Year 12 **Physics**

Student Name:

Practice Exam 2 (Units 3 & 4)

This sample exam has been prepared as part of the Pearson suite of resources for the Units 3 and 4 VCE Physics course, prescribed by the Victorian Curriculum and Assessment Authority.

Time allowed

Reading time: 15 minutes
Writing time: 2 hours and 30 minutes

Structure of this paper

Area of study	Number of questions	Number of questions to be answered	Marks
How do things move without contact?	5	5	28
How are fields used to move electrical energy?	3	3	23
How fast can things go?	5	5	42
How can waves explain the behaviour of light?	3	3	26
How are light and matter similar?	4	4	31
		Totals	150

Notes to students

- Write your name in the space provided above.
- A formulae and data booklet has been provided.
- The following items are approved for use in the examinations:
  - Standard items: pens (blue/black preferred), pencils, highlighters, erasers, sharpeners, rulers, pre-written notes (one folded A3 sheet or two A4 sheets bound together by tape)
  - Special items: one scientific calculator. Check with your teacher which calculators are approved to use in this examination.
- Answer all questions in the spaces provided using black or blue pen.
- You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.
- Diagrams are not drawn to scale (unless otherwise stated).
- Assume the value of g to be 9.8 m s^{-2}.

Disclaimer:

This is a practice examination. It represents Pearson Australia's view only of what would be useful preparation material for the VCE Units 3 and 4 externally assessed examination.

Unit 3

Area of Study 1 How do things move without contact?

Question 1

The diagram represents two conductors, both perpendicular to the page and both carrying equal currents into the page. In these questions ignore any contribution from the Earth's magnetic field. The arrows A to D and letters E to G represent options from which you are to choose in answering the following questions.

A

Q ●

D ← → B

P ●   X   R ●   X

C
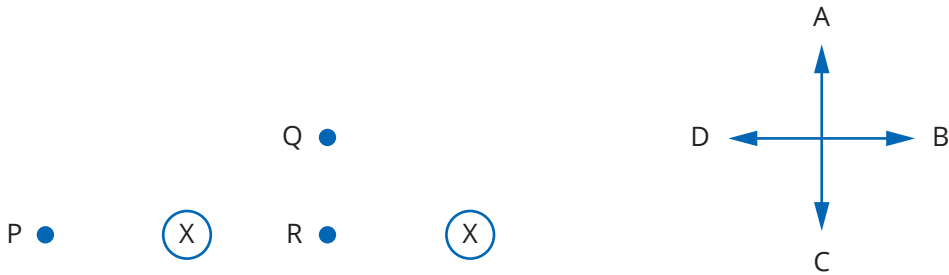
E Out of page

F Intro page

G Zero field

What is the direction of the magnetic field due to the two currents at the following points?

a point P ☐   (1 marks)

b point Q ☐   (1 marks)

c point R ☐   (1 marks)

Question 2

Two parallel metal plates are separated by a distance of 5 cm. A potential difference of 200 V is applied across the plates.

a What is the size of the electric field strength between the plates?   (2 marks)

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A proton is placed next to the positive plate.

b What size force will be exerted on the proton?   (2 marks)

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c How much energy, in joules, will be gained by the proton?   (2 marks)

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d What is the speed of the proton by the time it reaches the positive plate?
Take the mass of a proton to be 1.7×10^{-27} kg. (2 marks)

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Question 3

A remote vehicle sits on an asteroid of diameter 28 km. On top of the remote vehicle is an object, at a height of 1.2 m from the surface of the asteroid. The remote vehicle propels the object vertically upwards at 0.5 m s⁻¹. The object returns to the asteroid's surface 208 seconds after launch.

a What is the acceleration due to gravity on the surface of the asteroid? (3 marks)

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b What is the mass of the asteroid? (2 marks)

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Question 4

An asteroid orbits the Sun with a period of approximately 410 days. What is the average distance of the asteroid from the Sun? Take the mass of the Sun to be 1.99×10^{30} kg. (3 marks)

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Question 5

The diagram below shows a simplified diagram of a DC motor made by a physics student. It was built using two permanent magnets, a 6.0 V battery, a split ring commutator and a rectangular coil of wire consisting of 50 loops. As shown in the diagram, the coil is parallel to the magnetic field.

