

SAMPLE QUESTION PAPERS

DESIGN OF QUESTION PAPER

PHYSICS CLASS XI

TIME: 3 Hrs.

MAX. MARKS: 70

The weightage or the distribution of marks over different dimensions of the question paper shall be as follows:

A. Weightage to content/subject units

Sr. No.	Unit	Marks
1.	Physical world and measurement	03
2.	Kinematics	10
3.	Laws of motion	10
4.	Work, Energy and Power	06
5.	Motion of system of particles and rigid body	06
6.	Gravitation	05
7.	Properties of bulk matter	10
8.	Thermodynamics	05
9.	Behaviour of perfect gas and kinetic theory of gases	05
10.	Oscillation and waves	10
	Total	70

B. Weightage to form of questions

Sr. No.	Form of Question	Marks for each question	No. of Question	Total Marks
1.	Long Answer Type (1A)	5	3	15
2.	Short Answer (SAI)	3	09	27
3.	Short Answer (SAII)/ Multiple Choice Question (MCQ)	2	10	20
4.	Very Short Answer (VSA)/ Multiple Choice Question (MCQ)	1	08	08
	Total	–	30	70

1 Mark question may be Very Short Answer (VSA) type or Multiple choice Question with only one option correct.

2 Mark question may be Short Answer (SAII) or Multiple choice Question with more than one option correct.

C. Scheme of options

1. There will be no over all option.
2. Internal choices (either for type) on a very selective basis has been given in some questions.

D. Weightage to difficulty levels of questions

Sr. No.	Estimated difficulty level	Percentage
1.	Easy	15
2.	Average	70
3.	Difficult	15

Topic	VSA (1 Mark)	SAI (2 Marks)	SA II (3 Marks)	LA (5 Marks)	Total
I Physical Work and Measurement	1 (1)	2 (1)	—	—	3 (2)
II Kinematics	1 (1)	4 (2)	—	5 (1)	10 (4)
III Laws of Motion	1 (1)	—	9 (3)	—	10 (4)
IV Work, Energy and Power	1 (1)	2 (1)	3 (1)	—	6 (3)
V Motion of System of Particles & Rigid body	1 (1)	2 (1)	3 (1)	—	6 (3)
VI Gravitation	—	2 (1)	3 (1)	—	5 (2)
VII Properties of bulk of Matter	—	2 (1)	3 (1)	5 (1)	10 (3)
VIII Thermodynamics	—	2 (1)	3 (1)	—	5 (2)
IX Behavior of Perfect gas & Kinetic Theory of gases	1 (1)	4 (2)	—	—	5 (3)
X Oscillation & Waves	2 (2)	—	3 (1)	5 (1)	10 (4)
Total	8 (8)	20 (10)	27 (9)	15 (3)	70 (30)

SAMPLE PAPER I
PHYSICS – XI

Time : Three Hours

Max. Marks : 70

General Instructions

- (a) All questions are compulsory.
- (b) There are 30 questions in total. Questions 1 to 8 carry one mark each, questions 9 to 18 carry two marks each, questions 19 to 27 carry three marks each and questions 28 to 30 carry five marks each.
- (c) 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 three questions of five marks each. You have to attempt only one of the given choices in such questions.
- (d) Use of calculators is not permitted.
- (e) You may use the following physical constants wherever necessary :

$$c = 3 \times 10^8 \text{ ms}^{-1}$$

$$h = 6.6 \times 10^{-34} \text{ Js}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ TmA}^{-1}$$

$$\text{Boltzmann constant } k = 1.38 \times 10^{-23} \text{ JK}^{-1}$$

$$\text{Avogadro's number } N_A = 6.023 \times 10^{23} / \text{mole}$$

1. If momentum (P), area (A) and time (T) are taken to be fundamental quantities, then energy has the dimensional formula
 - (a) $[P^1 A^{-1} T^1]$
 - (b) $[P^2 A^1 T^1]$
 - (c) $[P^1 A^{-1/2} T^1]$
 - (d) $[P^1 A^{1/2} T^{-1}]$
2. The average velocity of a particle is equal to its instantaneous velocity. What is the nature of its motion?
3. A Force of $\mathbf{F} = (6\mathbf{i} - 3\mathbf{j})\text{N}$ acts on a mass of 2kg. Find the magnitude of acceleration.
4. The work done by a body against friction always results in
 - (a) loss of kinetic energy
 - (b) loss of potential energy
 - (c) gain of kinetic energy
 - (d) gain of potential energy.

5. Which of the following points is the likely position of the centre of mass of the system shown in Fig. 1.

- (a) A
- (b) B
- (c) C
- (d) D

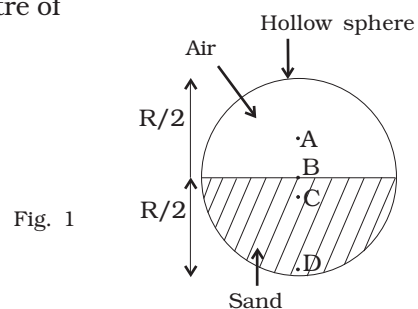


Fig. 1

6. Two molecules of a gas have speeds 9×10^6 m/s and 1.0×10^6 m/s, respectively. What is the r.m.s. speed?
7. A particle in S.H.M has displacement x given by $x = 3 \cos (5\pi t + \pi)$ where x is in metres and t in seconds. Where is the particle at $t = 0$ and $t = 1/2$ s?
8. When the displacement of a particle in S.H.M. is one-fourth of the amplitude, what fraction of the total energy is the kinetic energy?
9. The displacement of a progressive wave is represented by $y = A \sin(\omega t - kx)$, where x is distance and t is time.

Write the dimensional formula of (i) ω and (ii) k .

