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Tasmanian Secondary Assessment Board

Tasmanian Certificate of Education

External Assessment

1999

PH866 PHYSICS

SECTIONS A & B

Time: Two 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 10 Incorporate techniques of analysis and mathematical manipulation (algebraic, trigonometrical, numerical and graphical) to solve complex problems.

Pages: 36
Questions: 7

CANDIDATE INSTRUCTIONS

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

WRITE YOUR ANSWERS IN THE SPACES PROVIDED IN THIS BOOKLET.

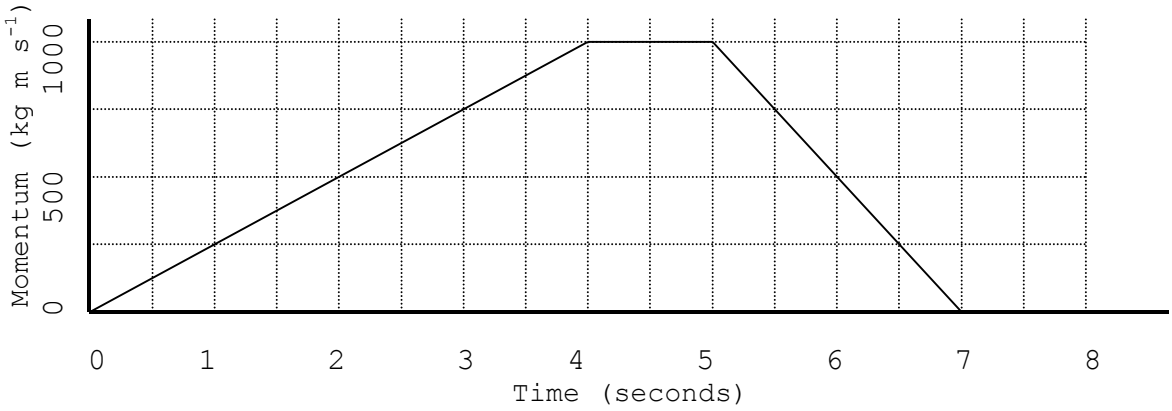
If you find that there is insufficient space for your answer, please use the odd-numbered blank page opposite the question and show clearly that you have done so. These blank pages may also be used for rough working.

SECTION A

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

Question 1 (You should spend about 15 minutes in total on this question.)

(a) The following diagram shows how the *momentum* of a car varies with time.



(i) What is the force acting on the car during the first 4 seconds? *(2 minutes)*

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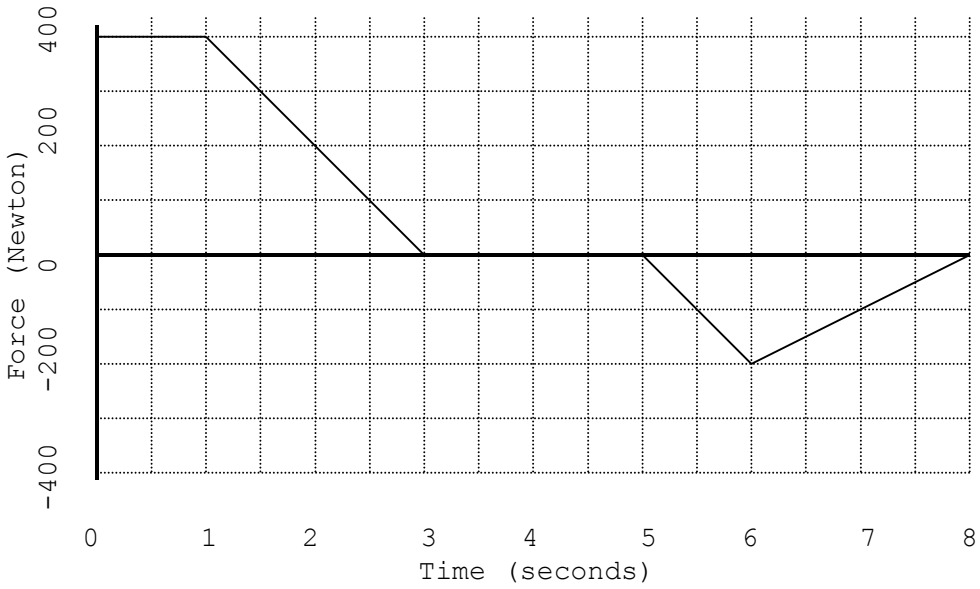
(ii) In the space below, *sketch* a graph of force versus time for the car over the 7 seconds of motion. *(3 minutes*)

Question 1 continues over the page.

Question 1 (continued)

(b) The following graph shows *force* acting on another car as a function of time. A negative force acts in the opposite direction to a positive force.



(i) What is the total change in the momentum of the car in the first 3 seconds? *(2 minutes)*

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(ii) What is the total change in the momentum of the car between 0 and 8 seconds. *(2 minutes)*

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(iii) On the above graph redraw the graph between 5 and 8 seconds so that the *total* momentum change of the car in the 8 seconds is zero. Justify your answer below. *(There are many possible correct answers to this question.)* *(3 minutes*

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Question 1 continues over the page.

Question 1 (continued)

(c) The following data shows how the acceleration varies with the horizontal force applied to a trolley.

Force N	0	10	20	30	40	50	60
Acceleration ms^{-2}	0	0	0	1.0	2.0	3.0	4.0

You wish to obtain the relationship between these two quantities by plotting a linear graph. Describe the graph that you would draw in order to do this, and give your reasons. There is **no** need to plot or sketch the graph. *(3 minutes)*

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Question 2 (You should spend about 30 minutes in total on this question.)

