R2024

No. of Printed Pages : 4

Register Number

11

PART – III

இயற்பியல் / PHYSICS

(English Version)

Time Allowed : 3.00 Hours] [Maximum Marks : 70

Instructions : (1) Check the question paper for fairness of printing. If there is any lack of fairness, inform the Hall Supervisor immediately

(2) Use **Blue** or **Black** ink to write and underline and pencil to draw diagrams.

PART – I

Note : (i) Answer **all** the questions. 15x1=15

(ii) Choose the most appropriate answer from the given **four** alternatives and write the option code and the corresponding answer.

1. One of the combinations from the fundamental physical constants is $\frac{hc}{G}$. The unit of this expression is

 (a) kg^2 (b) m^3 (c) s^{-1} (d) m

2. When a car takes a sudden left turn in the curved road, passengers are pushed towards the right due to

 (a) inertia of direction (b) inertia of motion

 (c) inertia of rest (d) absence of inertia

3. The position vector of the particle is r = $3t^2$i +5tj +9k. What is the acceleration of the particle at t = 1 sec.

 (a) 6 ms^{-2} (b) 5 ms^{-2} (c) 9 ms^{-2} (d) zero

4. The work done by the conservative force for a closed path is

 (a) always negative (b) zero

 (c) always positive (d) not defined

5. The centrifugal force appears to exist

 (a) Only in rotating frames (b) any inertial frames

 (c) in accelerated frames (d) both in inertia and non-Inertial frames

[Turn Over

6. The linear momentum and position vector of the planet is perpendicular to each other at
   (a) perihelion and aphelion (b) at all points
   (c) only at perihelion (d) no point
7. If a wire is stretched to double of its original length, then the strain in the wire is
   (a) 1 (b) 2 (c) 3 (d) 4
8. When a cycle tyre suddenly bursts, the air inside the tyre expands. This process is
   (a) isothermal (b) adiabatic
   (c) isobaric (d) isochoric
9. For a given gas molecule at a fixed temperature, the area under the Maxwell-Boltzmann distribution curve is equal to
   (a) $\frac{PV}{kT}$ (b) $\frac{kT}{PV}$ (c) $\frac{P}{NkT}$ (d) PV
10. The average translational kinetic energy of gas molecules depends on
    (a) number of moles and T (b) only on T
    (c) P and T (d) P only
11. In a simple harmonic oscillation, the acceleration against displacement for one complete oscillation will be
    (a) an ellipse (b) a circle (c) a parabola (d) a straight line
12. Which of the following represents a wave
    (a) $(x - vt)^3$ (b) $x(x + vt)$ (c) $\frac{1}{(x + vt)}$ (d) $\sin(x + vt)$
13. If the force is proportional to square of velocity, then the dimension of proportionality constant is
    (a) $[MLT^0]$ (b) $[MLT^{-1}]$ (c) $[ML^{-2}T]$ (d) $[ML^{-1}T^0]$
14. Which of the following is scalar quantity?
    (a) momentum (b) work (c) force (d) displacement
15. If the mass and radius of the earth are doubled then the acceleration due to gravity g
    (a) remains same (b) g/2
    (c) 2g (d) 4g

PART – II

Note : Answer **any six** questions. Question No. **24** is **compulsory.** **6x2=12**

16. State the principle of homogeneity of dimensions.
17. Define projectile. Give examples.
18. What is impulsive force?
19. Why is there no lunar eclipse and solar every month?
20. Distinguish between cohesive and adhesive forces.
21. Define latent heat capacity. Give its unit.
22. List the factors affecting the mean free path.
23. What is meant by resonance?
24. A car takes your turn with velocity 50 m/s on the circular road of radius of curvature 10 m. Calculate the centrifugal force experienced by a person a mass 60 kg inside the car?

PART – III

Note : Answer **any six** questions. Question No. **33** is **compulsory.** **6x3=18**

25. What are the uses of dimensional analysis?
26. Discuss any 6 properties of scalar product of two vectors.
27. State Newton's three laws.
28. Distinguish between elastic and inelastic collisions.
29. What are the factors affecting the surface tension of liquid?
30. Explain the linear expansion of solid.
31. State the laws of simple pendulum.
32. Distinguish between transverse waves and longitudinal waves.
33. The radius of the circle 3.12 m. Calculate the area of the circle with regard to signature Figure.

[Turn Over

PART – IV

Note : Answer **all** the questions. **5x5=25**

34. (a) Write a note on triangulation method and radar method to measure larger distances.

(OR)

(b) Explain in detail that triangle law of addition.

35. (a) Derive the expression for final speed of a particle moving in an inclined plane.

OR

(b) State and prove work-kinetic energy theorem

36. (a) Derive the expression for moment of inertia of a rod about its centre and perpendicular to the rod.

OR

(b) Derive an expression for escape speed.

37. (a) State and prove Bernoulli's theorem.

.

OR

(b) Derive Meyer's relation.

38. (a) Discuss in detail the energy in simple harmonic motion.

OR

(b) Derive Newton's formula for velocity of sound waves in air. Explain the Laplace's correction in it.

