Date: 04/09/2019

To,
The Principal
Shri. Mohatadevi Shikshan Sanstha
Pragati Mahavidyalaya, Sawkheda
Tq. Sillod, Dist. Aurangabad

Subject: Proposal to Run Certificate Course on "***Quantum Mechanics***" for the Academic Year 2019-20

Respected Sir,

I, Dr. Anil Dinkar Raut , Head of the Physics Department, am writing to propose the introduction of a certificate course entitled "***Quantum Mechanics***" for our Physics department students for the academic year 2019-20. This course is designed to provide students with a deeper understanding of the fundamental principles of quantum mechanics, which is a crucial area of study in modern physics.

The proposed course will have a duration of 32 hours and will cover the essential concepts and applications of quantum mechanics. The curriculum is tailored to enhance the students' theoretical and practical knowledge, equipping them with skills that are highly valuable in both academic and research settings.

We believe that offering this certificate course will greatly benefit our students by broadening their knowledge base and preparing them for future academic pursuits or careers in physics and related fields.

We kindly request your approval and support to run this course in the upcoming academic year. We are confident that this initiative will contribute significantly to the academic growth of our students and the reputation of our institution.

Thank you for considering this proposal. I am available to discuss any details or answer any questions you may have.

Yours sincerely,

Dr. Anil Dinkar Raut
Head of Department, Physics
Pragati Mahavidyalaya, Sawkheda
Tq. Sillod, Dist. Aurangabad

Shri Mohatadevi Shikshan Sanstha, Aurangabad.
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Estd: 2016

Mrs. Kaveri Palkar
President

Mrs. Archana Mukhekar
Secretary

Dr. Varsha Phalke
Principal

Ref No.: PMS/2019-2020/01

Date : 06/09/2019

To,
The Head of Department,
Physics Department,
Pragati Mahavidyalaya, Sawkheda,
Tq. Sillod, Dist. Aurangabad

Subject: Sanction to Run Certificate Course on ***"Quantum Mechanics"*** for the Academic Year 2019-20

Dear Sir,

I am pleased to inform you that the proposal has been reviewed and approved by the college administration.

You are hereby granted permission to run the certificate course ***"Quantum Mechanics"*** for a duration of 32 hours in the academic year 2019-20. We believe that this course will significantly enhance the educational experience of our students and contribute to their academic and professional development.

Please ensure that all necessary preparations are made to successfully conduct the course, including the arrangement of study materials, scheduling of classes, and appointment of qualified instructors. We trust that the Physics department will manage the course effectively and maintain high academic standards.

We wish you and your team success in this endeavor and look forward to seeing the positive impact it will have on our students.

Thank you for your initiative and dedication to enriching our academic programs.

Yours sincerely,

Varsha

Varsha Phalke
Principal
Pragati Mahavidyalaya,
Sawkheda Tq. Sillod,
Dist. Aurangabad

Varsha

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Mrs. Kaveri Palkar — President

Mrs. Archana Mukhekar — Secretary

Dr. Varsha Phalke — Principal

Seal

Ref No.: PMS/2019-2020/01 Date : 06/09/2019

NOTICE

Subject: Certificate Course on "*Quantum Mechanics*" for the Academic Year 2019-20

This is to inform all students of the Physics Department that a certificate course titled "*Quantum Mechanics*" will be offered in the upcoming academic year 2019-20. This 32-hour course is designed to provide an in-depth understanding of the fundamental principles of quantum mechanics and its applications.

Interested students are requested to register for the course by submitting the registration form available in the Physics Department office.

For further details, please contact the undersigned during office hours.

We encourage all eligible students to take advantage of this opportunity to enhance their knowledge and skills.

Head of Department, Physics

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Physics Department

Certificate Course in Quantum Mechanics

Academic Year 2019-20

Total Duration: 32 Hours

Course Overview:

This certificate course on ***Quantum Mechanics*** is designed to provide students with a foundational understanding of quantum mechanics principles and their applications in modern physics. The course will cover both theoretical and mathematical aspects of quantum mechanics, focusing on the physical interpretation and problem-solving techniques.

Course Objectives:

- To introduce the fundamental concepts of quantum mechanics.
- To develop mathematical techniques for solving quantum mechanical problems.
- To provide insights into the applications of quantum mechanics in various fields of physics.
- To enhance analytical and problem-solving skills in the context of quantum systems.

