Year 12 **Physics**

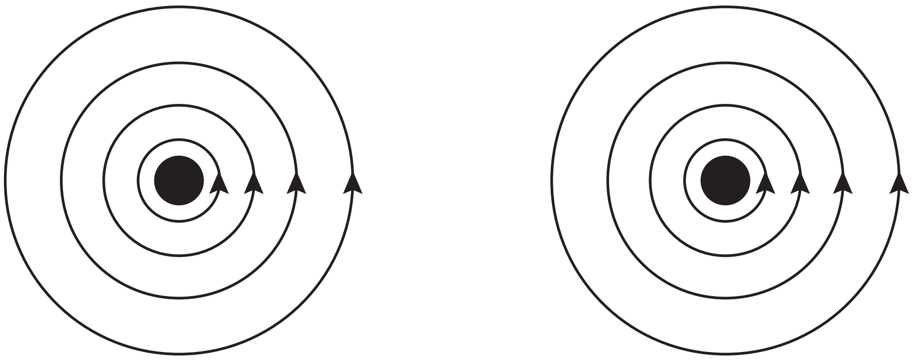
Practice Exam 1 (Units 3 & 4) **Answers**

Unit 3

Area of Study 1 **How do things move without contact?**

Question 1

a (1 mark)



b There is a force of attraction between the wires, as the fields are in opposite directions between the wires. (1 mark)

Question 2

a $F = k\frac{q_1 q_2}{r^2}$ (1 mark)

$$= \frac{9\times10^{9}\times1.6\times10^{-19}\times1.6\times10^{-19}}{(100\times10^{-12})^2}$$

$F = 2.3 \times 10^{-8}$ N (1 mark)

b Having $\frac{1}{9}$ of the force means the distance is 3 times greater. (1 mark)

$100 \times 10^{-12} \times 3 = 3 \times 10^{-10}$ m (1 mark)

c As the field is repulsive, at the very centre the field is 0 and so the magnitude of the force is also 0. (1 mark)

Question 3

a downwards (1 mark)

b $F = nI\ell B$

$= 5 \times 0.025 \times 0.04$ (2 marks)

$= 5.00 \times 10^{-3}$ N (1 mark)

c increasing the current or (1 mark)

increasing the strength of the magnetic field (1 mark)

d 0, as the side QR runs parallel to the magnetic field (1 mark)

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Question 4

a $E = W = Vq = 16\,000 \times 1.60 \times 10^{-19}$ (1 mark)

$E = 2.56 \times 10^{-15}$ J (1 mark)

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

$v = \sqrt{\frac{2E}{m}} = \sqrt{\frac{2 \times 2.56 \times 10^{-12}}{9.11 \times 10^{-31}}}$ (1 mark)

$v = 7.50 \times 10^7$ m s^{-1}. (1 mark)

b into the page (1 mark)

c $F = qvB = 1.60 \times 10^{-19} \times 1.5 \times 10^5 \times 20 \times 10^{-3}$ (1 mark)

$F = 4.80 \times 10^{-16}$ N (1 mark)

d $r = \frac{mv}{qB} = \frac{9.11 \times 10^{-31} \times 1.5 \times 10^5}{1.60 \times 10^{-19} \times 20 \times 10^{-3}}$ (1 mark)

$r = 4.27 \times 10^{-5}$ m (1 mark)

Question 5

a $r = 6.38 \times 10^6 + 6 \times 10^5 = 6.98 \times 10^6$ m (1 mark)

$\frac{m_S v^2}{r} = \frac{G m_S m_E}{r^2}$

$v = \sqrt{\frac{G m_E}{r}}$ (1 mark)

$v = \sqrt{\frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{6.98 \times 10^6}}$

$v = 7.55 \times 10^3$ m s^{-1} (1 mark)

b $v = \frac{2\pi r}{T}$ (1 mark)

$T = \frac{2\pi r}{v}$

$T = \frac{2\pi \times 6.98 \times 10^6}{7550}$

$T = 5.81 \times 10^3$ s (1 mark)

c $a = \frac{v^2}{r}$ (1 mark)

$a = \frac{7550^2}{6.98 \times 10^6}$

$a = 8.17$ m s^{-2} or 8.17 N kg^{-1} (1 mark)

d Objects in the satellite accelerate towards the Earth at the same rate as the satellite. Therefore, the reaction force on the objects is zero. (1 mark)

