PLACE LABEL HERE

Tasmanian Secondary Assessment Board

Tasmanian Certificate of Education

External Assessment

1997

PH866 PHYSICS

Time: Three Hours

On the basis of your performance in this examination, the examiners will provide a rating of A, B, C or D on each of the following criteria taken from the syllabus statement:

Criterion 2	Convey information in a variety of ways using established conventions and appropriate language.
Criterion 7	Formulate generalisations and make realistic predictions based on experimental data.
Criterion 9	Demonstrate and apply knowledge and understanding of terminology; definitions and laws; concepts, theories and models; and uses of measuring instruments of Physics.
Criterion 10	Incorporate techniques of analysis and mathematical manipulation (algebraic, trigonometrical, numerical and graphical) to solve complex problems.

INSTRUCTIONS FOR CANDIDATES

The Tasmanian Secondary Assessment Board Physics Formula Sheet and hand held, battery operated calculators may be used freely during the examination.

No other printed material will be allowed into the examination.

The exam consists of three sections:

Section A: Assesses Criteria 2 and 7 and is designed to take 45 minutes.
Section B: Assesses Criteria 2 and 9 and is designed to take 60 minutes.
Section C: Assesses Criteria 2 and 10 and is designed to take 75 minutes.

WRITE YOUR ANSWERS IN THE SPACES PROVIDED IN THIS BOOKLET.

For Questions 1 and 2 graph grids for you to use in your answer are on the odd numbered pages. There are also some spare grids. If you use these spare grids show clearly which you wish to have marked.

If you find that there is insufficient space for your answer, please use the odd-numbered blank page opposite the question and show clearly that you have done so. These blank pages may also be used for rough working. Some of these ‘blank’ pages have graph paper or diagrams in case you need them.

SECTION A

This section assesses **Criteria 2 and 7.** You should spend about 45 minutes in total on this section.

Question 1 (This question is designed to take about 20 minutes. It is suggested that you spend about 10 minutes on the graph, which will be important for the assessment of Criterion 2.)

You are a police officer in the Traffic Branch. You have set up your radar speed camera at a bend in the highway looking along a straight length of the road where the speed limit is 60 km hr^{-1}. A car appears in the distance coming along the road towards your camera which displays the time of day and the car's speed, as measured by the radar, every two seconds. You note the values, as shown in the table below, in which the times are seconds after 9.25 a.m. At 35 s time, your attention is distracted by a kookaburra in a tree across the road but the camera automatically photographs the car at time 36.2 s.

Time (seconds)	22	24	26	28	30	32	34	(36.2)
Speed (ms^{-1})	28.3	28.8	30	28.5	27.0	25.5	24	

(a) Draw a graph of the speed-time data in the table.

(b) Using the graph, and making any necessary calculations, answer the following.

(i) What happened at about 26 s?

....

....

(ii) What was the acceleration of the car after 26 s?

....

....

....

....

....

(iii) What was the speed of the car when it was photographed?

....

....

....

....

....

....

....

Question 1 continues over the page.

Graph for Question 1 (a)

Question 1 (continued)

(iv) Will the driver be fined for exceeding the speed limit?

....

....

....

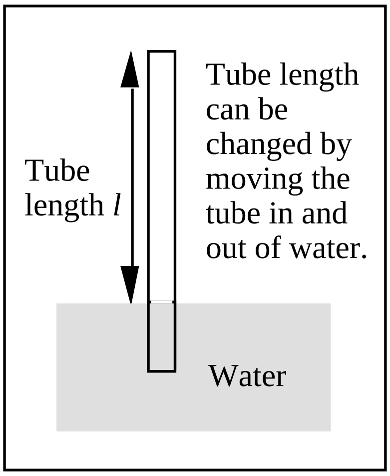
....

....

Spare Graph for Question 1 (a)

Question 2 (This question is designed to take about 25 minutes in total. It is suggested you spend about 15 minutes on the graphs, which will be important for the assessment of Criterion 2.)

The diagram opposite shows an experiment to measure the speed of sound in air, c, by determining how the **resonance frequency**, f, of a thin hollow tube, closed by the water at the lower end, depends on **tube length**, l. The tube length is adjusted by moving the tube in a water container.



The theory of standing waves in tubes shows that the set of formulae connecting the variables is:

$$\ell = \frac{c}{4f}, \quad \ell = \frac{3c}{4f}, \quad \ell = \frac{5c}{4f}, \quad \text{etc.}$$

The experiment is conducted as follows:

- The tube is clamped in place, fixing a value of tube length, l.
- The frequency of sound emitted by a nearby loudspeaker is varied until the tube resonates (ie. produces a louder sound) and the resonant frequency is recorded.
- The tube is then re-positioned to give a different tube length and the new resonant frequency is found.

The following experimental data was found relating tube length and resonant frequency.

***l* (m)**	0.625	0.364	0.313	0.156	0.938	0.469	0.625	0.625	0.727
***f* (hz)**	128	220	256	512	256	512	512	384	330

(a) Modify the data provided to enable you to plot a straight line graph showing the relationship between tube length and frequency. Explain why you chose the modification and write your modified data in the bottom row of the table above.

....

....

