

2020

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–I contains five multiple choice questions of one mark each, Section A–II contains very short answer questions of one mark each. Section B contains seven

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

- (e) There is no overall choice. However, an internal choice has been provided in one question of two marks, one question 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, $g = 9.8 \text{ ms}^{-2}$
 - (ii) Radius of the earth, $R_e = 6400 \text{ km}$
 - (iii) Universal gas constant, $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
 - (iv) Boltzmann constant, $K_B = 1.381 \times 10^{-23} \text{ J K}^{-1}$
 - (v) Velocity of light, $C = 3 \times 10^8 \text{ ms}^{-1}$
 - (vi) Young's modulus of steel, $Y = 2.0 \times 10^{11} \text{ Nm}^{-2}$
 - (vii) Avogadro number, $N = 6.023 \times 10^{23}$ per gram mole.

(3)

SECTION – A – I

(Multiple choice questions)

1. The dimensional formula of gravitational constant is 1

- (a) $M^1 L^1 T^{-2}$
- (b) $M^0 L^1 T^{-2}$
- (c) $M^{-1} L^3 T^{-2}$
- (d) $M^{-2} L^3 T^{-1}$

2. A man fires a bullet of mass 0.2 Kg with a speed of 5 m/s. The gun is of 1Kg mass. By what velocity does the gun recoil backwards? 1

- (a) 0.01 m/s
- (b) 0.1 m/s
- (c) 1 m/s
- (d) 10 m/s

3. The position of an object moving along x-axis is given by, $x = a + bt^2$ where $a = 2m$ and $b = 3 \text{ m/s}^2$ and t is measured in seconds. The velocity at $t = 2s$ is 1

- (a) 2 m/s
- (b) 6 m/s

(4)

(c) 12 m/s

(d) 14 m/s

4. The centre of mass of a system shall be 1

- (a) at the centre of the system
- (b) outside the system
- (c) inside the system
- (d) inside or outside the system

5. The displacement of a particle varies with time according to the relation: 1

$$y = a \sin \omega t + b \cos \omega t$$

- (a) The motion is oscillatory but not S.H.M.
- (b) The motion is S.H.M. with amplitude $a + b$
- (c) The motion is S.H.M. with amplitude $a^2 + b^2$
- (d) The motion is S.H.M with amplitude $\sqrt{a^2 + b^2}$

(5)

SECTION – A-II

(*Very short answer type questions*)

6. Can there be a physical quantity which has a unit but no dimensions? 1
7. Why a cricketer moves his hands backwards while holding a catch? 1
8. From your day to day experience, give an example in which a couple of force is applied. 1
9. Two identical solid balls, one of ivory and the other of wet-clay, are dropped from the same height on the floor. Which one will rise to a greater height after striking the floor and why? 1
10. When will the motion of a simple pendulum be simple harmonic? 1

SECTION – B

(*Short answer type I questions*)

11. The centripetal force (\vec{F}) acting on a particle moving uniformly in a circle may depend upon its mass (m), velocity (v) and radius (r) of the circle. Derive the formula for ' F ' using the method of dimensions. 2

(6)

12.

Either

A body of mass 2.5 Kg is moving with a constant speed of 45 m/s. A constant force is applied on the body such that the speed changes to 15m/s in 10 seconds. The direction of motion of the body is unchanged throughout its motion. What is the magnitude and direction of the force? 2

Or

A cyclist speeding at 5 m/s on a level road takes a sharp circular turn of radius 3 m without reducing the speed. The coefficient of static friction between the tyres and the road is 0.1. Will the cyclist slip taking the turn? 2

13. State work energy theorem. Hence derive its expression. 2

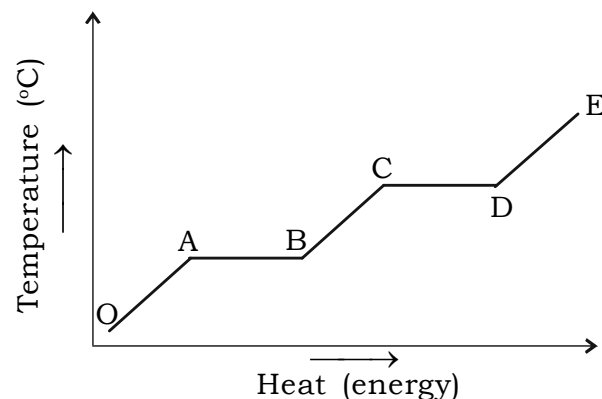
14. A rope of negligible mass is wound round a hollow cylinder of mass 3 Kg and radius 40 cm. What is the angular acceleration of the cylinder if the rope is pulled with a force of 30 N ? Given moment of inertia of the cylinder about its axis is 0.48 Kg m^2 . 2

15. The mass m of a substance undergoes a change from one state to another on application of heat of quantity Q given by 2

$$Q = m L$$

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What does L represent? Which parts of the following graph does L represent?