Thus, as apparent weight is the same as the reaction force, objects in the satellite experience apparent weightlessness. (1 mark)

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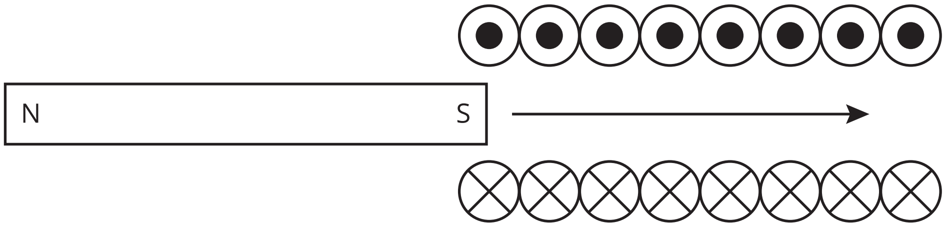
Question 6



The magnet moves into solenoid, that is, to the right. (1 mark)

Question 7

a As the loop enters the field, there is an increasing downward flux through the loop. The induced field must oppose this. (1 mark)

The induced field is therefore upwards through the loop. Using the right-hand grip rule, the induced current is from Q to P. (1 mark)

b To be halfway into the magnetic field, the loop has travelled 5 cm (the loop is 10 cm long). As it is travelling at 5 cm s^{-1}, the time taken to travel this distance is 1 s. (1 mark)

$$\varepsilon = N\frac{\Delta\Phi_B}{\Delta t}$$
$$= \frac{1 \times 0.5 \times 0.1 \times 0.05}{1}$$
$$= 2.5 \times 10^{-3}\ \text{V}$$ (1 mark)

c After 3 seconds, the loop has been completely inside the magnetic field for 1 second. As there is no change in flux, no EMF is induced. $\varepsilon = 0$. (1 mark)

d As the loop begins to leave the field, there is a decreasing downward flux through the loop. The induced field must oppose this. (1 mark)

The induced field is therefore downwards through the loop. Therefore, using the right-hand grip rule, the induced current is from P to Q. (1 mark)

Question 8

a $\frac{N_1}{N_2} = \frac{V_1}{V_2}$ (1 mark)

$\frac{140}{2100} = \frac{V_1}{300}$

V_1 = 20V AC RMS

peak voltage is therefore $\sqrt{2} \times 20 = 28.28$ V

peak-to-peak voltage is therefore $2 \times 28.28 = 56.56 \approx 57$ V (1 mark)

b As the input at the primary coil is DC, there will be no change in flux and there will be no voltage at the secondary coil. (1 mark)

Question 9

a $\Phi_B = B_{\perp} A$ (1 mark)

$= 2 \times 10^{-3} \times 0.1 \times 0.1$

$= 2 \times 10^{-5}$ Wb

b $\varepsilon = N \frac{\Delta\Phi_B}{\Delta t}$ (1 mark)

$= 5 \times \frac{2 \times 10^{-5}}{1 \times 10^{3}}$

$= 0.1$ V

c Slip rings (1 mark)

The slip rings ensure that one of the loop is always attached to the same ring so that the output is sinusoidal. (1 mark)

Question 10

a $P = VI$ (1 mark)

$3.6 \times 10^3 = 240 \times I$

$I = 15$ A in the line

b $V = IR$ (1 mark)

$V = 15 \times 1.5$

$V = 22.5$ V in the line

$240 - 22.5 = 217.5$ V at the farmhouse (1 mark)

c $P = I^2R$ (1 mark)

$P = 15^2 \times 1.5$

$P = 337.5$ W loss

$3600 - 337.5 = 3262.5$ W; 3.3 kW (1 mark)

Alternatively,

$P = VI$

$P = 217.5 \times 15$

$P = 3262.5$ W

d voltage in the line with transformer:

$20 \times 240 = 4800$ V (1 mark)

current in the line with transformer:

$P = VI$

$3600 = 4800 \times I$ (1 mark)

$I = 0.75$ A

power loss with transformer:

$P = I^2 R$

$P = 0.75^2 \times 1.5$ (1 mark)

