OFFICE OF TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

Tasmanian Certificate of Education
External Assessment 2018

PLACE YOUR CANDIDATE LABEL HERE

PHYSICS

(PHY415115)

PART 1

Time: 45 minutes

Pages:	16
Questions:	6
Attachments:	Information Sheet

Candidate Instructions

1. You **MUST** make sure that your responses to the questions in this examination paper will show your achievement in the criterion being assessed.
2. Answer **ALL** questions. Answers must be written in the spaces provided on the examination paper.
3. You should make sure you answer all parts within each question so that the criterion can be assessed.
4. This examination is 3 hours in length. It is recommended that you spend approximately 45 minutes in total answering the questions in this booklet.
5. The External Examination Information Sheet for Physics can be used throughout the examination.
6. All written responses must be in English.
7. TASC approved calculator can be used.

On the basis of your performance in this examination, the examiners will provide results on the following criterion taken from the course statement:

Criterion 5 Identify and apply principles of Newtonian mechanics including gravitational fields.

Total: /40

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Additional Instructions for Candidates

Show all working in your answers to numerical questions. Some credit will be given for unsimplified answers. Credit cannot be given for an incorrect answer unless it is accompanied by details of the working. Appropriate units must be included.

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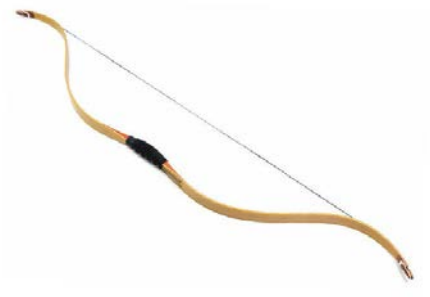
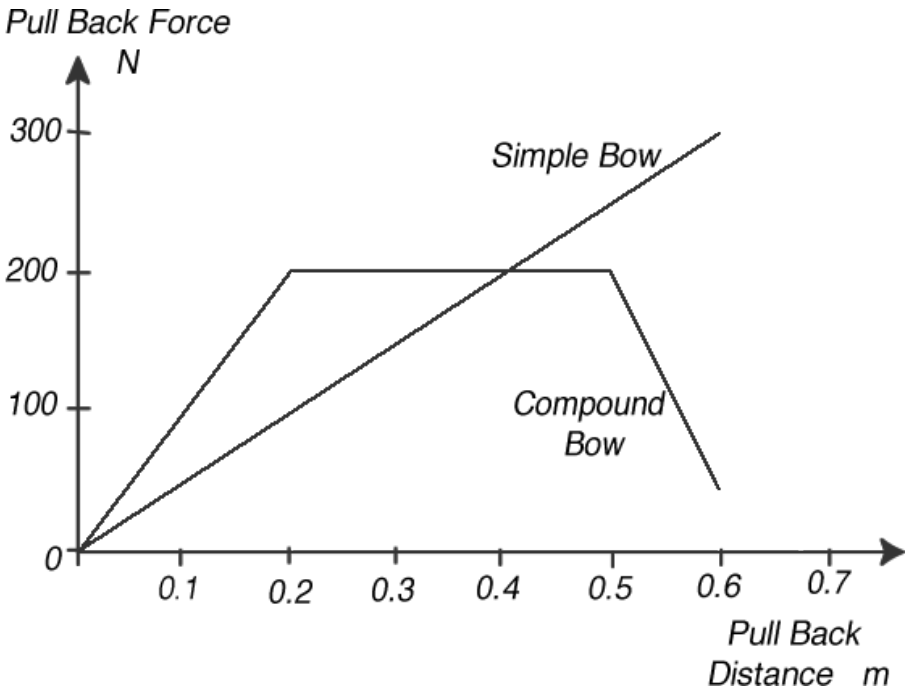
Question 1

For Marker Use Only

Two types of bows are used in archery, a simple classical bow and a bow called a compound bow.



The force vs distance graphs for pulling back the string is shown for each type.



Each are to be pulled back to 0.60 m.

(a) Comment on the ease of holding each bow back at 0.60 m while aiming. (1 mark)

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Question 1 continues.

Question 1 (continued)

For Marker Use Only

(b) Calculate the work done in pulling back to 0.60 m.

(i) Simple bow (1 mark)

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(ii) Compound bow (2 marks)

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(c) An arrow of mass 18.0 g is to be fired from the compound bow. If 60% of the stored energy is imparted to the arrow, calculate the final speed of the arrow.
(2 marks)

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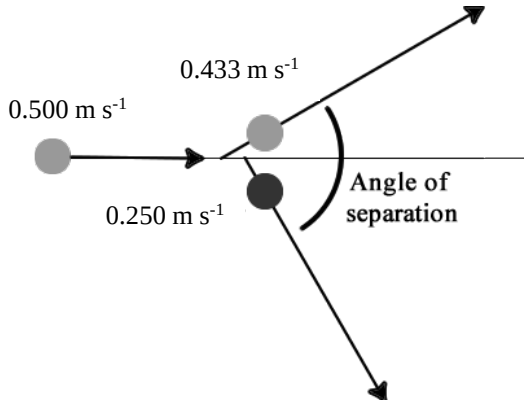
Question 2

For Marker Use Only

Two identical 0.150 kg balls collide on a billiard table. The first ball moving at 0.500 m s^{-1} strikes the stationary second ball. After, their velocities are 0.433 m s^{-1} for the first ball and 0.250 m s^{-1} for the other.



(a) Draw a momentum diagram of the collision.

(1 mark)

(b) Is the collision elastic? Justify your answer. (2 marks)

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Question 2 continues.

Question 2 (continued)

(c) Calculate the angle at which the balls separate after the collision. (3 marks)

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For Marker Use Only

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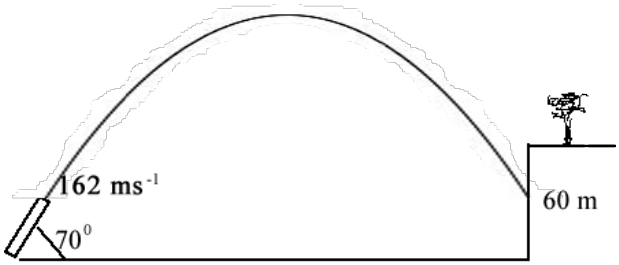
Question 3

For Marker Use Only

A mortar is a type of military artillery designed to fire a projectile (a bomb) over hills and over short ranges. A typical mortar bomb speed is 162 m s^{-1}, which is quite slow for artillery.

Suppose such a bomb is fired at an angle of 70º.



