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Tasmanian Secondary Assessment Board

PHYSICS

Senior Secondary 5C

Subject Code: PH866

External Assessment

2003

Section A

Time: 45 minutes

On the basis of your performance in this examination, the examiners will provide results 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.

Pages: 16
Questions: 3

CANDIDATE INSTRUCTIONS

Candidates **MUST** ensure that they have addressed **ALL** of the externally assessed criteria on this examination paper.

Answer **ALL** questions. Answers must be written in the spaces provided on the examination paper.

Recommended time:

Section A – 45 minutes.

The Physics Formula Sheet can be used throughout the examination.

No other printed material is allowed into the examination.

The following will be taken into account when determining your assessment on Criterion 2:

- numerical answers should have appropriate units and significant figures;
- vectors should have magnitude and direction;
- graphs should be in pencil and have appropriate scales, labelled axes, units, heading, clear point placement and a suitable line of best fit;
- diagrams should be used when appropriate (especially with vectors);
- answers should be clearly and logically explained.

A set of spare diagrams has been provided in the back of the answer booklet for you to use if required.

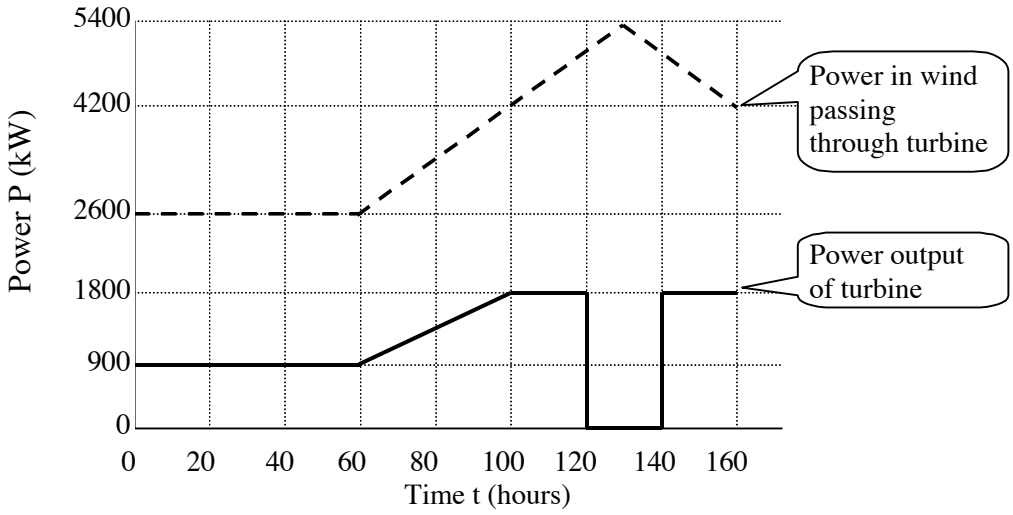
If you use a spare diagram, you MUST indicate you have done so in your answer to that question.

Questions (1) and (2) relate to a wind turbine power generator of the type currently being installed at Woolnorth in the north west of Tasmania. Approximately 55 such turbines will be installed and will have a total power generating capacity of 130 MW.

Question 1 (You should spend about 16 minutes in total on this question.)

The graph below shows how the following two quantities varied with time during one week.

- electrical power output of one wind turbine
- the power of the wind passing through the turbine.



(a) What is the total energy produced by the turbine over the period shown (160 hours)? Express this energy in kWh. (Remember: $E = Pt$) (4 minutes)

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(b) What is the *average* power output of the turbine for the period shown? (2 minutes)

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Question 1 continues opposite.

Question 1 (continued)

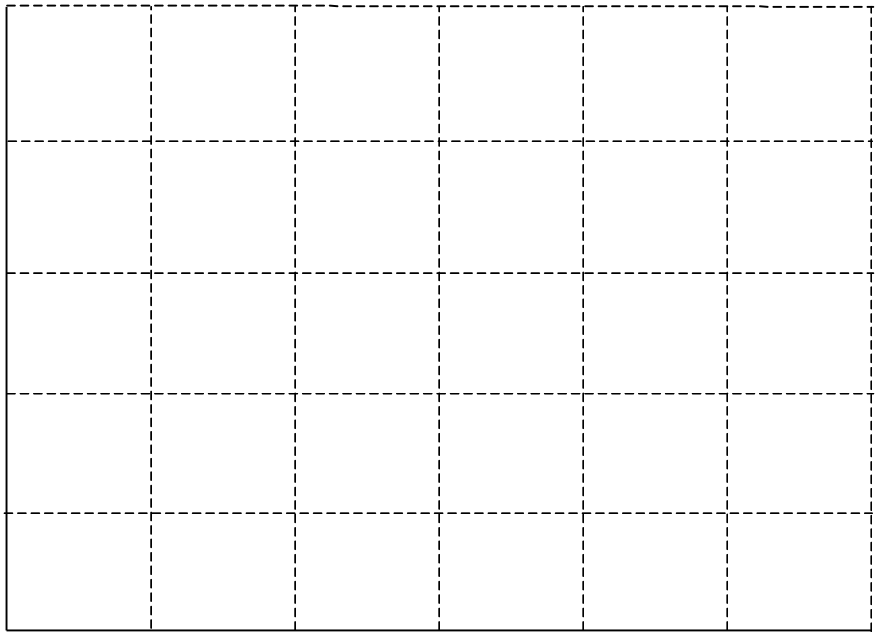
(c) The *efficiency* of the turbine is defined as

Efficiency = Power Output/Power In Wind

Using the axes below, sketch a graph of **efficiency vs power** in the wind. Be sure to label your axes and to show the scales on each axis. (6 minutes)

To assist you in doing this add to the table the efficiencies at 4200 kW and 5400 kW. You may wish to add some extra values to the table.

Wind Power (kW)	2600		4200				5400
Efficiency	0.346						



(d) What are **two** important features of the turbine power graph for wind powers over 4200 kW? Why do you think that the turbines have been designed to operate in this way? (4 minutes)

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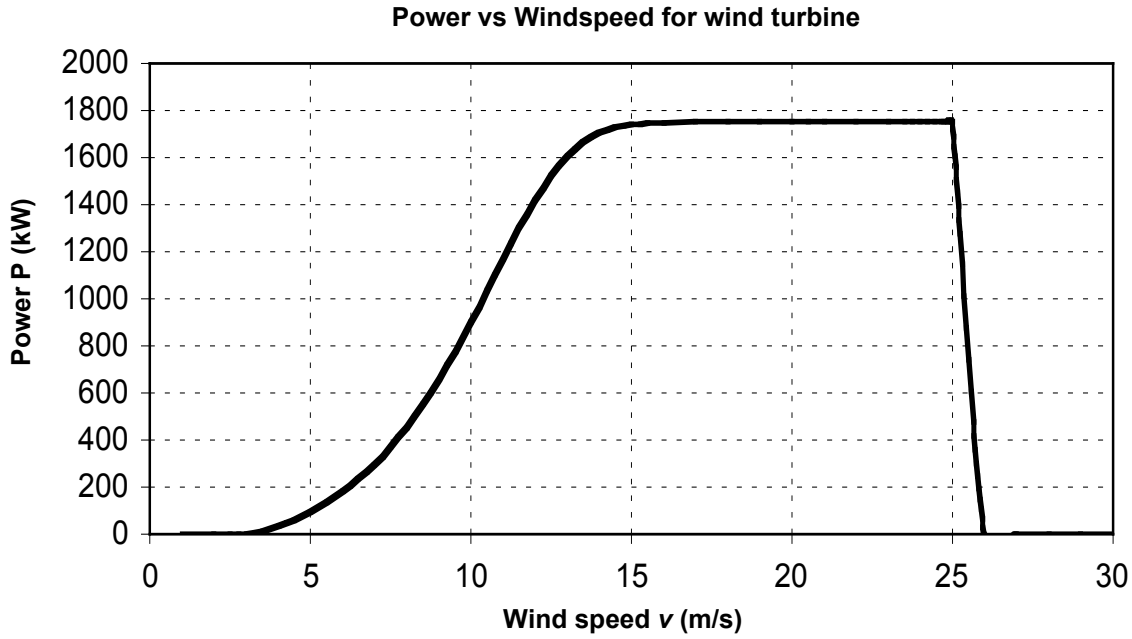
Question 2 (You should spend about 18 minutes in total on this question.)

The following graph shows how the power generated by a wind power generator used in Tasmania varies with wind speed.



The following table shows selected values of power and wind speed taken from the graph. The blank spaces are for you to fill in later.

Speed (ms^{-1})	1	3	4	6	8	9	10	11	12	16	18	25	26
Power (kW)	0	24	56	189	450	640	900	1167	1418	1748	1750	1750	0

The theoretical formula linking power generated P (watt) and wind speed v is:

$$P = \rho A c_p v^3$$ where ρ = density of air = 1.225 kgm^{-3}
A = area swept out by turbine = 3420 m^2
c_p = efficiency of turbine

For a commercial turbine this formula will be approximately correct for low to moderate wind speeds. At higher speeds the output is artificially decreased for safety reasons.

(a) By visually inspecting the above graph (no calculation required) estimate the maximum speed at which the above formula is correct. Briefly justify your estimate. (2 minutes)
NB: there is no 'correct' answer to this question: full marks will be given for any reasonable answer with logical justification.