$P = 0.844$ W

$\frac{0.844}{3600} \times 100 = 0.02\%$ loss with transformer (1 mark)

$\frac{337.5}{3600} \times 100 = 9.38\%$ loss without transformer

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Question 11

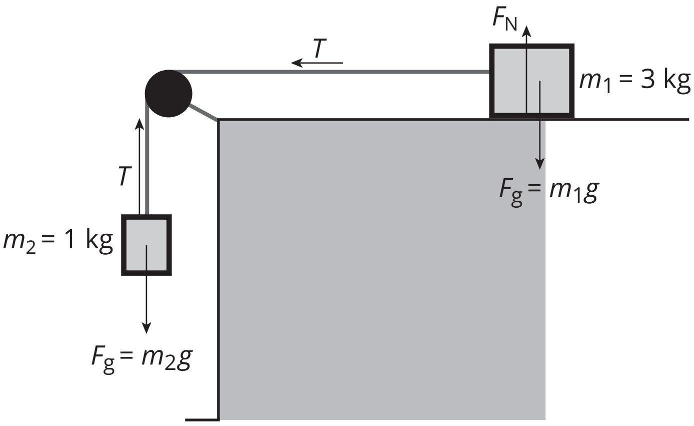
a $F_{net} = ma$, where the net force is due to gravity on the system (1 mark)

$F_g = 4a$

$1 \times 9.8 = 4a$

$a = 2.45\ \text{m s}^{-2}$ (1 mark)

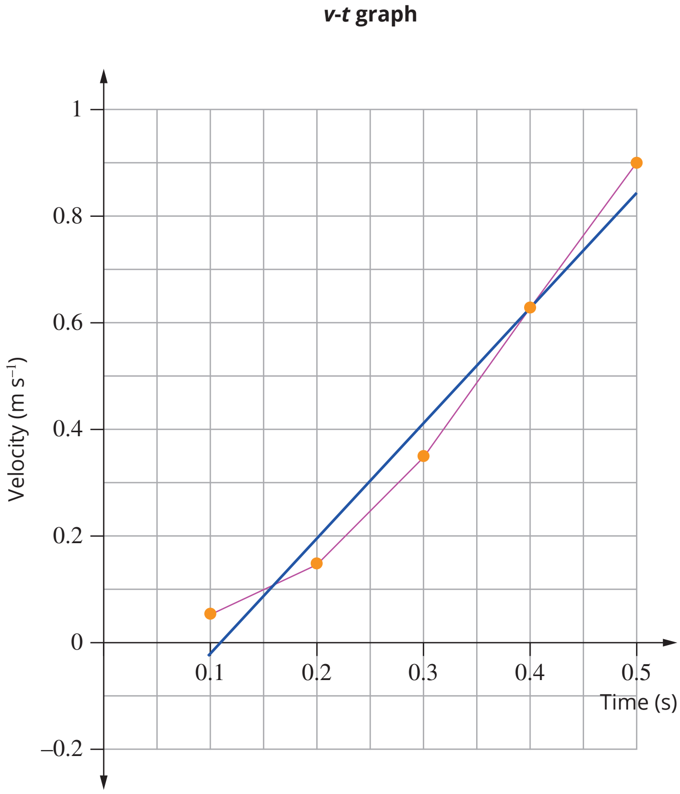
b



if some arrows provided allocate half marks (1 mark)

if all arrows provided give full marks allocated (2 marks)

c



d Acceleration is the gradient of the graph. Use the line of best fit.

$$a = \frac{0.85 - 0.1}{0.5 - 0.1}$$ (1 mark)

$a = 2.14\ \text{m s}^{-2}$

Note: answers will vary according to line of best fit (1 mark)

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e The change in the acceleration of the system is due to friction, so:

$F_{fr} = m\Delta a$ (1 mark)

$F_{fr} = 4 \times (2.45 - 2.14)$

$F_{fr} = 1.24$ N

Note: answers will vary according to answer for part **e** (1 mark)

Question 12

a For the vertical component of the javelin's motion:

$u_v = 20 \times \sin 38 = 12.31$ m s^{-1} (1 mark)

$v_v^2 = u_v^2 + 2as$

$0 = 12.31^2 + 2 \times (-9.80)\ s$

$s = \dfrac{12.31^2}{2 \times 9.80} = 7.74$ m (1 mark)

