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**Department of Physics**

**College of Education/Shaqlawa**

**University of Salahaddin**

**Subject: Quantum Mechanics**

**Course Book – (Year 4)**

**Lecturer's name:**

**Dr. Bestoon A Gozeh**

**Academic Year: 2022/2023**

**Course Book**

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| **1. Course name** | **Quantum Mechanics** | |
| **2. Lecturer in charge** | **Dr. Saman Qadir Mawlud** | |
| **3. Department/ College** | **Physics/Education** | |
| **4. Contact** | **e-mail:** [**saman.mawlud@su.edu.krd**](mailto:saman.mawlud@su.edu.krd)  **Tel:009647504789074** | |
| **5. Time (in hours) per week** | **Theory: 3**  **Practical: 0** | |
| **6. Office hours** | **Thursday from 9:00-11:00 AM or by an appointment** | |
| **7. Course code** | **EdPh0404** | |
| **8. Teacher's academic profile** | https://academics.su.edu.krd/saman.mawlud | |
| **9. Keywords** | **Quantum Mechanics, Concepts And Applications**  **Origin of Quantum Mechanics, Postulate of Quantum Mechanics** | |
| **10. Course overview:**  At the beginning we are going to review the main physical ideas experimental that defied classical physics and led to the birth of quantum mechanics. The introduction of quantum mechanics was prompted by the failure of classical physics in explaining a number of microphysical phenomena that were observed at the end of the nineteenth and early twentieth centuries.  In the second period we covered all the mathematical machinery to study quantum mechanics. The Schrodinger equation is one of the comerstones of the theory of quantum mechanics, it has the structure of a ***linear equation***. The formalism of quantum mechanics deals with **operator** that are linear and wavefunctions that belong to the abstract Hilbert Space. Quantum mechanics was formulated in two different ways by Schrodinger and Heisenberg. Schrodinger's wave mechanics and Heisenberg's matrix mechanics are the representation of general formalism of quantum mechanics in **continuous** and **discrete** basis systems respectively.  The formalism of quantum mechanics is based on a number of postulates. These postulates are in turn based on a wide range of experimental observations. These postulates cannot be derived; they result from experiment. They only represent the minimal set of assumptions needed to develop the theory of quantum mechanics. For this one has to turn to the theory built upon these postulate. So the accurate prediction power of quantum theory gives irrefutable evidence to the validity of the postulates upon which the theory is built. | | |
| **11. Course objective:**  The course will start with a brief description of quantum concepts: describing the old quantum mechanics (Niel's Bohr Postulate) in which the theoretical attempts of black body interpretation will declared, the transition breakthrough's from the failure of classical mechanics to quantum mechanics will studied, like wave aspects and particle aspects also be discussed.  The next topics introduces the mathematical tools of quantum mechanics implying the Dirac notations, operators, and wave mechanics.  One dimensional problems, angular momentum, and three dimensional problems will forms the other basic sections involving the particle bound potentials, Eignvalue sand Eigenvectors, orbital and spin intrinsic momentums, Harmonic oscillators and Density of states and effective density of states in 3D (bulk), 2D (quantum wells), 1D (wires), 0D (dots) semiconductors (3D);  The Hydrogen atom spectra and its associated wave functions including the concepts of degeneracy and non- degeneracy will derived.  Through the course syllabus the student will have the principal and basic information which enables him to understand and use the quantum mechanical concepts and applications in various branches of physics.  Thus, although we shall not need any truly complicated math, working knowledge of calculus, basic differential equations, and elements of linear algebra will be expected. | | |