10. 100 g of water is supercooled to -10°C . At this point, due to some disturbance mechanised or otherwise some of it suddenly freezes to ice. What will be the temperature of the resultant mixture and how much mass would freeze?

$$[S_w = 1\text{cal/g/}^\circ\text{C and } L_{\text{fusion}}^w = 80\text{cal/g}]$$

OR

One day in the morning to take bath, I filled up $1/3$ bucket of hot water from geyser. Remaining $2/3$ was to be filled by cold water (at room temperature) to bring the mixture to a comfortable temperature. Suddenly I had to attend to some work which would take, say 5-10 minutes before I can take bath. Now I had two options: (i) fill the remaining bucket completely by cold water and then attend to the work; (ii) first attend to the work and fill the remaining bucket just before taking bath. Which option do you think would have kept water warmer? Explain.

11. Prove the following;
For two angles of projection ' θ ' and $(90-\theta)$ (with horizontal) with same velocity ' V '
- (a) range is the same,
 - (b) heights are in the ratio: $\tan^2 \theta : 1$.
12. What is meant by 'escape velocity'? Obtain an expression for escape velocity of an object projected from the surface of the earth.

13. A fighter plane is flying horizontally at an altitude of 1.5 km with speed 720 km/h. At what angle of sight (w.r.t. horizontal) when the target is seen, should the pilot drop the bomb in order to hit the target?

14. A sphere of radius R rolls without slipping on a horizontal road. A, B, C and D are four points on the vertical line through the point of contact 'A' (Fig.2). What are the translational velocities of particles at points A, B, C, D? The velocity of the centre of mass is V_{cm} .

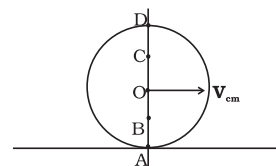


Fig. 2

15. A thermodynamic system is taken from an original state D to an intermediate state E by the linear process shown in the Fig. 3.

Its volume is then reduced to the original value from E to F by an isobaric process. Calculate the total work done by the gas from D to E to F.

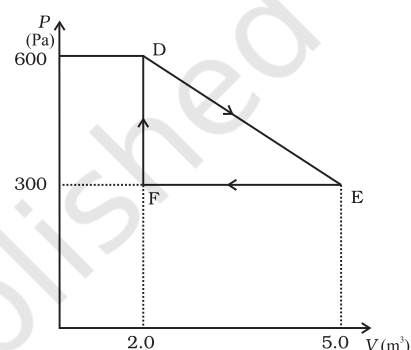


Fig. 3

16. A flask contains Argon and Chlorine in the ratio 2:1 by mass. The temperature of the mixture is 37°C . Obtain the ratio of (i) average kinetic energy per molecule and (ii) root mean square speed V_{rms} of the molecules of the two gases. Atomic mass of argon = $39.9u$; molecular mass of chlorine = $70.9u$.
17. Calculate the root mean square speed of smoke particles of mass $5 \times 10^{-17} \text{ kg}$ in Brownian motion in air at NTP?
18. A ball with a speed of 9 m/s strikes another identical ball at rest such that after collision the direction of each ball makes an angle 30° with the original direction. Find the speed of two balls after collision. Is the kinetic energy conserved in this collision process?
19. Derive a relation for the maximum velocity with which a car can safely negotiate a circular turn of radius r on a road banked at an angle θ , given that the coefficient of friction between the car tyres and the road is μ .
20. Give reasons for the following:–
 (a) A cricketer moves his hands backwards while holding a catch.
 (b) It is easier to pull a lawn mower than to push it.
 (c) A carpet is beaten with a stick to remove the dust from it.
21. A helicopter of mass 1000 kg rises with a vertical acceleration of 15 m s^{-2} . The crew and the passengers weight 300 kg . Give the magnitude and direction of the
 (a) force on the floor by the crew and passengers,
 (b) action of the rotor of the helicopter on the surrounding air,
 (c) force on the helicopter due to the surrounding air.
22. A woman pushes a trunk on a railway platform which has a rough surface. She applies a force of 100 N over a distance of 10 m . Thereafter, she gets progressively tired

and her applied force reduces linearly with distance to 50 N. The total distance through which the trunk has been moved is 20 m. Plot the force applied by the woman and the frictional force, which is 50 N. Calculate the work done by the two forces over 20m.

23. Derive equations of motion for a rigid body rotating with constant angular acceleration ' α ' and initial angular velocity ω_0 .
24. Derive an expression for the kinetic energy and potential energy of a satellite orbiting around a planet. A satellite of mass 200kg revolves around a planet of mass 5×10^{30} kg in a circular orbit 6.6×10^6 m radius. Calculate the B.E. of the satellite. $G = 6.6 \times 10^{-11} \text{ Nm}^2 / \text{kg}^2$.
25. State and prove Bernoulli's theorem.
26. Consider a cycle tyre being filled with air by a pump. Let V be the volume of the tyre (fixed) and at each stroke of the pump ΔV (V) of air is transferred to the tube adiabatically. What is the work done when the pressure in the tube is increased from P_1 to P_2 ?

OR

In a refrigerator one removes heat from a lower temperature and deposits to the surroundings at a higher temperature. In this process, mechanical work has to be done, which is provided by an electric motor. If the motor is of 1kW power, and heat is transferred from -3°C to 27°C , find the heat taken out of the refrigerator per second assuming its efficiency is 50% of a perfect engine.

27. Show that when a string fixed at its two ends vibrates in 1 loop, 2 loops, 3 loops and 4 loops, the frequencies are in the ratio 1:2:3:4.
28. (a) Define coefficient of viscosity and write its SI unit.
(b) Define terminal velocity and find an expression for the terminal velocity in case of a sphere falling through a viscous liquid.

OR

The stress-strain graph for a metal wire is shown in Fig. 4. The wire returns to its original state O along the curve EFO when it is gradually unloaded. Point B corresponds to the fracture of the wire.

- (i) Upto what point of the curve is Hooke's law obeyed?
- (ii) Which point on the curve corresponds to the elastic limit or yield point of the wire?
- (iii) Indicate the elastic and plastic regions of the stress-strain graph.
- (iv) Describe what happens when the wire is loaded up to a stress corresponding to the point A on the graph and then unloaded gradually. In particular explain the dotted curve.

