OFFICE OF TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

Tasmanian Certificate of Education
External Assessment 2017

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# PHYSICS

## (PHY415115)

## PART 1

Time: 45 minutes

| | |
|---|---|
| Pages: | 12 |
| Questions: | 4 |
| 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 2017 External Examination Information Sheet for Physics can be used throughout the examination.
6. All written responses must be in English.

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.

**Note:**

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**Question 1**

For Marker Use Only

A car with a mass of 1250 kg is travelling downhill on a road with a slope of 8.50º at a constant speed of 60.0 km $h^{-1}$. Assume that the total frictional force acting on the moving car is a constant 1810 N.

(a) What is the component of the car's weight down the slope? (1 mark)

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The driver, while travelling downhill then exerts a steady braking force of $4.00 \times 10^3$ N on the car.

(b) (i) Determine the net force on the car while braking. (1 mark)

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(ii) Calculate the distance that the car will take to stop. (2 marks)

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(c) Calculate the net force on the driver while stopping (the driver has a mass of 65.0 kg). (2 marks)

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**Question 1 continues.**

**Question 1 (continued)**

For Marker Use Only

(d) If the car was initially travelling up the same hill with the same speed of 60 km $h^{-1}$, calculate the distance the car would now take to stop. Assume that the frictional force remains a constant 1810 N and the braking force is again 4.00 x $10^3$ N. (4 marks)

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(e) Using Newton's Second Law and Newton's Third Law explain why an icy road will affect the stopping distance of the car. (4 marks)

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**/14**

**Question 2**

For Marker Use Only

The Earth spins on its axis once a day. The radius of the Earth is 6370 km.

(a) Show that the tangential speed of a person on the equator is approximately 500 m $s^{-1}$.
(2 marks)

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(b) What is the magnitude and direction of their acceleration while on the equator?
(2 marks)

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(c) Draw a labelled diagram to show the forces on a person of mass 75.0 kg who is standing on the equator. (2 marks)

**Question 2 continues.**

**Question 2 (continued)**

For Marker Use Only

(d) If the centripetal force on the person of mass 75.0 kg is 2.52 N what would be the reading if they were standing on an accurate set of scales? (Answer in N or kg). (2 marks)

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(e) How much work is done by the gravitational force of the Earth on the person in one complete revolution? Explain your answer. (2 marks)

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**Question 3**

For Marker Use Only

A golf ball of mass 45.5 g is hit at 75.0 m $s^{-1}$ at an angle of 12.0º to the horizontal and as it comes down it lands on a hill that is 10.0 m higher than from where it was hit. Assume there is no air resistance.

(a) Show that the initial vertical component of the velocity of the ball is approximately 16 m $s^{-1}$. (1 mark)

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(b) Calculate the velocity of the ball after 1.50 s. (3 marks)

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(c) Determine the maximum height reached by the ball. (2 marks)

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**Question 3 continues.**

**Question 3 (continued)**

For Marker Use Only

(d) Find the speed at which the ball will land on the higher ground. (2 marks)

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(e) Find the change in momentum in the first 0.500 s. (2 marks)

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**Question 4**

For Marker Use Only

A satellite of mass 2.50 x $10^3$ kg is to be placed in orbit around Mars at a height of 1.15 x $10^6$ m above the surface.

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|---|---|
| Mass of Mars | 6.42 x $10^{23}$ kg |
| Radius of Mars | 3.40 x $10^6$ m |
| Period of rotation for Mars | 8.86 x $10^4$ s |

(a) (i) Determine the orbital period of the satellite. (2 marks)

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(ii) Calculate the speed of the satellite. (1 mark)

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(b) Would a satellite in lower orbit have larger or smaller kinetic energy? Justify your answer. (2 marks)

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(c) What is the period of orbit of a Mars-synchronous satellite? (1 mark)

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# PHYSICS

## (PHY415115)

## PART 2

Time: 45 minutes

| | |
|---|---|
| Pages: | 16 |
| Questions: | 6 |
| Attachments: | Information Sheet |

### Candidate Instructions

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6. All written responses must be in English.