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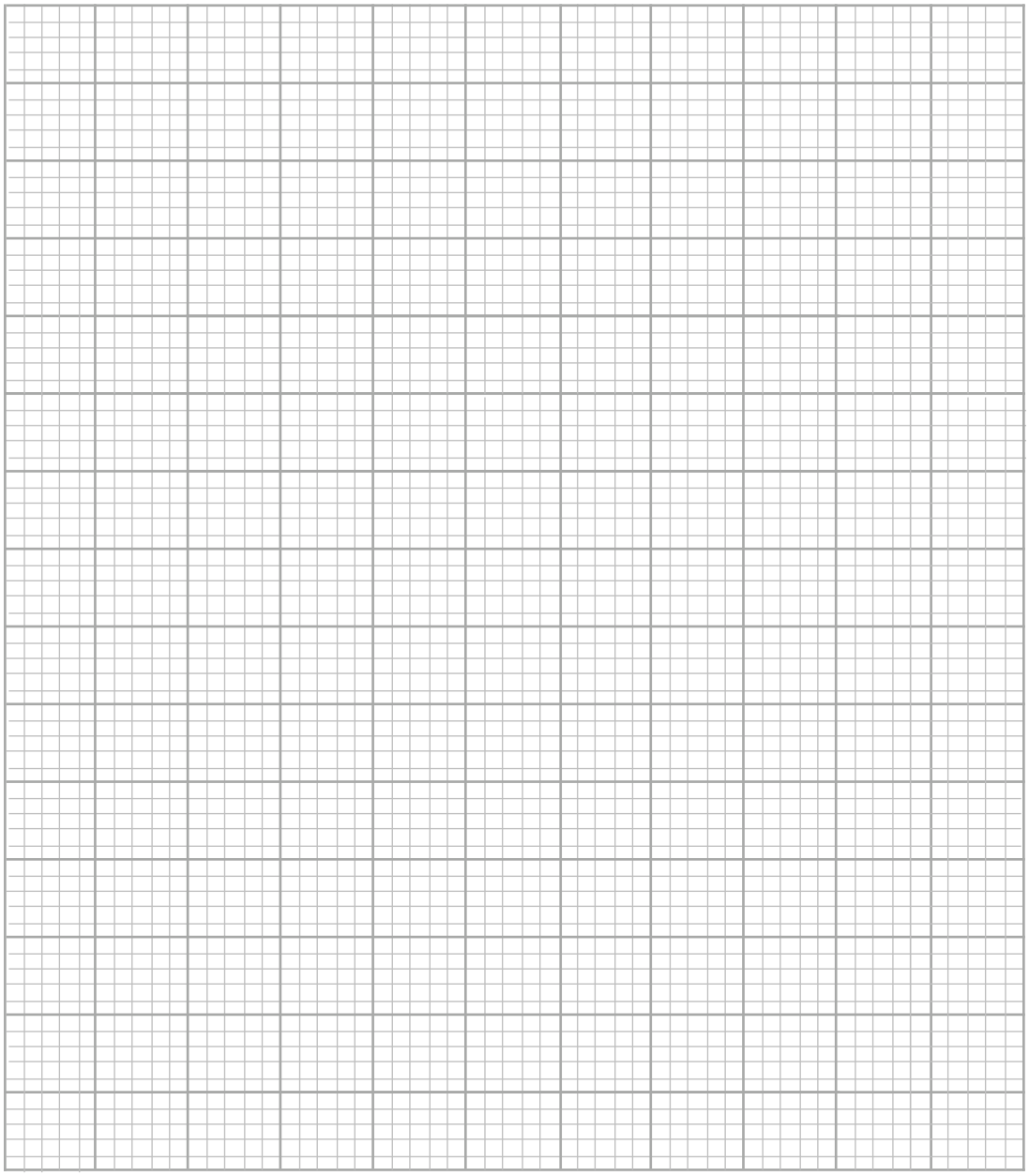
Question 2 continues opposite.

Question 2(continued)

(b) Modify the data for the range of wind speeds you have selected in part (a) opposite, to enable you to plot a straight line graph relating power P and wind speed v. Write your modified data in the blank spaces in the table opposite. (4 minutes)

(c) Plot a straight line graph relating P to v on the grid below. (8 minutes)



(d) Use your graph to determine the efficiency c_p of the turbine over the range for which the formula is correct. (4 minutes)

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Question 3 (You should spend about 11 minutes in total on this question.)

The following question applies (approximately) to large catamaran ships of the type produced by Incat in Hobart.

A large catamaran is powered by water jet engines. In order to determine the optimum diameter of the water jet, the graphs of catamaran hull speed against time shown opposite are determined using a computer.

(a) By drawing an appropriate tangent to the curve (which is drawn with a heavier line on the graph page), determine the acceleration of the catamaran when using the 0.5 m jet at time 0 seconds. (4 minutes)

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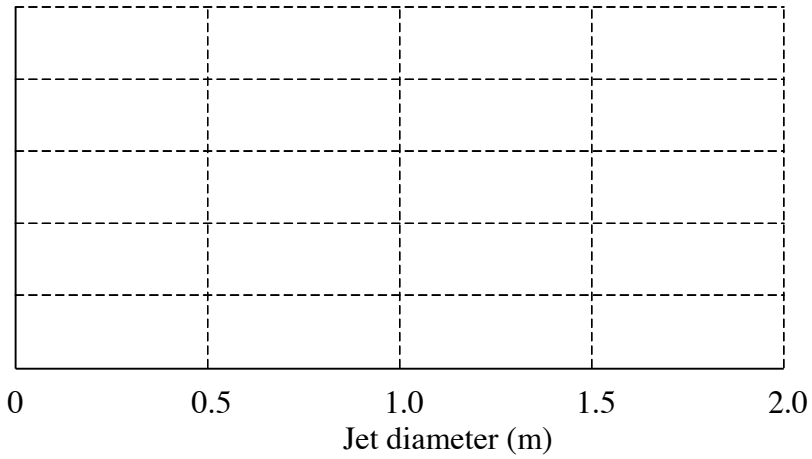
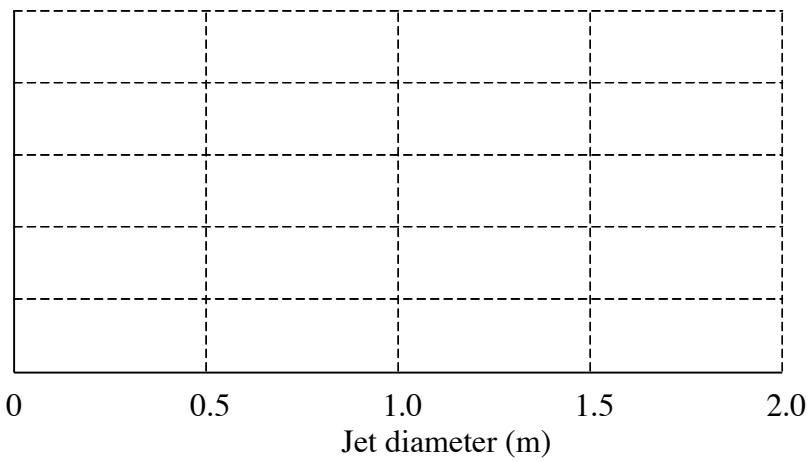
(b) Sketch a graph of initial acceleration against jet diameter. There is no need to calculate any values other than the value you have determined in part (a) above. (2 minutes)

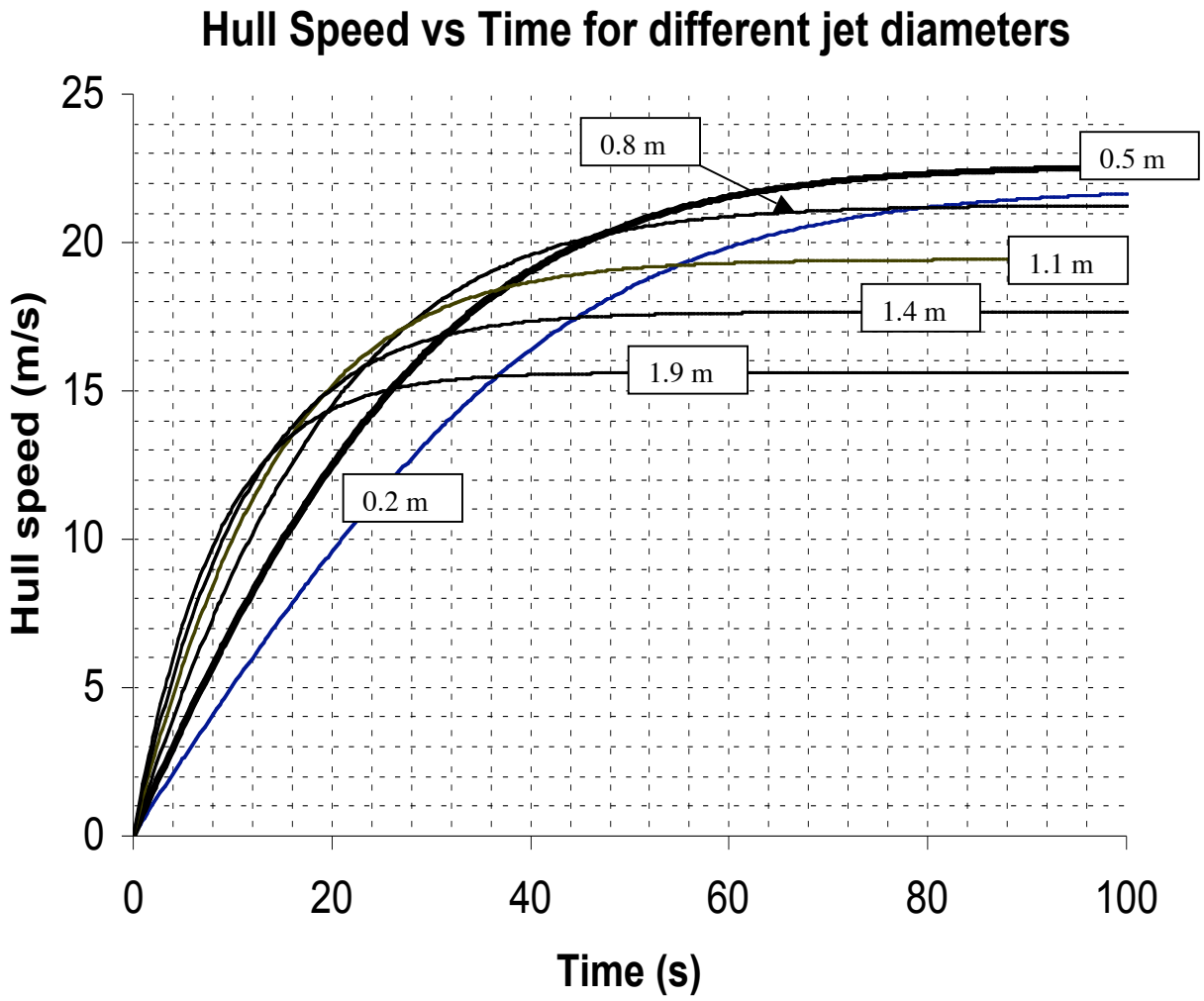


(c) Sketch a graph of final speed against jet diameter. (2 minutes)



Question 3 continues opposite.

