QUESTION PAPER
PHYSICS
CLASS XI

GENERAL INSTRUCTIONS

1. Attempt all Questions.
2. Question No. 1 to Question No. 4 are Multiple Choice Questions with only one correct choice for the answer. Each carries one mark.
3. Question No. 5 to Question No. 8 are Very Short Answer Type Questions and each carries one mark.
4. Question No. 9 to Question No.15 are Short Answer Type Questions carrying two marks each, provided with internal choice in one Question only.
5. Question No. 16 to Question No.26 are Short Answer Type Questions carrying three marks each, provided with internal choice in one Question only.
6. Question No. 27 to Question No. 29 are Long Answer Type Questions carrying five marks each, provided with internal choice in each Question.
7. Use of Calculators is not permitted. However, log tables may be requested.

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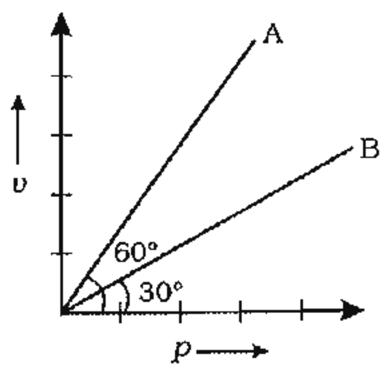
1. The pair of physical quantities which have the same dimensions is
   1. Force and Torque
   2. Force and Energy
   3. Torque and Angular momentum
   4. Energy and Torque.

2. The velocity (v) versus momentum (p) graph for two bodies A and B is as shown in the figure. The ratio of the masses A and B is
   1. 1:2
   2. 2:1
   3. 1:3
   4. 3:1



3. Moment of inertia of a ring of mass M and radius R about an axis passing through its centre and perpendicular to the plane is given by
   1. MR^2
   2. $MR^2/2$
   3. $MR^2/4$
   4. $MR^2/6$

4. A body executing SHM has acceleration which is directly proportional to
   1. displacement (x) and is in the same direction
   2. x^3 and is in the same direction
   3. x and is in the direction opposite to displacement
   4. x^2 and is in the direction opposite to displacement.

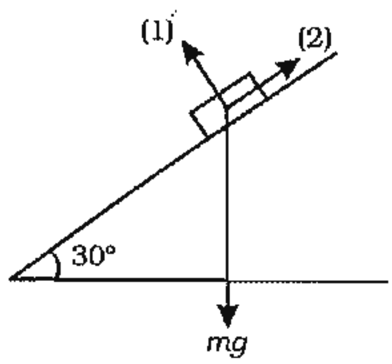
5. The momentum of a body of mass m is uniformly increasing. Plot a graph showing variation of its kinetic energy as a function of momentum.

6. Give the direction of the net force acting on a stone of mass 0.1 kg immediately after it is dropped from the window of a moving train.

7. What is the amount of work done by a body, moving with a speed v in a circular orbit of radius R?

8. In which of the medium: air or iron, is the speed of sound at STP greater?

9. A block of wood of mass 3 kg is resting on the surface of a rough inclined plane at an angle 30°, as shown in the figure
   a) Name the forces 1 and 2,
   b) Calculate the force 1.



10. a) Define coefficient of restitution.
    b) What is the value of coefficient of restitution for a
       i) perfectly elastic collision?
       ii) perfectly inelastic collision?

11. Derive an expression for the total energy of a satellite orbiting the earth. What is the significance of negative total energy?

OR

State and prove Kepler's second law of planetary motion.

12. Three small blocks of masses m, m and 2 m are placed at three corners of a triangle having coordinates (2, 1), (3, 1) and (3, 3) respectively. Find the centre of mass of the system.

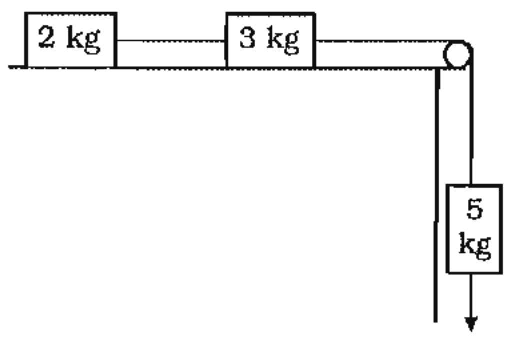
13. Show that there is always an excess pressure on the concave side of the liquid meniscus.

