

2025 DHS H2 Physics Prelim Paper 1 Suggested Solutions

1	2	3	4	5	6	7	8	9	10
B	D	C	B	C	C	A	D	B	D
11	12	13	14	15	16	17	18	19	20
B	A	D	B	B	A	D	B	D	A
21	22	23	24	25	26	27	28	29	30
D	B	B	C	A	D	A	C	A	C

**Worked Solutions & Explanations:**

1 B

$$< p > = (1002 + 998 + 997 + 1001 + 999)/5 = 999.4 \text{ kg m}^{-3}, \text{ closer to } 1000 \text{ kg m}^{-3}$$

$$\text{difference from true value} = 1000 - 999.4 = 0.6 \text{ kg m}^{-3}$$

$$\Delta p = \rho_{\text{max}} - \rho_{\text{avg}} = 1002 - 997 = 5 \text{ kg m}^{-3}$$

2 D

Maximum velocity when  $R = mg$

$$0.60 v = 3.0(9.81)$$

$$v = 49 \text{ m s}^{-1}$$

$$\text{At } 12 \text{ m s}^{-1}, F_{\text{net}} = mg - R = ma$$

$$a = \frac{3.0(9.81) - 0.6(12)}{3.0} = 7.4 \text{ m s}^{-2}$$

3 C

The total area under the velocity-time graph is the change in displacement.

4 B

For an object to float in equilibrium,  $U = m_{\text{ice}} g$

Since the pressure of the water increases with depth, there is a pressure difference between the top and bottom surface of the ice which results in an upward force on the ice that results in upthrust

5 C

Clockwise moments = Anticlockwise moments about the hinge  
 $(10000x)(2.0) = (50 \times 9.81)(2.5)$  — Eqn (1)

$$(10000x)(2.0) = (40 \times 9.81)(5.0) + (50 \times 9.81)(2.5) \text{ — Eqn (2)}$$

$$\text{Eqn (2) - Eqn (1), } x - x = 0.0981 \text{ m}$$

6 C

The net force on the sledge is zero when it slides down at constant velocity.

The vector triangle of forces on the sledge forms a closed polygon.

7 A

$$\text{Work done by the pump} = Fd = PAd = (5000)(600 \times 10^{-4})(0.40) = 120 \text{ J}$$

8 D

$$E_{\text{hydraulic}} = GPE = mgh$$

$$P = \frac{1.3 \times 10^9 \times 9.81 \times 2.0}{24 \times 60 \times 60} = 300 \text{ kW}$$

9 B

Minute hand makes one complete revolution in 1 hour.

$$v = r\omega = 3.00 \left( \frac{2\pi}{3600} \right) = 5.24 \times 10^{-3} \text{ m s}^{-1}$$

10 D

Such a motion is possible.

(Option A is incorrect)

In a binary star system, the centre of mass of two stars of unequal mass will not be at the midway point. It will be closer to star with mass  $M$ . Hence the radius of orbit of  $M$  is smaller than  $2M$ .

(Option C is incorrect)

For an orbit centred around its common centre of mass, position of centre of mass is fixed in space. For this condition to be satisfied, the two stars have to constantly be on opposite sides of the common centre of mass. Hence, they will have the same period of rotation and hence same angular velocity.

(Option D is the answer)

Since they have the same angular velocity and different radius, the speed at which each star orbits will also be different from  $v = r\omega$ .

(Option B is incorrect)

- 11 B  
At point P,  $F_{net} = 0$

$$\frac{GM_E m}{r^2} = \frac{GM_M m}{(R-r)^2}$$

$$\frac{r}{R-r} = \sqrt{\frac{M_E}{M_M}}$$

Rearranging and making  $r$  the subject,

$$r = \frac{R}{\sqrt{\frac{M_E}{M_M}} + 1}$$

- 12 A  
In moving from Q to P,

$$\frac{\phi_Q}{\phi_P} = \frac{f_Q}{f_P}$$

$$\phi_Q = \frac{r}{2r} (-800)$$

$$= -400 \text{ kJ kg}^{-1}$$

$$\Delta GPE = m\Delta\phi$$

$$= 1.0 \times 10^3 (-800 - (-400))$$

$$= -400 \text{ kJ}$$

- 13 D  
From the equation:  $\theta \text{ (K)} = \theta \text{ (}^\circ\text{C)} + 273.15$   
Gradient = 1  
y-intercept = 273.15

- 14 B  
When the basketball is pumped, work is done on the air in the ball to cause an increase in pressure. Work done on the gas is positive.  
Since this process is a fast process, little to no heat exchange happens and hence  $Q = 0$   
By 1<sup>st</sup> law of thermodynamics, the internal energy increases which accounts for the increase in temperature of the system.

- 15 B  
In lightly damped oscillations, the amplitude of the oscillations decreases exponentially. (i.e.  $A \propto e^{-x}$ )  
Since the total energy is proportional to the square of the amplitude, the total energy also decreases exponentially. ( $TE \propto e^{-2x}$ )

- 16 A  
Intensity received by ear =  $\frac{P}{4\pi r^2} = \frac{2000}{4\pi(7.8)^2} = 0.0262 \text{ W m}^{-2}$   
Power received by ear =  $P \times A_{ear} = 0.0262 \times 2.1 \times 10^{-3} = 5.49 \times 10^{-5} \text{ W}$

- 17 D  
Using Malus' Law,  $I = I_0 \cos^2 \theta$ ,  
 $I = 0$  when  $\theta = 90^\circ$   
 $I = 0.5 I_0$  when  $\theta = 135^\circ$   
 $I = I_0$  when  $\theta = 0^\circ$

- 18 B  
Fundamental frequency is  $f_0 = v / 2L$   
Frequencies of n-th harmonics =  $n f_0 = nv / 2L$

- 19 D  
For first order diffraction,  $d \sin\theta = \lambda$   
 $\lambda / d = \sin(28.6^\circ)$

- For 2<sup>nd</sup> order maxima,  $d \sin\theta_2 = 2\lambda$   
 $\theta_2 = \sin^{-1} [2 \sin(28.6^\circ)] = 73.2^\circ$   
To find maximum  $n$ ,  $d \sin 90 = n_{max} \lambda$   
 $n_{max} = d / \lambda = 2$  (rounded down to nearest integer)  
Therefore, maximum number of intensity maxima observed is 5

20 A

The upward electric force  $F_E$  on each sphere must be equal and opposite to each of its weight. (i.e.  $qE = mg$ )

Since the same electric field  $E$  is experienced by both spheres,  $\frac{q_x}{m_x} = \frac{q_y}{m_y} = \frac{g}{E}$

When the plates are brought closer together,  $E$  increases,  $F_E$  is now more than weight and the two charges will move upward.

The net force on each object is equal to the increase in  $F_E$  (i.e.  $q\Delta E = m\Delta a$ )

Since the charge to mass ratio  $\frac{q}{m}$  of the two spheres is the same, the acceleration is also the same.