Calculate:

(a) The horizontal and vertical components of this velocity. (2 marks)

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(b) The greatest height the bomb will reach. (2 marks)

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(c) The target is 60.0 m higher than the firing point. Determine the range of the bomb. (4 marks)

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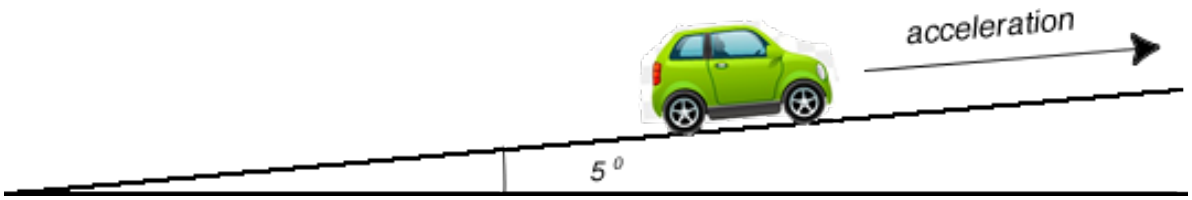
Question 4

For Marker Use Only

A rally car accelerates up a hill of slope 5^o for 15.0 s at a uniform acceleration from rest. The car has a mass of 1600 kg. At this point it has a speed of 150 km h^{-1}.



(a) Calculate the car's final kinetic energy. (1 mark)

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(b) Calculate the potential energy the car has gained. (2 marks)

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(c) If the engine was operating at a power of 200 kW, calculate the mechanical energy losses. (3 marks)

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For Marker Use Only

Question 5

Jupiter has four (4) major moons and many smaller moons.

Here is some data for the 2 major moons:

	Orbital Radius r m (x 10^8)		Period T s (x 10^5)	
Ganymede	10.7		6.18	
Callisto	18.8		14.4	

(a) In the spaces in the table, calculate appropriate values that will give a straight line when plotted. (1 mark)

(b) Do you expect this graph to pass through the origin? Quote a relevant formula. (1 mark)

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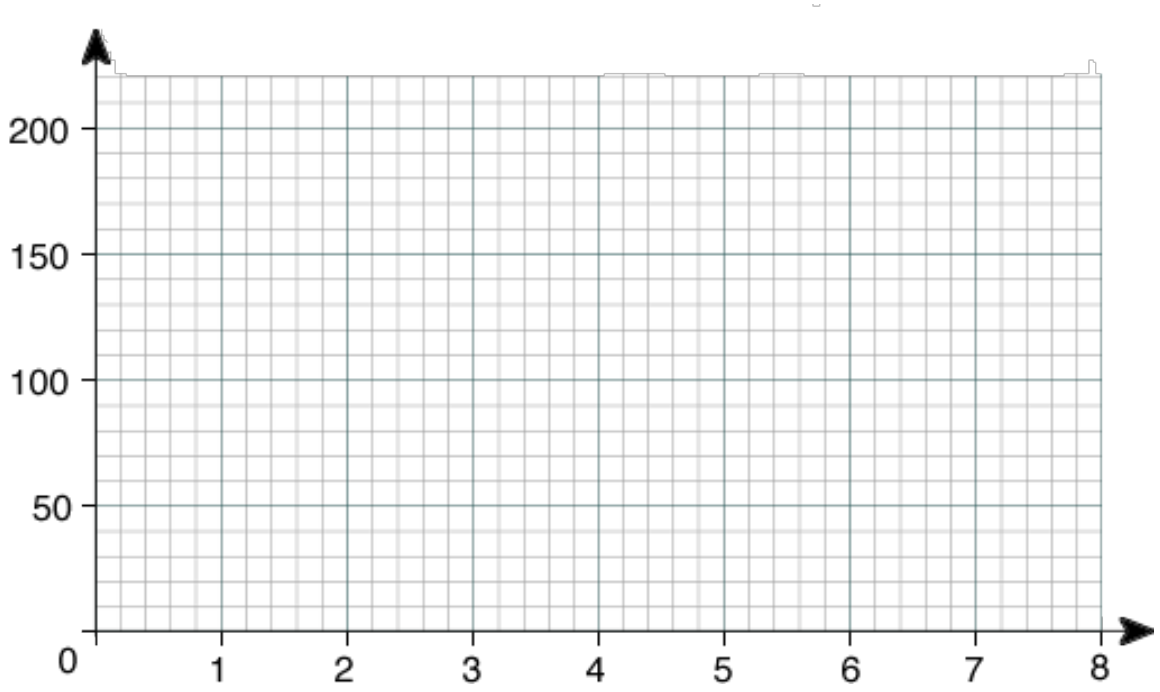
Question 5 continues.

For Marker Use Only

(c) Plot these values calculated on the graph below. (2 marks)



(d) Calculate the slope of this graph. (2 marks)

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(e) Hence find the mass of Jupiter. (2 marks)

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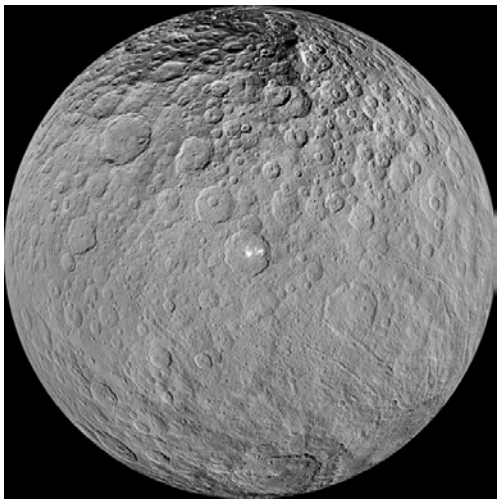
Question 6

For Marker Use Only

Ceres is the largest asteroid lying between the orbits of Mars and Jupiter.



(a) Ceres has a radius of only 473 km and a mass of 9.39 x10^{20} kg. It is much smaller than Earth's Moon. Calculate the gravitational field strength at Ceres' surface. (2 marks)

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(b) Ceres spins (rotates on its axis) once every 9.07 hours. Calculate the speed at which Ceres' equator moves. (1 mark)

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(c) Calculate the centripetal acceleration of an object on the equator of Ceres. (2 marks)

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Question 6 continues.