The following table shows data of displacement **s** against time **t** for a car accelerating uniformly from rest down a hill. The blank spaces in the table are for you to add calculated data later on.
The formula relating the displacement and time is:

$$s = \frac{1}{2} a t^2 \qquad a = \text{acceleration of car.}$$

Displacement **s** (m)	0	0.50	1.00	1.50	2.00	2.50	3.00	4.00
Time (s) **t**	0	0.91	1.28	1.57	1.87	2.02	2.22	2.68

(a) Modify the data to enable you to plot a straight line graph showing the relationship between displacement and time. Explain your reasoning below. Add your modified data to the above table, and plot the data on the axes given opposite. *(8 minutes)*

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(b) Determine the slope of your straight line graph and hence determine a value for the acceleration of the car. *(4 minutes)*

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Question 2 continues over the page.

Graph for Question 2 (a)

Spare graph for Question 2 (a)

Question 2 (continued)

(c) The graph opposite shows a curve of best fit for the original data.

Carefully draw tangents to the curved displacement versus time graph at the times 1.0, 1.5 and 2.0 seconds. In each case draw the slope of the tangent and record your slopes in the table below. The blank spaces in this table are optional, but you may wish to use them to record the measurements you have used to determine the slopes. Give an example of how you do your calculations in the space below. *(10 minutes)*

Time (s)	1.0	1.5	2.0
Slope ( )			

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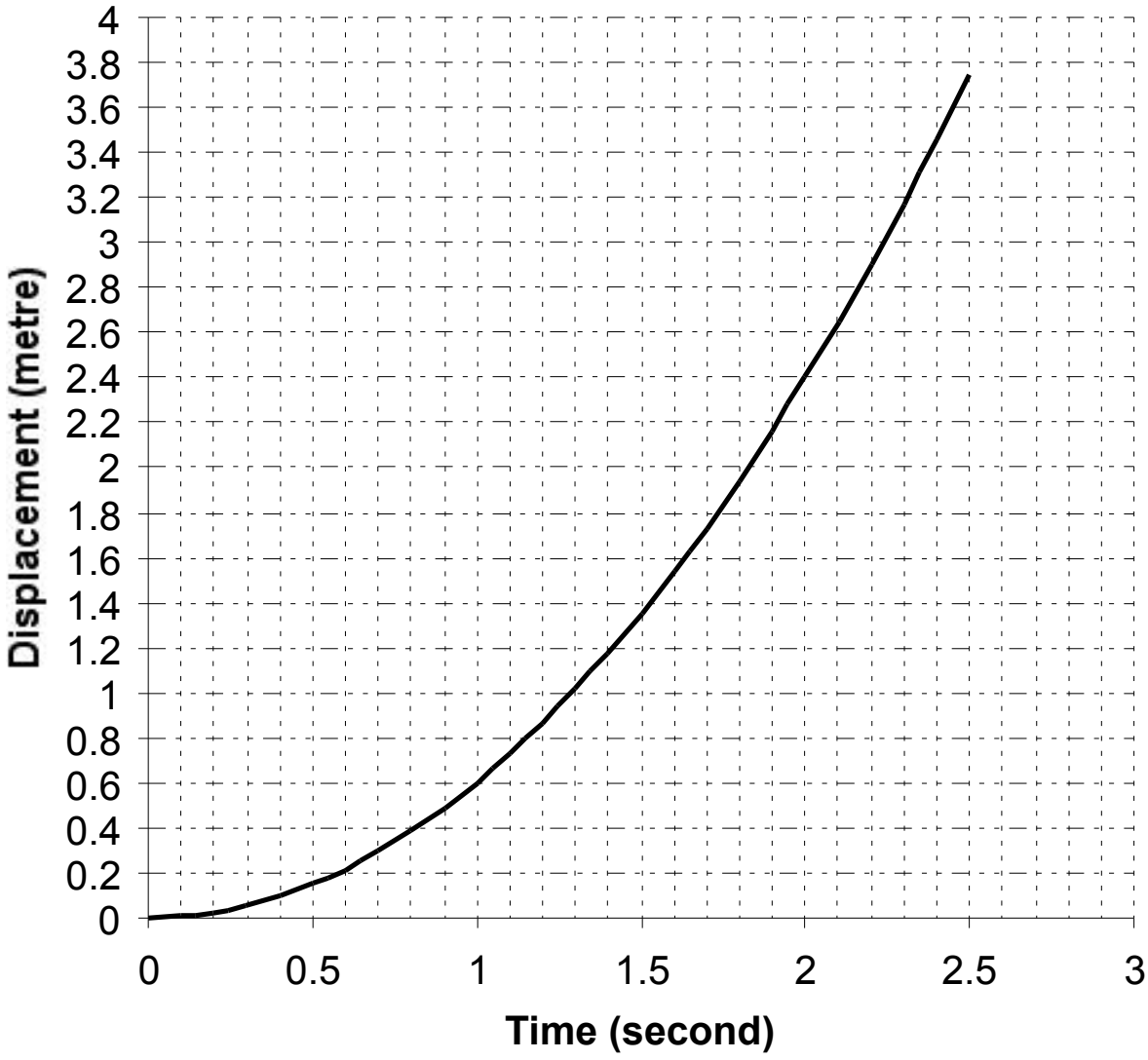
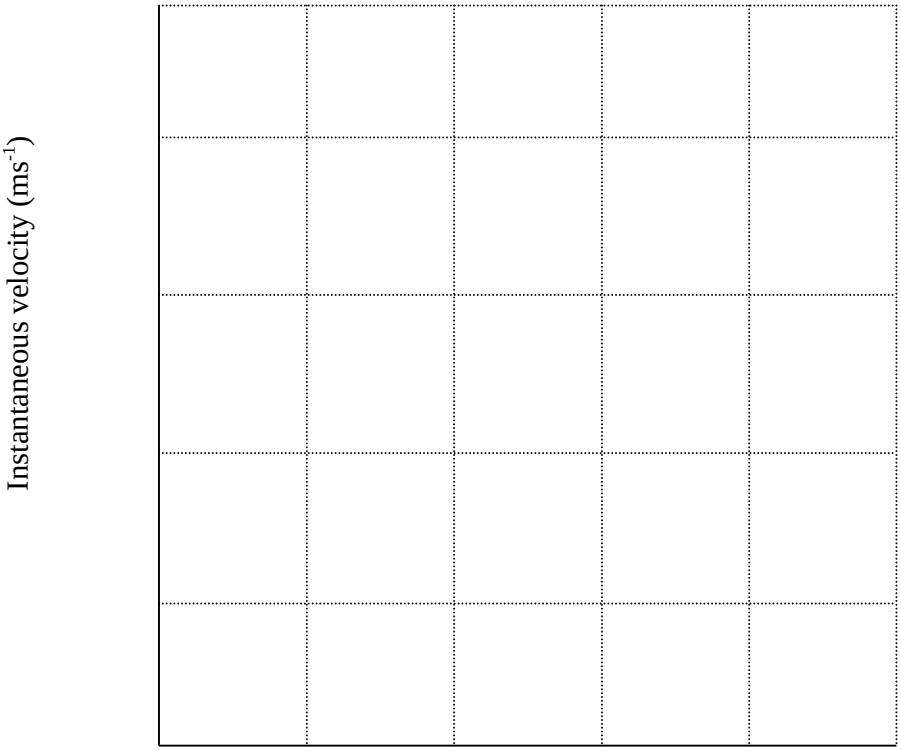
Graph for Question 2



