**2025 Preliminary Examination H2 Physics Solution**

**Paper 1**

**1** **A** The vector sum of the two components is not R.

**2** **A** The d will increase initially as Car Y moving slower and Car X. After that, Car Y will move with speed greater than Car X and the relative speed is increasing . Hence gradient is getter steeper.

**3** **C** Net force up the slope

$630-(15+30)g\sin 30° = (15+30)a$

$a = 9.095 \text{ m s}^{-2}$

For the 15 kg crate, net force up the slope

$R - 15g\sin 30° = 15a$

$R = 15a + 15g\sin 30° = 15(9.095 + 9.81\sin 30°) = 210 \text{ N}$

**4** **B** Energy stored during the process is the area under the force-extension graph

$= \frac{1}{2}(T_1 + T_2)(e_2 - e_1)$

$= \frac{1}{2}(T_1 + T_2)[(x_2 - x) - (x_1 - x)]$

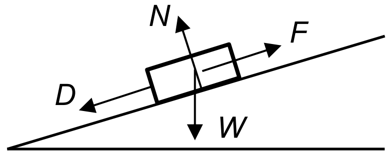
$= \frac{1}{2}(T_1 + T_2)(x_2 - x)$

**5** **A** For translational equilibrium, the net force has to be zero. Since the forces act in the opposite direction on the same object and have the same magnitude, the net force acting on the object is zero.
Option B: Even though the two forces act in opposite directions, they are spaced apart from each other which results in a torque or rotation. Hence, the object is not in equilibrium.
Option C: The direction of the torque of a couple depends on the direction of the two forces and is independent of the position of the pivot.
Option D: The pair of forces act on the same object, so they are not an action-reaction pair of forces.

**6** **D** $F = -\frac{dU}{dx}$

Magnitude of force = gradient of graph = $\frac{1.400 - 0.3125}{0.380 - 0.200}$ = 6.0 N

**7** **D** Drag force, $D$ = 250 N




Resolving forces along the slope

$F = D + mg\sin\theta = 250 + \left(900 \times 9.81 \times \frac{1.0}{12}\right) = 985.75 \text{ N}$

$P = Fv = 985.75 \times 24 = 23.7 \text{ kW}$

Alternative method:
$P$
= rate of work done against drag
+ rate of increase in GPE
= (250 × 24) + 900 × 9.81 × 2
= 23.7 kW

**8** **B** At the top of the circle,

$$T + mg = \frac{mv^2}{r}$$

$$T = \frac{mv^2}{r} - mg = \frac{(0.10)(6.0)^2}{0.50} - (0.10)(9.81) = 6.2 \text{ N}$$

**9** **B**

$$\phi = -G\frac{M}{r} = -G\left(\frac{1}{r}\right)(\text{volume} \times \text{density})$$

$$= -G\left(\frac{1}{r}\right)\left(\frac{4}{3}\pi r^3 \times \rho\right)$$

$$= -\frac{4}{3}\pi G\rho r^2$$

**10** **B**

$$G\frac{Mm_Y}{R_Y{}^2} = m_Y R_Y \omega_Y{}^2 \rightarrow \omega_Y{}^2 = G\frac{M}{R_Y{}^3} \rightarrow \omega_Y = \sqrt{G\frac{M}{R_Y{}^3}}$$

$$G\frac{Mm_X}{R_X{}^2} = m_X R_X \omega_X{}^2 \rightarrow \omega_X{}^2 = G\frac{M}{R_X{}^3} \rightarrow \omega_X = \sqrt{G\frac{M}{R_X{}^3}}$$

$$\frac{\omega_Y}{\omega_X} = \sqrt{\frac{G\frac{M}{R_Y{}^3}}{G\frac{M}{R_X{}^3}}} = \sqrt{\frac{R_X{}^3}{R_Y{}^3}} = (3)^{3/2}$$

in the same time $t$, $\frac{\theta_Y}{\theta_X} = \frac{\omega_Y}{\omega_X} = (3)^{3/2}$

$$\therefore \theta_Y = (3)^{3/2} \times 90^\circ = 467.7^\circ$$

$$467.7^\circ - 360^\circ = 107.7^\circ$$

Alternative method:

$$T^2 \propto r^3$$

$$T_X^2 = k(3r)^3$$

$$T_Y^2 = k(r)^3$$

$$\left(\frac{T_X}{T_Y}\right)^2 = 3^3$$

$$T_X = 5.196T_Y$$

X takes ¼ period to move thought 90°.

$$\frac{1}{4}T_X = 1.299T_Y$$

$$\theta_Y = 0.299 \times 360 = 108^\circ$$

**11** **C**

$$KE = \frac{1}{2}m\omega^2\left(x_0{}^2 - x^2\right)$$

$$PE = \frac{1}{2}m\omega^2 x^2$$

$$\frac{KE}{PE} = \frac{\left(x_0{}^2 - x^2\right)}{x^2} = 1$$

$$3.0^2 - x^2 = x^2$$

$$x = 2.1 \text{ m}$$

**12** **D** The child on a swing is pushed at regular intervals matching the swing's natural frequency, and the amplitude of the swing increases each time. This is an example of resonance where the driving frequency matches the natural frequency of the system.