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HIGHER SECONDARY FIRST YEAR REVISION EXAMINATION – JANUARY 2024

PHYSICS KEY ANSWER

Note:

1. Answers written with **Blue** or **Black** ink only to be evaluated.
2. Choose the most suitable answer in Part A, from the given alternatives and write the option code and the corresponding answer.
3. For answers in Part-II, Part-III and Part-IV like reasoning, explanation, narration, description and listing of points, students may write in their own words but without changing the concepts and without skipping any point.
4. In numerical problems, if formula is not written, marks should be given for the remaining correct steps.
5. In graphical representation, physical variables for X-axis and Y-axis should be marked.

PART – I

Answer all the questions. 15x1=15

Q. No.	OPTION	ANSWER	Q. No.	OPTION	ANSWER
1	(a)	Kg^2	9	(a)	PV / KT
2	(b)	Inertia of direction	10	(a)	Number of moles and T
3	(c)	$6ms^{-2}$	11	(d)	A straight line
4	(b)	Zero	12	(d)	Sin(x+vt)
5	(a)	Only in rotating frames	13	(d)	$[ML^{-1}T^0]$
6	(a)	Perihelion and aphelion	14	(b)	work
7	(a)	1	15	(b)	g/2
8	(b)	Adiabatic			

PART – II

Answer any **six** questions. Question number **24** is compulsory. 6x2=12

16	**Principle of homogeneity of dimensions.** The principle of homogeneity of dimensions' states that the **dimensions of all the terms in a physical expression should be the same.** For example, in the **physical expression $v^2 = u^2 + 2as$**, the dimensions of v^2, u^2 and 2 as are the same and equal to **$[L^2T^{-2}]$.**	2	2

17	**Projectile and Examples** When an **object is thrown in the air with some initial velocity** and then allowed to move under the action of gravity alone, the object is known as a projectile. **Examples:** 1. An object dropped from window of a moving train 2. A bullet fired from a rifle. 3. A ball thrown in any direction. 4. A javelin or shot put thrown by an athlete. 5. A jet of water issuing from a hole near the bottom of a water tank.	1 1	2
18	**Impulse or Impulse Force:** If a **very large force acts on an object for a very short duration**, then the force is called impulsive force or impulse.	2	2
19	**No lunar eclipse and solar eclipse every month:** **Moon's orbit is tilted 5^0 with respect to Earth's orbit**, only during certain periods of the year; the **Sun, Earth and Moon align in straight line leading to either lunar eclipse** or solar eclipse depending on the alignment	2	2
20	**Cohesive and adhesive force:** **The force between the like molecules which holds the liquid together** is called 'cohesive force'. **When the liquid is in contact with a solid, the molecules of the these solid and liquid will experience an attractive force** which is called **'adhesive force'.**	1 1	2
21	**Latent heat capacity and SI Unit:** Latent heat capacity of a substance is defined **as the amount of heat energy required to change the state of a unit mass of the material.** $Q = m \times L ; L = \frac{Q}{m}$ Where L = Latent heat capacity of the substance; Q = Amount of heat m = mass of the substance. The **SI unit for Latent heat capacity is J kg^{-1} .**	1 ½ ½	2
22	**Factors affecting the mean free path.** 1) Mean free path **increases with increasing temperature. As the temperature increases, the average speed of each molecule will increase.** It is the reason why the smell of hot sizzling food reaches several meter away than smell of cold food. 2) Mean free **path increases with decreasing pressure of the gas and diameter of the gas molecules.**	1 1	2

23	**Resonance:** The frequency of external periodic force (or driving force) matches with the **natural frequency of the vibrating body (driven). As a result, the oscillating body begins to vibrate such that its amplitude increases** at each step and ultimately it has a large amplitude. Such a phenomenon is known as resonance and the corresponding vibrations are known as resonance vibrations.	2	2
24	Centrifugal force is given by, $F_{cf} = \frac{mv^2}{r}$; $= \frac{60 \text{ x } 50 \text{ x } 50}{10}$; = 6 x 2500 F_{cf} =15000 N	1 ½ ½	2

