Physics Sample Paper Marking Scheme Class XI

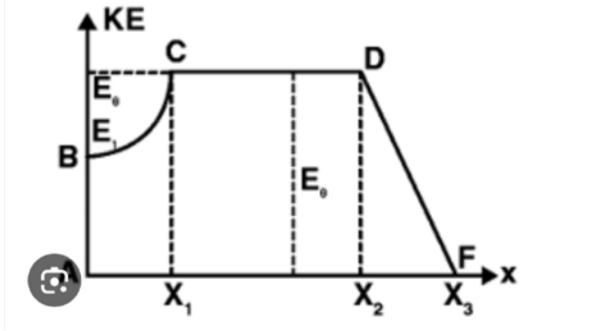
SECTION A

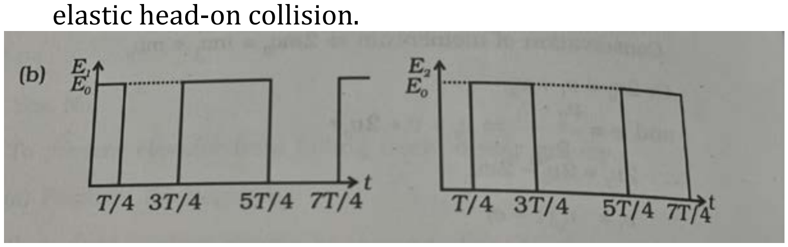
Q.No	Value Points / Expected Answers	Marks	Total Marks
1	(C)		1
2	(D)		1
3	(C)		1
4	(C)		1
5	(B)		1
6	(A)		1
7	(A)		1
8	(B)		1
9	(A)		1
10	(A)		1

11	(C)		1
12	(B)		1
13	(B)		1
14	(A)		1
15	(A)		1
16	(C)		1

SECTION B

Q.No	Value Points / Expected Answers	Marks	Total Marks
17	$\sigma = kE^aV^bT^c$ $MT^{-2} = k[ML^2T^{-2}]^a[LT^{-1}]^b[T]^c$ Equating the powers of a, b & c $a = 1$ $2a + b = 0$ $-2a - b + c = -2$ $\Rightarrow a = 1,\ b = -2,\ c = -2$ $\sigma = [EV^{-2}T^{-2}]$	½ 1 ½	2

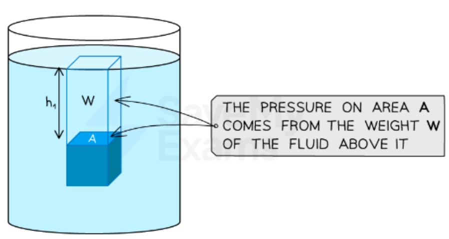
18			2
	$M \cdot E = K \cdot E + P \cdot E$		
	$E_0 = K \cdot E + V(x).$		
	$K \cdot E = E_0 - V(x).$	½	
	at $x = 0 \quad V(0) = E_0.$	½	
	$K \cdot E = 0.$		
	at $B \quad V(x) < E_0.$		
	$K \cdot E > 0.$	½	
	at C and $D \quad V(x) = 0.$		
	$K \cdot E = E_0.$		
	At $F \quad V(x) = E_0 \quad$ and $\quad K \cdot E = 0.$	½	
	OR		
	$V + K = E$		
	• **Region A** → not possible as V cannot be greater than total energy E	½	
	• **Region B** → Possible as V can be less than E	½	
	• **Region C** → Not possible as Kinetic energy cannot be greater than E	½	
	• **Region D** → Possible as potential energy can be greater than kinetic energy.	½	