Displacement versus time for moving car

Question 2 (continued)

(d) The tangent slopes measured in part (c) above represent the instantaneous velocity at the given times. Sketch a graph of velocity against time for the car, and use this graph to obtain another estimate of the acceleration of the car. *(8 minutes)*



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SECTION B

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

Question 3 (This question is designed to take about 15 minutes in total.)

(a) During the year your examiner was called upon to assist the driver of a car whose battery had lost charge. Starting from rest on a horizontal road, he and a friend had to push the car and driver until it had a speed of $4\ ms^{-1}$. At this speed the driver was able to start the car engine without the battery.

The following data applies to the situation:

Mass of car and driver	= 1200 kg
Horizontal force that can be exerted by each person on car	= 400 N
Frictional force of road on car	= 100 N

(i) Over what distance was the car pushed in order to reach the final speed of $4\ ms^{-1}$? *(3 minutes)*

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(ii) What has been the change in energy of the car? *(2 minutes)*

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(iii) What *total* work was done by the examiner and his friend while pushing the car? *(2 minutes)*

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(iv) What was the average power exerted by the examiner and his friend while pushing the car? *(2 minutes)*

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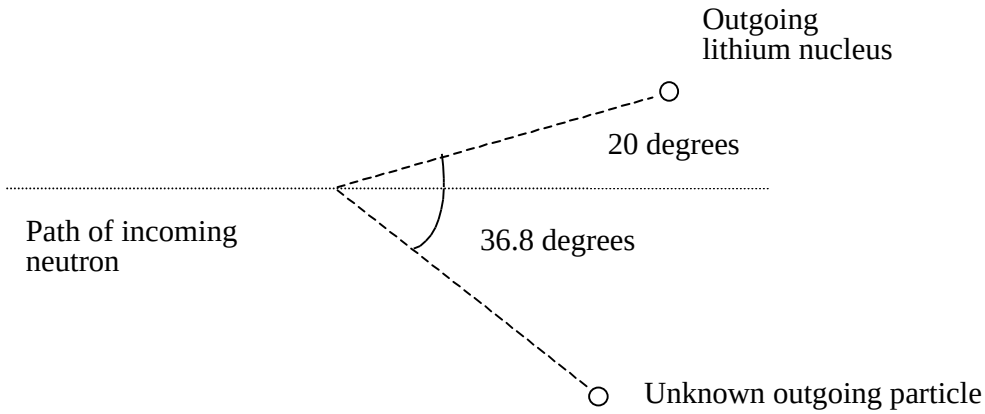
Question 3 continues over the page.

Question 3 (continued)

(b) The diagram shows a collision between a neutron and a stationary boron nucleus which react together. Two particles leave the collision **with equal speeds** as shown. One is a lithium nucleus (mass = 7 amu) and the other is unknown.



(i) Sketch a labelled triangle showing how momentum is conserved in this collision. *(2 minutes)*

(ii) Using momentum considerations, show that the mass of the unknown particle is about 4 atomic mass units. *(4 minutes)*
Note: There is no need to convert atomic mass units to kilograms when you perform your calculations.

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Question 4 (This question is designed to take about 15 minutes in total.)

(a) A satellite is in a circular orbit of radius 6780 km around the Earth.

