M.Sc. 2nd Semester Examination 2012

PHYSICS

PAPER – PHS-202

Full Marks : 40

Time : 2 hours

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

GROUP – A

[*Marks* : 20]

1. Answer any *two* of the following : 2 × 2

(*a*) Consider any arbitrary function F of co-ordinates (q_k) and canonical momenta (p_k) and time (t). Show that

$$\frac{dF}{dt} = \frac{\partial F}{\partial t} + [F, H]$$

where $[F, H]$ is the poisson bracket of F and H.

(*b*) A particle of mass m moves in a force field whose potential in spherical co-ordinates is

$$V = -\frac{K\cos\theta}{r^2}.$$

Find the Hamilton-Jacobi equation describing its motion.

(*c*) What kind of transformation is generated by the function $F = -\Sigma Qipi$?

2. Answer any *two* of the following : 3 × 2

(*a*) Show that the total angular momentum of a system of particles about a points is the sum of the angular momentum of the system about the centre of mass and angular momentum about the reference point of the system mass concentrated at the centre of mass.

(*b*) Derive Hamilton's principle from Newton's equation.

(*c*) Find the Lagrange's equation of motion for an electrical circuit comprising an inductance 'L' and capacitance 'C' in series. The capacitor is charged to 'q' coloumbs and the current flowing in the circuit is 'i' ampere *s*.

3. Answer any *one* of the following : 10 × 1

(*a*) The force on a particle of mass m and charge e, moving with a velocity $\vec{v}$ in an electric field $\vec{E}$ and magnetic field $\vec{B}$, is given by

$$\vec{F} = e\,(\vec{E} + \vec{v} \times \vec{B}),$$

If the field are expressed by the relation

$$\vec{E} = -\nabla\phi - \frac{\partial \vec{A}}{\partial t} \;;\; \vec{B} = \nabla \times \vec{A}$$

ϕ and A being the scalar and vector potential respectively, prove that the Lagrangian for the charged particle is

$$L = \frac{1}{2}\, m\, v^2 + e\,(\vec{A} \cdot \vec{v}) - e\phi$$

and hence derive the Hamiltonian for that. Whenever the Lagrangian for a system does not contain a co-ordinate explicitly, then choose the correct statement/statements.

(*i*) q_k is cyclic co-ordinate

(*ii*) p_k is cyclic co-ordinate

(*iii*) p_k is constant of motion

(*iv*) q_k is always zero.

The Lagrangian of a particle moving in a plane under the influence of a central potential is given by

$$L = \frac{1}{2} m (\dot{r}^2 + r^2 \dot{\theta}^2) - V(r)$$

Find the generalized momenta corresponding to r and θ. 5 + 3 + 1 +

(*b*) What is the physical significance of Hamilton's principle function ? Derive the Fermat's principle in geometrical optics from the Hamilton's principle of least action. Consider a two pendulum system which consists of two identical pendulums of length l and bobs of mass m each and the bobs are connected by a mass-less spring of spring constant K. The system can move in a vertical plane only . Set up the Lagrangian of the system. Write down Lagrange equation of motions. 2 + 4 +

GROUP – B

[*Marks* : 20]

Answer **Q.No.1 & 2** and any **one** from the rest

1. Attempt any *two* bits : 2 ×

(*a*) Apply periodic boundary condition to find the Fermi energy of 2D-Fermi gas in metal.

(*b*) An electron is confined in an one dimensional well of width 0·3nm. Find the spectral frequency resulting from transition from the first excited state to the ground state.

(*c*) Derive electrical neutrality condition when a semiconductor is doped with donor impurity.

2. Answer any *two* bits : 3×2

(*a*) Density of Al is $2{\cdot}7 \times 10^3$ kg/m^3 and its atomic weight is 27. Calculate the Fermi-Temperature of Al

(*b*) Find the ionization energy of the donor impurity atom in Germanium. $m_e^* = 0{\cdot}1\text{m}$ for Ge and dielectric constant = 15·8 for Ge.

(*c*) What is meant by Reduced zone scheme? What is –ve effective mass.

3. (*a*) Clearly explain what is the physical origin of energy gap and hence show that the energy gap depends on the magnitude of periodic potential. 7

(*b*) Prove that the effective mass can be expressed as,

$$m^* = \frac{\hbar^2}{d^2E/dk^2}.$$ 3

4. Find the density of states in the conduction bond of a semiconductor. Hence find the density of electrons in the conduction bond for a nondegenerate semiconductor. What is meant by low of mass action ?

3 + 5 +
