HBSE SAMPLE QUESTION PAPER

Class - XI

Session 2026-27

MARKING SCHEME

SUBJECT PHYSICS

SECTION-A (1 Mark Each)

Q1. (a) 4.8 g/cm^3

Q2. (b) $F^1v^{-1}T^1$

Q3. (b) Speed

Q4. (b) Force exerted by the ball

Q5. (b) 4 m

Q6. (b) Its momentum is doubled

Q7. (b) Decreases

Q8. (c) Internal energy

Q9. (d) Remains unchanged

Q10. (b) 0

Q11. MR^2

Q12. Yield point

Q13. Uniformly accelerated motion

Q14. (c) Infinite

Q15. $L = I\omega$

Q16. (A) Both Assertion (A) and Reason (R) are true, and R is the correct explanation of A.

Q17. (C) Assertion (A) is true, but Reason (R) is false

Q18. (C) Assertion (A) is true, but Reason (R) is false

SECTION-B (2 Marks Each)

Q19. Using dimensional analysis :

Let $d \propto \rho^x S^y f^z$.

Putting in the dimensions for each quantity: $[L] = [ML^{-3}]^x[MT^{-3}]^y[T^{-1}]^z$. 1

Equating powers of M, L, and T:

M: $0 = x + y \Rightarrow x = -y$

L: $1 = -3x \Rightarrow x = -1/3$. Therefore, $y = 1/3$. ½

T: $0 = -3y - z \Rightarrow z = -1$

Therefore, d $S^{1/3}$. Since the question states d $S^{1/n}$, comparing the powers gives n = 3. ½

Q20. Limiting Friction: It is the maximum value of static friction that comes into play when a body is just on the verge of sliding over the surface of another body. 1

Laws of Limiting Friction (any two):

1. The magnitude of limiting friction is directly proportional to the normal reaction between the two surfaces. ½

2. It depends on the nature of the surfaces in contact (their roughness or smoothness). ½

OR

Given u = 10m/s, v = 0, = 0.4, g = $10 m/s^2$.

Acceleration a = - g = -0.4 (10) = $-4 m/s^2$. ½

Using the equation $v^2 - u^2 = 2as$: ½

$0 - 10^2 = 2(-4)s$ or $-100 = -8s$ or s = **12.5 m**. 1

Q21. Given M = 5kg, m = 25 g = 0.025kg, v = 500m/s.

According to the conservation of momentum: MV + mv = 0 1

5 V + 0.025 (500) = 0 or 5V + 12.5 = 0 or V = -2.5m/s.

The recoil velocity of the gun is 2.5m/s. 1

OR

Mass of each ball m = 0.05kg. Initial velocities: u_1 = 16 m/s, u_2 = -16 m/s.

Final velocities after rebound: v_1 = -16 m/s, v_2 = 16 m/s. ½

Impulse = Change in momentum = $m(v_1 - u_1)$ ½

= 0.05(-16 - 16) = 0.05(-32) = -1.6 N.s or kg·m/s. 1

The magnitude of impulse imparted by each ball is 1.6N.s.

Q22. (i) Torque = Force x Perpendicular distance ½

= 2.5 (0.15) = 0.375 N·m. ½

(ii) Direction: Upwards (according to the right-hand rule). ½

(iii) Type of rotation: Anti-clockwise (counter-clockwise) rotation. ½

Q23. Variation of g with depth: The acceleration due to gravity decreases linearly with depth inside the Earth. ½

The formula is $g_d = g(1 – d/R)$, where d is the depth from the surface, R is the radius of the Earth, and g is the gravity at the surface. 1

At the center of the Earth (d = R), g_d becomes zero. ½

Q24. Given T = 300K, V_1 = 2 L, V_2 = 10 L, R = 8.31 J/mol·K.

Work done during an isothermal expansion: $W = nRT \ln(V_2/V_1)$. ½

W = 1 (8.31) (300) ln(10/2) = 2493 ln(5) 1

W = 2493 (1.609) = 4012J. ½

Q25. Given displacement: x = A sin(t).

