Year 12 **Physics**

Student Name: ______________________________

Practice Exam 1 (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	32
How are fields used to move electrical energy?	5	5	24
How fast can things go?	5	5	39
How can waves explain the behaviour of light?	4	4	29
How are light and matter similar?	4	4	26
		Total	**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.

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Unit 3

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

Question 1

a Complete the diagram below by drawing at least four field lines around the conductors. (1 mark)

b Given your answer to part **a**, state whether the wires are attracted towards or repelled from each other (1 mark)

The wires are:

___

Question 2

Two electrons, each with a charge of -1.6×10^{-19} C, are separated by a distance of 100 pm (picometres). X marks a point exactly midway between the two electrons.

a Using $k = 9.0 \times 10^9$ N m^2 C^{-2}, calculate the magnitude of the repulsive force that acts between the electrons. (2 marks)

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Due to the force of repulsion, the electrons move further apart. In doing so, the repulsive force between them reduces to one ninth of its original magnitude.

b How far apart are the electrons? Answer in metres. (2 marks)

___

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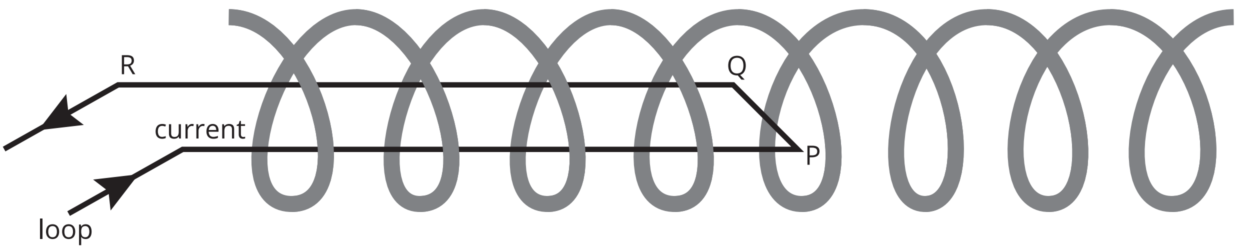
c An uncharged particle is placed at point X, midway between the electrons. What is the force on this uncharged particle? (1 mark)

___

Question 3

A single conductor loop is positioned inside a solenoid with its long axis parallel to the axis of the solenoid, as shown in the diagram below. The short side, PQ, is at right angles to the axis and is 25 mm long. The current in the loop is 5.0 A, while the current in the solenoid produces a magnetic field inside the solenoid of strength 40.0 mT to the right (→).



a What is the direction of the force on the coil on side PQ? (1 mark)

b What is the magnitude of this force on the side PQ? (3 marks)

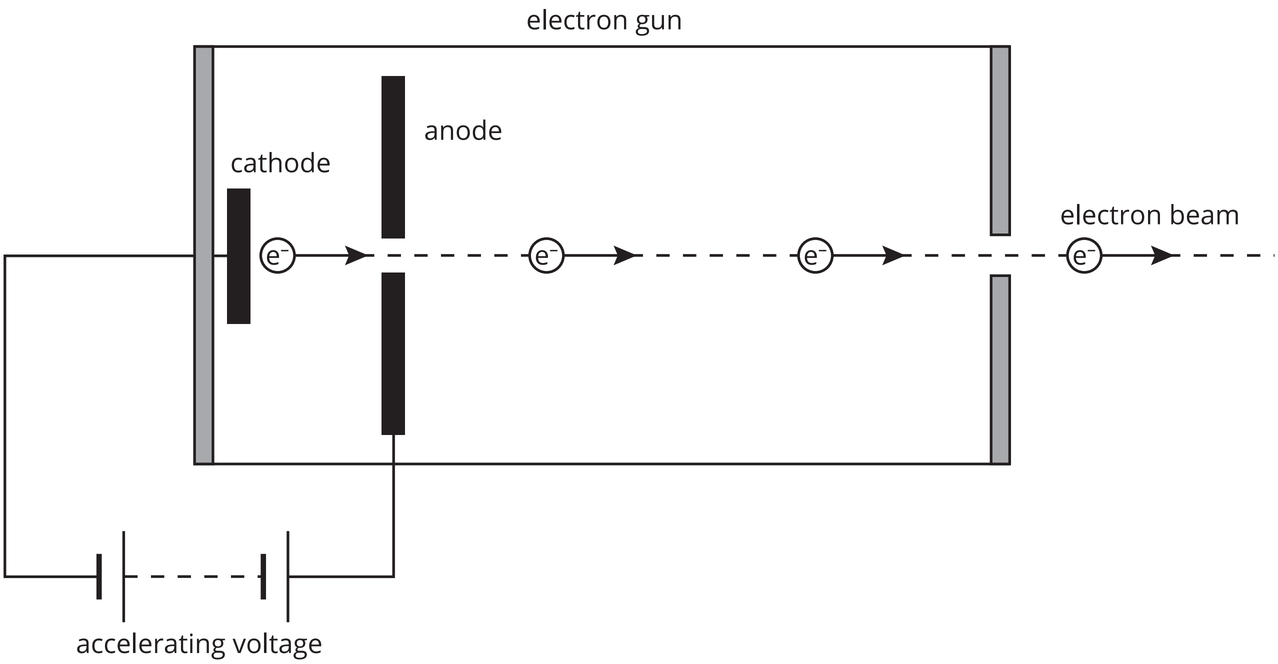
c Assuming no change to the dimensions of the conductor loop, describe how the force on side PQ could be increased. (2 marks)