The resistance of the coil is 4.0 Ω. The length of side WX is 6.0 cm and the length of side XY is 4.0 cm. The magnetic field is 0.08 T.
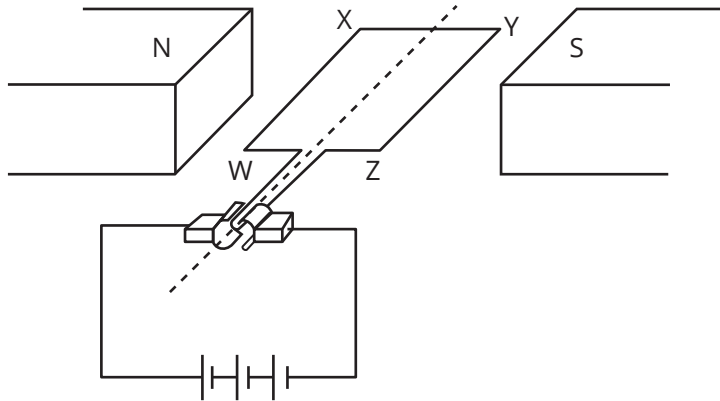
a Calculate the current flowing through the coil of wire. (2 marks)

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b Determine the size of the force acting on side WX when the coil is in the position shown in the diagram. (2 marks)

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c What is the size of the force acting on side XY when the coil is in the position shown in the diagram? Support your answer with suitable reasoning. (2 marks)

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d State the role of the split ring commutator in this circuit and explain how it achieves its purpose. (3 marks)

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Question 6

An alternating generator with a rotor turning at a frequency of 50 Hz has 200 turns in its stator armature coils. Each coil has an area of 100 cm². The magnetic field strength produced by the alternator's magnetising current is 0.50 T.

a If the peak output of the generator is 314 V, draw a graph of the output that would be observed if it was viewed on an oscilloscope. Draw the output from $t = 0$ to 40 ms.

(3 marks)
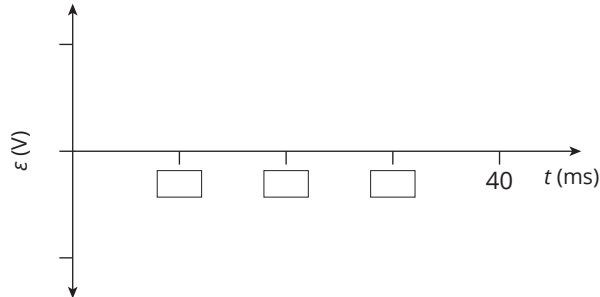
b Determine the magnitude of the average EMF induced in the conducting loop during one quarter of a revolution.

(2 marks)

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Question 7

Consider a wire coil in a magnetic field of strength 10 mT. The coil is initially completely inside the magnetic field and then is completely removed from the magnetic field in a time of 200 ms. The motion of the coil is shown in the diagram below. The coil has an area of 25 cm² and consists of 300 turns.
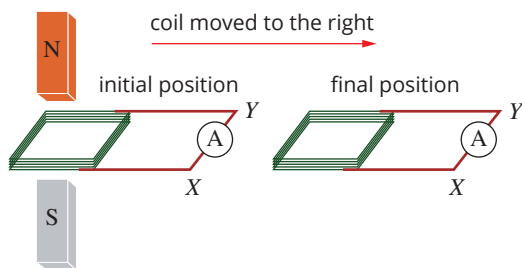
a What is the magnitude of the average emf induced in the coil as it moves from its initial position to its final position?

(2 marks)

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b If the coil has a total resistance of 2.5 Ω, what is the magnitude and direction of the average current induced in the coil as it moves from its original position to its final position?