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

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

Total: /40

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# Additional Instructions for Candidates

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- A spare set of diagrams has been provided in the back of the answer booklet for you to use if required. If you use the spare diagrams, you **MUST** indicate you have done so in your answer to that question.

**Question 5**

For Marker Use Only

Two parallel wires carrying an electric current are shown; **X** carries 350 A into the page, while **Y** carries 215 A out of the page. The wires are separated by a distance of 12.0 m.

(a) Sketch on the diagram below the expected resultant magnetic field pattern in the region around the wires. (2 marks)


(b) Determine the strength and direction of the magnetic field caused by the current in wire **X** at a point **P** that is 5.00 m below the wire **X**. (2 marks)

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**Question 5 continues.**

**Question 5 (continued)**

For Marker Use Only

(c) Calculate the resultant magnetic field strength at the point 7.00 m to the right of **X** on the line between the wires. (3 marks)

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**Question 6**

For Marker Use Only

A point **P** is situated 80.0 cm east of point **Q**.

A charge of +3.00 x $10^{-6}$ C is placed at **P** and a charge of -3.00 x $10^{-6}$ C is placed at **Q**.

(a) Sketch the expected resultant electric field pattern in the region around the charges. (2 marks)


(b) Find the magnitude and direction of the electric field at a point half way between the charges. (2 marks)

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(c) Calculate the force on an electron placed half way between the charges. (2 marks)

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**Question 7**

**For Marker Use Only**

The solar wind is a stream of charged particles that flows out from the sun in all directions at speeds of about $4.00 \times 10^5$ m $s^{-1}$.

(a) Which way would protons from the sun be deflected as they enter the Earth's magnetic field? Assume that the protons were initially heading toward the magnetic equator of the Earth. (2 marks)

(b) Determine the force exerted by the magnetic field of the Earth on these protons. Assume the strength of the Earth's magnetic field is 52.0 μT. (2 marks)

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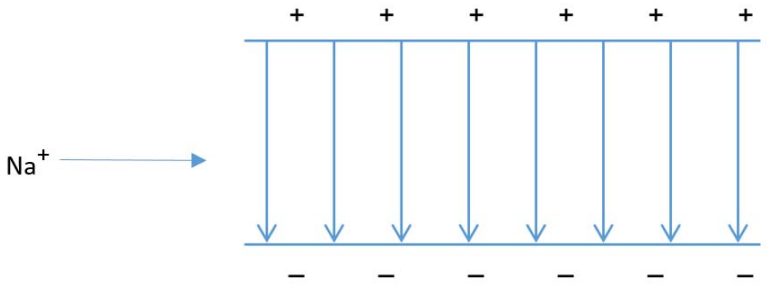
(c) Another solar wind proton strikes the magnetic field of the Earth in the Northern Hemisphere at an angle of 35º to the magnetic field. Sketch the path the proton would follow. (3 marks)

**/7**

**Question 8**

For Marker Use Only

A sodium ion $Na^+$ (mass = $3.82 \times 10^{-26}$ kg) that has been accelerated horizontally from rest, enters a uniform E-field created by two parallel plates 10.0 cm apart with a potential difference between them of $2.20 \times 10^3$ V.




(a) (i) What is the direction of the force on the ion? (1 mark)

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(ii) What is the shape of the path taken by the ion? (1 mark)

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(b) Calculate the magnitude of the acceleration of the ion just after it enters the electric field. (3 marks)

