Raffles Institution
Year 5-6 Physics Department

2024 H1 Physics Paper 1 Preliminary Examination Solution and Mark Scheme

Qn	Ans	Solution
1	**A**	A basketball has a mass of about 0.6 kg, or a weight of about 6 N.
2	**A**	Unit of $P = \dfrac{\text{kg m s}^{-2}}{\text{m}^2} = \text{kg m}^{-1}\ \text{s}^{-1}$ Unit of $\rho = \text{kg m}^{-3}$ unit of $\left(\dfrac{\Delta P}{\rho}\right)^n = \dfrac{\left(\text{kg m}^{-1}\ \text{s}^{-2}\right)^n}{\left(\text{kg m}^{-3}\right)^n} = \left(\text{m}^2\ \text{s}^{-2}\right)^n$ $\left(\text{m}^{2n}\ \text{s}^{-2n}\right)^n = \text{m s}^{-1}$ Comparing indices of m: $2n = 1 \Rightarrow n = ½$
3	**D**	$\dfrac{diff}{\Delta diff} = \dfrac{d_1 - d_2}{\Delta d_1 + \Delta d_2} = \dfrac{0.02 + 0.03}{16.24 - 12.78} \times 100 = 1.4\ \%$
4	**C**	At times t_1 and t_2 after release, ball falls through a distance of s_1 and s_2, respectively. $s_1 = \dfrac{1}{2}gt_1^2$ and $s_2 = \dfrac{1}{2}gt_2^2$ $h = s_2 - s_1 = \dfrac{1}{2}g(t_2^2 - t_1^2)$ $g = \dfrac{2h}{(t_2^2 - t_1^2)}$
5	**D**	The ball hits the floor at A and gets compressed from A to B. The ball uncompresses from B to C and leaves the floor at C. From B to C to D, the ball is moving away from the floor, before coming to an instantaneous rest at D. Hence, D is the time the ball has reached maximum height after bouncing from the floor.
6	**C**	From **0–t_1**, since a–t graph is constant, gradient of v–t graph **is constant**. From **t_1–t_2**, since a–t graph is decreasing, gradient of v–t graph **is decreasing**. After **t_1**, since a–t graph is zero, the velocity is constant.
7	**D**	Option A: Possible, if lift is decelerating / decreasing in speed on its way up. Option B: Possible, if lift is moving upwards at a constant speed. Option C: Possible, if lift is accelerating / increasing in speed on its way up. Option D: Hence, all options above is possible, depending on the lift’s acceleration.

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C

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Applying N2L on a system of both crates:

$$F_{net,both} = m_{both}a$$
$$100 - 5.0 \times 9.81 = 5.0 \times a$$
$$50.95 = 5.0 \times a$$
$$a = 10.19 \text{ m s}^{-2}$$

Applying N2L on 2.0 kg crate,

$$F_{net,2kg} = m_{2kg}a$$
$$100 - 2.0 \times 9.81 - T = 2.0 \times 10.19$$
$$T = 60 \text{ N}$$

OR

Applying N2L on 3.0 kg crate,

$$F_{net,3kg} = m_{3kg}a$$
$$T - 3.0 \times 9.81 = 3.0 \times 10.19$$
$$T = 60 \text{ N}$$

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B

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Impulse or the change in momentum is area under the force-time graph,

$$\Delta p = \int F dt$$
$$(400)(v - 4.5) = \tfrac{1}{2}(1.0)(400) - \tfrac{1}{2}(2.0)(800)$$
$$v - 4.5 = \frac{-600}{400} = -1.5$$
$$v = 4.5 - 1.5$$
$$= 3.0 \text{ m s}^{-1}$$

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D

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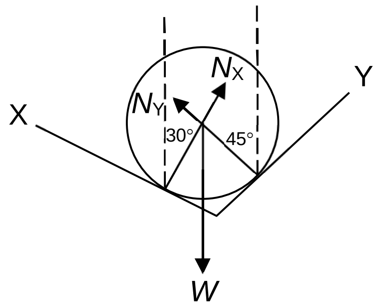
Resolving the normal forces horizontally,

$$N_Y \sin 45^o = N_X \sin 30^o$$
$$\frac{N_X}{N_Y} = \frac{\sin 45^o}{\sin 30^o} = 1.4$$



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C

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The resultant force of the road on the wheel is due to the upward normal force on the wheel and the leftward frictional force on the wheel.