14. State First Law of Thermodynamics. Apply this law to determine the change in the internal energy during adiabatic process.

15. Two non-reactive gases, each at temperature T, volume V and pressure P are mixed such that the temperature and volume of the mixture are T and V respectively. What would be the pressure of the mixture? Justify your answer on the basis of Kinetic Theory.

16. A body is thrown vertically upwards with a certain velocity from a point A located at height h, above the ground. It takes time t_1 to reach the ground. If it is thrown from the same point vertically downwards with the same velocity, it takes time t_2 to reach the ground. Show that the time t_3 it will take to reach the ground when it is dropped from rest from the same point is given by $t_3 = \sqrt{(t_1 \times t_2)}$.

17. Three blocks of masses 2 kg, 3 kg and 5 kg are connected to each other by means of a massless and inextensible string as shown in the figure below



Draw the diagram showing the directions of various forces involved. Also, calculate

i. acceleration of the system,

ii. the tension in each string.

(The value of g may be taken as 10 m/s^2.)

18. (a) Differentiate between elastic and inelastic collisions.

(b) A body of mass m_1 moving with velocity v_1 undergoes a head-on collision with another body of mass m_2 at rest. Considering it one dimensional elastic collision, deduce an expression for their velocities after collision.

OR

A block of mass M is suspended from fixed support through an inextensible string. A bullet of mass m is fired horizontally with a velocity v towards the block. It hits the block and gets embedded in it. Deduce an expression for (i) height to which block-bullet system rises up; and (ii) loss in the kinetic energy of bullet.

19. Why are roads banked? A train has to negotiate a turn of radius 200 m with a velocity of 54 km/h. The horizontal distance between two rails is 1.5 m. Find the height by which the outer rail should be raised for safe turning of train? (The value of g may be taken as 10 m/s^2.)

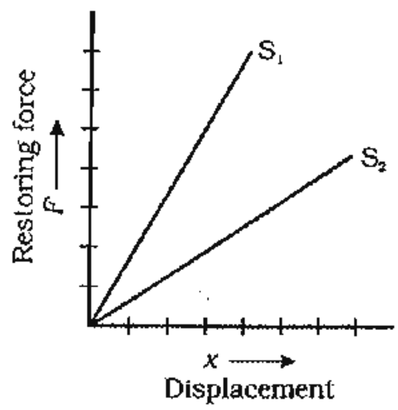
20. Imagine one starts from the centre of earth and moves radially away till the person reaches far away from the surface of earth. Plot a graph showing variation of acceleration due to gravity (g) with distance x from the centre of earth. How will the value of acceleration due to gravity on earth's surface change if the earth suddenly (i) shrinks to $1/8^{th}$ of its present volume; and (ii) stops rotating on its axis. Justify your answer.

21. (a) Name the factors on which angular momentum of a rotating body depends.

(b) A man of 100 kg is standing at the centre of a turntable, which is in the form of uniform circular disc of mass 200 kg and radius 2 m. The turntable is rotating at the rate of 10 rotations per minute. Find the speed of rotation of the turntable if the man moves to a point (i) 1 m; and (ii) 2 m, away from the centre.

22. N small liquid droplets each of radius r combine to form a single drop of radius R. Taking T, ρ *and* S as the surface tension, density and specific heat capacity of the liquid respectively. Deduce an expression for the change in (i) surface energy; and (ii) temperature in this process.

23. Restoring force (F) versus displacement (x) graphs for two springs S_1 and S_2 is as shown in the figure.



(i) Which of the two springs has greater value of force constant?
(ii) On which spring is more work done when both are (a) stretched by equal forces (F) and (b) stretched by equal amount (x)?
Justify your answers.

24. (a) Why is the efficiency of a real engine not equal to 1?

(b) A heat engine operates between its surrounding at 27 °C and unknown source temperature. Its efficiency gets doubled when the temperature of surroundings is reduced to – 23 °C and source temperature is increased by 100 °C. Find the temperature of source?