Question 6 (continued)

For Marker Use Only

(d) If you were standing on Ceres' equator, would you feel the full gravitational field strength contributing to your weight? Explain your reasons. (1 mark)

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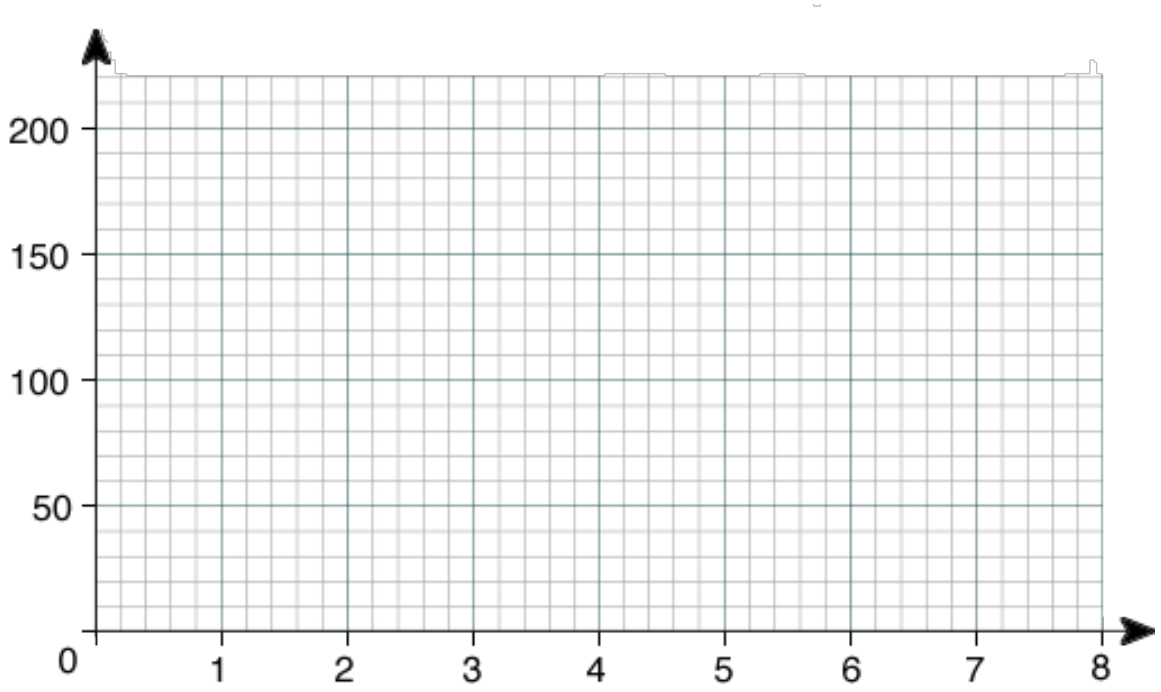
SPARE DIAGRAMS

Question 5 (c)



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OFFICE OF TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

Tasmanian Certificate of Education
External Assessment 2018

PLACE YOUR CANDIDATE LABEL HERE

PHYSICS

(PHY415115)

PART 2

Time: 45 minutes

Pages:	12
Questions:	6
Attachments:	Information Sheet

Candidate Instructions

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Criterion 6 Identify and apply principles and theories of electricity and magnetism.

Total: /40

Additional Instructions for Candidates

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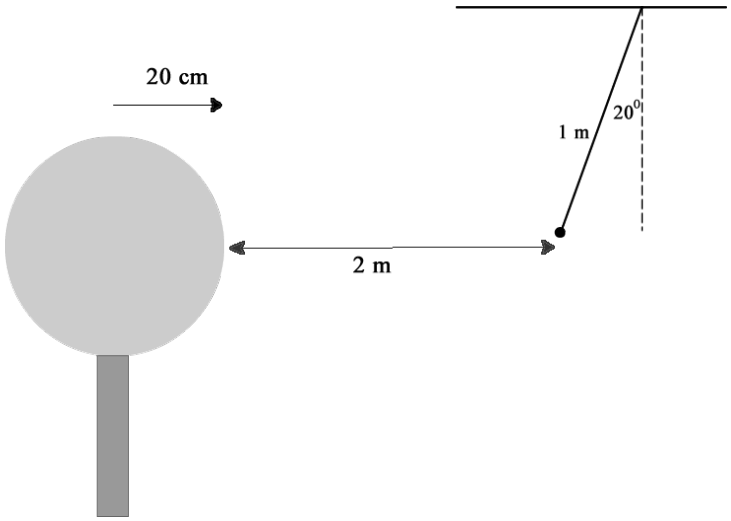
Question 7

For Marker Use Only

A van de Graaf generator of radius 20.0 cm is operating in your classroom.



A charged 5.00 mg ball is hanging from a 1 m thread at an angle of 20° to the vertical.

(a) Draw the forces on the ball. (2 marks)

(b) Show that the electrostatic force on the ball is about 1.8×10^{-5} N. (3 marks)

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(c) The charge on the ball is -5.00 nC. Find the electrostatic field strength in its vicinity. (1 mark)

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(d) If the ball is 2.00 m from the surface of the generator, determine the charge on the generator's surface? (2 marks)

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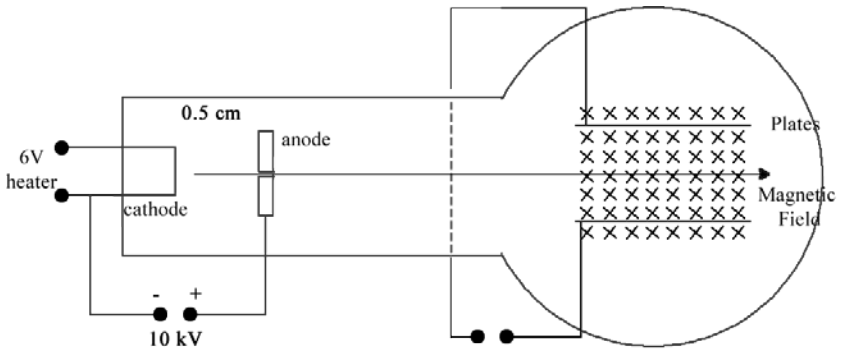
Question 8

For Marker Use Only

An electron accelerator consists of a cathode, usually heated to create thermionic emission, and an anode with a slit or hole in its centre.



(a) On the diagram, sketch the field lines between the cathode and anode. (1 mark)

(b) If the potential difference between the cathode and anode is 10.0 kV, and the separation is 0.500 cm, calculate the approximate electric field strength between the cathode and anode. (2 marks)

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(c) After passing through the hole, the electrons are no longer affected by the anode, even though they are leaving the positive charge on the anode. Why is this? (2 marks)

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Question 8 continues.

Question 8 (continued)

For Marker Use Only

(d) The electrons now enter a pair of charged parallel plates of field strength 3×10^5 V m^{-1} and a magnetic field of strength 5.06×10^{-3} T as in the diagram.

The electrons move in a straight line.