PART – II

Answer **any six** questions. Question number **33 is compulsory.** 6x3=18

25	**Applications (uses) of dimensional analysis** 1. Convert a physical quantity from **one system of units to another.** 2. **Check the dimensional correctness** of a given physical equation. 3. Establish **relations among various physical quantities.**	3x1=3	3
26	Properties of Dot product or Scalar Product: 1) The product quantity **$\vec{A}\cdot\vec{B}$ is always a scalar**. It is positive if the angle between the vectors is acute (i.e., < 90°) and negative if the angle between them is obtuse (i.e. 90°<θ< 180°). 2) The **scalar product is commutative**, i.e. $\vec{A}\cdot\vec{B} = \vec{B}\cdot\vec{A}$ 3) The **vectors obey distributive law** i.e. $\vec{A}\cdot(\vec{B}+\vec{C}) = \vec{A}\cdot\vec{B} + \vec{A}\cdot\vec{C}$ 4) The angle between the vectors $\theta = \cos^{-1}\left[\frac{\vec{A}\cdot\vec{B}}{AB}\right]$ 5) The **scalar product of two vectors will be maximum** when Cos θ = 1, i.e. θ = 0^0, i.e., when the vectors are parallel; $(\vec{A}\cdot\vec{B})_{max}$ = AB 6)The **scalar product of two vectors will be minimum,** when Cos θ = –1, i.e. θ = 180^0 $(\vec{A}\cdot\vec{B})_{min}$ = – AB when the vectors are anti-parallel. 7) If **two vectors $\vec{A}$ and $\vec{B}$, are perpendicular** to each other than their scalar Product $\vec{A}\cdot\vec{B}$ = 0 , because Cos 90^0 =0. Then the vectors $\vec{A}$ and $\vec{B}$. are said to be mutually orthogonal. 8) The scalar product of a vector with itself is termed as self-dot product and is given by $(\vec{A})^2 = \vec{A}\cdot\vec{A}$ = AA Cos θ = A^2 . Here angle θ = 0° The **magnitude or norm of the vector $\vec{A}$ is $\lvert\vec{A}\rvert$ = A = $\sqrt{\vec{A}\cdot\vec{A}}$** 9) In case of a unit vector $\hat{n}$, $\hat{n}\cdot\hat{n}$ = 1 x 1 x Cos 0 = 1. For example, $\hat{\imath}\cdot\hat{\imath} = \hat{\jmath}\cdot\hat{\jmath} = \hat{k}\cdot\hat{k}$= 1 10) In the case of **orthogonal unit vectors** $\hat{\imath}$, $\hat{\jmath}$ and $\hat{k}$, $\hat{\imath}\cdot\hat{\jmath} = \hat{\jmath}\cdot\hat{k} = \hat{k}\cdot\hat{\imath}$ = 1.1 Cos90^0 = 0 11) In terms of components the scalar product of $\vec{A}$ and $\vec{B}$ can be written As $\vec{A}\cdot\vec{B} = (A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k})\cdot(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}) = A_xB_x + A_yB_y + A_zB_z$ with all other terms zero. The magnitude of vector $\lvert\vec{A}\rvert$ is given by $\lvert\vec{A}\rvert = A = \sqrt{A_x^2 + A_y^2 + A_z^2}$	Any 6 6 x ½ =3	3

<table>
<tr>
<td>27</td>
<td>Newton's First Law:
i) Every object continues to be in the state of rest or of uniform motion (constant velocity) unless there is external force acting on it.
Newton's Second Law:
i) The force acting on an object is equal to the rate of change of its momentum $\vec{F} = \frac{d\vec{p}}{dt}$
Newton's Third law:
i) Newton's third law assures that the forces occur as equal and opposite pairs. An isolated force or a single force cannot exist in nature.
ii) Newton's third law states that for every action there is an equal and opposite reaction.</td>
<td>1

1

1</td>
<td>3</td>
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<tr>
<td>28</td>
<td>
<table>
<tr><th>Elastic Collision</th><th>Inelastic Collision</th></tr>
<tr><td>Total momentum is conserved</td><td>Total momentum is conserved</td></tr>
<tr><td>Total kinetic energy is conserved</td><td>Total kinetic energy is not conserved</td></tr>
<tr><td>Forces involved are conservative forces</td><td>Forces involved are non-conservative Forces</td></tr>
<tr><td>Mechanical energy is not dissipated</td><td>Mechanical energy is dissipated into heat, light, sound etc.</td></tr>
</table>
</td>
<td>Any 3
3x1=3</td>
<td>3</td>
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<tr>
<td>29</td>
<td>(1) The presence of any contamination or impurities considerably affects the force of surface tension depending upon the degree of contamination.
(2) The presence of dissolved substances can also affect the value of surface tension. For example, a highly soluble substance like sodium chloride (NaCl) when dissolved in water (H_2O) increases the surface tension of water. But the sparingly soluble substance like phenol or soap solution when mixed in water decreases the surface tension of water.
(3) Electrification affects the surface tension. When a liquid is electrified, surface tension decreases. Since external force acts on the liquid surface due to electrification, area of the liquid surface increases which acts against the contraction phenomenon of the surface tension. Hence, it decreases.
(4) Temperature plays a very crucial role in altering the surface tension of a liquid. Obviously, the surface tension decreases linearly with the rise of temperature.</td>
<td>Any 3
3 x 1
= 3</td>
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<td>30</td>
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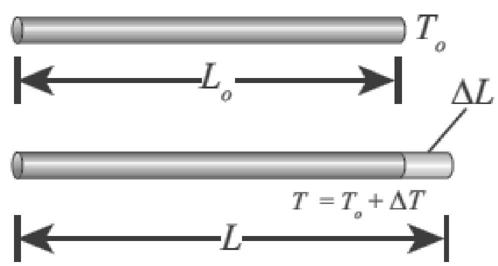
Linear expansion of solid:



In solids, for a small change in temperature ΔT, the fractional change in length $\left(\frac{\Delta L}{L}\right)$ is directly proportional to ΔT. $\frac{\Delta L}{L}$ = a_L ΔT

Therefore, $\alpha_L = \frac{\Delta L}{L \Delta T}$; Where, αL = coefficient of linear expansion.

