2023 Preliminary Examination H1 Physics Paper 1 Solutions

1 **D** $V = \frac{W}{Q} = \frac{W}{It} = \frac{Fd}{It}$

units of V $= \frac{\text{kg m s}^{-2} \times m}{\text{A} \times \text{s}} = \text{kg m}^2 \text{ s}^{-3} \text{ A}^{-1}$

2 **C** The average apple is between 70 and 100 grams. Weight = 0.100 × 9.81 = 0.98 N

3 **B** When θ is zero, $F_2 = F$ (largest), $F_1 = 0$ (smallest).
When θ is 90°, $F_2 = 0$ (smallest), $F_1 = F$ (largest).

4 **C** $s_1 = \frac{1}{2}a_1(4^2) = 8a_1$

$s_2 = \frac{1}{2}a_2(4^2) = 8a_2$

Hence, $s_1 - s_2 = 16 = 8(a_1 - a_2) \Rightarrow a_1 - a_2 = 2$

At t = 8 s,

$s_1 - s_2 = \frac{1}{2}(a_1 - a_2)(8^2)$

$= 64$ m

5 **B** $v^2 = u^2 - 2as$

$v = \sqrt{u^2 - 2as}$

$= \sqrt{2a\left(\frac{u^2}{2a} - s\right)}$

$= \sqrt{2a} \times \sqrt{\left(\frac{u^2}{2a} - s\right)}$

Hence, the graph of v against s is a "square-root" graph shifted to the right by $u^2/2a$ to the right and then reflected about the vertical line passing through $s = u^2/2a$.

6 **C** $v_y^2 = u_y^2 - 2gy$

At the highest point, $v_y = 0$. Hence,

$0 = u_y^2 - 2gy$

$u_y = \sqrt{2gy}$

Since the maximum height reached is the same for all three paths, u_y is the same too.
Option A: $S_y = u_yt + at^2$, since all three paths end on ground level, time of flight is the same. Path Z has the longest range. $S_x = u_xt$, path Z has the highest horizontal component and the largest initial speed $(u = \sqrt{u_x^2 + u_y^2})$.
Option B: $S_y = u_yt + at^2$, since all three paths end on ground level, time of flight is the same.
Option D: Path X has the shortest range. $S_x = u_xt$, path X has the lowest horizontal component.

7 **A** By Newton's second law, taking the direction of F_1 as positive,

$$F_{net} = ma$$
$$F_1 - F_2 = ma$$
$$a = \frac{F_1 - F_2}{m}$$

Since object was at rest, F_2 is initially zero $\left(\because F_2 \propto v^2\right)$ and acceleration is maximum initially. Acceleration then decreases as F_2 increases with increasing speed as object accelerates. Acceleration becomes zero eventually when $F_1 = F_2$ and object travels at constant (maximum) speed henceforth.

8 **A** W is the force the Earth exerts on the brick and S is the force the floor exerts on the brick. Hence, by Newton's third law, equal and opposite force to W is the force the brick exerts on the Earth, and equal and opposite force to S is the force the brick exerts on the floor.

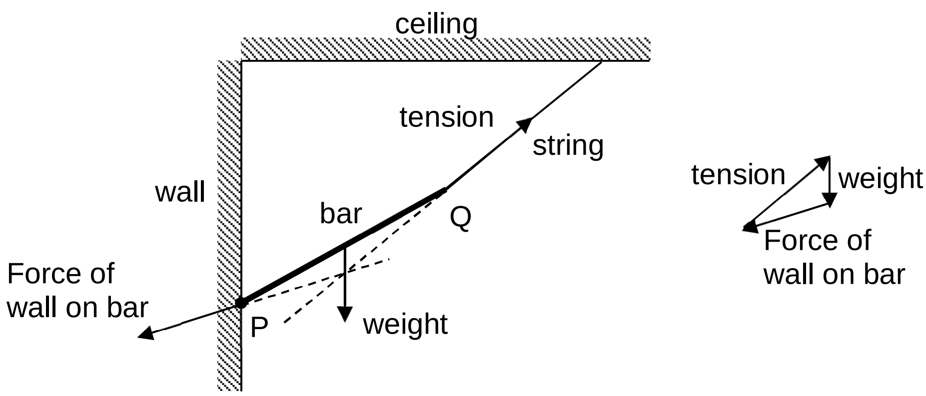
9 **C** Let the mass of trolley be m and the angle the slope makes with the horizontal be θ. By Newton's second law, taking the direction down the slope as positive,