Max height = 2.20 + 7.74 = 9.94 m (1 mark)

b Time to reach maximum height:

$v = u + at$

$0 = 12.31 + (-9.80)\ t$

$t = \dfrac{12.31}{9.80} = 1.26$ s (1 mark)

Time to travel from max height to ground:

$s = ut + \dfrac{1}{2}at^2$

$9.94 = 0 + 4.90\ t^2$

$t = \sqrt{\dfrac{9.94}{4.9}} = 1.42$ s (1 mark)

For the horizontal component of the javelin's motion and hence its range:

$t = 1.26 + 1.42 = 2.68$ s

$v_h = 20 \cos 38° = 15.76$ m s^{-1}

$s = v_h \times t = 15.76 \times 2.68 = 42.2$ m (1 mark)

c E_k when leaving athlete's hand:

$E_k = \dfrac{1}{2}mv^2$

$= \dfrac{1}{2} \times 0.85 \times (20)^2$

$= 170$ J

E_g when leaving athlete's hand:

$E_g = mg\Delta h = 0.85 \times 9.80 \times 2.20 = 18.3$ J (1 mark)

total energy = 170 + 18.3 = 188 J

So, E_k as the javelin strikes the ground is 188 J. (1 mark)

Question 13

a $v = \frac{2\pi r}{T}$

Thus, $r = \frac{vT}{2\pi}$ (1 mark)

$r = \frac{120 \times 20}{2\pi} = 382$ m

The radius, R, is 382 m. (1 mark)

b $F_g = mg = 5000 \times 9.80 = 4.90 \times 10^4$ N (1 mark)

$\cos 60° = \frac{F_g}{F_L}$ (1 mark)

$F_L = \frac{4.9 \times 10^4}{\cos 60°}$

$F_L = 9.8 \times 10^4$ N (1 mark)

Question 14

a $m = 0.025$ kg

$F_g = 0.025 \times 9.8 = 0.245$ N

$x = 0.005$ m

$F = k\Delta x$, where F is provied by F_g

$0.245 = k \times 0.005$ (1 mark)

$k = 49$ N m^{-1}

b $x = 0.045$ m

$E_s = \frac{1}{2}\kappa\Delta x^2$

$E_s = \frac{1}{2} \times 49 \times 0.045^2$

$E_s = \frac{1}{2}\kappa\Delta x^2$

$E_s = \frac{1}{2} \times 49 \times 0.05^2$ (1 mark)

$E_s = 0.0496$ J or 0.05 J (1 mark)

c $E_s = E_k = \frac{1}{2}mv^2$

$0.05 = \frac{1}{2} \times 0.025 \times v^2$ (1 mark)

$v = 2.0$ m s^{-1} (1 mark)

d $E_{\text{k at bottom of circle}} = E_{\text{k at top of circle}} + E_{\text{g at top of circle}}$

$0.05 = \frac{1}{2}mv^2 + mg\Delta h$

$0.05 = \frac{1}{2} \times 0.025 \times v^2 + 0.025 \times 9.8 \times 0.2$ (1 mark)

$V_{\text{at top of circle}} = 0.28\ \text{m s}^{-1}$ (1 mark)

To just make it around the circle, F_N at the top of the circle is 0 N, so:

$F_{\text{net}} = \frac{mv^2}{r}$ (1 mark)

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

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

$9.8 = \frac{v^2}{0.1}$

$v = 0.99\ \text{m s}^{-1}$

Velocity required to make it around circle is 0.99 m s^{-1}, however, the ball is travelling at 0.28 m s^{-1}, so the ball will not make it into the cup. (1 mark)

Question 15

a Let time on the Earth clock be t_{Ec}.

$t_{\text{Ec}} = \frac{s}{v} = \frac{24.6c}{0.82c}$ (1 mark)

$t_{\text{Ec}} = 30.0$ years (1 mark)

b Let time on the probe's clock be t_{pc}.

$t = t_0\gamma$

$t_{\text{Ec}} = \frac{t_{\text{pc}}}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$ (1 mark)

$t_{\text{pc}} = t_{\text{Ec}}\sqrt{(1-\frac{v^2}{c^2})}$

$t_{\text{pc}} = 30\sqrt{1-(0.82^2)}$

$t_{pc} = 17.2$ years (1 mark)

c Let the distance from Earth to the planet be L_{Ep}.