(i) What is the acceleration due to gravity at the position of the satellite? *(4 minutes)*
(Mass of Earth = 5.98×10^{24} kg)

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(ii) Show that the speed of the satellite in its orbit is $7670\ \text{ms}^{-1}$. *(3 minutes)*

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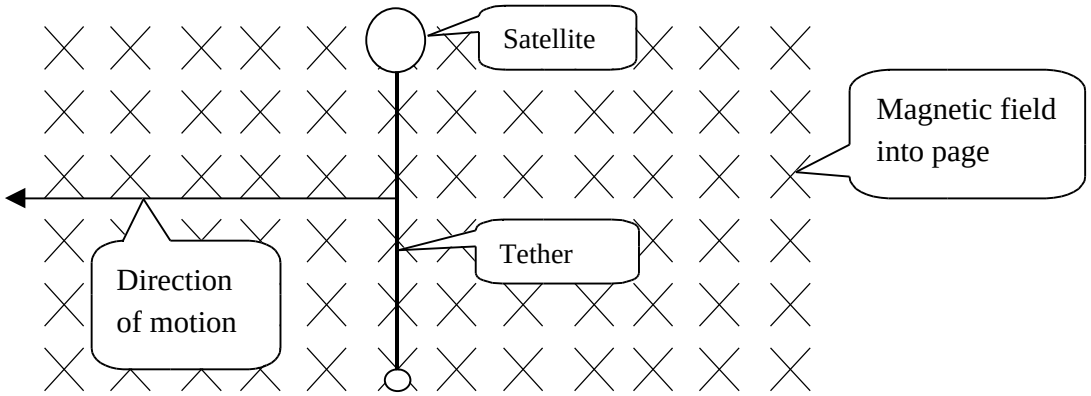
(b) A conducting wire (called a "tether") of length 20 km is connected between this satellite and a secondary satellite, and sweeps through the earth's magnetic field as shown in the diagram:



(i) If the earth's magnetic field has value 2×10^{-5} T in a direction perpendicular to the tether (as shown in the diagram) use the previously determined value for the speed of the satellite to show that the emf induced in the tether as a result of its motion through this field has a value of 3.07 kV. *(3 minutes)*

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Question 4 continues over the page.

Question 4 (continued)

(b) (ii) By making use of electrons and ions in the earth's upper atmosphere, it is possible to set up a complete electrical circuit in which current flows in response to this induced emf. If there is a current of 0.6 A in the tether, what is the total electrical power dissipated in the circuit?

(2 minutes)

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(iii) What total magnetic force is experienced by the tether in this situation? Specify the direction of this force in terms of the previous diagram (e.g. up, down, left or right).

(3 minutes)

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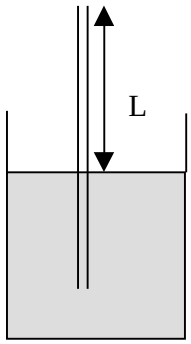
Question 5 (This question is designed to take about 15 minutes in total.)

(a) In a laboratory experiment to measure the speed of sound, a thin hollow tube is placed in a deep water container as shown in the diagram. When a 512 Hz tuning fork is set vibrating at the open mouth of the tube, a loud resonant sound is heard when the length L of the tube is equal to 0.166 m, 0.500 m and 0.833 m. Resonance is not obtained for any shorter value of the length.



(i) Sketch the standing wave patterns within the tube that explain the three different resonant lengths. *(3 minutes)*

(ii) Determine the speed of sound from these observations. You should ensure that you use *all* of the given data. *(4 minutes)*

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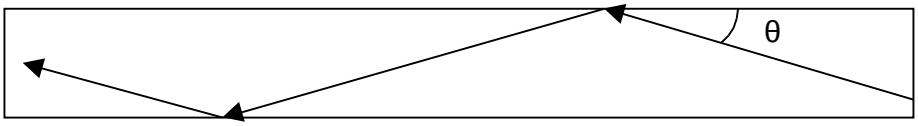
Question 5 continues over the page.

Question 5 (continued)

(b) The diagram below shows light passing along a block of glass of refractive index 1.52. The light is totally internally reflected at the walls of the glass. The angle θ between the light beam and the walls of the glass is 32°.



(i) What is the speed of the light within the glass? *(2 minutes)*

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(ii) When the glass is immersed in water of refractive index 1.34 it is found that instead of reflecting off the glass walls the light is refracted through the wall into the water. Show that the angle between the refracted light beam and the wall of the glass is about 16º in this case. *(3 minutes)*

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(iii) While the glass is inserted in water what is the *maximum* value of the angle θ between the light beam and the glass wall in order that the light be totally internally reflected within the glass? *(3 minutes)*

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

In a thunderstorm, lightning is produced when a large electrical current flows between a highly charged atmospheric cloud and the earth below.

(a) Consider a situation in which the following data applies:

Potential difference between cloud and earth = 1×10^9 V
Total charge which flows in a lighting "flash" = 200 C
Time taken for lightning "flash" = 200 μs

(i) Show that the electrical *current* in the lightning flash equals 1×10^6 A. *(1 minute)*

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(ii) What is the *power* of the lightning during the flash? *(2 minutes)*

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(iii) If the field strength between the cloud and the earth has an average value of 3×10^6 Vm^{-1} what is the distance between the cloud and the earth? *(2 minutes)*

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Question 6 continues over the page.