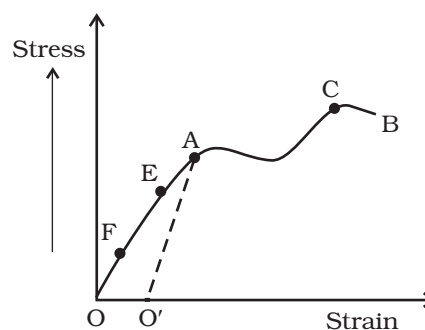


Fig. 4

- (v) What is peculiar about the portion of the stress-strain graph from C to B? Upto what stress can the wire be subjected without causing fracture?

29. It is a common observation that rain clouds can be at about a kilometre altitude above the ground.

- If a rain drop falls from such a height freely under gravity, what will be its speed? Also calculate in km/h. ($g = 10\text{m/s}^2$).
- A typical rain drop is about 4mm diameter. Estimate its momentum if it hits you.
- Estimate the time required to flatten the drop i.e. time between first contact and the last contact.
- Estimate how much force such a drop would exert on you.
- Estimate to the order of magnitude force on an umbrella. Typical lateral separation between two rain drops is 5 cm.

(Assume that the umbrella cloth is not pierced through !!)

OR

A cricket fielder can throw the cricket ball with a speed v_0 . If he throws the ball while running with speed u at an angle θ to the horizontal, find

- The effective angle to the horizontal at which the ball is projected in air as seen by a spectator.
- What will be time of flight?
- What is the distance (horizontal range) from the point of projection at which the ball will land?
- Find θ at which he should throw the ball that would maximise the horizontal range as found in (iii).
- How does θ for maximum range change if $u > v_0$, $u = v_0$, $u < v_0$?

30. (a) Show that in S.H.M., acceleration is directly proportional to its displacement at a given instant

(b) A cylindrical log of wood of height h and area of cross-section A floats in water. It is pressed and then released. Show that the log would execute S.H.M. with a time period,

$$T = 2\pi \sqrt{\frac{m}{A\rho g}}$$

where m is mass of the body and ρ is density of the liquid

OR

A progressive wave represented by

$$y = 5 \sin (100\pi t - 0.4\pi x)$$

where y and x are in m, t is in s. What is the

- (a) amplitude
- (b) wave length
- (c) frequency
- (d) wave velocity
- (e) magnitude of particle velocity.

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SAMPLE PAPER I
SOLUTIONS AND MARKING SCHEME

1. (d) (1)
2. Uniform motion (1)
3. $\mathbf{a} = (3\hat{\mathbf{i}} - 1.5\hat{\mathbf{j}}) \text{ m/s}^2$; $|\mathbf{a}| = 3.35 \text{ m/s}^2$ $(\frac{1}{2}) + (\frac{1}{2})$ (1)
4. (a) (1)
5. (c) (1)
6. $6.4 \times 10^6 \text{ m/s}$ (Formula $\frac{1}{2}$, Result $\frac{1}{2}$) (1)
7. -3m ; 0 m . $(\frac{1}{2}) + (\frac{1}{2})$ (1)
8. $\frac{K.E.}{E} = \frac{15}{16}$ (Formula $\frac{1}{2}$, Ratio $\frac{1}{2}$) (2)
9. (i) $[M^\circ L^\circ T^{-1}]$, (ii) $[M^\circ L^{-1} T^\circ]$ $1 + 1$ (2)
10. Resultant mixture reaches 0°C . 12.5 g of ice and rest of water. (1+1)

OR

The first option would have kept water warmer because according to Newtons law of cooling the rate of loss of heat is directly proportional to the difference of temperature of the body and the surrounding. In the first case the temperature difference is less so rate of loss of heat will be less. (2)

11. Proof $R_1 = R_2$ and $\frac{h_1}{h_2} = \frac{\tan^2 \theta}{1}$ $1 + 1$ (2)
 12. The minimum velocity of prejection of an object so that it just escapes the gravitational force of the planet from which its is projected. (1)
- $$\frac{1}{2}mv^2 = \frac{GMm}{R_e} \text{ or } v = \sqrt{\frac{2GM}{R_e}} \quad (1)$$
13. Let the time taken by the bomb to hit the target be t .

$$1500 = \frac{1}{2}gt^2$$

$$\text{Or, } t = \sqrt{300} = 17.32 \text{ s} \quad (1)$$

Horizontal distance covered by the bomb = $17.32 \times v$

$$= 17.32 \times 200 = 3464\text{m.}$$

$$\therefore \tan \theta = \frac{1500}{3464}$$

$$\text{or } \theta = \tan^{-1} 0.43 \quad (1)$$

$$14. \quad v_A = v_{CM} - \omega R = 0$$

$$v_{CM} = \omega R \quad (1/2)$$

$$v_B = v_{CM} - \frac{\omega R}{2} = v_{CM} / 2 \quad (1/2)$$

$$v_C = v_{CM} + \frac{\omega R}{2} = \frac{3}{2}v_{CM} \quad (1/2)$$

$$v_D = v_{CM} + \omega R = 2v_{CM} \quad (1/2)$$

$$15. \quad \text{Work done} = \text{area under the } P\text{-}V \text{ curve} \quad (1)$$

$$= \frac{1}{2}(300)(30) = 450\text{J} \quad (1)$$

$$16. \quad \text{Since Argon and Chlorine are both at the same temperature, the ratio of their average K.E. per molecule is } 1:1 \quad (1/2)$$

$$MV_{rms}^2 = \text{K.E. per molecule} = \frac{3}{2}kT. \quad (1/2)$$

$$\begin{aligned} \therefore \frac{V_{rms}(\text{Argon})}{V_{rms}(\text{Chlorine})} &= \sqrt{\frac{M(\text{Cl})}{M(\text{Ar})}} = \sqrt{\frac{70.9}{39.9}} \\ &= \sqrt{1.77} = 1.33 \quad (1/2+1/2) \end{aligned}$$