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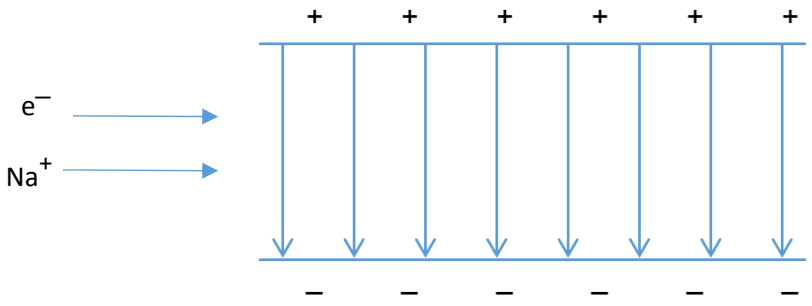
**Question 8 continues.**

(c) A sodium ion and an electron are travelling horizontally at the same speed and enter the electric field. On the diagram below draw the path taken by each particle. Justify your answer using suitable equations. (3 marks)

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(d) What is the acceleration of the sodium ion when it is 1.00 cm from the plate? (1 mark)

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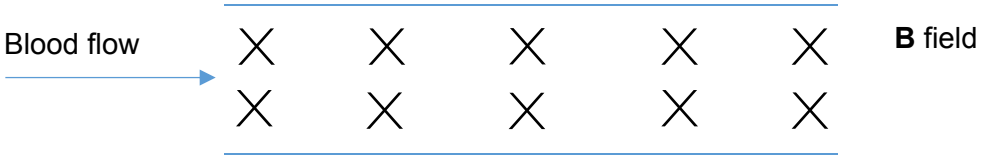
**/9**

**Question 9**

For Marker Use Only

The Hall Effect is the production of a potential difference (voltage) when a liquid containing charges is passed between the poles of a magnet. Doctors can use this to measure the velocity of blood in an artery because blood contains positive ions.




(a) If blood is flowing towards the right and passes through a magnetic field into the page, which way will positive ions be deflected? (1 mark)

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When a magnetic field of strength 0.200 T is applied the potential difference induced in two horizontal plates 5.00 cm apart is 1.10 mV.

(b) Calculate the velocity of the ions. (2 marks)

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(c) If the blood were flowing twice as fast what would be the voltage that is induced? (1 mark)

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**Question 10**

For Marker Use Only

When a strong magnet is dropped down a vertical aluminium tube 1 metre long it takes about 5 seconds to emerge from the bottom.

(a) Why does it take much longer to reach the bottom than a piece of iron of a similar mass that is dropped through the tube? (3 marks)

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(b) What would be the effect on the time of fall of the magnet of cutting vertical slits in the aluminum tube? (2 marks)

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(c) If a stronger magnet of the same mass was dropped down the tube, would the time taken to emerge change? Explain. (2 marks)

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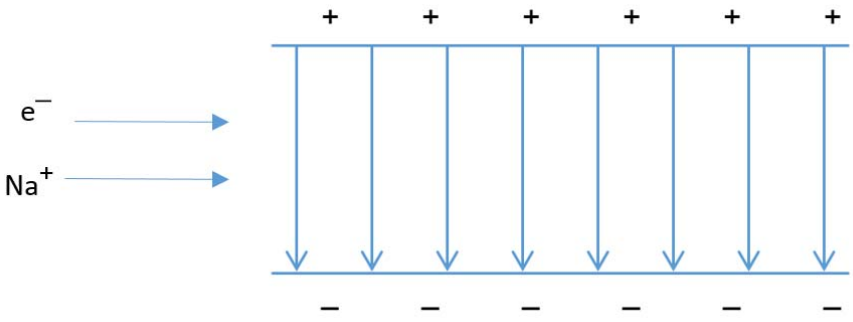
# SPARE DIAGRAMS

**Question 5**


**Question 6**


**Question 8**



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# PHYSICS

## (PHY415115)

## PART 3

Time: 45 minutes

| | |
|---|---|
| Pages: | 12 |
| Questions: | 5 |
| Attachments: | Information Sheet |

### Candidate Instructions

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

**Criterion 7** Identify and apply general principles of wave motion.

Total: /40

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# Additional Instructions for Candidates

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**Question 11**

For Marker Use Only

A chimney in a two storey house is 8.50 m high. It is effectively a column of air, closed at the bottom and open at the top.