Question 6 (continued)

(a) (iv) If the lightning passes down a copper water pipe, magnetic forces will destroy the pipe. As a result of these magnetic forces, will the pipe explode outwards or compress inwards?
(2 minutes)

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(v) As an estimate of the forces involved, determine the total force between two parallel copper wires each of length 10 m and 1.0 cm apart which each carry an electrical current of half the current in the lightning flash. *(3 minutes)*

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(b) A tree struck by lightning can burn or (if the interior of the tree is moist and conducting) explode as a result of the heat produced by the electric current in the tree.

(i) When the lightning flash of part (a) above strikes a tree, the full charge of the lightning flash flows through the tree which has an average potential difference of 1×10^8 volts across it during the flash. Show that the energy dissipated by the current in the tree is 2×10^{10} J.
(3 minutes)

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(ii) Given the relationship (in SI units)

Total energy = mass of tree × temperature rise × 3000

determine the temperature rise within the tree, which has a mass of 6.4 tonne. *(2 minutes)*

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

(a) Photons of sunlight with average wavelength 5×10^{-7} m strike a reflective "sail" on an interplanetary space probe at the rate of 2.5×10^{23} photons per second.

(i) Calculate the momentum of each photon, and hence show that the total momentum of the photons striking the sail every second is 3.3×10^{-4} kg m s^{-1}. *(3 minutes)*

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(ii) If the photons are reflected backwards from the sail (in the direction opposite their original direction of motion) without significant change in wavelength, what force do they exert on the sail? *(2 minutes)*

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Question 7 continues over the page.

Question 7 (continued)

(b) In 1987 a family of metal workers in Brazil discovered a canister of radioactive caesium 137 from an abandoned radiation therapy unit. The canister contained 100 g of the isotope $_{55}Cs^{137}$ which has a half life of 30.2 years (9.53×10^{8} seconds). Each atom of the isotope has a mass of 2.27×10^{-25} kg.

(i) Determine the decay constant of the caesium isotope and also determine the number of atoms of caesium in the canister. Hence show that the activity of the caesium in this canister equals 3.20×10^{14} Bq. *(5 minutes)*

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(ii) The maximum permissible activity for radioactive sources used in schools is about 1×10^{4} Bq. How long would it take for the activity of the caesium in this canister to reach this permissible value? *(5 minutes)*

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FOR EXAMINERS USE ONLY

SECTION A

Question	Criterion 7
1	
2	

Criterion 2	

SECTION B

Question	Criterion 10
3	
4	
5	
6	
7	

Criterion 2	

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Tasmanian Secondary Assessment Board

Tasmanian Certificate of Education

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1999

PH866 PHYSICS

SECTION C

Time: One Hour

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 9 Demonstrate and apply knowledge and understanding of terminology; definitions and laws; concepts, theories and models; and uses of measuring instruments of Physics.

Pages: 24
Questions: 3

CANDIDATE INSTRUCTIONS

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

WRITE YOUR ANSWERS IN THE SPACES PROVIDED IN THIS BOOKLET.

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 diagrams in case you need them.

SECTION C

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

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

(a) How could you measure the *gravitational* field strength of the earth's gravitational field in a school laboratory? *(3 minutes)*

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(b) How would a mass spectrometer enable you to determine the mass of an ion? *(6 minutes)*

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Question 8 continues over the page.

Question 8 (continued)

(c) How could you measure the *wavelength* of the light coming from a monochromatic sodium lamp using a double slit experiment? *(6 minutes)*

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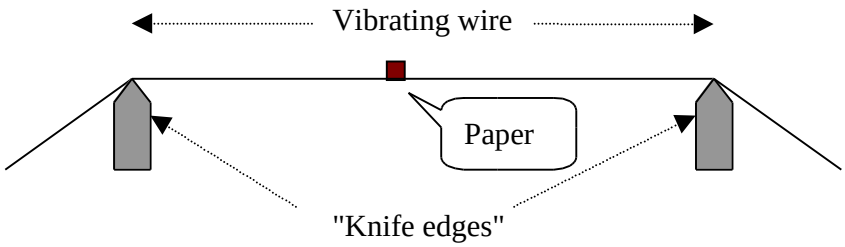
Question 9 (This question is designed to take about 30 minutes in total.)

ATTEMPT ONLY THREE of the parts (a) to (d) of this question.
Each part should take about 10 minutes.

a) An experiment to measure vibrations in a stretched length of wire is shown in the diagram:



The "knife edges" allow adjustment of the length of the vibrating section of the wire. The piece of paper loosely attached to the wire makes a vibrating sound when the part of the wire that it is attached to is vibrating.

(i) If a tuning fork is held close to the wire, with the paper suspended from the middle, it is found that the wire will vibrate only for certain wire lengths. Explain what is happening. Your explanation should include a description of what is meant by the term *resonance*.
(5 minutes)

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(ii) With the piece of paper in the *middle* of the wire, the wire vibrates in response to a tuning fork of frequency 256 Hz. When a tuning fork of double this frequency (512 Hz) is used instead, it is found that the piece of paper in the middle of the wire does not show any sign of vibration. However, if the piece of paper is moved to one quarter of the way along the wire, it does vibrate in response to the 512 Hz tuning fork. Explain what is happening, using diagrams to illustrate your explanation. *(5 minutes)*