21 D

Resistance of P is given by the expression  $\rho \frac{L}{A} = 4.0 \Omega$

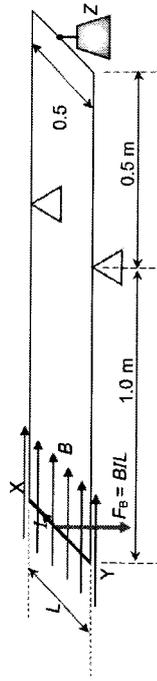
Resistance of Q is given by the expression  $\rho \frac{2L}{0.5A} = 4R_P = 16 \Omega$

Since the sheets are in series to each other, the total resistance is  $20 \Omega$ .

22 B

As the currents are in phase, attractive force exists between the conductors and this force varies sinusoidally with double the frequency.

23 B



use Fleming's left rule to determine the direction of current  $I$ : from Y to X

frame horizontal  $\Rightarrow$  net moment about the pivot axis = 0

$$\Rightarrow (BIL)(1.0 \text{ m}) = Z(0.5 \text{ m})$$

$$\Rightarrow \frac{Z}{I} = 2BL = 2(0.050)(0.5 \text{ m}) = \frac{1}{20}$$

24 C

$E$  and  $B_1$  form a velocity selector:  $B_1 Qv = QE \Rightarrow v = \frac{E}{B_1}$

So, ions P and Q have the same speed upon entering uniform magnetic field  $B_2$

inside  $B_2$ , both ions travel in circular paths. Magnetic force provides the centripetal force:

$$B_2 Qv = \frac{mv^2}{r}$$

$$\Rightarrow r = \frac{mv}{QB_2} = \frac{mE}{QB_1 B_2}$$

Since  $E$ ,  $B_1$ ,  $B_2$  are constants, we have

$$r_Q = r_P \left( \frac{m_Q}{m_P} \right) \left( \frac{Q_P}{Q_Q} \right) = 3.7 \left( \frac{1}{1.5} \right) \left( \frac{2}{1} \right) = 4.9 \text{ cm}$$

25 A

According to Fleming's LHR, the electrons in the rotating metal disc experience a magnetic force directed **radially outward**.

Along the radius PQ, this force drives the electrons towards the rim of the disc, resulting in a net negative charge at the rim (P) and a net positive charge at the center (Q). Consequently, P has a **lower** electric potential than Q.

Along the radius PQ, the current flows **from the rim (P) to the center (Q) within the disc**.

26 D

Initially,

$$V_1 = \frac{R}{(N_2/N_1)^2}$$

$$V_2 = \frac{R}{(N_2/N_1)^2}$$

If the number of turns in the primary is doubled, then

$$\frac{V_1}{V_2} = \frac{R}{(N_2/2N_1)^2} = 4 \frac{R}{(N_2/N_1)^2} = 4 \frac{V_1}{V_2}$$

$$\Rightarrow I_{p, \text{new}} = \frac{I}{4} \quad \text{so the answer is option D.}$$

**Q26 Alternative Explanation:**

When the number of turns in the primary is doubled, then  $V_s$  will be halved.

Since the load resistor is the same, from  $V_s = I_s R$ , the  $I_s$  will also be halved.

Therefore, since  $I_{s,f} = \frac{1}{2} I_{s,i}$  due to the change in turns ratio, and  $I_{s,f}$  is half of  $I_{s,i}$ , the new  $I_{p,f}$  is  $\frac{1}{4}$  of the original  $I_{p,i}$ .

**27**

**A**

$$E_{\text{difference}} = E_{\text{photon}} = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{633 \times 10^{-9}} = 1.96 \text{ eV}$$

This energy gap corresponds to the energy difference between W and X

**28**

**C**

$$\begin{aligned} \Delta x &\geq \frac{h}{\Delta p} \\ &= \frac{h}{0.01 p} \\ &= \frac{h}{0.01 \sqrt{2m_p E}} \\ &= \frac{6.63}{0.01 \sqrt{2(1.67 \times 10^{-27})(1.00 \times 10^8 \times 1.60 \times 10^{-19})}} \\ &= 2.87 \times 10^{-12} \text{ m} \end{aligned}$$

**29**

**A**

$\alpha$  particles are easily stopped. So  $\beta$  or  $\gamma$  particles are a better choice. To prevent harm to human and the environment, activity should fall quickly.

**30**

**C**

$$\begin{aligned} \text{energy released} &= \text{total BE of products} - \text{total BE of reactants} \\ &= 2.54 \times 3 - 2(1.09 \times 2) \\ &= 3.26 \text{ MeV} \end{aligned}$$

**2025 DHS Prelim Paper 2 Suggested Solutions**

- 1 (a) (i) mass/volume (ratio must be clear) **B1**  
 (ii)  $\text{kg m}^{-3}$  OR  $\text{kg/m}^3$  **B1**
- (b)  $v$  has unit of  $\text{m s}^{-1}$  **B1**  
 $\rho/\rho$  has unit of  $\text{kg m}^{-1} \text{s}^2/\text{kg m}^{-3}$  (no e.c.f from (a)) **M1**  
 $\sqrt{P/\rho}$  has unit of  $\text{m s}^{-1}$  **B1**  
 LHS = RHS so  $\gamma$  has no unit **A0**

**Marker's Comments:**  
 Common mistakes made by equating quantities to units will not be accepted.

- 2 (a) Using  $v^2 = u^2 + 2as$  **A1**  

$$v = \sqrt{0 + 2(5.0)(4.0)}$$

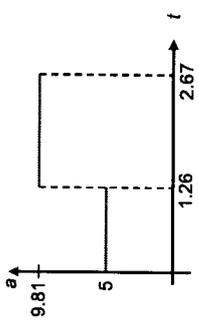
$$= 6.32 \text{ m s}^{-1}$$
 **A1**
- (b) Horizontal component =  $6.32 \cos 37.0^\circ$   
 $= 5.05 \text{ m s}^{-1}$  **A1**  
 Initial vertical component of velocity =  $6.32 \sin 37.0^\circ = 3.80 \text{ m s}^{-1}$   
 Using  $v_y^2 = u_y^2 + 2gs_y$   
 Final vertical component of velocity =  $\sqrt{3.80^2 + (2 \times 9.81 \times 15.0)}$   
 $= 17.6 \text{ m s}^{-1}$  **A1**
- (c) Ball rolling down the roof: using  $v = u + at$  **M1**  

$$t_1 = \frac{6.32 - 0}{5.00} = 1.264 \text{ s}$$
 Ball falling from edge of roof to ground: using  $v_y = u_y + gt$  **M1**  

$$t_2 = \frac{17.57 - 3.80}{9.81} = 1.404 \text{ s}$$
 Total time taken =  $1.264 + 1.404 = 2.668 = 2.67 \text{ s}$  **A1**

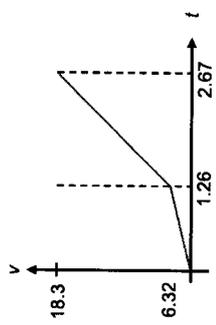
**Marker's Comments:**  
 Common mistakes made by using the wrong acceleration for calculation of the times.

