2024 DHS H1 Physics Prelim Paper 2 Suggested Solutions

1 **(a)** Rate of change of velocity **B1**

(b) **(i)** Using $s = ut + \frac{1}{2}gt^2$

$$g = \frac{2s}{t^2}$$

$$= \frac{2(3.59)}{0.860^2}$$ **C1**

$$= 9.70795$$

$$= 9.70 \text{ m s}^{-2}$$ **A1**

(ii) $$\frac{\Delta g}{g} = \frac{\Delta s}{s} + \frac{2\Delta t}{t}$$

$$\Delta g = 9.70795\left(\frac{1}{359} + \frac{2 \times 10}{860}\right)$$ **C1**

$$= 0.25$$

$$= 0.3 \text{ m s}^{-2} \text{ (to 1sf)}$$ **M1**

$$\therefore g = (9.7 \pm 0.3) \text{ m s}^{-2}$$ **A1**

(iii) In the presence of air resistance, the **time taken to travel the same vertical distance is longer**. **B1**

Hence, the value of *g* calculated by the student Y will be **lower** than student X. **B1**

(c) **(i)** The line of best fit minimises the distance between the line and the data points and hence, reduces the uncertainty due to random error **B1**

(ii) Systematic errors are suggested by the best-fit line **not passing through the origin.** **B1**

2 **(a)** Resultant force in any direction is zero. **B1**

Resultant torque about any axis is zero. **B1**

(b) **(i)** The single point at which the entire weight of the body can be considered to act. **B1**

(ii) Take moments about the hinge, by principle of moments,

Clockwise moments = Anticlockwise moments

$$T \cos 40 \times 5.0 = W \times d$$
$$120 \cos 40 \times 5.0 = 5(9.81) \times d \qquad \textbf{C1}$$
$$d = 1.8741$$
$$= 1.9 \text{ m} \qquad \textbf{A1}$$

(iii) By resolving the forces, the force by hinge on the beam R is

$$R_y = 120 \cos 40 - 5(9.81) = 42.875 \text{ N} \qquad R_x = 120 \sin 40 = 77.135 \text{ N} \qquad \textbf{C1}$$

$$R = \sqrt{R_x{}^2 + R_y{}^2}$$
$$= \sqrt{42.875^2 + 77.135^2} \qquad \textbf{C1}$$
$$= 88.250$$
$$= 88 \text{ N} \qquad \textbf{A1}$$

Let θ be the angle measured clockwise from the horizontal beam to R

$$\theta = \tan^{-1}\left(\frac{42.875}{77.135}\right)$$
$$= 29° \qquad \textbf{A1}$$

3 **(a)** The velocity of the object in uniform circular motion has constant magnitude, but it is **continuously changing direction**, so its velocity is not constant. **B1**

Since acceleration is the **rate of change of velocity**, and not speed, the **acceleration of the object is non-zero**. **B1**

However, as the centripetal force is always perpendicular to its velocity, the **work done by the centripetal force is zero**, hence there is **no change in kinetic energy** of the object and therefore it travels at constant speed. **B1**

OR

The acceleration of the object has constant magnitude, but its direction is **always perpendicular to the velocity** and towards the centre of its circular path, so the **speed will not change**. **B1**

(b) **(i)** The gravitational force exerted by the sun on the planet provides the centripetal force needed for the planets to undergo uniform circular motion. **M1**

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$ **M1**

$$v^2 = \frac{GM}{r}$$

$$v = \sqrt{\frac{GM}{r}}$$ **A0**

(ii) From a v against $\sqrt{r}$ graph, the gradient of the graph is

$$\sqrt{GM} = gradient$$

$$= \frac{(4.70 - 1.15) \times 10^4}{(41.0 - 10.0) \times 10^{-7}}$$

$$= 1.14516 \times 10^{10}$$ **M1**

$$M = \frac{gradient^2}{G}$$

$$= \frac{(1.14516 \times 10^{10})^2}{6.67 \times 10^{-11}}$$ **C1**

$$= 1.966 \times 10^{30} \text{ kg}$$

$$= 1.97 \times 10^{30} \text{ kg}$$ **A1**

(iii)

$$F_G = \frac{GMm}{r^2}$$

$$= \frac{(6.67 \times 10^{-11})(1.966 \times 10^{30})(0.642 \times 10^{24})}{(2.279 \times 10^8 \times 10^3)^2}$$ **C1**

$$= 1.62 \times 10^{21} \text{ N}$$ **A1**

(iv) **<u>Any one of the following reasons:</u>** **B1**

- Accuracy of graph due to limitations in scale, hence the gradient is an estimate
- Gravitational forces due to other planets were not taken into consideration
- The planets do not orbit the sun in a perfect circle but rather in an elliptical orbit, hence the orbital radius is an estimate.