$$17. \quad PV = \frac{1}{3} m V_{rms}^2 = \frac{m}{M} RT \quad (1)$$

$$V_{rms} = \sqrt{\frac{3(Nk)T}{N\mu}} = \sqrt{\frac{3kT}{\mu}} \quad (1/2)$$

$$= \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 273}{5 \times 10^{-17}}} \quad (1/2)$$

$$= 15 \times 10^{-3} \text{ m s}^{-1}$$

$$= 1.5 \text{ cm s}^{-1} \quad (1)$$

$$18. \quad m \times 9 = mv_1 \cos 30^\circ + mv_2 \cos 30^\circ \quad (1/2)$$

$$0 = mv_1 \sin 30^\circ - mv_2 \sin 30^\circ \quad (1/2)$$

$$v_1 + v_2 = 6\sqrt{3}$$

$$v_1 = v_2$$

$$v_1 = v_2 = 3\sqrt{3} \text{ m s}^{-1}$$

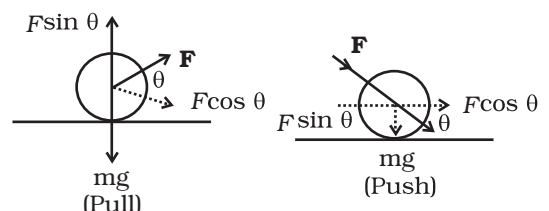
$$T_f - T_i = \frac{1}{2} m (3\sqrt{3})^2 \times 2 - \frac{1}{2} m \times 9^2 = -13.5m \text{ joule} \quad (1/2)$$

m is mass of either balls. So, K.E. is not conserved. (1/2)

$$19. \quad \text{Diagram, derivation of relation } V = \sqrt{\frac{rg(\tan \theta + \mu)}{1 - \mu \tan \theta}} \quad (1) + (2)$$

20. (a) He does so to increase the time taken for the catch. Since $F = Ma = M \frac{dv}{dt}$, (1)
therefore increasing the time for the catch reduces the impact of force by the ball on the hands.

(b) As seen from the figure, when the lawn mower is pulled by force \mathbf{F} at θ° to the horizontal, the horizontal component $\mathbf{F} \cos \theta$ causes translatory motion of the lawn mower while the vertical component cancels the weight of the lawn mower. (1)
If the lawn mower is pushed by a force \mathbf{F} at θ° to the horizontal, the horizontal component is again $F \cos \theta$, while the vertical component $F \sin \theta$ adds on to the weight mg , making it move difficult to push the lawn mower.



then $\frac{W}{Q} = \frac{1}{20}$ or $Q = 20W = 20\mu\text{KJ}$

and heat removed from lower temperature = 19 kJ. (1)

27. From the relation, $v = \frac{nv}{2L}$, the result follows.

Calculation of ratio of frequencies: $\left(\frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + 1\right)$

28. (a) Coefficient of viscosity for a fluid is defined as the ratio of shearing stress to the strain rate:

$$\mu = \frac{F/A}{v/l} = \frac{Fl}{vA} \quad (1)$$

SI unit of viscosity is poiseuille (Pl) (½)

(b) Terminal velocity is the constant maximum velocity attained by a body falling through a viscous fluid when viscous force nullifies the net downward force.

(1)

Derivation of $v_T = \frac{2}{9}r^2 \frac{(\rho - \rho_L)}{\eta}$ (2½)

OR

(i) Upto point P. (1+1+1+1+1)

(ii) Point E

(iii) Elastic region : O to E

Plastic region : E to B

(iv) Strain increases proportional to the load upto P. Beyond P, it increases by an increasingly greater amount for a given increase in the load. Beyond the elastic limit E, it does not retrace the curve backward. The wire is unloaded but returns along the dotted line AO'. Point O', corresponding to zero load which implies a permanent strain in the wire.

(v) From C to B, strain increases even if the wire is being unloaded and at B it fractures. Stress upto that corresponding to C can be applied without causing fracture.

29. (a) $v = \sqrt{2gh} = \sqrt{2 \times 10 \times 1000} = 141\text{m/s} = 510\text{km/h}$ (1+1+1+1+1)

(b) $m = \frac{4\pi}{3}r^3\rho = \frac{4\pi}{3}(2 \times 10^{-3})^3(10^3) = 3.4 \times 10^{-5}\text{kg}$

$P = mv \approx 4.7 \times 10^{-3}\text{kg m/s} \approx 5 \times 10^{-3}\text{kg m/s}$

- (c) diameter $\approx 4\text{mm}$

$$\Delta t \approx d/v = 28\mu\text{s} \approx 30\mu\text{s}$$

(d) $F = \frac{\Delta P}{\Delta t} = \frac{4.7 \times 10^{-3}}{28 \times 10^{-6}} \approx 168\text{N} \approx 1.7 \times 10^2\text{N}$

- (e) A typical umbrella has 1m diameter

$$\therefore \text{Area of cross-section} = \pi d^2 / 4 \approx 0.8\text{m}^2$$

With average separation of 5cm, no. of drops that will fall almost simultaneously

$$\text{is } \frac{0.8\text{m}^2}{(5 \times 10^{-2})^2} \approx 320$$

OR

(i) $\tan^{-1} \left(\frac{v_o \sin \theta}{v_o \cos \theta + u} \right)$ (1+1/2+1+1+1/2+1/2+1/2)

(ii) $\frac{2v_o \sin \theta}{g}$

(iii) $R = \frac{2v_o \sin \theta (v_o \cos \theta + u)}{g}$

(iv) $\theta_{\max} = \cos^{-1} \left[\frac{-u + \sqrt{u^2 + 8v_o^2}}{4v_o} \right]$

(v) $\theta_{\max} = 60^\circ$ for $u = v_o$, $\theta_{\max} = 45^\circ$ for $u = 0$

$$u < v_o :$$

$$\theta_{\max} \approx \cos^{-1} \left(\frac{1}{\sqrt{2}} - \frac{u}{4v_o} \right) = \pi/4 \quad (\text{if } u \ll v_o)$$

$$u > v_o : \theta_{\max} \approx \cos^{-1} \frac{v_o}{u} = \pi/2 \quad (\text{if } v_o \ll u)$$

30. (a) In S.H.M. the displacement of the particle at an instant is given by

$$y = r \sin \omega t$$

$$\text{Velocity, } v = \frac{dy}{dt} = r\omega \cos \omega t$$

$$\text{Acceleration } a = \frac{dv}{dt} = -\omega^2 r \sin \omega t = -\omega^2 y \quad (1)$$

So, acceleration of a body executing S.H.M. is directly proportional to the displacement of the particle from the mean position at that instant.