(d) (i)



**B1: Shape**  
**B1: Correct labelled values (allow ecf)**

(ii)



**B1: Shape**  
**B1: Correct labelled values (allow ecf)**

**Marker's Comments:**  
 Common mistakes made is inappropriate spacing of the time, velocity and acceleration in the sketch.

- 3 (a) uniform electric and magnetic fields normal to each other AND charged particle enters region normal to both fields correct B direction w.r.t. E for zero deflection For no deflection,  $v = E/B$  **B1**
- Marker's Comments:**  
 Many did not state that for no deflection,  $v = E/B$ .
- (b)  $r = mv/BQ$ , so B proportional to m **C1**  
 $B = (0.680) \times (8786) = 0.6879 \text{ T}$  **A1**  
 $\Delta B = 7.9 \times 10^{-3} \text{ T}$

**Marker's Comments:**  
 Most were able to solve this part. Some did not calculate the change but instead gave the value of the calculated magnetic field as the answer.

4 (a)

$$F = \frac{Qq}{4\pi\epsilon_0 r^2} = \frac{(3.20 \times 10^{-7})^2}{4\pi(8.85 \times 10^{-12})(2 \times 0.50 \sin 3.0^\circ)^2} = 0.33616 = 0.34 \text{ N (to 2sf)}$$

C1

A1

**Marker's Comment:**  
Most students knew which formula to apply but often times made mathematical errors such as forgetting to square, or did not x 2 after resolving for the horizontal distance of the central line to the centre of one sphere.

(b) By considering the forces on one sphere,

$$\tan \theta = \frac{F_e}{W} \\ m(9.81) = \frac{0.33616}{\tan 3.0^\circ} \\ m = 0.65385 = 0.65 \text{ kg (to 2sf)}$$

C1

A1

Note: Allow ecf:

**Marker's Comment:**

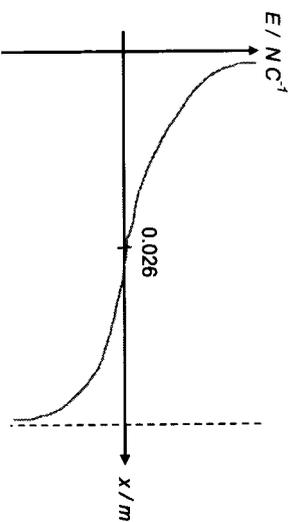
Quite a number did not attempt. Those who attempted generally managed to resolve correctly either by finding the tension first or use of the tangent function directly. A small number just simply divided the electric force by  $g$ .

(c) (i) The electric potential at a point is the work done per unit positive charge in bringing a small test charge from infinity to that point. B1

**Marker's comment:**

Generally the responses were missing certain key words (e.g. "work done per unit charge...") or used wrong key words (e.g. "bring a small point charge...")

(iii)



B1: Correct Shape

B1: Intercept the horizontal axis at the midway point.

**Marker's comment:**

Varied responses of graphical shapes were seen. Most wrong answers gave the U-shaped graph above the horizontal axis. Many did not label the value of the x-intercept.

(iii) Since the electric field strength  $E$  is related to the potential as B1

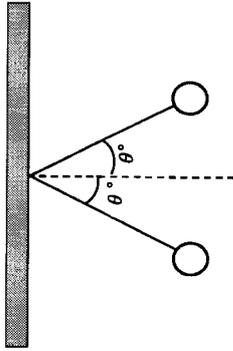
$$E = -\frac{dV}{dx}, \text{ and the graph in Fig. 4.2 is } E \text{ against } x.$$

The potential difference between two points can be found by B1 determining the area under the graph between the two points.

**Marker's comment:**

Not very well done. Most responses suggested that gradient of the  $E-x$  graph can be used to find the potential difference. Those who identified correctly that area of the graph is to be used often did not explain how did they arrive at that method.

(d)



B1

Each sphere will be deflected by the same, but smaller than before angle  $\theta$  from the vertical. ( $\theta < 3.0^\circ$ )

Note:

- Zero is given if diagram / explanation suggests unequal angle from centre vertical line.
- BOD if diagram has at least 1 angle unlabelled but there is clear symmetry about the centre vertical line

Marker's Comment:

Often times the angles in the diagram was not clearly labelled neither does their explanation often suggest that both spheres are deflected to the same extent. BOD was very often exercised as long as students drew a somewhat symmetrical diagram.

5 (a)

Acceleration is directly proportional to the displacement.

Acceleration is always in the opposite direction to its displacement

(b) (i) 0.034 m

(ii)

$$\omega = \frac{v_0}{x_0}$$

$$= \frac{0.60}{0.034}$$

$$= 17.647$$

$$= 18 \text{ rad s}^{-1}$$

C1

A1

Marker's Comment:

Parts (a) and (b) were generally well done.

(c) (i)

Upwards is taken to be positive from the graph,

$$F_{\text{net}} = N - W = -m\omega^2 x$$

B1

When the object loses contact,  $N = 0$

(Concept must be correct, incorrect concept penalise this 1 mark)

$$mg = m\omega^2 x$$

$$x = \frac{g}{\omega^2}$$

$$= \frac{9.81}{17.647^2}$$

$$= 0.0315$$

$$= 0.032 \text{ m}$$

C1

A1

Marker's comment:

Many responses revealed misconceptions amongst students. These include:

- $F_{\text{net}} = 0$  (contradiction as this would mean acceleration  $\neq 0$ )
- $N = W = m\omega^2 x$  (this would imply that  $W = 0$  since  $N = 0$ )
- $mg = -m\omega^2 x$  (implies  $W$  is opposite direction to  $F_{\text{net}}$ )

if students somehow managed to obtain the correct mathematical working despite the obvious conceptual error, marking was very lenient to award partial credit for these responses. Students should also refrain from forcefully removing "-" signs from their workings as this would violate equivalence in their workings.

(ii)

C marked at (0.032, 0.2)

B1

Note: e.c.f. only if marked in 1<sup>st</sup> quadrant.

Marker's comment:

Students found this challenging. Most students did not mark point C on the curve but rather on its x-value on the horizontal axis. Students who managed to get the right answer to c(i) often failed to consider the context of the oscillation (starting point and subsequent motion) and marked it in the 4<sup>th</sup> quadrant instead.

6 (a) (i)

cannot predict when a particular nucleus will decay

or

cannot predict which nucleus will decay next

B1

(ii)

(decay is) not affected by external (environmental) factors

B1

(b) fluctuations in (measured) count rate

B1

(c) The average time taken for the initial number of nuclei (or activity) of that particular radioactive nuclide to reduce to half of its initial value. B1

**Marker's Comment:**  
The word 'average' is crucial because individual nuclear decay is unpredictable. Half-life describes the statistical behaviour of many nuclei, not a precise countdown for each nucleus. Distinguish 'nuclide' = a specific isotope type (e.g. C-14), 'nucleus' = individual atomic core.

