
# Department of Physics

# College of Science

# University of Salahaddin

# Subject: Atomic Physics

# Course Book – (Year 2)

# Lecturer's name: Adeeb Omer Jafir

# Academic Year: 2022/2023

# Course Book

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| **1. Course name** | **Atomic physics** |
| **2. Lecturer in charge** | **Adeeb Omer Jafir** |
| **3. Department/ College** | **Physics / Science** |
| **4. Contact** | **e-mail: adeeb.jafir@su.edu.krd**<br>**Tel: 07504038244** |
| **5. Time (in hours) per week** | **Theory: 3**<br>**Practical: 2** |
| **6. Office hours** | **6** |
| **7. Course code** | |
| **8. Teacher's academic profile** | I graduate from Salahaddin University in 2004. I worked at 2005 as assistant physics for two and half year in nuclear and general physics lab., In 2009 I finished my MSc degree in thin films physics and start as Assistant Lecturer Teaching different subjects as: material science for fourth stage student, classical mechanics and properties of matter for first class physics . In 2017 I get my PhD degree in nuclear physics and from that time, as a lecturer, I am in charge in teaching atomic physics for 2nd class students, teaching practical atomic physics and supervising its lab. |
| **9. Keywords** | |

## 10. Course overview:

The course will start with a brief description of Modern Physics namely, special theory of relativity, wave-particle duality of light and material particles, atomic structure, quantum mechanics, quantum theory of the hydrogen atom, Many-electron atoms and the periodic table, molecules, solids and nuclear structure.

The lectures are easy to understand with simple language and lucid style, the mathematical treatment is clear and explanatory and the student will experience no difficulty in understanding the subject. The lectures also contain a large number of clearly illustrated diagrams and solved problems wherever necessary.

The course aims to lay the foundational concepts for students who would take up more advanced and specialized topics in later years

## 11. Course objective:

After the student studied and takes classical mechanic lectures in first class stage, they are ready now to understand the differences between the classical physics and modern physics and then prepare to understand the modern physics.

Students should become familiar with the principles and basic equations of the special theory of relativity and quantum mechanics and their applications in various fields of physics, for example;

solid-state, nuclear, and particle physics . To be aware of the limitations of classical physics, the origin of modern physics and the experimental evidence that led to its birth.

To demonstrate and solve selected problems, which develop, needed analytical skills.

To enhance the ability of the student for self-learning.

This knowledge will be applied in more advanced and specialized topics to be studied in later years.

## 12. Student's obligation

The class attendance on time is the first obligation of the student.

To get the best of the course, it is suggested that you attend classes as much as possible for all the material discussed in class. Come to class prepared physically and mentally. During the two courses three compulsory written exams will be done beside three or more pop quizzes inside the lectures. As well solving exercises of the text book(concept of modern physics).

## 13. Forms of teaching

Different teaching rules and manners will be used to fulfil the objectives of the annual teaching subject: power point presentation for the head titles and definitions and summary of conclusions, classification of materials and any other illustration, solving problems on the white board, besides worksheet will be designed to let the chance for practicing on several aspects of the course.

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.

## 14. Assessment scheme

The students are required to do three examinations in class rooms, one at the beginning of the year and others at the mid and the end. The examination has 40 (attendance and examination),. There will be final exam on 60 marks so that the final grade will be based upon the following criteria:

Mean of the three exams: 40%

Final exam: 60%

## 15. Student learning outcome:

The atomic physic courses are academic theoretical courses with practical. The student enters the course should have a good known about the classical mechanics in order to

compare with modern physics.

Upon the successful completion of this course, the student should be able to

know the concept of the special theory of Einstein's postulates: the Principle Relativity and the constancy of the speed of light, inertial frame of reference, the Doppler effect, the change of dimension of (L,M,T) when the particles speed comparable with the speed of light, the relativistic momentum and energy and the relation between them, massless particles, relativistic velocity addition in terms of Lorentz transformation, the particle properties of waves in terms of black body radiation, photoelectric effect , Compton effect and pair production, loss of energy when the wave transfer through the materials. wave properties of matter, wave particle duality , uncertainty principles, understand quantum mechanical theory and applications, understand the organization of the periodic table, including the properties shared by groups and periods, understand, measure, and predict spectra, describe the effect known as spin-orbit coupling, explain what is meant by total angular momentum, J, illustrates the fundamental aspects of molecular physics, use quantum mechanics at different levels to understand the structure and dynamics of molecules, dealing many electron configuration.