25. (a) Distinguish between C_p and C_v.

(b) Five moles of a diatomic gas at 100 °C are mixed with 3 moles of a monatomic gas at 40 °C under the conditions of constant volume. Calculate the final temperature of the mixture.

26. (a) The length of the string of a simple pendulum is measured to be 20.0 cm known to 1 mm accuracy. The time for 100 oscillations of the pendulum is found to be 90 s using a wrist watch of 1 s resolution. Based on this data, find the percentage error in the determination of the value of g.

(b) The length of a rectangle is more than its breadth. Which out of the two will contribute more in the calculation of percentage error in the area and why?

27. (a) Define instantaneous velocity. How does one find instantaneous velocity from a displacement – time graph?

(b) Draw the nature of a velocity – time graph for a body moving with a uniform acceleration having initial velocity u. Use this graph to derive an expression for the distance covered by it in time t.

OR

(a) A body is thrown with a velocity u making angle θ with the ground. Show that it describes a parabolic path.

(b) Show that there are two instants of time for attaining the same height during the flight of a projectile. Hence show that the sum of these times is equal to the total time of flight.

28. (a) A wire of alloy material, suspended from a rigid support, is being continuously loaded. Draw and label its stress-strain curve upto its breaking point. Explain in what region of this curve Hook's law is valid.

(b) Determine the volume contraction of a solid copper cube of 10 cm edge when subjected to a hydraulic pressure of 7.0×10^6 Pa. [Given the bulk modulus of elasticity of copper = 140×10^9 N/m^2.]

OR

(a) State and verify Bernoulli's principle.

(b) A cylindrical vessel of uniform cross-section contains liquid upto the height H. At a depth $h = H/2$ below the free surface of a liquid there is an orifice. Using Bernoulli's theorem, find the velocity of efflux of the liquid.

29. (a) A particle is executing simple harmonic motion such that it oscillates equally on both the sides from the mean position. Deduce expressions for its kinetic and potential energies at any instant. Find the point at which the particle has equal kinetic and potential energies.

(b) Show that the motion of a particle represented by

$$y = \sin \omega t - \cos \omega t$$

is simple harmonic with a period of $(2\pi/\omega)$.

OR

(a) What is Doppler effect of sound? Obtain an expression for the apparent frequency of sound when the source and the listener are approaching each other.

(b) A harmonic wave travelling along z axis on a string is described by

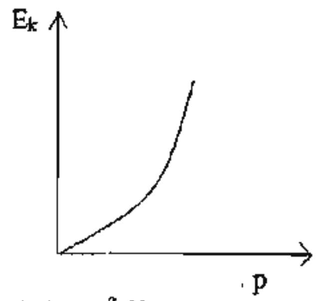
$$y\,(z, t) = 2.5 \sin (0.5z + 50\,\pi t + \pi/4)$$

Here y and z are in cm and t is in s. Find (i) the frequency; and (ii) the velocity of the wave.

MARKING SCHEME
PHYSICS
CLASS XI

Marks

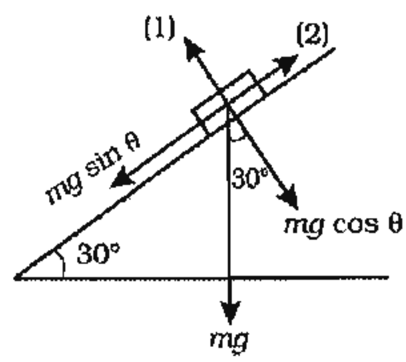
1.	4	1
2.	3	1
3.	1	1
4.	3	1
5.		1



[Hint: $KE = p^2/2m$ or $KE \propto p^2$]

6.	Vertically downward	1
7.	Zero	1
8.	Iron	1
9. (a)	Force (1) – Normal reaction	½
	Force (2) – Force of static friction	½

(b)



½

∴ Force (1) = $mg \cos\theta$

= $3 \times 10 \cos 30° = 15$ N. ½

[Hint: As the block remains in contact with the inclined plane]

10. (a) It is defined as the ratio of the magnitude of the relative velocity of separation after collision of two bodies to the magnitude of the relative velocity of approach before their collision. 1