$$F_{\text{net}} = ma$$
$$mg\sin\theta = ma$$
$$a = g\sin\theta$$

where g is the acceleration of free fall.
Acceleration is independent of mass.

10 **D** The initial momentum of the 2 kg sphere is 8 kg m s^{-1} to the right. The initial momentum of the 3 kg sphere is 18 kg m s^{-1} to the left. The total initial momentum (before collision) is 10 kg m s^{-1} to the left. Thus, both spheres cannot come to rest at the same time, otherwise principle of conservation of linear momentum will be violated.

11 **A** At equilibrium, the lines of action of three forces must meet at a point.
The arrows in the vector triangle must form a closed loop.



12 **B** Since the student's head is only rotating, there is no resultant force acting on the head.

The rotation of her head is produced by the couple acting on her head.

13 **B** clockwise moment about pivot $=$ anticlockwise moment about pivot

$$\left(V_{wood}\rho_{wood}g\right)(x)=\left(V_{plastic}\rho_{plastic}g\right)(2.0x)$$

$$\frac{\rho_{plastic}}{\rho_{wood}}=\frac{V_{wood}(x)}{V_{plastic}(2.0x)}$$

$$=\frac{(5.0xA)(x)}{(xA)(2.0x)} \qquad (A \text{ is the cross-sectional area})$$

$$=2.5$$

14 **D** Work done is area under the force extension graph.
This would be the work done to stretch the spring from x_1 to x_2.

15 **C**

$$\text{total gain in energy} = \text{total loss in energy}$$

$$\text{gain in GPE}_\text{P} + \text{gain in KE}_\text{PQ} = \text{loss in GPE}_\text{Q} + \text{W.D. against friction}$$

$$m_P g(1.5\sin 30^\circ - 0) + \text{gain in KE}_\text{PQ} = m_Q g(1.5-0) - f(1.5)$$

$$\text{gain in KE}_\text{PQ} = m_Q g(1.5) - f(1.5) - m_P g(1.5\sin 30^\circ)$$

$$=(4.0)(9.81)(1.5)-(2.5)(1.5)-(3.0)(9.81)(1.5\sin 30^\circ)$$

$$=33.0375$$

$$=33\text{ J}$$

16 **A** Work done against resistive forces $=400\times 1000$ J

$$\text{Energy from fuel } = \frac{400\times 1000\text{ J}}{0.16}$$

$$\text{Mass of fuel needed} = \left(\frac{400\times 1000}{0.16}\right)\Big/45\times 10^6 \text{ kg}$$

$$=55.6\text{ g} \approx 56\text{ g}$$

17 **B**

Power $p=Fv=F\times(u+at)=F\times at=F\times\left(F/m\right)t$

Since force F is constant, $p\propto t$

$\therefore$ graph of p vs t is a straight line passing through the origin.

18 **D**

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

$$1.2+0.040\times 9.81=\frac{mv^2}{0.30}$$

$$\frac{1}{2}mv^2=0.23886$$

By conservation of energy,

$$\frac{1}{2}mv^2+mgh=\frac{1}{2}mu^2$$

$$0.23886+0.040\times 9.81\times(2\times 0.30)=\frac{1}{2}\times 0.040\times u^2$$

$$u^2=23.715$$

$$a=\frac{u^2}{r}=\frac{23.715}{0.30}=79.1\text{ m s}^{-2}$$

19 **A** Angular velocity and angular displacement are the same for both points since they are rotating on the same disc.