(d) (i) activity (of X at time  $t$ )

B1

(ii)

• Y is a stable isotope

• total number of nuclei is constant

• half-life (of X) is 13.6 s

• decay constant (of X) is  $0.051 \text{ s}^{-1}$  [ $\ln 2/t_{1/2} = \ln 2/13.6 \text{ s} = 0.051 \text{ s}^{-1}$ ]

• amount (of X) at  $t = 0$  is 0.066 mol

[ $n_0 = N_0/N_A = 4.00 \times 10^{22}/6.02 \times 10^{23} = 0.066 \text{ mole}$ ]

• activity (of X) at  $t = 0$  is  $2.0 \times 10^{21} \text{ Bq}$

[ $A_0 = \lambda N_0 = (0.051)(4.00 \times 10^{22}) = 2.0 \times 10^{21} \text{ Bq}$ ]

Any three points, 1 mark each

B3

**Marker's Comment:**  
Incorrect to say Y's half-life is longer than X's. Y is stable (doesn't decay), so the concept of half-life doesn't apply to Y.

(e) mass of 1 nucleon =  $(7.3 \times 10^{-4}) / (4.0 \times 10^{22})$

C1

nucleon number = mass of nucleus /  $(1.66 \times 10^{-27})$

C1

=  $(7.3 \times 10^{-4}) / (4.0 \times 10^{22} \times 1.66 \times 10^{-27})$

= 11 and given as an integer

A1

OR

number of moles =  $(4.0 \times 10^{22}) + (6.02 \times 10^{23}) = 0.0664 \text{ mol}$

molar mass =  $(7.3 \times 10^{-4} \text{ kg}) + (0.0664 \text{ mol}) = 0.011 \text{ kg mol}^{-1} = 11 \text{ g mol}^{-1}$

For a nuclide, the molar mass (in  $\text{g mol}^{-1}$ ) is numerically equal to the nucleon number A. Therefore: A = 11 and given as an integer

7 (a) (i)

The photoelectric effect is the emission of (photo)electrons from a cold metal surface when electromagnetic radiation of sufficiently high frequency is incident upon it. B1

**Marker's Comment:**  
State the photoelectric effect as an observed phenomenon first, then use photon theory to explain why threshold frequency exists in part (ii) - don't mix definition with explanation.

(ii)

Electromagnetic radiation can exist as discrete quanta of energy known as photons with energy  $E = hf$  where  $h$  is the Planck constant and  $f$  is the frequency of the electromagnetic radiation. B1

When photons are incident on the metal, electrons in the metal can absorb and gain the photon's energy to overcome the energy needed to bring it to the surface and the work function in order to escape from the metal surface. B1

There is a minimum energy of photon needed to minimally overcome the work function of the metal, which corresponds to the surface-most electrons being ejected. Since the energy of the photon is directly proportional to the frequency of electromagnetic radiation, there is a minimum threshold frequency for the photoelectric effect to occur. B1

(b) (i)

$E = hf$

C1

work function =  $6.63 \times 10^{-34} \times 8.8 \times 10^{14}$   
=  $5.8 \times 10^{-19} \text{ J}$

A1

(ii)

$hf = \phi + \frac{1}{2}mv_{\text{max}}^2$

C1

$6.63 \times 10^{-34} \times 11 \times 10^{14} = 5.8 \times 10^{-19} + \frac{1}{2} \times 9.11 \times 10^{-31} \times v_{\text{max}}^2$

C1

$v_{\text{max}} = 5.7 \times 10^5 \text{ m s}^{-1}$

A1

**Marker's Comment:**  
The common errors: using  $\phi$  instead of  $m_e$  in kinetic energy formula and calculating stopping potential instead of maximum speed.

8 (a)

$$d_{avg} = \frac{53+67}{2} = 60 \text{ m}$$

$$\Delta d = \frac{67-53}{2} = 7 \text{ m}$$

$$\text{Percentage uncertainty} = \frac{7}{60} \times 100\% = 12\% \text{ (to 2sf)}$$

C1

A1

**Marker's comment:**

Common error was not dividing the range by 2.

(b)(i)

The gravitational force exerted on Dimorphos by Didymos provides the centripetal force

M1

$$\frac{GMm}{r^2} = mr\omega^2$$

$$\frac{GMm}{r^2} = mr \left( \frac{2\pi}{T} \right)^2$$

M1

Rearranging and making  $T^2$  the subject,  $T^2 = \frac{4\pi^2 r^3}{GM}$

A0

(b)(ii)

The orbital radius decreased

B1

The orbital period of Dimorphos decreased from 11.9 hours to 11.4 hours after DART's impact. Since  $T^2$  is proportional to  $r^3$ , when the orbital period decreases, the radius of its orbit will also decrease

B1

**Marker's Comment:**

Part (b) was generally well done. Common error in (b)(ii) was stating that  $T$  was proportional to  $r$ .

(c)(i)

For the two patterns to be just distinguishable (or resolved), the central maximum of one must lie on the first minimum of the other.

B1

**Marker's Comment:**

Not well done. Many students referred to Rayleigh's Criterion in terms of the minimum angle for resolution.

(c)(ii)

$$b \sin \theta = \lambda$$

$$\sin \theta = \frac{\lambda}{b}$$

For the two asteroids to be just distinguishable, their angular separation from the perspective the telescope lens,  $\theta_\lambda = \frac{\lambda}{r}$ , equal to  $\theta$ . Since  $\theta$  and  $\theta_\lambda$  is small,

$$r = s \left( \frac{b}{\lambda} \right)$$

$$= 1189 \left( \frac{208 \times 10^{-3}}{700 \times 10^{-9}} \right)$$

$$= 3.53 \times 10^6 \text{ m}$$

C1

A1

**Note:**  $\lambda$  can be any value between 400 nm to 700 nm. (visible light range)  
Accepted values of  $r$  range from  $3.53 \times 10^6$  m to  $6.18 \times 10^6$  m.

**Marker's Comment:**

Very poorly done, only a small handful managed to get this right. Vast majority who attempted centred their working around the field of view value of  $0.29^\circ$ , which showed that students were not clear in their understanding of the differences between what is meant by field of vision vs Rayleigh's Criterion.

(d)(i)

The ROSA solar array delivers 120 W of power per kilogram of the solar array.

B1

**BOD:** delivers 120 W of power per kilogram of the engine / generator.

**Do not accept:** delivers 120 W of power per kilogram of the spacecraft / DART / fuel burnt

**Marker's comment:**

Students who got this right generally answered to the context of the question. Many did not read that ROSA is a solar panel which means that the fuel burnt does not affect the power to mass ratio.