d What is the magnitude of the force on the side QR? (1 mark)

Question 4

An electron gun is used to inject electrons into a synchrotron. The electron gun releases electrons from its cathode, which are then accelerated across a potential difference of 16 kV.

The distance between the cathode and anode is 25 cm. Below is a schematic diagram of an electron gun.



a With what speed will the electrons exit the electron gun? (4 marks)

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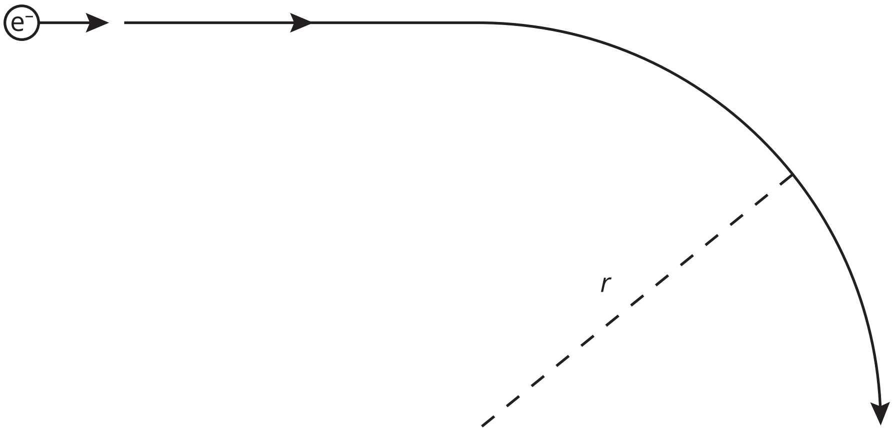
The electron gun's accelerating voltage was adjusted so that the exiting electrons were travelling at a speed of 1.5×10^5 m s^{-1}. The path taken by the electrons as they entered a magnetic field of strength 20 mT is shown below.



b State the direction of the magnetic field that causes the electrons to follow the path shown above. (1 mark)

____

c What is the magnitude of the force acting on the electrons as they travel through the magnetic field? (2 marks)

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d What is the radius of the arc of the circle that the electrons follow while they are in the magnetic field? (2 marks)

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Question 5

A weather satellite is placed in orbit 600 km above the Earth's surface.

a What orbital velocity must this satellite have? (3 marks)

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b Calculate the period of orbit of the satellite. (2 marks)

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c What acceleration due to the Earth's gravitational field does the satellite experience? (2 marks)

d Why do objects in the satellite experience apparent weightlessness? (2 marks)

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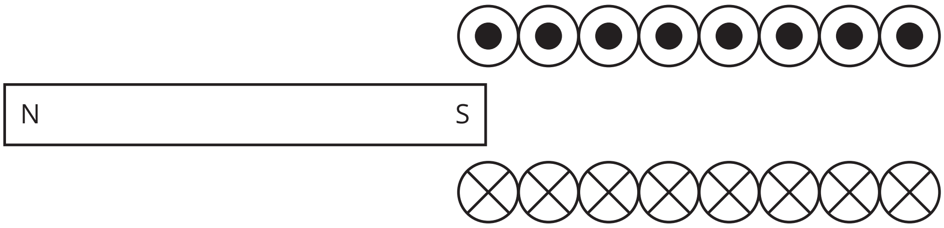
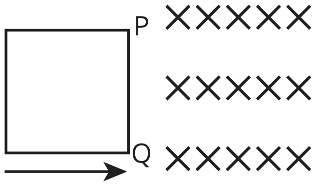
Question 6

