Reg. No. ☐☐☐☐☐☐☐

St Aloysius College (Autonomous)
Mangaluru
Semester III – P.G. Examination – M.Sc. Physics
February - 2022
QUANTUM MECHANICS - II

Time: 3 hrs.

Max Marks: 70

PART - A
Answer all questions choosing ONE from each unit. (15x4=60)

UNIT- I

1. a) If X, Y and Z are linearly independent vectors, determine whether **(5)** X+Y, Y+Z and Z+X are linearly independent or not.

b) Discuss the meaning of completeness in a Hilbert space giving an **(5)** example.

c) Prove that the orthonormal kets $|k\rangle$ on an n-dimensional Hilbert space **(5)** satisfy the relation $\sum_{k=1}^{n}|k\rangle\langle k| = I$, the identity operator

OR

2. a) Prove that the eigen values of a Hermitian matrix are real and **(7)** eigenvectors belonging to different eigenvalues are orthogonal using Dirac's ket and Bra notation.

b) Using the generalized uncertainty principle and the properties of **(8)** position and momentum operators, show that $\Delta x\, \Delta p_x \geq \frac{\hbar}{2}$.

UNIT- II

3. a) Discuss the Schrodinger picture and obtain the equation of motion **(7)** satisfied by operator.

b) Solve the one-dimensional simple harmonic oscillator problem using **(8)** the operator method.

OR

4. a) Obtain the Clebsch-Gordon coefficient for the addition of angular **(10)** momentum for $j_1 = 1$ and $j_2 = \frac{1}{2}$.

b) Show that $a^+|n\rangle = \sqrt{n+1}|n+1\rangle$

(5)

UNIT- III

5. a) Discuss the time-independent perturbation theory for a non- **(10)** degenerate system and obtain expressions for correction to energy and wave function at first order perturbation.

b) Show that the correction to energy at first order perturbation to **(5)** energy of an oscillator due to an interaction $H' = bx^3$ is zero, (b here is a constant).

OR

6. a) Discuss time-dependent perturbation theory and hence derive the **(10)** Fermi Golden Rule.

b) Show that the expectation value of the Hamiltonian of a system is **(5)** never less than the ground state energy of the system.

UNIT- IV

7. a) Set up the Dirac equation for a free particle and show that the Dirac   **(8)**
        operators $\alpha_x, \alpha_y, \alpha_z$ and β are 4x4 traceless Hermitian matrices.

    b) Explain the concept of second quantization and write the basic steps   **(7)**
        in quantizing Schrodinger equation.

OR

8. a) Describe how the negative energy solutions correspond to the states   **(6)**
        of an anti-particle.

    b) Obtain the non-relativistic limit of the Dirac equation for an electron in   **(9)**
        an external magnetic field and hence arrive at the formula for the
        magnetic moment of the electron.

PART – B   **(5x2=10)**

Answer any TWO questions:

9. a) Evaluate the commentators $i) [J^2, J_+]; ii) [J_+, J_-]$

   b) Show that $\vec{s} \cdot \vec{s} = \frac{1}{4}$ and $\vec{s} \cdot \vec{s} = -\frac{3}{4}$ for triplet and singlet spin states of
       a two electron system.

   c) Explain WKB approximation.

   d) Show that $\vec{\sigma} \cdot \vec{p}$ commutes with the Dirac Hamiltonian.

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PH 572.3

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CONDENSED MATTER PHYSICS - II

Max Marks: 70

Time: 3 hrs.