(c) **(i)**

Planet	m / 10^{24} kg	r / 10^8 km	v / 10^4 m s^{-1}	a / 10^{-4} m s^{-2}
Mercury	0.330	0.579	4.74	388
Venus	4.87	1.082	3.50	113
Earth	5.97	1.496	2.98	58.0

B1

B1

Mars	0.642	2.279	2.41	25.4

Note: a can be calculated using $\frac{v^2}{r}$

(ii) $v = r\omega$

$\omega = \frac{v}{r}$

$= \frac{3.50 \times 10^4}{1.082 \times 10^8 \times 10^3}$ **C1**

$= 3.23 \times 10^{-7}$ rad s^{-1} **A1**

(d) For a satellite to be geostationary, the orbital period must be the same as the time taken for the Earth to rotate 1 round about its own axis (T = 24 hours) and orbits the Earth at a fixed distance from the centre of the Earth. **B1**

Since the gravitational acceleration provides the centripetal acceleration,

$$r\omega^2 = \frac{GM_E}{r^2}$$

$$r = \sqrt[3]{\frac{GM_E}{\omega^2}}$$

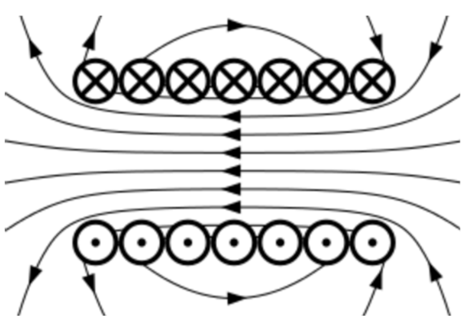
$$= \sqrt[3]{\frac{6.67 \times 10^{-11}(5.97 \times 10^{24})}{\left(\frac{2\pi}{24 \times 60 \times 60}\right)^2}}$$ **C1**

$$= 42230 \text{ km}$$ **M1**

Hence, satellite C is a geostationary satellite. **A1**

4 **(a)** **(i)** A region of space where a (non-contact) force is felt. **B1**

(ii)



B1: Correct direction of arrows
B1: Correct field pattern

(b) (i) Out of the page **B1**

(ii) The magnetic force provides the centripetal force,

$$Bqv = \frac{mv^2}{r}$$

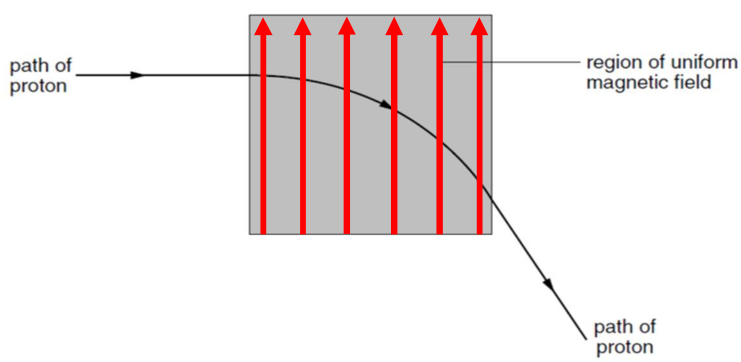
$$r = \frac{mv}{Bq}$$

$$= \frac{1.67 \times 10^{-27} \times 4.5 \times 10^{6}}{0.12 \times 1.6 \times 10^{-19}}$$ **C1**

$$= 0.39141$$

$$= 0.39 \text{ m}$$ **A1**

(c) (i) **B1**



- Field lines must be drawn with a ruler
- Draw at least 5 field lines directed upwards with equal spacing between adjacent field lines.