(2 marks)

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c What is the direction of the induced current in the coil when it is returned to its original position? Explain. (2 marks)

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Question 8

Electricity from a water-driven alternator of output 1000 V AC is transmitted by several kilometres of transmission lines to a step-down transformer which provides 250 V AC for a mill.

a Briefly describe the principle by which an alternator/generator produces electricity. Support your answer with a diagram. (3 marks)

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b The primary (high-voltage) winding of the transformer consists of 2000 turns. How many turns are there in the secondary winding? (2 marks)

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The alternator produces 200 kW of electrical power when the mill is working. The total resistance of the high-voltage transmission lines is 0.2 Ω.

c What is the current flowing in the transmission lines when the mill is working? (2 marks)

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d What is the power loss in the high-voltage transmission lines when the mill is working? (2 marks)

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e The mill engineer is concerned about the power loss in the transmission lines from the alternator to the mill. State what steps the engineer could take to reduce this loss. Explain how this can reduce the transmission losses. (3 marks)

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Question 9

A student devises an experiment with an air track glider of mass 0.5 kg. To begin with the glider is stationary on an air track inclined at 25° as represented below.
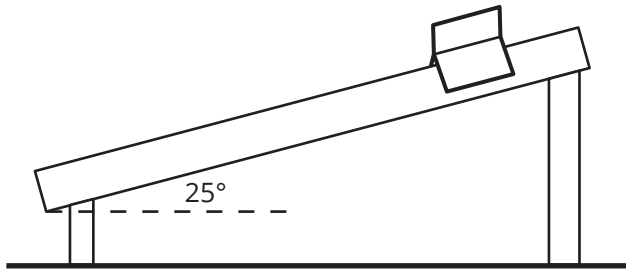
a Label the forces acting on the stationary glider on the diagram above. Assume negligible friction. (1 mark)

The aim of the experiment is to study the effect of the angle on the acceleration of the glider. To measure the acceleration, the glider was released (from rest) and the time taken for it to travel the length of the incline was measured using photogates. The air track provides a frictionless surface for the glider to move along.

b Write an expression for the acceleration of the glider, a, in terms of the length of the incline, x, and the time taken for it to travel the incline, t. (1 mark)

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The following data was collected in the experiment:

θ (°)	x (m)	t (s)	a (m s⁻²)	sin θ°
10	2	1.5		0.174
15	2	1.2		0.259
20	2	1.1		0.342
25	2	1.0		0.423
30	2	0.9		0.500

c Complete the table of results. (2 marks)

d On the axes below, plot a graph of a versus sin $\theta°$. Make sure to place the dependent variable on the vertical axis. (3 marks)
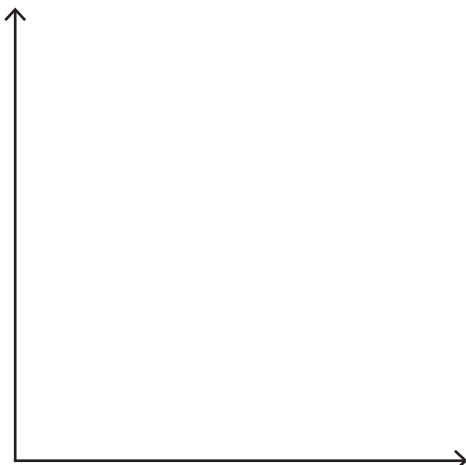
e Draw a line of best fit through the data and from it calculate the gradient of the graph. What is the significance of the gradient? (2 marks)

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f Write a suitable conclusion for this experiment given the results obtained. (3 marks)

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Question 10

A motorcycle stunt rider is designing a stunt to jump a series of trucks lined up side-by-side to give a total length of 50 m. The rider will need to reach a maximum height of 8 m to ensure that the trucks are cleared. The rider will take off from a ramp at an angle of 30°. The diagram below illustrates the jump.

start position   take off ramp

30°

a Calculate the speed at which the motorcycle needs to leave the ramp to reach the required height. (3 marks)

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b Confirm that this take-off speed is sufficient to cover the required distance. (3 marks)

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The stunt rider plans to start the ride on the flat and accelerate towards the take-off ramp.

c Without changing the motorcycle or the take-off ramp, suggest what change to the design of the stunt can help ensure the rider takes off at the required speed. Explain your answer using appropriate physics terminology. (3 marks)