ΔL = Change in length; L = Original length;

ΔT = Change in temperature

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1</td>
<td>3</td>
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<tr>
<td>31</td>
<td>

Laws of simple pendulum:

Law of length: For a given value of acceleration due to gravity, the time period of a simple pendulum is **directly proportional to the square root of length of the pendulum. T** $\alpha \sqrt{l}$

Law of acceleration: For a fixed length, the time period of a simple pendulum is **inversely proportional to square root of acceleration due to gravity. T** $\alpha \frac{1}{\sqrt{g}}$

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<td>1 ½
1 ½</td>
<td>3</td>
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<tr>
<td>32</td>
<td>

S. No.	Transverse Wave	Longitudinal Wave
1	**In transverse wave motion, the constituents of the medium oscillate** or vibrate about their mean positions in a direction perpendicular to the direction of propagation (direction of energy transfer) of waves.	In **longitudinal wave motion, the constituent of the medium oscillate or vibrate about their mean positions in a direction parallel** to the direction of propagation (direction of energy transfer) of waves.
2	The disturbances are in the form of **crests and troughs.**	The disturbances are in the form of **compressions and rarefactions.**
3	Transverse waves are possible in **elastic medium.**	Longitudinal waves are possible in **all types of media** (solid, liquid and gas).

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<td>1
1
1</td>
<td>3</td>
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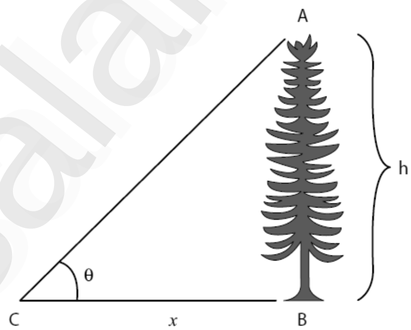
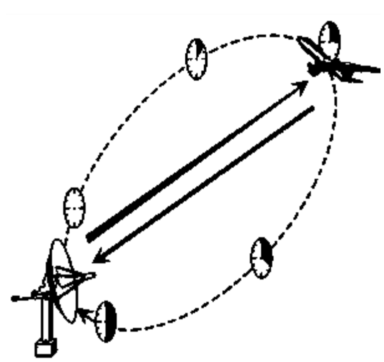
33	$A = \pi r^2$; = 3.14 x 3.12 x 3.12 ; = 30.57m² **A = 30.6 m²** (rounding off with significant figure3	1 1 1	3

PART – IV

Answer **all** the questions. 5x5=25

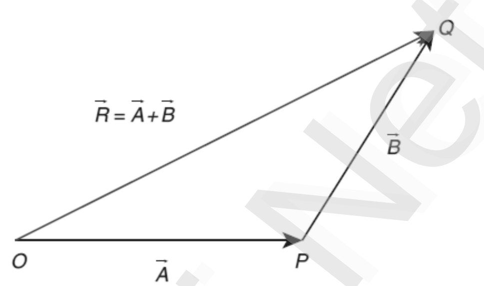
34 (a)	**Measurement of large distances:** For measuring larger distances such as the height of a tree, distance of the **Moon or a planet from the Earth,** some special methods are adopted. **Triangulation method, parallax method and radar method are used to determine very large distances.** **Triangulation method for the height of an accessible object:** Let **AB = h be the height of the tree** or tower to be measured. Let C be the point of observation at distance *x* from B. Place a range finder at C and measure the angle of elevation, ∠ACB = θ as shown in Figure. From right angled triangle **ABC,** **$\tan\theta = \frac{AB}{BC} = \frac{h}{x}$** (or) **height $h = x \tan\theta$** Knowing the distance *x*, the height h can be determined.  **RADAR method:** The word RADAR stands for **Radio Detection and Ranging.** Radar can be used **to measure accurately the distance of a nearby planet** such as Mars. In this method, **radio waves are sent from transmitters which, after reflection from the planet, are detected by the receiver.** By measuring, the time interval (t) between the instants the radio waves are sent and received, the distance of the planet can be determined as $d = \frac{v \times t}{2}$. where **v is the speed of the radio wave.** As the time taken (t) is for the distance covered during the forward and backward path of the radio waves, it is divided by 2 to get the actual distance of the object. This method can also be **used to determine the height, at which an aero-plane flies from the ground.** 	1 1 ½ 1 ½ 1	5

34 (b)

The triangle law of addition.

1) Represent the vectors $\vec{A}$ and $\vec{B}$ by the two adjacent sides of a triangle taken in the same order. Then the resultant is given by the third side of the triangle taken in the opposite order. 1

2) The **head of the first vector $\vec{A}$ is connected to the tail of the second vector $\vec{B}$. Let θ be the angle between $\vec{A}$ and $\vec{B}$. Then $\vec{R}$ is the resultant vector connecting the tail** of the first vector $\vec{A}$ to the head of the second vector $\vec{B}$.