Question 3 (continued)



(d) When choosing the optimum size for the jet, the designer must take into account:

- Final top speed
- Manoeuvrability at low speed (which depends on acceleration at low speed)

By considering the two graphs on page 8, decide on the optimum size of the jet and justify your answer. (3 minutes)

NB: there is no 'correct' answer for this question – you will be marked on how you justify your answer.

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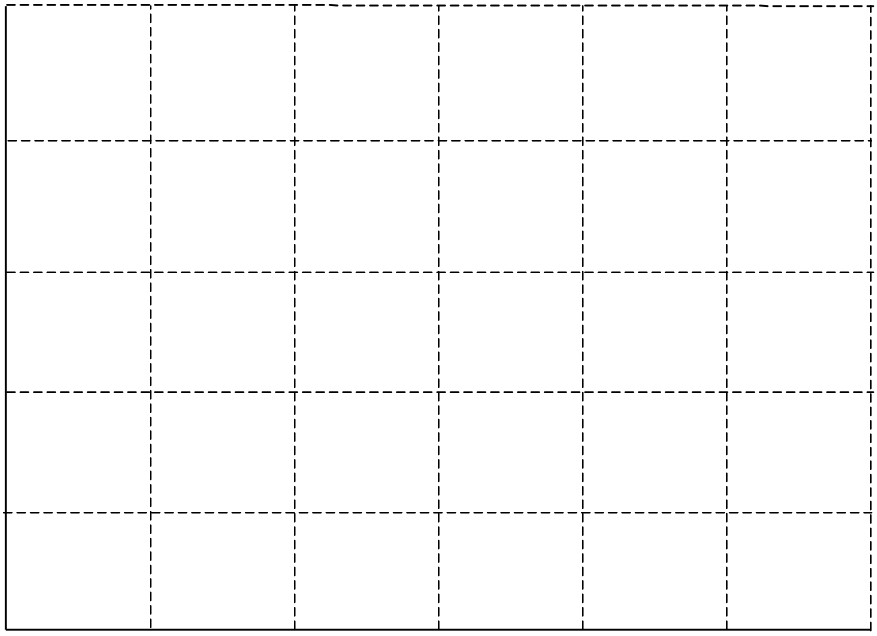
SPARE DIAGRAMS FOR SECTION A

Question 1 (c)

Wind Power (kW)	2600		4200				5400
Efficiency	0.346						

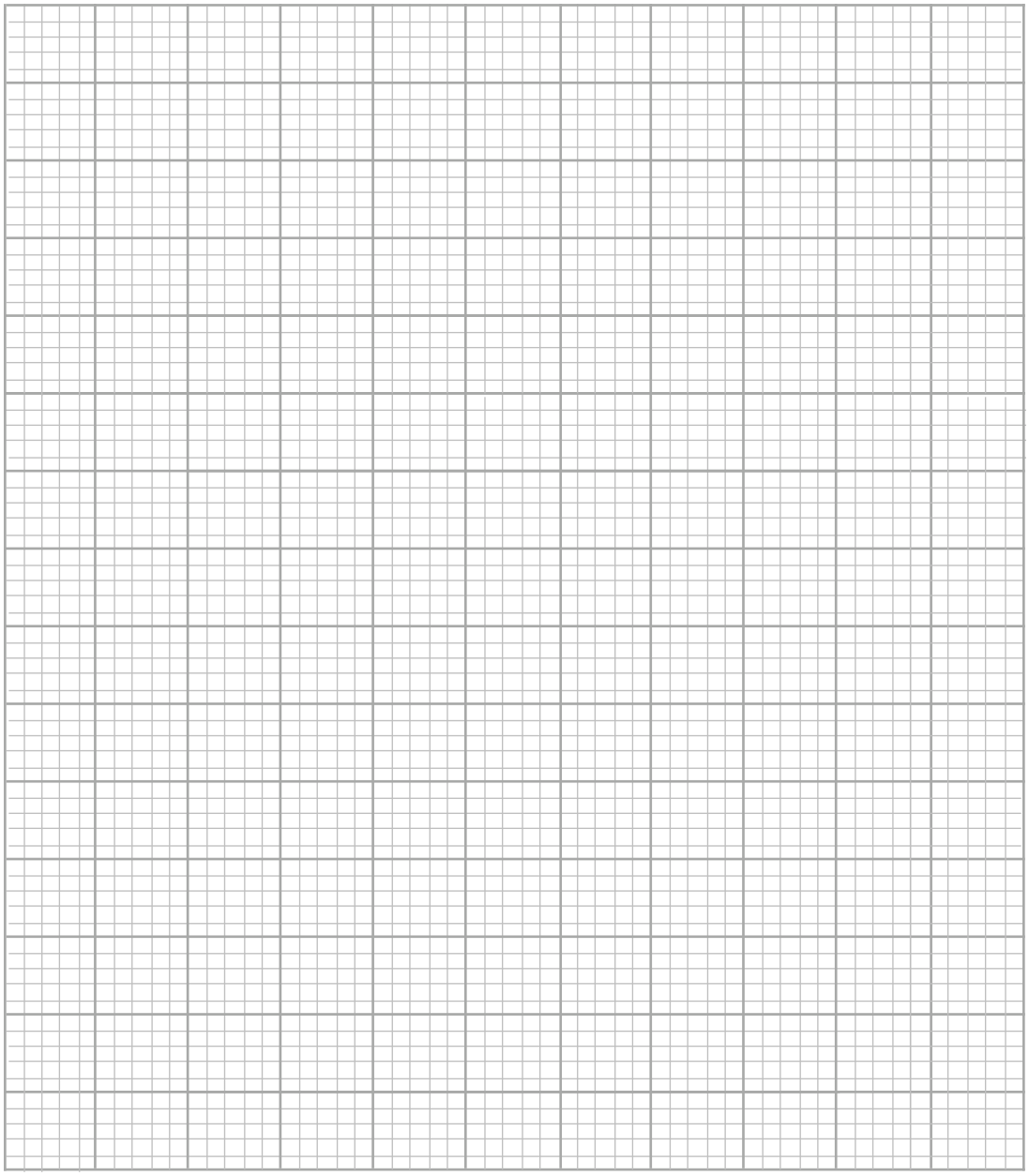


Question 2

Speed (ms^{-1})	1	3	4	6	8	9	10	11	12	16	18	25	26
Power (kW)	0	0	33.3	178	452	655	900	1167	1418	1748	1750	1750	0

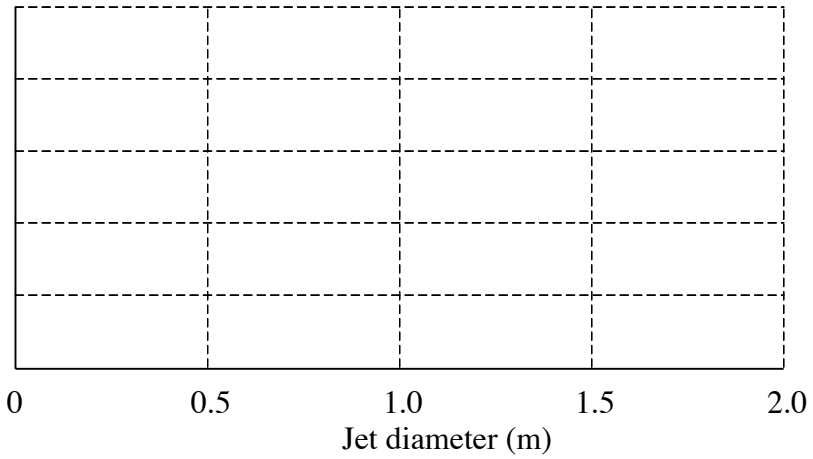
SPARE DIAGRAMS FOR SECTION A

Question 2 (c)

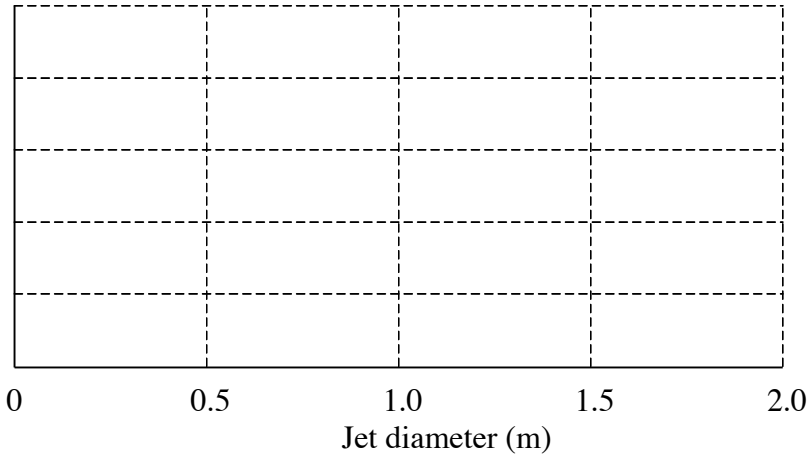


SPARE DIAGRAMS FOR SECTION A

Question 3 (b)



Question 3 (c)



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FOR EXAMINERS USE ONLY

SECTION A

Question	Criterion 7
1	
2	
3	

Criterion 2	

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Tasmanian Secondary Assessment Board

PHYSICS

Senior Secondary 5C

Subject Code: PH866

External Assessment

2003

Section B

Time: 75 minutes

On the basis of your performance in this examination, the examiners will provide results 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 10 Incorporate techniques of analysis and mathematical manipulation (algebraic, trigonometrical, numerical and graphical) to solve complex problems.

