RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College under University of Calcutta)

(20)

THIRD YEAR

B.A./B.SC. FIFTH SEMESTER (July – December), 2012

Mid-Semester Examination, September 2012

Date : 10/09/2012

Time : 2 pm – 4 pm

PHYSICS (Honours)

Paper : V

Full Marks : 50

Use two Answer Scripts. One for each section.

Scetion - I

Answer five questions taking at least two from Gr-A and Gr-B

Group - A

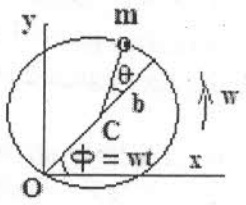
1. Lagrange's equation of motion can be expressed in two equivalent ways

a) $\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_a}\right) - \frac{\partial T}{\partial q_a} = Q_a$ b) $\frac{\partial \dot{T}}{\partial \dot{q}_a} - 2\frac{\partial T}{\partial q_a} = Q_a$

Verify that a) and b) give the same equation of motion for the Kepler problem in a force field, $\vec{F} = -\frac{k}{r^2}\hat{r}$, k is a constant. 5

2. Show that if the Lagrangian does not depend explicitly on time, then the quantity $E = \Sigma\, \dot{q}_a \frac{\partial L}{\partial \dot{q}} - L$ is a constant of motion. Hence show that E = T+V, when the kinetic energy T is a homogeneous quadratic function of the generalized velocities, and the potential energy V is velocity independent. 5

3. A bead of mass m slides freely on a friction less circular wire of radius b, that rotates in a horizontal (x-y) plane about a point O on the wire with constant angular velocity ω. Given the geometry of the figure below, obtain Lagrange's equation of motion. Show that the bead oscillates as a pendulum of length $l = \frac{g}{\omega^2}$. 5



4. Show that if $L(q, \dot{q}, t)$ is the Lagrangian of a holonomic dynamical system, then $L' = L + \frac{d}{dt} f(q, t)$, is also an equivalent Lagrangian of the system. 5

5. The Lagrangian of a system is given by $L(\vec{r}, \vec{v}) = r^2 + \vec{r} \cdot \vec{v} + v^2$, $(\vec{v} = \frac{d}{dt}\vec{r})$

i) Is the system translationally invariant ?

ii) Is the system rotationally invariant ? 5

Group - B

6. Starting from the Lorentz Transformation, show that a rod of rest length L is measured to have a length $L\sqrt{1 - \frac{v^2}{c^2}}$ when moving along its length with a uniform velocity v. 5

7. Pions have a half life of $1.77 \times 10^{-8} s$. They are produced from an accelerator at a velocity of 0.99c. What is the distance from their production point within which half of these particles are likely to decay ? [Take $c = 3 \times 10^8$ m/s]. 5

8. An inertial observer sees a second observer is moving with a uniform velocity v. The second observer sees an object to be moving with a uniform velocity u with respect to it in a direction

opposite to the direction in which the first observer appears to be moving w. ·.t it. Fi ɔd the velocity of the object as seen by the first observer. 5

Section - II

Answer any five questions

9. Find the de Broglie wave lengths of an electron with kinetic energy i) 1 Kev, ii) 1 Mev. 5

10. Obtain an expression for the energy of the recoil electron in Compton scattering in terms of the scattering angle. 5

11. Verify if the given operators are Hermitian : i) $\frac{\partial}{\partial x}$. ii) $\frac{\partial^2}{\partial x^2}$ 5

12. Write down the time dependent Schrodinger equation and obtain the equation of continuity. What is its physical significance ? 5

13. Write down the fundamental postulates of quantum mechanics. 5

14. What is Larmor precession? Hence explain the idea of space quantization. 2+3

15. a) Derive an expression for Lande' g - factor for one electron atom. 2
b) The Na -atom has ground state configuration ($1s^2\ 2s^2\ 2p^6\ 3s^1$). Find the spectroscopic notation of ground and first excited states. Hence explain the origin of D_1 and D_2 lines. 3

16. A two level laser system has $E_1 = -13.6eV$, $\Delta E_1 = 8.28 \times 10^{-7} eV$ and $E_2 = -3.4eV$, $\Delta E_2 = 2.07 \times 10^{-7} eV$. Assuming the emission to have only the natural broadening, calculate the spontaneous life time and spectral width of $E_2 \rightarrow E_1$ transition. 5