PH 571.3 Reg. No. : | | | | | | |

St Aloysius College (Autonomous)
Mangaluru
Semester III– P.G. Examination – M.Sc. Physics
JANUARY-2021
QUANTUM MECHANICS II

Time: 3 Hours **Max. Marks: 70**

PART - A

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

UNIT - I

1.a) State and prove Schwartz inequality. **(8)**

b) Check whether the following net of vectors are linearly independent or not. $\vec{A} = (1,2,3), \vec{B} = (2,3,1), \vec{C} = (3,1,2)$ **(4)**

c) Using Dirac ket & bra notation, show that the product of the Hermitian operators is Hermitian, if and only if they commute. **(3)**

OR

2.a) Using Dirac ket & bra notation, show that the eigen values of the Hermitian operators are real and eigen vectors corresponding to distinct eigen values are orthogonal. **(6)**

b) Obtain the matrix representation of the linear operator. **(6)**

c) Given $|\Psi> = \begin{bmatrix} -1+i \\ 3 \\ 2+3i \end{bmatrix}, <\emptyset| = (6, -i, 5)$, find

i) $|\Psi><\emptyset|$ ii) $<\emptyset|\Psi>$ **(3)**

UNIT - II

3.a) Obtain the equation of motion in Schrodinger formulation. **(6)**

b) Given $\hat{H} = \frac{\hat{p}_x^2}{2m} + \frac{1}{2}k\hat{x}^2$, evaluate the commutator in Heisenberg formulation i) $[\hat{x}, \hat{H}]$ ii) $\hat{p}_x, \hat{H}$ **(4)**

c) Show that $\hat{J}_{\pm}|j,m> = \sqrt{(j \mp m)(j \pm m + 1)}\hbar\,|j,m \pm 1>$ **(5)**

OR

4.a) Discuss the addition of two angular momenta and obtain the relation between the eigen functions in the coupled and uncoupled representation and hence explain Clebsch-Gordon coefficients. **(8)**

b) Show that $\hat{a}|n> = \sqrt{n}\,|n-1>$ **(4)**

c) Evaluate the following commutators.

i)$[\hat{J}_+, \hat{J}_-]$ ii) $[\hat{J}^2, \hat{J}_2]$ **(3)**

UNIT - III

5.a) Derive the condition under which the WKB approximation can be used. **(7)**

b) Deduce the expressions for the first order perturbation corrections when the energy levels of the unperturbed state are non-degenerate. **(8)**

Contd...2

OR

6.a) Write down the Hamiltonian for the hydrogen molecule, using the variational method, obtain the equilibrium distance between the two nuclei and the binding energy of the molecule. (7)

b) Discuss the time-dependent perturbation theory and hence deduce Fermi's Golden rule for the transition probability per unit time. (8)

UNIT - IV

7.a) State the assumptions involved in deriving the Dirac equation and hence derive the Dirac equation for the moving spin $^1/_2$ particle. (8)

b) Starting from the Klein-Gordon equation, obtain the equation of the continuity. (7)

OR

8.a) Show that the probability density in positive definite for a Dirac particle. (8)

b) Derive the Euler-Lagrangian equation for the Classical field. (7)

PART – B

Answer any <u>TWO</u> questions **(5x2=10)**

9.a) If $\vec{x},\vec{y}\,\&\,\vec{z}$ are linearly independent vectors determine whether $\vec{x}+\vec{y}$, $\vec{y}+\vec{z}$, & $\vec{z}+\vec{x}$ are linearly independent or not.

b) For bosons evaluate the following commutators
i) $[\hat{a}_k,\hat{N}_k]$ ii) $[\hat{a}_k^+,\hat{N}_k]$
Where $N_k=\hat{a}_k^+\hat{a}_k$ in the number operator.

c) Prove that the parity of the spherical harmonics, $Y_{lm}(\theta,\varphi)$ is $(-1)^l$.

d) Show that there is no Zeeman effect for the ground state of the hydrogen atom.