....

....

....

(b) Plot your modified data on the graph opposite. Draw appropriate line(s) of best fit. (**Note:** There may be more than one line of best fit.)

Explain the reason for any single point not fitting on a straight line.

....

....

....

....

....

Question 2 continues over the page.

Graph for Question 2 (b)

Spare Graph for Question 2 (b)

Question 2 (continued)

(c) By using the theoretical formulae, analyse **one** of your straight line graphs to determine the value of the speed of sound, *c*.

....

....

....

....

....

....

....

....

Question 2 continues over the page.

Question 2 (continued)

(d) In practice, there are a number of complications in doing this experiment. Two are:

- if the air temperature increases, the speed of sound will increase;
- if we make allowance for the width of the tube, the theoretical formulae become

$$\ell = \frac{c}{4f} + D, \quad \ell = \frac{3c}{4f} + D, \quad \ell = \frac{5c}{4f} + D, \text{ etc}$$

where D is a quantity proportional to the width of the tube.

In the space below, carefully sketch **three** graphs.

- *All the graphs should be drawn using the axis below.*
- *There is no need to include any numerical values on your graphs.*
- *Label the three graphs (i), (ii), (iii) as follows :*

(i) The first graph is a sketch copy of one of your graphs from part (b) of this question.

(ii) The second graph shows how the first graph would be modified if the air temperature was increased.

(iii) The third graph shows how the first graph would be modified if a tube of large width was used.

SECTION B

This section assesses **Criteria 2 and 9.** You should spend about 60 minutes in total on this section.

Question 3 (This question is designed to take about 16 minutes.)

(a) Three of the **conservation laws** used in Physics are:

- the law of conservation of **mass**
- the law of conservation of **energy**
- the law of conservation of **mass-energy**.

(i) Which of these laws is regarded as **always** true?

....

(ii) Under what circumstances can the other two laws be regarded as **not** being true?

....

....

(b) (i) In everyday life we often hear statements such as, 'this person has a weight of 70 kg'. From the point of view of a physics student, what is wrong with this statement?

....

....

....

....

(ii) How would you modify a set of bathroom scales to give the correct reading on the moon?

....

....

....

....

(c) (i) What is meant by the **wavelength** of a wave?

....

....

....

....

(ii) What is meant by the **frequency** of a wave?

....

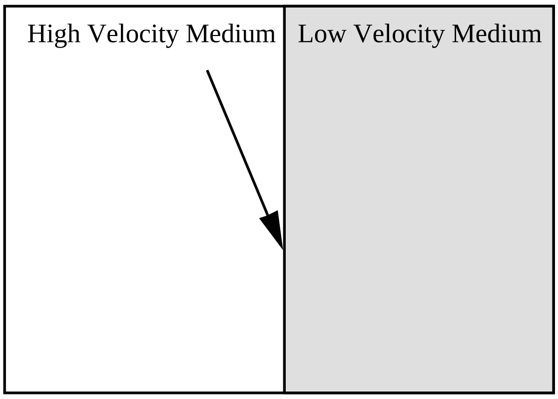
....

....

....

Question 3 continues over the page.

Question 3 (continued)



(iii) When a wave passes from a medium in which it has a high velocity to a medium in which it has a low velocity (as shown in the diagram above) what happens to:

Its direction of travel (show on the diagram)?

Its frequency?

....

Its wavelength?

....

(d) (i) Explain what is meant by the term **electric field**.

....

....

....

....

(ii) A completely drawn **electric** field line starts on a positive charge and ends on a negative charge. A completely drawn **magnetic** field line is drawn as a closed loop. Explain why there is this difference between the ways that we represent electric and magnetic fields.

....

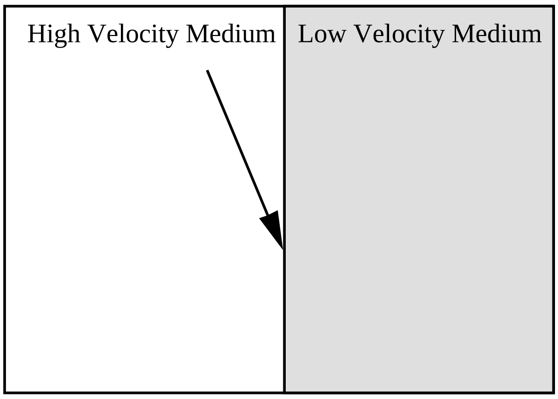
....

....

....

....

Spare Diagram for Question 3 (c) (iii)



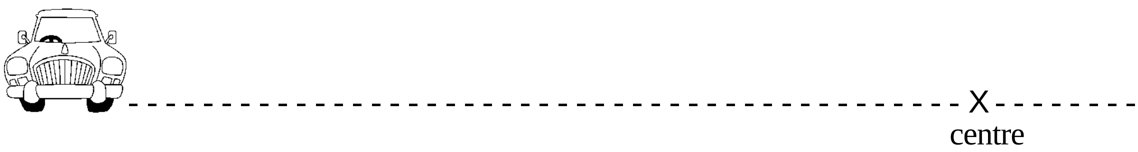
Question 4 (This question is designed to take about 32 minutes.)

