Raffles Institution
Year 5-6 Physics Department

2023 Year 5 H2 Physics Promotional Examination Solution

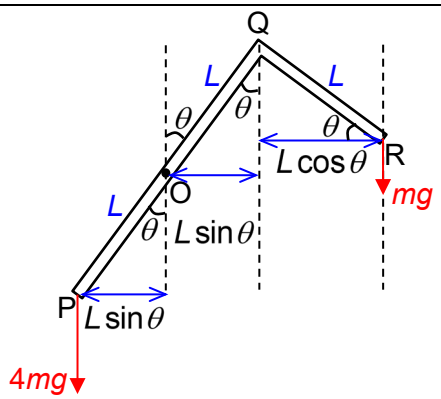
Section A

Qn	Ans	Solution
1	B	$V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi\left(\frac{d}{2}\right)^3$ $\frac{\Delta V}{V} = 3\frac{\Delta d}{V}$ Gradient of the graph is 3.
2	D	milli – 10^{-3} micro – 10^{-6} nano – 10^{-9}
3	C	$s_{\text{bus}} = u_{\text{bus}}t = 12 \times 30 = 360$ m $s_{\text{car}} = u_{\text{car}}t + \frac{1}{2}at^2$ $360 + 12 + 3.2 = 0 + \frac{1}{2}a(30)^2$ $a = 0.83378 = 0.83$ m s^{-2}
4	A	from velocity-time graph, $\Delta v = -0.15 - 0.2$ $= 0.35$ m s^{-1} By Newton's third law, force on cart = –force on sensor impulse on cart = –area under force-time graph of sensor $m(\Delta v) = -\frac{1}{2}(0.08 - 0.02)(40)$ $m(-0.35) = -1.2$ $m = 3.4286 = 3.4$ kg
5	D	Option A (incorrect): Upthrust on an object is equal to its weight only if the object is floating (i.e. in equilibrium). Option B (incorrect): Upthrust does not depend on the mass of the object. It depends on the mass and hence the volume of the liquid displaced by the submerged object. The volume of liquid displaced depends on the volume of the fully submerged object, which can be different even if the two objects have the same mass. Option C (incorrect): Upthrust is due to the difference in fluid pressure at the top and bottom surfaces of the object. Option D (correct): Upthrust is numerically equal to the weight of the liquid displaced by the submerged object. Hence upthrust depends on the density of the liquid and the volume of the liquid displaced. Since both spheres have the same dimensions, both displace the same volume of liquid when fully submerged and hence experience the same upthrust.

6 **C**

Taking moments about O,

$$4mg\left(L\sin\theta\right) = mg\left(L\sin\theta + L\cos\theta\right)$$
$$3\sin\theta = \cos\theta$$
$$\tan\theta = \frac{1}{3}$$
$$\theta = 18.435 = 18.4°$$



7 **C**

Power is the rate of transfer of energy. Hence the gradient of the graph is power.
Maximum power occurs between $t = 4$ s to $t = 6$ s, when the gradient is the largest.

$$\text{maximum power output to lift container} = \frac{40-10}{6-4} = 15 \text{ kW}$$

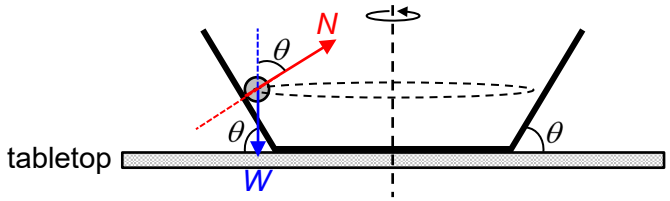
$$\text{Since efficiency} = \frac{\text{power output}}{\text{power input}},$$

$$\text{power input (supplied)} = \frac{\text{power output}}{\text{efficiency}} = \frac{15}{0.65} = 23.077 = 23 \text{ kW}$$

8 **B**

$$v = \omega r$$
$$= \frac{2\pi}{T} r$$
$$= \frac{2\pi\left(1.50\times10^{11}\right)}{365\times24\times60\times60}$$
$$= 29886 = 2.99\times10^{4} \text{ m s}^{-1}$$

9 **A**



The centripetal force on the ball is the resultant of the contact force and weight. The centripetal force points horizontally towards the centre of the horizontal circle.