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Question 11

A centrifuge is a device that rotates test tubes at very high speeds to separate components suspended in a liquid. The diagram below represents a centrifuge containing a test tube.
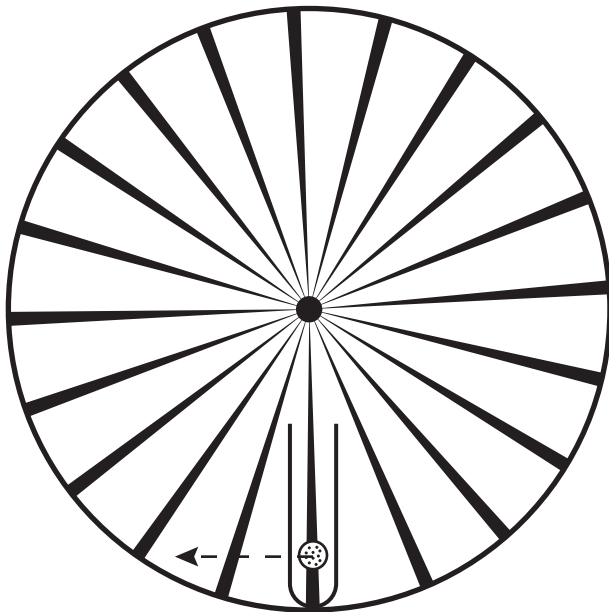
The centrifuge rotates at 75 000 rpm (revolutions per minute) in a clockwise direction. The open end of the test tube is 5 cm from the axis of rotation (centre of the circle) and the closed end is 15 cm from the axis.

a At any point in its motion, a suspended particle has the tendency to move in a straight line as represented by the red arrow in the diagram above. Explain why it does not continue to move in a straight line but rotates around the axis of the centrifuge. (2 marks)

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b Determine the centripetal acceleration at the open end of the test tube. (4 marks)

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c What is the centripetal acceleration at the closed end of the test tube? (2 marks)

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d If the contents of the test tube have a mass of 11.5 g, what force must the bottom of the test tube withstand? (2 marks)

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Question 12

A student uses a 1 m long spring in an experiment. She hangs a 2 kg mass from it and finds that its new length is 1.2 m. Assume that the spring obeys Hooke's law.

a Show that the spring constant has a value of 98 N m^{-1} for this spring. (2 marks)

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b How much spring potential energy is stored in the spring at this new stretched length? (2 marks)

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c The student pulls the mass down a further 10 cm. How much spring potential energy is stored in it now? (1 mark)

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From this position (marked as point C on the figure below), the student releases the mass. Upon releasing the mass, the spring oscillates about point B as shown in the diagram below.
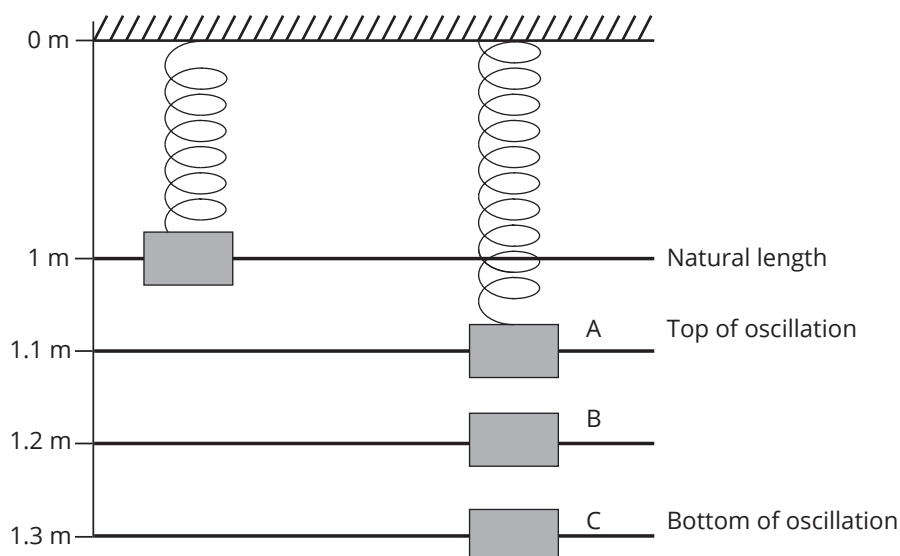
d Calculate the velocity of the mass at point B. (4 marks)