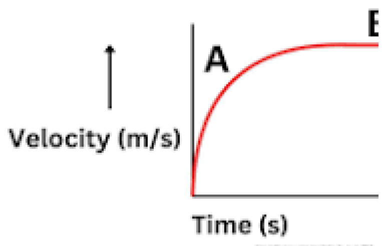
19	**Figure (i)** $x = t\,;\, a_x = 0$ **Figure (ii)** $y = t^2\,;\, a_y = 2\ \text{m/s}^2$ $v_y = 2t$ $a_y = \frac{dv_y}{dt} = 2$ $\therefore\ \vec{F} = m \times (a_x\hat{i} + a_y\hat{j})$ $= 1 \times (2\hat{j})$ $= 2\text{N along } y\text{-axis}$ OR $v(t) = \frac{dx}{dt} = \alpha + 2\beta t + 3\gamma t^2$ $\because\quad a(t) = \frac{dv}{dt} = 2\beta + 6\gamma t$ $a(2) = 2(4) + 6(5)(2)$ $= 8 + 60 = 68\ \text{ms}^{-2}$ $\text{Force} = m \times a$ $= 1 \times 68$ $= 68\ \text{N}$	½ ½ ½ ½ ½ ½ ½ ½	2
20	(a) The two bobs will execute simple harmonic motion (SHM) with the same time period, continuously exchanging their energy and momentum upon each elastic head-on collision. 	1 1	2

21	(a) The two bodies may be made up of different materials and have different thermal capacities. (b) When the piston is pushed down rapidly, the air inside the pump is compressed adiabatically, leaving insufficient time for heat exchange with the surroundings. The work done on the air increases its internal energy, causing its temperature to rise and the pump to become warm.	1 1	2

SECTION C

Q.No	Value Points / Expected Answers	Marks	Total Marks
22	**(a)** False. In two-dimensional motion, even if the speed remains constant, the direction of velocity may change. Since displacement is a vector quantity, equal displacements in equal time intervals occur only when both the magnitude and direction of velocity remain constant (uniform velocity). (b) $\frac{dv}{dt} = -2.5\sqrt{v}$ $\frac{1}{\sqrt{v}}\, dv = -2.5\, dt$ $v^{-1/2}\, dv = -2.5\, dt$ $\int_{6.25}^{0} v^{-1/2}\, dv = -\int_0^t 2.5\, dt$ $\left[\frac{v^{1/2}}{1/2}\right]_{6.25}^{0} = -2.5[t]_0^t$ $-5 = -2.5t$ $t = \frac{-5}{-2.5} = 2 \text{ seconds.}$	1 ½ ½ ½ ½	3

23	$$I = I_1 + I_2 + I_3 + \ldots + I_n$$ $$= \frac{GM}{r_1^2} + \frac{GM}{r_2^2} + \ldots$$ $$= GM\left[\frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{4^2} + \frac{1}{8^2} + \ldots\right]$$ $$= GM\left[1 + \frac{1}{4} + \frac{1}{16} + \frac{1}{64} + \ldots\right]$$ $$= GM \cdot \left[\frac{1}{1 - \frac{1}{4}}\right]$$ $$= GM \times \frac{4}{3} = G \times 3 \times \frac{4}{3} = 4G$$	½ ½ 1 1	3
24	(a) The reading of barometer decreases as P= ρgh ⇨ h=P /ρg ⇨ As it moves up g= g+a ⇨ h'=P/ ρ(g+a) (b)  The weight, W, of the fluid above area A is given by: W =mg Using the density equation, mass can be given as: ρ=mV m=ρV=ρAh	1 ½ ½	3