| **12. Student's obligation**  A list of additional useful problems will be given to help the student further sharpen your understanding of the subject and your problem solving skills. The students are required to do these problems, although you may find it useful to do so. Because this subject is One course, so that the students are required to do at least two closed exam during this semester besides other assignments and each student must prepare full report at the end of the year. All exams have marks, full report also has marks, the classroom activities count marks and mark for attendance too.  لێره‌ مامۆستا به‌رپرسیارێتی قوتابی خوێندکار ڕوونده‌کاته‌وه‌ سه‌باره‌ت به‌ کۆرسه‌که‌ بۆ نموونه‌ ئاماده‌بوونی قوتابیان له‌ وانه‌کاندا، له‌ تاقیکردنه‌وه‌کاندا، راپۆرت و ووتار نووسین... هتد. | | |
| **13. Forms of teaching**  Our lecture is depending directly on showing the strong point in the lecture via data show depending on the power point program… and solve problem on the white board with the students.  لێره‌ مامۆستا ڕێگه‌ی وانه‌‌ ووتنه‌وه‌ ده‌نووسێت، بۆ نموونه‌:‌ داتاشۆ و پاوه‌رپۆینت، ‌سه‌ر ته‌خته‌ڕه‌ش، ته‌خته‌ی سپی، سمارتبۆرد یان‌ مه‌لزه‌مه‌... هتد | | |
| **14. Assessment scheme**  All exams have 20 marks, full report has 5 marks, the classroom activities count (Homework) has 10 and for Quiz 5 Marks. So that the final grade will be based upon the following criteria:  Mid- semester exam: 20%  Homework, Classroom participation and assignments: 10%  Report: 5%  Quiz: 5%  Final Exam: 60%  Breakdown of overall assessment and examination  لێره‌ مامۆستا جۆری هه‌ڵسه‌نگاندن (تاقیکردنه‌وه‌کان یان ئه‌زموونه‌کان) ده‌نووسێت بۆ نموونه‌ تاقیکردنه‌وه‌ی مانگانه‌، کویزه‌کان، بیرکردنه‌وه‌ی ڕه‌خنه‌گرانه (پریزه‌نته‌یشن)، ڕاپۆرت نووسین، ووتار نووسین‌ یان ئاماده‌نه‌بوونی خوێندکار له‌ پۆلدا...هتد. ئامانه‌ چه‌ند نمره‌ی له‌سه‌رده‌بێت و مامۆستا چۆن نمره‌کان دابه‌شده‌کات؟‌ | | |
| **15. Student learning outcome:**  Quantum mechanics plays a very important role in the Physics field, during the years I teaching Quantum Mechanics, I have notices that students generally find it easier to learn its underlying ideas than to handle the practical aspects of the formalism. What is true is that the students at the Physics department who were all selected after a stiff entrance examination, and whose ambitions in life were diverse – in science, in industry, in business, in high public office – all had to follow this introductory physics course. As a consequence, the challenge was to try to get them interested in the field whatever their future goals were. Of course, quantum mechanics is an ideal subject because one can be interested in it for a variety of reasons, such as the physics itself, the mathematical structure of the theory, its technological spinoffs, as well as its philosophical or cultural aspects. So the task was basically to think about the pedagogical aspects, in order to satisfy audiences that went up to many students during the last 10 years.  پڕکردنه‌وه‌ی ئه‌م خانه‌یه‌ زۆر گرنگه‌، مامۆستا ده‌رئه‌نجامه‌کانی فێربوون ده‌نووسێت. بۆ نموونه‌: ڕوونی ئامانجه‌ سه‌ره‌کیه‌کانی کۆرسه‌که‌ (بابه‌ته‌که‌) بۆ خوێندکار‌  گونجاندنی ناوه‌ڕۆکی کۆرسه‌که‌ به‌ پێویستی ده‌ره‌وه‌ و بازاڕی کار  قوتابی چی نوێ فێرده‌بێت له‌ ڕێگه‌ی پێدانی ئه‌م کۆرسه‌وه‌؟  This should not be less than 100 words | | |