(d)(ii) Total mass of ROSA array =  $2 \times 16.95$   
 $= 33.9 \text{ kg}$

$P = 33.9 \times 120$   
 $= 4068$   
 $= 4070 \text{ W (to 3sf)}$

C1

A1

**Marker's Comment:**  
 Common error was not realising that students are supposed to use the mass of ROSA, instead the mass used was either the mass of fuel burnt or mass of DART

(e)(i) Xenon has a relatively high atomic mass compared to Argon or Krypton. B1

Hence when the Xenon ions are being expelled at higher momentum for the same ion speed, the thrust force generated is greater B1

OR Xenon has lower ionization energy than Argon or Krypton. B1

Hence, it requires less energy to create Xenon ions to be used in the ion thruster B1

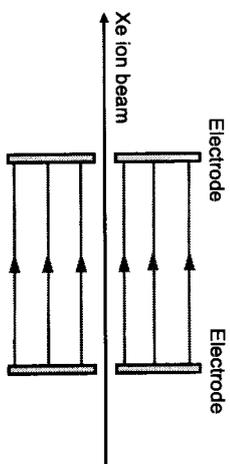
OR Xenon has the highest number of electrons / largest atomic radii due to its high nucleon number. B1

Hence, less energy is needed to remove valence electron to form Xenon ions since there are electrons that are further away from the nucleus / less tightly bound to the Xenon nucleus. B1

**Marker's Comment:**  
 Most were able to identify that Xenon has either highest mass number or proton number, but their subsequent explanations often showed misconceptions.

The most common misconception was that a high mass would therefore mean that Xenon would release the most energy via nuclear fission. Another fairly common misconception was that students were unable to distinguish ionisation energy vs binding energy and students often times suggested that the binding energy of Xenon is lower and hence it needs less energy to form Xenon ions.

(e)(ii)



- 6 horizontal parallel lines, equally spaced apart pointing leftwards

B1

**Note:** 0 m for free-hand drawings

**Marker's Comments:**  
 Most drawings had an issue with the equal spacing. Many had a much larger space between the middle 2 field lines compared to the others.

(e)(iii) By Conservation of Energy, B1

$$\text{Gain in KE} = \text{Loss in } U_e$$

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

Since the Xe ion has 131 nucleons and has a charge of  $+1.60 \times 10^{-19} \text{ C}$  due to having 1 electron removed,

$$\frac{1}{2} (131 \times 1.66 \times 10^{-27})(40000)^2 = (1.60 \times 10^{-19})V$$

$$V = 1087.3 \text{ V}$$

$$= 1100 \text{ V (to 2sf)}$$

C1

A1

**Marker's Comment:**  
 Many did not attempt. Common errors were to assume that the charge of Xenon ion is +54e or did not convert  $40 \text{ km s}^{-1}$  to  $\text{m s}^{-1}$ .

(e)(iv) At the maximum exhaust speed of ejection,

$$F = \frac{dp}{dt} = \frac{dm}{dt}v$$

$$\frac{dm}{dt} = \frac{F_{\text{max}}}{v_{\text{max}}} = \frac{235 \times 10^{-3}}{40000} = 5.875 \times 10^{-6} \quad \text{C1}$$

$$\begin{aligned} \text{no. of Xe ions expelled per second} &= \frac{dm}{dt} \div m_{\text{Xe}} \\ &= \frac{5.875 \times 10^{-6}}{131 \times 1.66 \times 10^{-27}} \quad \text{C1} \\ &= 2.70 \times 10^{19} \quad \text{A1} \end{aligned}$$

**Marker's Comment:**

Most did not attempt. A handful used the mass of proton instead of the value of  $u$ .



**2025 DHS Prelim Paper 3 Suggested Solutions**

- 1 (a) Gravitational field strength at a point is defined as the gravitational force **B1**  
exerted per unit mass placed at that point. **M1**

- (b) Since gravitational field strength  $g$  is the gravitational force  $F$  exerted per unit **M1**  
mass,

$$g = \frac{F}{m}$$

- and the gravitational force exerted by the point mass on another body with **M1**  
mass  $m$  is  $F = \frac{GMm}{r^2}$  **A0**

$$g = \frac{F}{m} = \frac{\left(\frac{GMm}{r^2}\right)}{m} = \frac{GM}{r^2}$$

Note: Do not accept answers with just working but no explanations.

**Marker's Comment:**

Credit requires explanation of the physics steps. Candidates must state Newton's law, reference the field strength definition from part (a), and explain the substitution process. Simply writing equations and algebra without explaining the reasoning shows mathematical manipulation but not physics understanding.

- (c) (at surface,) lines (of force) are radial **B1**  
Earth has large radius / height above surface is small, so lines are **B1**  
(approximately) parallel  
and equally spaced **B1**

**Marker's Comment:**

Candidates must answer the question as asked. The requirement is to explain using lines of gravitational force (field lines), not mathematical expressions. Credit requires describing how field lines near the surface appear parallel and uniformly spaced, showing constant field strength. Using  $g = GM/r^2$  arguments ignores the specified approach.

- 2 (a) The rate of change of momentum of a body is directly proportional to the **B1**  
resultant force acting on the body and occurs in the direction of the resultant force.

**Marker's Comment:**

Many did not write the correct Newton's 2<sup>nd</sup> law of motion. A few stated the force is  $ma$ .

- (b) (i)  $p = \Delta(mv)$  **C1**  
 $= -65 \times 10^{-3} (5.2 + 3.7)$  **A1**  
 $= -0.58 \text{ N s}$

- (ii)  $F = (0.58) / (7.5 \times 10^{-3}) = 77 \text{ N}$  **A1**  
(c) (i) Force on the wall from the ball is equal to the force on ball from **B1**  
the wall  
but in the opposite direction **B1**

(general statement of Newton's third law only score 1 mark)

2. momentum change of ball is equal **B1**  
and opposite to momentum change of the wall

OR since there is no external resultant force acting on the system (ball and wall), the total momentum of the system is conserved

OR total change in momentum of ball and wall is zero

**Marker's Comment:**

Common mistakes such as the word 'resultant' was missed out in stating Principle of Conservation of Linear Momentum. Change in momentum was wrongly calculated without considering momentum as a vector.

- (ii) kinetic energy (of ball and wall) is reduced / not conserved, inelastic. **B1**  
(allow relative speed of approach does not equal to relative speed of separation)

**Marker's Comment:**

Kinetic energy was 'different/not equal' will not be credited.

- 3 (a) The moment of a force about a point is the product of the force and the **B1**  
perpendicular distance from that point to the line of action of the force.

- (b) (i) Taking moments about point A and since the sum of the clockwise **C1**  
moments must equal the sum of the anticlockwise moments, **A1**

$$8.0(9.81)\left(\frac{7.5}{2}\right)\cos 37^\circ + 12.0(9.81)(7.5\cos 37^\circ) = T(3.8)$$

$$\text{Hence } T = 2.5 \times 10^2 \text{ N (to 2 s.f.)}$$

(ii) Since net horizontal force must be zero,  $F_H = 2.5 \times 10^2 \text{ N}$   
 Since net vertical force must be zero,

$$F_V = 8.0 \times 9.81 + 12.0 \times 9.81 = 2.0 \times 10^2 \text{ N}$$

$$F = 3.2 \times 10^2 \text{ N}$$

$$\tan \theta = F_V / F_H$$

$$\theta = 39^\circ, \text{ anticlockwise above horizontal.}$$

A1  
 C1  
 A1

**Marker's Comment:**  
 Most were unable to give the right definition of moment. Quite a number were also unable to take moments of forces correctly and solve for the value of the tension.