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Semester III– P.G. Examination – M.Sc. Physics
JANUARY-2021
CONDENSED MATTER PHYSICS II

Time: 3 Hours **Max. Marks: 70**

PART - A

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

UNIT - I

1.a) Explain the mechanism of ionic conductivity in pure alkali halide crystals. **(10)**

b) Discuss the mode of decay mechanism for thermoluminescence. **(5)**

OR

2.a) Give an account of different types of dislocations in crystals and their characteristics. Write a note on Berger's vector. **(8)**

b) Explain the Landou theory of phase transition. **(7)**

UNIT – II

3.a) Discuss the Brillouin theory of paramagnetism. **(8)**

b) Derive Bloch $T^{3}/2$ law in ferromagnetism. **(7)**

OR

4.a) Describe the molecular field theory of ferromagnetism. **(10)**

b) Explain Spinel structure in Ferrimagnets. **(5)**

UNIT - III

5.a) Illustrate the phenomenon of nuclear magnetic resonance using classical equation of motion of nuclear dipoles. **(8)**

b) Obtain an expression for the rate of energy absorption in ESR. **(7)**

OR

6.a) Explain briefly (i) Magnetic resonance imaging.
(ii) Ferromagnetic resonance. **(8)**

b) Explain the influence of nuclear motion on NMR Spectra. **(7)**

UNIT – IV

7.a) Derive an expression for the local electric field acting on an atom. Explain the terms depolarization field and Lorentz field. **(8)**

b) Define complex dielectric constant. Show that energy loss in a dielectric is proportional to loss angle. **(7)**

OR

8.a) Discuss the optical modes in the ionic crystal. **(8)**

b) Obtain an expression for dielectric constant as a function of frequency when an insulator is exposed to high frequency electric fields. **(7)**

PART – B

Answer any <u>TWO</u> questions. **(5x2=10)**

9.a) The energy required to create Schottky vacancy in a material is 2 eV. Find the concentration of the vacancies at 300 K.

b) Explain Spin waves and magnons.

c) Write a note on relaxation mechanism.

d) Explain polarization and polarizability.

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PS 573.3 Reg. No.

St Aloysius College (Autonomous)

Mangaluru

Semester III – P.G. Examination – M.Sc. Physics

JANUARY-2021

RELATIVITY AND COSMOLOGY

Time: 3 hrs. **Max Marks: 70**

PART - A

Answer all questions choosing ONE from each unit. **(18x3=54)**

UNIT- I

1. a) Using the postulates of relativity, arrive at the Lorentz transformations. Show that for v<<c, they reduce to the Galilean transformations. **(8)**

b) Define the curvature tensor and mention its properties using it, arrive at the Ricci tensor. **(6)**

c) Write down the Christoffel symbols and mention their properties. **(4)**

OR

2. a) What is length contraction? Show that this is a consequence of the postulates of relativity. **(7)**

b) Write down the relativistic force law. Work-out its time-like component and interpret the expression. **(7)**

c) Given a rank-'1' contravariant tensor, show that taking straight forward derivative is erroneous. Explain the reasons. **(4)**

UNIT- II

3. a) Using heuristic principles, arrive at Einstein's field equations. **(10)**

b) Discuss the bending of light's path from a gravitational source as a consequence of general relatibity. **(8)**

OR

4. a) What are the steps involved in arriving at Schwarzschild's solution of field equations? Hence, show that this predicts black-hole solutions. **(10)**

b) Outline the Rebka-Pound experiment and discuss how it validates the predictions of general relativity. **(8)**

UNIT- III

5.a) Discuss the implications of the Big-bang theory. Mention experimental evidences to this theory. **(10)**

b) What is Olbers' paradox? **(8)**

OR

6.a) Briefly discuss the Universe and the conditions during the Planck time and how it evolved as per current understanding. **(9)**

b) What are the alternate theories apart from Big-bang theory for the origin and fate of the universe? **(9)**

Contd...2

PART – B

(4x4=16)

Answer any FOUR questions:

7.a) What is time-dilation? Suggest how it can be tested experimentally.

b) Discuss the geometry of space-time in a Minkowski metric.

c) What are raising and lowering of indices? Give examples.

d) What is so "special" about special relativity? How is it different from "general" relativity?

e) Discuss the principle of equivalence in general relativity.

f) What is gravitational red shift? Explain.

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