HS/XI/Sc/Ph/23

2023

PHYSICS

(Theory)

Full Marks : 70

Time : 3 hours

The figures in the margin indicate full marks for the questions

General Instructions :

(a) 15 minutes time has been allotted to read this question paper. The question paper will be distributed exactly 15 minutes before the commencement of the examination. The students will read the question paper only and will not write any answer on the remaining empty spaces on the question paper during this period.

(b) All questions are compulsory. There are 30 questions in all.

(c) This question paper has five sections: Section–A (I and II), Section–B, Section–C, Section–D and Section–E.

(d) Section–A-1 contains five multiple choice questions of one mark each, Section–A-II contains five very short answer type questions of one mark each. Section–B contains seven short answer type questions of two

marks each. Section–C contains nine short answer type questions of three marks each. Section–D contains one value based question of four marks and Section–E contains three long answer type questions of five marks each.

(e) There is no overall choice. However, an internal choice has been provided in one question of two marks, two questions of three marks and all the three questions of five marks weightage. You have to attempt only one choice in such questions.

(f) You may use the following values of standard physical constants wherever necessary.:

(i) Acceleration due to gravity, $g = 9.8\ ms^{-2}$

(ii) Radius of the earth, $R_e = 6400$ km

(iii) Mass of the earth, Me = 5.972×10^{24} Kg

(iv) Gravitational constant, G = $6.67 \times 10^{-11}\ Nm^2Kg^{-2}$.

(v) Bulk modulus of water, B = $2.2 \times 10^9\ Nm^{-2}$

(vi) Density of water, $\rho_w = 1000kg\ m^{-3}$

(vii) Velocity of light, C = $3 \times 10^8\ ms^{-1}$

(viii) Universal gas constant, R = $8.314\ J\ mol^{-1}\ K^{-1}$

(ix) Boltzmann constant, $k_B = 1.381 \times 10^{-23}\ J\ K^{-1}$

(x) Avogadro's Number, N = $6.023 \times 10^{23}\ mole^{-1}$

SECTION – A – I

(Multiple choice questions)

1. A structural steel rod of Young's modulus 2.0×10^{11} N m^{-2} has a radius and length of 10 mm and 1m, respectively. A 100 kN force stretches the rod along its length. The stress is. 1

(a) $3.18 \times 10^{8} Nm^{-2}$

(b) $3.18 \times 10^{9} Nm^{-2}$

(c) $3.18 \times 10^{10} Nm^{-2}$

(d) $3.18 \times 10^{6} Nm^{-2}$

2. A circular disc has mass M and radius R. The moment of inertia about its diameter is 1

(a) MR^2

(b) $MR^2/2$

(c) $MR^2/4$

(d) $MR^2/6$

3. A body of mass 2 kg travels according to the law $x(t) = pt + qt^2 + rt^3$, where p = 3 ms^{-1}, q = 4ms^{-2} and r = 5ms^{-3}. The force acting on the body at t = 2 seconds is 1

(a) 68N

(b) 134N

(c) 158N

(d) 136N

4. The root mean square speed of the molecules of a gas with molar mass M at absolute temperature T is 300 ms^{-1}. If the molar mass is doubled and the absolute temperature is halved, what will be the root mean square speed of the molecules? 1

(a) 300 ms^{-1}

(b) 150 ms^{-1}

(c) 75 ms^{-1}

(d) 50 ms^{-1}

5. A device thate works on Bernoulli's theorem is the 1

(a) Voltmeter

(b) Screw gauge

(c) Venturi-meter

(d) Spherometer.

SECTION – A–II

(*Very short answer type questions*)

6. Define Poisson's ratio in solids. 1

7. State the law of equipartition of energy for a gas system. 1

8. 5.74 g of a substance occupies 1.2 cm^3. Express its density in proper significant figures. 1

9. "When a vector $\vec{A}$ is multiplied by a negative number λ", What will you get? 1

10. State second law of thermodynamics. 1

SECTION – B

(*Short answer type questions*)

11. Mention two properties of a conservative force. 2

12. On an average a human heart is found to beat 75 times in a minute. Calculate its frequency and period. 2

13. State Pascal's law for fluids. Name one application. 1 + 1 = 2

14. *Either*

Consider a simple pendulum having a bob attached to a string that oscilates under the action of the force of gravity. Suppose that the time period of oscillation of the simple pendulum depends on its length (l), the mass of the bob (m) and acceleration due to gravity (g). Using the method of dimensions, derive the expression for the time period. 2