(a) What is the lowest frequency of sound that will cause the air in the chimney to resonate? Show on the diagram where the nodes and antinodes will occur. (3 marks)

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(b) Since we are only able to hear sounds above 20 Hz, what is the lowest resonant frequency sound that we could hear from the chimney? Show on the diagram the standing wave that is set up. (3 marks)

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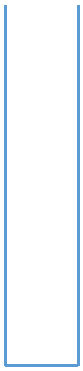
**Question 11 continues.**

**Question 11 (continued)**

For Marker Use Only

(c) Mark on the diagram below the way a particle of air at the top of the chimney would be oscillating when the air column in the chimney is **resonating**. Label the position(s) where the amplitude of the standing wave would be least. (2 marks)



(d) On a very cold day in winter the speed of sound is less. Will this change the pitch of the sound that you hear coming from the chimney? Explain your answer. (2 marks)

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**Question 12**

For Marker Use Only

Blue light has a frequency that is about 40% greater than the frequency of red light.

(a) When light from a red laser is shone onto a single slit of width $5.50 \times 10^{-5}$ m, diffraction of the light occurs and a diffraction pattern would be visible on a screen placed some distance away. Draw a sketch below to show the shape of this diffraction pattern. (2 marks)

(b) How would the size of the diffraction pattern of light from a blue laser differ from that of a red laser? (1 mark)

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(c) Why are coherent light sources needed to observe interference effects of light? (2 marks)

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(d) What does it mean to say that a laser is a source of coherent light? (3 marks)

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**Question 13**

For Marker Use Only

A length of piano wire 80.0 cm long is supporting a mass of 5.00 kg.

(a) If the mass of the wire is 16.0 g, find the velocity of a wave in the wire. (2 marks)

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(b) Calculate the velocity of a wave in a similar piece of wire that is twice as long, and supporting the same mass of 5.00 kg. (2 marks)

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(c) Determine the lowest frequency note that the wire in part (b) would produce if made to vibrate. (2 marks)

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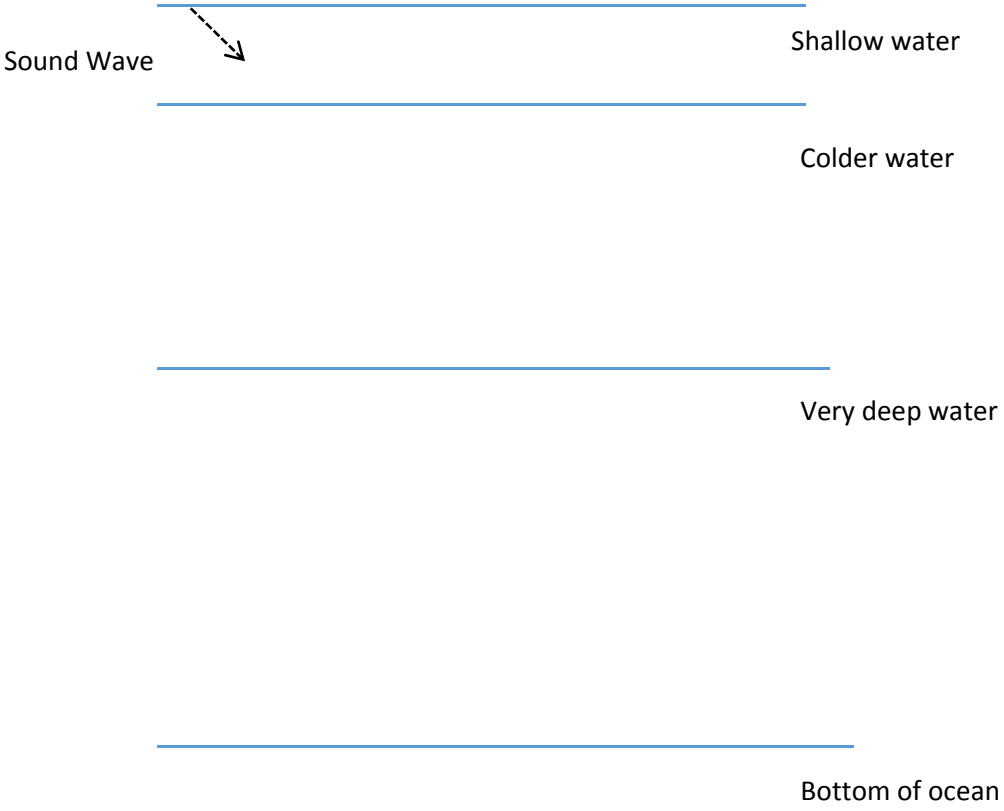
**Question 14**