ATTEMPT ONLY FOUR of the parts (a)-(f) of this question.

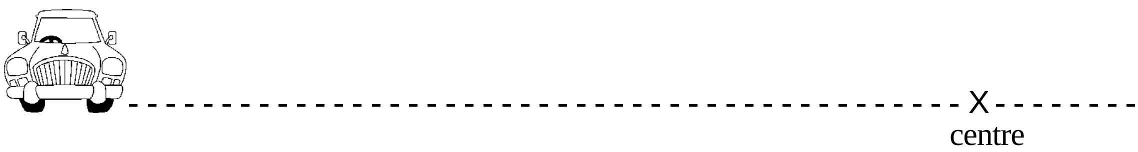
Each part should take about 8 minutes.

(a) (i) If an object moves in a circular path at constant speed, there must be a net force acting on it towards the centre of that path. What is the main source of this force in the situation shown in which a car travels around a circular path on a horizontal road? Illustrate your answer with a scale vector diagram showing **all** the main forces acting on the car.

....



(ii) Show below the forces acting on the car as in (i) above if the road is covered in ice.



How would you describe and explain the motion of the car in this icy road situation?

....

....

....

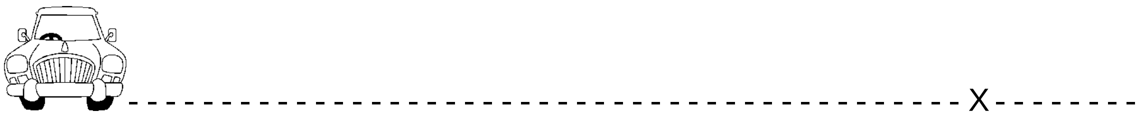
....

....

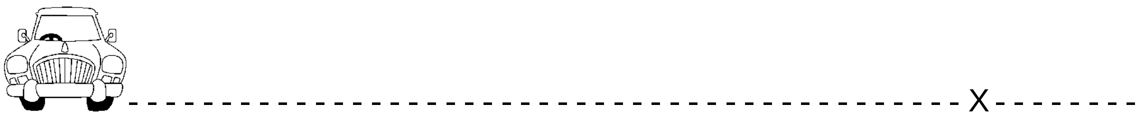
(iii) Show to scale the forces exerted by the earth and the moon on each other as they move through space.

Question 4 continues over the page.

Spare Diagram for Question 4 (a) (i)



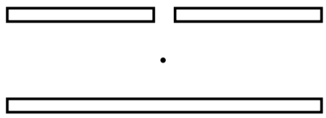
Spare Diagram for Question 4 (a) (ii)



Spare Diagram for Question 4 (a) (iii)

Question 4 (continued)

(b) In a Millikan type experiment performed **in a vacuum**, a charged oil drop is stationary between charged plates.



(i) In the space below sketch a scale diagram of the major forces acting on the oil drop and label the forces.

(ii) If the drop in (i) were moving steadily upwards at constant velocity, draw and label a scale diagram in the space below of the major forces on the drop in this case.

(iii) If you did this experiment with several drops, you might obtain the following values for the charges on the oil drops.

+12.0	+4.0	+2.0	-2.0	-10.0	-16.0	+8.0	$\times\ 10^{-19}$ C

What could you conclude regarding the nature and properties of electric charge from this set of data? Explain your reasoning fully.

....

....

....

....

....

....

Question 4 continues over the page.

Question 4 (continued)

Please Note: Descriptive answers **only** are required in the following question – no calculations are required.

(c) Communications satellites can be placed in many different types of Earth orbits and are frequently placed in **either**

- geostationary orbits (at altitudes of about 36 000 km above the Earth's surface); **or**
- lower earth orbits (at altitudes of about 1 000 km above the Earth's surface).

(i) How do the orbital **periods** of satellites in these two types of orbits compare?

....

....

....

....

....

....

(ii) How do the **paths** of each of these two types of satellites over the Earth's surface compare?

....

....

....

....

....

....

(iii) You are designing a satellite communications system which should enable a person on any part of the Earth to carry on a conversation with another person on any other part of the Earth. What would be the advantages and disadvantages of each of the above satellite systems for this purpose?

....

....

....

....

....

....

....

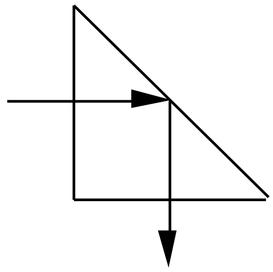
....

....

Question 4 continues over the page.

Question 4 (continued)

(d) The light entering the glass prism (shown opposite) is **totally internally reflected** off the diagonal face of the prism.



(i) What is meant by the phrase **total internal reflection**?

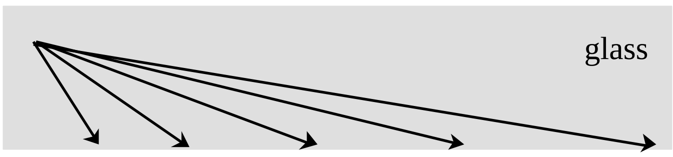
....

....

