Course Syllabus — Basic Atomic and Nuclear Physics (AES-2021)

Credit Hours: 4 Credit hours

Prerequisites: Physics Principles (AES-1016)

QFE Level: 5

Knowledge: Comprehensive, specialized knowledge within a broad field of work or discipline, including an understanding of the underlying theoretical and abstract concepts with significant depth in some areas. A broad understanding of allied knowledge and theories in related fields of work or disciplines including related regulations, standards, codes, conventions and procedures. An understanding of information assembly, retrieval methods and logical problem-solving techniques from a range of sources. Recognition of sources of current knowledge and the integration of concepts from related fields. Literacy to comprehend and/or produce coherent texts covering complex relations from an array of information and contexts. Numeracy covering an array of mathematical procedures and representations and contexts.

Skills: Technical, creative and conceptual skills appropriate to solving a wide-range of problems associated with a field of work or discipline that include a comprehensive range of specialist cognitive and practical skills appropriate to diagnosing and implementing solutions to abstract, familiar and nonroutine problems within a field of work or discipline. Use of appropriate information retrieval methods and tools and techniques associated with the field of work or discipline. Comprehensive communication and information technology skills to present, explain and/or critique complex matters. Literacy skills to comprehend and/or produce, from array of information, coherent texts covering complex relations. Numeracy skills to select, apply, reflect and communicate an array of mathematical procedures and representations and contexts

Competence:

Autonomy and responsibility: Can take responsibility for coordinating the implementation of appropriate approaches to complex work procedures and processes, resources or learning, including leading teams within a technical or paraprofessional activity. Can exercise coordination and/or supervision in routine, familiar and some nonroutine work or learning contexts. Can coordinate technical, design processes in routine, familiar, nonroutine and an array of contexts with support available, if required. Can express an internalized, personal world view, in the context of an understanding of socio-cultural relationships.

Role in context: Can function with autonomy in technical and coordination contexts and support paraprofessional roles under guidance can function both independently and in a coordination role with multiple groups. Can take responsibility for coordinating the development of individuals and groups. Can review and develop the performance of self and others.

Self-development: Can evaluate own learning and identify learning needs in a familiar environment. Can take responsibility for and plan own learning within a managed and nonroutine environment. Can comprehend and observe ethical standards.

Course Description

This course covers the basic knowledge of nuclear reactor operation and related aspects. It includes demonstrating knowledge of atomic stability, radioactive decay, nuclear radiation, fission process, reactor kinetics and reactor operation.

Instructors: TBD, TBD@adpoly.ac.ae

Schedule and Duration: 15 weeks plus examination week. 4 hours lecture/week.

Course Objectives

The overall objective of this course is to develop the student's understanding of nuclear reactor operation and related aspects such that they can demonstrate knowledge of atomic structure, stability, radioactive decay, nuclear radiation, fission process, reactor kinetics and reactor operation, and apply this knowledge to solve simple problems associated with nuclear reactor operation.

Textbook

1. ACAD Basic Curriculum, Nuclear Science, General Physics Corporation, Elkridge, Maryland, 2003.

Attendance

Sessions start on the hour. Students arriving after the session starts will be counted absent. Students will receive warnings and potential penalties from the Student Services Office or their sponsor if they reach 5%, 10%, and 15% absence. After 15% absence, students will receive a FA (fail due to absence) grade.

Academic Honesty Policy

Students must conduct their studies at AD Poly honestly, ethically, and in accordance with accepted standards of academic conduct. Any form of academic conduct which is contrary to these standards is academic misconduct, for which AD Poly may penalize the student.

Specifically, it is academic misconduct for a student to:

- Present copied, falsified, or improperly obtained data as if it were the result of laboratory work, field trips, or other investigatory work;
- Include in the student's individual work material which is the result of significant assistance from another person if that assistance was unacceptable according to the instructions or guidelines for that work;
- Cheat or attempt to cheat; or
- Plagiarize (knowingly presenting the work or property of another person as if it were one's own)

Abu Dhabi Polytechnic considers cheating or attempting to cheat a serious offense that will result in disciplinary action taken against involved individuals. Students caught cheating or attempting to cheat will earn an "F" grade in the course.

Course Learning Outcomes (CLOs)

Upon successful completion of the course a student should be able to:

CLO 1: Demonstrate knowledge of components, structure, and identification of the atom.

CLO 2: Demonstrate knowledge of mass defect and binding energy.

CLO 3: Demonstrate knowledge of radioactive decay and interactions of radiation with matter.