## 16. Course Reading List and References:

1-``concepts of modern physics``, 6th Edition, Arthur Beiser (2003).
2-Modern Physics" by K. Krane, 3ed ., John Wiley and Sons Inc., 2012.
3-"Modern Physics" by serway , 3 Ed.,, 2003.
4-"introduction to modern physics 'by R.B. Singh., 2ed edition, volume I.,2009

| **17. The Topics:** | **Lecturer's name** |
|---|---|
| Chapter 1: Relativity:<br><br>Special Relativity, Time Dilation, Doppler Effect, Length Contraction, Twin Paradox, Relativistic Momentum, Mass and Energy, Energy and Momentum, The Lorentz Transformation, Space time and relativistic velocity addition. | Adeeb Omer Jafie<br><br>ex: (9 hrs)<br><br>weeks (1 + 2+3) |
| CHAPTER2: Particle Properties of Waves<br><br>Electromagnetic Waves, Blackbody Radiation, Photoelectric Effect, X- Rays, X-Ray Diffraction, Compton Effect, Pair Production, Photons and Gravity, gravitational mass | Adeeb Omer Jafie<br><br>ex: (9 hrs)<br><br>weeks (4 + 5 and 6) |
| First short exam | 50 minutes |

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| CHAPTER3 : Wave Properties of Particles<br><br>De Broglie Waves, Describing a Wave, Phase and Group Velocities, Particle Diffraction, Particle in a Box, Uncertainty Principle ,Uncertainty Principle ,Applying the Uncertainty Principle | Adeeb Omer Jafie<br><br>ex: (9 hrs)<br><br>weeks (7 + 8 and 9) |
| CHAPTER4: Atomic Structure<br><br>The Nuclear Atom, Electron Orbits, Atomic Spectra, The Bohr Atom, Energy Levels and Spectra, Correspondence Principle, Nuclear Motion, Atomic Excitation, The Laser, Rutherford Scattering | Adeeb Omer Jafie<br>(3 hrs)<br>week (10 + 11 and 12) |
| Second short examination | 50 minutes |
| **REVIEW** | Adeeb omer jafir<br>(3 HrS)<br>Week(13 and 14) |
| **First examination** | Adeeb Omer Jafie<br><br>ex: (2 hrs) |

## 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.

| Evaluation policy | | |
|---|---|---|
| Assessment type | Expected date | Weight % |
| First quiz | November | 10 |
| Second quiz | December | 10 |
| First exam | January | 20 |
| Total | | 40 |

## 18. Examinations:

University of salahaddin | Final examination | Duration time

College of science | year : | 2 hours

Department of physics | 2nd class Atomic Physic exam.

***Note: each question contain the same marks***

***Q1/ choose the correct answer for the following (10 marks)***

***1.A space ship moves towards you at 1/3c, where c is the speed of light. The space ship emits a beam of light in your direction. As measured in your frame of reference, the speed of the light emitted by the space ship is:***

*(a) 4/3c (b)c (c)2/3c (d)1/3c*

***2..The resolution to the Twin Paradox lies in the observation that***

*(a) No two people can be exactly the same age*

*(b) the twin that stays on the Earth ages differently because of the Earth's gravitational field*

*(c)the predictions of special relativity only apply to sub atomic particles*

*(d) one of the twins must accelerate in order to leave Earth and comeback.*

***3. The work function is***

*(a) the minimum energy needed to remove an electron from a material*

*(b) the work done against dissipative forces when removing electrons from materials*

*(c) the same for all materials*

*(d) the energy needed to detach an electron from a lattice ion*

***4. Electrons accelerated through a potential difference of 30,000 V strike the target of an X-ray tube. What is the short wavelength limit of the X rays produced?***