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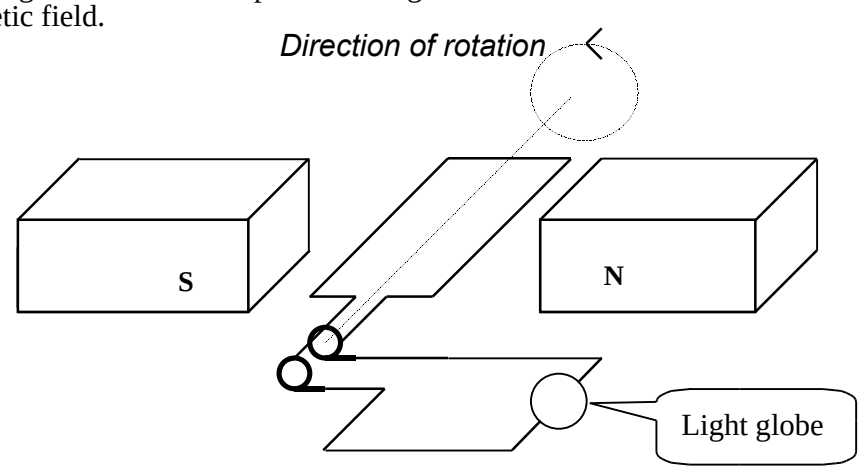
Question 9 continues over the page.

Question 9 (continued)

(b) The diagram shows a simple electric generator in which a coil of wire rotates inside a strong magnetic field.



(i) With labeled arrows, indicate the following on the diagram: *(2 minutes)*

- the direction of the magnetic field in the region of the coil
- the direction of the (conventional) current flowing in the external circuit.

(ii) Is the current produced by this generator alternating or direct? Explain your answer. *(2 minutes)*

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(iii) At the position of the coil shown in the diagram, is the value of the current at a maximum or is it zero? Explain. *(3 minutes)*

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(iv) A direct current electric **motor** also contains a wire coil which rotates in a magnetic field. Explain how you would modify the above arrangement so as to obtain such a DC motor. Draw a diagram to illustrate your answer in the space opposite. *(3 minutes)*

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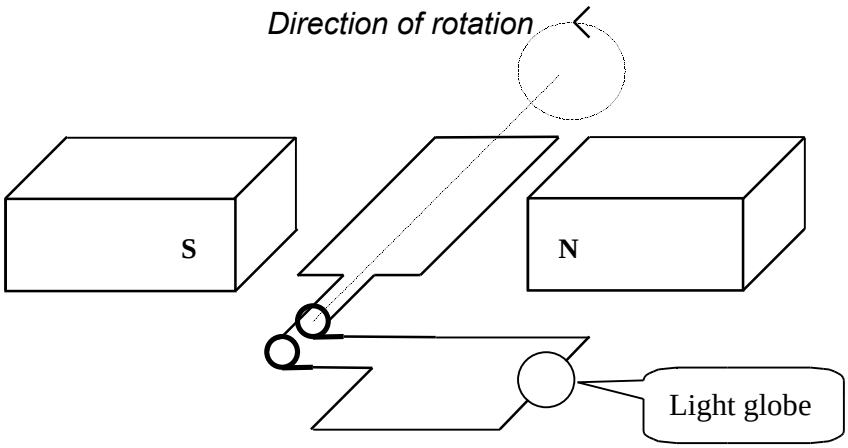
Question 9 continues over the page.

Spare diagram for Question 9 (b)



Space to draw diagram for answer to Question 9 (b) (iv)

Question 9 (continued)

(c) The greatest problem associated with nuclear reactors is the disposal of waste radioactive material produced in the reactors. There was considerable controversy in 1999 over a proposal to bury much of the world's radioactive waste in central Australia.

(i) By what nuclear processes do reactors produce this waste? *(3 minutes)*

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(ii) One proposal to eliminate this nuclear waste is to irradiate it with neutrons, so converting it into other non-radioactive isotopes. One major waste isotope is technetium-99, $_{43}Tc^{99}$.

When irradiated with a neutron, this produces a nucleus of technetium -100 which decays quickly to stable ruthenium - 100, $_{44}Ru^{100}$.

Write out the nuclear equations for the following processes, indicating the nature of any particles involved in the reaction. *(2 minutes)*

· the production of technetium – 100 .....

· the radioactive decay of technetium - 100 .....

(iii) Given the following further information:

· technetium - 99 has a half life of 200,000 years,

· 6 tonnes of technetium - 99 is produced by reactors around the world every year, and it dissolves in water,

explain why it is important to remove the technetium - 99. *(3 minutes)*

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(iv) Technetium -100 has a half life of 15 seconds. Why is it necessary for the usefulness of the above process that it should have a short half life? *(2 minutes)*

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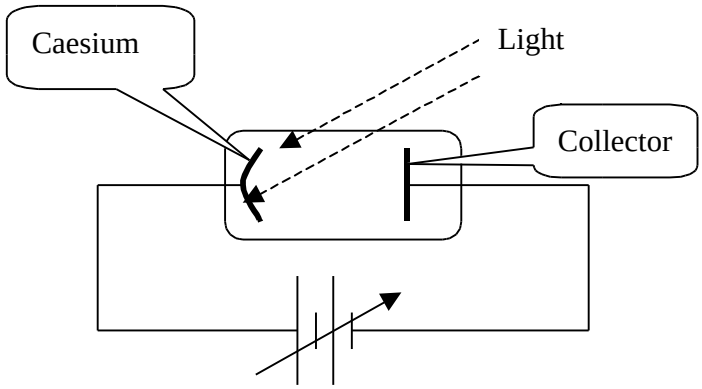
Question 9 continues over the page.