(i) What direction is the electric field between the plates? (2 marks)

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(ii) Calculate the speed of the electrons. (2 marks)

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(e) Show that the electron accelerator PD at 10.0 kV gives this same speed. (3 marks)

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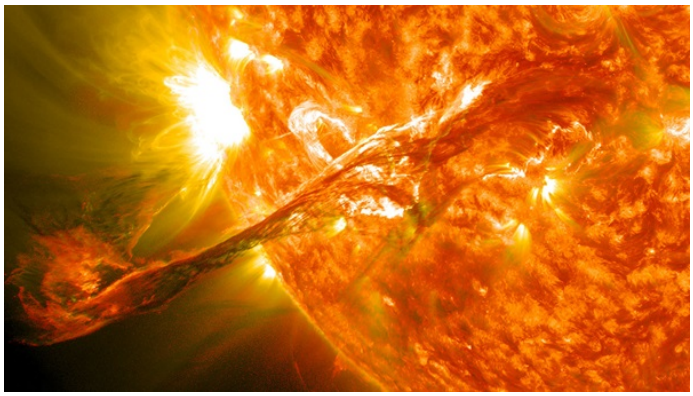
Question 9

For Marker Use Only

The Sun has magnetic storms leading to “prominences” consisting of protons travelling along magnetic field lines between sunspots. These field lines have a strength of about 0.001 T.



The protons are ejected from the Sun into the prominence magnetic field at an angle of 30° across and a speed of 3×10^6 m s^{-1}.

(a) Calculate:

(i) the component of the velocity perpendicular to the field line. (1 mark)

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(ii) the component parallel to the field line. (1 mark)

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(b) If the field lines of the prominence are about 2×10^5 km long from one sunspot to another, estimate the time for the ejected protons to re-enter the sun’s surface. (2 marks)

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(c) Calculate the radius of gyration of the protons. (3 marks)

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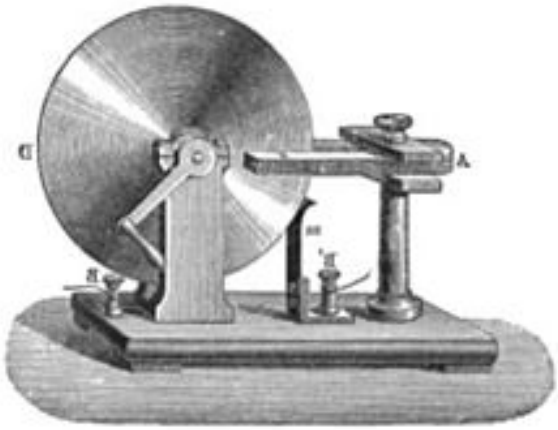
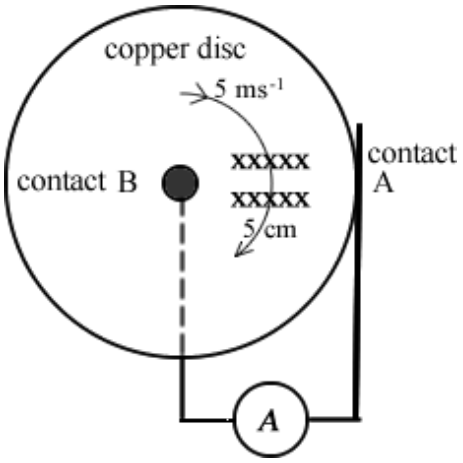
Question 10

For Marker Use Only

One of the earliest generators is the Faraday Disc.





It consists of a copper disc of very low resistance, with contacts at the centre and rim.
The disc is rotated through a powerful magnetic field.
Suppose 5 cm of the disc passes through a magnetic field of 0.2 T at 5 m s^{-1}.

(a) Is the charge at contact A positive or negative? (1 mark)

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(b) Determine the emf generated at the contacts. (2 marks)

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(c) If a current of 0.1 A is produced, calculate the force that must be applied to the disc to keep it rotating at this speed. (2 marks)

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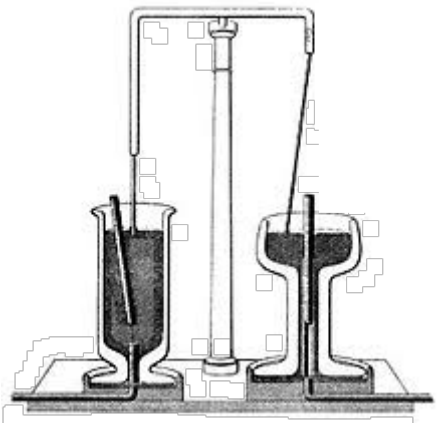
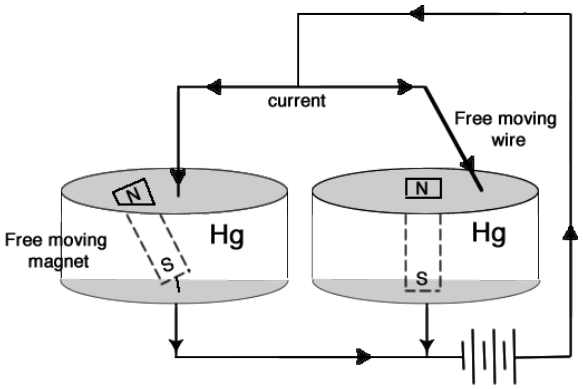
Question 11

For Marker Use Only

Faraday invented two electric motors in 1821. Each motor consisted of a jar containing the metal mercury. One had a wire straight down into it and a magnet freely floating upwards; the south pole is at the bottom and the north pole is at an angle near the wire.

The other had a fixed vertical magnet with the north pole out of the mercury and a wire freely suspended at an angle into the mercury near the magnet.

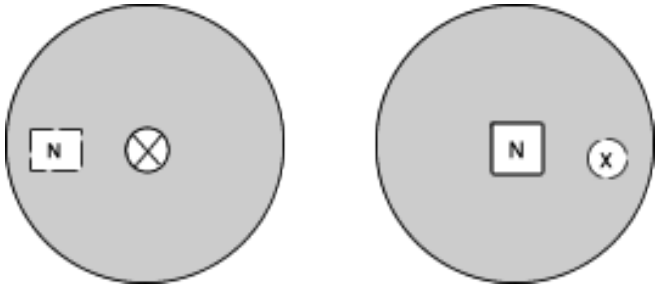




Current from a DC battery was passed through both wires downwards.

(a) On the sketch below, sketch the magnetic fields on the top of each mercury bowl of the central current wire on the left, and the central magnet on the right.

(2 marks)



(b) What will happen to the freely moving magnet in the left bowl? (1 mark)

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(c) What will happen to the freely moving wire carrying a current downwards in the right bowl? (1 mark)

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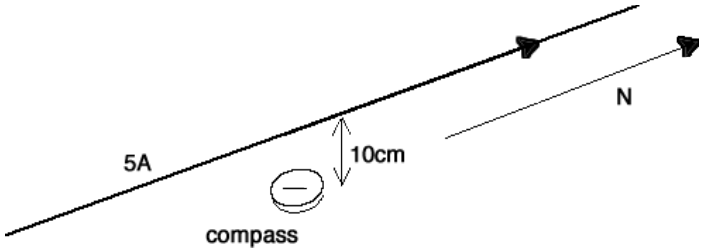
Question 12

For Marker Use Only

A long wire runs horizontally in a magnetic north/south horizontally. A compass is placed 10 cm directly beneath the wire and aligns with the Earth's field that has a value of 2.00×10^{-5} T.