	Substituting this expression for mass into the weight equation gives: W=ρAhg Therefore, the pressure exerted on area A can be given as: $p = \frac{F}{A} = \frac{W}{A} = \frac{\rho Ahg}{A} = \rho hg$ ⇨ h=P /ρg ⇨ As it moves up g= g+a ⇨ h'=P/ ρ(g+a) OR  (a) Reason : After some time it attains terminal velocity (b) A cricket ball has a relatively large radius. It attains a much higher terminal velocity than a small sphere. It would require a very tall column of a highly viscous liquid to reach terminal velocity.	½ ½ 1 1 1	
25	For the massless pulley B, The upward forces from the two segments of string 1 must balance the downward tension from string 2. $\therefore T_2 = 2T_1$ ------- (2) For Block m_1 (moving downward): $m_1 g - T_1 = m_1 a_1$ ------- (3) For Block m_2 (moving upwards): $T_2 - m_2 g = m_2 a_2$ ------- (4) Using eqs (1), (2), (3) & (4) we get: $T_1 = \frac{3m_1 m_2 g}{4m_1 + m_2}$ $T_2 = \frac{6m_1 m_2 g}{4m_1 + m_2}$	1 ½ ½ ½ ½	3

26	$$dQ = 0$$ $$dU = -\Delta W$$ $$\implies nC_V dT = +146 \times 10^3 \text{ J}$$ $$\implies \frac{nfR}{2} \times 7 = 146 \times 10^3$$ [where, f is degree of freedom] $$\implies \frac{10^3 \times f \times 8.3 \times 7}{2} = 146 \times 10^3$$ $$\therefore f = 5.02 \approx 5$$ So, it is a diatomic gas.	½ ½ ½ 1 ½	3
27	(a) Humid air has a lower density than dry air. Since the speed of sound is inversely proportional to the square root of the density of the medium, sound travels faster in humid air. $v \propto 1/\rho^{1/2}$ where ρ is the density of the medium. (b) The speed of sound increases with temperature. As the frequency of the source remains constant, the wavelength changes according to $v=f\lambda$. Hence, an increase in temperature changes the wavelength of the sound wave. $V \propto T^{1/2}$ (c) Solids possess both bulk and shear elasticity, enabling them to support both longitudinal and transverse waves. Gases have negligible shear rigidity and therefore cannot sustain transverse waves; they can propagate only longitudinal waves.	1 1 1	3

28	**(a)** **(i)** Average Kinetic Energy, for all three types of molecules P, Q and R will be same. **(ii)** R.M.S. speed: molecule $(P) >$ molecule $(Q) >$ molecule **(b)** Volume occupied by 1 g mole of gas at NTP $= 22400$ c.c. $\because$ Number of molecules in 1 c.c. of hydrogen $= \dfrac{6.023 \times 10^{23}}{22400} = 2.688 \times 10^{19}$ Hydrogen gas being diatomic, has 5 degree of freedom $\therefore$ total number of degree of freedom $= 5 \times 2.688 \times 10^{19}$ $= 13.44 \times 10^{19}$	½ ½ ½ ½ ½	3

SECTION D

Q.No	Value Points / Expected Answers	Marks	Total Marks
29	(i) B (ii) D (iii) C (iv) C OR A	1 1 1 1 1	4

30	(i) Low conductivity (ii) Reduce to half (iii) $$\frac{Q}{t} = \frac{\kappa A(T_{out} - T_{insid})}{l}$$ $$= \frac{0.022 \times 2.5 \times (35 + 15)}{60 \times 10^{-3}}$$ $$\frac{0.022 \times 2.5 \times 50}{60 \times 10^{-3}}$$ $$= 0.045 \times 10^{3} \text{ J/s}$$ OR 1. **Total Thermal Resistance (R_{total}):** $$R_{\text{total}} = R_1 + R_2$$ 2. **Expressing Resistances**: $$\frac{d_1 + d_2}{K_{\text{eff}} \cdot A} = \frac{d_1}{K_1 \cdot A} + \frac{d_2}{K_2 \cdot A}$$ 3. **Simplify by Canceling Area (A):** $$\frac{d_1 + d_2}{K_{\text{eff}}} = \frac{d_1}{K_1} + \frac{d_2}{K_2}$$ $$\frac{d_1 + d_2}{K_{\text{eff}}} = \frac{d_1 K_2 + d_2 K_1}{K_1 K_2}$$ 4. **Solve for K_{eff}:** $$K_{\text{eff}} = \frac{(d_1 + d_2) \cdot K_1 K_2}{d_1 K_2 + d_2 K_1}$$	1 1 1 1 ½ ½ ½ ½	4