Course Structure:

Module 1: Introduction to Quantum Mechanics **(4 Hours)**

- Historical Development of Quantum Theory
- Wave-Particle Duality
- The Heisenberg Uncertainty Principle
- Fundamental Postulates of Quantum Mechanics
- Introduction to Quantum States and Operators

Module 2: Mathematical Foundation of Quantum Mechanics **(6 Hours)**

- Complex Numbers and Linear Algebra
- Eigenvalues and Eigenvectors
- Dirac Notation and Hilbert Spaces
- Operators in Quantum Mechanics
- Commutators and Uncertainty Relations

Module 3: The Schrödinger Equation **(6 Hours)**

- Time-Dependent and Time-Independent Schrödinger Equation
- Properties of the Schrödinger Equation
- Probability Density and Current
- Expectation Values and Operators
- Applications to Free Particles and Particle in a Box

Module 4: Quantum Systems in One Dimension **(6 Hours)**

- Potential Wells and Barriers
- The Harmonic Oscillator
- Tunneling Effect
- Quantum Mechanical Tunneling
- Bound States and Scattering States

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Date : — / — /20 –

Module 5: Quantum Systems in Three Dimensions (5 Hours)

- The Hydrogen Atom
- Angular Momentum in Quantum Mechanics
- Quantum Numbers and Electron Orbitals
- Spin and the Pauli Exclusion Principle
- Introduction to Spin-Orbit Coupling

Module 6: Approximation Methods in Quantum Mechanics (5 Hours)

- Time-Independent Perturbation Theory
- The Variational Principle
- WKB Approximation
- Applications to Real-World Quantum Systems
- Introduction to Quantum Computation and Information

Module 7: Applications of Quantum Mechanics (4 Hours)

- Quantum Mechanics in Atomic Physics
- Quantum Mechanics in Molecular and Solid-State Physics
- Introduction to Quantum Field Theory
- Quantum Entanglement and Quantum Computing
- Recent Advances and Future Directions in Quantum Mechanics

Course Assessment:

- **Assignments:** 20%
- **Mid-term Exam:** 30%
- **Final Exam:** 50%

Reading Materials:

1. *Introduction to Quantum Mechanics* by David J. Griffiths
2. *Principles of Quantum Mechanics* by R. Shankar
3. *Quantum Mechanics: Concepts and Applications* by Nouredine Zettili
4. Additional Lecture Notes and Resources Provided by the Instructor

Course Prerequisites:

- Basic knowledge of classical mechanics and electromagnetism.
- Familiarity with differential equations and linear algebra.

Varsha

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8. **The energy levels of a particle in a one-dimensional infinite potential well are given by:**
   - A) En=n2ℏ2π22mL2E_n = \frac{n^2 \hbar^2 \pi^2}{2mL^2}En=2mL2n2ℏ2π2
   - B) En=nℏ2π22mL2E_n = \frac{n \hbar^2 \pi^2}{2mL^2}En=2mL2nℏ2π2
   - C) En=n2ℏ22mL2E_n = \frac{n^2 \hbar^2}{2mL^2}En=2mL2n2ℏ2
   - D) En=n2ℏ2L22mE_n = \frac{n^2 \hbar^2 L^2}{2m}En=2mn2ℏ2L2
9. **Which of the following is an eigenvalue of the energy operator (Hamiltonian)?**
   - A) Position
   - B) Kinetic energy
   - C) Probability density
   - D) Energy
10. **In the hydrogen atom, the quantum number that determines the size of the orbitals is:**
   - A) Principal quantum number (n)
   - B) Azimuthal quantum number (l)
   - C) Magnetic quantum number (m_l)
   - D) Spin quantum number (s)
11. **The concept of quantization of angular momentum is introduced by:**
   - A) Heisenberg
   - B) Schrödinger
   - C) Bohr
   - D) Pauli
12. **In the time-independent Schrödinger equation, the term that represents the total energy of the system is:**
   - A) Kinetic energy
   - B) Potential energy
   - C) Hamiltonian
   - D) Wave function
13. **For a particle in a one-dimensional potential well of length L, what is the ground state wavelength?**
   - A) λ=2L\lambda = 2Lλ=2L
   - B) λ=L\lambda = Lλ=L
   - C) λ=2Ln\lambda = \frac{2L}{n}λ=n2L
   - D) λ=L2\lambda = \frac{L}{2}λ=2L
14. **Which of the following is not a valid quantum number?**
   - A) Principal quantum number (n)
   - B) Orbital quantum number (l)
   - C) Magnetic quantum number (m_l)
   - D) Energy quantum number (E)
15. **The time-independent Schrödinger equation describes:**
   - A) The behavior of a quantum system as a function of time
   - B) The energy levels of stationary states
   - C) The wave function as a function of time
   - D) The interaction between particles

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16. **Which principle explains why electrons occupy different orbitals in an atom?**
- A) Aufbau principle
- B) Hund's rule
- C) Pauli exclusion principle
- D) Heisenberg uncertainty principle

17. **The quantum mechanical treatment of a harmonic oscillator introduces:**
- A) Constant energy levels
- B) Equidistant energy levels
- C) Random energy levels
- D) Variable energy levels

