2024 Physics Prelim Exam H1 Paper 2 suggested solutions

1(a)

$$s_y = u_y t + \frac{1}{2} g t^2$$

From Fig. 1.1, $s_y = 1.75$ m and t = 0.600 s [1]

$$\therefore g = \frac{2s_y}{t^2} = \frac{2(1.75)}{(0.600)^2}$$

$$= 9.722 \text{ m s}^{-2}$$

$$= 9.72 \text{ m s}^{-2} \quad [1]$$

(b) % uncertainty = actual uncertainty/ data point. [1]

Hence the larger the data point, the smaller the % uncertainty since the absolute uncertainty is fixed. Hence more reliable. [1]

(c)

$$\frac{\Delta g}{g} = \frac{\Delta s_y}{s_y} + 2\frac{\Delta t}{t} \quad [1]$$

$$\Delta g = [\frac{0.001}{1.75} + 2(\frac{0.006}{0.600})](9.722)$$

$$=0.2 \text{ m s}^{-2} \quad [1]$$

$$g = 9.7 \pm 0.2 \text{ m s}^{-2} \quad [1]$$

(d) Since $s_y = ½gt^2$, plot a graph of s_y against t^2, where, s_y = vertical distance travelled by the sphere, t = time taken to travel s_y. The gradient = ½*g.* [1]

Random error is reduced when a best fit line is drawn using all the data points. [1]

2(a) By the principle of conservation of momentum, since there is no external force acting, the total change in momentum of the of ball and wall = 0. [1]

Therefore the change in momentum (impulse) of the wall is equal and opposite to the change in momentum of the ball . [1]

Therefore, Student A is wrong.

(b) Taking values from Fig 2.2,
Total momentum before collision = (1.2 x 4) + 0 = 4.8 kg m s^{-1} [1]
Total momentum after collision = (1.6 x 3.6) + (-0.8 x 1.2) = 4.8 kg m s^{-1} [1]

Since total momentum before collision is equal to the total momentum after collision, momentum is conserved in this collision. [1]

(c) Relative speed of approach = 4.0 – 0 = 4.0 m s^{-1}
Relative speed of separation = 1.6 – (-0.8) = 2.4 m s^{-1} [1]

Since relative speed of approach is not equal to relative speed of separation, the collision is inelastic. [1]

3(a) Electric field strength at a point is electric force per unit positive charge at that point. [1]

(b)(i)
$$F = (2e)E \quad [1]$$
$$= 2\times(1.6\times10^{-19})(7.5\times10^{4})$$
$$= 2.4\times10^{-14}\text{ N} \quad [1]$$

(b)(ii) Time taken for alpha particles to travel 1 m in the horizontal direction,

$$t = \frac{s_x}{u_x} = \frac{1.0}{1.50\times10^{7}}$$
$$= 6.67\times10^{-8}\ s \quad [1]$$

(b)(iii) Acceleration in the vertical direction,

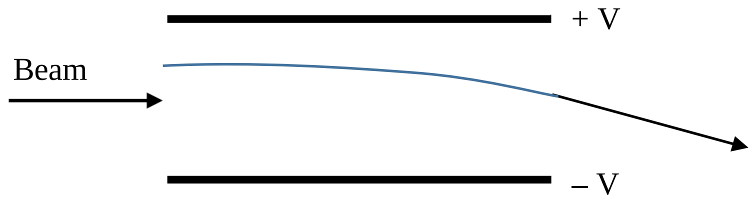
$$a = \frac{F}{m} = \frac{F}{4u} = \frac{2.4\times10^{-14}}{4\times1.66\times10^{-27}} = 0.3614\times10^{13}\ ms^{-2} \quad [1]$$

Displacement in vertical-direction during time t,

$$s = \frac{1}{2}at^2 = \frac{1}{2}(0.3614\times10^{13})(6.67\times10^{-8})^2 = 0.008039 \approx 0.0080\ m \quad [1]$$

The particles will not hit any of the plates as the vertical displacement of the electron is less than 0.0125 m when it is travellling between the two parallel plates.

