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

2021

(Held in January/February, 2022)

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 : 1×5=5

(a) A particle of mass m moves along a straight line and attached towards a point on this line with a force proportional to the distance x from the point. The Lagrangian of the system is

(i) $\frac{1}{2}mv^2 + \frac{1}{2}kx^2$ *(ii)* $\frac{1}{2}mv^2 - \frac{1}{2}kx^2$

(iii) $mv^2 + \frac{1}{2}kx^2$ *(iv)* $\frac{1}{2}mv^2 - kx$

(b) The rest mass of an electron is m_0. What will be its mass when it moves with velocity 0·6c?

(i) m_0 *(ii)* $\frac{5}{4}m_0$

(iii) $\frac{4}{5}m_0$ *(iv)* $2m_0$

(c) A body with a charge q starts from rest and acquire a velocity 0·5c. Then the new charge on it is

(i) $q\sqrt{1-(0\cdot5)^2}$ (ii) $\frac{q}{\sqrt{1-(0\cdot5)^2}}$

(iii) $q\sqrt{1-0\cdot5}$ (iv) q

(d) If ϕ is the scalar potential and $\vec{A}$ is the vector potential, the total potential energy of a charged particle in an electromagnetic field is

(i) $q\phi+\frac{q}{c}(\vec{A}\cdot\vec{B})$ (ii) $q\phi+\frac{q}{c}(\vec{A}\cdot\vec{E})$

(iii) $q\phi-\frac{q}{c}(\vec{A}\cdot\vec{v})$ (iv) $q\phi+\frac{q}{c}(\vec{A}\cdot\vec{\phi})$

(e) For a linear oscillatory system, the total energy is proportional to

(i) square of the time period

(ii) amplitude

(iii) square of the amplitude

(iv) square of the frequency

2. (a) Discuss qualitatively the equations of motion of Newton, Lagrange and Hamilton highlighting the difference between the three. 5

(b) Set up the Lagrange's equation for a simple pendulum and solve for θ. 4+3=7 *(c)* State and explain Hamilton's (variational) principle and derive Lagrange's equation from it. 2+4=6

Or

Explain homogeneity of time and isotropy of space and their connection with conserved quantities. 3+3=6

(d) Given that the Hamiltonian has implicit dependence on time, prove that it is a constant of motion. 5

Or

Show that the shortest distance between two points in a plane is a straight line.

3. *(a)* Explain dynamical equilibrium with examples. 2

(b) Find the expressions for frequencies of two-coupled one-dimensional harmonic oscillator. 6

4. *(a)* A muon (life time 2×10^{-6} sec) traveling through the laboratory at three-fifths the speed of light. How long does it last in the laboratory? 4

(b) Two electrons are leaving a radioactive sample in opposite directions, each having a speed $0{\cdot}67c$ with respect to the sample. The relative speed of one electron to the other is $1{\cdot}34c$ according to classical physics. What is the relativistic result? 3

(c) Show that the space-time interval is an invariant under Lorentz transformation. 4

(d) Write down the Lorentz transformation equation in matrix form. 3

Or

Is it possible for an external force to be acting on a system and relativistic momentum to be conserved? Explain.

(e) Construct Minkowski space and calibrate it. 5

(f) Explain simultaneity, length contraction and time dilation with the help of space-time diagram. 3

(g) Discuss the physical conditions of space-like and time-like intervals. 2+2=4

(h) Deduce the relativistic energy momentum relation $E^2 = p^2c^2 + m_0^2c^4$. 4

Or

Discuss Doppler effect from four-vector perspective.

(i) Define four-vector, rest mass energy, world line and proper time. 1×4=4

5. (a) Define fluid, liquid and gas, and establish the equation of continuity for fluid. 3+5=8

(b) Write the expression for Reynolds' number and explain the states of flow of liquid for lower and higher Reynolds' number. 2

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