Velocity (v): Differentiating displacement with respect to time:

v = d/dt = d/dt(A sin(t)) = A cos(t). 1

Acceleration (a): Differentiating velocity with respect to time:

a = dv/dt = d/dt(Acos(t)) = $-A^2$ sin(t) = $-^2$ x. 1

SECTION-C (3 Marks Each)

Q26. Specific Heat at Constant Pressure (C_p): The amount of heat energy required to raise the temperature of one mole of a gas by 1°C (or 1 K) while keeping its pressure constant. 1

Specific Heat at Constant Volume (C_v): The amount of heat energy required to raise the temperature of one mole of a gas by 1°C (or 1 K) while keeping its volume constant. 1

Why $C_p > C_v$: At a constant volume, all the supplied heat is entirely utilized to increase the internal energy of the gas. However, at a constant pressure, the supplied heat is used both to increase the internal energy AND to do external work against the surrounding pressure as the gas expands. Hence, more heat is needed at constant pressure. 1

Q27. Stokes' Law: It states that the backward viscous drag force (F) acting on a small spherical body of radius r moving with terminal velocity v through a fluid of viscosity η is given by $F = 6\pi\eta rv$. 1

Terminal Velocity calculation:

Let the radius of a small drop be r. Volume of 2 drops = $2 \times 4/3\ \pi r^3$. Let the combined drop have radius R.

$4/3\ \pi R^3 = 2 \times 4/3\ \pi r^3 \Rightarrow R = 2^{(1/3)}r$. 1

Since terminal velocity $v \propto r^2$, the new terminal velocity $V \propto R^2$.

$V = (2^{(1/3)})^2 \times v_{initial} = 2^{(2/3)} \times 20 \approx 1.587 \times 20 \approx 31.75$ cm/s. 1

OR

Using the capillary rise formula $h = 2S \cos\theta / r\rho g$. 1

Given: r = 0.025 mm = 2.5×10^{-5} m, $\rho = 0.8 \times 10^3$ kg/m³, $S = 3.0 \times 10^{-2}$ N/m, $\cos\theta = 0.3$, g = 10 m/s².

$h = (2 \times (3.0 \times 10^{-2}) \times 0.3) / ((2.5 \times 10^{-5}) \times (0.8 \times 10^3) \times 10)$ 1

$= (1.8 \times 10^{-2}) / 0.2 = 0.09$ m or 9 cm. 1

Q28. Degrees of Freedom: The total number of independent coordinates or independent ways in which a dynamic system can absorb energy or move without violating any given constraint. 1

For a diatomic gas molecule at room temperature: The value is 5 (3 translational degrees of freedom and 2 rotational degrees of freedom).

Breakdown of Degrees of Freedom (f = 5) 1

Translational (3): Movement along the X, Y, and Z axes. ½

Rotational (2): Rotation around two axes perpendicular to the molecular bond. ½

Q29. i) Radius of Gyration (k): It is defined as the perpendicular distance from the axis of rotation to a point where the entire mass of the body can be assumed to be concentrated, such that its moment of inertia remains the same as the actual body ($I = Mk^2$). 1

ii) Coefficient of Viscosity (η): The tangential force required per unit area to maintain a unit velocity gradient between two parallel fluid layers. 1

iii) Ratio of Speeds: The probable speed (v_p), average speed (v_{avg}), and root mean square speed (v_{rms}) for gas molecules are in the ratio: 1

$\sqrt{2} : \sqrt{8/\pi} : \sqrt{3}$

Q30. Scalar (Dot) Product: The dot product of two vectors yields a scalar quantity equivalent to the product of their magnitudes and the cosine of the angle between them: $\vec{A} \cdot \vec{B}$ = AB cos θ. ½

Properties: It is commutative ($\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$) and distributive over vector addition. ½+½

Vector (Cross) Product: The cross product yields a vector whose magnitude is AB sin θ and direction is perpendicular to the plane containing both vectors: $\vec{A} \times \vec{B}$ = (AB sin θ)n̂. ½