(b) Let the block be pressed and let the vertical displacement at the equilibrium position be x_o .

At equilibrium

$$mg = \text{Buoyant force}$$

$$= A \cdot x_o \cdot \rho \cdot g$$

When it is displaced by a further displacement x , the buoyant force is $A(x_o + x)\rho g$

Net restoring force

$$= \text{Buoyant force} - \text{weight}$$

$$= A(x_o + x)\rho g - mg$$

$$= (A\rho g)x \text{ . i.e. proportional to } x.$$

$$\therefore T = 2\pi\sqrt{\frac{m}{A\rho g}}$$

OR

(a) 5m (b) 5m (c) 50Hz (d) 250ms^{-1} (e) $500\pi \text{ms}^{-1}$.

(1+1+1+1+1)

Sample Paper II Blue Print

Topic	VSA (1 Mark)	SAI (2 Marks)	SA II (3 Marks)	LA (5 Marks)	Total
I Physical Word and Measurement	1(1)	1(2)	—	—	3
II Kinematics	—	2(2)	2(3)	—	10
III Laws of Motion	—	1(2)	1(3)	1(5)	10
IV Work, Energy and Power	1(1)	1(2)	1 (3)	—	6
V Motion of System of Particles & Rigid Body	—	—	2 (3)	—	6
VI Gravitation	1(1)	2(2)	—	—	5
VII Properties of Bulk Modules Bulk Matter	2(1)	—	1(3)	1(5)	10
VIII Thermodynamics	2(1)	—	1(3)	—	5
IX Behavior of Perfect Gas & Kinetic Theory of Gases	1(1)	2(2)	—	—	5
X Oscillations & Wave	—	1(2)	1(3)	1(5)	10
Total					70

SAMPLE PAPER II

Time : Three Hours

Max. Marks : 70

- (a) All questions are compulsory.
- (b) There are 30 questions in total. Questions 1 to 8 carry one mark each, questions 9 to 18 carry two marks each, questions 19 to 27 carry three marks each and questions 28 to 30 carry five marks each.

(c) There is no overall choice.

(d) Use of calculators is not permitted.

(e) You may use the following physical constants wherever necessary :

$$c = 3 \times 10^8 \text{ms}^{-1}$$

$$h = 6.6 \times 10^{-34} \text{Js}$$

$$\mu_o = 4\pi \times 10^{-7} \text{TmA}^{-1}$$

$$\text{Boltzmann constant } k = 1.38 \times 10^{23} \text{ JK}^{-1}$$

$$\text{Avogadro's number } N_A = 6.023 \times 10^{23} / \text{mole}$$

1. Modulus of rigidity of liquids is

(a) infinity; (b) zero; (c) unity; (d) some finite small non-zero constant value.

2. If all other parameters except the one mentioned in each of the options below be the same for two objects, in which case (s) they would have the same kinetic energy?

(a) Mass of object A is two times that of B.

(b) Volume of object A is half that of B.

(c) Object A is falling freely while object B is moving upward with the same speed at any given point of time.

(d) Object A is moving horizontally with a constant speed while object B is falling freely.

3. If the sun and the planets carried huge amounts of opposite charges,

(a) all three of Kepler's laws would still be valid.

(b) only the third law will be valid.

(c) the second law will not change.

(d) the first law will still be valid.

4. Which of the following pairs of physical quantities does *not* have the same dimensional formula?

- (a) Work and torque.
- (b) Angular momentum and Planck's constant.
- (c) Tension and surface tension.
- (d) Impulse and linear momentum.

5. An ideal gas undergoes four different processes from same initial state (Fig.1). Four processes are adiabatic, isothermal, isobaric and isochoric. Out of A, B, C, and D, which one is adiabatic?

- (a) (B)
- (b) (A)
- (c) (C)
- (d) (D)

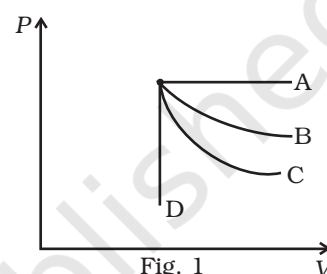


Fig. 1

6. Why do two layers of a cloth of equal thickness provide warmer covering than a single layer of cloth of double the thickness?
7. Volume versus temperature graphs for a given mass of an ideal gas are shown in Fig 2 at two different values of constant pressure. What can be inferred about relations between P_1 & P_2 ?

- (a) $P_1 > P_2$
- (b) $P_1 = P_2$
- (c) $P_1 < P_2$
- (d) data is insufficient.

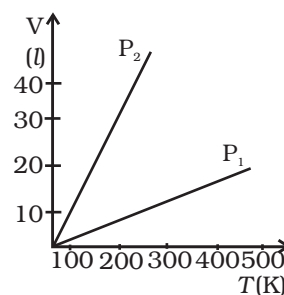


Fig. 2

8. Along a streamline
- (a) the velocity of a fluid particle remains constant.
 - (b) the velocity of all fluid particles crossing a given position is constant.
 - (c) the velocity of all fluid particles at a given instant is constant.
 - (d) the speed of a fluid particle remains constant.
9. State Newton's third law of motion and use it to deduce the principle of conservation of linear momentum.

10. A graph of x vs t is shown in Fig. 3. Choose correct alternatives from below. (2)

- (a) The particle was released from rest at $t = 0$.
- (b) At B, the acceleration $a > 0$.
- (c) At C, the velocity and the acceleration vanish.
- (d) Average velocity for the motion between A and D is positive.
- (e) The speed at D exceeds that at E.