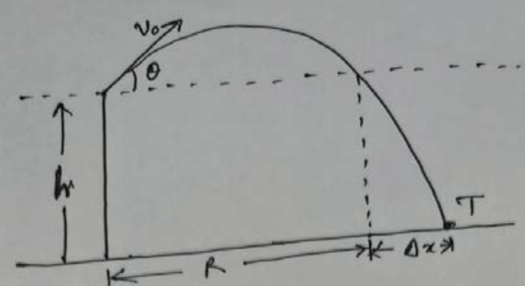
SECTION E

Q.No	Value Points / Expected Answers	Marks	Total Marks
31	(i) **(a)** Initial velocity in x-direction, $u_x = u + v_0 \cos\theta$ $u_y =$ Initial velocity in y-direction $= v_0 \sin\theta$ where angle of projection is θ. Now, we can write $\tan\theta' = \dfrac{u_y}{u_x} = \dfrac{v_0 \sin\theta}{u + v_0 \cos\theta}$ $\Rightarrow \theta' = \tan^{-1}\left(\dfrac{v_0 \sin\theta}{u + v_0 \cos\theta}\right)$	1	5
	(b) Let T be the time of flight. As net displacement is zero over time period T. $y = 0, u_y = v_0 \sin\theta, a_y = -g, t = T$ We know that $y = u_y t + \dfrac{1}{2} a_y t^2$ $\Rightarrow$ $0 = v_0 \sin\theta T + \dfrac{1}{2}(-g)T^2$ $\Rightarrow$ $T\left[v_0 \sin\theta - \dfrac{g}{2} T\right] = 0 \Rightarrow T = 0, \dfrac{2v_0 \sin\theta}{g}$	1	

$T = 0$, corresponds to point O.
Hence,

$$T = \frac{2v_0 \sin\theta}{g}$$

(ii)



½

Maximum Horizontal Range $R = \frac{V_0^2}{g}$ for $\theta = 45^\circ$

Taking motion in vertical direction

$$h = (-V_0 \sin\theta)t + \frac{1}{2} g t^2 \quad \text{—} \ (1)$$ ½

Taking motion in horizontal direction

$$(R + \Delta x) = V_0 \cos\theta \times t$$ 1

$$t = \left(\frac{R + \Delta x}{V_0 \cos\theta}\right) \quad \text{—} \ (2)$$

Put (2) in (1)

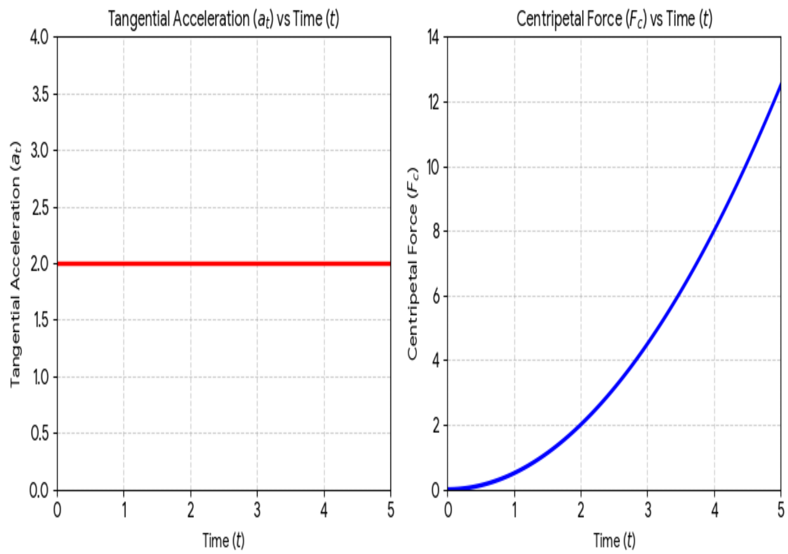
$$h = -(R + \Delta x)\tan\theta + \frac{1}{2} g \frac{(R + \Delta x)^2}{V_0^2 \cos^2\theta}$$ 1