For Marker Use Only

The speed of sound in oceans depends on many factors. Temperature and pressure are two important variables.

- Near the surface, the temperature decreases with depth and this causes the speed of sound to decrease.
- At greater depths, increases in pressure cause the speed of sound to increase again.

(a) On the diagram below, show the path of the sound wave as it travels down through the ocean. (3 marks)




**Question 14 continues.**

**Question 14 (continued)**

For Marker Use Only

(b) Where **in the ocean** might total internal reflection take place? (2 marks)

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(c) If the speed of sound in two adjoining layers of water are 1450 m $s^{-1}$ and 1480 m $s^{-1}$, what would be the critical angle for a sound wave? (2 marks)

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(d) A sound wave travelling in the air at 80º to the water surface is partially transmitted and partially reflected.

If the speed of sound in the top layer of the water is 1430 m $s^{-1}$, find the angle of refraction. (3 marks)

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**Question 15**

For Marker Use Only

Two thin parallel slits are separated by a distance of 0.250 mm. When a laser of wavelength 633 nm is shone onto them an interference pattern can be observed on a screen 8.75 m away.

(a) Show that the distance between successive fringes is approximately 2 cm. (1 mark)

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(b) What is the path difference that will cause the 5th dark band? (1 mark)

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(c) Determine the angle between the centre of the interference pattern and the 5th dark band. (2 marks)

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(d) Since light from a laser is polarised, what would happen if a sheet of polaroid material was placed between the laser and the slits and then rotated through 360º? (2 marks)

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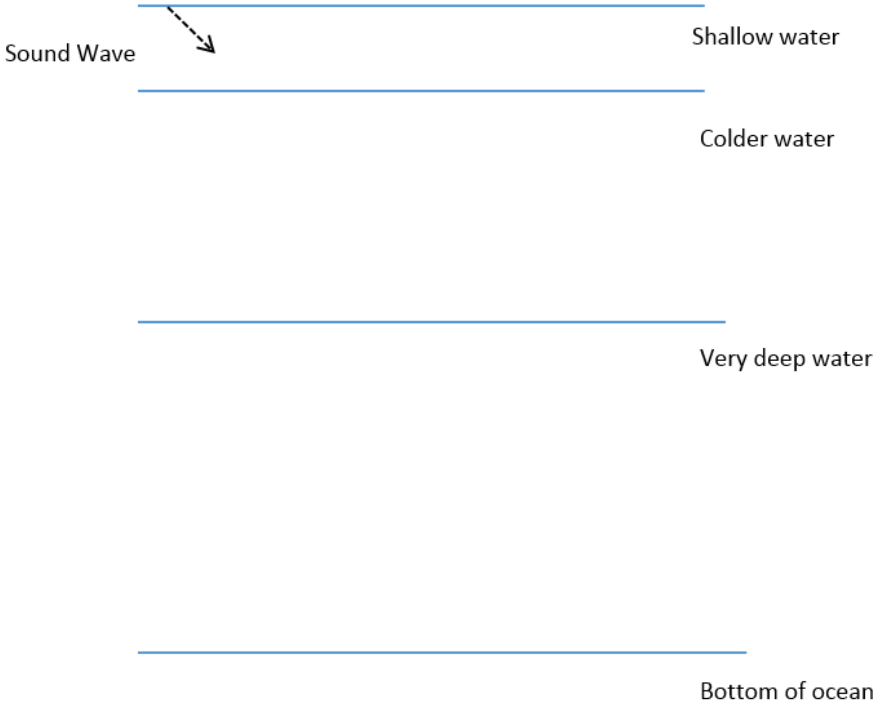
# SPARE DIAGRAMS

