

**2025 / FYUG / ODD / SEM /
PHYDSC-302T / 203**

FYUG Odd Semester Exam., 2025

PHYSICS

(5th Semester)

Course No. : PHYDSC-302T

**(Introduction to Classical Mechanics and
Electromagnetic Theory)**

Full Marks : 70

Pass Marks : 28

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

UNIT—I

1. Answer any two from the following questions : $2 \times 2 = 4$

(a) Define degrees of freedom. What is the number of degrees of freedom of a single particle moving freely in space?

(b) Name the constraint which is dependent on time. Give one example.

(Turn Over)

(2)

- (c) Write two characteristics of motion of a particle under central force.

2. Answer any one of the following questions :

- (a) (i) Define centre of mass of a system of particles. Write down the expressions of velocity and acceleration of centre of mass of two-particle system. Show that centre of mass of two particles divides the line joining the two particles internally in inverse ratio of their masses. 1+2+3=6
- (ii) What do you mean by constraints? Distinguish between holonomic and non-holonomic constraints with examples. 1+3=4
- (b) (i) Define central force. Show that two-body central force problem can be reduced to the equivalent one-body problem. 1+5=6
- (ii) State and prove Kepler's 2nd law. 1+3=4

UNIT—II

3. Answer any two from the following questions :

2×2=4

- (a) Define generalized coordinates and generalized velocities.

(3)

State Hamilton's principle.

Obtain an expression of Lagrangian of a free-falling body in uniform gravity.

Answer any one of the following questions : 10

- (i) What do you mean by virtual displacement and virtual work? State d'Alembert's principle. 2+1=3
- (ii) Obtain Lagrange's equation for conservative system from d'Alembert's principle. 7
- (i) Define Lagrangian of a system. What do you mean by cyclic coordinate? Obtain the equation of motion of a simple pendulum by Lagrangian method. 1+2+3=6
- (ii) A particle moves in one dimension such that the Lagrangian is given by

$$L = \frac{1}{12} m^2 \dot{x}^4 + m \dot{x}^2 v - v^2$$

where v is a function of x . Show that the equation of motion of the particle is

$$m\ddot{x} + \frac{\partial v}{\partial x} = 0$$

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(Turn Over)

(Continued)

UNIT—III

5. Answer any two of the following questions : 2×2=4

- (a) Explain the physical significance of Hamiltonian.
- (b) Discuss the advantages of Hamiltonian formalism.
- (c) The Lagrangian of a compound pendulum is given by

$$L = \frac{1}{2} I \dot{\theta}^2 + Mgl \cos \theta$$

Obtain the Hamiltonian of the system.

6. Answer any one of the following questions : 10

- (a) (i) Define Hamiltonian of a system. Obtain the Hamiltonian of a simple harmonic oscillator and hence find its equation of motion. 2+4=6
- (ii) Show that if Lagrangian does not contain time explicitly, Hamiltonian is a constant of motion. 4
- (b) (i) Obtain Hamilton's canonical equations of motion. 4

- (ii) Applying Hamiltonian formalism, obtain the equation of motion of a particle in a central force field. Also show that angular momentum is conserved, when a particle moves under central force. 4+2=6

UNIT—IV

Answer any two of the following questions : 2×2=4

- (a) Define magnetic flux. Give its SI unit.
- (b) A coil has an inductance of 0.04 H. Calculate the induced e.m.f. when the current in the coil changes at the rate of 10 As^{-1} .
- (c) Why should the core of the transformer be laminated?

Answer any one of the following questions : 10

- (a) (i) State Faraday's law of electromagnetic induction. What is a solenoid? Obtain an expression for the coefficient of self-induction of a long solenoid. 2+1+3=6
- (ii) What is mutual induction? Calculate the coefficient of mutual induction between two coaxial solenoids. 1+3=4

(Turn Over)

(6)

- (b) (i) What do you mean by a transformer? Describe its principle, construction and theory of a transformer. 1+(1+2+3)=7
- (ii) A step-up transformer works on 220 V and gives 2 A to an external resistor. The turn ratio between the primary and secondary coils is 2:25. Assuming 100% efficiency, find the secondary voltage, primary current and power delivered. 2

UNIT—V

9. Answer any two of the following questions :

- (a) What is displacement current density? Is it linked with the motion of free charges? 2×2=4
- (b) What is dielectric constant? How is it related to the refractive index in case of dielectrics?
- (c) State Poynting theorem.

10. Answer any one of the following questions :

- (a) (i) Explain gauge transformation. Discuss Coulomb gauge. Mention advantage and disadvantage of Coulomb gauge. 2+2+2=6

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(7)

- (ii) Explain skin depth. Calculate the frequency at which the skin depth in seawater is 1 m. 2+2=4
- (Given $\sigma = 4.3 \text{ mho m}^{-1}$ and $\mu = 4\pi \times 10^{-7} \text{ Hm}^{-1}$).

- (i) Write down Maxwell's equations in electromagnetism. Starting from Maxwell's equations, show that in a dielectric medium

$$1. \nabla^2 \vec{E} = \mu\epsilon \frac{\partial^2 \vec{E}}{\partial t^2}$$

$$2. \nabla^2 \vec{H} = \mu\epsilon \frac{\partial^2 \vec{H}}{\partial t^2}$$

$$2+(2\frac{1}{2}+2\frac{1}{2})=7$$

- (ii) Show that electromagnetic wave is transverse in nature. 3

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