



Department of Physics

College of Science

University of Salahaddin

Subject: Quantum Mechanics

Course Book – (Master Students)

Lecturer's name: Dr Amir Abdulrahman Ahmad

Academic Year: 2020/2021

Course Book

1. Course name	Quantum Mechanics I, MSc Course
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	<p>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.</p> <p>B.Sc. of Physics from 2000 M.Sc. of Solid-State Physics 2003 Ph. D of Nanotechnology 2014 from Jagiellonian University, Krakow/Poland Assist Lecturer Sept 2003 – Sept 2014 Instructor Sep 2014 – up to date</p>
9. Keywords	Quantum Mechanics, Origin of Quantum Mechanics, Postulate of Quantum Mechanics, Mathematical Foundation of QM
10. Course overview: <p>This course includes materials of the first semester master students in foundation of Quantum Mechanics. The whole purpose of the course is to give a firm understanding of fundamental concepts of quantum world. The course requires a good knowledge of vector calculus, trigonometric functions and a basic knowledge of probability theory is also required.</p> <p>For the beginning we start from introducing the frontiers of physics from classical to quantum world. We introduce the first astonishing concept in QM the wave-particle duality. Then we present the Copenhagen interpretation, Heisenberg's Formalism</p>	

and the idea of collapse to an eigenstate after a measurement. Wave-particle duality concept needs more attention such that we introduce fundamentals of wave equation, simple harmonic motion. Its worth to mention the idea of representing a particle in QM and the concept of Wavepacket. Light has been the mystery of beginning of 20th century, we introduce the Electromagnetic theory of light and Maxwell's conjectures about light. Then wavefunction and wave equation is treated in more detail the outcome of which is the birth of Schrodinger's Equation. We continue with the idea of Dirac Delta function and the Gaussian wavefunction and the mathematical concept behind the Fourier transformation and ultimately the wavepacket.

We shed light on the equation of continuity in physics and QM, application of Schrodinger equation to solve free particle and particle in a box wavefunction and outcome of concept of confinement.

The last part of the course is a bout the techniques and language of QM. The operator's Algebra and introducing the important operators in QM being the Hermitian and Projection operators.

Through Operator commutator algebra and deriving Baker-Campbell-Harsdorf (BCH) theorems we then can define the generalized Heisenberg's Uncertainty Principle of any two arbitrary Hermitian Operators.

Lastly but not the list we then go for the Dirac Notation and postulates of QM.

11. Course objective:

The most important objective of the course is to give a firm introduction of the fundamental concepts of QM. We introduce the mathematics and physics behind the wired quantum world and try to give the interpretations using the proper mathematical language. The students will know the concept of energy quantization its origin and then realize the thinking about the quantum world in a different way. To do better in QM students should be well equipped with the mathematical skills, these skills are reviewed in this course.

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.

لئره ماموستا بهر پرسياري تي قوتايي خوئندكار پرونده كاتهوه سهارهت به كورسه كه يو نمونه ناماده بوني قوتايان له وانه كانداه،

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.

لیره ماموستا ریگهی وانه ووتنهوه دهنووسیت، بۆ نمونه: داتاشو و پاوه پۆینت، سهر تهخته پرش، تهخته ی سپی، سمارتپورد یان مهلزمه... هتد

14. Assessment scheme

Students are asked to prepare a well-organized review on a topic according to the regulations required to publish in Salahaddin University Journal. The review acquires 50% of the final mark and the rest is to pass a final written exam about the whole theoretical material of the course.

Breakdown of overall assessment and examination

لیره ماموستا جۆری ههلسنگاندن (تاقیکردنوه ماکان یان ئهمزموونهکان) دهنووسیت بۆ نمونه تاقیکردنوهی مانگانه، کویزهکان، بیرکردنوهی رهنهگرانه (پریزنتیشن)، راپورت نووسین، ووتار نووسین یان ئامادهنبوونی خویندکار له پۆلدا... هتد. ئامانه چهند نمرهی لهسهر دهییت و ماموستا 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.

پرکردنوهی ئهم خانهیه زۆر گرنگه، ماموستا دهر ئه نجامهکانی فیزیوون دهنووسیت. بۆ نمونه: پرونی ئامانجه سهرمهکیهکانی کۆرسهکه (بابهتهکه) بۆ خویندکار گونجاندنی ناوهڕۆکی کۆرسهکه به پێویستی دهرمه و بازاری کار قوتابی چی نوێ فیردهییت له ریگهی پیدانی 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:*

Stephen Gasiorowicz: Quantum Physics, 3rd Edition, Wiley International edition 2003.