A current of 5.00 A is passed north through the wire.

(a) Calculate the magnetic field strength due to the wire where the compass is placed. (2 marks)

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(b) In what direction will the compass point when the current is flowing north? (2 marks)

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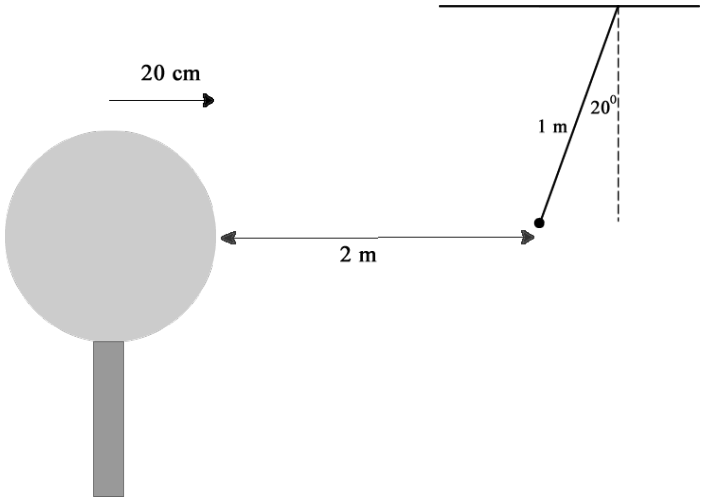
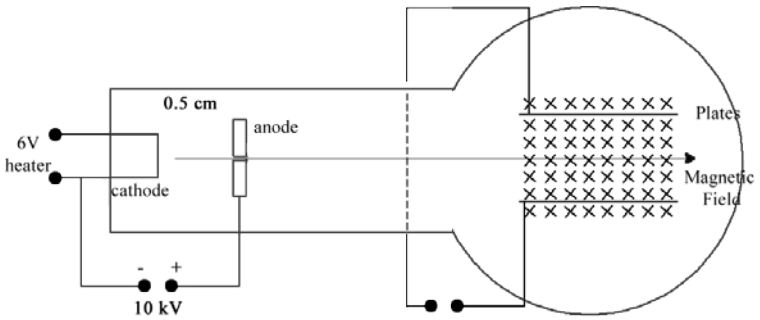
SPARE DIAGRAMS

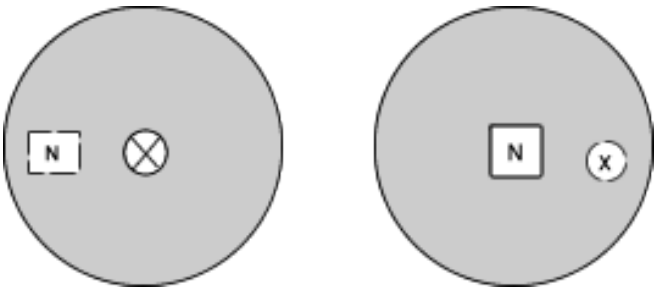
Question 7



Question 8



Question 11



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PHYSICS

(PHY415115)

PART 3

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Criterion 7 Identify and apply general principles of wave motion.

Total: /40

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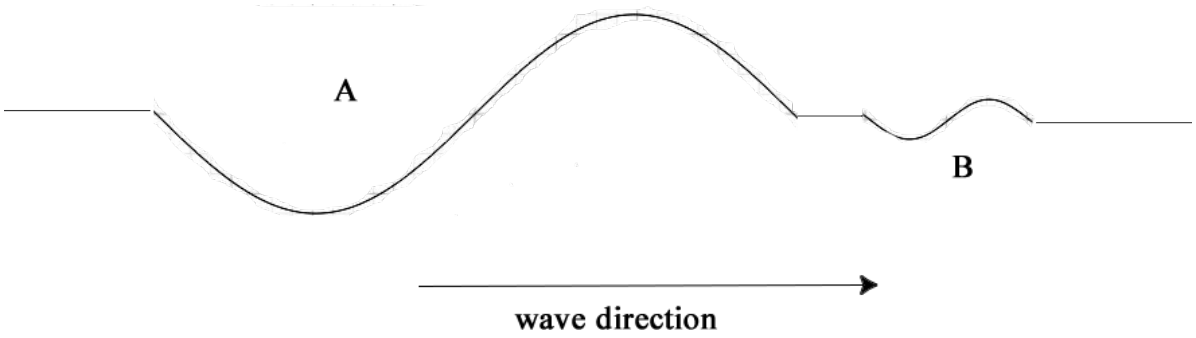
Question 13

For Marker Use Only

The speed of a sea wave in deep water is given by the equation, $v = 1.24\sqrt{\lambda}$.

Two sea waves are travelling in the same direction.



The first wave, A, is created by storms in the ocean and is often called a “swell”. It has a wavelength of 40 m.

(a) Calculate the speed of this wave A. (1 mark)

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The second wave, B, is created by local winds and has a wavelength of 10 m.

(b) Calculate the speed of wave B. (1 mark)

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(c) The drawing above shows the two waves moving from left to right.

Complete **two** sketch diagrams showing subsequent patterns as the waves pass each other. (2 marks)

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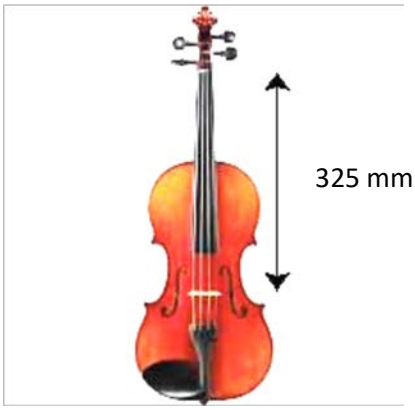
Question 14

For Marker Use Only

A violin string is 325 mm long between the bridges supporting it. The thinnest string, called the "E" string, is tuned to a frequency of 660 Hz.



(a) Calculate the wavelength of the fundamental frequency.

(1 mark)

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(b) If this string has a mass per length of 0.420 g m^{-1}, calculate the tension. (3 marks)

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(c) Whilst being played the string warms due to friction. Consequently, during a concert, the violin "E" string starts to make a "beating" sound of 10 beats each second when played with a flute at the same note.

Tightening the "E" string raises it back to its original pitch.

Calculate the vibration frequency of the "E" string when it went out of pitch. (2 marks)

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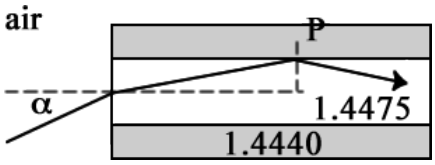
Question 15

For Marker Use Only

Communications companies often use optical fibres to transfer data across the world or to houses. The light used is in the infrared band at 1500 nm.