Complete the diagram below by showing the direction of movement of the magnet that generates the current in the solenoid represented below. (1 mark)



Question 7

A square conducting loop has side length 10 cm. It is moving with constant velocity into a magnetic field of strength 0.5 T. The field is directed vertically downwards. The magnetic field covers a square area of 20 cm by 20 cm. The loop just begins to enter the magnetic field. (The diagram below, which is not to scale, shows the arrangement when viewed from above.)



a As the loop just begins to enter the magnetic field, in which direction does an induced current flow through the conducting loop: P to Q or Q to P? Explain. (2 marks)

The conducting loop travels towards the magnetic field at a speed of 5 cm s^{-1}.

b Calculate the magnitude of the average EMF induced in the loop when it is halfway into the magnetic field. (2 marks)

c What is the average EMF induced in the loop 3 seconds after it starts to enter the magnetic field? (1 mark)

d What is the direction of the induced current along the side PQ just as it begins to leave the magnetic field? Explain. (2 marks)

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Question 8

An ideal transformer has 140 turns in the primary coil and 2100 turns in its secondary coil. An AC voltage is connected to the primary coil and an AC RMS voltage of 300 V is measured at the secondary coil.

a Calculate the peak-to-peak voltage at the primary coil. (2 marks)

The transformer is removed from this circuit and placed in another circuit. A DC voltage is connected to the primary coil and a voltage of 20 V is applied across the primary coils of the transformer.

b What voltage is measured at the secondary coils of the transformer? (1 mark)

Question 9

A student sets up a generator. It consists of a square conducting loop with side length 0.1 m and 5 turns. The loop is in a uniform magnetic field of 2.0 mT.

a Calculate the magnitude of the flux in the loop. (1 mark)

b The conducting loop is rotated a quarter turn in 1 ms. Determine the magnitude of the average EMF induced in the conducting loop. (1 mark)

c The student wishes to make sure that the generator produces an AC output. What type of connection should they use to join the conducting loop to an external circuit? Explain. (2 marks)

Question 10

A farmer has installed a generator on a nearby hill, along with a power line consisting of two cables with a total combined resistance of 1.5 Ω. The output of the generator is 240 V (RMS) with a maximum power of 3.6 kW. The farmer connects the system to a farmhouse just near the hill.

a Calculate the current in the power line when the appliances in the farmhouse are turned on. (1 mark)

b Calculate the voltage at the farmhouse when the appliances are turned on. (2 marks)

c Calculate the power at the farmhouse when the appliances are turned on. (2 marks)

The farmer adds a transformer to each end of the power lines in an effort to reduce the power losses in the lines. The farmer uses a 1:20 transformer near the generator and a 20:1 transformer near the house.

d Compare the power losses experienced in the circuit before the transformers are used with the losses experienced when the transformers were in place. In your answer, express the power loss in each case as a percentage of the supplied power. (4 marks)

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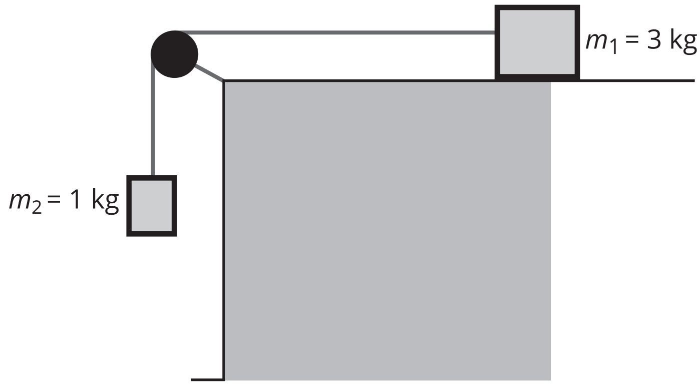
Question 11

A student sets up a controlled experiment using an air track to provide a frictionless surface. The student connects two masses, m_1 and m_2, with an inextensible string as shown in the diagram below.