(b)(iv)



Parabolic path curves upward inside the plates

Straight path outside the plates

4(a) Magnetic flux density is defined to be the magnetic force acting per unit current and per unit length on a conducting wire [1]
placed at right angles to the direction of the magnetic field. [1]

(b)(i) Direction of the magnetic flux density is *into* the plane of the page. [1]

(ii) Magnetic force on a charge particle, $F_B = Bqv\sin\theta$ [1]

$$= \left(4.8\times10^{-3}\right)\left(1.6\times10^{-19}\right)\left(1.7\times10^{7}\right)\left(\sin 90°\right)$$
$$= 1.3\times10^{-14}\ \text{N}$$ [1]

(iii) For circular motion, magnetic force provides for the circular motion,

$$\therefore F_B = \frac{mv^2}{r}$$ [1]

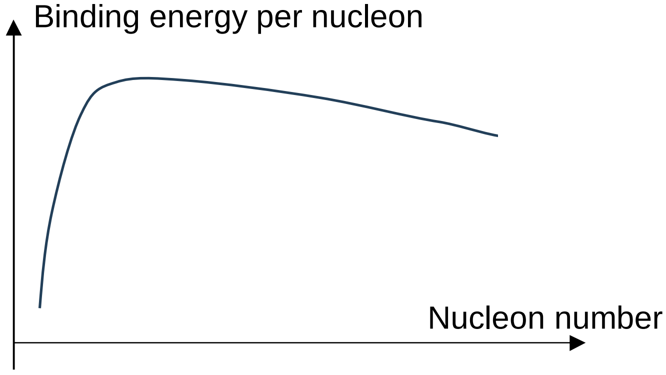
Therefore, the electron will move in a circular motion of radius,

$$r = \frac{mv^2}{F_B}$$
$$= \frac{\left(9.11\times10^{-31}\right)\left(1.7\times10^{7}\right)^2}{1.3\times10^{-14}} = 0.020\,\text{m}$$ [1]

Required distance, $d = 2r = 2\left(0.020\right) = 0.040\,\text{m}$ [1]

5(a) It is the energy needed to completely separate the nucleus into its constituent nucleons. [1]

(b)



(c)

- The parent nucleus starts on the far right side of the graph. [1]
- The daughter nuclei end up on the higher part of the curve towards the left, with higher binding energy per nucleon. [1]
- This means that the daughter nuclei are more stable than the parent nucleus, which means energy must be released in the process. [1]

(d)(i) $^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}K + 2\,^{1}_{0}n$ [1]

(ii) Energy released = change in binding energy

= total final binding energy – initial binding energy [1]

= [(8.32 x 141) + (8.51 x 92) – (7.59 x 235)] x 10^6 x 1.60 x 10^{-19}

= 2.7582 x 10^{-11} J [1 for correct conversion from eV to J]

= 2.76 x 10^{-11} J [1]

(iii) Total energy obtained = no. of nuclei x energy released in 1 reaction [1]

$$= \frac{\text{Total mass}}{\text{Mass of 1 nucleus}} \times 2.7582 \times 10^{-11}$$ [1]

$$= \frac{1.00 \times 10^{-4}}{235 \times 1.66 \times 10^{-27}} \times 2.7582 \times 10^{-11}$$

= 7.07 x 10^9 J [1]

6(a)(i) Both ISS and astronaut experience free fall directed to the centre of the earth due to gravity, [1]

So there is no contact force by ISS on astronaut. [1]