(b) (i) 1 ½

(ii) 0 ½

11. Total energy $= K.E. + P.E.$

$= \frac{1}{2} mv^2 + (- GMm/r)$ ½

$= \frac{1}{2} m \left[\sqrt{\frac{Gm}{r}} \right]^2 - G \frac{Mm}{r}$

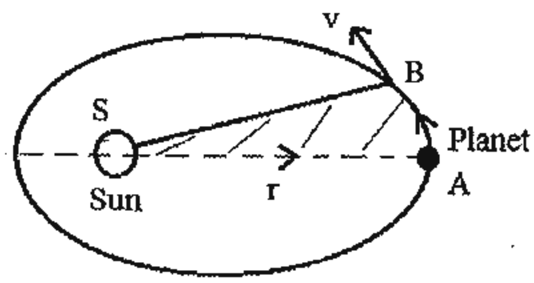
$= - 1/2\ (GMm/r)$ ½

Negative sign of total energy signifies that the satellite remains bound to the earth while orbiting around the earth. ½

OR

Kepler's second law states that the radius vector drawn from the Sun to the planet sweeps equal areas in equal intervals of time or the areal velocity of the planet around the Sun remains constant.

Proof: ½



Area swept in time Δt, $\Delta \bar{A} = \frac{1}{2}(\bar{r} \times \overline{AB}) = \frac{1}{2} \bar{r} \times \bar{v}\,\Delta t$ ½

$\therefore \frac{\Delta \bar{A}}{\Delta t} = \frac{1}{2m}(\bar{r} \times m\bar{v}) = \frac{\bar{L}}{2m}$ ½

As angular momentum $(\vec{L})$ of the planet is constant,

$\therefore \frac{\Delta \bar{A}}{\Delta t} = \text{constant}$ ½

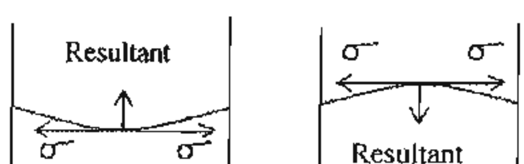
12. $X_{cm} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$ ½

$= \frac{m \times 2 + m \times 3 + 2m \times 3}{m + m + 2m} = \frac{11}{4}$ ½

$Y_{cm} = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3}{m_1 + m_2 + m_3}$ ½

$= \frac{m \times 1 + m \times 1 + 2m \times 3}{m + m + 2m} = 2$ ½

13.



½ each

For the liquid meniscus to remain in its curved shape i.e. in equilibrium, the pressure on the concave side must be greater than on convex side. 1

14. According to this law, when heat is supplied to a system capable of doing the work, then the amount of heat absorbed by the system is equal to the sum of the change in the internal energy of the system and the amount of work done by the system. 1

From $dQ = dU + dW$

For adiabatic change, $dQ = 0$ ½

$\therefore \quad dU = -dW$ ½

15. From kinetic theory, $P = \frac{1}{3}\frac{M c_{rms}^2}{V}$

$\therefore P \propto \frac{M\ c_{rms}^2}{V}$ ½

But, $c_{rms}^2 \propto T$ ½

$\therefore P \propto \frac{MT}{V}$ ½

Due to mixing of the two gases, only M increases (doubled).
Hence, the pressure exerted gets doubled i.e. $2P$. ½

16. (a) When thrown vertically upwards,

From $s = ut + ½ at^2$ ½

Using sign convention

$$-h = ut + \frac{1}{2}(-gt^2)$$ ½

$$-h = ut_1 - \frac{1}{2}gt_1^2 \qquad (1)$$ ½

(b) When thrown vertically downwards

$$-h = ut_2 - \frac{1}{2}gt_2^2 \qquad (2)$$ ½

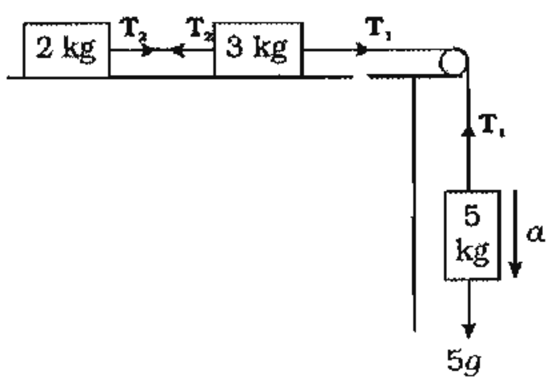
(c) When dropped from rest

$$-h = -\frac{1}{2}gt_3^2 \qquad (3)$$ ½

Using equations (1), (2) and (3), the desired relation is 1

$$t_3 = \sqrt{t_1 \times t_2}$$

17.