Pages: 16
Questions: 5

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CANDIDATE INSTRUCTIONS

Candidates **MUST** ensure that they have addressed **ALL** of the externally assessed criteria on this examination paper.

Answer **ALL** questions. Answers must be written in the spaces provided on the examination paper.

Recommended time:

Section B – 75 minutes.

The Physics Formula Sheet can be used throughout the examination.

No other printed material is allowed into the examination.

The following will be taken into account when determining your assessment on Criterion 2:

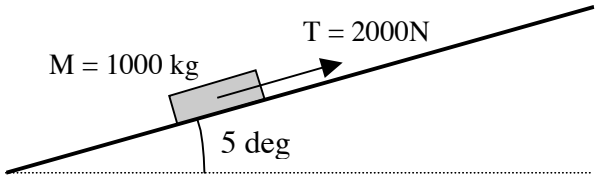
- numerical answers should have appropriate units and significant figures;
- vectors should have magnitude and direction;
- graphs should be in pencil and have appropriate scales, labelled axes, units, heading, clear point placement and a suitable line of best fit;
- diagrams should be used when appropriate (especially with vectors);
- answers should be clearly and logically explained.

A set of spare diagrams has been provided in the back of the answer booklet for you to use if required.

If you use a spare diagram, you MUST indicate you have done so in your answer to that question.

Question 4 (You should spend about 15 minutes in total on this question.)

(a) During the year your examiner, working in his garden, had to move a rock of mass 1.0 tonne (1000 kg) up a slope inclined at 5° to the horizontal. By using a pulley system he was able to exert a tension force T of 2000 N on the rock parallel to the slope.



(i) Calculate the gravitational force acting on the rock. (1 minute)

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(ii) Show that the *component* of the gravitational force acting parallel to the slope is equal to 854N *down* the slope. (2 minutes)

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(iii) Assuming the rock is moving with constant speed, what is the magnitude of the *frictional* force acting on the rock? (2 minutes)

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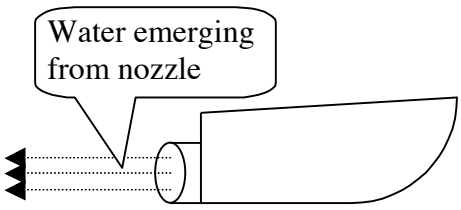
(iv) Complete the diagram to show vectors representing all significant forces acting on the rock. (2 minutes)

Question 4 continues opposite.

Question 4 (continued)

(b) A jet boat operates by forcing water through a nozzle as shown in the diagram. The speed of the water leaving the nozzle is 32.0 ms^{-1} and the total amount of water emerging from the nozzle is 1.00×10^4 kg s^{-1}. *In the following problems you are assuming that the initial velocity of the water before entering the jet is zero.*



(i) What is the magnitude of the **force** exerted on the water jet by the engine? (2 minutes)

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(ii) Determine the **kinetic energy** of the water which emerges from the nozzle every second, and hence show that the **power** required to expel the water is equal to 5.1 MW. (3 minutes)

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(iii) A different jet design uses a *smaller* nozzle which passes only 5.0×10^3 kg s^{-1} of water. If the same power (5.1 MW) is used to drive this smaller jet as in part (ii) above, determine the force exerted on the jet. (3 minutes)

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A correct answer to the following question will gain bonus marks.

(iv) Comment on the difference between your answer to parts (i) and (ii).

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Question 5 (You should spend about 15 minutes in total on this question.)

(a) *Natural uranium contains the alpha emitters U238, U235 and U234. Depleted uranium ("DU") contains mainly U238 with reduced amounts of the other isotopes. DU has been used, with much controversy, as an anti-tank weapon. It is claimed that DU is "40% less radioactive than natural uranium".*

The following information applies to the main **alpha** particle emitters in 1.00 gram samples of natural and depleted uranium. The activity of U235 can be ignored.

	Half life (seconds)	*Half life (years)*	Number of atoms in 1 g of **natural** uranium	Number of atoms in 1 g of **depleted** uranium
U238	**1.41×10^{17}**	*4.47×10^{9}*	**2.51×10^{24}**	**2.53×10^{24}**
U234	**7.73×10^{12}**	*2.45×10^{5}*	**1.39×10^{20}**	**2.1×10^{19}**

(i) Complete the following table to show the **activities** (in Bequerel) of U234 and U238 in one gram of natural uranium and the total activity. Show your working below.(3 minutes)

	Natural Uranium	Depleted Uranium
Activity of U238 (Bq)		1.24×10^{7}
Activity of U234 (Bq)		1.9×10^{6}
Total activity (Bq)		1.43×10^{7}

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(ii) What is the activity of 1.0 g of depleted uranium after 1.0×10^{6} years? (4 minutes)

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Question 5 continues opposite.

Question 5 (continued)

(b) While the precise value of the universal gravitational constant is difficult to measure, the product

GM = Universal Gravitational constant × Mass of earth

can be accurately determined from knowledge of the radius of the earth and the acceleration due to gravity at the surface of the earth.

(i) Appropriate average values for the acceleration due to gravity at the earth's surface and the earth's radius are 9.80665 ms^{-2} and 6.3754×10^6 m respectively. Show that these values give a value of GM of 3.986×10^{14} m^3s^{-2} (where M = mass of the earth). (2 minutes)

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(ii) The average distance from the earth to the moon is 3.8440×10^8 m. Using the value of GM in the previous problem, show that the orbital period of the moon (the 'lunar month') about the earth is 2.372×10^6 seconds. (4 minutes)

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(iii) The moon is currently moving away from the earth at 3.74 cm / year. Assuming that this rate has been constant, was the 'month' *shorter* or *longer* in the past? Explain your choice. (2 minutes)

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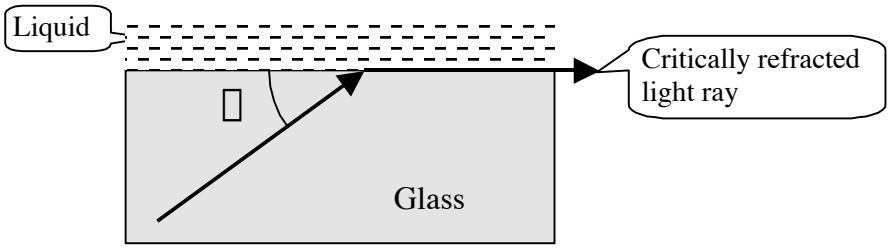
Question 6 (You should spend about 15 minutes in total on this question.)

(a) The diagram shows an arrangement which is used to measure the refractive indices of various liquids. The refractive indices of the glass and liquid are 1.75 and 1.5 respectively.



What is the value of the angle between the glass-liquid interface and an incoming ray of light which is critically refracted at the interface? (4 minutes)

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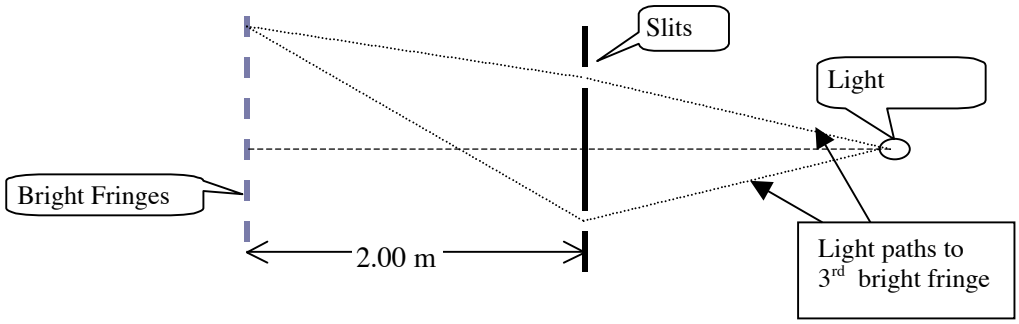
(b) In a Young's double slit experiment, two slits placed 1.00 cm apart are illuminated with coherent light of wavelength 5.00×10^{-7} m. The diagram shows the arrangement, together with the two paths of light which combine to form the 3rd bright fringe out from the central fringe.



(i) What is the distance between adjacent bright fringes at a distance 2.00 m from the slits? (2 minutes)

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(ii) What is the path difference (in wavelengths) between the two rays of light which form the 3rd bright fringe? (1 minute)

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Question 6 continues opposite.

Question 6 (continued)

(c) Light of wavelength 5.00×10^{-7} m is passed through transparent plastic of refractive index 1.50 and thickness 1.00×10^{-5} m.

(i) Find the speed of the light in the plastic. (1 minute)

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(ii) Show that the wavelength of the light in the plastic is 3.33×10^{-7} m. (2 minutes)

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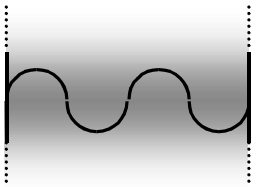
(iii) Show that there are 30 complete waves across the thickness of the plastic. (To illustrate this, the diagram shows a representation of *two* complete waves across a thin sheet of plastic.) (2 minutes)



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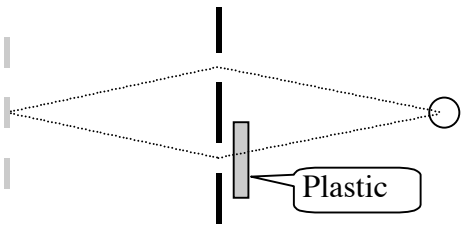
(d) The piece of plastic in part (c) is placed in front of *one* of the slits in part (b) above.

(i) What is the path difference (in wavelengths) between the two rays of light which meet at the centre of the fringe pattern? (3 minutes)



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Correct answers to this question will gain bonus marks.

(ii) What change will be produced by the plastic in the observed fringe pattern?

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Question 7 (You should spend about 15 minutes in total on this question.)