18. **The term 'tunneling' in quantum mechanics refers to:**
- A) The particle moving through a potential barrier
- B) The particle reflecting off a barrier
- C) The particle gaining energy from the barrier
- D) The particle being absorbed by the barrier

19. **The operator associated with the angular momentum in quantum mechanics is:**
- A) L^=−iℏddθ\hat{L} = -i \hbar \frac{d}{d\theta}L^=−iℏdθd
- B) L^=−iℏd2dθ2\hat{L} = -i \hbar \frac{d^2}{d\theta^2}L^=−iℏdθ2d2
- C) L^=−iℏddϕ\hat{L} = -i \hbar \frac{d}{d\phi}L^=−iℏdϕd
- D) L^=−iℏd2dϕ2\hat{L} = -i \hbar \frac{d^2}{d\phi^2}L^=−iℏdϕ2d2

20. **Which of the following represents a bound state in a quantum system?**
- A) Negative energy state
- B) Zero energy state
- C) Positive energy state
- D) Infinite energy state

21. **In quantum mechanics, the spin quantum number describes:**
- A) The orientation of the electron's orbital
- B) The energy level of the electron
- C) The intrinsic angular momentum of the electron
- D) The shape of the electron's orbital

22. **The de Broglie wavelength of a particle is inversely proportional to:**
- A) Its mass
- B) Its velocity
- C) Its energy
- D) Its momentum

23. **The energy of a photon is given by:**
- A) E=12mv2E = \frac{1}{2}mv^2E=21mv2
- B) E=ℏωE = \hbar \omegaE=ℏω
- C) E=mc2E = m c^2E=mc2
- D) E=p2/2mE = p^2 / 2mE=p2/2m

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24. **In the context of quantum mechanics, what does 'superposition' refer to?**
- A) A particle being in multiple states simultaneously
- B) A particle having a definite position
- C) A particle having a definite momentum
- D) A particle being at rest

25. **Which of the following equations is used to describe the time evolution of a quantum state?**
- A) Heisenberg's equation
- B) Schrödinger's equation
- C) Newton's equation
- D) Maxwell's equations

26. **The quantum number that describes the orientation of the orbital in space is:**
- A) Principal quantum number (n)
- B) Azimuthal quantum number (l)
- C) Magnetic quantum number (m_l)
- D) Spin quantum number (s)

27. **Which quantum mechanical principle is used to explain the discrete energy levels of electrons in an atom?**
- A) Heisenberg uncertainty principle
- B) Bohr's model of the atom
- C) Pauli exclusion principle
- D) Schrödinger equation

28. **The concept that a particle can be described as a wave is attributed to:**
- A) Heisenberg
- B) Schrödinger
- C) de Broglie
- D) Planck

29. **In quantum mechanics, what does the term 'quantum entanglement' refer to?**
- A) Particles being in the same place at the same time
- B) Particles being in a superposition of states
- C) Particles being instantaneously connected over any distance
- D) Particles having no interaction with each other

30. **Which of the following describes a system where the energy levels are quantized?**
- A) Free particle in infinite space
- B) Particle in a one-dimensional box
- C) Classical harmonic oscillator
- D) Moving car

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Answer Key

1. D) The principle of superposition
2. B) Heisenberg uncertainty principle
3. C) Potential energy term
4. B) The integral of the wave function squared over all space should be 1
5. A) p^=−iℏddx\hat{p} = -i \hbar \frac{d}{dx}p^=−iℏdxd
6. B) Azimuthal quantum number (l)
7. B) No two electrons in an atom can have the same set of quantum numbers
8. A) En=n2ℏ2π22mL2E_n = \frac{n^2 \hbar^2 \pi^2}{2mL^2}En=2mL2n2ℏ2π2
9. D) Energy
10. A) Principal quantum number (n)
11. C) Bohr
12. C) Hamiltonian
13. A) λ=2L\lambda = 2Lλ=2L
14. D) Energy quantum number (E)
15. B) The energy levels of stationary states
16. A) Aufbau principle
17. B) Equidistant energy levels
18. A) The particle moving through a potential barrier
19. A) L^=−iℏddθ\hat{L} = -i \hbar \frac{d}{d\theta}L^=−iℏdθd
20. A) Negative energy state
21. C) The intrinsic angular momentum of the electron
22. B) Its velocity
23. B) E=ℏωE = \hbar \omegaE=ℏω
24. A) A particle being in multiple states simultaneously
25. B) Schrödinger's equation
26. C) Magnetic quantum number (m_l)
27. B) Bohr's model of the atom
28. C) de Broglie
29. C) Particles being instantaneously connected over any distance
30. B) Particle in a one-dimensional box

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