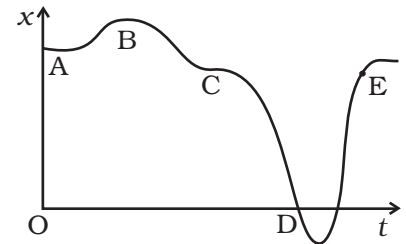
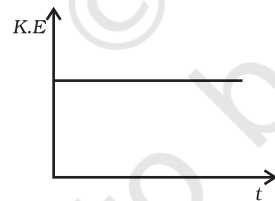


Fig. 3

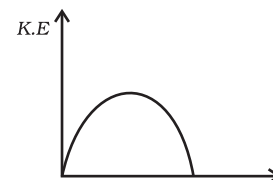
11. A vehicle travels half the distance L with speed V_1 and the other half with speed V_2 then its average speed is

- (a) $\frac{V_1 + V_2}{2}$
- (b) $\frac{2V_1 + V_2}{V_1 + V_2}$
- (c) $\frac{2V_1 V_2}{V_1 + V_2}$
- (d) $\frac{L(V_1 + V_2)}{V_1 V_2}$

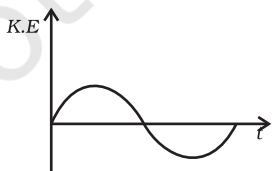
12. Which of the diagrams shown in Fig. 4 most closely shows the variation in kinetic energy of the earth as it moves once around the sun in its elliptical orbit?



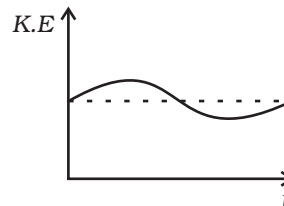
(a)



(b)



(c)



(d)

Fig. 4

13. The vernier scale of a travelling microscope has 50 divisions which coincide with 49 main scale divisions. If each main scale division is 0.5 mm, calculate the minimum inaccuracy in the measurement of distance.
14. A vessel contains two monatomic gases in the ratio 1:1 by mass. The temperature of the mixture is 27°C . If their atomic masses are in the ratio 7:4, what is the (i) average kinetic energy per molecule (ii) r.m.s. speed of the atoms of the gases.
15. A 500kg satellite is in a circular orbit of radius R_e about the earth. How much energy is required to transfer it to a circular orbit of radius $4R_e$? What are the changes in the kinetic and potential energy? ($R_e = 6.37 \times 10^6 \text{ m}$, $g = 9.8 \times \text{m s}^{-2}$.)
16. A pipe of 17 cm length, closed at one end, is found to resonate with a 1.5 kHz source. (a) Which harmonic of the pipe resonate with the above source? (b) Will resonance with the same source be observed if the pipe is open at both ends? Justify your answer. (Speed of sound in air = 340 m s^{-1})
17. Show that the average kinetic energy of a molecule of an ideal gas is directly proportional to the absolute temperature of the gas.
18. Obtain an expression for the acceleration due to gravity at a depth h below the surface of the earth.
19. The position of a particle is given by $\mathbf{r} = 6t\mathbf{i} + 4t^2\mathbf{j} + 10t\mathbf{k}$ where r is in metres and t in seconds.
- (a) Find the velocity and acceleration as a function of time.
- (b) Find the magnitude and direction of the velocity at $t = 2\text{s}$.
20. A river is flowing due east with a speed 3m/s . A swimmer can swim in still water at a speed of 4 m/s (Fig. 5).
- (a) If swimmer starts swimming due north, what will be his resultant velocity (magnitude and direction)?
- (b) If he wants to start from point A on south bank and reach opposite point B on north bank,
- (i) which direction should he swim?
- (ii) what will be his resultant speed?
- (c) From two different cases as mentioned in (a) and (b) above, in which case will he reach opposite bank in shorter time?
21. (a) A raindrop of mass 1 g falls from rest, from a height of 1 km and hits the ground with a speed of 50 m s^{-1} .
- (i) What are the final K.E. of the drop and its initial P.E.?
- (ii) How do you account for the difference between the two?
- (Take $g = 10\text{ms}^{-2}$).

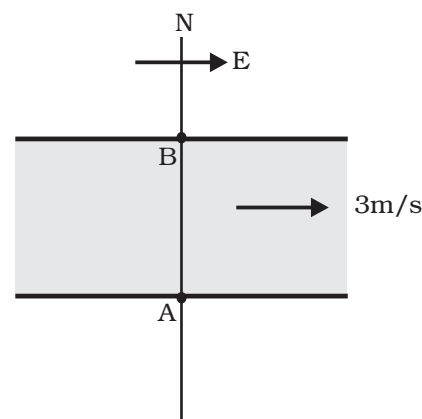


Fig. 5

- (b) Two identical ball bearings in contact with each other and resting on a frictionless table are hit head-on by another ball bearing of the same mass moving initially with a speed V as shown in Fig. 6.

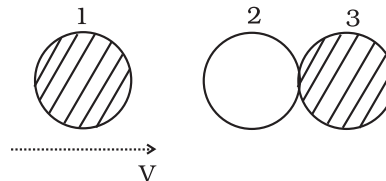


Fig. 6

If the collision is elastic, which of the following (Fig. 7) is a possible result after collision?

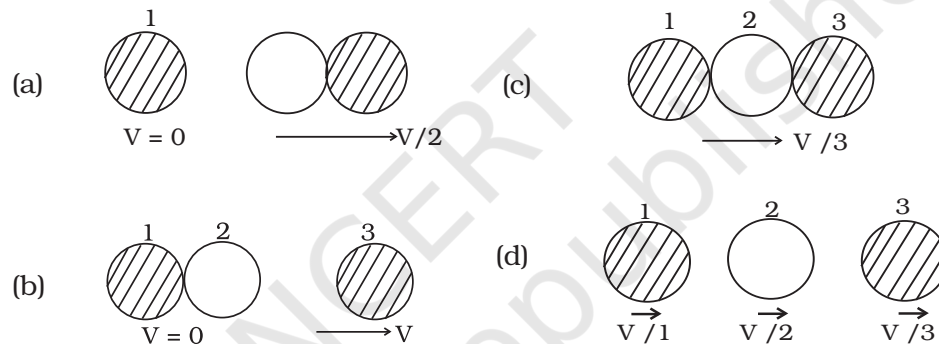


Fig. 7

22. Explain why:

- (a) It is easier to pull a hand cart than to push it.
 (b) Figure 8 shows (x, t) , (y, t) diagrams of a particle moving in 2-dimensions. If the particle has a mass of 500 g, find the force (direction and magnitude) acting on the particle.

