Department of Physics

College of Science

University of Salahaddin

Subject: Quantum Mechanics

Course Book – (Year 3 - Applied)

Lecturer's name: *Dr Amir Abdulrahman Ahmad*

Academic Year: 2020/2021

Course Book

1. Course name	**Quantum Mechanics**
2. Lecturer in charge	**Asst. Dr. Amir Abdulrahman Ahmad**
3. Department/ College	
4. Contact	**e-mail: amir.ahmad@su.edu.krd** **Tel:**
5. Time (in hours) per week	**Theory: 3** **Practical: 0**
6. Office hours	**4**
7. Course code	
8. Teacher's academic profile	**I have more than 17 years' experience teaching of different subjects such as: Electricity and Magnetism, General Physics, Analytical Mechanics, Mathematical Physics, Statistical Physics, Solid State Physics and Quantum Mechanics also I have four (9) papers published in different foreign journals. Supervising M.Sc. student during my duty in the college. Participation in different conferences and meeting worldwide. I served as the Head of Physics Department 2016-2020 during which I have organized the scientific and administration affairs of the department to the desired level and organized dozens of national and international workshops and conferences.** **B.Sc. of Physics from 2000** **M.Sc. of Solid-State Physics 2003** **Ph. D of Nanotechnology 2014 from Jagiellonian University, Krakow/Poalnd** **Assist Lecturer** Sept 2003 – Sept 2014 **Instructor** Sep 2014 – up to date
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, Eigenvalue 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 tow 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.

لێرە مامۆستا بەرپرسیارێتی قوتابی خوێندکار ڕوونەکاتەوە سەبارەت بە کۆرسەکە بۆ نموونە ئامادەبوونی قوتابیان لە وانەکاندا، لە تاقیکردنەوەکاندا، ڕاپۆرت و ووتار نووسین... هتد.

13. Forms of teaching

Our lecture is depend 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.

لێرە مامۆستا ڕێگەی وانە ووتنەوە دەنووسێت، بۆ نموونە: داتاشۆ و پاوەرپۆینت، سەر تەختەڕەش، تەختەی سپی، سمارتبۆرد یان مەلزەمە... هتد

14. Assessment scheme

All exams have 30 marks, full report has 5 marks, the classroom activities count and for attendance 5 Marks. So that the final grade will be based upon the following criteria:
Mid- semester exam: 30%
Classroom participation and assignments: 5%
Report: 5%
Final Exam: 60% .

Breakdown of overall assessment and examination

لێرە مامۆستا جۆری هەڵسەنگاندن (تاقیکردنەوەکان یان ئەزموونەکان) دەنووسێت بۆ نموونە تاقیکردنەوەی مانگانە، کویزەکان، بیرکردنەوەی ڕەخنەگرانە (پریزەنتەیشن)، ڕاپۆرت نووسین، ووتار نووسین یان ئامادەنەبوونی خوێندکار لە پۆلدا...هتد. ئامانە چەند نمرەی لەسەردەبێت و مامۆستا چۆن نمرەکان دابەشدەکات؟

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.

پرکردنەوەی ئەم خانەیە زۆر گرنگە، مامۆستا دەرئەنجامەکانی فێربوون دەنووسێت. بۆ نموونە: ڕوونی ئامانجە سەرەکیەکانی کۆرسەکە (بابەتەکە) بۆ خوێندکار

گونجاندنی ناوەڕۆکی کۆرسەکە بە پێویستی دەرەوە و بازاڕی کار
قوتابی چی نوێ فێردەبێت لە ڕێگەی پێدانی ئەم کۆرسەوە؟

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.

P.J.E. Peebles: Quantum Mechanics, Princeton University Press.

D. Park: Introduction to the Quantum Theory (3rd Ed), McGraw-Hill.

A. Goswani: Quantum Mechanics (2nd Ed), Wm.C. Brown Publishers.

- Key references:
- Useful references:
- Magazines and review (internet):

17. The Topics:	Lecturer's name
Introduction to Quantum World: The limits and short comes of Classical Physics, Necessity of having a new theory to explain the Wave-Particle Duality Phenomenon (Photoelectric, Compton Effects, Pair production and Annihilation of matter, de Broglie hypothesis; Thomson Experiment and Heisenberg uncertainty principle).	Dr. Amir A.Ahmad ex: (3 hrs)
Failure of Classical Mechanics: Black body Radiation, attempts to explain the black body radiation curve, Max Planck Formula of Black Body Radiation and the quantization of Energy.	Dr. Amir A.Ahmad ex: (3 hrs)

Basic principles of history of atoms and old quantum mechanics (Niel's Bohr postulate)	Dr. Amir A.Ahmad ex: (3 hrs)
Presenting a particle in Quantum Mechanics, the idea of Wavepacket, Fourier transformation, building a wavepacket.	Dr. Amir A.Ahmad ex: (3 hrs)
Wavepacket velocity; The idea of Wavepacket, Phase Velocity and Group Velocity	Dr. Amir A.Ahmad ex: (3 hrs)
First Examination	
Mathematical form of Wavefunction	Dr. Amir A.Ahmad ex: (6 hrs)
Week 9 - 11: Derivation of Schrodinger's Equation: Application of Schrodinger Equation such as Free Particle and a particle in a Box.	Dr. Amir A.Ahmad ex: (6 hrs) ex: Weeks (Nine – Ten)
Week 12 - 13: Mathematical Foundation of Quantum Mechanics: Operators, Eigenfunction and Eigenvalue problem.	Dr. Amir A.Ahmad ex: (6 hrs)
Week 14: Hermitian Operators, position and momentum operators as examples.	Dr. Amir A.Ahmad ex: (6 hrs)
Week 15: Commutators Algebra: Angular momentum Operator	Dr. Amir A.Ahmad ex: (3 hrs)
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	Quantum Mechanics I
College of Science	Time: 3 Hours
Physics Department	First Trail
3rd year Students	Date: 23/5/2021

Note: Attempt All Questions.

Q1: When light of a given wavelength is incident on a metallic surface, the stopping potential for the photoelectrons is 3.2 V. if a second light source whose wavelength is double that of the first is used, the stopping potential drops to 0.8 V. calculate the wavelength of the first radiation. **(10 Marks)**

Q2: For a Free particle solve the time dependent Schrodinger equation and show that its solution is **(10 Marks)**

$$\psi(x,t) = Constan\ e^{\frac{i}{\hbar}(px-\frac{p^2}{2m}t)}$$

Q3: Write a normalized wavefunction $\psi(x)$ which is a superposition of three different states $\varphi_i(x)$ with equal probabilities. **(10 Marks)**

Q4: Show the following commutator relations **(20 Marks)**

1- $[\hat{A}, \hat{B}\hat{C}] = [\hat{A}, \hat{B}]\hat{C} + \hat{B}[\hat{A}, \hat{C}]$
2- $[\hat{x},\ \hat{L}_y] = i\hbar\hat{z}$
3- $[\hat{x}, \hat{p}\ ] =\ i\hbar$
4- $[\ \hat{L}_x, \hat{L}^2] = 0$

Q5: What is a Hermitian Operator, write the mathematical expression and then show that the momentum operator is Hermitian. (**10 Marks**)

Good Luck

Instructor: Amir A. Ahamd PhD

Keep Calm and do Quantum Mechanics.

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 ناوەڕۆکی بابەتەکانی کۆرسەکە پەسەند بکات و جەند ووشەیەک بنووسێت لەسەر شیاوی ناوەڕۆکی کۆرسەکە و واژووی لەسەر بکات.

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