1

Let a be the acceleration of the system

For Block of mass 5 kg

$Mg - T_1 = Ma$

or, $5g - T_1 = 5a \qquad (1)$ ½

For 3 kg block, $T_1 - T_2 = 3a \qquad (2)$

For 2 kg block, $T_2 = 2a$ (3)

Using equations (1), (2) and (3) and solving, we get

$a = g/2$ ½

$T_1 = 5g/2$ ½

$T_2 = g$ ½

18.

Before Collision After Collision 1

Applying, conservation of linear momentum and kinetic energy, we have

$\therefore\ m_1u_1 = m_1v_1 + m_2v_2$ (1) ½

and $\frac{1}{2} m_1u_1^2 = \frac{1}{2} m_1v_1^2 + \frac{1}{2} m_2v_2^2$

or $m_1u_1^2 = m_1v_1^2 + m_2v_2^2$ (2) ½

Using equations (1) and (2), we have

$u_1 + v_1 = v_2$

Using it, we get

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) u_1$$ ½

and $$v_2 = \frac{2m_1 u_1}{m_1 + m_2}$$ ½

OR

Applying conservation of momentum and mechanical energy, we have

$mu = (m + M)\, v$ (1) ½

$\frac{1}{2} mu^2 = \frac{1}{2}(m + M)v^2 + \Delta E_k$ (2) ½

Here ΔE_k is the loss of K.E. of the bullet

and $\frac{1}{2} (m + M)v^2 = (m + M)gh$ (3) ½

Using equations (1), (2) and (3), we get

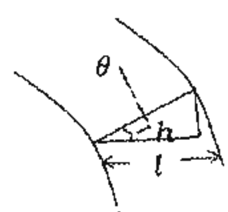
$$h = \left(\frac{m^2u^2}{2g\,(m + M)}\right)$$ 1

and $$\Delta E_k = \left[\frac{mMu^2}{2\,(m + M)}\right]$$ ½

19. On a banked curved road, the necessary centripetal force is provided by the horizontal component of the normal reaction and not by the frictional force between the tyres and the road. Hence, wear and tear of the tyres is reduced. 1

$\tan\theta = h/l$ ½

Also, $\tan\theta = v^2/rg$ ½

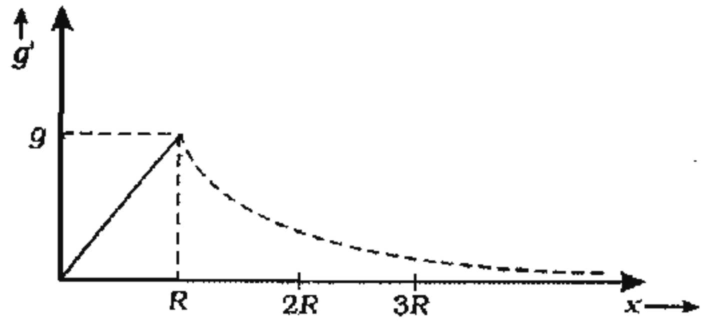


Using equations (1) and (2), we get ½

$h = v^2 l/rg$

= 0.169 m or 16.9 cm ½

20.