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A

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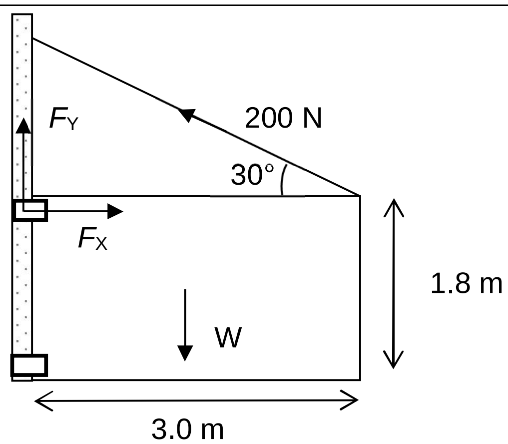
Take moments about the lower hinge, (so that we can ignore F_Y and force exerted by lower hinge)

F_X (1.8) + (40)(9.81)(1.5)
= (200 sin30°)(3.0) + (200 cos30°)(1.8)

F_X = 13 N to the right



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13

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A

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Work done by force is area under *F*–*s* graph, not *s*–*F* graph. Energy *P* is returned or released upon removal of force, and energy *Q* is used to permanently stretch to spring, i.e., energy used to separate the particles of the spring further apart.

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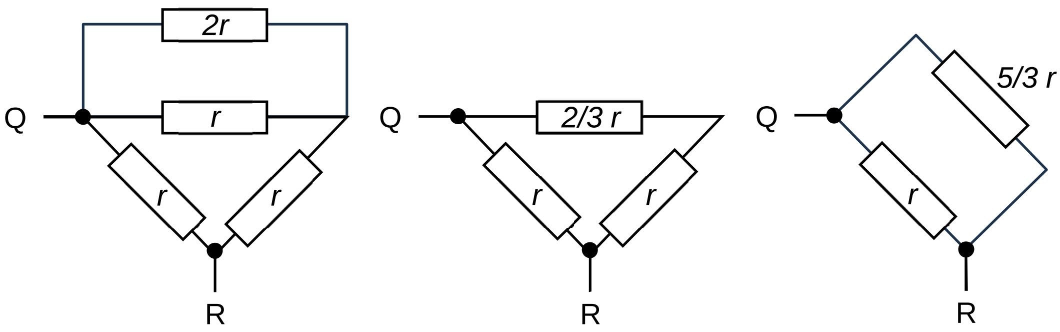
14	**D**	$P = Fv$ $12\times10^3 = F\left(\dfrac{72\times10^3}{60\times60}\right)$ $F = 600\text{ N}$ $E_{\text{from fuel}} = E_{\text{to car}}$ $(0.30)(40\times10^6)(m) = (12\times10^3)(1\times60\times60)$ $m = 3.6\text{ kg}$
15	**B**	Since speed of block remains constant, net force on block is zero. Therefore, magnitude of frictional force is equal to magnitude of component of weight along slope. Hence, rate of work done by frictional force = –*Fv* = –(*mg* sin 25°)(2.0) = –13.3 W
16	**C**	$\omega_m = \dfrac{2\pi}{60\times60}$ $\omega_h = \dfrac{2\pi}{12\times60\times60}$ $\dfrac{v_m}{v_h} = \dfrac{r_m\omega_m}{r_h\omega_h} = 1.5\dfrac{12\times60\times60}{60\times60} = 18$
17	**B**	Applying Newton's 2nd Law along the vertical and horizontal directions: vertically: $N\sin15° = \dfrac{mv^2}{r}$ (1) horizontally: $N\cos15° - mg = 0$ (2) $(1)\div(2):\ \tan15° = \dfrac{v^2}{rg}$ $v = \sqrt{(150)(9.81)(\tan15°)}$ $= 20\text{ ms}^{-1}$
18	**A**	The gravitational force of attraction between the two stars provides the centripetal force for the stars to undergo uniform circular motion about the same centre with the same angular speed ω, where *r* is the radius of orbit of star of mass *m* and *R* is the radius of orbit of star of mass *M*: $\dfrac{GMm}{d^2} = mr\omega^2 = MR\omega^2$ $mr\omega^2 = MR\omega^2$ $mr = MR$ Since X has a larger mass M, its radius R will be smaller. In addition, both stars must orbit diametrically opposite each other and in the same direction to maintain the same centre of orbit.