An optical fibre consists of a core of extreme high purity glass of diameter of 8 μm surrounded by another glass of lower refractive index.



The inner glass has a refractive index of 1.4475 and the outer one, a refractive index of 1.4440.

(a) (i) Calculate the speed of the infrared light in the inner core. (2 marks)

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(ii) Determine the time it takes for a signal to travel 16 000 km between Sydney and New York. (1 mark)

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(b) Calculate the critical angle between the two glasses of the fibre. (3 marks)

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(c) Calculate the incident angle α from air to glass such that the ray will refract to the critical angle at P. (3 marks)

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Question 16

For Marker Use Only

A thin, high quality wine glass rim can be made to resonate, even break, when certain frequencies are played from a loudspeaker or the human voice.

(a) Explain what is meant by the term “resonate”. (1 mark)

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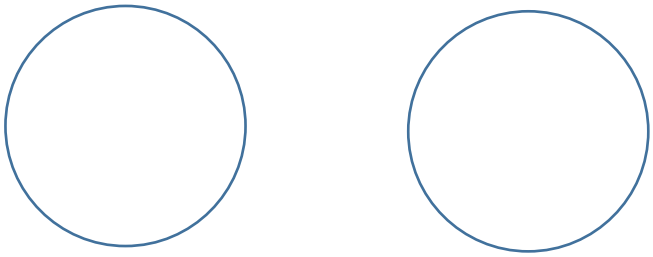
(b) Standing waves can only exist as full waves on a circle. Sketch the fundamental and first overtone standing waves on the circles representing the rims below. (2 marks)



(c) If the fundamental frequency is 200 Hz, what is the frequency of the first overtone? Justify this answer. (2 marks)

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Question 16 continues.

Question 16 continued

For Marker Use Only

(d) The radius of the rim is 3.00 cm, calculate the speed of the rim wave. (2 marks)

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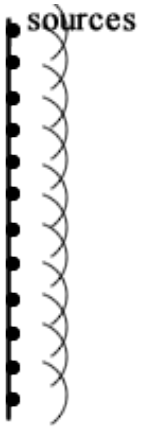
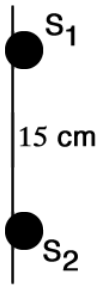
Question 17

For Marker Use Only

A military radar system is called “a phased array radar”. It consists of many equally spaced sources controlled by computer aided switching. It has no moving parts.



Consider two only neighbouring sources of radio waves. The sources are 15.0 cm apart and the wavelength of operation is 10.0 cm.



(a) If the sources emit the waves at the same moment, determine with the aid of the diagram above, how many antinodal lines will be formed. (2 marks)

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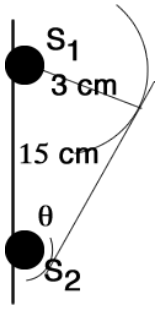
Question 17 continues.

(b) These antinodal lines can be directed away from the centre line by **delaying** the emission of one of the sources.

Suppose S_2 is delayed so the wave from S_1 has travelled 3.00 cm before S_2 emits.



Calculate the angle θ that the central antinodal line will be rotated. (2 marks)

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(c) Determine the time delay needed for the S_2 emission. (1 mark)

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(d) Sketch the new, redirected antinodal pattern. (2 marks)

(e) What will be the effect of having many equally spaced sources instead of two on the emitted pattern? (1 mark)

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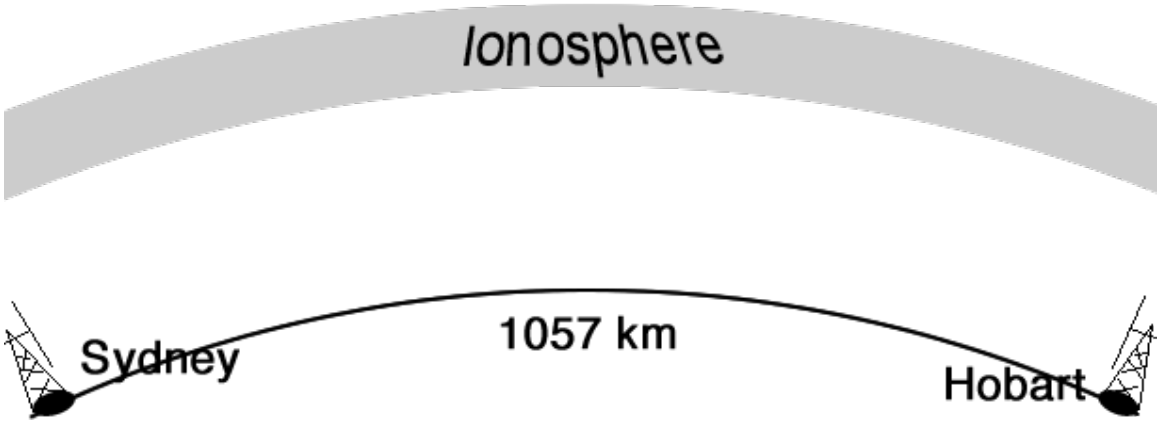
Question 18

In the upper atmosphere, ionisation by the Sun's radiation leads to the layer called the "Ionosphere". This layer is about 100 km above the surface but changes height depending on the Sun's activity and whether it is day or night. The ionosphere consists of electrons and ionised atoms and molecules.



Being highly charged, the ionosphere can both reflect and refract radio waves transmitted from Earth.

A radio station for transmitting between Hobart and Sydney (1057 km) is proposed.

Earth is curved with a radius of 6300 km.

(a) Without using the ionosphere, given the curvature of the Earth, which of the two wavelengths, 1 m or 200 m, is more likely to work over this range. Justify. (2 marks)

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(b) Is a reflection from the ionosphere more or less likely to cause the signal to reach Sydney? Justify. (2 marks)

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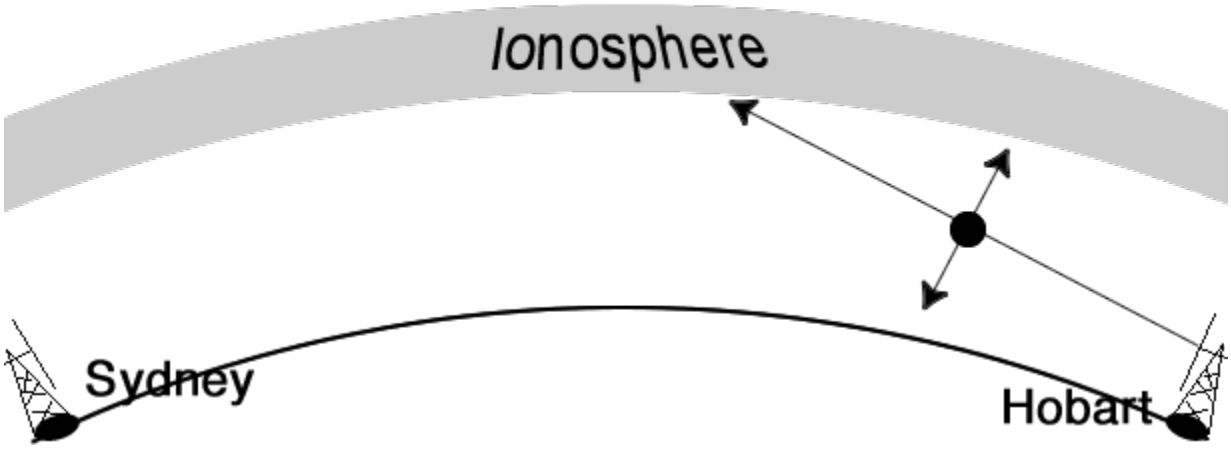
Question 18 continues.

