Seat No. : _____

NF-129

November-2025

M.Sc., Sem.-III

PHY-501 : Physics
(Advanced Quantum Mechanics and Instrumentation)
(New)

Time : 2:30 Hours] **[Max. Marks : 70**

1. (A) Get scattering amplitude with Born approximation. **7**
1. (B) Find Born Approximation condition for getting scattering amplitude. **7**

OR

1. (A) Describe briefly Optical theorem. **7**
1. (B) Deliberate briefly scattering from a square well potential. **7**

2. (A) What are the Clebsh-Gordan co-efficients ? Explain their significance briefly. **7**
2. (B) Explain addition of angular momentum. **7**

OR

2. (A) Explain spin angular momentum. Show that $S_+\alpha = S\_\beta = 0$. **7**
2. (B) (a) Write the eigenvalue and eigenvector relations for the operators J^2 and J_z.
(b) Obtain the matrix representations of the operators J^2 and J_z. **7**

3. (A) Prove that Klein-Gordan (KG) equation is appropriate only for spin zero particle. State remark on the probability density explanation of this equation. **7**
3. (B) Describe properties of Dirac matrices and also prove that such matrices must be even dimensional. **7**

OR

3. (A) State the expression for energy of a charged particle obeying Klein-Gordon equation in a Coulomb potential. Explain the significance of the different terms. **7**
3. (B) Explain the Dirac equation for a relativistic electron placed in a central potential. Thus, deduce the total angular momentum and quantum numbers of electron. **7**

4. (A) What are the principles used for detection of temperature ? And explain in brief, "Resistance Thermometer" as a temperature detector. **7**

4. (B) Explain in detail, "Types of noises in electrical systems". **7**

OR

4. (A) Explain in brief, "Capacitive Transducer" with (i) change in overlapping area of plates and (ii) change in distance between two plates. **7**

4. (B) Explain in detail, "Signal conditioning and recovery". **7**

5. Answer in brief Any **Seven** questions from the following : **14**

(Each question is of **two** mark).

(i) What is the quantity called when the negative of the scattering amplitude in the zero-energy limit, obtained using the partial wave method, is taken ?

(ii) What is the scattering called in atomic and molecular physics when it occurs from several centers ?

(iii) Write the importance of the deviation function in 1st Born approximation,

(iv) How does the spin term modify the energy levels of a particle in a magnetic field ?

(v) Define a spherical tensor operator of rank k.

(vi) State the Wigner-Eckart theorem in one sentence,

(vii) What are negative energy states ? What is hole ?

(viii) Solve $\alpha_x\alpha_y + \alpha_y\alpha_x = 0$.

(ix) Compute $[L_x, [L_y, L_z]]$

(x) What is the characteristic of Thermistors ?

(xi) What is the importance of Noise Figure ?

(xii) How the phase difference detected between the reference signal voltage and the noise with time progress in lock-in-amplifier ?

Seat No. : _____

NF-129

November-2025

M.Sc., Sem.-III

PHY-501 : Physics

(Nuclear Physics-I, Advanced Quantum Mechanics-I and Instrumentation)

(Old)

Time : 2:30 Hours] **[Max. Marks : 70**

Instructions : 1. Attempts **all** questions.

2. Symbols and terminology have their usual meanings.

1. (A) Write names of basic nuclear properties and define magnetic moment and show that magnetic dipole moment of a nucleus in a definite parity is not equal to zero. **7**

1. (B) Discuss electric quadrupole moment using orthogonality state and show that electric quadrupole moment can have non-zero only when $I \geq 1$. **7**

OR

1. (A) Discuss effect of external magnetic field on a hyperfine structure. **7**

1. (B) What are molecular excitations ? Discuss the determination of nuclear angular momentum I from the band spectrum of diatomic molecules with identical nuclei. **7**

2. (A) Write brief description of deuteron and explain nuclear exchange forces. **7**

2. (B) Discuss in details on n-p scattering below 10MeV energy. **7**

OR

2. (A) Discuss p-p scattering at low energy, obtain the differential scattering cross-section σ_{sc}. **7**

2. (B) Write short note on Yukawa's meson theory of nuclear forces. **7**

3. (A) Using Green's function for an outgoing wave in scattering problem, calculate the amplitude in the first Born approximation. **7**

3. (B) Discuss Optical theorem and write its importance. **7**

OR

3. (A) Give the theory of Born approximation and discuss its validity for a low energy scattering process using Yukawa potential. **7**

3. (B) Estimate the scattering cross-section using Born approximation for a screened Coulomb potential. **7**

4. (A) Using necessary diagrams, explain :
(i) Optical transducers and (ii) Capacitive transducers **7**

4. (B) Explain ways to enhance the S/N. Mention advantages of signal filtering and shielding. **7**

OR

4. (A) Enlist desired characteristics of transducer. Explain LVDT and Thermocouple transducers. **7**

4. (B) Define S/N and show that for multistage cascade amplifier, efforts should be made to reduce the noise due to the first stage. **7**

5. Answer the following : **(any Seven)** **14**

1. A negative nuclear quadrupole moment indicates the nucleus is _____ and that of positive indicates is _____.
2. The ground state of deuteron is _____ and _____.
3. What do you mean by Bartlett Exchange Forces ?
4. If R is the radius of the nucleus having mass number A, then $R = R_0 A^{1/3}$, where $R_0 = 1.1 \times 10^{-15}$ m is the distance of closest approach to the nucleus & is known as _____.
5. In case of model for nucleus $Q_B = \frac{2}{5}[Z_e (a^2 - b^2)]$, _____ is the value of 'a' and 'b' for $Q_B > 0$.
6. The splitting caused by _____ and _____ of nucleus is known as Hyperfine structure.
7. Write the unit of differential cross-section.
8. Write importance of deviation function in first Born approximation.
9. State difference between Born and Eikonal approximation.
10. What do you mean by Lock in amplifier ?
11. Draw a schematic of Piezoelectric transducer.
12. Define sensitivity of a transducer.

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