The string passes over a frictionless pulley and the mass of the string can be considered negligible.

a Calculate the acceleration of m_2. (2 marks)

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____

b Using arrows, draw the forces acting on m_1 and m_2. (2 marks)

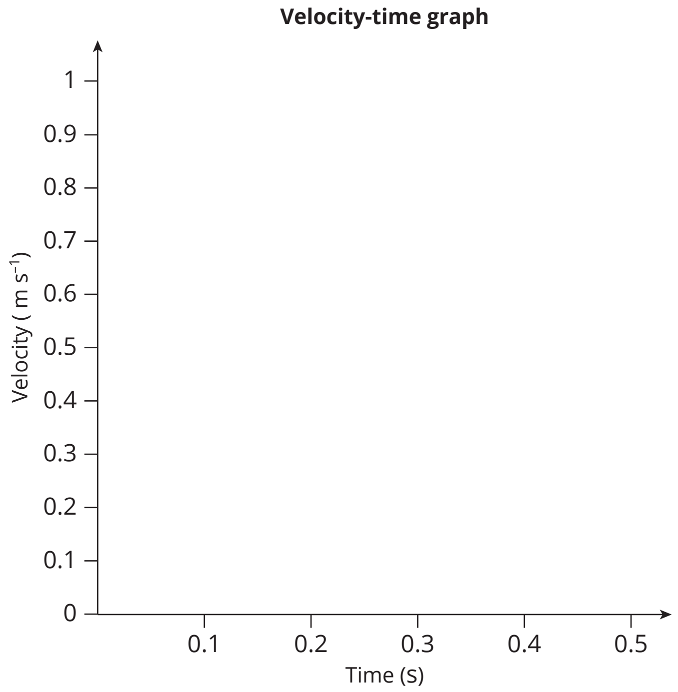
____

____

The student now turns off the air to the air track, so that the surface is no longer frictionless. The pulley remains frictionless. The student collects the following data about the magnitude of the velocity of m_1 and therefore m_2:

time (s)	velocity (m s^{-1})
0.1	0.05
0.2	0.15
0.3	0.35
0.4	0.65
0.5	0.9

c Plot a graph of the data on the axes below and include a line of best fit for the data.



d Calculate the acceleration of m_2 from the graph. (2 marks)

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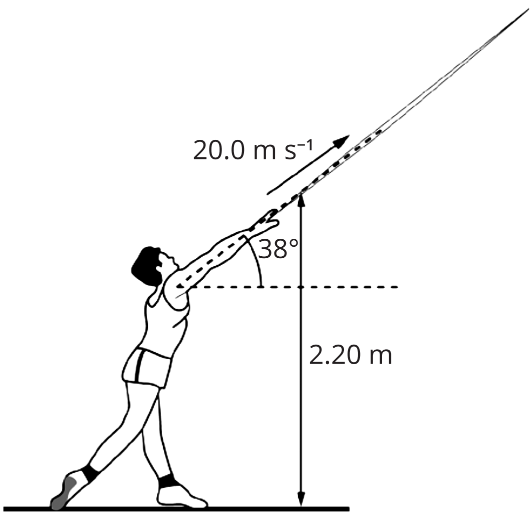
e Calculate the size of the friction force, F_{fr}, acting. (2 marks)

____

____

Question 12

During a school athletics competition, an athlete threw a javelin as shown below.



At the moment it left the athlete's hand, the 0.85 kg javelin was at a height of 2.2 m above the ground and travelling at 20 m s^{-1} at an angle of elevation of 38°.

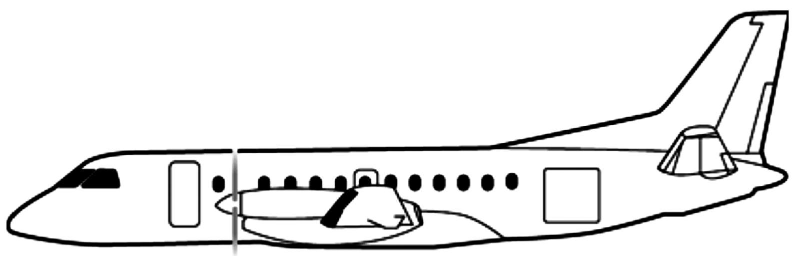
a What was the maximum height above the ground reached by the javelin? Ignore the effects of air resistance. (3 marks)

b How far horizontally from its point of release did the javelin land? Ignore the effects of air resistance. (3 marks)

c How much kinetic energy does the javelin have when it strikes the ground at the end of its flight? (2 marks)