Question 18 continued

For Marker Use Only

(c) If the incident radio wave is unpolarised, as shown by the dot and arrows, what degree of polarisation can be expected for the REFLECTED radio beam?
Indicate this on the diagram below. (2 marks)



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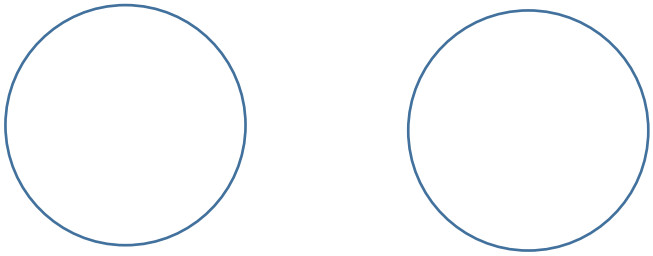
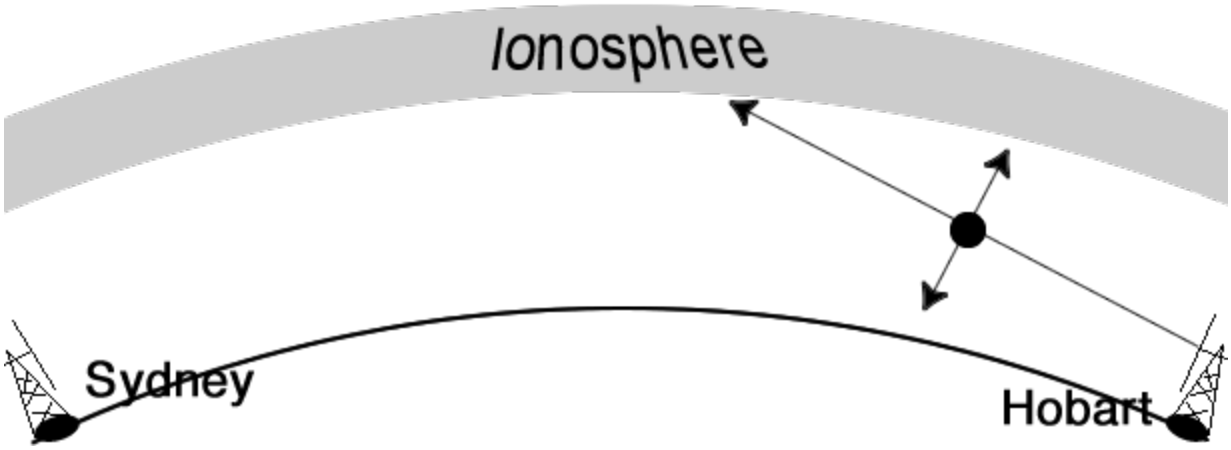
SPARE DIAGRAMS

Question 16



Question 18 (c)



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Tasmanian Certificate of Education
External Assessment 2018

PLACE YOUR CANDIDATE LABEL HERE

PHYSICS

(PHY415115)

PART 4

Time: 45 minutes

Pages:	12
Questions:	6
Attachments:	Information Sheet

Candidate Instructions

1. You **must** make sure that your responses to the questions in this examination paper will show your achievement in the criterion being assessed.
2. Answer **all** questions. Answers must be written in the spaces provided on the examination paper.
3. You should make sure you answer all parts within each question so that the criterion can be assessed.
4. This examination is 3 hours in length. It is recommended that you spend approximately 45 minutes in total answering the questions in this booklet.
5. The External Examination Information Sheet for Physics can be used throughout the examination.
6. All written responses must be in English.
7. TASC approved calculator may be used.

On the basis of your performance in this examination, the examiners will provide results on the following criterion taken from the course statement:

Criterion 8 Identify and apply principles of the wave-particle nature of light, atomic and nuclear physics and models of the nucleus and nuclear processes.

Total: /40

Additional Instructions for Candidates

Show all working in your answers to numerical questions. Some credit will be given for unsimplified answers. Credit cannot be given for an incorrect answer unless it is accompanied by details of the working. Appropriate units must be included.

Note:

- When candidates are asked to ‘show that’:
    - a candidate should calculate their own answer to three significant figures and use this subsequently.
    - a candidate who is unable to determine the required value should use the value given by the examiner in subsequent parts of the question.

Question 19

For Marker Use Only

(a) Stars are classified according to temperature and line spectra. The brightest of known stars are “O” type stars with a surface temperature of about 40 000 K.

(i) Calculate the peak wavelength of this type of star. What colour will it appear to the naked eye? (2 marks)

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(ii) Another type of star has the same surface temperature as an O type, but it is very dim and difficult to see even with big telescopes. What would that imply about the size of this star compared with the O type star? (1 mark)

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(b) When an O type star reaches the end of its life it progresses to a Type II supernova. These are characterised by very strong hydrogen line emission spectra.

If the H line spectrum is very strong, what does this imply about the presence of hydrogen? (1 mark)

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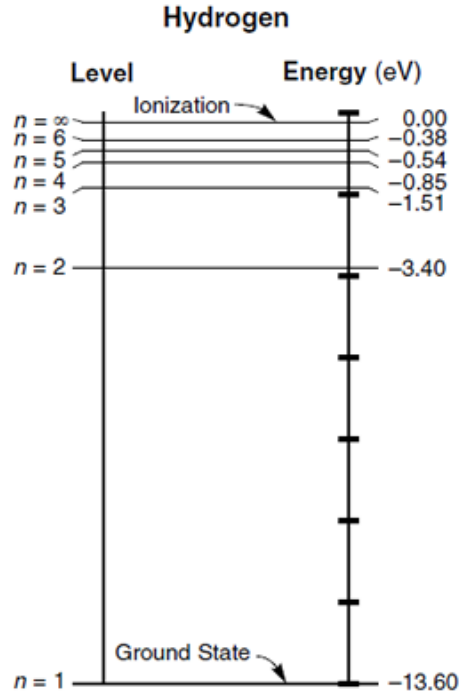
Question 19 continues.