**Question 11**

**Question 14**



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# PHYSICS

## (PHY415115)

## PART 4

Time: 45 minutes

| | |
|---|---|
| Pages: | 8 |
| Questions: | 5 |
| Attachments: | Information Sheet |

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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

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**Question 16**

For Marker Use Only

(a) The peak wavelength emitted by a black body is described by Wien's Law.

(i) What is meant by the peak wavelength? (2 marks)

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(ii) Sketch a graph with labelled axes to show the peak wavelength. (2 marks)

(b) The radiation emitted by the sun has a peak wavelength of 502 nm.

(i) What is the temperature of the region of the sun that is emitting this radiation? (1 mark)

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(ii) What is the energy of a photon of light with the peak wavelength? (2 marks)

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(iii) As the sun slowly cools what will be the effect on the peak wavelength? (1 mark)

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**Question 17**

For Marker Use Only

Einstein was the first person to explain the photoelectric effect.

(a) What is the work function of a material? Give two units that it can be measured in. (2 marks)

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(b) To observe the photoelectric effect with copper, the light shining on the copper must have a frequency greater than $1.13 \times 10^{15}$ Hz. Calculate the work function of copper. (2 marks)

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(c) What will be the maximum energy of the photoelectrons emitted from copper if the incoming light has a frequency of $7.21 \times 10^{15}$ Hz? (2 marks)

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(d) What will be the effect on the maximum kinetic energy of the photoelectrons if the intensity of the incoming light is doubled? Assume that the light is above the threshold frequency. (1 mark)

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(e) If the power of the incoming light (frequency of $7.21 \times 10^{15}$ Hz) is 1.50 nW, how many photons will be hitting the copper every second? (2 marks)

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**Question 18**

For Marker Use Only

A hospital uses an X-ray tube to produce X-rays that have a minimum wavelength of $1.50 \times 10^{-12}$ m.

(a) Calculate the minimum voltage required to produce these X-rays. (2 marks)

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(b) Determine the momentum of one of these X-ray photons. (2 marks)

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(c) What are the risks that need to be considered by a doctor before giving an X-ray? (2 marks)

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**Question 19**

For Marker Use Only

A commonly used radioisotope in medicine is Iodine-125 which has a half-life of $5.13 \times 10^5$ s (59.40 days). The initial activity of a sample of iodine is $1.56 \times 10^8$ Bq.

(a) What will be the activity of the sample after 75 days? (2 marks)

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(b) Define a Becquerel? (1 mark)

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(c) How long will it take until the activity of the iodine is one tenth of the initial activity? (3 marks)

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(d) Calculate the number of atoms of I-125 in a sample that has an activity of $1.56 \times 10^9$ Bq. (3 marks)

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**Question 20**

For Marker Use Only

Tritium is an isotope of hydrogen with 2 neutrons in the nucleus. It can be made by bombarding $^{6}_{3}\mathrm{Li}$ with a slow neutron.

(a) What other nucleus would be formed in the reaction? Write an equation for the nuclear reaction. (2 marks)

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(b) The energy released in this transmutation is 4.80 MeV.
Calculate the mass defect in kg. (2 marks)

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(c) Tritium decays by $\beta^-$ emission. Write the equation for this decay. (1 mark)

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(d) The half-life of tritium is 12.3 years. At one of the damaged Fukushima nuclear reactors in Japan, the activity caused by tritium is estimated to be 875 TBq.

The isotopic mass of tritium is 3.016049 amu.

Find the mass of tritium currently at the reactor. (3 marks)

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