Put $\theta = 45^\circ$ Then

$$\boxed{h = \Delta x\left(1 + \frac{\Delta x}{R}\right)}$$

OR

(i)

		1+1	
	(ii) $a_x = 3\cos 120° = -\frac{3}{2}$	½	
	$a_y = 3\sin 120° = 3 \times \frac{\sqrt{3}}{2}$	½	
	$v_x = -2 + \left(-\frac{3}{2}\right) \times 2 = -5$	½	
	$v_y = 4 + \frac{3\sqrt{3}}{2} = 6.6$	½	
	$v = v_x\hat{i} + v_y\hat{j}$ $v = -5\hat{i} + 6.6\hat{j}$	½	
	$\tan\beta = \frac{v_y}{v_x} = -\frac{6.6}{5} = -1.32$	½	
32	(i) When the two rotating discs are brought into contact, friction acts between the discs only. This friction is an		5

internal force for the two-disc system. Since no external torque acts on the system about the common axis of rotation, the total angular momentum remains conserved. 1

(ii)

- Moments of inertia of the discs = I_1 and I_2
- Initial angular speeds = ω_1 and ω_2
- Final common angular speed = ω

Initial angular momentum

$L_i = I_1\omega_1 + I_2\omega_2$ 1

After contact, both discs rotate together.

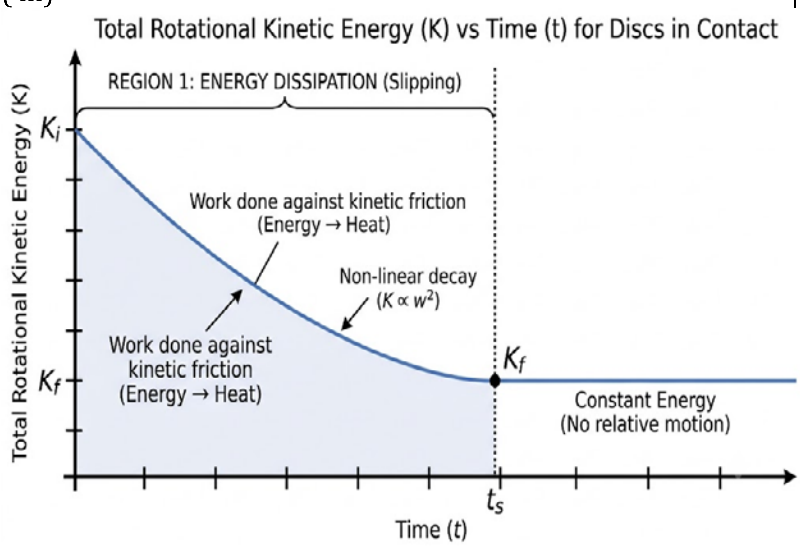
$L_f = (I_1 + I_2)\omega$

Apply conservation of angular momentum

$I_1\omega_1 + I_2\omega_2 = (I_1 + I_2)\omega$ 1

$\omega = I_1\omega_1 + I_2\omega_2 / (I_1 + I_2)$

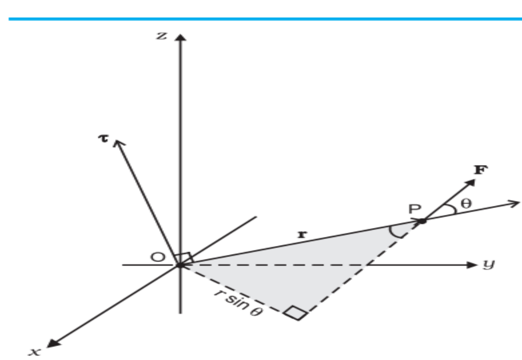
(iii)