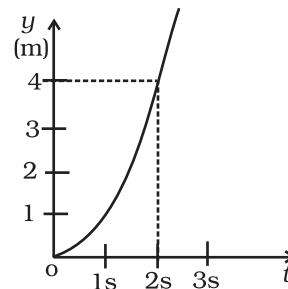
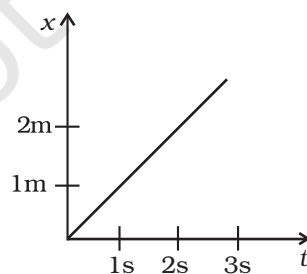


Fig. 8

23. (a) State parallel axis and perpendicular axis theorem.
- (b) Find the moment of inertia of a sphere about a tangent to the sphere, given the moment of inertia of the sphere about any of its diameters to be $\frac{2MR^2}{5}$, where M is the mass of the sphere and R is the radius of the sphere.
24. A 3m long ladder weighing 20 kg leans on a frictionless wall. Its feet rest on the floor 1 m from the wall Find the reaction forces of the wall and the floor. (3)
25. A fully loaded Boeing aircraft has a mass of 3.3×10^5 kg. Its total wing area is 500 m^2 . It is in level flight with a speed of 960km/h. (a) Estimate the pressure difference between the lower and upper surfaces of the wings. (b) Estimate the fractional increase in the speed of the air on the upper surface of the wing relative to the lower surface.
(The density of air $\rho = 1.2 \text{ kg m}^{-3}$)
26. Explain briefly the working principle of a refrigerator and obtain an expression for its coefficient of performance.
27. Derive an expression for the apparent frequency of the sound heard by a listener when source of sound and the listener both move in the same direction.
28. (a) Show that for small amplitudes the motion of a simple pendulum is simple harmonic, hence obtain an expression for its time period.
- (b) Consider a pair of identical pendulums, which oscillate independently such that when one pendulum is at its extreme position making an angle of 2° to the right with the vertical, the other pendulum is at its extreme position making an angle of 1° to the left of the vertical. What is the phase difference between the pendulums?
29. (a) What is capillary rise? Derive an expression for the height to which a liquid rises in a capillary tube of radius r .
- (b) Why small drops of a liquid are always spherical in shape.
30. (a) Derive an expression for the maximum safe speed for a car on a banked track, inclined at angle α to the horizontal. μ is the coefficient of friction between the tracks and the tyres.
- (b) A 100 kg gun fires a ball of 1kg from a cliff of height 500 m. It falls on the ground at a distance of 400m from the bottom of the cliff. Find the recoil velocity of the gun. (acceleration due to gravity = 10 m s^{-2})

SAMPLE PAPER II

SOLUTIONS AND MARKING SCHEME

1. (b) (1)
2. (e) (1)
3. (c) (1)
4. (c) (1)
5. (c) (1)
6. Air enclosed between two layers of cloth prevents the transmission of heat from our body to outside. (1)
7. (a) (1)
8. (b) (2)
9. Statement (1)

$$\frac{d\mathbf{p}_1}{dt} = -\frac{d\mathbf{p}_2}{dt} \text{ or } \frac{d}{dt}(\mathbf{p}_1 + \mathbf{p}_2) = 0 \quad (\frac{1}{2})$$

$$\Rightarrow \mathbf{p}_1 + \mathbf{p}_2 = \text{constant} . \quad (\frac{1}{2})$$
10. (a), (c), (e) (2)
11. (c) (2)
12. (d) (2)
13. 0.01 mm (2)
14. (i) 1:1, (ii) 1.32:1 (2)
15. $\Delta E = 11.75 \times 10^9 \text{ J}$ (1)

$$\Delta KE = -11.75 \times 10^9 \text{ J} \quad (\frac{1}{2})$$

$$\Delta PE = -23.475 \times 10^9 \text{ J} \quad (\frac{1}{2})$$

16. (a) $\frac{n \times 340 \times 10^2}{4 \times 17} = 500n$, where n is the harmonic for a closed pipe. Closed pipe vibrates in 3rd harmonic with source of 1.5 KHz. (1)

(b) For a pipe open at both ends,

$$\frac{n \times 340 \times 10^2}{2 \times 17} = 10^3 n \text{ where } n \text{ is the harmonic. No integral value of } n \text{ is possible for 1.5 KHz. So answer is No.} \quad (1)$$

17. $P = \frac{1}{3} \frac{MC^2}{V}$ (1/2)

$$PV = \frac{1}{3} MC^2 = \frac{2}{3} K.E \quad (1/2)$$

$$PV = nRT \quad (1/2)$$

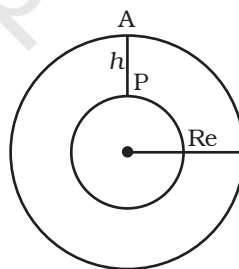
$$K.E \propto T \quad (1/2)$$

18. $AP = h$ (1/2)

$$g' = \frac{GM'}{(R_e - h)^2} \quad (1/2)$$

$$M' = \frac{4}{3} \pi (R_e - h)^3 \rho \quad (1/2)$$

$$g' = g \left(1 - \frac{h}{R_e} \right) \quad (1/2)$$



19. (a) $\mathbf{v} = 6\mathbf{i} + 8t\mathbf{j}$ (1+1+1)

$$\mathbf{a} = 8\mathbf{j}$$

(b) $\mathbf{v} = 6\mathbf{i} + 16\mathbf{j}$ or $v = \sqrt{36 + 256} = 19.8 \text{ m/s}$.