(a) A calcium atom loses two of its electrons to form a doubly charged positive ion. What is the electrostatic force it exerts on an electron which is 4.0×10^{-10} m from it? (2 minutes)

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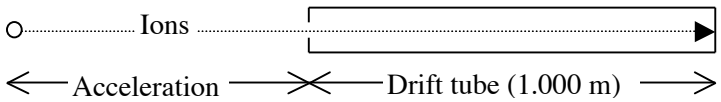
(b) The mass of calcium ions is determined in a 'time of flight' mass spectrometer by accelerating the ions through a potential difference and then finding the time taken for them to move at constant speed through a 'drift tube'.



(i) If the time taken to travel through the drift tube is 2.275 μs and the length of the tube is 1.000 m, what is the speed of the ions in the drift tube? (1 minute)

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(ii) If the ions were accelerated through a potential difference of 2.00×10^{4} V prior to entering the drift tube and have a charge equal to two electronic charges, show that their kinetic energy in the drift tube is 6.4×10^{-15} J. (2 minutes)

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(iii) What is the mass of the ions? (2 minutes)

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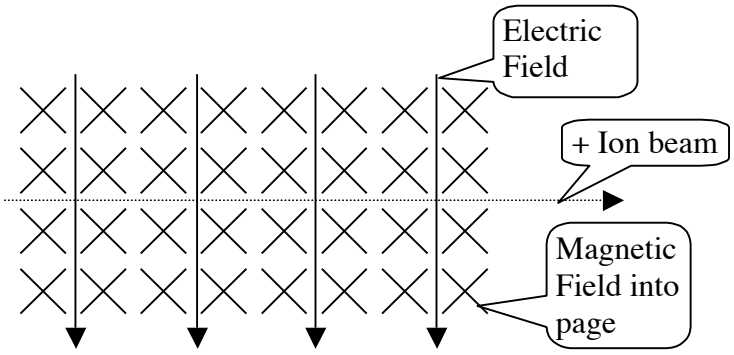
Question 7 continues opposite.

Question 7 (continued)

(c) In a conventional mass spectrometer, positive ions first pass through a region containing mutually perpendicular electric and magnetic fields as shown in the diagram.



(i) On the diagram draw vector arrows representing the **magnetic** and **electric** forces acting on the positive ions. Label your arrows clearly. (1 point)

(ii) Write down the expressions for the electric force and the magnetic force acting on the moving ions and show that the magnetic force is equal in magnitude and opposite in direction to the electric force when the **velocity v** of the ions has magnitude:

$v = E/B$ E = electric field strength
B = magnetic field strength (2 minutes)

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(iii) The electric field is produced by a potential difference of 289.7 V across parallel metal plates that are 2.000 cm apart. The magnetic field has magnitude 0.1000 T. Using the expression from part (ii) show that the magnetic and electric forces cancel if the ions have a velocity of 1.449×10^5 ms^{-1} in the direction shown. (2 minutes)

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(iv) When ions having a speed 1.449×10^5 ms^{-1} enter a magnetic field of strength 0.1000 T they are deflected into a circular path of radius 0.3000 m. What is the **mass to charge** ratio m/q for the ions? (3 minutes)

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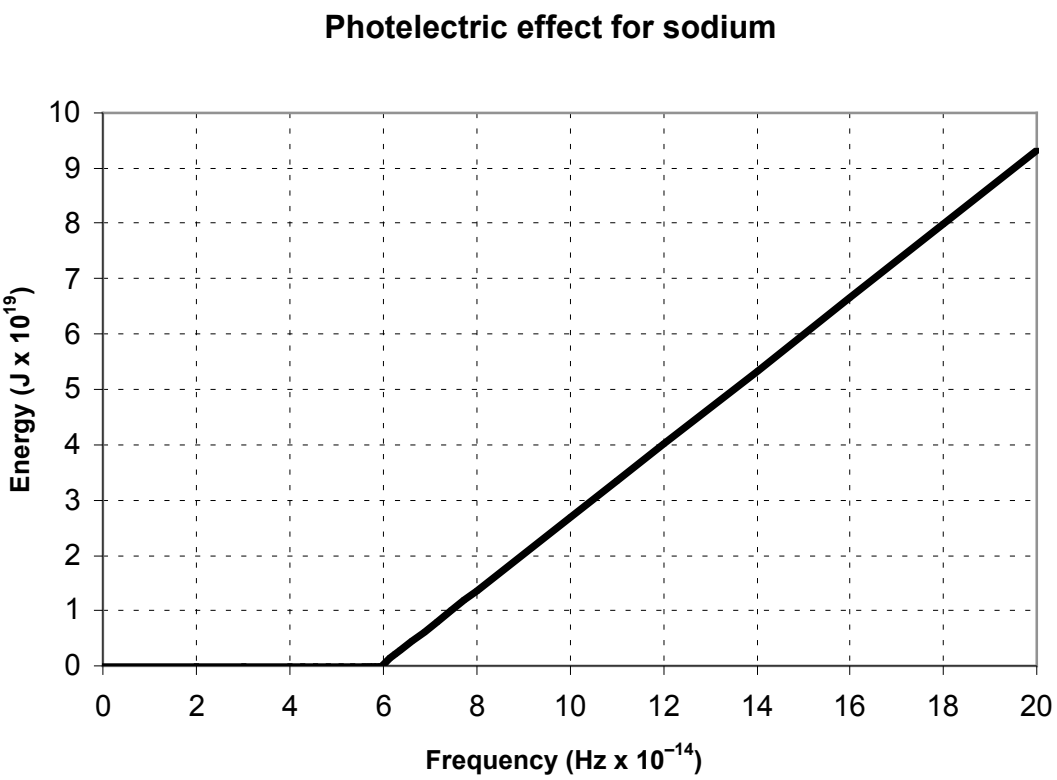
Question 8 (You should spend about 15 minutes in total on this question.)

(a) The graph below shows how the energy of photoelectrons emitted from sodium metal in a vacuum varies with the frequency of the illuminating light.



(i) What is the value of Planck's constant that can be obtained from the graph? (3 minutes)

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(ii) What is the value of the *work function* of sodium? (2 minutes)

(Use the value of Planck's constant obtained in (i) above.)

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(iii) Using the above axes, plot the corresponding graph for zinc given that zinc has a threshold frequency of 10.4×10^{14} Hz. (2 minutes)

Question 8 continues opposite.

Question 8 (continued)

(b) A proposal to send a tiny space probe to a nearby star within a human lifetime involves accelerating the probe by irradiating it (from earth) with a beam of microwaves. The microwaves bounce off the space probe reversing direction initially without significant loss of energy. Relevant data are as follows:

- Mass of probe = 20 g
- Wavelength of microwaves = 3.0 cm
- Power in microwave beam = 1.0×10^{10} W

(i) Show that the *energy* of each microwave photon is 6.63×10^{-24} J. (1 minute)

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(ii) Show that the *number* of photons striking the probe every second is 1.51×10^{33}. (2 minutes)

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(iii) Show that the *momentum* of each photon is 2.21×10^{-32} kgms^{-1}. (1 minute)

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(iv) What is the *acceleration* of the probe? (4 minutes)

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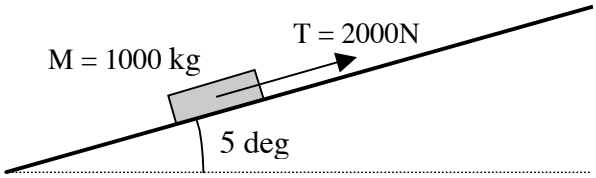
SPARE DIAGRAMS FOR SECTION B

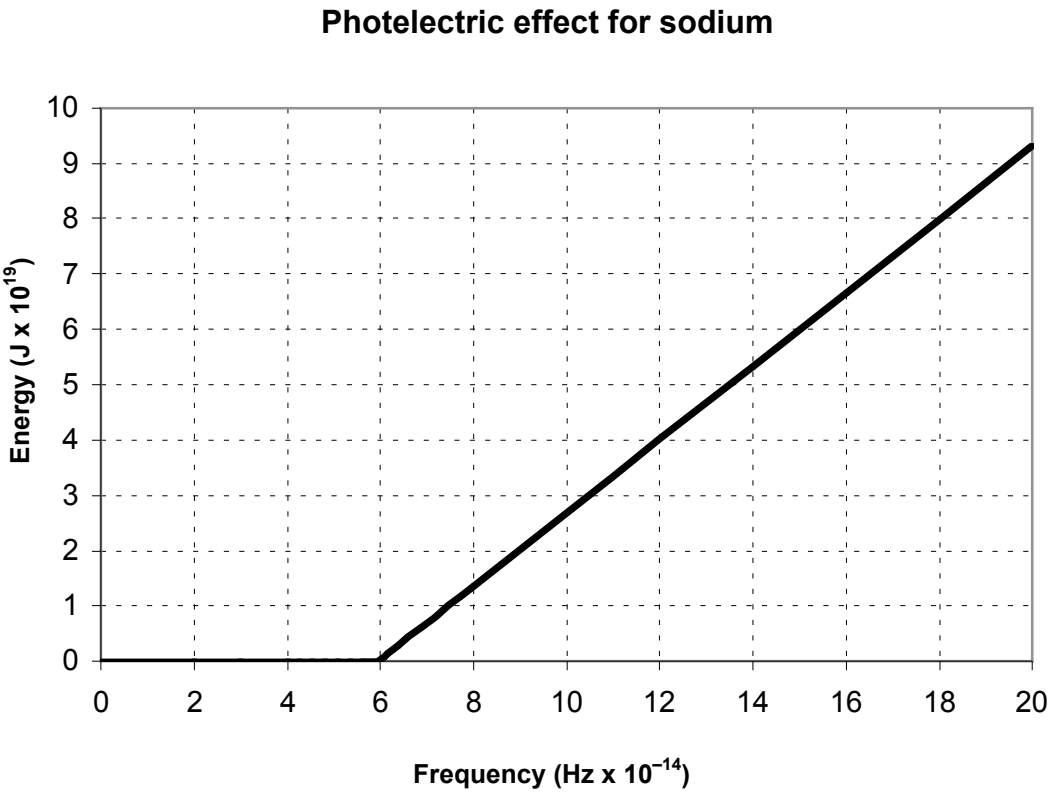
Question 4 (a)



Question 5 (a)(i)

	Natural Uranium	Depleted Uranium
Activity of U238 (Bq)		1.24×10^7
Activity of U234 (Bq)		1.9×10^6
Total activity (Bq)		1.43×10^7

Question 8 (a)



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FOR EXAMINERS USE ONLY

SECTION B

Question	Criterion 10
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5	
6	
7	
8	

Criterion 2	

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Tasmanian Secondary Assessment Board

PHYSICS

Senior Secondary 5C

Subject Code: PH866

External Assessment

2003

Section C

Time: 60 minutes

On the basis of your performance in this examination, the examiners will provide results 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: 20
Questions: 3

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CANDIDATE INSTRUCTIONS

Candidates **MUST** ensure that they have addressed **ALL** of the externally assessed criteria on this examination paper.