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Question 13

The rest length of a spacecraft is 75 m. As it passes by a space station, its length is measured to be 60 m. What is the speed of the spacecraft relative to an observer on the space station? (2 marks)
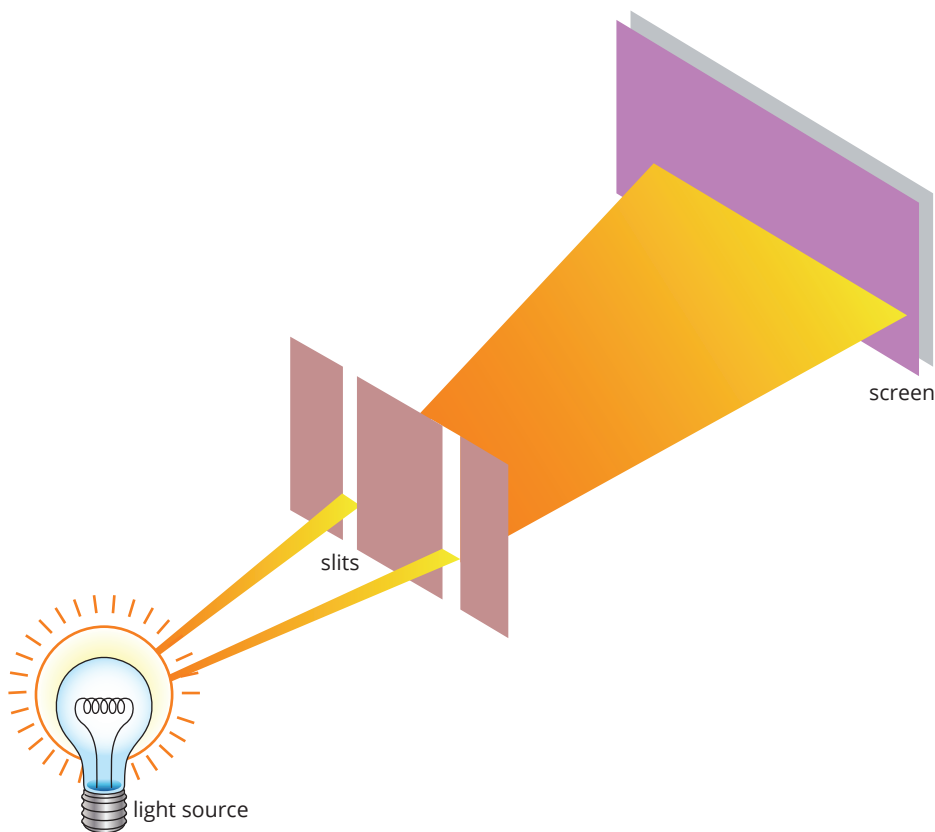
Unit 4

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

Question 14

Two students wish to conduct an experiment similar to Young's double-slit experiment.

The aim of the students' experiment is: to demonstrate the wave-nature of light.


a   What kind of light source should the students select in order to conduct a valid experiment and obtain the interference pattern obtained by Young? Explain.   (2 marks)

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The students created a table to summarise their findings.

b   Complete the table using the terms 'increased spread' or 'decreased spread' to describe the effect on the interference pattern the students can expect when conducting their experiment.   (4 marks)

Change made	Effect on spread of interference pattern
increase slit separation	
decrease slit separation	
increase slit to screen distance	
decrease slit to screen distance	

