay modes will be explained to them. The characteristics of the different particles and their antiparticle will be explained to the students.
15	REVISION	This is the week preceding the final examination. At this time, evaluation will be done to assess how far the students' expectations

		for the course have been met.