Department of Physics

College of Science

University of Salahaddin

Subject: Principles of Nuclear Physics
Course Book – 4th Year General

Lecturer's Name: Dr. Mohammed I. Hussein

Academic Year: 2022/2023 /First Semester

Course Book

<table>
<tr><td>1. Course name</td><td>Principles of Nuclear Physics</td></tr>
<tr><td>2. Lecturer in charge</td><td>Dr. Mohammed Issa Hussein</td></tr>
<tr><td>3. Department/ College</td><td>Physics / Science</td></tr>
<tr><td>4. Contact</td><td>e-mail: mohamm.hussein@su.edu.krd</td></tr>
<tr><td>5. Time (in hours) per week</td><td>Theory: 3 (3 theoretical)
Practical: 0</td></tr>
<tr><td>6. Office hours</td><td>4</td></tr>
<tr><td>7. Course code</td><td></td></tr>
<tr><td>8. Teacher's academic profile</td><td>My Academic studies starts with the acceptance in the B.Sc. program in 1998 as an undergraduate student in Physics department and extended as I finished the following education degrees

<u>Education:</u>
<table>
<tr><td>B.Sc, 2003</td><td>Physics</td></tr>
<tr><td>M.Sc.2012</td><td>Nuclear Physics</td></tr>
<tr><td>Ph.D. 2020</td><td>Nuclear Physics</td></tr>
</table>
As I awards my first Academic title in 2012 and later on
<u>Academic titles attained:</u>
<table>
<tr><th>Academic title</th><th>Date of attainment</th></tr>
<tr><td>Assistant Lecturer</td><td>24/4/2012</td></tr>
<tr><td>Lecturer</td><td>27/7/2020</td></tr>
<tr><td></td><td></td></tr>
</table>
I have more than 18 years’ experience teaching, during my academic life I have tough, the following subjects for undergraduate students such as: General Physics of the first year Environmental department, General Physics lab. of the 1st year physics, , General Physics lab. of the 2nd year Gelogy and Environment Science Dept., Modern physics Lab of the 2nd year students, Nuclear physics lab for 3rd medical physics, Nuclear physics and Principels of Nuclear physics for the 4th year of physics students, also I have five papers are published in different local and foreign journals.

I participated in many international and local conferences and I published many scientific articles..</td></tr>
</table>

	- I awarded the following academic tites in Salahaddin University-Erbil / College of Science/ Physics Departement **- BSc. in 2003.** **- MSc. in 2012 .** **- Assist. Lecturer from 2012 to 2020.** **- PhD. in 2020 .** **- Lecturer from 2020 until now.**
9. Keywords	**Basic Nuclear Concepts, Nuclear Structure , Interactions of Nuclear Radiations with matter.**

10. Course overview:

The course will start with a brief description of nuclear concepts: label, nomenclature, size, mass, density, charge, and spin of nuclei. The next topic which forms the principle of the subject is the nuclear structure involving a necessitate elements of quantum mechanics (as an introduction to understanding nuclear physics), nuclear constituent, nuclear force, nuclear binding energy, and nuclear models. The former topics imply the time-independent nuclear properties. The basic of nuclear radiation detection methods will be reviewed through studying the interactions of different types of nuclear radiation with matter.

The nuclear radioactive decay, and nuclear transmutations which represent the time-dependent properties of nuclei will be treated as extensions of the nuclear structure. The detection mechanism of nuclear radiations by different types of nuclear detectors will be explained and assessed principally, as well as the radiation dosimetry and the biological effects of radiation constitutes a brief overview of the medical and environmental applications of nuclear radiations.

11. Course objective:

After the student studied and takes Atomic Physics lectures in their previous stage, they are ready now to understand the differences between the atomic scale and nuclear scale and then prepare to understand the actual source of nuclear force and power.

The world in which we live today proceeds with inventing new technological aspects and ideas, and nuclear physics is one of the most attracted and focused branch due to its important application as a new energy resource and a mass destruction weapon that all the society and countries are in effort to obtaining this technology. For this the study and taking this course will be in need for students to have the elementary information concerning the physical aspects concerning this modern branch of science.

12. Student's obligation

The class attendance on time is the first obligation of the student. During the two courses three compulsory written exams will be done beside three or more pop quizzes

inside the lectures. As well solving exercises and given problems is the student duties.