*(a) There is no limit. (b) 0.0242 nm (c) 0.0165 nm (d) 0.0414 nm*

***5. If the stopping potential difference in a photoelectric experiment is 3 V, what is the maximum kinetic energy in electron volts of the emitted electrons?***

*(a) 1 eV (b) 2 eV (c) 3 eV (d) 4 eV*

*6. According to the Heisenberg uncertainty principle, _____.*

*a. the position of a particle cannot be measured precisely*

*b. the momentum of a particle cannot be measured precisely*

*c. neither the position nor the momentum of a particle can be measured precisely*
*d. the position and momentum of a particle can be measured precisely, but not at the same time*

***7. Which of the following is / are deduced from the Rutherford's scattering experiment?***

*(1) There are neutrons inside the nucleus.*
*(2) α particles are helium nucleus.*
*(3) Most of the mass is concentrated at the centre of atom.*
*A. (3) only B. (1) and (2) only*
*C. (2) and (3) only D. (1), (2) and (3)*

***8. What is the de Broglie wavelength of an electron (me = 9.11 × $10^{-31}$ kg) moving at a velocity of 3.0 × $10^{7}$ m/s (10% of the speed of light)?***

*a. less than 3.9 × $10^{-12}$ m b. 2.4 × $10^{-11}$m c. 3.3 × $10^{-8}$m d. greater than 1.1 × $10^{-4}$m*

***9.Why is a probability wave required to describe an electron's location?***

*a. The electron's location can be precisely determined.*
*b. Electrons violate Heisenberg's uncertainty principle.*
*c. The electron may be found at various distances from the nucleus.*
*d. The electron has less probability of being at the first Bohr orbit than at any other distance.*

***10. In the Bohr model of the atom, the kinetic energy of the system is equal to:***

*a. zero b. the kinetic energy of the nucleus c. the kinetic energy of the electron*
*d. the kinetic energy of the nucleus plus the electron*

***Q2(5+5 marks)***

**A-** A woman leaves the earth in a spacecraft that makes a round trip to the nearest star, 4 light-years distant, at a speed of 0.9c. How much younger is she upon her return than her twin sister who remained behind?

***B-*** An x-ray photon of initial frequency 3.0 x $10^{19}$ Hz collides with an electron and is scattered through $90^{o}$. Find its new frequency.

***Q3/ (5+5 marks)***

*A-* The sun's mass is 2.0 x $10^{30}$ kg and its radius is 7.0 x $10^{8}$ m. Find the approximate gravitational red shift in light of wavelength 500 nm emitted by the sun.

*B- Find the wavelength of the spectral line that corresponds to a transition in hydrogen from the n = 10 state to the ground state. In what part of the spectrum is this?*

***Q4/ (5+5 marks)***

*A- Show that the frequency of the photon emitted by a hydrogen atom in going from the level n = 1 to the level n is always intermediate between the frequencies of revolution of the electron in the respective orbits.*

*B-* Find the probability that a particle in a box L wide can be found between x = 0 and x = L/n when it is in the nth state.

***Q5/ (5+5 marks)***

*A- In the Bohr model of the hydrogen atom, what is the magnitude of the orbital magnetic moment of an electron in the nth energy level?*

*B- Show that the energy-level spacing of a harmonic oscillator is in accord with the correspondence principle by finding the ratio $\Delta En/En$ between adjacent energy levels and seeing what happens to this ratio as $n \to \infty$ .*

***Q6/(5+5 marks)***

*A- A beam of electrons enters a uniform 1.20-T magnetic field.(a)Find the energy difference between electrons whose spins are parallel and antiparallel to the field. (b) Find the wavelength of the radiation that can cause the electrons whose spins are parallel to the field to flip so that their spins are antiparallel.*

*B- Explain why the x-ray spectra of elements of nearby atomic numbers are qualitatively very similar, although the optical spectra of these elements may differ considerably.*

Good lucks

Dr. Adeeb Omer Jafir