CLO 4: Demonstrate knowledge of nuclear cross section, fission, and neutron classification.

CLO 5: Demonstrate knowledge of neutron life cycle.

CLO 6: Demonstrate knowledge of delayed neutrons and reactor kinetics.

CLO 7: Demonstrate knowledge of reactivity coefficients.

CLO 8: Demonstrate knowledge of plant operations.

Course Topics

CT 1: Basic atomic structure. Atomic structure, atomic mass unit, isotopes, and chart of nuclides.

CT 2: Radioactive decay. Forces within atoms, binding energy, types of radiation and radioactive decay, half-life, and nuclear interactions.

CT 3: Fission process. Neutron cross sections, fission process, reactor kinetics, neutron classification, neutron life cycle, and reactivity.

CT 4: Residual heat. Sources of decay heat and residual heat and its significance.

CT 5: Basic reactor operation. Basic nuclear reactor design, reactor startup and shutdown, reactivity control methods, reactor response to control rod, boron concentration and fission products poison; reactivity coefficients, and basics of reactor operation.

ABET Student Outcomes

The Higher Diploma in Nuclear Technology program student outcomes (SO) are taken from the 2019 ABET (Accreditation Board for Engineering and Technology) standard. Student Outcome 2 is from the associate degree standard and Student Outcomes 1, 3, 4, and 5 from the bachelor's degree standard.

SO1. An ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly defined engineering problems appropriate to the discipline;

SO2. An ability to design solutions for well-defined technical problems and assist with the engineering design of systems, components, or processes appropriate to the discipline;

SO3. An ability to apply written, oral, and graphical communication in broadly defined technical and non-technical environments; and an ability to identify and use appropriate technical literature;

SO4. An ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes; and

SO5. An ability to function effectively as a member as well as a leader on technical teams.

Table 1: Relation Course Topics (CTs) to Course Learning Outcomes (CLOs)

	CT1	CT2	CT3	CT4	CT 5
CLO1	H	M	M		
CLO2	M	H	M		
CLO3	M	H			
CLO4	M		H		
CLO5		M	H		H
CLO6		M	H		H
CLO7			M		H
CLO8			H	H	H

H: High, M: Moderate, L: Low

Table 2: Relation Course Learning Outcomes (CLOs) to Students Outcomes (SOs*)

	SO1	SO2	SO3	SO4	SO5
CLO1	H	M			
CLO2	H	M			
CLO3	H	M			
CLO4	H	M			
CLO5	H	M			
CLO6	H	M			
CLO7	H	M			
CLO8	H	M			
Average	H	M			

H: High, M: Moderate, L: Low

Week-by-Week Teaching Plan

Week	Topic	Content	Page
1	Course introduction and basic atomic structure	Course schedule, course rules, history of the discovery of the atom and atomic structure	Chapter 1 Page 1
2	Basic atomic structure	Atomic Mass Unit, atomic number, identification of atoms, isotopes, chart of nuclides	Chapter 1 Pages 2-7
3-4	Mass defect and binding energy	Types of forces within an atom, nuclear stability, mass defect and binding energy; and types of radiation (alpha, beta, gamma and neutrons)	Chapter 2 Pages 1-13
5-6	Radioactive decay	Radioactive decay process, radiation interactions, neutron interactions, half-life, and radioactivity calculations	Chapter 3 Pages 1-23

7	Fission process	Microscopic and macroscopic cross sections, atomic density, fission process, neutron flux, fission products, fissile materials, decay heat, and neutron classification	Chapter 4 Pages 1-12
8	Midterm examination	Summative assessment covering the first half of the course	
9	Neutron life cycle	Reactor criticality concept, reactor power states, neutron balance, six-factor formula, and reactivity	Chapter 5 Pages 1-10
10-11	Basics of reactor kinetics	Delayed neutrons, neutron precursors, delayed neutron fraction, reactor period, Reactor Startup Rate (SUR), doubling time, prompt criticality	Chapter 6 Pages 1-16
12	Reactivity coefficients	Introduction to reactivity coefficients, reactor parameters that affect reactor power, moderator, Doppler, pressure and void reactivity coefficients	Chapter 7 Pages 1-6
13-15	Reactor operation	Basic nuclear reactor design, reactor startup, neutron source, estimated critical positions, reactivity balance, reactor power control (control rod and chemical shim), fission product poison, reactor core power distribution, shutdown margin, fuel burnup, decay heat, and reactor operation parameters	[1] Chapter 8 Pages 1-16
	Final examination	Summative and comprehensive assessment	