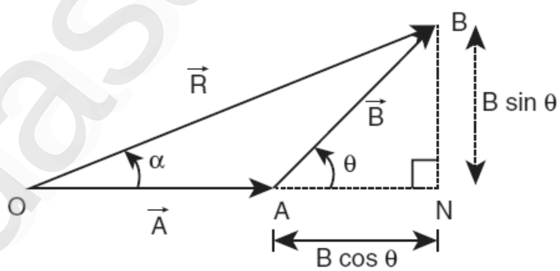


3) The magnitude of $\vec{R}$ (resultant) is given geometrically by the length of $\vec{R}$ (OQ) and the direction of the resultant vector is the angle between

$\vec{R}$ and $\vec{A}$ Thus we write $\vec{R} = \vec{A} + \vec{B}$. ∵ $\vec{OQ} = \vec{OP} + \vec{PQ}$

Magnitude of resultant vector:

4) Consider the triangle ABN, which is obtained by extending the side OA to ON. ABN is a right angled triangle. ½



$\text{Cos } \theta = \frac{AN}{B}$ ∴ AN = B Cos θ *and*

$\text{Sin } \theta = \frac{BN}{B}$ ∴ BN = B Sin θ 1

For ΔOBN,

we have $OB^2 = ON^2 + BN^2$

$\Rightarrow R^2 = (A + B\cos\theta)^2 + (B\sin\theta)^2$

$\Rightarrow R^2 = A^2 + B^2\cos^2\theta + 2AB\cos\theta + B^2\sin^2\theta$ 1½

$\Rightarrow R^2 = A^2 + B^2(\cos^2\theta + \sin^2\theta) + 2AB\cos\theta$

$\Rightarrow \mathbf{R} = \sqrt{\mathbf{A^2 + B^2 + 2AB\,Cos\theta}}$

which is the magnitude of the resultant of *A* and *B*

Direction of resultant vectors:

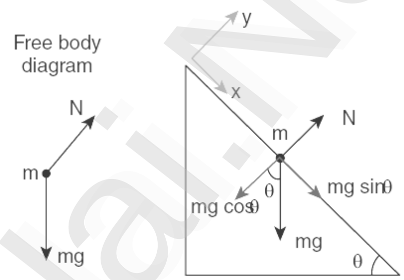
5) If θ is the angle between $\vec{A}$ and $\vec{B}$, then

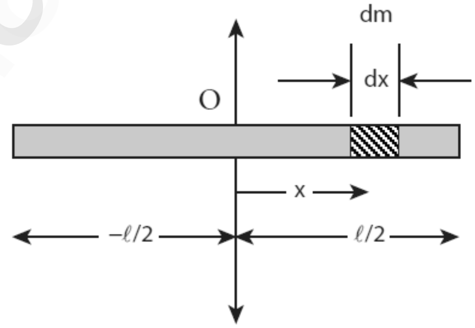
$|\vec{A} + \vec{B}| = \sqrt{A^2 + B^2 + 2AB\,\text{Cos}\theta}$

If $\vec{R}$ makes an angle α with $\vec{A}$, then in ΔOBN, $\tan\alpha = \frac{BN}{ON} = \frac{BN}{OA+AN}$ 1

$\tan\alpha = \left(\frac{B\,\text{Sin}\theta}{A+B\,\text{Cos}\theta}\right)$; $\alpha = \tan^{-1}\left(\frac{B\,\text{Sin}\theta}{A+B\,\text{Cos}\theta}\right)$

Total: 5

35 (a)	**A particle moving in an Inclined Plane:** i) To draw the free body diagram, the block is assumed to be a point mass Since the motion is on the inclined surface, we have to choose the **coordinate system parallel to the inclined surface** as shown in Figure. ii) The gravitational force mg is **resolved in to parallel component** mg sinθ along the inclined plane and **perpendicular component** mg cosθ perpendicular to the inclined surface Figure. iii) Note that the angle made by the gravitational force (mg) with the perpendicular to the surface is equal to the angle of inclination θ iv) There is **no motion (acceleration) along the y axis.** Applying Newton's second law in the direction  $-mg\cos\theta\hat{j} + N\hat{j} = 0$(No acceleration) By comparing the components on both sides, $N - mg\cos\theta = 0$ $N = mg\cos\theta$ v) The magnitude of normal force (N) exerted by the surface is equivalent to mg *cos*θ . The object slides (with an acceleration) along the x direction. Applying Newton's second law in the x direction $mg\sin\theta\,\hat{i} = ma\,\hat{i}$ By comparing the components on both sides, we can equate mg sinθ =ma.The acceleration of the sliding object is a = g sinθ vi) Note that the acceleration depends on the angle of inclination θ. If the angle θ is 90 degrees, the block will move vertically with acceleration *a* = *g*. Newton's kinematic equation is used to find the speed of the object when it reaches the bottom. The acceleration is constant throughout the motion. $v^2 = u^2 + 2as$ along the x direction vii) The acceleration a is equal to g sin θ. The initial speed (u) is equal to zero as it starts from rest. Here, s is the length of the inclined surface. **The speed (v) when it reaches the bottom is** $v = \sqrt{2sg\sin\theta}$	1 1 1 ½ ½ 1	5
35 (b)	**Work – Kinetic Energy Theorem:** 1) It states that work done by the force acting on a body is equal to the change produced in the kinetic energy of the body. 2) Consider a body of mass m at rest on a frictionless horizontal surface. 3) The work (W) done by the constant force (F) for a displacement (s) in the same direction is, W = Fs ------------ (1) The constant force is given by the equation, F = ma --------- (2) The **third equation of motion** can be written as, $v^2 = u^2 + 2as$ $a = \frac{v^2 - u^2}{2s}$ ------------------ (3) Substituting for a in equation (2), $F = m\left(\frac{v^2-u^2}{2s}\right)$ ------------ (4) Substituting equation (4) in (1), $W = m\left(\frac{v^2}{2s}s\right) - m\left(\frac{u^2}{2s}s\right)$	1 1	5