19	**A**	$I=\frac{E}{R}=\frac{E}{\frac{\rho L}{A}}=\frac{\pi d^2 E}{\rho L}$ $I\propto\frac{d^2}{\rho}$ $\frac{I_X}{I_Y}=\frac{\left(\frac{1}{4}d\right)^2\times\rho}{d^2\times\frac{1}{2}\rho}=\frac{1\times 2}{16\times 1}=\frac{1}{8}$ $\frac{I_X}{I_{total}}=\frac{1}{9}$
20	**B**	$I=I_{electrons}+I_{ions}$ $12.2\times10^{-3}=\left(2.58\times10^{16}\right)\times\left(1.60\times10^{-19}\right)+N'\times\left(3.20\times10^{-19}\right)$ $N'=2.52\times10^{16}\ \text{s}^{-1}$
21	**B**	From the graph, E = 3.0 V $E=Ir+V$ $3.0=(0.75)r+0.8$ $r=\frac{3.0-0.8}{0.75}=2.93\,\Omega$
22	**D**	There is no current flowing from one circuit to the other. Hence, the p.d. across the 100 Ω and 200 Ω resistors are the same. $V_{100\Omega}=V_{200\Omega}$ $\left(\frac{100}{50+100}\right)\times12=\left(\frac{200}{R+200}\right)\times24$ $R=400\ \Omega$
23	**B**	Assume that the lower potential terminal of the cell is 0 V. Hence, potential at A is equal to p.d. across the 11 Ω resistor and potential at B is equal to p.d. across the 1.5 Ω resistor. $\therefore V_{AB}=V_A-V_B=V_{11\Omega}-V_{1.5\Omega}=\left(\frac{11}{11+1.0}\right)6-\left(\frac{1.5}{1.5+3.0}\right)6=3.5\ \text{V}$

24	**A**	Assume each resistor has resistance r. Across PR: $R_{eff} = \left(\frac{1}{2r}+\frac{1}{2r}\right)^{-1} = r$ Across QS: $R_{eff} = \left(\frac{1}{2r}+\frac{1}{r}+\frac{1}{2r}\right)^{-1} = \frac{1}{2}r$ Across PS & QR: $R_{eff} = \left(\frac{1}{r}+\frac{3}{5r}\right)^{-1} = \frac{5}{8}r$ (see below) 
25	**D**	The electron experiences a downward force within the electric field which causes it to gain speed in the vertical direction. Upon exiting the field, the electron's speed has increased.
26	**B**	Gain in K.E. of electron is due to work done on it by the electric field: $W = Fd$ $= qEd$ $= (1.60\times10^{-19})(3.0\times10^{5})(0.080)$ $= 3.8\times10^{-15}$ J
27	**C**	The current in wire X produces a magnetic field along the circumference of coil Y in the clockwise direction. This magnetic field is parallel to the current in coil Y. Hence. no magnetic force acts on any part of coil Y.
28	**C**	Energy released = (89 × 8.6169 + 144 × 8.2656) – (235 × 7.5909) = 173.289 = 173 MeV
29	**C**	Option A: ${}^{A}_{Z}X^{*} \rightarrow {}^{A}_{Z}X + \gamma$ (same element) Option B: ${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-1}X + {}^{4}_{2}\alpha + {}^{0}_{-1}\beta$ (different element) Option C: ${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z}X + {}^{4}_{2}\alpha + 2\left({}^{0}_{-1}\beta\right)$ (different isotope) Option D: ${}^{A}_{Z}X \rightarrow {}^{A-8}_{Z-3}X + 2\left({}^{4}_{2}\alpha\right) + {}^{0}_{-1}\beta$ (different element)
30	**B**	For X, $\left(\frac{1}{2}\right)^{\frac{t}{T_X}} = \frac{1}{8} = \left(\frac{1}{2}\right)^{3} \Rightarrow \frac{t}{T_X} = \frac{\lg(1/8)}{\lg(1/2)} = 3$. For Y, $\left(\frac{1}{2}\right)^{\frac{t}{T_Y}} = \frac{1}{4} = \left(\frac{1}{2}\right)^{2} \Rightarrow \frac{t}{T_Y} = \frac{\lg(1/4)}{\lg(1/2)} = 2$. $\frac{T_X}{T_Y} = \frac{2}{3} = 0.67$

7A
8B
8C
7D