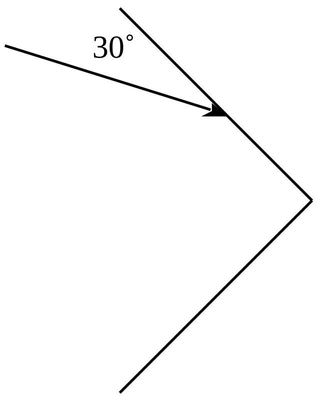
....

....

To illustrate your answer, complete the ray diagram below to show what happens to the rays of light after they reach the lower edge of the block of glass, assuming that some of the rays are totally internally reflected and some are not.



(ii) The diagram shows a two dimensional version of the red and white retroreflectors on posts alongside our highways. A ray of light strikes the first reflecting surface with an incidence angle of 30˚.



Carefully complete the path of this ray of light as it passes through the retroreflector and out again, marking in the values of all important angles.

What is the relationship between the incoming and outgoing rays?

....

....

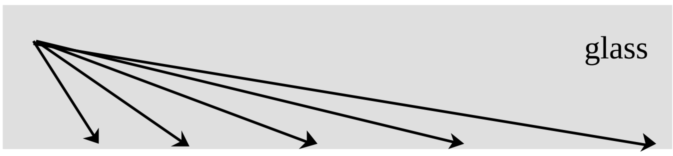
....

Does the angle of incidence effect this relationship between the incoming and outgoing rays?

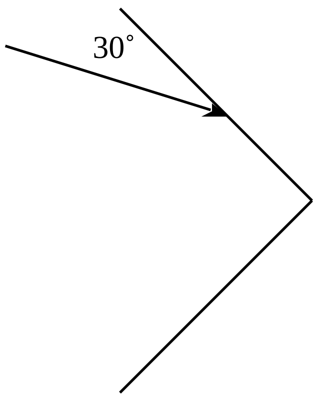
....

Question 4 continues over the page.

Spare Diagram for Question 4 (d) (i)

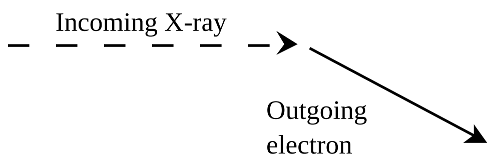


Spare Diagram for Question 4 (d) (ii)



Question 4 (continued)

(e) In a **Compton Experiment** with X-rays shown in the diagram, an X-ray travels in the direction shown by the dotted line. An electron is observed to emerge along the path shown.



(i) Sketch on the diagram above a possible path of the outgoing X-ray photon after the collision with the electron.

(ii) Compare the energy, frequency and wavelength of the incoming and outgoing photons. Explain.

....

....

....

....

....

....

....

(iii) What important properties of X-rays does this experiment illustrate?

....

....

....

....

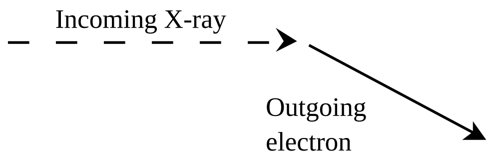
....

....

....

Question 4 continues over the page.

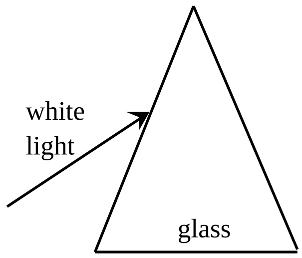
Spare Diagram for Question 4 (e) (i)



Question 4 (continued)

(f) When white light passes through a prism, as shown below, the light is **dispersed** into a **spectrum** in which the different colours in the light are separated and can be viewed on a distant screen.

(i) Given that the refractive index of the prism glass for red light is less than that for blue light, show on the diagram below the approximate paths of rays of red and blue light as they pass through the prism.



(ii) Discuss the significant features of the spectrum of the electromagnetic radiation that would be emitted by excited hydrogen atoms.

....

....

....

....

(iii) What is the significance of this spectrum in the development of atomic physics?

....

....

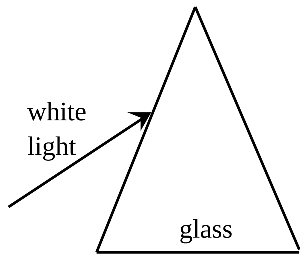
....

....

....

....

Spare Diagram for Question 4 (f) (i)