Question 9 (continued)

(d) In the apparatus shown below, light striking the caesium surface knocks electrons across to the collector. The electrons then continue to move around the circuit forming a "photocurrent". The power supply (which has adjustable voltage) opposes this photocurrent, and it is found that above a certain voltage, called the "stopping potential", the photocurrent is reduced to zero.



(i) How does the *intensity* of the light influence the stopping potential? *(1 minute)*

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(ii) How does the *frequency* of the light influence the stopping potential? A full answer to this will include a sketch graph. *(4 minutes)*

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(iii) Briefly describe how Einstein explained the above observations. What was the importance of Einstein's theory to the development of modern Physics? *(5 minutes)*

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

Attempt Part I OR Part II

Part I

(a) Light can be *polarised*. Discuss what is meant by this term and illustrate your answer with an appropriate diagram. *(4 minutes)*

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(b) (i) What is meant by the term *diffraction*? *(3 minutes)*

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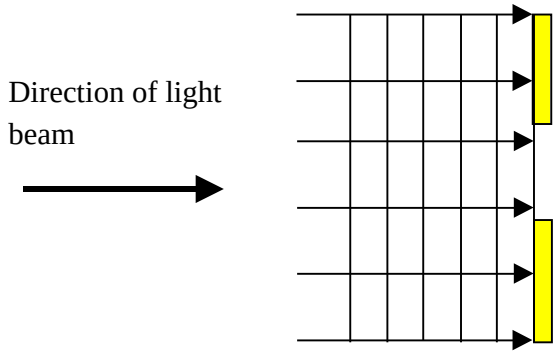
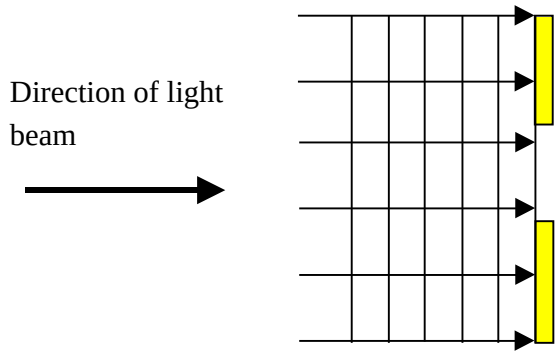
(ii) The following diagram shows both *rays* and *wavefronts* for a parallel beam of light incident on a slit in an opaque screen. Complete the diagram to show both rays and wavefronts for the light which passes through the slit. *(2 minutes)*



Question 10 continues over the page.

Spare diagram for Question 10 (b) (ii)

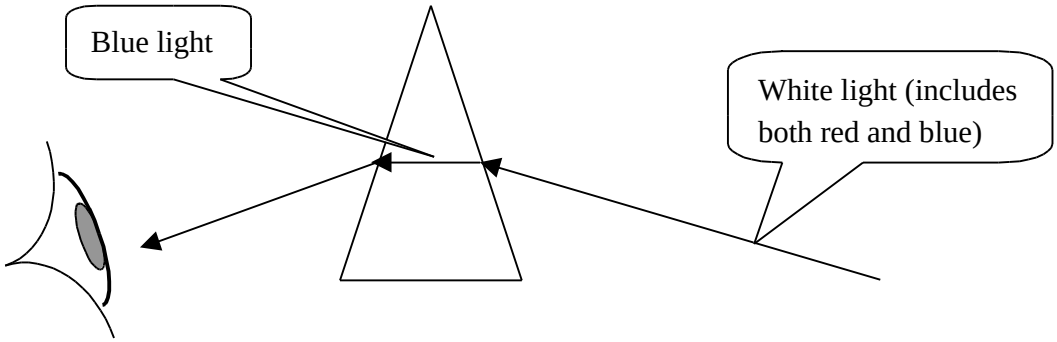


Question 10 (continued)

(c) A beam of white light enters a prism. The diagram shows the subsequent path of a ray of **blue** light through the prism. A person looking in the direction shown sees a rainbow coloured spectrum.

(i) On the diagram show the path of a ray of **red** light through the prism. (The refractive index of the prism for red light is less that it is for blue light.) *(2 minutes)*

(ii) For the person looking through the prism, would the red light coming from the prism **appear** to be *above* or *below* the blue light? Explain your answer illustrating your reasoning on the diagram. *(4 minutes)*



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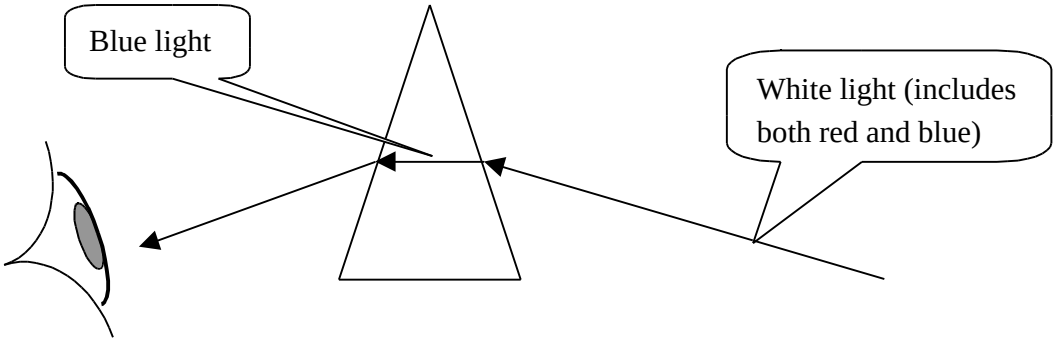
Question 10 continues over the page.