	W = ½ mv^2 – ½ mu^2 ------------------- (5)	1	
	The expression for kinetic energy: i) The term ½ (mv^2) in the above equation is the kinetic energy of the body of mass (m) moving with velocity (v). **KE = ½ mv^2** ----------------- (6)	½	
	ii) Kinetic energy of the body is always positive. From equations (5) and (6) **ΔKE = ½ mv^2 – ½ mu^2** ---------------(7) thus, W = ΔKE iii) The expression on the right hand side (RHS) of equation (7) is the change in kinetic energy (ΔKE) of the body.	1	
	iv) This implies that **the work done by the force on the body changes the kinetic energy of the body**. This is called work-kinetic energy theorem.	½	
36 (a)	**Moment of Inertia of a Rod:** 1) Let us consider a uniform rod of mass (M) and length (*l*) as shown in Figure. Let us find an expression for moment of inertia of this rod about an **axis that passes through the center of mass and perpendicular to the rod.**	1	5
	2) First an origin is to be fixed for the coordinate system so that it coincides with the center of mass, which is also the geometric center of the rod. The rod is now along the x axis. 3) We take an infinitesimally small mass (dm) at a distance (x) from the origin. The moment of inertia (dI) of this mass (dm) about the axis is, **dI = (dm)x^2** As the mass is uniformly distributed, the mass per unit length (λ) of the rod is, $\lambda = \frac{M}{l}$ The (dm) mass of the infinitesimally small length as, dm = λ, dx = $\frac{M}{l}$dx.  	1	
	The moment of inertia (I) of the entire rod can be found by integrating dI, I = $\int dI = \int (dm)x^2$; $\int \left(\frac{M}{l}dx\right)x^2$; I = $\frac{M}{l}\int x^2 dx$	1	
	4) As the **mass is distributed on either side of the origin, the limits for integration are taken from** – $\frac{l}{2}$ to $\frac{l}{2}$ I = $\frac{M}{l}\int_{-\frac{l}{2}}^{\frac{l}{2}} x^2 dx$		

	$= \frac{M}{l}\left[\frac{x^3}{3}\right]_{\frac{-l}{2}}^{\frac{l}{2}}$ $I = \frac{M}{l}\left[\frac{l^3}{24} - \left(-\frac{l^3}{24}\right)\right] \qquad = \frac{M}{l}\left[\frac{l^3}{24} + \frac{l^3}{24}\right]$ $I = \frac{M}{l}\left[2\left(\frac{l^3}{24}\right)\right]$; $I = \frac{1}{12} ml^2$	1 1	
36 (b)	**Escape speed.** 1) Consider an object of mass M on the surface of the Earth. **When it is thrown up with an initial speed v_i , the initial total energy of the object is** $E_i = ½ MV_i^2 - \frac{GMM_E}{R_E}$ ---------------- 1 Where M_E, is the mass of the Earth and R_E - the radius of the Earth. The term $-\frac{GMM_E}{R_E}$ is the potential energy of the mass M. 2) When the object reaches a height far away from Earth and hence treated as approaching infinity, **the gravitational potential energy becomes zero [U (∞) = 0] and the kinetic energy becomes zero as well**. Therefore, **the final total energy of the object becomes zero. This is for minimum energy and for minimum speed to escape.** Otherwise Kinetic energy can be non-zero. $E_f = 0$, According to the law of energy conservation, $E_i = E_f$ ------- 2 Substituting (1) in (2) we get, $½ MV_i^2 - \frac{GMM_E}{R_E} = 0$ $½ MV_i^2 = \frac{GMM_E}{R_E}$ ---------------- 3 3) The escape speed, the minimum speed required by an object to escape Earth's gravitational field, hence replace, V_i with V_e. i.e, $½ MV_e^2 = \frac{GMM_E}{R_E}$ $V_e^2 = \frac{GMM_E}{R_E} . \frac{2}{M}$; $V_e^2 = \frac{2GM_E}{R_E}$ ------------ 4 Using $g = \frac{GM_E}{R_e}$ – – – – – – – – – – – – – – – 5 $V_e^2 = 2gR_E$; $V_e = \sqrt{2gRE}$ ------------- 6 From equation (6) the escape speed depends on two factors: **acceleration due to gravity and radius of the Earth**. It is completely independent of the mass of the object.	1 1 1 1 1	5

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<td>37(a)</td>
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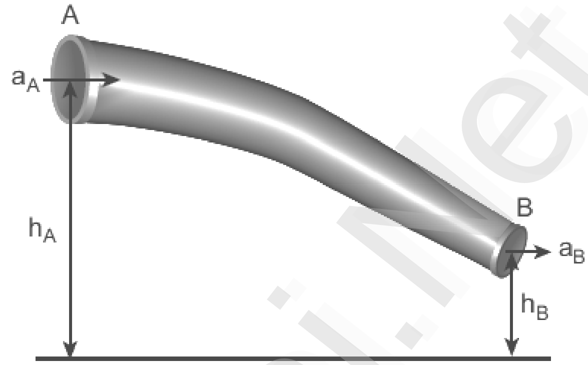
Bernoulli's theorem:

According to Bernoulli's theorem, **the sum of pressure energy, kinetic energy, and potential energy per unit mass of an incompressible, non-viscous fluid in a streamlined flow remains a constant.**

$\frac{P}{\rho} + \frac{1}{2}v^2 + gh =$ **Constant**, this is known as Bernoulli's equation.