**13** **C** Let the intensity of incident light be $I_0$. By Malus's law,

$I = I_0 \cos^2 30° \quad ... \quad (1)$

When filter is rotated anticlockwise by an angle of 45°, the transmission axis is 15° from the vertical. The new intensity $I'$,

$I' = I_0 \cos^2 15° \quad ... \quad (2)$

(2) ÷ (1),

$$\frac{I'}{I} = \left(\frac{\cos 15°}{\cos 30°}\right)^2$$

$I' = 1.2I$

**14** **C** Let length of tube be *L*. The wavelengths $\lambda$ of the lowest frequencies of sound produced are:

$$L = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}, \frac{7\lambda}{4}, ... = \left(\frac{2n-1}{4}\right)\lambda, \quad n \in \text{¢}^{+}$$

$$\lambda = \frac{4L}{2n-1}$$

$v = f\lambda$

$$f = \frac{v}{\lambda}$$

$$= \left(\frac{2n-1}{4L}\right)v, \quad n \in \text{¢}^{+}$$

$$= \frac{v}{4L}, \frac{3v}{4L}, \frac{5v}{4L}, \frac{7v}{4L}, ...$$

$$= f_0, 3f_0, 5f_0, 7f_0 \quad \left(\text{where the lowest frequency } f_0 = \frac{v}{4L}\right)$$

Hence, the different frequencies,

$= 92 \text{ Hz}, 3 \times 92 \text{ Hz}, 5 \times 92 \text{ Hz}, 7 \times 92 \text{ Hz}, ...$

$= 92 \text{ Hz}, 276 \text{ Hz}, 460 \text{ Hz}, 644 \text{ Hz}, ...$

**15** **A** $d \sin\theta = n\lambda$

$d \sin 50.8° = 3\lambda \quad ... \quad (1)$

For highest order, let $\theta = 90°$ (and sin 90° = 1).

$d = n\lambda \quad ... \quad (2)$

$(2) \div (1), \qquad \frac{1}{\sin 50.8°} = \frac{n}{3}$

$$n = \frac{3}{\sin 50.8°}$$

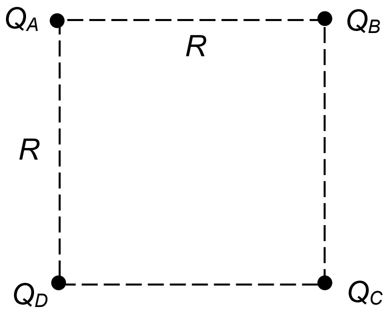
$n = 3.87$

Hence, highest order is 3.

**16** **D** Molecules move with different speeds, which can be different from the root-mean-square speed.

**17** **A** The water molecules collide with the walls of the bottle and rebound with greater velocities. Hence, the total microscopic kinetic energy of the water molecules increases.

**18** **B**




$$\text{EPE} = \frac{1}{4\pi\varepsilon_0}\left(\begin{array}{l}\dfrac{Q_AQ_B}{R} + \dfrac{Q_AQ_D}{R} + \dfrac{Q_AQ_C}{\sqrt{2}R} \\ + \dfrac{Q_BQ_C}{R} + \dfrac{Q_BQ_D}{\sqrt{2}R} + \dfrac{Q_CQ_D}{R}\end{array}\right)$$

$$\begin{aligned}\text{EPE} &= \frac{1}{4\pi\varepsilon_0}\left[\begin{array}{l}2\times\dfrac{(-1.0\times10^{-5})(5.0\times10^{-6})}{2}\times\dfrac{(-1.0\times10^{-5})(-1.0\times10^{-5})}{2\sqrt{2}} \\ +2\times\dfrac{(-1.0\times10^{-5})(5.0\times10^{-6})}{2}+\dfrac{(5.0\times10^{-6})(5.0\times10^{-6})}{2\sqrt{2}}\end{array}\right] \\ &= -0.50 \text{ J}\end{aligned}$$

**19** **D** A negatively charged particle moves from region of lower potential to region of higher potential.
Option A: This statement is correct at the mid-point between a charge of +$Q$ and a charge of $-Q$.
Option B: This statement is correct at the mid-point between a charge of +$Q$ and a charge of +$Q$.
Option C: $E$ tends asymptotically toward zero as $r$ increases. So, $\frac{dE}{dr}$ decreases as $r$ increases.