NOTE:

Candidates have a choice in Question 10. Answer THREE of the four parts.

Candidates have a choice in Question 11. Answer parts (a), (b) and (c) OR parts (d), (e) and (f).

Answers must be written in the spaces provided on the examination paper.

Recommended time: Section C – 60 minutes.

The Physics Formula Sheet can be used throughout the examination.

No other printed material is allowed into the examination.

The following will be taken into account when determining your assessment on Criterion 2:

- numerical answers should have appropriate units and significant figures;
- vectors should have magnitude and direction;
- graphs should be in pencil and have appropriate scales, labelled axes, units, heading, clear point placement and a suitable line of best fit;
- diagrams should be used when appropriate (especially with vectors);
- answers should be clearly and logically explained.

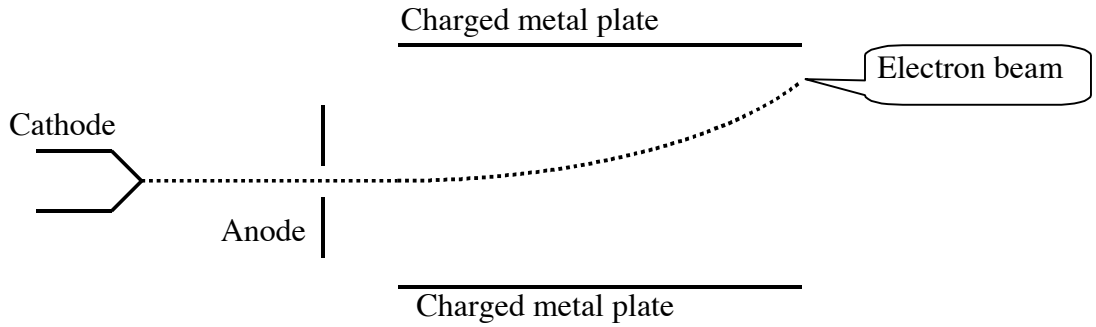
A set of spare diagrams has been provided in the back of the answer booklet for you to use if required.

If you use a spare diagram, you MUST indicate you have done so in your answer to that question.

Question 9 (You should spend about 15 minutes in total on this question.)

This question concerns various aspects of the electron.

(a) The electron was first discovered in a "cathode ray tube" such as is shown in the diagram. The electrons are emitted by the **cathode**, are accelerated towards the **anode** and are then deflected by an **electric field** between two charged parallel metal plates.



On the diagram label as "+" (positive) or "−" (negative) the

- Cathode
- Anode
- Both metal plates.
- Show also the electric field lines between the two plates. (3 minutes)

(b) A Millikan type experiment gave the following values for the charges on six oil drops in units at 10^{-19}C

$$+ 6.0, + 8.0, - 4.0, - 10.0, + 8.0, -6.0$$

What is the most likely value for the electronic charge, based on these results? Explain.

NB. Your answer may not be the same as the generally accepted answer.

(4 minutes)

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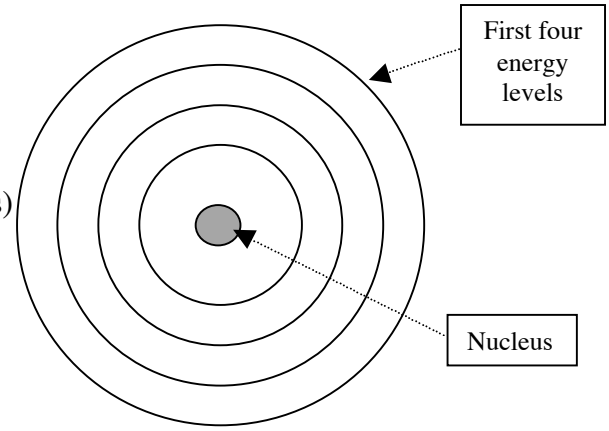
Question 9 continues opposite.

Question 9 (continued)

(c) Explain how observations of the **line emission spectrum** of excited hydrogen gas provided evidence for the discovery that electrons occupy distinct energy levels in atoms.(4 minutes)

Your answer should include arrows representing some appropriate electron jumps in the diagram opposite.



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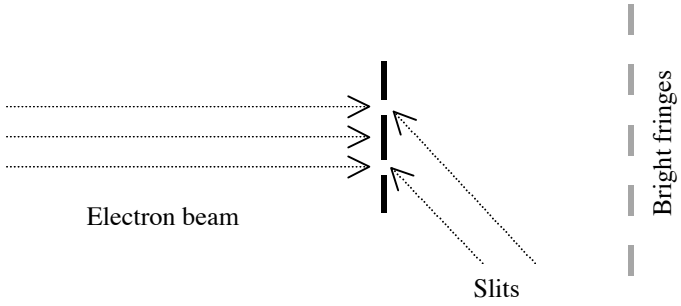
(d) When a beam of electrons is fired at a series of slits separated by a distance comparable with the size of an atom, an interference pattern can be detected at the other side of the slits.



- What further property of electrons does this experiment illustrate?
- Why are the interference fringes not likely to be seen if the slits had dimensions of those suitable for a Young's experiment with light? (4 minutes)

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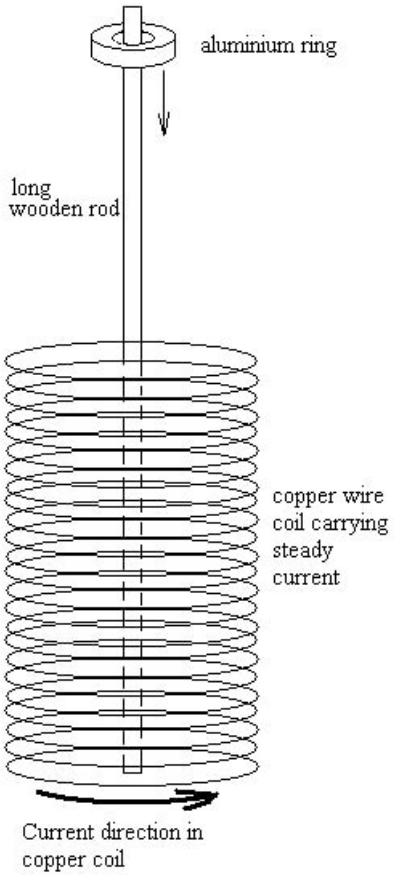
Question 10 (You should spend about 30 minutes in total on this question.)

Answer THREE of the four parts to this question.

(a) The adjacent diagram shows an aluminium ring sliding down a long wooden rod. A steady current is passed through a fixed copper coil which surrounds the wooden rod.



(i) What is meant by "Lenz's Law" applied to a conductor moving through a magnetic field?
(3 minutes)

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(ii) On the diagram draw, and carefully label using the letters (A), (B), (C) and (D).
(4 minutes)

(A) the magnetic field lines produced by the current flowing in the coil;

(B) the magnetic field lines due to the induced current in the aluminium ring;

(C) the direction of induced current in the aluminium ring;

(D) the direction of magnetic force on the aluminium ring.

(iii) Describe how the magnetic force (magnitude and direction) varies as the aluminium ring falls from the position shown, down the wooden rod and out the other side of the coil. You may assume that the magnetic field within the coil is uniform. (3 minutes)

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Question 10 continues opposite.

Question 10 (continued)

(b) (i) Discuss what is meant by the "total internal reflection" of light incident from one medium onto another. Your answer should include reference to the refractive index of each medium. (3 minutes)

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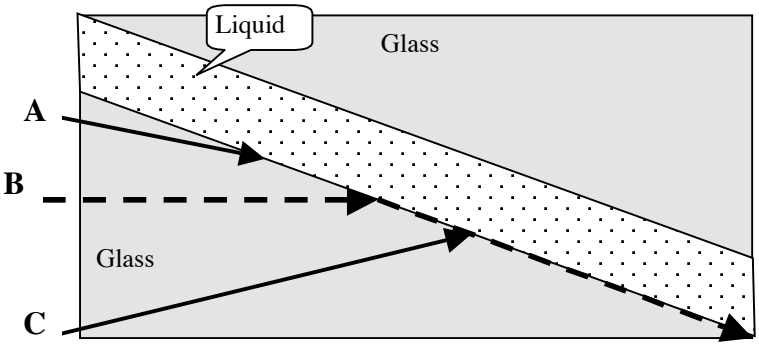
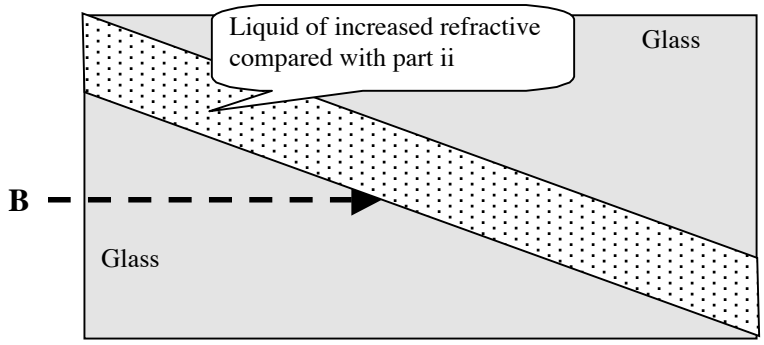
The following diagram shows the basic construction of a refractometer used to measure the refractive index of various liquids. A sample of liquid is placed between two glass prisms. The glass has a ***higher*** refractive index than each of the liquids in the following questions.