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

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

17. The Topics:	Lecturer's name
<u>Introduction to Quantum World:</u> Physics Frontiers from Classical to Quantum world, the first astonishing concept in QM, the wave-particle duality. Foundation of Quantum theory, Copenhagen Interpretation. Heisenberg's Formalism, Schrodinger's wave mechanics, Collapse to an eigenstate after a measurement.	Dr. Amir A.Ahmad ex: (3 hrs)
<u>Wave-Particle Duality:</u> particles or waves which one is more fundamental? simple harmonic motion and wave, wave equation, deBroglie postulate, Bohr's Atomic Model, Representing a Particle in QM, Mathematical representation, General form of a wavefunction.	Dr. Amir A.Ahmad ex: (3 hrs)
<u>Wave Equation and Schrodinger's Equation:</u> Light is a wave, Electromagnetic theory of light, wave equation and Maxwell's conjectures, wavefunction and the wave equation, Derivation of Schrodinger's Equation.	Dr. Amir A.Ahmad ex: (3 hrs)
<u>Dirac Delta Function:</u> Gaussian Integrals and Gaussian Function, Dirac Delta function definition. Delta function in QM the integral form, Fourier integral theorem and Fourier transform of Gaussian function, Parseval's	Dr. Amir A.Ahmad ex: (3 hrs)

Theorem, Time and Frequency Domains.	
<p><u>Evolution of the wave function;</u> wavefunction and it's time evolution.</p> <p>Why do macroscopic wavefunction do not evolve in time considerably?</p>	<p>Dr. Amir A.Ahmad ex: (3 hrs)</p>
First Examination	
<p><u>Equation of Continuity:</u> continuity equation in general physics and QM, concept of positive and negative divergence, Gauss's divergence theorem, Transmission and reflection coefficients.</p>	<p>Dr. Amir A.Ahmad ex: (6 hrs)</p>
<p><u>Application of Schrodinger's Equation:</u> Properties of a valid and well-behaved wavefunction, properties of Schrodinger Equation, Application of Schrodinger Equation such as Free Particle and a particle in a Box.</p>	<p>Dr. Amir A.Ahmad ex: (6 hrs)</p> <p>ex: Weeks (Nine – Ten)</p>
<p><u>Mathematical Foundation of Quantum Mechanics:</u> Operators, Linear operators, Eigenfunction and Eigenvalue problem. Important operators in QM, Operator commutators, first and second Baker-Campbell-Hausdorff (BCH) Theorems, Projection operator and completeness, Inverse and Unitary operators.</p>	<p>Dr. Amir A.Ahmad ex: (6 hrs)</p>
<p><u>Expectation value and Generalized Uncertainty Principle,</u> Uncertainty principle, expectation value of operators, Ehrenfest's Theorem, Expectation value of</p>	<p>Dr. Amir A.Ahmad ex: (6 hrs)</p>

Momentum Operator, Generalized Heisenberg Uncertainty Principle.	
Dirac Notation and Postulates of QM: Dirac Notation, Postulates of QM, The superposition and the concept of Hilbert Space, Properties of Hilbert Space, the evolution of the systems state, spatial evolution generator, Infinitesimal____and finite unitary transformation, Properties of unitary transformation, finite unitary transformation, spatial and time transformations.	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:	

Assignment on Duality of wave and matter

A1: Determine where a particle is most likely to be found whose wavefunction is given by $\psi(x) = \frac{1+ix}{1+ix^2}$

A2: The state of a free particle at $t=0$ confined between two walls separated by a is described by the following wave function:

$$\psi(x, 0) = A \sin\left(\frac{n\pi}{a} x\right)$$

a- Normalize the wavefunction.

b- Calculate the probability of finding the particle in the region $\frac{3a}{4} \leq x \leq a$ for $n=1$ and $n=2$.

A3: the time required for a wave packet to move the distance equal to the width of the wavepacket is $\Delta t = \Delta x / v_g$, show that the time and the uncertainty in the energy of the particle satisfy the uncertainty relation $\Delta E \cdot \Delta t = h$, where

$$\Delta E = \hbar \Delta \omega.$$

A4: the amplitude $A(k)$ of the wavefunction

$$\psi(x, t) = \int_{-\infty}^{+\infty} A(k) e^{i(kx - \omega_k t)} dk$$

Is given by

$$A(k) = \begin{cases} 1 & \text{for } k_0 - \frac{1}{2} \Delta k \leq k \leq k_0 + \frac{1}{2} \Delta k \\ 0 & \text{elsewhere} \end{cases}$$

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**پیداچوونہوہی ھاوہل**

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 ھاوئەڵێکی ئەکادیمیەوہ سەیر بکەیت و ناوەرۆکی بابەتەکانی کۆرسەکە پەسەند بکات و جەند ووشەیک بنووسیت لەسەر شیاوی ناوەرۆکی کۆرسەکە و واژووێ لەسەر بکات. ھاوئەڵ ئەو کەسەیکە کە زانیاری ھەبێت لەسەر کۆرسەکە و دەبێت پلەێ زانستی لە مامۆستا کەمتر نەبێت.