The students observe a very clear interference pattern on the screen. The centre band of the pattern, labelled X, is a bright band as shown in the diagram below. The point Y is on the second bright band away from the centre. The distance from one of the slits to X and to Y differs by 920 nm.
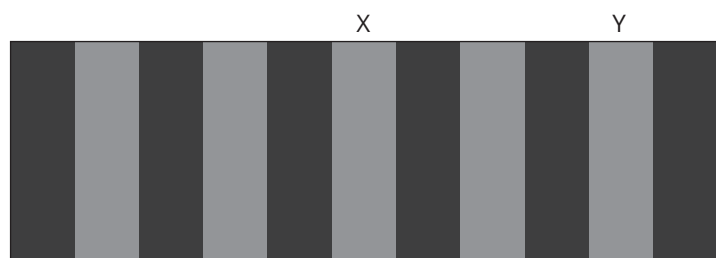

c What wavelength of light did the students use to conduct their experiment? Express your answer in nm. (3 marks)

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d Given your understanding of Young's double slit experiment, write a suitable conclusion for the experiment the students conducted. (3 marks)

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Question 15

The following diagram shows a ray of light travelling from medium 1 into medium 2, with absolute refractive indices n_1 and n_2 respectively. Assume $\theta_1 = 19°$ and $\theta_2 = 29°$ and medium 2 is air ($n_2 = 1.0$).
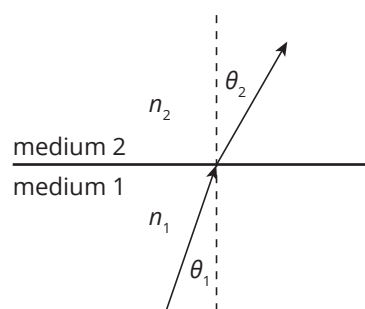
a Calculate the value of n_1. (2 marks)

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b Assuming that the speed of light in air = 3.0×10^8 m s^{-1}, calculate the speed of light in medium 1. (2 marks)

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c Determine the critical angle for light passing from medium 1 into medium 2. (2 marks)

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d Explain what happens to the light ray if the critical angle is exceeded. (1 mark)

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e Which medium is the more optically dense? Justify your answer. (2 marks)

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Question 16

The following diagram shows the mean positions of the particles in a wave versus the distance from the wave source. The wave is travelling towards the right at 100 m s^{-1}.
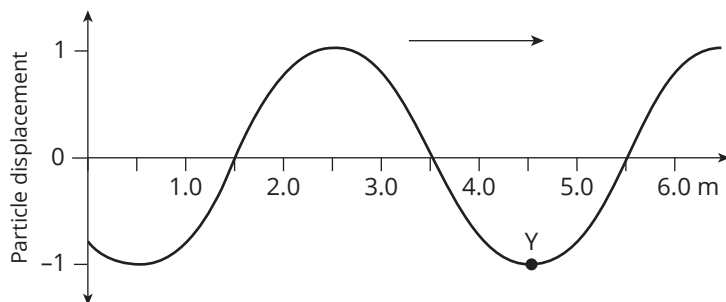
a What is the wavelength of the wave? (1 mark)

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b Describe the direction in which a particle at Y will move in the very next instance. (1 mark)

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c In which direction is the energy of the wave moving? (1 mark)

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d Calculate the frequency and period of the wave. (2 marks)

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Area of Study 2 How are light and matter similar?

Question 17

A domestic microwave oven is rated at 1000 W and uses a frequency of 2500 MHz. Calculate the number of photons emitted per second by the magnetron that produces the microwaves in the oven. (4 marks)

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Question 18

Consider the energy level diagram for the hydrogen atom shown below. A photon of energy 14.0 eV collided with a hydrogen atom in the ground state.


$n = \infty$		$E = 0$
$n = 4$		$E = -0.88$ eV
$n = 3$		$E = -1.51$ eV
$n = 2$		$E = -3.39$ eV
$n = 1$		$E = -13.6$ eV
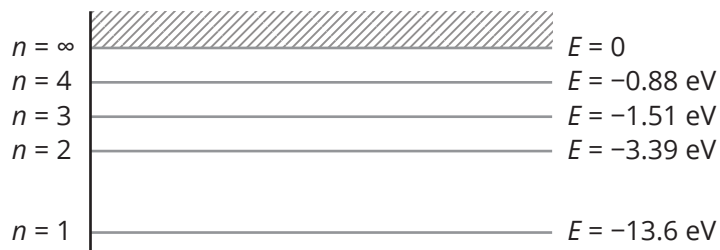
a Explain why this collision will eject an electron from the atom. (2 marks)

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b Calculate the energy of the ejected electron in electron volts and joules. (2 marks)

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Question 19

The diagram below shows a photograph of the diffraction patterns obtained by a group of students. They investigated the diffraction pattern created when a beam of electrons passed through a very thin film of gold foil and then the pattern created when X-rays were used instead of electrons.

