5 SEM TDC DSE PHY (CBCS) 1 (H)

2024

(November)

PHYSICS

(Discipline Specific Elective)

(For Honours)

Paper : DSE–1

(Classical Dynamics)

Full Marks : 80

Pass Marks : 32

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer : 1×8=8

(a) Classical mechanics describes the motion of

(i) microscopic object

(ii) macroscopic object

(iii) Both *(i)* and *(ii)*

(iv) None of the above

(b) The conditions which restrict the motion of the system are called

(i) constraints

(ii) degrees of freedom

(iii) generalized coordinates

(iv) None of the above

(c) In Lagrange's equations, virtual displacement does not involve

(i) space

(ii) time

(iii) number of particles

(iv) None of the above

(d) The space containing generalized coordinate is called

(i) generalized space

(ii) configuration space

(iii) Euclidean space

(iv) None of the above

(e) For a mass-less particle, energy-momentum relation is given by

(i) $E = pc$

(ii) $E = p^2c^2$

(iii) $E = \frac{p}{c}$

(iv) $E = \frac{p}{c} + 1$

(f) An invariant interval (I) will be time-like for

(i) $I > 0$

(ii) $I < 0$

(iii) $I = 0$

(iv) $I = \infty$

(g) The time component of momentum 4-vector (p°) is given by

(i) $p^\circ = \gamma m_0 c$

(ii) $p^\circ = m_0 c$

(iii) $p^\circ = \frac{m_0 c}{\gamma}$

(iv) $p^\circ = \frac{m_0}{c}$

(h) In the case of streamline flow, the loss of energy is

(i) minimum

(ii) maximum

(iii) zero

(iv) None of the above

2. *(a)* Explain the motion of a charged particle in a uniform and constant magnetic field. 4

(b) Define generalized coordinates and obtain the expression for generalized force. 1+2=3

Or

Find the Lagrange's equations of motion for an electrical circuit comprising an inductance L, capacitance C. The condenser is charged to q coulombs and the current flowing in the circuit i amperes. 3

(c) Find the equation of motion of one-dimensional harmonic oscillator using Hamilton's principle. 3

3. *(a)* Derive Hamilton's canonical equations of motion in generalized coordinates. 4

Or

A bead slides without friction on a wire, which is rotating with angular velocity, ω in the force free space. Deduce the corresponding Lagrange's equations of motion.

(b) Show that if a given co-ordinate is cyclic in Lagrangian, it will be cyclic in Hamiltonian. 2

(c) Explain, why Hamiltonian approach is superior than Lagrangian approach. 2

(d) Discuss the motion of a particle in a central field of force using concept of Hamiltonian. 5

Or

A particle of mass M moves on a plane in the field of force given by

$$F = -\hat{r}\, Kr\cos\theta$$

where K is constant and $\hat{r}$ is the radial unit vector.

(i) Will the angular momentum of the particle about the origin be conserved? Justify your statement.

(ii) Use Lagrange's equations to find the differential equation of the orbit of the particle. 2+3=5

4. *(a)* Using potential energy curve, explain the concept of stable and unstable equilibrium. 3

(b) What are normal coordinates? Discuss the normal frequencies of a vibrating string fixed at both ends. 2+4=6

Or

Two masses m_1 and m_2 resting on a smooth surface are joined together by a spring of negligible mass and spring constant, K. Length of spring at rest is l_0. Assuming that the motion remains one-dimensional, find the normal frequency and normal coordinates of vibration. 6

5. *(a)* Write the Lorentz coordinate transformation equations. 2

(b) Write short notes on any *two* of the following : 3×2=6

(i) Invariant interval

(ii) Four (4)-velocity

(iii) Space-time diagrams

Or

Consider two twins *A* and *B* of age 20 years. Twin *B* takes a round trip space voyage to a star at velocity $v = 0{\cdot}99\,c$. According to those of us on earth, the star is 40 light years away. What will be the ages of *A* and *B* when *B* finishes his trip? 6

(c) If two events are simultaneous but separated in space in frame *S*, will they be simultaneous in any other frame *S'*? Explain. 3

(d) Write the mathematical expressions for relativistic mass and relativistic momentum. 1+1=2

6. *(a)* Derive the mathematical expression of four acceleration. 4

(b) Explain the concept of four energy-momentum relation. 4

Or

A proton is moving with velocity $0{\cdot}999\,c$ relative to the laboratory. Calculate the

energy and the momentum as observed in a frame travelling in the same direction with velocity $0{\cdot}99\,c$ with respect to the laboratory. 4

(c) What is Minkowski diagram? Draw and explain world line in the context of a line cone. 2+3=5

7. Derive the expression for relativistic observed frequency of light in terms of 4-vector. 5

Or

The spectral line of $\lambda = 5000$ AU in the light coming from a distant star is observed at 5200 AU. Find the recessional velocity of the star. What is the distance of the galaxy? 4+1=5

8. *(a)* What do you understand by 'pressure at a point in a liquid'? Define thrust. Why is the thrust always perpendicular to the surface in contact with it? 1+1+1=3

(b) Distinguish between streamline and turbulent motion of a liquid. 2

(c) Three capillaries of same length, but internal radii r, $2r$ and $3r$ are connected in series and liquid flows through them under streamline conditions. If the pressure across the whole system is 77 cm of water, calculate the pressure across the first capillary. 4

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