16. What happens to the internal energy of a gas during
- (i) Isothermal expansion
 - (ii) Adiabatic expansion

2

17. Calculate rms velocity of oxygen molecule at 27°C

2

SECTION — C

(Short answer type – II Questions)

18. *Either*

Derive the equations of motion:-

(i) $S = ut + \frac{1}{2}at^2$ and

(ii) $v^2 = u^2 + 2as$ graphically

Where, the symbols have their usual meanings.

3

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OR

Show that motion in a plane can be treated as two separate simultaneous one dimensional motions with constant acceleration along two perpendicular directions.

3

19. State Newton's Second Law of Motion. Hence, derive the expression $F = ma$ by calculus method where the symbols have their usual meanings.

3

20. Show that for an elastic collision of two bodies in one dimension, the relative velocity of approach is equal to the relative velocity of separation.

3

21. *Either,*

A ring, a disc and a sphere, all having the same radius and mass, roll down an inclined plane from the same height. Which of these will reach the bottom first? Explain why.

3

OR

Define Moment of Inertia and radius of gyration. If the moment of inertia of a thin rod of mass 'M' and length 'L' about an axis through its centre and perpendicular to its length is $\frac{ML^2}{12}$, calculate its radius of gyration.

1 + 1 + 1 = 3

- 22.** State and Prove Stoke's law using dimensional analysis. 1 + 2 = 3

- 23.** (a) Define Young's Modulus.

(b) A structural steel rod has a radius of 10 mm and a length of 1.0 m. A 100 kN force stretches it along its length. Calculate (i) stress and strain on the rod. (Given Young's modulus of steel rod is $2.0 \times 10^{11} \text{ N/m}^2$). 1 + 2 = 3

- 24.** Three vessels of equal capacity have gases at the same temperature and pressure. The first vessel contains Neon (monatomic), the second contains chlorine (diatomic), and the third contains uranium hexafluoride (polyatomic).

- (a) Do the vessels contain equal number of molecules?
(b) Is the root mean square speed of the molecules same in three cases? Justify.

1 + 2 = 3

- 25.** A bat emits ultrasonic sound of frequency 1000 kHz in air. If this sound meets a water surface, what is the wavelength of

- (a) the reflected sound?
(b) the transmitted sound? (Given speed of sound in air is 340 m/s and in water is 1486 m/s).

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

- 26.** A boy pulls a string attached to a wooden block with a force of 30 N. The angle between the string and the horizontal ground is 30° . How much is 3

- (a) the effective value of the force that tends to move the block along the ground
(b) the quantity of force tending to lift the block vertically upward.

SECTION — D

(Value based question)

- 27.** During summers in India, one of the most common practice to keep cool is to make ice balls of crushed ice, dip it in flavoured sugar syrup and sip it. For this a stick is inserted into crushed ice and is squeezed in the palm to make it into the ball. Equivalently in winter, in those areas where it snows, people make snow balls and throw around. Explain the formation of ball out of crushed ice or snow in the light of P-T diagram of water. 4

SECTION — E

(Long answer type)

- 28.** *Either*

State parallelogram law of vector addition. Find the magnitude and direction of the resultant of two vectors \vec{A} and \vec{B} in terms of their magnitudes and angle between them. 1 + 4 = 5

(11)

Or

What is projectile motion? Find an expression for the time of flight and horizontal range of a projectile projected with a speed V and making an angle θ with respect to the horizontal direction.

1 + 2 + 2 = 5

29.

Either

- (a) Obtain an expression for acceleration due to gravity ' g ' at a height above the surface of the earth. Draw a graph showing the variation of ' g ' with height. 3
- (b) At what height above the earth's surface, the value of ' g ' is half of its value on earth's surface? (Given $R = 6400$ km) 2

Or

- (a) Derive an expression for escape velocity of an object from the surface of a planet 3
- (b) Using the expression for escape velocity from the surface of the planet earth, calculate the numerical value of escape velocity of a body of mass 10 kg from the surface of the earth ($R = 6.4 \times 10^6 m$). 2

30.

Either

- (a) Derive the equation of the time period of a simple pendulum. 3
- (b) Show that the length of a second pendulum is nearly 1 m. 2

(12)

Or

What is simple harmonic motion? Mention two of its characteristics. Show that the force acting on a particle of mass ' m ' in simple harmonic motion is proportional to the displacement and is directed towards the mean position.

1 + 1 + 3 = 5

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