20 **A**
$$\frac{GMm}{r^2}=\frac{mv^2}{r}$$
$$\frac{GM}{r}=v^2$$
$$\frac{v_Q}{v_P}=\sqrt{\frac{r_P}{r_Q}}$$
$$v_Q=\sqrt{\frac{1}{3}}\,v$$

21 **B**
$$P=\frac{V^2}{R}$$
$$R_\text{A}=240\ \Omega,\ R_\text{B}=2.215\ \Omega$$
$$R=\rho\frac{L}{A}=\rho\frac{L}{\left(\frac{\pi d^2}{4}\right)}\quad\Rightarrow R\propto\frac{1}{d^2}\quad\Rightarrow d\propto\frac{1}{\sqrt{R}}$$
$$\frac{d_A}{d_B}=\sqrt{\frac{R_B}{R_A}}=\sqrt{\frac{2.215}{240}}=\sqrt{9.229\times10^{-3}}=0.096$$

22 **C** p.d. across the 400 Ω resistor = p.d. across the 600 Ω resistor

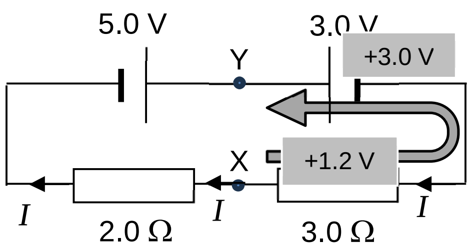
Since $I=\dfrac{V}{R}$,

Current through the 600 Ω resistor = $\left(\dfrac{400}{400+600}\right)I=\dfrac{2}{5}I$

$$\frac{\text{power dissipated across 120 }\Omega}{\text{power dissipated across 600 }\Omega}=\frac{I^2(120)}{\left(\frac{2}{5}I\right)^2(600)}=1.25=1.3$$

23 **D** Effective e.m.f. = 2.0 V

p.d. across the 3.0 Ω resistor = $\dfrac{3.0}{2.0+3.0}(2.0)=1.2\text{ V}$



p.d. between X and Y = 1.2 + 3.0 = 4.2 V
(going from negative terminal to positive terminal

24 **B** Use Fleming's left hand rule to determine the direction of the forces.

25 **B**
$$F_1=B_1IL$$
$$F_2=B_2IL=(0.5B_1\cos20^\circ)IL=0.5F_1\cos20^\circ=0.5\left(7.5\times10^{-3}\right)\cos20^\circ=3.5\times10^{-3}\ \text{mN}$$ 2

26 **C**
$$F_\text{B}=ma$$
$$Bqv=\frac{mv^2}{r}\quad\Rightarrow\quad r=\frac{mv}{Bq}\quad\Rightarrow r\propto\frac{m}{q}$$
$$\frac{r_\text{Li}}{r_\text{O}}=\frac{m_\text{Li}}{m_\text{O}}\times\frac{q_\text{O}}{q_\text{Li}}=\frac{7}{16}\times\frac{2}{1}=\frac{7}{8}$$

27 **A** Each α decay causes the nucleus to lose 4 nucleons including 2 protons.
After 8 α decays, the nucleus has 241 – 8(4) = 209 nucleons left,
and 94 – 8(2) = 78 protons left.
After 5 β decays, the nucleus has 78 + 5 = 83 protons, which matches $^{209}_{83}\mathrm{Bi}$.

28 **D** Total energy of products = 939 + 940 = 1879 MeV
Total mass of deuteron = 1876 MeV
Hence, the deuteron needs to capture an energy of 1879 – 1876 = 3 MeV

29 **D** The mass of the radioisotope has no effect on safety concerns.
Option A: Short half-life will be preferred so that the radioisotope is not radioactive in the body for too long.
Option B: The daughter nucleus should not be harmful to the body.
Option C: The intensity should not be too high to cause harm.

30 **B** This shows the random nature of radioactive decay.
Option A: This is due to the law of decay, and not the spontaneous nature.
Option C: This is the spontaneous nature in which the rate of decay is unaffected by external conditions.
Option D: This is a fact not related to random nature.