**20** **C**

$$I = nAvq = \frac{N_e}{V}Ave = \frac{N_e}{AL}Ave = \frac{N_e}{L}ve$$

$$I = \frac{4.8\times10^{22}}{0.20}\times3.2\times10^{-5}\times1.60\times10^{-19} = 1.2 \text{ A}$$

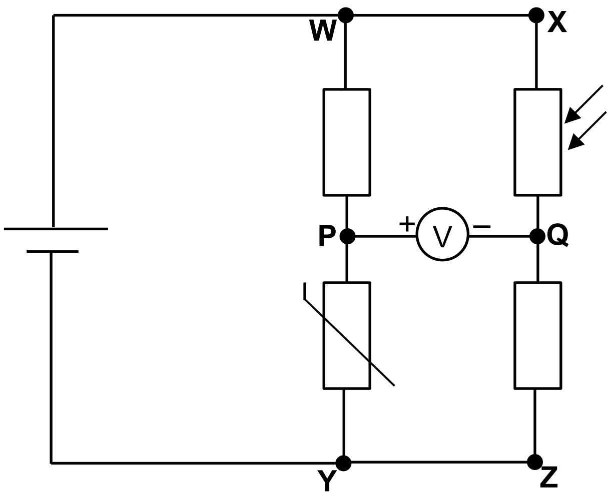
**21** **B**

$$R_{eff} = \left(\frac{1}{2}+\frac{1}{5}+1\right)^{-1} = 0.5882\ \Omega$$

$$V = 5.0\times0.5882 = 2.9412 \text{ V}$$

$$I = \frac{2.9412}{2.0} = 1.5 \text{ A}$$

**22** **A**



When temperature increases, $R_{LDR}$ decreases, $V_{PY}$ decreases, $V_{WP}$ increases and $V_P$ decreases.
When light intensity increases, $R_{thermistor}$ decreases, $V_{XQ}$ decreases, $V_Q$ increases.
Hence, $V_{PQ} = (V_p - V_Q)$ decreases.

**23** **B** The magnitude of the magnetic force remains constant as the orientation of the magnetic field and direction of current does not change. The torque is not constant as the perpendicular distance between the couple will vary as the loop rotates.

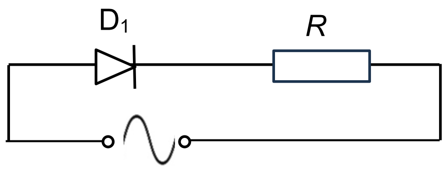
**24** **D**

$$B = \mu_o nI = (4\pi \times 10^{-7})\left(\frac{950}{0.80}\right)(2.0) = 2.985 \times 10^{-3} \text{ T}$$

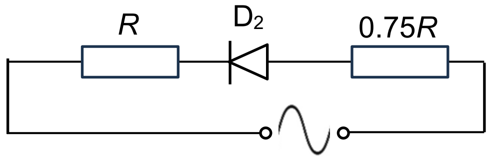
$$\varepsilon = \frac{\Delta NBA}{\Delta t} = \frac{2 \times 96 \times \left(2.985 \times 10^{-3}\right) \times \left(1.6 \times 10^{-3}\right)}{0.24} = 3.8 \text{ mV}$$

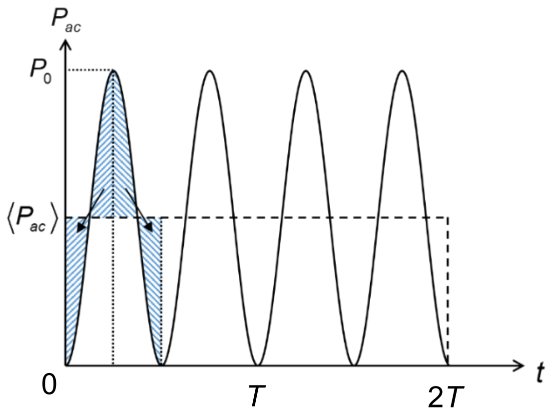
**25** **B** The current in the wire produces a magnetic flux density into the plane of the paper in the circular coil. As the coil moves away, the magnetic flux linkage in the coil decreases. By Lenz law, the direction of the induced current is clockwise to oppose this decrease.
By conservation of energy, kinetic energy decreases as current is induced.

**26** **C** For the first half cycle:
Only diode D1 is conducting and the effective resistance in the circuit is $R$.




In the second half cycle:
Only diode D2 is conducting and the effective resistance in the circuit is $1.75R$.




For half of a cycle,

$$\text{mean power} = \frac{1}{2}P_0 = \frac{V_0^2}{2R}$$

$$P = \frac{\frac{V_0^2}{2R} + \frac{V_0^2}{2(1.75R)}}{2} = 0.39\frac{V_0^{\ 2}}{R}$$

**27** **B** According to Heisenberg's uncertainty principle, $\Delta p_r \Delta r \geq h$.
Having a well-defined radius means $\Delta r = 0$, which means $\Delta p_r = \infty$.
Yet, based on the model, the radial momentum is zero.

**28** **A** The sharp characteristic lines are due to inner-shell electron transitions in the target atoms; electrons knocked out by incident electrons, followed by higher-level electrons filling the vacancies and releasing energy as X-rays.

**29** **C** total energy of gamma photons = rest mass energy of the two particles

$$2E_\gamma = 2mc^2$$

$$E_\gamma = \left(9.11 \times 10^{-31}\right)\left(3.0 \times 10^8\right)^2 = 8.2 \times 10^{-14} \text{ J}$$

**30** **D** energy released $= BE_{\text{product}} - BE_{\text{reactant}}$

$= \left[ \left( 8.4 \times 144 + 8.5 \times 90 \right) - \left( 7.6 \times 235 \right) \right] \times 10^{6} \times 1.6 \times 10^{-19}$

$= 3.02 \times 10^{-11}$ J