Spare diagram for Question 10 (c) (ii)



Question 10 (continued)

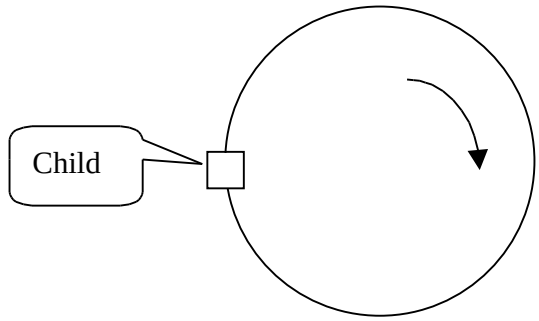
OR

Part II

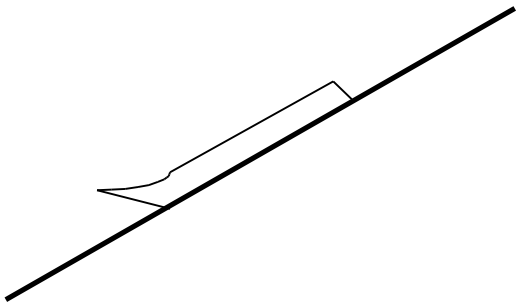
(a) The following diagram is a view from above of a child sitting on a horizontal circular platform rotating in a clockwise direction. On the diagram draw vectors representing the

- *velocity* $\underline{v}$,
- *acceleration* $\underline{a}$, and
- *resultant force* $\underline{F}$

acting on the child, labelling each vector. *(3 minutes)*



(b) (i) The diagram shows a sled moving down a hill at constant speed. Draw labelled arrows on the diagram representing the three main forces acting on the sled and (in the space to the right of the diagram) draw a diagram of vector addition showing clearly the sum of these forces. *(3 minutes)*



(ii) In terms of your force diagram, discuss what would happen if the sled encountered a patch of ground which presented less friction than the situation in (i) above. *(3 minutes)*

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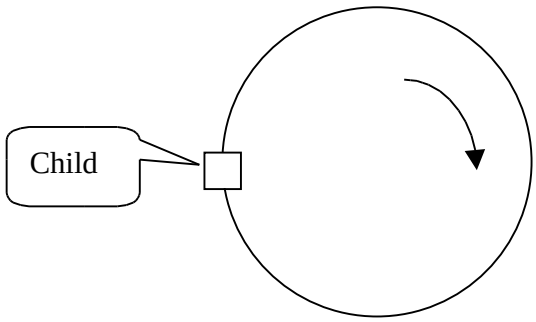
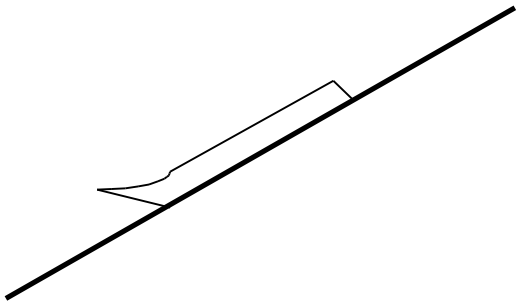
……

Question 10 continues over the page.

Spare diagrams for Question 10 Part II (a) and (b) (i)

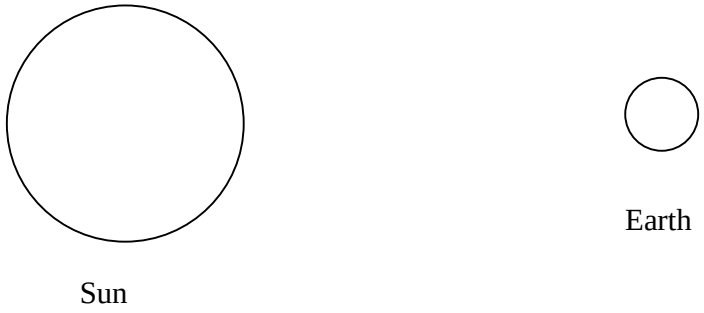




Question 10 (continued)

(c) The diagram shows the earth orbiting around the sun. The diagram is not to scale. On the diagram show labelled vector arrows representing:

- the gravitational force exerted on the sun by the earth $\mathbf{F_1}$
- the gravitational force exerted on the earth by the sun $\mathbf{F_2}$ *(2 minutes)*



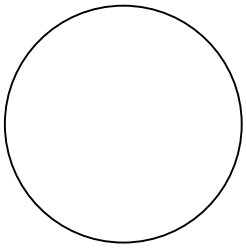
(d) An astronaut journeys from the earth to the moon in a spaceship which:

- is initially on the launching pad on earth,
- accelerates uniformly upwards under rocket power,
- then, with rockets off, moves under the influence only of the earth's and the moon's gravity until it is near the moon,
- then decelerates under rocket power until it lands on the moon,
- finally is at rest on the moon.

Draw a labelled sketch graph to describe the changes in the *apparent weight* of the astronaut at different stages in the journey.

(4 minutes)

Spare diagram for Question 10 (c)



Sun

Earth

FOR EXAMINERS USE ONLY

SECTION C

Question	Criterion 9
8	
9 (a)	
9 (b)	
9 (c)	
9 (d)	
10 Part I	
10 Part II	

Criterion 2	