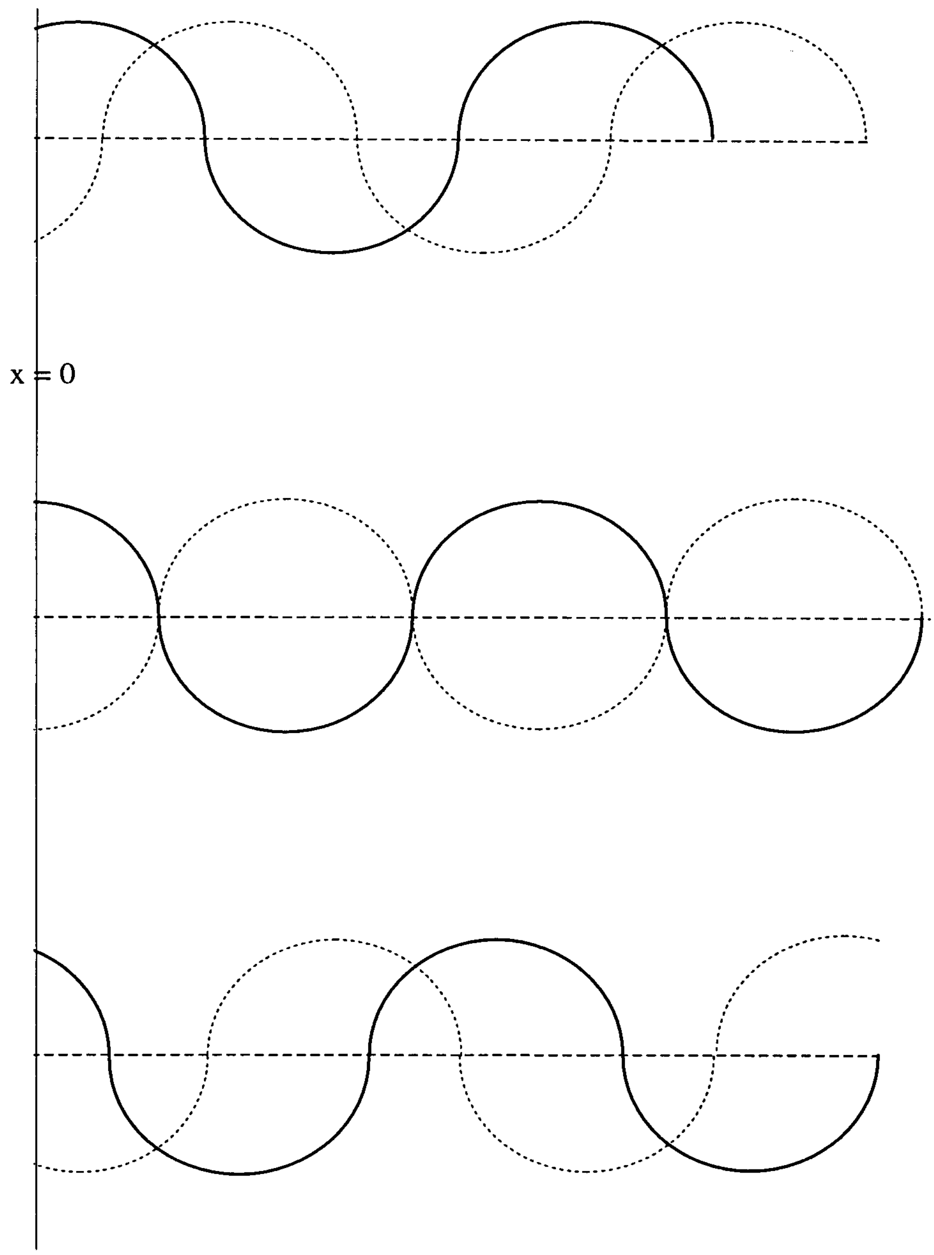


Question 5 (This question is designed to take about 12 minutes in total. The diagrams that you are asked to draw in this question will be important for your assessment of Criterion 2.)

ATTEMPT ONLY the EITHER on this page or the OR on page 34.