1

(i) As earth shrinks to $1/8^{th}$ of its present volume, new radius R, becomes half its initial radius R. ½

∴ From $g = G\frac{M}{R^2}$

Due to gravity on earth's surface becomes four times its initial value (g) ½

(ii) Value of g increases and becomes maximum

As $g' = g - R\,\omega^2 \cos^2 A$ ½

If $\omega = 0$, $g' = g$ ½

21. (a) Two factors are (i) moment of inertia and (ii) angular velocity of the body about the axis of rotation ½ + ½

(b) i. Applying conservation of angular momentum

$I_T\omega_1 = (I_T + I_m)\,\omega_2$ ½

$½\, m_T R_T^2 \times 10 = (½\, m_T R_T^2 + m_m x^2)\,\omega_2$

$½ \times 200 \times 2^2 \times 10 = (½ \times 200 \times 2^2 + 100 \times 1^2)\,\omega_2$ ½

$\therefore \omega_2 = 8$ rotations per minute

ii. $I_T\omega_1 = (I_T + I_m)\,\omega_2$ ½

$\therefore \omega_2 = 5$ rotations per minute ½

22. Change (decrease) in surface area due to combination

$\Delta A = 4\pi r^2 N - 4\pi R^2$

∴ Change in surface energy $\Delta U = \mathbf{T.dA}$ ½

$\Delta U = T \times 4\pi\,(Nr^2 - R^2)$ ½

∴ Heat produced $Q = \Delta U = 4\pi \times T\,(Nr^2 - R^2)$ ½

Let, Q be rise in temperature of drop

From $Q = m\,s\,\theta$ ½

or $\therefore m\,s\,\theta = 4\pi \times T\,(Nr^2 - R^2)$ ½

$(4\pi/3)\,R^3 \rho\, s\,\theta = 4\pi \times T\,(Nr^2 - R^2)$

$\therefore \theta = (3T/\rho s) \times [(Nr^2/R^3) - (1/R)]$

But $(4\pi/3)\,R^3 = N \times (4\pi/3)\,r^3$

$\therefore Nr^2 = (R^3/r)$

$\therefore \theta = (3T/\rho s) \times [(1/r) - (1/R)]$ ½

23. (i) S_1 ½

Force constant K ($=F/x$)

i.e. slope of the line is greater for S_1. ½

(ii) (a) Work done in stretching a spring by a force (F)

$W = ½ Kx^2 = ½ K(F/K)^2 = (F^2/2K)$ ½

∴ More work will be done on S_2. ½

(b) Work done in stretching a spring by x

$W = ½ Kx^2$ ½

∴ More work will be done on S_1. ½

24. (a) In a real engine, the working substance has to reject some heat to its surroundings *i.e.* $Q_2 \neq 0$

Hence, efficiency, $\eta = 1 - (Q_2/Q_1) < 1$ 1

(b) From, $\eta = 1 - (T_2/T_1)$ ½

$\eta_1 = 1 - [(273 + 27)/T_1] = 1 - (300/T_1)$ (1) ½

and, $\eta_2 = 1 - \{[(273 + (-23)]/(T_1 + 100)\}$

$\eta_2 = 1 - [250/(T_1+100)]$ (2) ½

But since $\eta_2 = 2\eta_1$

On solving equations (1) and (2), we get

$T_1 = 400$ K or 127 °C ½

25. Difference between C_p and C_v. 1

Let the final temperature of the mixture be T

∴ Heat lost of 5 moles of diatomic gas = Heat gained by 3 moles of mono atomic gas

$5 \times (5/2) R \times (373 - T) = 3\times(3/2) R \times (T - 313)$ 2

On solving it, we get

$T = 357.1$ K or 84.1 °C 1

26. (a) From $T = 2\pi\sqrt{(l/g)}$

$g = 4\pi^2(l/g)$

or $g \propto (l/T^2)$ 1

Maximum percentage error in determination of the value of g

$(\Delta g/g) \times 100 = (\Delta l/l) \times 100 + 2 (\Delta T/T) \times 100$

$= (0.1/20) \times 100 + 2 \times (1/90) \times 100$ %

$= 2.72$ % 1

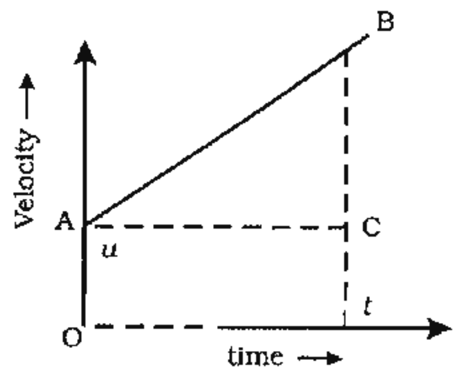
(b) Breadth.