Electrons diffraction | X-ray diffraction
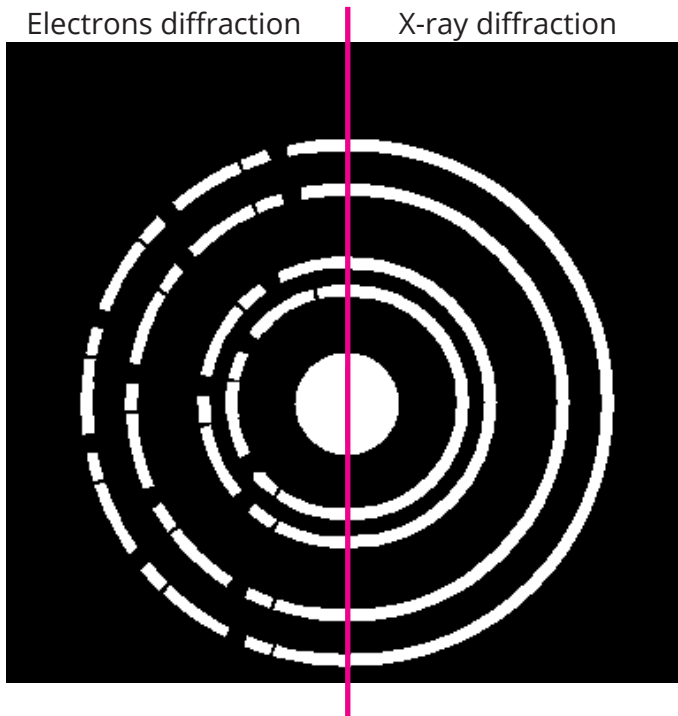
The electrons used in the experiment were accelerated to a speed of 1.8×10^7 m s^{-1} before passing through the gold foil.

a Calculate the de Broglie wavelength of the electrons used. Show your working.   (2 marks)

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b State and explain the effect on the electron diffraction pattern if the accelerating voltage applied to the electron were increased.   (3 marks)

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c Determine the energy of a photon of the X-rays used. Show your working.   (2 marks)

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**d** State why the diffraction pattern obtained using electrons is the same as that obtained using X-rays. (2 marks)