Question 13

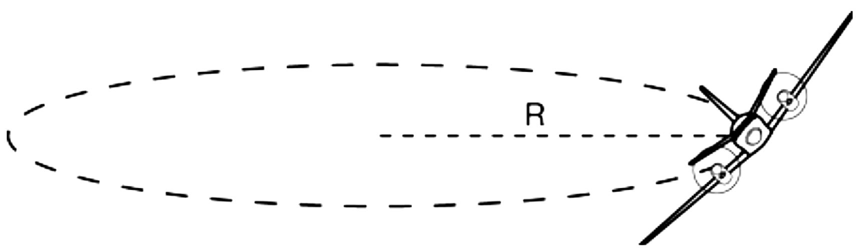
A pilot of mass 75 kg flies in an aircraft as shown below.



The combined mass of the pilot and aircraft is 5000 kg.

Initially, the pilot flies in a horizontal circle as shown by the diagrams in parts **a** and **b** of this question.

a While flying in a horizontal circle, as represented below, the aircraft travels at a constant speed of 120 m s^{-1} and takes 20 seconds to complete one full circle. What is the radius, *R*, of the horizontal circle that the aircraft flies around? (2 marks)



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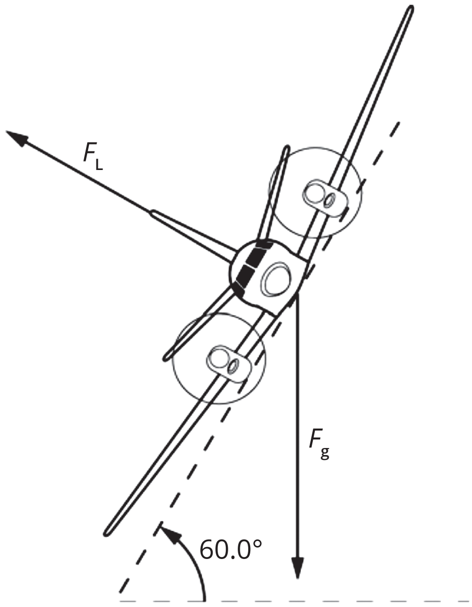
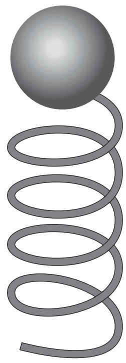
b The diagram below shows the only two unbalanced forces acting on the aircraft during the manoeuvre to fly the horizontal circle shown in part **a** of this question. Calculate the magnitude of the lift force, F_L. (3 marks)



Question 14

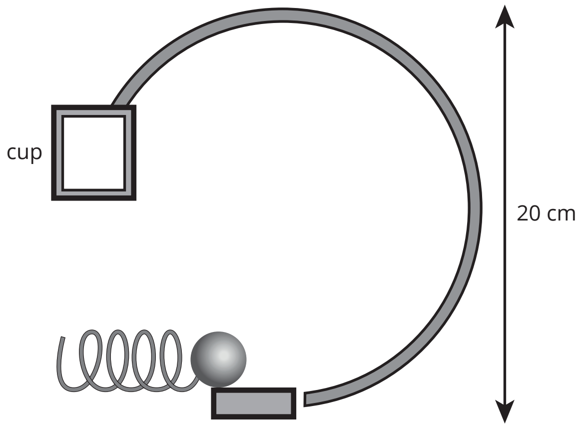
A student loads a ball bearing of mass 25 g onto a spring as shown in the diagram below.



With the ball just resting on the spring, it compresses by 0.5 cm.

a Calculate the value of the spring constant for this spring. (1 mark)

The student now arranges the same spring and ball bearing next to a circular track as shown in the figure below.



The student pulls back on the spring and compresses it by 4.5 cm.

b What is the total energy stored in the spring at this point? (2 marks)

The spring is released and the ball bearing is launched along the inside of the circular track.

c What is the launch speed of the ball bearing? (2 marks)

In order for it to land in the cup at the end of the track, the ball needs to maintain contact with the track at all times.

d Does the ball make it into the cup? Justify your answer with calculations. (4 marks)

Question 15

A space probe is sent to make observations of a planet orbiting a star in a neighbouring galaxy.

The planet is 24.6 light-years from Earth and the probe is sent from Earth with a speed 0.82*c*.

