4/PHY-251 Syllabus-2023

2025

(May–June)

FYUP : 4th Semester Examination

PHYSICS

(Classical Mechanics—I and Special Theory of Relativity)

(PHY–251)

Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer *any* **ten** questions

1. What are constraints? Give its classification. Explain holonomic and non-holonomic constraints with examples. 1+1½+2½+2½=7½

2. What are generalized coordinates? Give examples. Obtain the expression for generalized displacement, generalized velocity and generalized acceleration. 1½+2+2+2=7½

3. *(a)* What is virtual displacement? 1½

(b) State d'Alembert's principle. Using this principle, derive the Lagrange's equation of a system moving under the action of the force. 1+5=6

4. *(a)* What are the limitations of Newtonian formulation? How are they overcome in Lagrangian formulation? 3

(b) Obtain the Lagrangian and the equation of motion of a simple pendulum oscillating in the vertical plane. 4½

5. State and prove the law of conservation of linear momentum for a system of particles using generalized coordinates. 1½+6=7½

6. *(a)* What is Hamiltonian? Explain its physical significance. 1+1½=2½

(b) Show that for a conservative system the Hamiltonian is equal to the total energy of the system. 3

(c) What are the advantages of Hamiltonian formulation over Lagrangian formulation? 2

7. State Hamilton's principle. Establish Hamilton's canonical equations in Cartesian and polar coordinates. 1+3+3½=7½

8. *(a)* Using Hamilton's canonical equations, obtain the equation of motion of a harmonic oscillator. 6

(b) What are cyclic coordinates? 1½

9. *(a)* What are inertial and non-inertial frames of reference? Give one example each. 2

(b) Write down the Galilean transformation equations and show that Newton's second law is invariant under Galilean transformation. 1½+4=5½

10. *(a)* State and explain the basic postulates of the special theory of relativity. 2+1½=3½

(b) Explain why no-fringe shift was observed in Michelson-Morley experiment. What is the implication of the null result? 2+2=4

11. *(a)* Starting from Lorentz transformation equation, obtain the expression for length contraction and time dilation. 2+2=4

(b) The half-life of pion at rest is $1 \cdot 8 \times 10^{-8}$ seconds. What will be its half-life if it is moving with a speed $V = 2 \times 10^{7}$ m/sec relative to the observer? 3½

12. *(a)* Calculate the length of the rod in a frame of reference moving with a speed of 0·6c. The proper length of the rod is 5 m. 3

(b) Obtain the relation showing the variation of the mass of the object with speed. 4½

13. Establish Einstein's mass-energy relation. Discuss the importance of this relation with examples. 5+2½=7½

14. *(a)* Show that the rest mass energy of an electron is 0·511 MeV. 3

(b) An absorption line of wavelength 550 nm was detected by a stationary galaxy *A*. How fast and in what direction (relative to galaxy *A*) should galaxy *B* be moving in order to observe the same line red-shifted to 700 nm? 4½

15. *(a)* What do you understand by rest mass? Show that the rest mass of a photon is zero. 1+3=4

(b) At what speed should an object move so that its mass is twice the rest mass? 3½

16. What are position four-vector, velocity four-vector, momentum four-vector? Write down the components of these vectors. 7½

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