EITHER

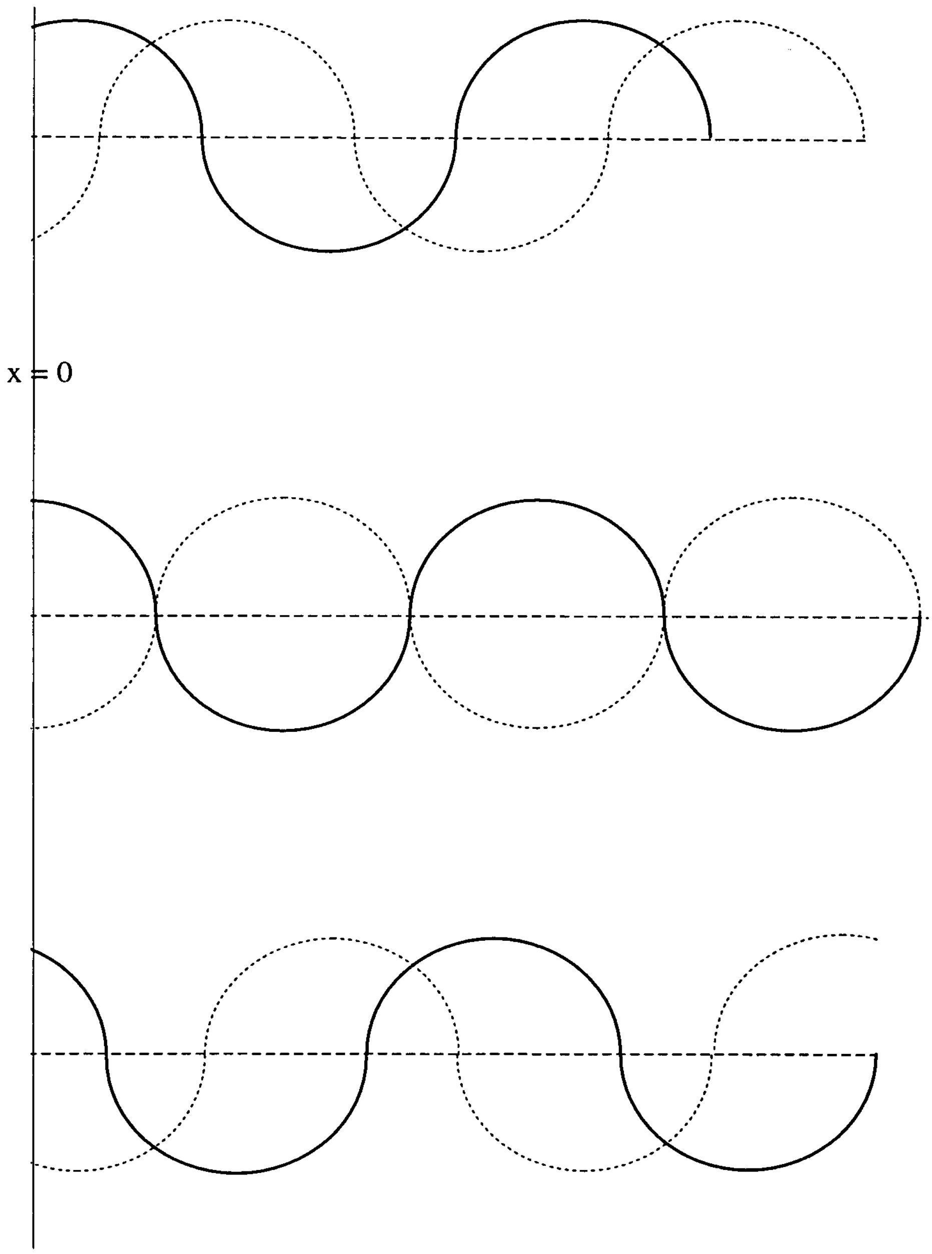
Two waves of equal amplitude, wavelength and frequency travel in opposite directions along a string. The following diagram shows the positions of the two separate waves at three different times.



(a) On each diagram above, draw the **resultant** wave pattern obtained by superposing the two separate wave patterns shown.

Question 5 continues over the page.

Spare Diagram for Question 5 (a)



Question 5 (continued)

(b) How would you describe the final resultant wave pattern? Give any details that you can, including positions of nodes and antinodes. A sketch diagram should be part of your answer.

....

....

....

....

....

(c) A string is fixed at both ends and plucked, causing it to vibrate.

(i) Sketch **three** of the possible standing wave patterns that can be set up in the string.

(ii) Explain, in terms of the diagrams in the first part of this question, how the standing waves are set up in the string.

....

....

....

....

....

....

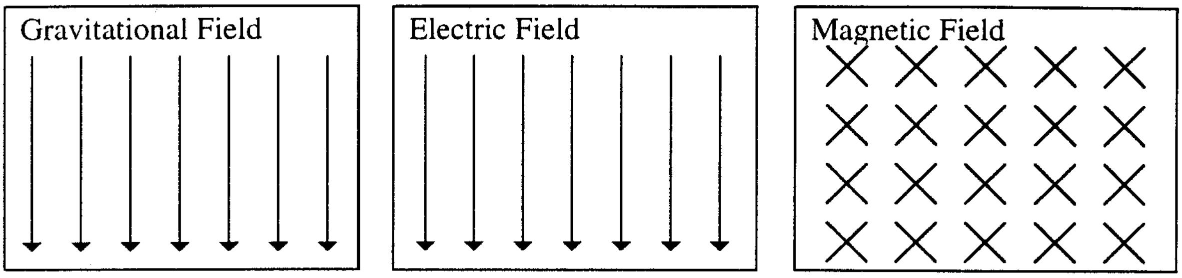
Question 5 continues over the page.

Spare Diagram for Question 5 (c) (i)

Question 5 (continued)

OR

Separate gravitational, electric and magnetic fields are arranged as shown in the following diagrams.



(a) A small, positively charged object is located in each of the fields.

Complete the table below to show the **direction of the force** (if there is a force) on the charged object in each of these fields, under the two alternative conditions of motion given in the table. If there is no force acting, write 'no force'.

*NB: Possible force directions are **Up**, **Down**, **Left**, **Right**, **In** (to the page), **Out** (of the page).*

Motion of Object	**Gravitational Field**	**Electric Field**	**Magnetic Field**
Object is stationary in the field.			
Object is moving from left to right through field.			

(b) The charged object for each field enters it from the left, moving to the right.

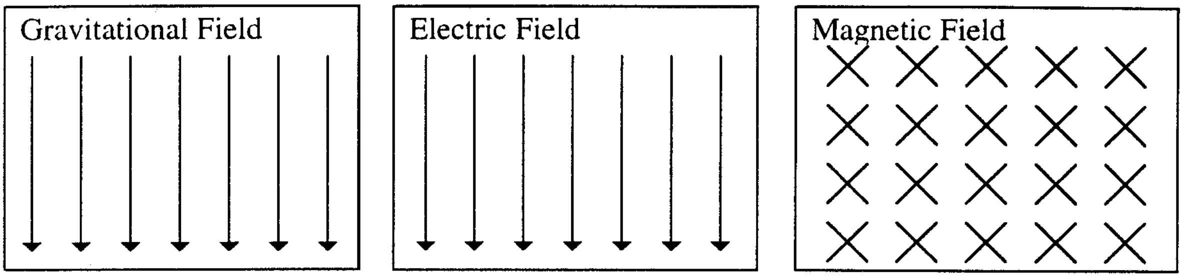
(i) On each field diagram above, sketch the subsequent path of the object as it moves through the field.