4 (a) (i) The internal energy of a substance is the sum of the random distribution of kinetic and potential energies associated with the molecules of a system. B1

**Marker's Comment:**  
 Many responses were not specific enough to associate internal energy with the molecules of a system. A handful stated the first law of thermodynamics rather than the definition of internal energy.

(ii) At the same temperature, water vapour and water have the same total kinetic energy of molecules but water vapour has higher total potential energy of molecules (due to weaker intermolecular forces of attraction)  
 Hence the internal energy per unit mass of water vapour is higher than that of water. B1

**Marker's Comment:**  
 Not very well done, many misconceptions were surfaced. Most common misconception was reasoning that having stronger intermolecular forces of attraction would result in higher potential energy.  
 Another common misconception was to compare the particle motion of liquid vs solid (molecules sliding past each other vs moving around at high speeds). Students would often reason that because of this difference, water vapour molecules would have higher kinetic energy instead of linking it to the concept of temperature.

(b) (i)  $\frac{pV}{T} = nR = \text{constant}$

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$$

$$\frac{101000(15000)}{288} = \frac{890 \times V_2}{228}$$

$$V_2 = 1.3476 \times 10^6$$

$$= 1.35 \times 10^6 \text{ m}^3$$

A1  
 C1

**Marker's Comment:**  
 Most common error was not realising that T is not a constant, and using  $p_1 V_1 = p_2 V_2$  for the calculation instead.

(ii)  $KE_{\text{avg}} = \frac{3}{2} kT$   
 $= \frac{3}{2} (1.38 \times 10^{-23})(228)$   
 $= 4.72 \times 10^{-21} \text{ J}$  B1

(iii)  $\Delta U = U_f - U_i$   
 $= \frac{3}{2} p_f V_f - \frac{3}{2} p_i V_i$   
 $= \frac{3}{2} [(890(1.3476 \times 10^6) - (101000)(15000))]$   
 $= -4.7345 \times 10^6$   
 $= -4.73 \times 10^6 \text{ J}$  A1

**Marker's Comment:**  
 (b)(ii) was well done in general. However, (b)(iii) was not, with a fairly wide range of errors. Common errors include:  
 • Using (initial – final) to compute change  
 • Using wrong formula (e.g.  $\Delta U = p_f V_f - p_i V_i$ )  
 • Finding difference between average KE rather than U

5 (a) (i) Constant phase difference B1

**Marker's Comment:**  
 Many did not know the definition with many different variants of wrong answers. These include comparing the frequency, wavelength, type of wave, speed or stated that the sources must always be in / have the same phase for coherence.

(ii) The vapour produces photons when electrons de-excite from a higher energy state to a lower energy state. **B1**

The de-excitation of electrons is a random process. **B1**

The photons emitted are produced at random time intervals and therefore the phase difference between the emitted photons is not constant. **B1**

Note: Mechanism must be correct to be awarded the last two B1 marks.

**Marker's Comment:**

Poorly done despite being very lenient. Most tried to smoke their way through by using the explanation for absorption/emission spectra wholesale to explain. (e.g. vapour absorbs white light to undergo excitation and re-emits photon in all directions during de-excitation)

Most did not understand that monochromatic meant only 1 wavelength is being seen/produced, which led to subsequent explanations contradicting monochromatism (e.g. different wavelengths / frequencies produced)

More serious misconceptions include:

- Associating the low pressure of the vapour to the production of light.
- Associating the motion of the vapour molecules to the production of light. (e.g. photons are emitted when vapour molecules move around at high speeds)
- Diffraction occurred which caused a difference in phase.
- Using X-ray production or photoelectric effect to explain the production of photons.

(b) (i) **Any 2 of the following:** **B2**

- Waves have equal or approximately equal amplitude
- The slit separation must be of the same order of wavelength as the wave
- The distance between the two slits must be small compared to the distance between the source and screen.
- The waves from the two sources must be unpolarised or polarised in the same plane

**Marker's Comment:**

Not very well done. Many gave conditions for superposition to occur rather than for two source interference to be observable or repeated conditions that would be implied by coherence (e.g. same frequency).

A handflut brought in Rayleigh's Criterion as a condition for observable interference pattern. There were also quite a number that could not distinguish between slit width vs slit separation.

(ii) 
$$x = \frac{\lambda D}{a}$$

$$= \frac{590 \times 10^{-9} \times 2.3}{1.2 \times 10^{-3}}$$

$$= 1.1308 \times 10^{-3}$$

$$= 1.1 \times 10^{-3} \text{ m (to 2sf)}$$
**C1**

[-1 m] if students did not use or arrive at formula to get the final answer. (i.e. used a  $\sin\theta = n\lambda$  in conjunction with  $\tan\theta = x/D$  without arriving at  $x = \lambda D/a$ .) **A1**

**Marker's Comment:**

Generally well done. Note for students that used first principles that they should arrive at the stated formula in the syllabus via the use of small angle approximation before solving for the final answer.

(iii) Since  $I \propto A^2$ ,

$$\frac{I_A}{I_B} = \frac{A_A^2}{A_B^2}$$

$$\frac{I}{\frac{1}{3}I} = \frac{A_A^2}{A_B^2}$$

$$A_B = \frac{1}{\sqrt{3}} A_A$$
**M1**

By principle of superposition, the amplitude of a dark fringe near P is

$$A = A_A - A_B$$

$$= A_A - \frac{1}{\sqrt{3}} A_A$$

$$= \left(1 - \frac{1}{\sqrt{3}}\right) A_A$$
**M1**

Therefore, intensity of dark fringe is:

**C1**

$$\frac{I_{\text{image}}}{I} = \frac{A^2}{A_A^2}$$

$$I_{\text{image}} = \left( \frac{A^2}{A_A^2} \right) I$$

$$= \left( 1 - \frac{1}{\sqrt{3}} \right)^2 I$$

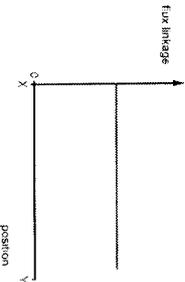
$$= 0.17863 I$$

$$= 0.18 I$$

A1

**Marker's Comment:**  
Students found this challenging. Many left this blank or did not know where to start from. A handful got values of more than  $I$  for dark fringe, this is impossible. Common misconception was to merely do a subtraction of the intensities from slit A and B to get the intensity of the dark fringe.