(ii) Three rays of light A, B and C travel through the first prism to the liquid as shown. Ray B is critically refracted. Complete the diagram to show the subsequent paths taken by the two rays A and C within the refractometer. (2 minutes)



(iii) The adjacent diagram shows the same system as above, but with a liquid of ***slightly increased*** refractive index than in part (ii) but still less than that of glass. Show the new path of the ray B. (2 minutes)



(iv) Explain how the apparatus could be used to determine the refractive index of any liquid. (3 minutes)

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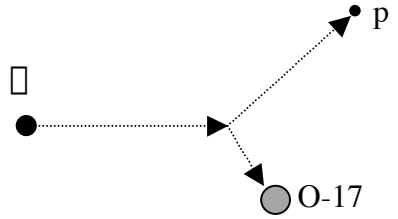
Question 10 continues over the page.

Question 10 (continued)

(c) In the following questions, give a *brief* explanation of your answers.

(i) An alpha particle strikes a stationary nucleus of nitrogen-14 causing a nuclear reaction with the emission of a proton and a nucleus of oxygen-17. The diagram shows the velocities of the α particle (before the collision) and the proton and oxygen nucleus (after the collision).



- Would you expect *momentum* to be conserved in this collision? Illustrate your answer with a vector triangle. (2 minutes)

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- Would you expect the *kinetic energy* of the products to equal the kinetic energy of the incoming proton? (2 minutes)

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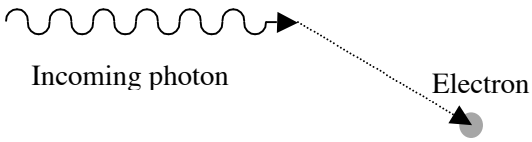
(ii) In a Compton scattering experiment, an X ray photon is scattered by an initially stationary electron which rebounds as shown in the diagram.



- On the diagram, sketch the path of the scattered photon. Explain the physical law which supports your choice of path. (2 minutes)

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- How will the *wavelength* of the scattered photon compare with that of the incoming photon? (2 minutes)

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- How would you expect the *energy* of the incoming photon to compare with the *total energy* of the scattered photon and the electron? (2 minutes)

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Question 10 continues opposite.

Question 10 (continued)

(d) *Natural uranium contains (among others) the isotopes U238 and U235. This is processed into "enriched" uranium which contains most of the U235 as well as U238 and "depleted" uranium which is mostly U238.*

(i) Complete the right hand sides of the following equations for the reactions of two isotopes of naturally occurring uranium when bombarded by neutrons: (2 minutes)

$_{92}U^{238} + {}_{0}n^{1} \rightarrow$ U

$_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{38}Sr^{90} +$ Xe $+ 3\ {}_{0}n^{1}$

(ii) Fission reactors use "enriched" uranium in which the proportion of U235 has been considerably increased. With reference to the above two equations, explain why enriched uranium is better able to maintain a fission reaction than natural uranium. (3 minutes)

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(iii) "Depleted" uranium contains mainly U238 which undergoes the following sequence of transformations:

$_{92}U^{238} \rightarrow {}_{90}Th^{234} \rightarrow {}_{91}Pa^{234} \rightarrow {}_{92}U^{234} \rightarrow {}_{90}Th^{230}$

How many

- Alpha particles .....
- Beta particles .....

are emitted in the transformation of a single atom of $_{92}U^{238}$ to $_{90}Th^{230}$? (2 minutes)

(iv) Artillery shells made from depleted uranium burn on impact to produce fine particles of uranium *compounds* which become embedded in the surrounding soil and may be breathed in by people. Are these particles radioactive? Explain. (3 minutes)

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Question 11 (You should spend about 15 minutes in total on this question.)

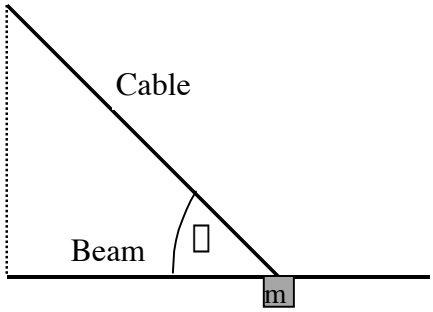
Answer EITHER parts (a), (b) and (c)

OR parts (d), (e) and (f)

of this question.

(a) *This question illustrates the principle of a "cable stayed" cantilever bridge such as the Batman Bridge over the Tamar River in Tasmania. The mass of the roadway can be regarded as being 'concentrated' at the base of the diagonal cable.*

A mass m is supported by a diagonal cable and a horizontal beam as shown in the diagram.



(i) Using the same scale to represent forces, draw two vector triangles showing the three main forces acting on the mass m for two values of the angle θ between cable and beam:

• θ as shown in the diagram

• θ about half that shown in the diagram

(3 minutes)

(ii) In which of these two situations will the stronger cable be required to support the mass m? Use your vector triangles to justify your answer. (3 minutes)

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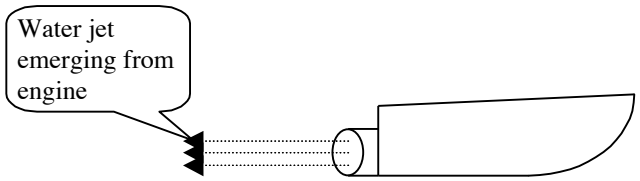
Question 11 continues opposite.

Question 11 (continued)

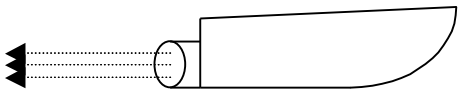
(b) A jet boat, starting from rest, accelerates up to a final constant velocity.

(i) Draw, to scale, vector arrows showing the **thrust** force exerted by the water jet on the boat and the **frictional** force acting on the boat in the three situations shown below. You should assume that the thrust force is the same in each case. (3 minutes)

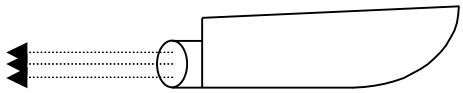
- The velocity of the boat is zero, but the boat is accelerating.



- The velocity of the boat has not reached its final maximum value.



- The velocity of the boat is at its final maximum value.



(ii) Explain, in terms of the physical principles involved, how the jet of water leaving the boat in a backwards direction imparts a thrust in the forward direction on the boat. (3 minutes)

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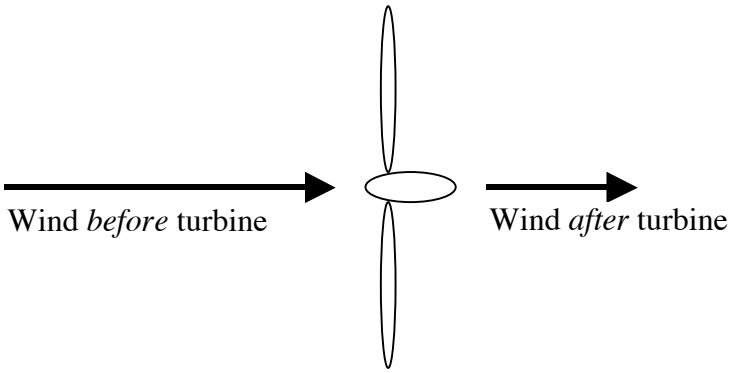
(c) The diagram shows the flow of air through a wind turbine (viewed side on). The arrows represent the velocity of the air before and after it passes through the turbine.



The efficiency of a wind turbine (that is, the fraction of the energy in the wind which is converted by the turbine into "useful" energy) will always be less than 100%. Suggest reasons why this is so. (3 minutes)

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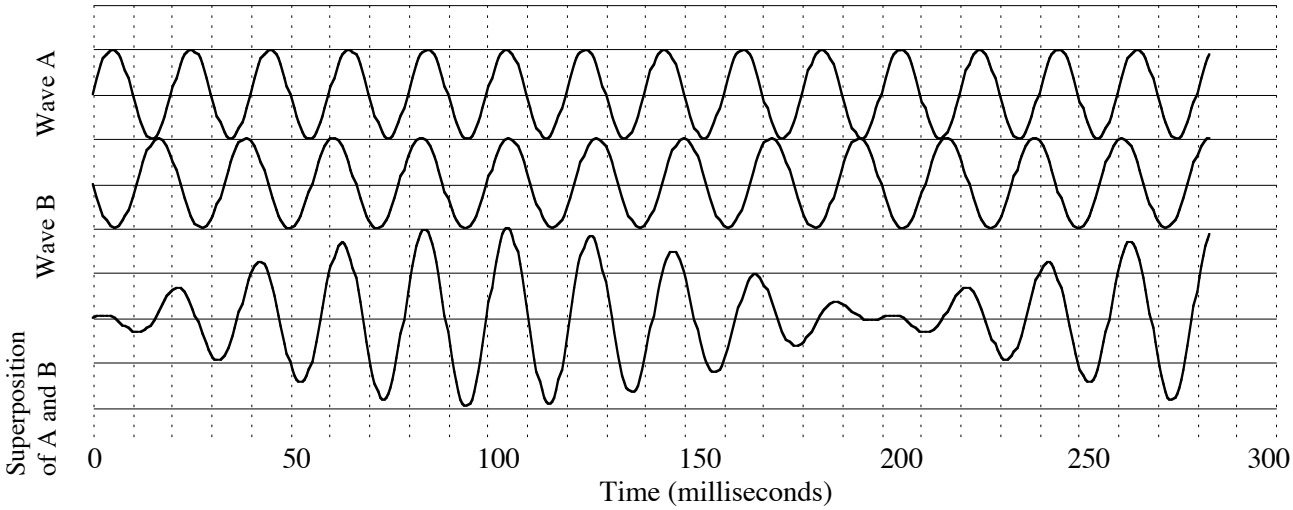
Question 11 continues over the page.

Question 11 (continued)

OR

(d) The graphs below show representations of two independent sound waves A and B travelling through the same medium, together with the superposition of A and B in the medium.



