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

2022

(Nov/Dec)

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) An alpha particle with mass m, charge $2e$ enters into a magnetic field B with velocity v perpendicular to the direction of the magnetic field. The radius of the curved path is

(i) $\frac{mv}{eB}$ (ii) $\frac{mv}{2eB}$

(iii) $\frac{2mv}{eB}$ (iv) $\frac{mv}{4eB}$

(b) In Lagrange's equation, if there are N numbers of particles and so the generalized coordinates are

(i) $n = N - K$

(ii) $n = 3N - K$

(iii) $n = 3N$

(iv) $n = 3n - K$

(c) Hamilton proved that the actual path followed by the physical system between the two states in the given time is the one for which this integral is

(i) maximized

(ii) negative

(iii) minimized

(iv) undefined

(d) For small amplitude oscillation potential energy curve with respect to distance travelled from equilibrium position is

(i) parabolic

(ii) hyperbolic

(iii) elliptical

(iv) circular

(e) The time dilation factor of a muon travelling with a velocity of 80% that of velocity of light is

(i) 0·60

(ii) 1·66

(iii) 0·20

(iv) 5·0

(f) The relativistic formula for kinetic energy is

(i) $T = (m - m_0)c^2$

(ii) $T = mc^2$

(iii) $T = \frac{1}{2}mc^2$

(iv) $T = m_0c^2$

(g) If an object approaches the speed of light, then its mass

(i) becomes zero

(ii) becomes double

(iii) remains same

(iv) becomes infinite

(h) Which of the following is the basic principle of fluid mechanics?

(i) Momentum principle

(ii) Energy equation

(iii) Continuity equation

(iv) All of the above

2. *(a)* Show that the radius of curvature of a charged particle moving at right angles to a magnetic field is proportional to its momentum. 2

Or

Find the gyro-radius and cyclotron frequency of *(i)* a proton and *(ii)* an electron travelling with velocity 10 cms^{-1} in a field of 10000 gauss.

(b) Define generalized coordinates and state the expressions for *(i)* generalized velocity and *(ii)* generalized force. 1+1+1=3

(c) Find the Lagrange's equations of motion for an electrical circuit comprising an inductance L and capacitance C. The condenser is charged to q coulomb and the current flowing in the circuit is I ampere. 3

3. *(a)* Establish the equation of motion of one-dimensional harmonic oscillator using Hamilton's principle. 4

(b) A mass m is at one end of a spring of natural length l and spring constant K. Find Lagrangian of the system and apply Lagrange's equation of motion. (The mass moves up and down in the vertical direction.) 4

Or

Find the expression for Hamiltonian of a particle moving under a central force field and also write Hamilton's equation of motion for this particle.

(c) Derive Hamilton's canonical equations of motion in generalized coordinates and explain the significance of Hamiltonian. 3+2=5

Or

Discuss the situations under which the energy of a system of interest is conserved and show that energy is essentially the generalized momentum conjugate to time. 5

4. *(a)* What do you understand by stable and unstable equilibria? 3

(b) A solid homogeneous cylinder of radius r rolls without slipping on the inside of stationary large cylinder of radius R.

(i) Find the equation of motion.

(ii) What is the period of small oscillations about the stable equilibrium position? 3+3=6

Or

What are normal coordinates? Discuss the normal frequencies of a vibrating string fixed at both ends, treating it as the limiting case of a system of coupled particles. 6

5. *(a)* Show how Lorentz transformation equations are superior to Galilean transformations. 2

(b) With the help of Lorentz transformation, deduce an expression for the apparent time interval measured in a frame of reference that has a velocity v relative to the watch used for measurement of time. 3

Or

A meson has a speed $0{\cdot}8c$ relative to the ground. Find how far the meson relative to the ground, if its speed remains constant and the time of its flight, relative to the system, in which it is at rest, is 2×10^{-8} sec.

(c) Obtain Einstein's formula for addition of velocities. 3

(d) How does mass change with velocity? Show that c is the ultimate speed of the particles. 2+1=3

(Continued)

6. *(a)* Derive an expression for the kinetic energy of a relativistic particle. Hence deduce the Einstein's mass-energy relation. 3+1=4

(b) Deduce the expressions for 4-velocity and 4-acceleration. 2+2=4

(c) A rocket ship is 100 m long on the ground. When it is in flight, its length is 99 m to an observer on the ground. What is its speed? 4

Or

The total energy of a particle is exactly twice its rest energy. Calculate its speed.

7. *(a)* Obtain an expression for the velocity of a particle in terms of relativistic momentum and energy. 5

(b) Assuming the law of conservation of momentum to be correct in every inertial frame, show that by the use of transformation of energy and momentum, the relativistic energy is conserved in a two-particle system. 5

Or

A spectral line of wavelength 4×10^{-7} m in the spectrum of light from a star is

(Turn Over)

found to be displaced from its normal position towards the red end of the spectrum by an amount equivalent to 10^{-10} m. What velocity of the star would account for this?

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

(b) Define coefficient of viscosity. Establish Poiseuille's equation. What are the limitations of the equation? 3

Or

A vessel of cross-section 20 sq. cm has a horizontal capillary tube of length 10 cm and internal radius 0·5 mm at its bottom. It is initially filled with water to a height of 20 cm above the capillary tube. Find the time taken by the vessel to empty one-half of its contents, given that viscosity of water is 0·01 poise.

(c) Derive Navier-Stokes equation. What is the incompressibility condition in Navier-Stokes equation? 3+1=4

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