6 (a) (i) non-zero horizontal straight line from X to Y B1



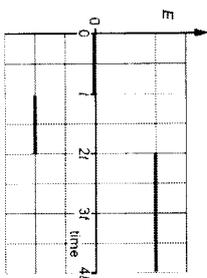
(ii) constant flux density (inside coil) B1  
either (magnetic) flux linkage proportional to flux density B1  
or  $\phi = BAN$  and  $B$ ,  $A$  and  $N$  are all constant

**Marker's Comment:**  
Very few were able to explain the constant flux linkage even though the correct line was drawn.

(iii)  $\phi = BAN$  C1  
 $= 0.080 \times 0.71 \times 10^{-4} \times 64$   
 $= 3.6 \times 10^{-4} \text{ Wb}$

(iv) sketch showing: A1

- $E$  is zero from time 0 to time  $t$  and non-zero after time  $t$  B1
- $E$  has constant non-zero magnitude between time  $t$  and time  $4t$  B1
- $E$  has same constant non-zero value of one sign between time  $t$  and time  $2t$ , and opposite sign between time  $2t$  and time  $4t$  B1



(b) current in spring creates a magnetic field around the spring B1

either (magnetic) fields around adjacent turns interact to cause a force to be exerted (between the turns) M1  
or current in one turn interacts with (magnetic) field due to adjacent turns to cause force to be exerted (between the turns)  
(magnetic force) is attractive so distance (between turns) decreases A1

**Marker's Comment:**  
Faraday's Law was applied to explain the change in distance which was wrong. A few managed to explain this part well.

7 (a) number of cycles per unit time B1

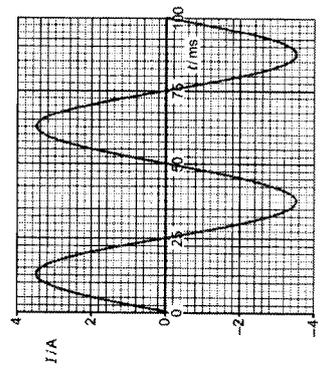
**Marker's Comment:**  
Poorly done. Common errors include referring frequency to the number of times the current changes direction, not being able to distinguish between an oscillation, wave or rotation with cycles, and also using the period as a base to define frequency (e.g. inverse of period, time taken for one complete oscillation etc.)

(b) (i) period =  $2\pi / 40\pi = 0.050 \text{ s} = 50 \text{ ms}$  A1

**Marker's Comment:**

Small handful needs to be mindful of their use of variables. There is a difference between what is meant by period  $T$  vs time  $t$ .

- (ii) sinusoidal curve, starting at (0, 0) and initially increasing from there **B1**
- periodic line showing 2 cycles with period 50 ms from  $t = 0$  to  $t = 100$  ms **B1**
- all peaks shown at  $I = +3.5$  A and all troughs shown at  $I = -3.5$  A **B1**



(iii)  $I_{r.m.s} = 3.5/\sqrt{2}$   
 $= 2.5$  A **A1**

(c)  $P = I^2 R$

$P_0 = 3.5^2 \times 680 (= 8330$  W)

$P_{avg} = I_{r.m.s}^2 R = \left(\frac{3.5}{\sqrt{2}}\right)^2 (680) (= 4165$  W)

$\frac{P_{avg}}{P_0} = \frac{4165}{8330} = \frac{1}{2}$  therefore,  $P_{avg} = \frac{1}{2} P_0$

**Note:** full working with substitution of values shown to get credit. Explicit comparison with calculation must be made to obtain last A1 mark.

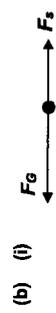
**Marker's Comment:** Generally parts (b) and (c) were well done. Some read off the scale wrongly which usually resulted in them drawing a graph with amplitude 3.0 A instead of 3.5 A.

Students should also be mindful of the requirements of a "show" question. They are required to show their workings fully, including making explicit mathematical comparison to show the result by calculation. A number jumped to the conclusion after finding the values of  $P_0$  and  $P_{avg}$  without doing a proper mathematical comparison.

8 (a) (i)  $a = \omega^2 r = \left(\frac{2\pi}{24 \times 60 \times 60}\right)^2 (6370 \times 10^3)$   
 $= 3.37 \times 10^{-2} \text{ m s}^{-2}$  **C1**  
**A1**

**Marker's Comment:** The question asks for centripetal acceleration, not gravitational acceleration. Some using  $g = GM/r^2$  are calculating the wrong quantity.

(ii)  $F_g = \frac{GMm}{r^2}$   
 $= \frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})(1.00)}{(6370 \times 10^3)^2}$   
 $= 9.83$  N **C1**  
**A1**



**B1: Correct Magnitude**  
**B1: Correct Direction**

**Marker's Comment:** Draw forces in the radial direction: gravitational force towards Earth's centre (leftward) and spring tension away from centre (rightward). Ensure vector lengths show relative magnitudes and show only the object - force diagrams should not include Earth, spring, or other objects.

(ii)  $F = ma$   
 $F_g - F_s = ma$  **C1**

$9.83 - F_s = 1.00 \times 3.37 \times 10^{-2}$

$F_s = 9.80$  N (no ECF) **A1**

- (iii) At the equator, part of the gravitational acceleration provides centripetal acceleration for Earth's rotation. Hence, the measured free fall acceleration would be slightly less than the true gravitational acceleration alone. **B1**  
**B1**

**Marker's Comment:** Part of gravity's "effort" goes into maintaining the circular motion, leaving less available to accelerate objects downward: true gravitational acceleration ( $9.83 \text{ m s}^{-2}$ ) = centripetal acceleration at equator ( $0.037 \text{ m s}^{-2}$ ) + apparent gravitational acceleration measured ( $9.80 \text{ m s}^{-2}$ )

- (c) (i) When the tension in the rope is less than the weight of the person, the resultant force acting on the person is in the same direction as his velocity, causing the person to speed. When the tension in the rope is more than the weight of the person, the resultant force acting on the person is opposite in direction to his velocity, causing the person to slow down.  
Consequently, the person will achieve maximum speed when the resultant force acting on him is zero, accompanied by a corresponding acceleration of zero.