Because $(\Delta b/b) > (\Delta l/l)$ 1

27. (a) Definition of instantaneous velocity. 1

The instantaneous velocity can be found by knowing the value of slope of displacement-time graph at that instant. ½

(b)



Acceleration $(a) = (BC/AC)$, or $BC = a \times AC = at$ ½ 1 ½

Distance (s) covered in time t

= area of ABDO

= area of rectangle OACD + area of ΔABC ½

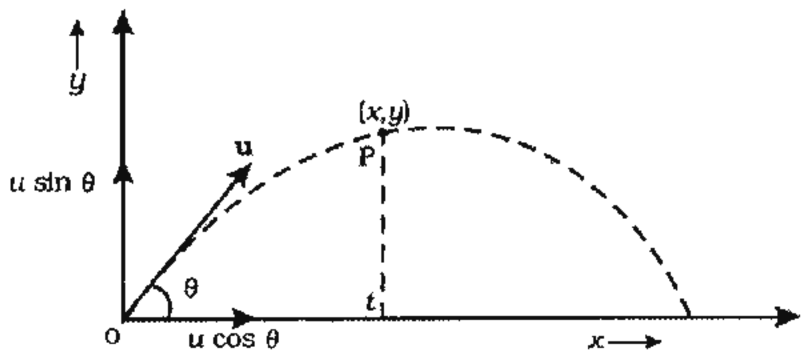
= $(AO \times OD) + ½ \times AC \times BC$ ½

= $u \times t + ½\, t \times at$

$\therefore\ s = ut + ½\, at^2$ ½

OR

(a)



Let the body be at point P after time t

$\therefore\ x = u \cos\theta\, t$ ½

and from $s = ut + ½\, at^2$ (1)

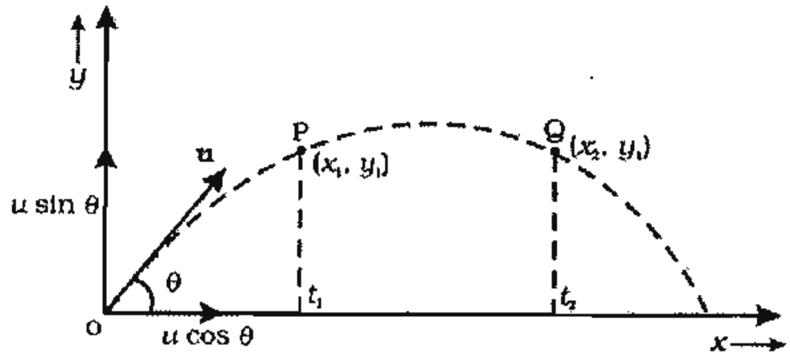
$y = (u \sin\theta)\, t - ½ gt^2$ (2) ½

Putting $t = x/(u \cos\theta)$ in equation (2) and on simplifying we get

$y = x \tan\theta - g/(2u^2 \cos^2\theta)\, x^2$ (3) ½

Equation (3) is of the form $y = Ax - Bx^2$, which is an equation of a parabola. ½

(b)



½

At point P $\quad y_1 = u\sin\theta\, t_1 - \frac{1}{2} g t_1^2$ ½

And at point Q $\quad y_2 = u\sin\theta\, t_2 - \frac{1}{2} g t_2^2$ ½

But $\quad y_1 = y_2$

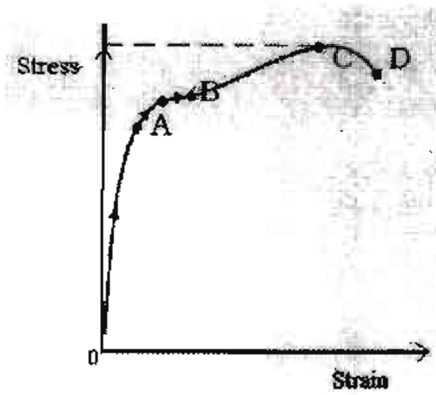
$\therefore \; (u\sin\theta\, t_1 - \frac{1}{2} g t_1^2) = (u\sin\theta\, t_2 - \frac{1}{2} g t_2^2)$ ½

$\therefore \; u\sin\theta\,(t_2 - t_1) = g/2\,(t_2^2 - t_1^2)$

$\therefore \quad t_1 + t_2 = 2u\sin\theta/g$ ½

$=$ Time of flight ½

28. (a)



1

Labelling

OA - Proportional elastic region

AB - Non-proportional elastic region, Point B being yield point

BC - Plastic region, Point C gives Ultimate Tensile Strength

Point D - Breaking point 1½

In region OA, stress is directly proportional to strain.