13. Forms of teaching

All the lecture outlines are prepared and will be a subject of open discussion inside the lectures. In the beginning of each lecture a brief summary of the previous lecture will be remembered and the headlines of the forward lecture is identified and determined. The materials given in the lecture is always accompanied by the illustrations and detail derivations with the aid of white board and available animations; beside this for every physical phenomenon there will be scientific and live discussion which assists the student to understand the subjects. The lectures will be given mainly in the English language. Throughout the lectures as well as at the end of each chapter there will be home work problems given to the students as a review and assessments. In the last half hour of each lecture there will be a seminar prepared by a student whom selects a nuclear subject to be prepared as a presentation and will be open to discussion.

14. Assessment scheme

Knowledge of assigned readings, satisfactory completion of short assignments, class participation, and in-class work will constitute the students assessment program.
Grades will be based on timely completion of assignments, improvement over the study year, the quality of the discussions, and class attendance and participation.
There will be at least three written assignments in this class and a final examination, So that the final grade will be based upon the following criteria:
Mean of three examination: 40% (+ attendance and participation)
Final examination: 60%
Attendance and participation in class will also be averaged into your final mean grade former to the final examination.

15. Student learning outcome:

The Nuclear courses are academic theoretical courses. The student enters the course should have a good mathematical skills especially the linear Algebra and differential equations beside the well understanding of atomic physics principles. As it's known, the physics have a crucial roles in all the applicable science branches like communication, medicine, industry, environment, Information technology, astronomy …etc.; the understanding of exact role of modern physics is not complete unless the physicist will be familiar with the nuclear physics and elementary particles. Moreover, the theories concerning the philosophy of life creation and universe evolution based on the knowledge extracted from nuclear reaction yields which form new and heaver elements. Thus throughout the course syllabus the student will haves the principal and basic information which enables him to understand and use the theoretical and practical concepts and applications in various branches of physics and life.

16. Course Reading List and References:

1. Meyerhof W.E., Elements of Nuclear Physics, McGraw-Hill, Inc. USA, (1967).
2. Krane K.S., Introductory Nuclear Physics, John Willey & Sons, Inc., Singapore and Canada 1988.
3. Evans R. D., The Atomic Nucleus, McGraw-Hill, Inc., (1955).
4. Kaplan I., Nuclear Physics, Addison-Wesley Publishing Company, inc., (1962).
5. Beiser A., Concepts of Modern Physics, Sixth Edition, McGraw-Hill Companies, Inc., (2003).
6. Tsoulfanidis N., Landsberger S., Measurement Detection of Radaiation, 4th Edition, Taylor & Francis Group, LLC. (2015).
7. Mittal V. K., Verma R. C., Gupta S. C., Introduction to Nuclear and Particle Physics , Third Edition, PHI Learning Private Limited, Delhi, (2013).

17. The Topics:	**Lecturer's Name/ Weeks Number per chapter**
CHAPTER ONE **BASIC NUCLEAR CONCEPTS** 1.1 Basic Nuclear Properties 1.1.1 Nomenclature 1.1.2 Nuclear Mass 1.1.3 Exact Atomic Mass and Mass Excess 1.1.4 Nuclear Size 1.1.5 Nuclear Charge Distributions	Dr. Mohammed I. Hussein 04/9/2022 Weeks (1, 2 and 3)
CHAPTER TWO **NUCLEAR STRUCTURE** 2.1 Nuclear Binding Energy 2.2 Separation Energy Systematics 2.3 Abundance Systematics of Stable Nuclides	Dr. Mohammed I. Hussein Weeks (4, 5, 6, 7, 8, and 9)