(ii) Complete the following table which describes the motion of the object through the field.

Question	**Gravitational Field**	**Electric Field**	**Magnetic Field**
Shape of path of object (circular, parabolic or straight line)			
Does the kinetic energy of the object increase, decrease or remain constant?			

Question 5 continues over the page.

Spare Diagram for Question 5 (b) (i)



Question 5 (continued)

(c) (i) What is meant by the term **gravitational field strength**?

....

....

....

....

(ii) Describe a simple experiment to measure the gravitational field strength in a laboratory.

....

....

....

....

....

....

....

....

(iii) The units for gravitational field strength are both Nkg^{-1} and ms^{-2}, each unit emphasising a different property of gravitational field strength. What does each unit tell you about the meaning of gravitational field strength?

....

....

....

....

....

....

....

....

SECTION C

This section assesses **Criteria 2 and 10**. You should spend about 75 minutes in total on this section.

Question 6 (This question is designed to take about 15 minutes.)

(a) A sky diver of mass 70 kg jumps from a balloon which is stationary in the air and she falls for 17.8 s before opening the parachute. Just as the parachute opened her speed was 62.6 ms^{-1}.

(i) Calculate the average acceleration during the 17.8 s of fall.

....

....

....

(ii) Why is this value not equal to 'g'?

....

....

(iii) If she were just above the atmosphere (and able to survive there), how long would it have taken her to reach the same speed?

....

....

....

....

Suppose that, instead of jumping from the balloon, she had jumped from an aeroplane travelling towards the east so that there would have been an immediate horizontal wind resistance to her motion. The force of this wind resistance is 400 N.

(iv) Draw a vector diagram of the forces acting on her immediately after she leaves the plane.

Question 6 continues over the page.

Question 6 (continued)

(v) Calculate the resultant force and hence her acceleration.

....

....

....

....

....

....

(b) A centrifuge used in biochemistry has a rotor designed to impose on a small sample an acceleration of 150 000 times the acceleration due to gravity. The sample is a liquid of mass 1.0 g at the bottom of a tube and is 15 cm from the axis of the rotor.

When the centrifuge rotor is spinning to give the required acceleration, calculate:

(i) the speed of the sample;

....

....

....

....

....

....

(ii) the force which the sample exerts **on the bottom of its tube**. Your answer should include a careful explanation of how you obtain the **direction** of the force.

....

....

....

....

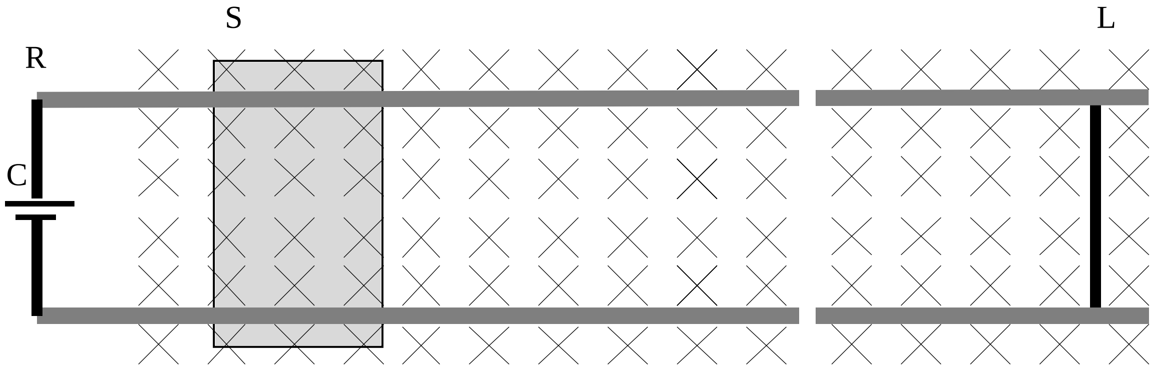
....

....

Question 7 (This question is designed to take about 15 minutes in total.)

The following is a design for a magnetic gun:

> The cell (C) maintains a steady voltage between the two conducting rails (R) enabling a steady current to flow through the conducting moveable sled (S) intended to carry a projectile. Because this current flows through a magnetic field, the sled accelerates to the right in the diagram and when it comes to a stop the projectile is allowed to keep moving.



This part of the diagram refers to part (a)

This part of the diagram refers to part (b)

(a) Given that:

- the distance between the rails is 10 cm;
- the magnetic field strength is 0.5 T;
- the current flowing through the sled is 1000 A;
- the mass of the sled and projectile is 50 g.

(i) Determine the magnetic force acting on the sled.

....

....

....

....

....

....