$L = \frac{L_0}{\gamma}$ (1 mark)

$L = L_{\text{Ep}}\sqrt{(1-\frac{v^2}{c^2})}$

$L = 24.6\sqrt{1-(0.82^2)}$

$L = 14.1$ light years (1 mark)

d **i** c (3.00×10^8 m s^{-1}) (1 mark)

ii c (3.00×10^8 m s^{-1}) (1 mark)

iii The speed of EMR is a constant at 3.00×10^8 m s^{-1} in all frames of reference (Einstein's second postulate). (1 mark)

Unit 4

Area of Study 1 How can waves explain the behaviour of light?

Question 16

a The central band is a bright band. (1 mark)

At the centre, the path difference is 0, and constructive interference occurs between waves from S_1 and S_2. (1 mark)

b $\Delta x = \frac{\lambda L}{d}$

$\Delta x \propto L$

Therefore as distance to screen decreases so will Δx. (1 mark)

The fringes are closer and brighter. (1 mark)

c The third non-central dark band is a node where $n = 3$. (1 mark)

$PD = (n - \frac{1}{2})\lambda$ (1 mark)

$= 2.5 \times 450 \times 10^{-9}$

$PD = 1.1\ \mu m$ (1 mark)

d The wave model. (1 mark)

Young's experiment produces an interference pattern as a result of constructive and destructive interference. (1 mark)

Constructive and destructive interference is a wave phenomenon. (1 mark)

e The central band is still bright. (1 mark)

A diffraction pattern also produces dark and bright bands, with the central always being a bright band. (1 mark)

Question 17

a (3 marks)

$\boldsymbol{\theta_1}$	$\boldsymbol{\theta_2}$	**sin** $\boldsymbol{\theta_1}$	**sin** $\boldsymbol{\theta_2}$	$\frac{\sin\theta_1}{\sin\theta_2}$
15°	10°	0.259	0.174	1.489
25°	18°	0.423	0.309	1.369
30°	27°	0.500	0.454	1.101
40°	27°	0.643	0.454	1.416
45°	29°	0.707	0.485	1.458

Award 1 mark for approximately every 4 correct responses. Make sure the number of decimal places is correct.

b Exclude value for 30° angle as this could be an error.

$\text{average} = \frac{1.89 + 1.369 + 1.416 + 1.485}{4}$ (1 mark)

$= 1.433$

$= 1.43$ to 2 decimal places

$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$

$\frac{\sin(\theta_1)}{\sin(\theta_2)} = \frac{n_2}{n_1}$ (where $n_1 = 1.000$)

$n_2 = 1.43$ (experimentally) (1 mark)

c $1.46 - 1.43 = 0.03$ (1 mark)

$\frac{0.03}{1.46} \times 100 = 2.05\%$ (1 mark)

d random error (1 mark)

It occurred in one data value suggesting it is not systematic. If the percentage error calculated was greater, this could suggest systematic error, but at this value, it most likely isn't. (1 mark)

Question 18

a The fundamental vibration, n = 1 has wavelength:

$$\lambda = \frac{2l}{n}$$

$$= \frac{1 \times 1.3}{1}$$

$$= 2.6 \text{ m}$$ (1 mark)

b $\frac{1170}{260} = 4.5$

1170 Hz is not a whole number multiple of 260 Hz. (1 mark)

Therefore 1170 Hz standing waves are not possible. (1 mark)

c $v = f\lambda$

$v = 260 \times 2.6$

$v = 676 \text{ m s}^{-1}$ (1 mark)

Question 19

a **D.** The apparent frequency of the sound increases (1 mark)

b **E.** The apparent frequency of the sound decreases (1 mark)

c **D.** The apparent frequency of the sound increases (1 mark)

d **A.** The sound is unchanged (1 mark)

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Area of Study 2 How are light and matter similar?