Hence, Hooke's law is valid only in OA region . ½

(b) Bulk modulus $\quad K = (pv/\Delta v)$ ½

or $\quad \Delta v = (pv/K)$

$= (7 \times 10^6 \times 10^{-3})/(140 \times 10^9)$ 1

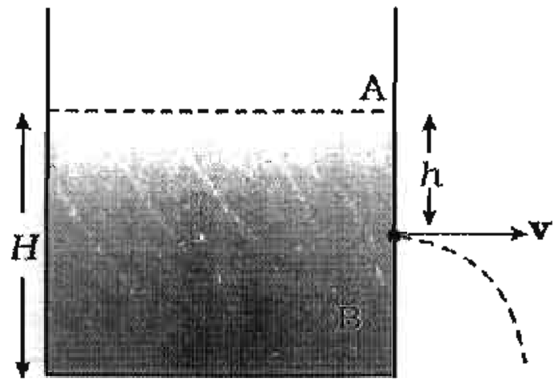
$= 0.05 \times 10^{-6}\ m^3$ ½

OR

(a) Statement for Bernoulli's principle 1

Verification of Bernoulli's principle 2

(b)



1

Appling Bernoulli's principle at a point A
on surface and at point 'B' on the hole, we get
$P_A + \rho gH = P_B + \frac{1}{2}\rho v^2 + \rho g(H - h)$
Since tank is open to atmosphere, $P_A = P_B$
$\therefore \quad v \quad = \quad \sqrt{(2gh)}$ 1

29. (a) $x = A \sin \omega t$
$\therefore$ Particle velocity, $v = (dx/dt) \quad = A\omega \cos\omega t$
Kinetic energy of the particle $= \frac{1}{2}mv^2 = \frac{1}{2}\, m\omega 2A^2 \cos^2\omega t$
or $\quad E_K \quad = \frac{1}{2}KA^2\cos^2\omega t$ 1
Potential energy of the particle
= work done to displace the particle further by dx

$dw \quad = Fdx = \int_0^x Kx\,dx$

$= \frac{1}{2}Kx^2$

or $\quad$ potential energy $= \frac{1}{2}KA^2\sin^2\omega t$ 1

For kinetic and potential energies to be equal at a point
$\frac{1}{2}KA^2\cos^2\omega t = \frac{1}{2}Kx^2$
or $A^2(1 - \sin^2\omega t) = x^2$
$A^2\,[1 - (x^2/A^2) = x^2$
$A^2 - x^2 = x^2$
or $\quad x = \pm A/\sqrt{2}$ 1

(b) $y \quad = \sin\omega t - \cos\omega t$
$= \sqrt{2}\,(\sin\omega t \times \cos\pi/4 - \cos\omega t \times \sin\pi/4)$
$= \sqrt{2}\,\sin(\omega t - \pi/4)$ 1½
Hence, it represents SHM with time period
$T = 2\pi/\omega$ ½

OR

(a) Meaning/statement of Doppler effect 1
Derivation of $v' = [(c + v_l)/(c - v_s)]v$ 2

(b) Comparing given equation with

$y(z, t) = A \sin[(2\pi (z/\lambda) \div 2\pi(t/T) + \phi)]$ ½

(i) we get $(2\pi/T) = 50\pi$

Frequency, $\nu = 1/T = 25$ Hz ½

(ii) $(2\pi/\lambda) = 0.5$

$\lambda = 4\pi$ cm ½

Velocity of wave, $v = \nu\lambda$

$= 25 \times 4\pi$

$= 100\pi$ or 314 cm/s ½