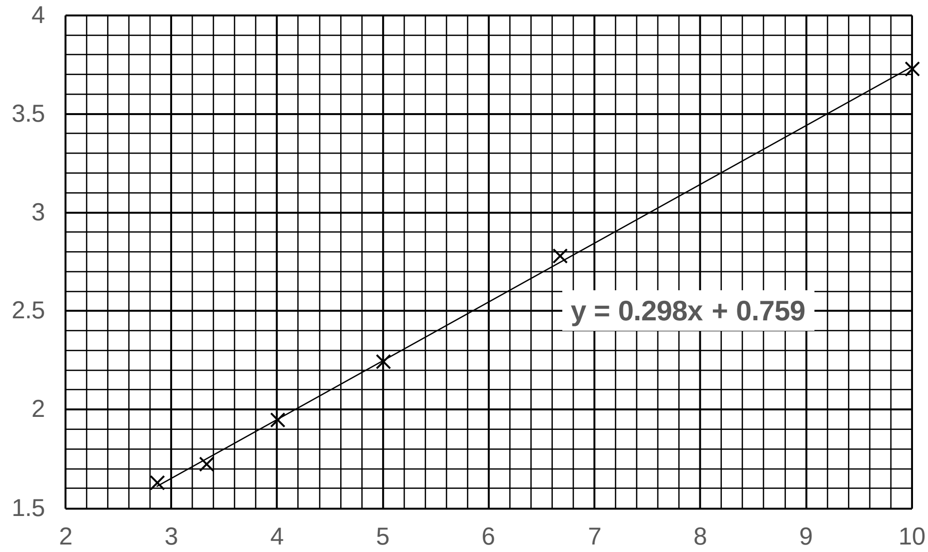
6(a)(ii) g' =8.825 m s^{-2} [1]

6(b)(i) T=0.7835 [1]

$1/T^2$=1.629 [1]

$1/M$=2.86 [1]

6(b)(ii)



best fit straight line with line thickness not comparable to half sq [1]
p = 0.298 kg s^{-2} [1]
q = 0.759 s^{-2} [1]

6(b)(iv)

For $\dfrac{1}{T^2} = \dfrac{p}{M} + q \rightarrow T = \sqrt{\left(\dfrac{p}{M} + q\right)^{-1}}$

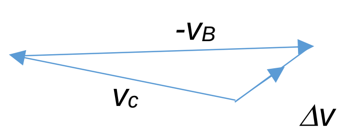
For M = 0.5 kg, $T = \sqrt{\left(\dfrac{0.298}{0.5} + 0.759\right)^{-1}} = 0.859$ s [1]

$\Delta T = \dfrac{2(0.298)(0.858)^3}{0.5} \times (10\%) = 0.08$ s (1 s.f.) [1]

6(b)(v) Yes. Since the expected ΔT = 0.08 s, the expected variation for 20 oscillations is 20 x 0.08 = 1.6 s. [1] Human reaction error in using a stop watch is about 0.3 s, so a variation of 1.6 s should be detectable. [1]

7(a)(i) It meant a displacement of 20.0 m in 1.0 second.

(ii) Let the velocity at position B be v_B.



correct v_B (showing greater magnitude than v_c). [1]
correct Δv (do not accept vertically upwards). [1]

(iii)

Total mechanical energy = Kinetic energy + Potential energy [1]

$$= \frac{1}{2}mv_A{}^2 + mgh_A$$

$$= \frac{1}{2}(560)(20)^2 + (560)(9.81)(25.0)$$

$$= 2.49 \times 10^5 \text{ J} \quad [1]$$

(iv)

Total energy at D = total energy at A [1]

$$\frac{1}{2}mv_D^2 + mgh_D = 2.49 \times 10^5 [1]$$

$$\frac{1}{2}(560)v_D^2 + (560)(9.81)(30) = 2.49 \times 10^5$$

$$v_D = 17.3 \text{ m s}^{-1} \quad [1]$$

(v)

At D, weight and normal contact force provide the centripetal force.