Question 20

a $\Delta E = \frac{hc}{\lambda} = \frac{4.14 \times 10^{-15} \times 3.00 \times 10^{8}}{9.74 \times 10^{-8}}$ (1 mark)

$\Delta E = 12.75$ eV (1 mark)

Transition will be between energy levels 4 and 1. (1 mark)

b $E_5 - E_4 = 13.06 - 12.75 = 0.31$ eV (1 mark)

$E_5 - E_1 = 13.06 - 0.00 = 13.06$ eV

$E = \frac{hc}{\lambda}$

$0.31 = \frac{4.14 \times 10^{-15} \times 3.00 \times 10^{8}}{\lambda}$

$\lambda = 4 \times 10^{-6}$ m

(longest wavelength) (1 mark)

$E = \frac{hc}{\lambda}$

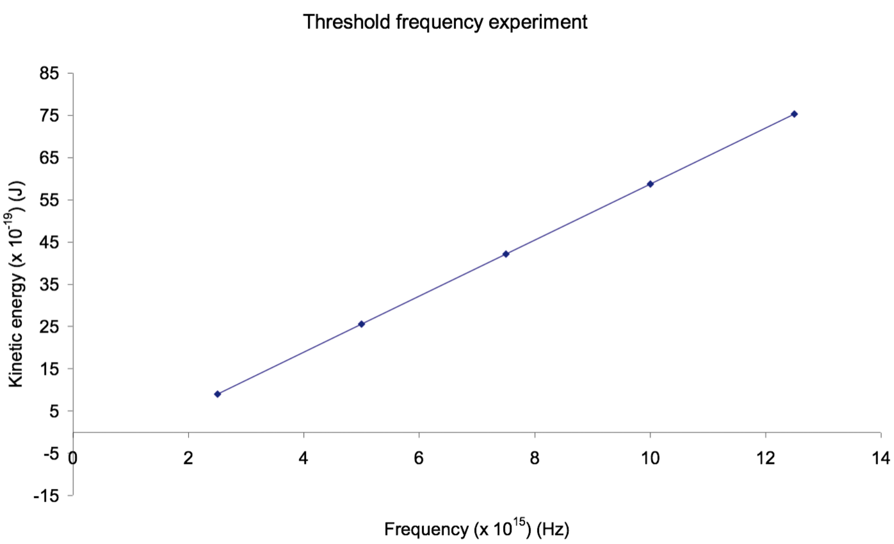
$13.06 = \frac{4.14 \times 10^{-15} \times 3.00 \times 10^{8}}{\lambda}$

$\lambda = 9.5 \times 10^{-8}$ m

(shortest wavelength) (1 mark)

Question 21

a



frequency on *x*-axis (1 mark)

axes labelled with units (1 mark)

appropriate scales on axes (1 mark)

accurate plot (1 mark)

points joined with a line (1 mark)

b Recognition that threshold frequency is found by extending the graph back to intercept with *x*-axis. Value is 1.1×10^{15} Hz (accept values 1 – 1.3×10^{15} Hz). (1 mark)

c Recognition that work function is found by extending the graph back to intercept with *y*-axis. (1 mark)

value is 7.52×10^{-19} J (accept values $7 - 8 \times 10^{-19}$ J) (1 mark)

d uses the relationship $\frac{\Delta y}{\Delta x}$ to find slope (1 mark)

value should be 6.63×10^{-34} (1 mark)

e slope will be 6.63×10^{-34} (1 mark)

f This phenomenon is evidence for the particle nature of light (EMR). (1 mark)

There is no (significant) time delay between light striking the surface and photoelectrons being emitted. This cannot be explained with a wave model. (1 mark)

There is a threshold frequency. A wave model predicts that long exposure of any frequency should cause the photoelectric effect. (1 mark)

Question 22

a $E = hf$

$40.8 = 4.14 \times 10^{-15} \times f$

$F = 9.86 \times 10^{15}$ Hz (1 mark)

b $c = f\lambda$

$3.0 \times 10^{8} = 9.86 \times 10^{15} \times \lambda$

$\lambda = 3.0 \times 10^{-8}$ m (1 mark)

c $\lambda = \frac{h}{mv}$

$3.0 \times 10^{-8} = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times v}$ (1 mark)

$v = 2.4 \times 10^{4}$ m s^{-1} (1 mark)

Question 23

Making the slit narrower decreases the uncertainty about the photon's position (i.e. Δx would decrease) (1 mark)

As Δx and Δp are inversely proportional, the uncertainty in momentum must increase. This leads to an increase in spread of the pattern. (1 mark)

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