The probe carries an atomic clock that was synchronised with a similar clock on Earth at the start of the journey.

a How long will the journey take as measured by the clock on Earth? (2 marks)

b How long will the journey take as measured by the clock on the probe? (2 marks)

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c From the space probe's frame of reference, what is the distance travelled to reach the planet? (2 marks)

d On arrival at the planet, the space probe sends signals of its measurements back to Earth using various parts of the electromagnetic spectrum.

i At what velocity will the signals travel from the probe's frame of reference? (1 mark)

ii At what velocity will the signals travel from the Earth's frame of reference? (1 mark)

ii Explain your answers to **i** and **ii**. (1 mark)

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

Question 16

Two students set up an experiment similar to Young's double-slit experiment. They use monochromatic light of wavelength 450 nm. An interference pattern is produced on a nearby screen.

a Describe the appearance of the central band of the interference pattern produced on the screen. Explain how it occurs. (2 marks)

The screen is moved closer to the slits.

b What effect will this have on the appearance of the interference pattern observed on the screen? (2 marks)

c Determine how much further the third non-central dark band is from one slit compared with the other slit. (3 marks)

d Which model of light does this experiment support? Explain. (3 marks)

The double slit is removed and replaced with a single slit.

e Describe the appearance of the central band of the interference pattern produced. (2 marks)

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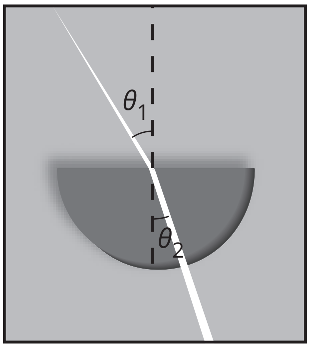
Question 17

A student conducts an experiment in order to measure the refractive index of a semi-circular perspex block.



The data obtained is shown in the table below. The angle θ_1 represents the angle of incidence at the flat side of the block. The angle θ_2 represents the angle of refraction as the light enters the block. The light does not refract again as it leaves the curved side of the block.

$\boldsymbol{\theta_1}$	$\boldsymbol{\theta_2}$	**sin** $\boldsymbol{\theta_1}$	**sin** $\boldsymbol{\theta_2}$	$\dfrac{\sin\boldsymbol{\theta_1}}{\sin\boldsymbol{\theta_2}}$
15°	10°	0.259	0.174	1.489
25°	18°			
30°	27°			
40°	27°			
45°	29°			

a Complete the table of values, expressing all figures to three decimal places. (3 marks)

b Using the data collected, and by excluding any outliers, calculate the value of the refractive index of perspex to two decimal places. Assume that the refractive index of air is n = 1.000. (2 marks)

c The quoted value for the refractive index of this particular perspex block is 1.46. Calculate the percentage error in the experimental value obtained (to two decimal places). (2 marks)

d What type of error, systematic or random, is most likely to have contributed to the error calculated in part **c**? Explain. (2 marks)

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Question 18

A 1.3 m string, fixed at both ends, is made to vibrate. The fundamental frequency is found to be 260 Hz. Assume the tension in the string is constant.

a What is the wavelength of the fundamental vibration? (1 mark)

____

b Is it possible to produce standing waves of frequency 1170 Hz in this string? Explain. (2 marks)

____

____

c What is the speed of the wave in the string? (1 mark)

____

Question 19

The information below is to be used to answer the following questions.

A The sound is unchanged.

B The frequency of the sound increases.

C The frequency of the sound decreases.

D The apparent frequency of the sound increases.

E The apparent frequency of the sound decreases.

A siren sounds from a fire truck. As an observer, you hear the sound change depending on your movement relative to the fire truck. You and the fire truck are stationary to begin with. How do the following movements change the sound you hear?

a You are driving towards the stationary fire truck. (1 mark)

____

b You are driving away from the fire truck. (1 mark)

____

c You are stationary and the truck moves towards you. (1 mark)

____

d You are approaching the truck at 30 m s^{-1} and the truck is moving away from you at 30 m s^{-1}. (1 mark)