(i) What are the values of the *periods* of the waves A and B respectively? (2 minutes)

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(ii) Describe what an observer listening to the combination of the two waves would hear. (A full answer will give a numerical value.) (2 minutes)

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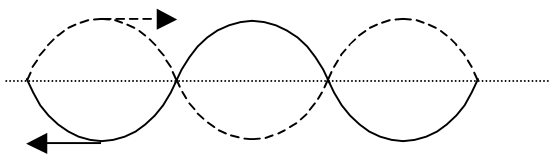
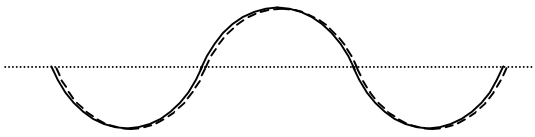
(e) Two waves of equal amplitude and wavelength travel in opposite directions along a stretched string. The following two diagrams show the positions of each wave at two separate instants.

(i) Using the same horizontal axes, sketch waves showing the *superposition* of the two waves at the two instants shown. (2 minutes)





Question 11 continues opposite.

Question 11 (continued)

(ii) Briefly describe the overall wave pattern which results from the superposition of these two waves. (2 minutes)

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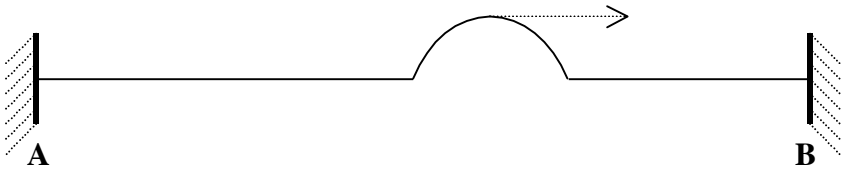
(f) A length of string is held between two fixed ends

(i) A pulse travels along a string from A to B as shown. On the same diagram show the shape of the pulse after it is reflected from B. (1 minute)



(ii) If the string is subject to regularly repeated sideways vibrations it is found that at some vibration frequencies a standing wave pattern is set up in the string.

- Describe, with diagrams, some of the standing waves that can be set up in the string. (3 minutes)

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- Standing waves can only be maintained when the string is vibrated at certain fixed frequencies. Explain why standing waves cannot be maintained at other frequencies. (3 minutes)

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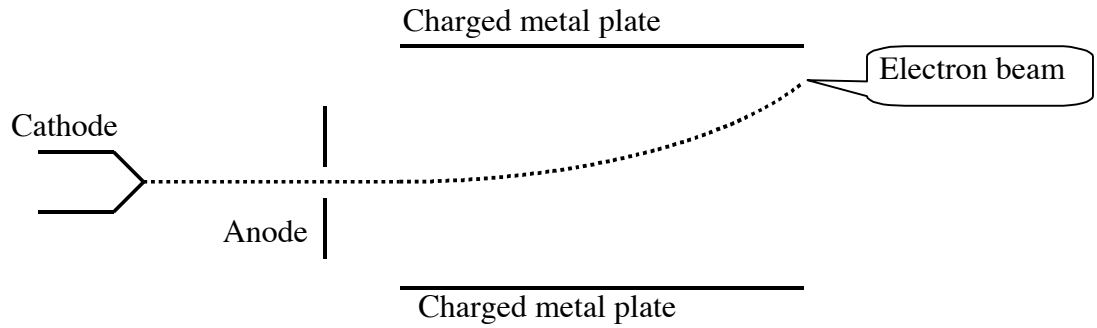
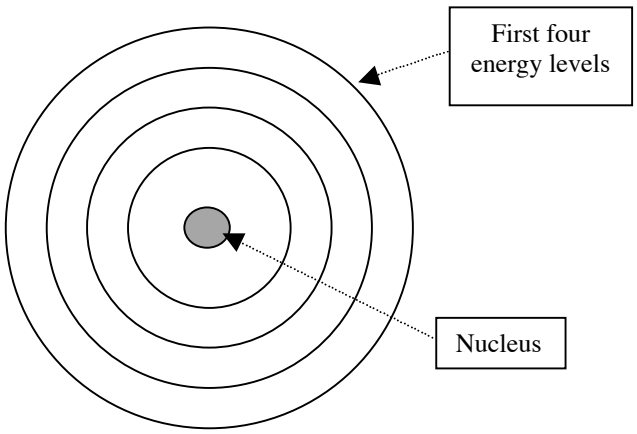
SPARE DIAGRAMS FOR SECTION C

Question 9(a)

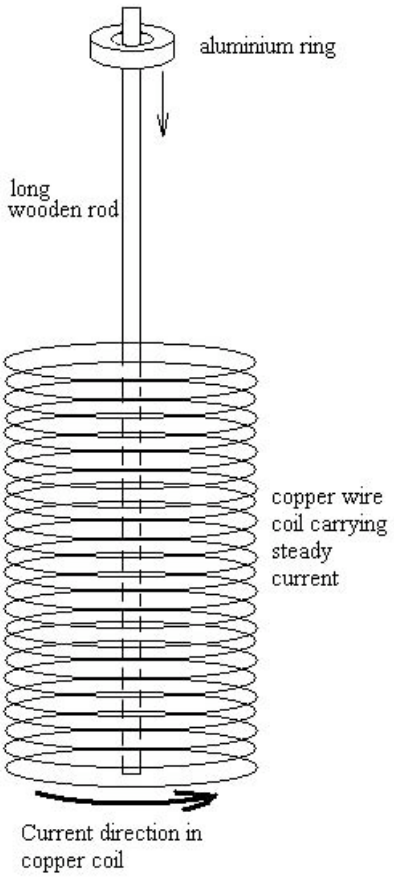


Question 9(c)



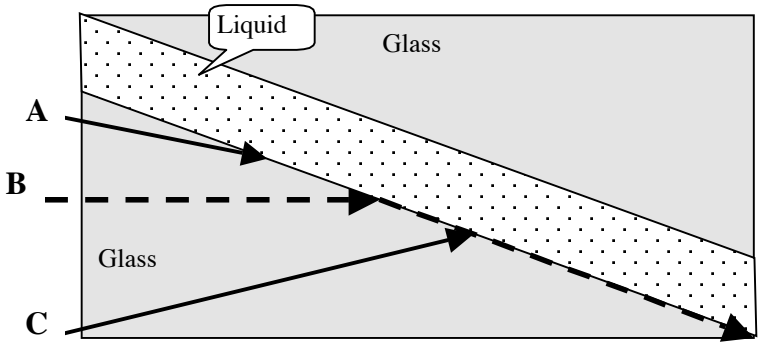
SPARE DIAGRAMS FOR SECTION C

Question 10 (a)(ii)

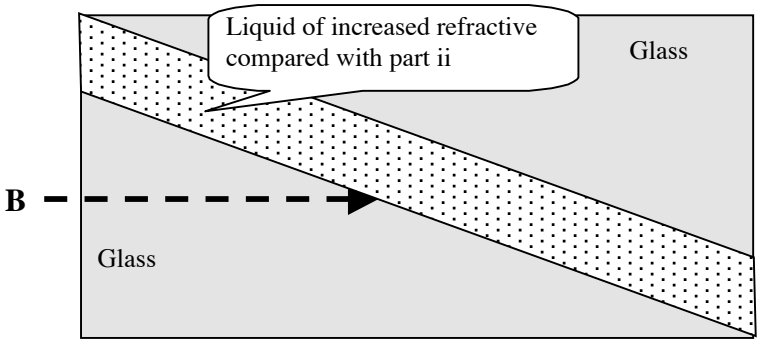


SPARE DIAGRAMS FOR SECTION C

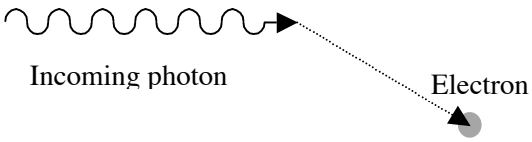
Question 10(b)(ii)



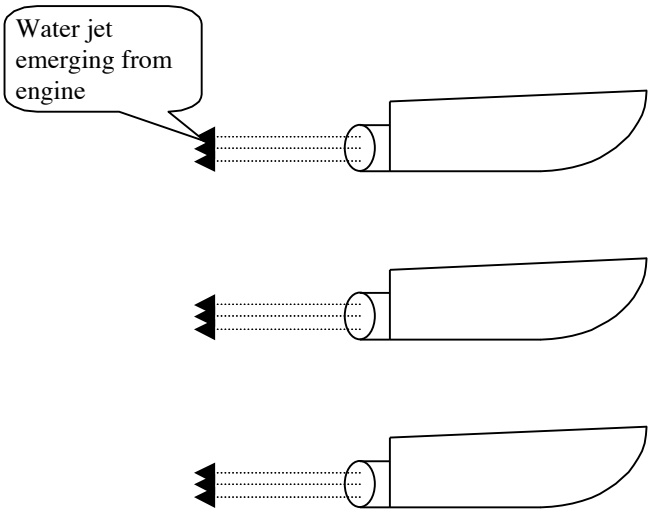
Question 10(b)(iii)



Question 10(c)(ii)



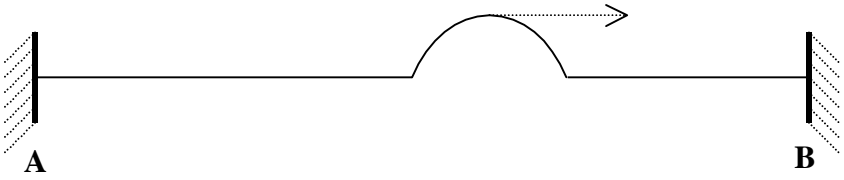
Question 11(b)(i)



SPARE DIAGRAMS FOR SECTION C

Question 11(e)(i)

Question 11(f)(i)



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FOR EXAMINERS USE ONLY

SECTION C

Question	Criterion 9
9	
10(a)	
10(b)	
10(c)	
10(d)	
11(a)	
11(b)	
11(c)	
11(d)	
11(e)	
11(f)	

Criterion 2	