(ii) Show that the velocity of the sled after it has moved through a distance of 1.25 m is 50 ms^{-1}.

....

....

....

....

....

....

Question 7 continues over the page.

Question 7 (continued)

(b) To stop the sled, it is allowed to pass from the end of the rails over a small gap to a second pair of rails that are electrically joined by a metal link (L). The magnetic field is also present for these rails.

(i) What emf is induced across the sled as it enters the second pair of rails?

....

....

....

....

....

....

....

....

(ii) A current of 12.5 A is induced in the sled, which has mass 20 g. Calculate the acceleration of the sled.

....

....

....

....

....

....

....

....

Question 8 (This question is designed to take about 15 minutes in total.)

(a) A metal has work function 2.9 eV. The surface of the metal is illuminated by ultraviolet light of wavelength 350 nm.

(i) What is the energy of one photon of the light? Give your answer in both joules and electron volts eV.

....

....

....

....

....

(ii) What is the **smallest** energy needed to remove a photoelectron from the surface of the metal?

....

(iii) What is the **maximum** kinetic energy of the photoelectrons emitted from the metal surface?

....

....

....

....

....

....

(iv) What is the **minimum** kinetic energy of the photoelectrons emitted from the metal surface?

....

Question 8 continues over the page.

Question 8 (continued)

(b) The electron in the hydrogen atom can have different energies, depending on the quantum number of the orbit occupied by the electron. The following table shows the energies of the electron in the first 5 orbits.

Orbital Quantum Number (n)	1	2	3	4	5
Orbital Energy (10^{-19} J)	-21.78	-5.45	-2.42	-1.36	-0.87

An electron jumps from the n = 4 orbit to the n = 2 orbit.

(i) What is the change in energy of the electron? Has the electron lost or gained energy?

....

....

....

(ii) What is the wavelength of the photon emitted as the electron changes orbits?

....

....

....

....

....

(iii) What energy is needed to ionise the atom by ejecting an electron from the n = 3 orbit?

....

....

....

Question 9 (This question is designed to take about 15 minutes in total.)

(a) The small, six wheeled rover that landed on the planet Mars on 6 July 1997 had a mass of 10 kg on Earth. Mars has a mass of 6.42×10^{23} kg and a radius of 3.38×10^{6} m.

(i) Calculate ‘g’ on the surface of Mars.

....

....

....

....

....

(ii) Hence calculate the weight of the rover on Mars.

....

....

....

....

....

(iii) The rover is coasting along at 2 cm s^{-1} when it hits a rock of 0.5 kg mass, which sticks to it. Calculate the rover’s new velocity.

....

....

....

....

....

....

....

....

Question 9 continues over the page.

Question 9 (continued)

(b) The following information is given about the H atom:

- charge on proton = + 1.6 x 10^{-19} C
- charge on electron = −1.6 x 10^{-19} C
- distance between proton and electron = 5.3 x 10^{-11} m
- mass of electron = 9.1 x 10^{-31} kg

(i) Using this information, determine:

the force of electrostatic attraction between the electron and the proton in this model of the hydrogen atom;

....

....

....

....

....

....

the acceleration of the electron.

....

....

....

....

....

....

(ii) This force on the electron causes it to move in a circular path. Show that the speed of the electron in this circular orbit is 2.2 x 10^{6} ms^{-1}.

....

....

....

....

....

....

....

....

Question 10 (This question is designed to take about 15 minutes in total.)

(a) It has been reported that the nuclear processing plant at Sellafield in Britain has released 4×10^{13} Bq of Caesium -137, which is now detectable throughout the Arctic Sea. While this is much less than the total amount of radioactivity released in nuclear accidents and by nuclear testing in other areas of the world, it is having a significant impact on the Arctic.

(i) If the half life of ^{137}Cs is 30 years, what is the **decay constant** associated with the radioactive decay of ^{137}Cs ?

....

....

....

....

....

....

(ii) Hence show that the total number of atoms of ^{137}Cs that has been released into the sea by Sellafield is 5.46×10^{22}.

....

....

....

....

....

....

(iii) How long would it take for the activity of this ^{137}Cs to decrease to a much more acceptable 10^{10} Bq?

....

....

....

....

....

....

Question 10 continues over the page.

Question 10 (continued)

(b) ^{137}Cs decays by β^- emission to a stable isotope of barium.

(i) Write the nuclear transformation equation for the decay of ^{137}Cs. (The atomic number of caesium is 55.)

....

....

....

(ii) Given that the mass difference for the equation is 1.26×10^{-3}u (atomic mass units), determine the energy emitted in the decay of one atom of ^{137}Cs.

....

....

....

....

....

....

(iii) Calculate the total power of the ^{137}Cs released from Sellafield. Is it a significant contributor to global warming?

....

....

....

....

....

....

FOR EXAMINERS USE ONLY

SECTION A

Question	Criterion 7	Criterion 2	
1			
2			

SECTION B

Question	Criterion 9	Criterion 2	
3			

4 (a)			
4 (b)			
4 (c)			
4 (d)			
4 (e)			
4 (f)			

5 (either)			
5 (or)			

SECTION C

Question	Criterion 10	Criterion 2	
6			
7			
8			
9			
10			