\mathbf{v} makes an angle of $\tan^{-1} (8/3)$ with x-axis.

20. (i) 5 m/s at 37° to N. (3)

(ii) (a) $\tan^{-1} (3/\sqrt{7})$ of N, (b) $\sqrt{7} \text{ m/s}$

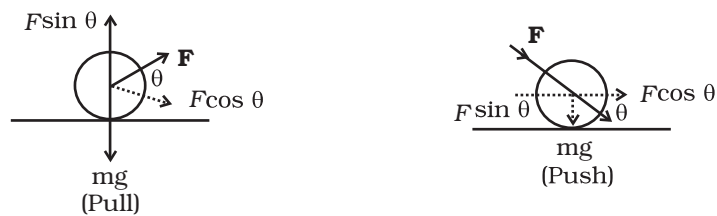
(iii) in case (i) he reaches the opposite bank in shortest time.

21. (i) (a) 1.25 J , 10J

(b) Difference is due to the work done by viscous force of air

- (ii) (b) (3)

22. (a) (1)



$F \sin \theta$ reduces the downward force in the case of pull.

- (b) $x = t, y = t^2$

$$a_x = 0, a_y = 2 \text{ m s}^{-1}$$

$$F = 0.5 \times 2 = 1 \text{ N, along } y\text{-axis} \quad (2)$$

23. (a) Statement of parallel axis theorem (1)

- (b) $\frac{7}{5} MR^2$ (Using parallel axis) (1)

Statement of perpendicular axis theorem (1)

24. Let F_1 and F_2 be the reaction forces of the wall and the floor respectively.

$$N - W = 0 \quad (3)$$

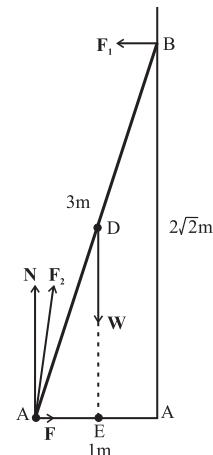
$$F - F_1 = 0 \quad (1/2)$$

$$2\sqrt{2} F_1 - (1/2) W = 0 \quad (1/2)$$

$$W = N = 20 \times 9.8 \text{ N} = 196 \text{ N}$$

$$F = F_1 = W / 4\sqrt{2} = 34.6 \text{ N} \quad (1/2)$$

$$F_2 = \sqrt{F^2 + N^2} = 199.0 \text{ N} \quad (1/2)$$



The force F_2 makes an angle α with the horizontal

$$\tan \alpha = N / F = 4\sqrt{2}, \alpha = \tan^{-1} 4\sqrt{2} \quad (1/2)$$

25. (a) The weight of the Boeing aircraft is balanced by the upwards force due to the pressure difference:

$$\Delta P \times A = 3.3 \times 10^5 \text{ kg} \times 9.8 \text{ m s}^{-2} \quad (1/2)$$

$$\begin{aligned} \Delta P &= (3.3 \times 10^5 \text{ kg} \times 9.8 \text{ m s}^{-2}) / 500 \text{ m}^2 \\ &= 6.5 \times 10^3 \text{ Nm}^{-2} \end{aligned} \quad (1/2)$$

- (b) The pressure difference between the lower and upper surfaces of the wing is

$$\Delta P = (\rho / 2)(v_2^2 - v_1^2) \quad (1/2)$$

where v_2 is the speed of air over the upper surface and v_1 is the speed under the bottom surface.

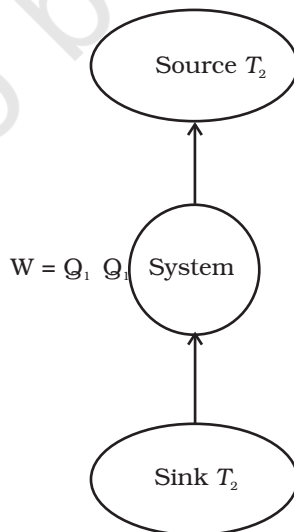
$$v_2 - v_1 = \frac{2\Delta P}{\rho(v_2 + v_1)} \quad (1/2)$$

$$v_{av} = (v_1 + v_2) / 2 = 960 \text{ km/h} = 267 \text{ m s}^{-1} \quad (1/2)$$

$$(v_2 - v_1) / v_{av} = \Delta P / \rho v_{av}^2 \cong 0.08 \quad (1/2)$$

26. (a) Principle of reverse heat engine (1)

- (b) (1)



$$(c) \beta = \frac{T_2}{T_1 - T_2} \quad (1)$$

$$27. v = v_o \left(\frac{v + v_o}{v + v_s} \right). \quad (3)$$

28. (a) Diagram of simple pendulum with forces (1)

Deviation of

$$T = 2\pi \sqrt{\frac{l}{g}} \quad (2)$$

$$(b) \theta_1 = \theta_o \sin(\omega t + \delta_1)$$

$$\theta_2 = \theta_o \sin(\omega t + \delta_2)$$

$$\text{For the first, } \theta = 2^\circ, \therefore \sin(\omega t + \delta_1) = 1$$

$$\text{For the 2nd } \theta = -1^\circ, \therefore \sin(\omega t + \delta_2) = -1/2$$

$$\therefore \omega t + \delta_1 = 90^\circ, \omega t + \delta_2 = -30^\circ$$

$$\therefore \delta_1 - \delta_2 = 120^\circ \quad (2)$$

29. (a) Definition of capillary action (1)

Diagram of capillary rise (½)

Derivation (1½)

(b) Due to surface tension, liquid drops take the shape of minimum area which is sphere (2)

30. (a) Diagram (1)

Deviation of

$$\text{formula } V_s = \left[\left(\frac{\mu + \tan \alpha}{1 - \mu \tan \alpha} \right) rg \right]^{1/2} \quad (2)$$

(b) 0.4 m s^{-1} (2)

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