$$mg + N = F_c [1]$$

$$N = mg + \frac{mv^2}{r} [1]$$

$$= (560)(9.81) + \frac{(560)(17.3)^2}{15}$$

$$= 1.67 \times 10^4 \text{ N} \quad [1]$$

(b)(i)

$$T = 24 \text{ hours} \quad [1]$$

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{(24 \times 60 \times 60)}$$

$$= 7.3 \times 10^{-5} \text{ rad s}^{-1} \quad [1]$$

(ii)

Gravitational force provides centripetal force

$$\frac{GMm}{r^2} = mr\omega^2 \qquad [1]$$

$$r = \sqrt[3]{\frac{GM}{\omega^2}} = \sqrt[3]{\frac{(6.67\times10^{-11})(5.9\times10^{24})}{(7.3\times10^{-5})^2}}$$

$$= 4.2\times10^{7}\,\text{m} \qquad [1]$$

(iii) Communication, weather forecasting or navigation (GPS)

(iv)

Application	Advantage	Disadvantage
Communication	No break in the signal transmissions as it is fixed position in sky.	High altitude so there is a significant lag time in the signal transmissions.
Weather		
Navigation		

8(a)(i) Resistance = $\frac{\rho l}{A}$ [1]

$$= \frac{\rho l}{\left(\frac{\pi d^2}{4}\right)} \qquad \text{Cross sectional area of wire, } A = \frac{\pi d^2}{4}$$

$$= \frac{1.50\times10^{-6}\times6.0\times10^{-2}}{\left(\frac{\pi\left(0.30\times10^{-3}\right)^2}{4}\right)}$$

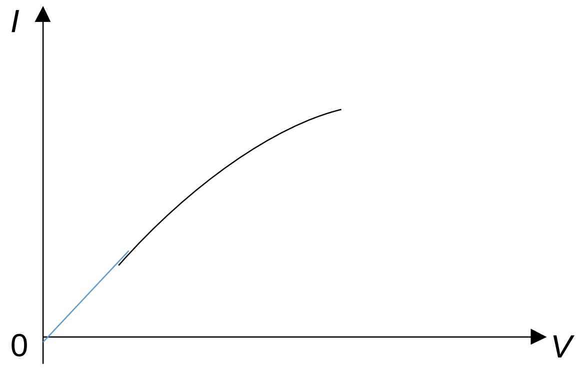
= 1.273 [1]

= 1.3 Ω

(ii)1. e.m.f. is the amount of other forms of energy converted to electrical energy per unit charge delivered by a source of e.m.f. [1]

p.d. is the amount of electrical energy converted to other forms of energy per unit charge flowing through a device. [1]

2.



[1; no need to show negative quadrant]

3. Read off the corresponding value of *I*.

Resistance = $\frac{V}{I}$ [1; must have both statements]

4. Fraction of power delivered = $\frac{\text{Power dissipated through X}}{\text{Total power dissipated in circuit}}$

$= \frac{I^2 R_X}{I^2 (R_X + R_{variable})}$ (R_X and $R_{variable}$ are in series)

[1]

$= \frac{R_X}{(R_X + R_{variable})}$

$= \frac{1.3}{(1.3 + 0.50)}$

= 0.72 [1]

(b)(i)

- As the resistance of the rheostat is increased, the total resistance across the voltmeter is increased. [1]
- Using the potential divider principle, the p.d. across the voltmeter will take up a bigger fraction of the e.m.f. [1]
- So the voltmeter reading will increase. [1]

(ii) S is to prevent short circuit of the cell [1] when the rheostat is set to 0 Ω. [1]

(iii)1. If voltmeter reads 1.2 V, then p.d. across S = 3.0 -1.2
= 1.8 V [1]

∴ current delivered by cell = current through S
= 1.8 / 0.60
= 3.0 A [1]

2. Current through rheostat = 1.2 / 10
= 0.12 A [1]

Current through bulb = Main current – current through rheostat [1]
= 3.0 – 0.12
= 2.9 A [1]

3.
- When the rheostat is set to 0 Ω, a current will still flow through S. [1]
- So power will be wasted [1], that's why the suggestion is not practical.