Properties: It is anti-commutative ($\vec{A} \times \vec{B} = -(\vec{B} \times \vec{A})$) and its magnitude represents the area of the parallelogram formed by the two vectors. ½+½

OR

Law of Parallelogram: If two vectors acting simultaneously at a point can be represented in magnitude and direction by the adjacent sides of a parallelogram, their resultant is represented completely by the diagonal passing through that point. 1

Resultant Force:

$R = \sqrt{(A^2 + B^2 + 2AB \cos \theta)}$ ½

$R = \sqrt{(3^2 + 4^2 + 2(3)(4) \cos(60°))} = \sqrt{(9 + 16 + 24(0.5))}$ ½

$= \sqrt{(25 + 12)} = \sqrt{37} \approx 6.08$ N. 1

SECTION-D (5 Marks Each)

Q31. A) Calculus Derivation:

Second Equation ($s = ut + 1/2at^2$): Velocity v = ds/dt, ds = vdt.

Since v = u + at, we have ds = (u + at)dt. Integrating both sides within limits 0 to t for time, and 0 to s for displacement: 1

$\int_0^S ds = \int_0^t (u + at)\, dt$ or $s = ut + 1/2at^2$. 1

Third Equation ($v^2 - u^2 = 2as$): Acceleration a = dv/dt = (dv/ds) (ds/dt) = v dv/ds. 1

Thus, ads = vdv. Integrating both sides (limits 0 to s for displacement, and u to v for velocity):

$a \int_0^S ds = \int_u^v v\,dv$ or $2as = v^2 - u^2$. 1

B) Projectile Problem :

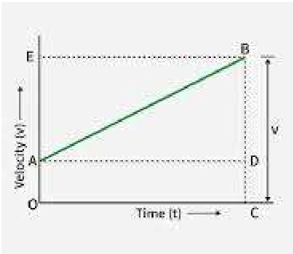
Maximum horizontal range $R_{max} = u^2/g = 160$ m.

The maximum vertical height to which the cricketer can throw the ball is when it is thrown straight up (angle = 90°), which gives $H_{max} = u^2/2g$. ½

Since $u^2/g = 160$, $H_{max} = 160/2 = 80$ m. ½

OR

A) Graphical Derivation : 1



Second Equation: Displacement s = Area under v-t graph = Area of rectangle + Area of triangle ½

$= ut + 1/2(t)(v - u)$. Since $v - u = at$, substituting gives $s = ut + 1/2at^2$. ½

**Third Equation: Displacement s = Area of trapezium = $1/2(u + v)t$. ½

From the first equation of motion, $t = (v – u)/a$. Substituting this yields $s = 1/2\ (v + u)(v - u)/a$

$2as = v^2 - u^2$. ½

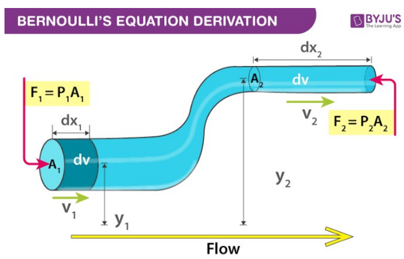
B) Projectile Problem :

Given u = 19.6 m/s, = 30^0. (Using standard g = 9.8 m/s^2).

Time of Flight: T = 2u sin g = 2(19.6) sin(30^0) / 9.8 = (39.2 x 0.5) / 9.8 = 2s. 1

Horizontal Distance (Range): R = u^2 sin(2) / g = $(19.6)^2$ sin(60^0) / 9.8 = 39.2 x 0.866 = 33.9 m. 1

Q32. A) Bernoulli's Theorem: It states that for the streamline flow of an ideal (incompressible and non-viscous) fluid, the sum of pressure energy, kinetic energy, and potential energy per unit volume is constant everywhere. Mathematically: P + ½ v^2 + gh = constant. 1