PART - A

Answer all questions choosing ONE from each unit.   (15x4=60)

UNIT- I

1. a) What are ferroelectric materials? How are they classified? Explain.   **(7)**

   b) Discuss the Landau's theory of ferroelectric phase transitions.   **(8)**

OR

2. a) What are dislocations in crystal? Give their classifications and discuss their characteristics.   **(7)**

   b) Obtain an expression for the formation of Frenkel defect in crystal.   **(8)**

UNIT- II

3. a) Describe spinel and garnet structures.   **(7)**

   b) What are spin waves in ferromagnets? Derive dispersion relation for the same.   **(8)**

OR

4. a) Describe the indirect exchange interaction mechanism in anti-ferromagnetism.   **(6)**

   b) Discuss the molecular field theory of ferrimagnetism and obtain an expression for magnetic susceptibility above Curie temperature.   **(9)**

UNIT- III

5. a) Explain briefly the electron spin resonance. Describe the mechanisms of magnetic relaxation in paramagnetic materials.   **(7)**

   b) Explain the following: **(8)**
      (i) Influence of nuclear motion on NMR line width.
      (ii) Chemical shift with suitable example

OR

6. a) Explain FT-NMR spectroscopy.   **(7)**

   b) Write a note on (i) Quadrupole effect in NMR (II) Ferromagnetic resonance.   **(8)**

PH 572.3

UNIT- IV

7.a) Discuss in brief the various mechanisms of polarization possible in a dielectric medium. **(7)**

b) Obtain an expression for the local field in a dielectric medium possessing cubic symmetry. **(8)**

OR

8.a) Discuss the propagation of elastic waves for a solid possessing a cubic symmetry when the propagation occurs in [100] . **(7)**

b) What are elastic constants for cubic crystal and derive an expression for its stiffness constant? **(8)**

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PART – B

Answer any TWO of the following questions: **(2x5=10)**

9.a) State and explain Fick's laws of diffusion in solids.

b) Explain the crystalline anisotropy in ferromagnetic materials.

c) With a block diagram explain the working of NMR spectrometer.

d) Find the dielectric constant of Rochelle salt at 50^0C, given Curie constant =3100, Curie temperature = 121K.

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RELATIVITY & COSMOLOGY

Time: 3 hrs.   Max Marks: 70

PART - A

Answer all questions choosing ONE from each unit. (15x4=60)

UNIT- I

1. a) How is Newtonian mechanics altered in special relativity? Why? **(4)**

   b) Discuss length contraction and time dilation. Why can't they be observed in day-to-day affairs of the world? **(7)**

   c) Arrive at the relativistic energy-momentum relation. What happens to massless particles? **(7)**

OR

2. a) What is parallel transport? Discuss its necessity and the role of affine connections. **(6)**

   b) What is wrong with Galilean velocity addition formula? By deriving the corresponding relativistic relation, show how the problem is rectified. **(6)**

   c) What are geodesics? For a freely-moving particle in space time, arrive at the equation of motion. Is this a geodesic path? **(6)**

UNIT- II

3. a) Mention the shortcomings of Newtonian gravity theory. **(4)**

   b) Discuss the principle of general covariance and its consequences. **(6)**

   c) What experimental validations for general Relativity exist? Discuss. **(8)**

OR

4. a) Using heuristic arguments arrive at Einstein's field equations. Comment on the nature of these equations **(10)**

   b) Discuss in detail the Pound-Rebka experiment and its consequences. **(8)**

UNIT- III

5. a) Explain in detail the observations of Penzias and Wilson. What are the implications? **(9)**

   b) What is the Big Bang Theory? What experimental proofs support this theory? **(9)**

OR

6.a) What is Olber's paradox?   (6)

b) Explain Cosmic inflation and how it affected the evolution of the   (6)
Universe.

c) What alternate models for origin of Universe exist?   (6)

PART – B   (4x4=16)

Answer any <u>FOUR</u> questions:

7.a) Mention the postulates of relativity. Differentiate between inertial
and non-inertial reference frames.

b) Arrive at the Ricci tensor from the curvature tensor. Mention its
properties.

c) Write a note on mass-energy equivalence and its implications.

d) Briefly discuss the concept of gravitational lensing.

e) Write a note on non-trival singularities in Schwarzschild solution.

f) What is Hubble's law? What are its consequences?

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