Proof:



Let us consider a flow of liquid through a pipe AB as shown in Figure. Let V be the volume of the liquid when it enters A in a time *t* which is equal to the volume of the liquid leaving *B* in the same time. Let a_A, v_A and PA be the area of cross section of the tube, velocity of the liquid and pressure exerted by the liquid at *A* respectively.

Let the **force exerted by the liquid at A is $F_A = P_A a_A$**

Distance travelled by the liquid in time t is $d = v_A t$

Therefore, the work done is $W = F_A d = P_A a_A v_A t$

But $a_A v_A t = a_A d = V$, volume of the liquid entering at A.

Thus, the **work done is the pressure energy (at A), $W = F_A d = P_A V$**

Pressure energy per unit volume at A = $\frac{\text{Pressure energy}}{\text{Volume}} = \frac{P_A V}{V} = P_A$

Pressure energy per unit mass at A = $\frac{\text{Pressure energy}}{\text{Mass}} = \frac{P_A V}{m} = \frac{P_A}{\frac{m}{V}} = \frac{P_A}{\rho}$

Since m is the mass of the liquid entering at A in a given time, therefore, pressure energy of the liquid at A is $E_{PA} = P_A V = P_A V \times \left(\frac{m}{m}\right) = m\frac{P_A}{\rho}$

Potential energy of the liquid at A, $P_{EA} = mg\,h_A$,

Due to the flow of liquid, the **kinetic energy of the liquid at A,**

$KE_A = ½\,mV_A^2$

Therefore, the total energy due to the flow of liquid at A,

$E_A = EP_A + KE_A + PE_A$

$E_A = m\frac{P_A}{\rho} + ½\,mV_A^2 + mgh_A$

Similarly, let a_B, v_B, and P_B be the area of cross section of the tube, velocity of the liquid, and pressure exerted by the liquid at B. Calculating the total energy at E_B, we get $E_B = m\frac{P_B}{\rho} + ½\,mV_B^2 + mgh_B$

From the **law of conservation of energy, $E_A = E_B$**

$E_A = m\frac{P_A}{\rho} + ½\,mV_A^2 + mgh_A = E_B = m\frac{P_B}{\rho} + ½\,mV_B^2 + mgh_B$

$\frac{P_A}{\rho} + ½\,V_A^2 + gh_A = \frac{P_B}{\rho} + ½\,V_B^2 + gh_B =$ **constant**

Thus, the above equation can be written as $\frac{P}{\rho g} + \frac{1}{2}\frac{v^2}{g} + h =$ **constant**

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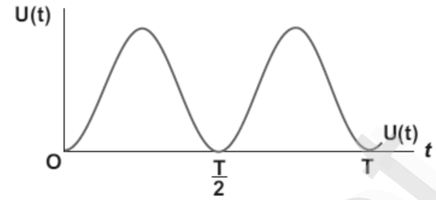
37 (b)	**Meyer's relation** 1) Consider μ mole of an ideal gas in a container with volume V, pressure P and temperature T. 2) When **the gas is heated at constant volume the temperature increases by dT. As no work is done by the gas, the heat that flows into the system will increase only the internal energy**. Let the change in internal energy be dU. If Cv is the molar specific heat capacity at constant volume, $\mathbf{dU = \mu C_v dT}$ ------------ 1 3) Suppose the gas is heated at constant pressure so that the temperature increases by dT. If 'Q' is the heat supplied in this process and 'dV' the change in volume of the gas. $\mathbf{Q = \mu C_p dT}$ ----------- 2 4) If W is the work done by the gas in this process, then W = PdV ------------3 But from the first law of thermodynamics, **Q = dU + W** --------4 Substituting equations (1), (2) and (3) in (4), we get, $\mathbf{\mu C_p dT = \mu C_v\, dT + PdV}$ -----------5 5) For mole of ideal gas, the equation of state is given by PV = μRT ⇒ PdV+VdP = μRdT ---------- 6 Since the pressure is constant, dP=0 $\therefore C_p dT = C_v dT + RdT$ $\mathbf{\therefore C_P = C_v + R}$ **(or)** $\mathbf{C_p - C_v = R}$ ----------- 7 This relation is called Meyer's relation	1 1 1 1 1	5
38 (a)	**Energy in Simple Harmonic Motion:** **a. Expression for Potential Energy** 1) **For the simple harmonic motion, the force and the displacement are related** by Hooke's law $\vec{F} = -k\vec{r}$ 2) Since force is a vector quantity, **in three dimensions it has three components.** Further, the force in the above equation is a conservative force field; such a force can be derived from a scalar function which has only one component. In one dimensional case **F = − kx** --------------- (1) **The work done by the conservative force field is independent of path.** The potential energy U can be calculated from the following expression. $F = \frac{dU}{dx}$ ------------ 2 Comparing (1) and (2), we get $-\frac{dU}{dx} = -kx$; dU = kxdx 3) This work done by the force F during a small displacement dx stores as potential energy $U(x) = \int_0^x kx'\,dx = \frac{1}{2}(x')^2\Big\vert_0^x = \frac{1}{2}kx^2$ ------ 3 From equation $\omega = \sqrt{\frac{k}{m}}$, we can substitute the value of force constant	½ ½	5