| **16. Course Reading List and References‌:**  **Books**: *There are many good introductory texts on QM, for example:*  **D. J. Griffiths**: Introduction to Quantum Mechanics, Prentice Hall.  **N. Zettili**: Quantum Mechanics, Concepts and Applications, Wiley.  **R. L. Liboff**: Introductory Quantum Mechanics, Fourth Edition, Addison Wesley.  **J. M. Cassels**: Basic Quantum Mechanics (2nd Ed), Macmillan.  ▪ Key references:  ▪ Useful references:  ▪ Magazines and review (internet): | | |
| **17. The Topics:** | | **Lecturer's name** |
| Basic principles of Particle Nature of Wave like (Photoelectric and Compton Effects and Pair production and Annihilation of matter) and Wave Nature of Particle such as (de Broglie hypothesis; Thomson Experiment and Heisenberg uncertainty principle). | | ex: (3 hrs)  ex: 12/10/2020 |
| Failure of Classical Mechanics : Black body Radiation | | ex: (3 hrs)  ex: Week Two |
| Basic principles of history of atoms and old quantum mechanics (Niel's Bohr postulate) | | ex: (3 hrs)  ex: Week Three |
| Postulates of Quantum Mechanics  **First Postulates:** Wave Function  **Second Postulates:** Operators | | ex: (3 hrs)  ex: Week Four |
| **Third Postulates:** Eignfunction and eigenvalue  **Fourth Postulates:** Time Evolution of Hamiltonian Operator. | | ex: (3 hrs)  ex: Week Five |
| Derive of Schrodinger Equation | | ex: (6 hrs)  ex: Weeks (six – seven) |
| Application of Schrodinger Equation such as the particle in a well, harmonic oscillator and hydrogen atom. | | ex: (6 hrs)  ex: Weeks (eight – nine) |
| Theory of the angular momentum in Quantum Mechanics. | | ex: (6 hrs)  ex: Weeks (ten – eleven) |
| The Simple Harmonic Oscillator. | | ex: (6 hrs)  ex: Weeks(twelve-thirteen) |
| Density of states and effective density of states in 3D (bulk), 2D (quantum wells), 1D (wires), 0D (dots) semiconductors (3D); | | ex: (3 hrs)  ex: Weeks (fourteen) |
| **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:**  **Q.1\ Choose the correct(s) answer:** **[10 Marks]**  **1. The photoelectric effect best demonstrates**  a. the wave nature of light, b. the particle nature of light, c. both of these, d. none of these  **2. In the photoelectric effect, the brighter the illuminating light on the surface, the greater**  a. the number of ejected electrons, b. the velocity of ejected electrons  c. both of these, d. neither of these  **3. In the double slit experiment with electrons, the pattern observed on the screen is**  a. wave-like, b. particle-like, c. neither of these, d. both of these  **4. In the relationship E = h*f* for a photon emitted from an atom, the symbol E is used to represent the energy**  a. of the emitted photon, b. difference between atomic energy states producing the photon  c. both of these, d. neither of these  **5. If a proton and an electron have identical momenta, the longer wavelength belongs to the**  a. proton, b. electron, c. Both are the same.  **Q.2\** | | |
| **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 پێداچوونه‌وه‌ی هاوه‌ڵ**  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).*  ئه‌م کۆرسبووکه‌ ده‌بێت له‌لایه‌ن هاوه‌ڵێکی ئه‌کادیمیه‌وه‌ سه‌یر بکرێت و ناوه‌ڕۆکی بابه‌ته‌کانی کۆرسه‌که‌ په‌سه‌ند بکات و جه‌ند ووشه‌یه‌ک بنووسێت له‌سه‌ر شیاوی ناوه‌ڕۆکی کۆرسه‌که و واژووی له‌سه‌ر بکات.  هاوه‌ڵ ئه‌و که‌سه‌یه‌ که‌ زانیاری هه‌بێت له‌سه‌ر کۆرسه‌که‌ و ده‌بیت پله‌ی زانستی له‌ مامۆستا که‌متر نه‌بێت.‌‌ | | |