10 **C**

Work done by the gravitational force,

$$W_{F_g} = -W_{F_{ext}}$$
$$= -m(\phi_f - \phi_i)$$
$$= -1\left[-\frac{3GM}{2R} - \left(-\frac{GM}{R}\right)\right]$$
$$= \frac{GM}{2R}$$

11	**A**	By conservation of energy, $E_{\text{surface}} = E_{\text{infinity}}$ $-\frac{GMm}{R} + \frac{1}{2}mv_{escape}^{\ 2} = 0$ $v_{escape} = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G\rho\left(\frac{4}{3}\pi R^3\right)}{R}} = \sqrt{\frac{8}{3}\pi\rho G R^2} \Rightarrow v_{escape} \propto \sqrt{\rho R^2}$ $\frac{v_{escape,M}}{v_{escape,E}} = \sqrt{\frac{\rho_M R_M^{\ 2}}{\rho_E R_E^{\ 2}}}$ $v_{escape,M} = \left(\sqrt{\left(\frac{4}{5}\right)\left(\frac{1}{4}\right)^2}\right)(11.2)$ $= 2.5044 = 2.50 \text{ km s}^{-1}$
12	**D**	Option A (incorrect): Maximum transfer of energy from the driving system to the oscillating system occurs only at resonance. Option B (incorrect): With a decrease in damping, less energy is lost from the oscillating system. The total energy of the oscillating system should increase. Option C (incorrect): With a decrease in damping, less energy is lost from the oscillating system. The amplitude at resonance should increase. Option D (correct): With a decrease in the degree of damping, the frequency at which resonance occurs increases. Since $T = 1/f$, the period of the driving force decreases.
13	**B**	The *x*-*t* graph shows the displacement from the equilibrium position of one particle at different times as it oscillates in simple harmonic motion. Option A (incorrect): At P, the particle is at maximum displacement from the equilibrium position. Its acceleration is maximum. Option B (correct): Since P and Q are $\frac{1}{4}T$ apart, their phase difference $\phi = \frac{(1/4)T}{T} \times 360° = 90°$. Option C (incorrect): Horizontal axis is time. OS represents two periods. Option D (incorrect): At P, the particle is at maximum displacement and is momentarily at rest. Hence its kinetic energy at P is zero. At R, the particle is at the equilibrium position and its speed is maximum. Hence its kinetic energy at R is maximum. The velocity of the particle at various times can also be determined from the gradient of the *x*-*t* graph.

14	**B**	Option A (incorrect): In a stationary wave, points R and S oscillate π rad out of phase with each other. The phase difference between them is π rad. Option B (correct): In a stationary wave, points Q and S oscillate in phase with each other with different amplitudes. Amplitude varies from zero at the nodes to a maximum at the antinodes. Option C (incorrect): Point P is a node which does not oscillate. At the node, the incident and reflected waves always meet π rad out of phase with each other such that the resultant displacement is always zero. Option D (incorrect): The stationary wave is formed by the superposition of the incident wave and the reflected wave. Hence the amplitude of the incident wave is half the amplitude of point Q.
15	**D**	The third order maxima in the interference pattern are missing as they coincide with the first order minima of the single slit diffraction envelope. single slit first order minima: $b\sin\theta = \lambda$ ----- (1) double slit maxima: $a\sin\theta = n\lambda$ ----- (2) $\frac{(2)}{(1)}$: $\frac{a}{b} = n$ $\frac{0.60}{b} = 3$ $b = \frac{0.60}{3} = 0.20$ mm