Question 19 (continued)

For Marker Use Only

(c) The energy range of the electron orbits is listed in the diagram below.



Energy Levels for the Hydrogen Atom

Which quantum levels are associated with the photon H_α of wavelength 656 nm? Show working. (3 marks)

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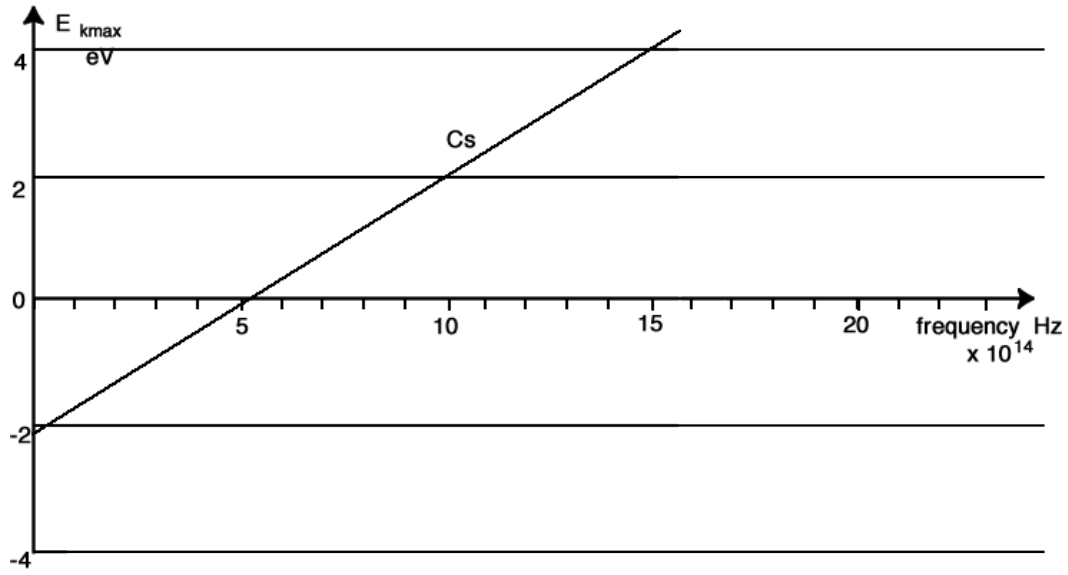
Question 20

For Marker Use Only

The $E_{K(max)}$ vs frequency graph of the metal caesium is given below.



(a) What is the work function of the metal in eV? (1 mark)

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(b) Calculate the wavelength at which the photoelectric effect is first noted. (2 marks)

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(c) Using a ruler, draw the equivalent line on the graph above for aluminium, Al, which has a work function of 4.08 eV. (1 mark)

(d) Use the graph to estimate the maximum kinetic energy of the photoelectrons emitted when photons of wavelength of 273 nm strike aluminium. (2 marks)

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Question 21

For Marker Use Only

An X-ray photon has a wavelength of 1.00×10^{-11} m.

(a) Calculate the photon's momentum. (1 mark)

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The photon enters a solid and is scattered by an electron. The new scattered photon emerges at 90^0 to its original direction with a wavelength of 1.24×10^{-11} m.

(b) Construct an appropriate diagram to calculate the momentum of the scattered electron. (2 marks)

(c) Calculate the scattered electron velocity. (3 marks)

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Question 22

For Marker Use Only

In the interior of the Sun, energy is created by the proton-proton cycle whereby four protons are converted into a helium $^4_2\mathrm{He}$ nucleus.

(a) Complete the nuclear equation describing this process. (2 marks)

$$4\ {}^1_1p \rightarrow {}^4_2\mathrm{He} + \_\_\_ + \_\_\_\_$$

(b) Calculate the energy emitted by one of the above nuclear processes in MeV.
(Mass $^4_2\mathrm{He}$ = 4.002604 u) (2 marks)

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(c) The Sun is 1.50 x 10^{11} m from Earth. At this radius, each square metre receives 1.36 kW in total electromagnetic radiation.

Given the area of a sphere is $A = 4\pi r^2$, show that the total energy emitted by the Sun in one second is about 4 x 10^{26} J. (2 marks)

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(d) Calculate the mass loss per second by the Sun through radiation. (1 mark)

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(e) Show that about 9 x 10^{37} nuclear reactions each second are required to produce this energy output. (2 marks)

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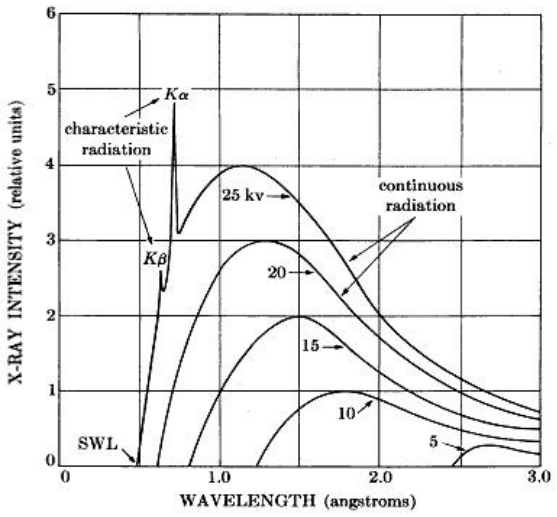
Question 23

For Marker Use Only

X-rays are usually produced by high energy electrons entering tungsten metal and interacting with both the electron structure and nucleus.

The graphs below represent the X-ray spectrum produced by tungsten.



The curves represent the spectrum at accelerating potential differences of 5 kV to 25 kV.

(a) For the curve for 25 kV, show that the shortest wavelength generated corresponds to the point marked SWL. (An angstrom is 1 x 10^{-10} m.) (2 marks)

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(b) What process generates the overall curve including the shortest wavelength? (1 mark)

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(c) The spikes marked K_α and K_β only start to appear on the 25 kV curve. Different elements place these spikes at different wavelengths. What process generates the spikes? (2 marks)

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Question 24

Potassium -40, $^{40}_{19}K$, is a naturally occurring radioisotope occurring at a percentage of 0.0100% of all potassium. It has a half-life of 1.30 x 10^9 years.

For Marker Use Only

A banana has approximately 400 mg of potassium.

(a) What mass of K-40 exists in a banana? (1 mark)

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(b) Calculate the activity of such a banana. (3 marks)

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(c) K-40 decays by β^- emission. Give the nuclear decay equation. (2 marks)

(d) Given the activity at a Geiger counter, due to background radiation of all other sorts, is approximately 24 counts min^{-1}, will a banana placed near a detector, make a noticeable change to the count rate observed? Justify. (1 mark)

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