k = mω² in equation (3), U(x) = m $\omega^2 x^2$

4) where ω is the natural frequency of the oscillating system. For the particle executing simple harmonic motion from equation $x = A \sin \omega t$

$U(t) = \frac{1}{2} m\omega^2 A^2 \sin^2 \omega t$ ------------4 ½

This variation of U is shown below.



b. Expression for Kinetic Energy

½

Kinetic energy $KE = \frac{1}{2} m v_x^2 = \frac{1}{2} m \left(\frac{dx}{dt}\right)^2$

Since the particle is executing simple harmonic motion, from equation

$y = A \sin \omega t$; $x = A \sin \omega t$ Therefore, velocity is $v_x = \frac{dx}{dt} A\, \omega \cos \omega t$

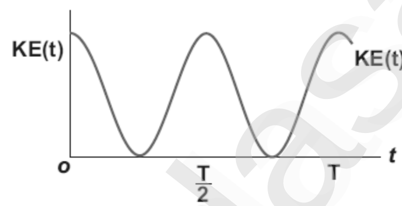
$$= a\omega\sqrt{1-\left(\frac{x}{A}\right)^2} \; ; v_x = \omega\sqrt{A^2 - x^2} \text{ -------------- } 5$$

1

Hence, $KE = \frac{1}{2} m v_x^2 = \frac{1}{2} m\omega^2 (A^2 - x^2)$ ------------ 6

$KE = \frac{1}{2} m\omega^2 A^2 \cos^2 \omega t$ ------------- 7

This variation with time is shown below.



c. Expression for Total Energy

Total energy is the sum of kinetic energy and potential energy

$E = KE + U$ ------------8 ; **$E = \frac{1}{2} m\,\omega^2 (A^2 - x^2) + \frac{1}{2} m\,\omega^2 x^2$**

Hence, cancelling x^2 term, $E = \frac{1}{2} m\,\omega^2 A^2$ = Constant ----------9 1

Alternatively, from equation (4) and equation (7),

we get the total energy as **$E = \frac{1}{2} m\omega^2 A^2 \sin^2 \omega t + \frac{1}{2} m\omega^2 A^2 \cos^2 \omega t$**

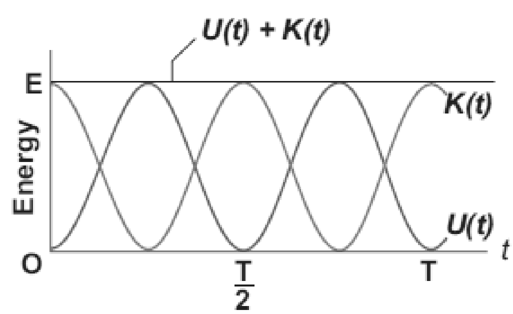
$E = \frac{1}{2} m\omega^2 A^2 (\sin^2 \omega t + \cos^2 \omega t)$

From trigonometry identity,

$(\sin^2 \omega t + \cos^2 \omega t) = 1$

$E = \frac{1}{2} m\omega^2 A^2$ = Constant.

which gives the law of conservation of total energy 1



This is depicted in Figure. Thus the amplitude of simple harmonic oscillator, can be expressed in terms of total energy. **$A = \sqrt{\frac{2E}{m\omega^2}} = \sqrt{\frac{2E}{k}}$**

38 (b)	Newton assumed that **when sound propagates in air, temperature of the medium remains constant (OR)** Heat produced during **compression (pressure increases, volume decreases)**, and heat lost during **rarefaction** (**pressure decreases, volume increases)**.	½	
	$PV = \text{Constant}$	½	
	$P = -V\frac{dP}{dV} = K_T$	½	
	$V_T = \sqrt{\frac{K_T}{\rho}} = \sqrt{\frac{P}{\rho}}$	½	
	$V_T \approx 280\ ms^{-1}$	½	
	Laplace's correction: **Temperature is no longer considered as a constant (OR)** Laplace assumed that when the sound propagates through a medium, the **particles oscillate very rapidly** such that the **compression and rarefaction occur very fast.** Hence the exchange of **heat produced due to compression** and **cooling effect due to rarefaction** do not take place, because, air (medium) is a bad conductor of heat.	½	5
	$Pv^{\gamma} = \text{Constant}$	½	
	$\gamma^{P} = -V\frac{dP}{dV} = K_A$	½	
	$V_A = \sqrt{\frac{K_A}{\rho}} = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\gamma}V_T$	½	
	$V_A = 331.30\ ms^{-1}$	½	