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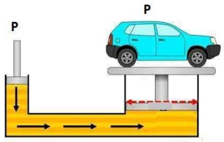
(Proof of $P + ½\ v^2 +\ gh$ = constant (any method) involves calculating the net work done on a fluid element in a pipe of varying cross-section and equating it to the change in its mechanical energy via the work-energy theorem). 2

B) Reynolds Number: It is a dimensionless parameter that determines the nature of fluid flow (laminar or turbulent) through a pipe. 1

OR

Pascal's Law: The pressure applied to an enclosed, incompressible fluid is transmitted undiminished to every portion of the fluid and the walls of the containing vessel. 1

Any one Application: Hydraulic lift used to lift heavy vehicles (Explanation). 1



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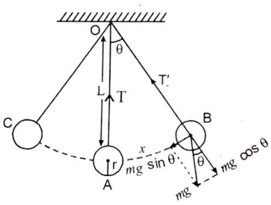
Numerical: Given D_1 = 5 cm, D_2 = 60 cm, F_1 = 50 N.

Using Pascal's Law: $F_1 / A_1 = F_2 / A_2$ or $F_2 = F_1 (D_2^2\ D_1^2)$ 1

$= 50 (60^2 / 5^2) = 50 (144) = 7200$ N. 1

Q33. A) Ideal Simple Pendulum: An ideal simple pendulum consists of a heavy point mass (bob) suspended by a perfectly inextensible, weightless, and perfectly flexible string from a rigid support. 1



Simple Pendulum 1

Derivation (Torque method): For a small angular displacement ,

the restoring torque is =-mgL sin   = -mgL. ½

Since = I α and $I = mL^2$, we get $mL^2\ \alpha$ = -mgL. ½

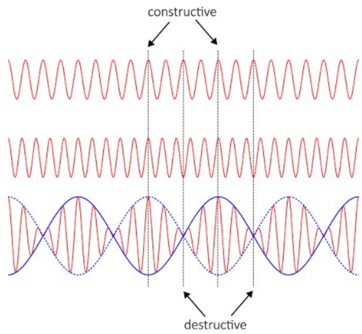
$-mgL\theta \Rightarrow \alpha = -(g/L)\theta$. This matches the SHM condition $\alpha = -\omega^2\theta$ where $\omega = \surd(g/L)$.

Time period $T = 2\pi/\omega = 2\pi\surd(L/g)$. 1

B) Tuning Forks: If tuning forks of frequency n_1 and n_2 produce n beats per second, the unknown frequency is $n_2 = n_1 \pm n$. 1

OR

A) Beats: The phenomenon of regular periodic variation in the intensity of sound due to the superposition of two sound waves of slightly different frequencies traveling in the same direction. 1



1

(Graphically represented by two constituent waves forming a resultant wave with a pulsating envelope).

B) Derivation: Let equations of the two waves be $y_1 = a \sin(2\pi n_1 t)$ and $y_2 = a \sin(2\pi n_2 t)$. Superposition gives $y = y_1 + y_2 = 2a \cos(2\pi(n_1-n_2)/2\ t) \sin(2\pi(n_1+n_2)/2\ t)$. 1

The amplitude modulates with frequency $(n_1-n_2)/2$, reaching maximum twice per cycle, making the beat frequency $n = n_1 - n_2$. (Prove this using maxima and minima condition.) 2

SECTION-E (Case Study - 4 Marks Each)

Q34. Elastic Collision

(i) C (Both momentum and kinetic energy) 1

(ii) B (0) 1

(iii) They will perfectly exchange their velocities (the moving body will come to rest, and the resting body will move with the initial velocity of the first body). 1

(iv) The lost kinetic energy appears primarily in the form of heat, sound, or deformation energy of the bodies. 1

Q35. Satellite Motion

(i) B (Centripetal force) 1

(ii) B (8 km/s) 1

(iii) 24 hours (Matches Earth's rotation period) 1

(iv) The time period will increase. According to Kepler's Third Law ($T^2 \propto R^3$), as the orbital radius (R) increases, the time period (T) also increases. 1

Here is the complete answer key for the Physics sample paper according to standard marking schemes.