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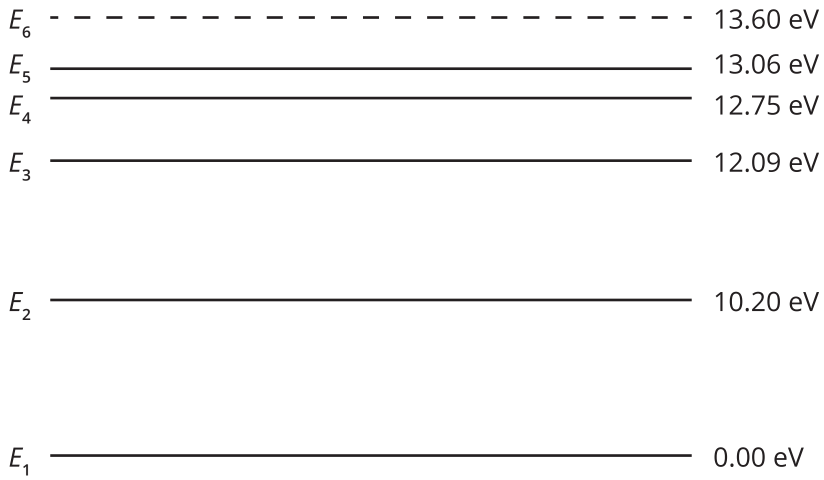
Area of Study 2 How are light and matter similar?

Question 20

The energy level diagram for hydrogen shown below can be used to answer the following question.



A satellite equipped with an instrument to measure radiation emitted in the ultraviolet region of the electromagnetic spectrum records a wavelength of 9.74×10^{-8} m.

a Between which two energy levels must the hydrogen atom's electron transition to produce this line? (3 marks)

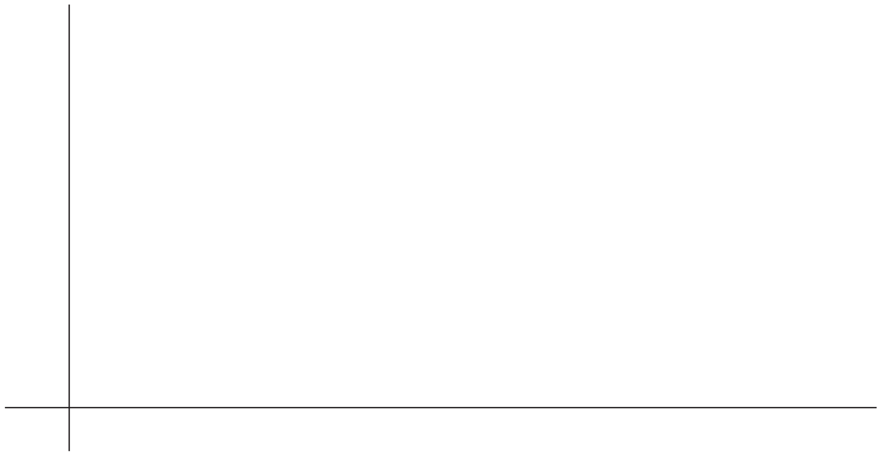
b An atom is in the 13.06 eV state and returns to ground state by emitting one or more photons. What are the wavelengths of the most energetic and the least energetic photons that could be emitted? (3 marks)

Question 21

In an experiment to determine the threshold frequency and work function for a particular metal, a researcher measured the kinetic energy of the electrons ejected from the metal's surface at a range of frequencies. The results are tabulated below.

Frequency ($\times 10^{15}$) (Hz)	Kinetic energy of electron ($\times 10^{-19}$) (J)
2.50	9.055
5.00	25.63
7.50	42.20
10.0	58.78
12.5	75.36

a Plot a graph of frequency against kinetic energy on the axis provided below. Make sure to label the axes appropriately. (5 marks)



b Use data from the graph to determine the threshold frequency for the metal. (1 mark)

c Use data from the graph to determine the work function for the metal. (2 marks)

d Determine the slope of the line. (2 marks)

The researcher carries out the same experiment to determine the threshold frequency and work function for a second metal, and graphs the frequency against kinetic energy.

e Predict the slope of the line for this second metal. (1 mark)

f Which model of light does this experiment provide evidence for? Justify your answer. (3 marks)

Question 22

A photon has 40.8 eV of energy.

a Calculate the frequency of the photon. (1 mark)

b Calculate the wavelength of the photon. (1 mark)

c How fast must an electron of mass 9.1×10^{-31} kg travel to have a de Broglie wavelength equal to the wavelength of the photon? (2 marks)

Question 23

Consider the diffraction of a particle through a single slit. By referring to Heisenberg's uncertainty principle, explain why the diffraction pattern obtained spreads out when the slit is made narrower. (2 marks)

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