- (ii) Man is moving at maximum speed when resultant force acting on him is zero.

$$mg = ke$$

$$\Rightarrow e = \frac{mg}{k} = \frac{80.0 \times 9.81}{120} = 6.54 \text{ m}$$

Applying Principle of Conservation of Energy:  
total energy before stepping off = total energy at maximum speed  $v$

$$0 + 0 + mg(L + e) = \frac{1}{2}mv^2 + \frac{1}{2}ke^2 + 0$$

where  $L$  is the natural length of the rope.

$$v = \sqrt{\frac{2mg(L + e) - ke^2}{m}}$$

$$= \sqrt{\frac{2 \times 80.0 \times 9.81 \times (25.0 + 6.54) - 120 \times (6.54)^2}{80.0}}$$

$$= 23.6 \text{ m s}^{-1}$$

- (iii) Let  $x$  to be the extension when the person is at the lowest point  
Applying Principle of Conservation of Energy:  
GPE at highest point = EPE at lowest point

$$mg(L + x) = \frac{1}{2}kx^2$$

$$80.0 \times 9.81(25.0 + x) = \frac{1}{2}(120)x^2$$

$$60x^2 - 784.8x - 19620 = 0$$

$$x = 25.8 \text{ m}$$

- (iv) 1. At highest point,  
GPE =  $mg(L + x) = 80.0 \times 9.81 \times (25.0 + 25.8)$   
 $= 3.99 \times 10^4 \text{ J}$

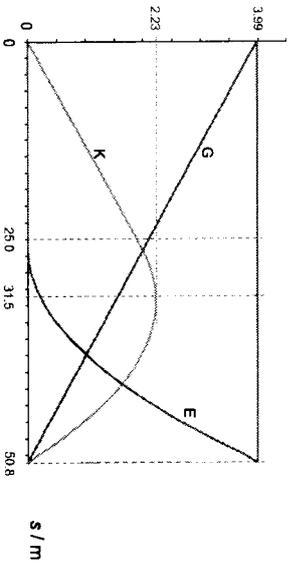
Straight GPE line with correct labels on y-axis and x-axis.

B1

2. Quadratic EPE curve with correct start and end points ( $s = 25.0 \text{ m}$  &  $s = 50.8 \text{ m}$  respectively).
3.  $KE_{\text{max}} = \frac{1}{2}mv^2 = \frac{1}{2} \times 80.0 \times 23.6^2 = 2.23 \times 10^4 \text{ J}$

B1

$E / 10^4 \text{ J}$



**Marker's Comment:**  
Energy graphs must show correct curvature direction. EPE varies as  $\frac{1}{2}kx^2$  giving a concave up (U-shaped) curve, not concave down, and KE changes in a curved manner once the rope stretches. Include numerical energy values and key displacement markers (natural length, at maximum KE, and maximum extension).

- 9 (a) By varying the resistance of the variable resistor  $R$  from its maximum resistance to zero

B1

- (b) (i) False, because the resistance values are not constant. Each point on the graph represents a different resistance setting. To test Ohm's law ( $V \propto I$  for constant  $R$ ), the resistance must remain fixed while voltage is varied.

B1

OR

False. To test Ohm's law, the same resistance value must be used throughout the experiment. Here, the variable resistor is set to different values at each measurement, so we cannot conclude it doesn't obey Ohm's law from this data.

OR

False. To test Ohm's law, the current through a fixed resistance is measured as the p.d. across it is varied. In this experiment, the resistance itself is being changed, not the applied voltage, so this is not a valid test of Ohm's law.

(ii) False. The battery does not supply electrons - the electrons are already in the conductor. Instead, the battery acts as an electrical 'pump' that provides e.m.f./electric field to make these existing free electrons drift through the circuit, producing current.

(c) (i) The graph is a plot of  $V = E - Ir$   
Hence, the V-intercept is  $E = 3.00 \text{ V}$ . **A1**

(ii) Gradient  $= -r = \frac{3.00 - 0.20}{0.0 - 4.0} = \frac{2.80}{-4.0} = -0.70 \Omega$   
So  $r = 0.70 \Omega$   
Deduct 1 mark if gradient is positive or if  $r$  is negative. **C1**  
**A1**

**Marker's Comment:**  
Reading accuracy from graph is crucial. Select two widely spaced points that lie exactly on grid intersections to minimise reading errors when calculating internal resistance. Poor coordinate estimation, especially for points between grid lines, leads to significant errors in the final answer. Use clear intersection points wherever possible.

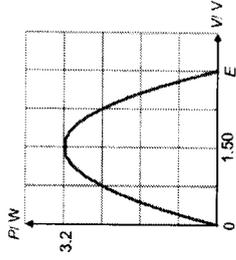
(d) (i) Power output is maximum when  $R = r = 0.70 \Omega$ .  
Using potential divider rule,  $V = \frac{1.5 \text{ V}}{2}$  (allow ECF) **A1**

(ii)  $P_{\text{max}} = \frac{V^2}{R} = \frac{1.5^2}{0.70} = 3.2 \text{ W}$   
**M1**  
**A1**

Alternatively:  
Draw a line of gradient  $0.70 \Omega$  to determine values of  $V$  and  $I$  at point of intersection  $(2.1, 1.50)$  when  $R$  is  $0.70 \Omega$ . **M1**

Hence,  $P_{\text{max}} = 2.1 \text{ A} \times 1.50 \text{ V} = 3.2 \text{ W}$  (to 2 s.f.) **A1**

(iii)



Quadratic graph opens down.  
Symmetrical about  $V = E/2$  (peak is at  $1.50 \text{ V}$ ,  $3.2 \text{ W}$ ). **B1**  
**B1**

(e) (i)  $\eta = \frac{IV}{IE} = \frac{V}{E} = \frac{1.50}{3.00} = 50\%$  **A1**

(ii) Maximum efficiency is achieved when value of  $R$  is maximum, i.e.,  $10 \Omega$ . (Reject  $R = \infty$ ). **A1**

Proof:

$$\eta = \frac{I^2 R}{IE} = I \frac{R}{E} = \left( \frac{E}{r+R} \right) \frac{R}{E} = \frac{R}{r+R} = \frac{1}{r/R+1}$$

Hence, for efficiency  $\eta$  to approach 100%, the term  $r/R$  in the denominator must approach zero, that is,  $R$  must be large (which would mean lower power output) or  $r$  must be small (not a marking point here).

(iii) Maximum power transfer is more desirable because the goal is to produce the loudest sound, which requires maximum power delivered to the loudspeaker. **B1**

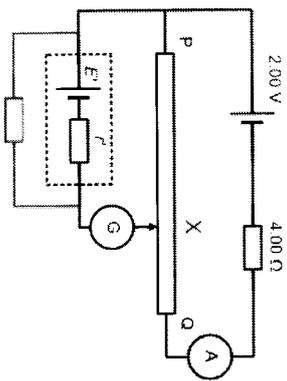
High efficiency ( $R \gg r$ ) minimises energy waste but reduces the actual power delivered to the speaker, whilst maximum power transfer ( $R = r$ ) provides the loudest sound despite being less efficient. **B1**

Note: Both points must be correct. Any contradiction in answers will score 0.

(f) (i) Using potential divider rule,  $V_{\text{eq}} = \frac{6.00}{6.00 + 4.00} \times 2.00 = 1.20 \text{ V}$  **M1**

$E' = \frac{0.600}{1.000} \times 1.20 = 0.720 \text{ V}$  **A1**

(ii)



B1

Fig. 9.4

Connect a resistor across the lower branch to allow current to flow through  $r$  so that its value can be determined from  $V_{PQ} = E' + Ir'$ .

(iii)

From  $Q = It$ ,  
 $2000 \times 10^{-3} \text{ Ah} = (0.080 \text{ A}) t$   
 $\Rightarrow t = 25 \text{ h}$

C1  
A1