(ii) For the proton to pass through undeflected, the electric force must be equal in magnitude but opposite in direction to the magnetic force on the proton such that the net force on the proton is zero. **B1**

By Newton's first law, when the net force is zero, the proton will continue its state of motion and travel straight through undeflected. **B1**

Since the direction of electric field denotes the direction of force exerted on a positive charge (such as protons), in order to exert an upward electric force on the proton, the electric field lines are directed upwards. **B1**

(iii) $Bqv = qE$

$E = Bv$

$= 0.12(4.5 \times 10^6)$ **C1**

$= 5.4 \times 10^5 \text{ N C}^{-1}$ **A1**

5 **(a)** **(i)** ${}^{214}_{83}Bi \rightarrow {}^{4}_{2}He + {}^{210}_{81}Tl$ **B1**

${}^{214}_{83}Bi \rightarrow {}^{0}_{-1}e + {}^{214}_{84}Po$ **B1**

(ii) $\Delta m = m_{\text{reactants}} - m_{products}$

$= 213.9987u - 209.9901u - 4.0015u$

$= 0.0071u$ **C1**

$E_{released} = \Delta mc^2$

$= (0.0071)(1.66 \times 10^{-27})(3.0 \times 10^8)^2$ **C1**

$= 1.06074 \times 10^{-12}$

$= 1.06 \times 10^{-12} \text{ J}$ **A1**

(iii) The gamma rays are produced from the decay of different daughter nuclei, hence the energy of the gamma ray for each decay is different **B1**

(b) **(i)** Number of nuclei $= n \times N_A$

$= \dfrac{2.0 \times 10^{-6}}{214} \times 6.03 \times 10^{23}$ **M1**

$= 5.626 \times 10^{15}$

$= 5.6 \times 10^{15}$ **A0**

OR

Number of nuclei $= \dfrac{m_{total}}{m_{Bi}}$

$= \dfrac{2.0 \times 10^{-6} \times 10^{-3}}{213.9987 \times 1.66 \times 10^{-27}}$ **M1**

$= 5.6300 \times 10^{15}$

$= 5.6 \times 10^{15}$ **A0**

(ii) $N = N_0\left(\frac{1}{2}\right)^{2.7}$

$= 5.6\times10^{15}\left(\frac{1}{2}\right)^{2.7}$ **C1**

$= 8.6\times10^{14}$ **A1**

(iii) When a cell is exposed to ionising radiation, it creates ions which breaks the bonds within DNA and cause mutations. **B1**

This leads to creation of tumour cells or cell death. **B1**

OR

Ionising radiation can cause the formation of free radicals which are highly reactive and can form many harmful compounds such as hydrogen peroxide. **B1**

This initiates harmful chemical reactions within the cells and as a result, the cells undergo a variety of structural changes which lead to altered functions of the cells. **B1**

6 **(a)** **(i)** As the hammer is released and is in freefall, the gravitational potential energy of the hammer is being converted into kinetic energy of the hammer. **B1**

Upon striking the pile, the hammer does work on the pile. Since the collision is perfectly inelastic, some of the initial kinetic energy possessed by the hammer is lost while the remaining is converted into kinetic energy of the pile-hammer system. **B1**

As the pile-hammer system is driven into the riverbed, kinetic energy of the pile-hammer system is dissipated by the force exerted by the riverbed as heat and sound energy until it comes to a stop. **B1**

(ii) $GPE = mgh$

$= 1.0\times10^{3}\times9.81\times5.0$ **C1**

$= 49050$

$= 49000$ J **A1**

(iii) loss in GPE = gain in KE

$$49050 = \frac{1}{2}mv^2$$

$$49050 = \frac{1}{2}(1.0 \times 10^3)v^2$$

$$v = \sqrt{\frac{2(49050)}{1.0 \times 10^3}}$$ **C1**

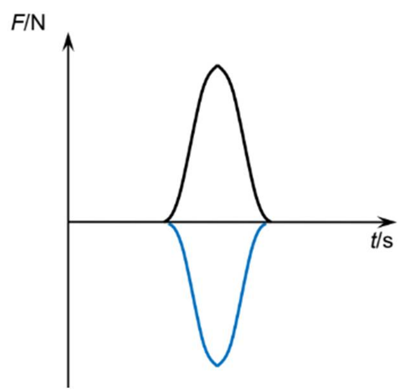
$$= 9.9045$$

$$= 9.9 \text{ m s}^{-1}$$ **A1**

(b) **(i)** The Principle of Conservation of linear momentum states that the total momentum of a system of interacting bodies is constant **B1**

provided no external resultant force acts on the system. **B1**

(ii)



B1

By Newton's third law, the force by the hammer on the pile is equal and opposite in direction to the force by the pile on the hammer. **B1**

The negative and positive areas under the force-time graph represent the changes in momentum (or impulses) of the objects. **B1**

Since the areas under the force time-graphs are equal in magnitude and opposite in sign, the total change in momentum for the two-trucks system is zero since total momentum of system is constant. **B1**

(iii) By conservation of momentum,

$$9.9(1.0 \times 10^3) + 0 = (1.0 \times 10^3 + 2.0 \times 10^3)v_f$$

$$v_f = \frac{9.9\left(1.0 \times 10^3\right)}{(3.0 \times 10^3)}$$ **C1**

$$= 3.3 \text{ m s}^{-1}$$ **A1**

(iii) Inelastic **B1**

the relative speed of approach of 9.9 m s^{-1} is not equal to the relative speed of separation of 0 m s^{-1}. **B1**

Must quote appropriate values of RSS and RSA to earn 2nd B1 mark.

