

2022

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.
- (b) All questions are compulsory.
- (c) This question paper has five sections.
- (d) There is no overall choice. However, an internal choice has been provided in some questions.
- (e) Useful Data:
 - (i) Acceleration due to gravity, $g = 9.8 \text{ ms}^{-2}$
 - (ii) Radius of the earth, $R_e = 6400 \text{ km}$

- (iii) Boltzmann constant, $k_B = 1.381 \times 10^{-23} \text{ J K}^{-1}$
- (iv) Avogadro's Number, $N = 6.023 \times 10^{23} \text{ mole}^{-1}$

SECTION – A – I

(Multiple choice questions)

1. The electric force between two protons is about 1
 - (a) 10^{28} times gravitational force
 - (b) 10^{36} times gravitational force
 - (c) 10^{18} times gravitational force
 - (d) 10^{20} times gravitational force
2. The percentage error in the measurement of radius of a sphere is 2%. Then the percentage error in the measurement of volume is 1
 - (a) 1 %
 - (b) 6 %
 - (c) 4 %
 - (d) 8 %

(3)

3. The dimension of ab in the relation 1

$$E = \left(\frac{b - x^2}{at} \right) \text{ is}$$

- (a) $[M^{-1}L^2T]$
- (b) $[M^{-2}LT^2]$
- (c) $[M^0LT^{-2}]$
- (d) $[M^0L^2T^{-2}]$

where E is energy, x is distance and t is time

4. The instantaneous angular position of a point on a rotating wheel is given by 1

$$\theta(t) = 2t^3 - 6t^2$$

The torque on the wheel will become zero at

- (a) $t = 1\text{s}$
- (b) $t = 0.5\text{s}$
- (c) $t = 0.25\text{s}$
- (d) $t = 2\text{s}$

5. The linear momentum is increased by 50%, then kinetic energy will be increased by 1

- (a) 50%
- (b) 100%
- (c) 125%
- (d) 25%

(4)

SECTION – A–II

(Very short answer type questions)

6. A body covers a distance L m along a semicircular path. What is the magnitude of displacement of the body? 1

7. Show that vectors 1

$$\vec{A} = 2\hat{i} - 3\hat{j} + 4\hat{k} \text{ and}$$

$$\vec{B} = -6\hat{i} + 9\hat{j} - 12\hat{k} \text{ are parallel to each other.}$$

8. A cricket player has to lower his hands while catching a ball. Why? 1

9. What provides the centripetal force to a satellite revolving around the earth? 1

10. What is geostationary satellite? 1

(5)

SECTION – B

(Short answer type questions)

11. Derive an expression for kinetic energy of a mass m , moving with velocity v . 2

12. Obtain the relation between torque and angular momentum. 2

13. If the period of revolution of Neptune is 165 earth year, what is its orbital radius? 2

14. Prove that elastic energy density is $\frac{1}{2} \times (\text{stress}) \times (\text{strain})$. 2

15. Define specific heats of a gas and show that the difference between them is constant. 2

16. *Either*
What is degrees of freedom? Discuss degrees of freedom of a molecule of diatomic gas. 2

Or
Define specific heat. Why do gases have two specific heats?

(6)

17. A harmonic oscillation is represented by: 2
 $y = 0.34 \cos(3000t + 0.74)$, where y and t are in m and s respectively.

Find (i) Amplitude
(ii) Angular Frequency
(iii) Period
(iv) Initial Phase

SECTION — C

(Short answer type – 3 marks)

18. Derive the relation (graphically):- 3

$$S = ut + \frac{1}{2}at^2$$

where symbols have usual meanings.

19. *Either*
A block slides down an incline of 30° with an acceleration $\frac{g}{4}$. Find the co-efficient of kinetic friction. 3

Or
A horizontal force of 1.2 kg wt is applied to a 1.5 kg block, which rests on a horizontal surface. If the co-efficient of friction is 0.3, find the acceleration produced in the block. 3

(7)

- 20.** A ball rolls down the top of a stairway with a horizontal velocity of 1.8 m/s. The steps are 0.2 m high and 0.2 m wide. Which step will the ball hit first? 3
- 21.** What are elastic and inelastic collisions? Show that for an elastic collision in one dimension, the relative velocity of approach before collision is equal to relative velocity of separation after collision. 3
- 22.** Discuss the effect of depth on the value of 'g'. Also draw a graph showing the variation of 'g' with distance from the centre of the earth. 3
- 23.** Define surface tension. Derive a relation between surface tension and surface energy. 1 + 2 = 3
- 24.** Derive an expression for excess pressure inside a soap bubble. 3
- 25.** What should be the average velocity of water in a tube of radius 0.005m so that the flow is just turbulent? The viscosity of water is 0.001 Pa-s. 3

(8)

- 26.** *Either*
Define co-efficient of thermal conductivity and explain the formula used. 3
Or
State and explain Newton's Law of cooling.

SECTION — D

(Value based question) (4 marks)

- 27.** The world is full of waves, the two main types of waves are:
- (i) mechanical wave
 - (ii) electromagnetic wave
- (a) Give two examples of mechanical waves. 1
- (b) Give two examples of electromagnetic waves. 1
- (c) What in reality is a wave? 1
- (d) How do you connect life to a wave? 1

SECTION — E

(Long answer type)

- 28.** *Either*
Prove that the path of a projectile projected at an angle θ with the vertical is a parabola. Show that the range of a projectile for two angles of projection α and β is the same, where $\alpha + \beta = 90^\circ$. 3 + 2 = 5
Or

(9)

- (i) State and explain parallelogram law of vectors.
- (ii) The resultant of two vectors \vec{A} and \vec{B} is perpendicular to \vec{A} . The resultant has magnitude $\frac{B}{2}$. Find the angle between the vectors. $3 + 2 = 5$

29.

Either

- (a) Define isothermal change. Calculate the amount of work done when a perfect gas expands isothermally. 3
- (b) Calculate the difference in temperature of water at the top and bottom of a waterfall of height 420m. 2

Or

- (a) Derive an expression for the pressure exerted by a perfect gas on the basis of kinetic theory. 3
- (b) Calculate the rms velocity of CO_2 molecules at NTP. 2

30.

Either

- (a) Show that for small oscillation, the motion of a simple pendulum is simple harmonic. 3

(10)

- (b) A body of mass 0.1 kg is executing SHM of amplitude 1m and period 0.2s. What is the maximum value of force acting on it. 2

Or

- (a) Discuss Newton's formula for the speed of sound waves in a medium. What correction was applied by Laplace and why? 3
- (b) Discuss the various modes of vibration of an air column in an open organ pipe. 2

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