Or

Suppose the magnitude of the centripetal force (F) that acts on an object moving uniformly in a circle depends upon the mass (m), velocity (υ) of the object and radius of the circle (r). Using the method of dimensions, derive the expression for the force. 2

15. Using Newton's second law of motion and calculus method, show that the force ($\vec{F}$) acting on an object with constant mass (m) is related to the object's acceleration ($\vec{a}$) as 2

$$\vec{a} \; \alpha \; \vec{F}$$

16. A force F when applied on a block, placed on a floor, at an angle of 60^o to the direction of displacement of 5m, performs 150J of work. Find the force applied. What is the work done against? 1 + 1 = 2

17. Explain why small drops of water are spherical in shape. 2

SECTION — C

(Short answer type questions)

18. A wave travelling along a string is described by $y(x,t) = 0.005 \sin (80.0x - 3.0t)$, in which the numerical constants are in SI units (0.005 m, 80.0 rad m^{-1} and 3.0 rad s^{-1}). Calculate 3

(a) wavelength of the wave

(b) frequency of the wave and

(c) displacement $y(x,t)$ at a distance x = 30.0 cm and time t = 20 seconds.

19. State Kepler's laws of planetary motion. 3

20. Define the terms: (i) isothermal process, (ii) isobaric process, (iii) adiabatic process. 1 + 1 + 1 = 3

21. Consider an isolated system of two particles that will collide once with each other at any time. Show that the system obeys the law of conservation of linear momentum. 3

22. *Either*

Calculate the magnitude and direction of the resultant vector of $\vec{P} + \vec{Q}$, where $\vec{P} = \hat{i} + 5\hat{j}$ and $\vec{Q} = -2\hat{i} + 3\hat{j}$. 3

Or

If $\vec{A} = 4\hat{i} - 3\hat{j}$ and $\vec{B} = -\hat{i} + \hat{j}$, Calculate (i) $\vec{A} \times \vec{B}$, (ii) $\vec{B} \times \vec{A}$, (iii) $\vec{A} \times \vec{A}$ and (iv) show that $\vec{A} \times \vec{B} = -(\vec{B} \times \vec{A})$.

1 + 1 + $\frac{1}{2}$ + $\frac{1}{2}$ =3

23. Write down Hooke's law for elastic materials. The average depth of Indian Ocean is about 3000m. Calculate the fractional compression of water at the bottom of the ocean. 3

24. *Either*

Derive an expression for the kinetic energy of a rigid body rotating with uniform angular velocity ω and hence define moment of inertia. 3

Or

A particle of constant mass (m) undergoes rotational motion due to an external torque ($\vec{\tau}$), show that

$$\vec{\tau} = \frac{d\vec{L}}{dt},$$

where the symbols have their usual meanings. Mention one condition that $\vec{L}$ will be constant. 3

25. Obtain an expression for acceleration due to gravity at a depth d below the surface of the earth. 3

26. When two bodies make a head-on elastic collision, show that the coefficient of restitution equals 1. 3

SECTION — D

(Value based question)

27. In our daily lives, we come across three distinct modes of heat transfer:

Conduction, Convection and Radiation.

(i) From your experiences, explain with an example the following mechanisms.

(a) Conduction 1

(b) Convection and 1

(c) Radiation 1

(ii) What is meant by black body radiation? 1

SECTION — E

(Long answer type questions)

28. *Either*

Why the projectile only has constant downward acceleration? Obtain the expressions for maximum height and time of ascent or time of rise for a projectile. 1 + 4 =5

Or

Why do we need banking for a curved road? Obtain an expression for maximum speed that a car can safely travel on a curved road banked at an angle θ. 1 + 4 =5

29. *Either*

Show that the total mechanical energy of a particle executing simple harmonic motion under a conservative force is independent of time. 5

Or

Two identical sinusoidal waves have the same angular frequency, wavelength and amplitude but, their phase difference is ϕ are travelling along a stretched string in the positive direction of the x–axis. Using the principle of superposition of waves, show the waves will give rise to another sinusoidal wave. What happen when $\phi = \pi$? 5

30. *Either*

(a) Define gravitational potential energy. 1

(b) Derive an expression for the gravitational potential energy of a body at any height h above the surface of the earth. 4

Or

(a) Derive an expression for the escape velocity of a body from the surface of the earth. 4

(b) Calculate the numerical value of escape velocity of a satellite of mass 1000 kg from the surface of the earth. Conclude your result. $\frac{1}{2} + \frac{1}{2} = 1$

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