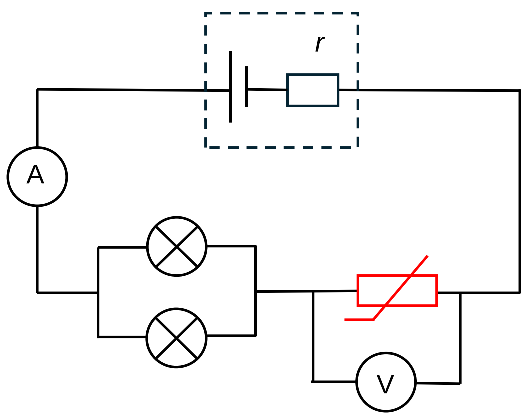
(c) **(i)**

$$KE = \frac{1}{2} m_{total} v^2$$
$$= \frac{1}{2}(3.0 \times 10^3)(3.3)^2$$
$$= 16335 \text{ J}$$

$$\text{Work done by force} = \text{Loss in KE}$$
$$F \times d = 16335$$
$$F = \frac{16335}{8.1 \times 10^{-3}}$$ **C1**
$$= 2.0167 \times 10^6$$
$$= 2.0 \times 10^6 \text{ N}$$ **A1**

(ii) Assume that the resistive force is a constant. **B1**

7 **(a)**



B1

(b) **(i)** Rate of flow of electric charges. **B1**

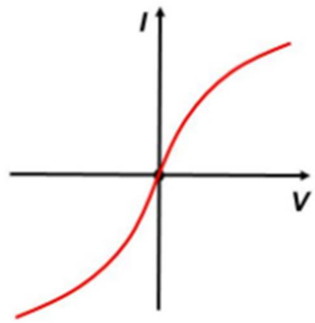
(ii) e.m.f. of a source can be defined as the **work done per unit charge** when **non-electrical energy is transferred into electrical energy** when the charge is moved **round a complete circuit**. **B1**

(c) **(i)** As the temperature increases, the resistance of the thermistor decreases. **B1**

This results in a greater potential difference across the light bulbs in parallel by the potential divider principle. **B1**

Since the power dissipated by the bulb increases by $\frac{V^2}{R}$, the brightness of the bulb increases when temperature increases, vice versa. **B1**

(ii)



B1

(iii) As the potential difference increases, the current increases and the energy dissipated as heat increases causing the temperature of the filament to increase. **B1**

The higher temperatures cause the lattice ions to vibrate more vigorously and increases the rate of collisions between free mobile electrons and the lattice ions. **B1**

Hence, the resistance increases with increasing potential, and hence the current increases non-linearly with the increase in potential difference as illustrated in (c)(ii). **B1**

(d) **(i)**

$$R_T = \frac{V}{I}$$

$$= \frac{6.53}{0.725}$$ **C1**

$$= 9.0069$$

$$= 9.01\,\Omega$$ **A1**

(ii) By considering the potential difference across each component,

$$\varepsilon = \frac{1}{2}IR + IR_T + Ir$$

$$\varepsilon = \frac{1}{2}(0.725)(15) + 6.53 + 0.725r$$ **C1**

$$\varepsilon = \frac{1}{2}(0.614)(15) + 7.37 + 0.614r$$ **C1**

Solving for ε and r,

$$\varepsilon = 12.0 \text{ V}$$ **A1**

$$r = 0.0676\ \Omega$$ **A1**

(iii) $P = I^2R$

$= \left(\frac{0.614}{2}\right)^2 (15)$ **C1**

$= 1.413$

$= 1.41\ \text{W}$ **A1**

(d)

$R = \rho\frac{l}{A}$

$l = \frac{AR}{\rho}$

$= \frac{\pi\left(\frac{6.0\times10^{-5}}{2}\right)^2 (15)}{7.9\times10^{-7}}$ **C1**

$= 0.053685$

$= 0.054\ \text{m}$ **A1**