1 (for sketching)

1(for labelling)

OR



(i) 1

	(ii) Let a force **F** act at an angle θ with the position vector **r**. Resolving the force into two mutually perpendicular components: • **Radial component:** $F_r = F\cos\theta$ (along the position vector) • **Tangential component:** $F_t = F\sin\theta$ (perpendicular to the position vector) The torque due to the applied force is $\tau = rF\sin\theta$. Since $F_t = F\sin\theta$, $\tau = r\,F_t$. For the radial component, $\tau_r = rF_r\sin 0^\circ = 0$, Because the radial force acts along the line joining the point of application and the axis of rotation, giving zero perpendicular distance (moment arm). Hence, • **Tangential component alone produces torque.** • **Radial component produces no torque.** (iii) No. The weight acts vertically downward, parallel to the hinge axis. Hence, its component perpendicular to the axis of rotation is zero, so the torque about the hinge axis is zero**.** Therefore, the weight of the door does not cause it to rotate about its hinges.	1 1 2	
33	(i) Harmonics are integral multiples of the fundamental frequency, whereas overtones are frequencies higher than the fundamental. Since the first harmonic is the fundamental itself, it is not an overtone. Hence, every overtone is a harmonic, but the first harmonic is not an overtone.	1	5

	(ii) $$\lambda = \frac{4L}{3}$$ $$\therefore \nu_1 = \frac{v}{\lambda} = \frac{3v}{4L} \text{ —— } (1)$$	1	
	for figure (B) $$\lambda = \frac{4L}{5}$$ $$\therefore \nu_2 = \frac{v}{\lambda} = \frac{5v}{4L} \text{ —— } (2)$$	1	
	Hence $\nu_1 : \nu_2 = 3 : 5$		
	(iii) **Sol^n** Let time t_1 taken by the stone to fall into well under gravity is given by $$t_1 = \sqrt{\frac{2h}{g}}$$	½	
	time (t_2) taken for the splash to travel height (h) is given by $$t_2 = \frac{h}{v}$$	½	
	$$\therefore \quad t_1 + t_2 = 1.45\,\text{s}$$ $$\sqrt{\frac{2h}{g}} + \frac{h}{v} = 1.45$$ $$\sqrt{\frac{2h}{9.8}} + \frac{h}{332} = 1.45$$ $$\boxed{h = 9.9\text{ m}}$$	1	
	OR		

(i)

$$4v^2 = 50 - x^2$$

$$v = \frac{1}{2}\sqrt{50 - x^2} = \omega\sqrt{A^2 - x^2}$$ ½

$\therefore$ On comparing, we get

$$\omega = \frac{1}{2}\ \text{rad s}^{-1}$$ ½

$$\therefore T = \frac{2\pi}{\omega}$$

$$\frac{x}{7} = \frac{2\pi}{(1/2)}$$ ½

$$\boxed{x = 88\ \text{m}}$$ ½

(ii) (**a**)

(i) The two springs are connected in parallel, so the force constant of the combination is

$$k' = k + k = 2k \quad \text{--- (1)}$$ ½

Now,

$$T = 2\pi\sqrt{\frac{m}{k'}} \quad \text{--- (2)}$$ ½

or

$$k' = \frac{4\pi^2 m}{T^2} \Rightarrow \frac{4 \times (3.14)^2 \times 12}{(1.5)^2} = 210.34\ \text{N}$$ ½

$$\therefore k = \frac{k'}{2} = 105.17\ \text{Nm}^{-1}$$ ½

(b)

(ii) With block M ($M > m$):
Time period of oscillation becomes

$$T' = 2\pi\sqrt{\frac{M + m}{k'}} \quad \text{--- (3)}$$ ½

From (2) and (3):

$$\frac{3}{1.5} = \sqrt{\frac{M + 12}{12}}$$

$$\therefore M = 36\ \text{kg}$$ ½