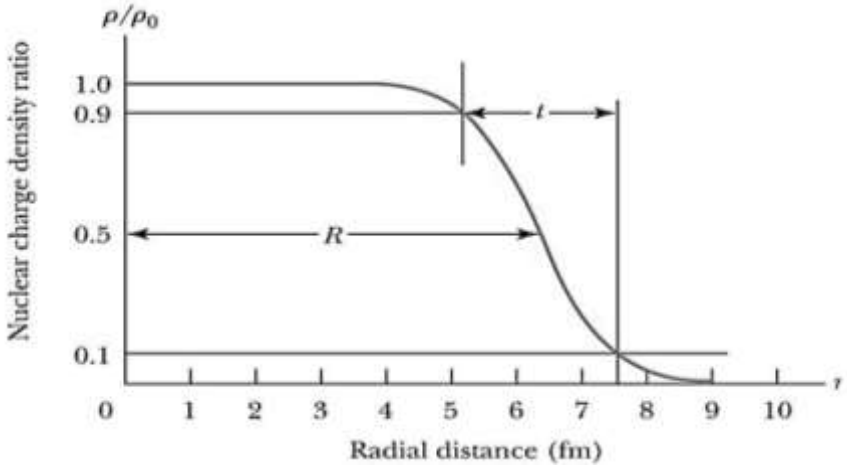
2.4 Liquid-Drop Model. Semiempirical Mass formula 2.4.1 Coulomb Energy of a Spherical Nucleus 2.4.2 Asymmetry Energy 2.4.3 Parity 2.5 Shell Model 2.5a Experimental Basis of the Shell Model 2.5b Single-particle Shell Model 2.5c Spin-orbit Coupling Model 2.6 Nuclear Spin	
First Examination	Monthly Examination 1 hour
CHAPTER THREE **INTERACTIONS OF NUCLEAR RADIATIONS WITH MATTER** 3.1 Nuclear Radiations Categories 3.2 Interaction of Charged Particles with Matter 3.3 Stopping Power 3.3.1 Stopping Power Due to Ionization and Excitation 3.4 Interaction of Gamma Radiation with Matter 3.4a Attenuation of Gamma Rays 3.4b Compton Effect 3.4c Photoelectric Effect 3.4d Pair Production	Dr. Mohammed I. Hussein weeks (10, 11, 12, 13, and 14)
18. Practical Topics (If there is any)	
In this section The lecturer shall write titles of all practical topics he/she is going to give during the term. This also includes a brief description of the objectives of each topic, date and time of the lecture	

19. Examinations:

Salahaddin University-Erbil
Science College
Physics Department
4th Year Students / General

Subject: Principles of Nuclear Physics
Final Exam / First Trial
Date: / /2022
Time Duration: 3 Hours

Q.1: From the figure below, show that the skin thickness is $4.4a$ (5 marks)



Q.2: An 0.2 MeV proton makes a head-on collision with an alpha particle at rest. What is distance of closest approach in Fermi? (10 marks)

Q.3: Determine the separation energy of neutron and proton of the following nuclides?

$^{7}_{3}Li \quad and \quad ^{9}_{4}Be$ (5 marks)

Q.4: Determine the ground state total angular momentum and the parity of the following elements $^{15}_{8}\mathrm{O}$, $^{39}_{19}\mathrm{K}$. (10 marks)

Q.5: Explain the following in brief: (10 marks)

1. Bremsstrahlung radiation. 2. Stopping power. 3. Linear attenuation coefficient.
4. Half-value thickness. 5. Compton wavelength.

Q.6: Write an equation for each of the following (10 marks)

1. Stopping power due to ionization–excitation for p, d, t, α

2. Stopping power due to ionization–excitation for electrons
3. The recoil kinetic energy of the electron in Compton Effect.
4. The minimum energy of the scattered photon in Compton Effect
5. The kinetic energy of the pair

Q.7: The gamma-ray photon collides with an electron at rest. It is scattered through 90^0, what is it frequency after collision, if it's initial frequency is $(3 \times 10^{19}$ Hz)? (10 marks)

Constants

$Mp = 1.007825032$ u , $Mn = 1.008665$ u , $M(^6_2He) = 6.018886$ u

$M(^6_3Li) = 6.015122794$ u , $M(^7_3Li) = 7.016004548$ u , $M(^8_3Li) = 8.022485$ u

$M(^8_4Be) = 8.005304$ u , $M(^9_4Be) = 9.012182$ u.

Good Luck **Dr. Mohammed I. Hussein**

20. Extra notes:

Here the lecturer shall write any note or comment that is not covered in this template and he/she wishes to enrich the course book with his/her valuable remarks.

21. Peer review پێداچوونەوەی هاوەڵ

This course book has to be reviewed and signed by a peer. The peer approves the contents of your course book by writing few sentences in this section.

(A peer is person who has enough knowledge about the subject you are teaching, he/she has to be a professor, assistant professor, a lecturer or an expert in the field of your subject).

ئەم کۆرسبووکە دەبێت لەلایەن هاوەڵێکی ئەکادیمیەوە سەیر بکرێت و ناوەرۆکی بابەتەکانی کۆرسەکە پەسەند بکات و جەند ووشەیەک بنووسێت لەسەر شیاوی ناوەرۆکی کۆرسەکە و واژووی لەسەر بکات.

هاوەڵ ئەو کەسەیە کە زانیاری هەبێت لەسەر کۆرسەکە و دەبیت پلەی زانستی لە مامۆستا کەمتر نەبێت.