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Question 20

In an experiment designed to investigate the photoelectric effect, a group of physics students allowed light of various frequencies to fall on a metal plate coated in scandium (Sc). The diagram below shows the electric circuit used by the students to collect their data.
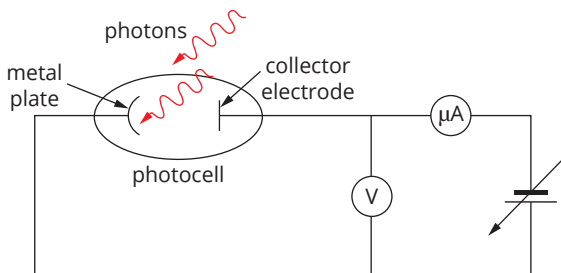
The data they collected is shown in the graph below.
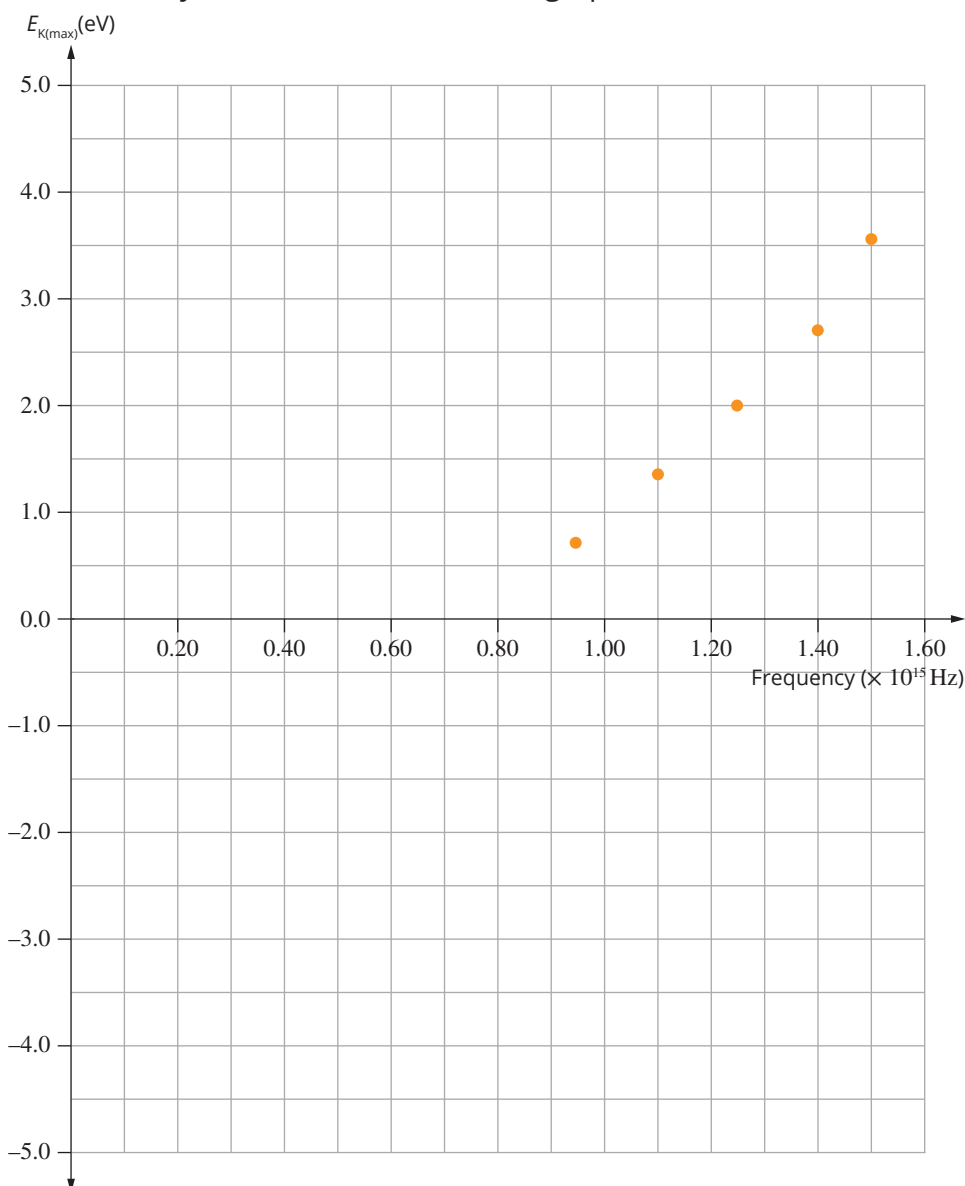
a From the data on the graph, what value would the students obtain for Planck's constant? Include the units in your answer. (3 marks)

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b From the data on the graph, what is the minimum energy required to remove photoelectrons from the scandium (Sc) plate? (1 mark)

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c Explain why the existence of a threshold frequency supports the particle model and not the wave model for light. (2 marks)

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The students replaced their scandium (Sc) photocell with one in which the metal plate was coated in caesium (Cs). Caesium has a work function of 2.1 eV.

The students then shone light from a 5.0 mW (5.0×10^{-3} W) monochromatic blue laser of wavelength $\lambda = 460$ nm onto the caesium photocell.

d Determine the velocity of the electrons ejected from the caesium. (6 marks)

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The students repeated their original experiment using caesium (Cs) instead of scandium (Sc).

e On the graph for the original experiment, draw a line for the graph that would be obtained for the caesium experiment. (2 marks)