2017

M.Sc. Part–I Examination

PHYSICS

PAPER—I

Full Marks : 75

Time : 3 Hours

The figures in the margin indicate full marks.

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

Illustrate the answers wherever necessary.

Use separate Answerscripts for Gr. A & Gr. B.

Group—A

[*Marks : 30*]

1. Answer any *four* of the following : 4×2

(a) Prove that if there exist a generating function G, such that $\frac{\partial G}{\partial t} = L - \bar{L}$, where $L, \bar{L}$, being the Lagrangian in the old set of coordinate and new set of coordinate respectively, then the transformation is Cannonical.

(b) The Lagrangian of an harmonic oscillator is given by

$$L(q,\dot{q}) = \frac{1}{2}\dot{q}^2 - \frac{1}{2}\omega^2 q^2 - \alpha q^3 + \beta q \dot{q}^2$$

Where, α, β and ω are constants. Obtain the corresponding Hamiltonian.

(c) In Rutherford's α-particle scattering experiment, 10^5 α-particles are at an angle 2°, calculate the number of a-particles scattered at an angle of 10°.

(d) An electrical circuit contains a capacitor of capacity C and an inductor of inductance L in series. Find the Lagrange's equation of motion when current flowing through the circuit is I.

(e) Obtain the relation between Hamilton's principal function and Hamilton's characteristic function.

(f) The mutual potential energy ϕ of a two particles system is given as $\phi = \frac{a}{r^2} - \frac{b}{r}$, where r represent separation between two particles and a, b are two

negative constants. Prove that no stable equilibrium is possible in this case.

(g) State principle of Least action. Prove that this principle may be written in the form $\Delta \int_{t_1}^{t_2} T dt = 0$ for a conservative system where T represent kinetic energy of the system.

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

(a) Tow masses m_1 and m_2 are connected by a weightless spring of spring constant k and placed on a frictionless horizontal plane. The natural length is equal to the separation of the masses when both are stationary.

Show that the masses can oscillate with frequency

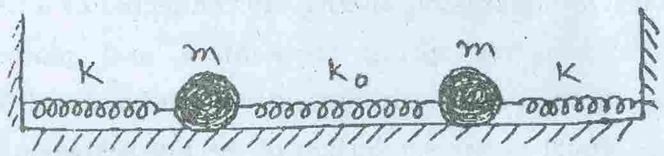
$\frac{1}{2\pi}\sqrt{K/\mu}$, where μ is the reduced mass.

(b) Using variational principle, prove that the shortest distance between any two points in a plane is an straight line.

(c) What do you mean by Euler's angles ? Explain terms spin angular velocity, precessional and nutational velocity in this regard.

3. Answer any *two* of the following : 2×8

(a) Two masses (each of mass m) are connected by massless spring of spring constant k and the system can freely slide on a smooth horizontal surface, as shown in figure below :



The ends of the spring are fixed on vertical wall.

Determine

(i) Lagrangian of the system

(ii) normal frequencies of the system.

Also clearly explain symmetric and antisymmetric mode of the system.

Prove that the ratio of two normal frequencies are independent of mass and spring constant.

2+3+2+1

4. (a) A particle moves in the x-y plane under the influence of a central force depending only on its distance from the origin. Then

(i) set up the Hamillonian for the system

(ii) Write Hamiltonian equations of motion.

(iii) Show that angular momentum is conserved in this case.

(b) Obtain the equation of motion of a particle of mass m down a frictionless inclined plane of angle θ by using Lagrange's equation. (2+3+1)+2

5. (a) State and prove Hamilton-Jacobi equation for Hamilton's principal function

(b) Explain now it can be used to solve Kepler's problem for a particle in an inverse square central force field.

3+5

Group—B

[*Marks : 45*]

Answer *Q. No. 1* and any *three* from the rest.

1. Answer any *three* from the following : 3×3

   (a) Aluminium has an fcc structure. Its density is $2.7 \times 10^3 \text{ kg/m}^3$. Calculate the unit cell dimension and atomic diameter.

   (b) Prove that five fold rotational symmetry is not possible in a Bravis lattice.

   (c) What is meant by glide ? Describe different glides which exist in a solid.

   (d) Find the Brillown zone of fcc lattice.

   (e) Find an expression of Hall coefficient in a metal.

   (f) Prove that effective number of free electrons in a solid is maximum when the band is half filled.

   (g) Clearly distinguish type 1 and type-II superconductor.

2. (a) Device Laue equation considering the scattering of X-ray from a crystal.

   (b) Find the structure factor of a BCC crystal and indicate the condition of systematic absence.

   9+3

3. (a) Derive the dispersion relation for a linear monatomic chain in one dimension.

   (b) Find the density of states for a linear chain of vibrating atoms. What in Van Hove singularity ?

   6+5+1

4. (a) Prove that Fermi energy in a metal decreases with increase of temperature.

   (b) Evaluate the temperature at which there is 1% probability that a state with an energy 0.5 eV above the Fermi energy will be occupied by an electron.

   9+3

5. (a) What is the physical origin of energy gap in a solid?

   (b) Show that number of wave functions in an energy band is equal to the number of unit cells in the direct lattice.

   (c) The E-k relation in a particular semiconductor is given by $E = Ak^2 + Bk^3$, where A and B an positive constants. Find the wavelength for which the electron group velocity is zero. 6+3+3

6. (a) Discuss orientational polarizability and obtain an expression of Lorentz-Debye equation.

(b) Clearly distinguish type 1 and type II superconductor.

(c) What is Hund's Rule? 7+3+2

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