Tasmanian Certificate of Education

PHYSICS

Senior Secondary

Subject Code: PHY315114

External Assessment

2014

Part 1

Time: approximately 45 minutes

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

Criterion 5   Demonstrate knowledge and understanding of Newtonian mechanics including gravitational fields.

Section Total
/40

Pages: 16
Questions: 5

TASMANIAN QUALIFICATIONS AUTHORITY

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CANDIDATE INSTRUCTIONS

You **MUST** make sure that your responses to the questions in this examination paper will show your achievement in the criteria being assessed.

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

Note:

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This examination is 3 hours in length. In total it is recommended that you spend approximately 45 minutes answering the questions in this part.

The 2014 External Examination Information Sheet for Physics can be used throughout the examination.

No other written material is allowed into the examination.

All written responses must be in English.

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Question 1

The diagram below shows a person on snow skis sliding down a snow-covered slope at **constant speed**. The mass of the person and skis combined is 75.0 kg and the force of friction between the skis and the slope is 150 N.
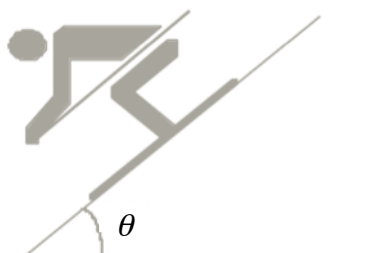
(a)   On the diagram, draw the main forces acting on the skier. Then, in the space on the right, draw a clear vector diagram of those forces. Your vectors should be clearly labelled and drawn roughly to scale.   (3 marks)

(b)   Show that the smallest angle (to the horizontal) which will allow the skier to slide down the slope, without pushing, is approximately 12˚.   (2 marks)

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Question 1 continues.

Question 1 (continued)

A while later, the skier is towed **up** the same slope at a constant speed of 1.50 m s^{-1}. The frictional forces remain the same.

(c)   Calculate the amount of work done by the tow-rope in **one second**.   (3 marks)

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(d)   What power is required to tow the skier up the slope?   (1 mark)

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Question 2

Modern cars incorporate 'crumple zones' where the body of the car is designed to undergo controlled collapse during a crash. Older cars were usually built with rigid bodies.

(a)   Explain in terms of the forces involved why modern cars are safer for passengers during a crash.   (2 marks)

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A Crash Data Retrieval (CDR) system is designed to record information about the motion of a car both before and during a collision. The first graph shows the speed of a modern car from the moment the driver saw a hazard until just before the collision. The second graph relates to the motion of the car during the actual collision.

Speed vs time before collision

Speed vs time for car during collision
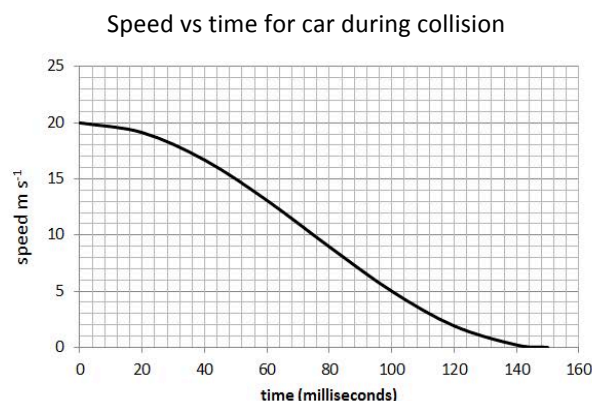
(b)   Determine, for the period before the collision:

(i)   the reaction time of the driver   (1 mark)

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(ii)   the maximum deceleration of the car.   (2 marks)

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Question 2 (b) continues.

Question 2 (b) (continued)

    (iii)   how far the car travelled during this period before the collision.   (2 marks)

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(c)   Determine an approximate value of the maximum deceleration of the car during the collision.   (2 marks)

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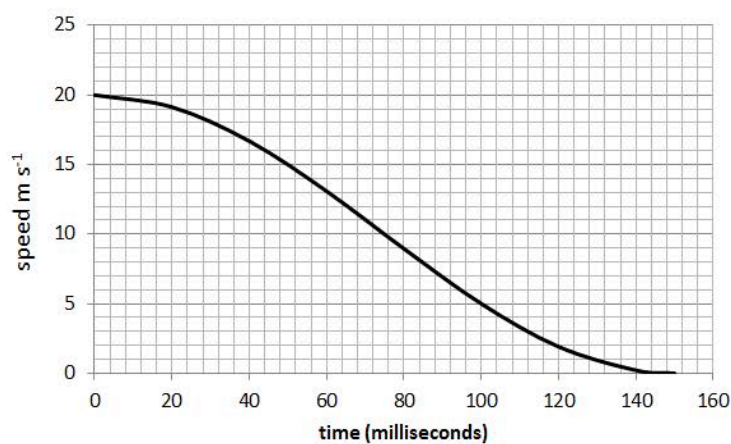..

(d)   On the copy of the second graph reproduced here, draw a likely curve for a collision involving an **older** car. Justify your answer.   (2 marks)

Speed vs time for car during collision

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/11

For Marker Use Only

Question 3

On a golf course, the 11th hole features a 35.0 m drop from the tee to the green. A golfer on the tee hits a ball with a speed of 45.0 m s^{-1} and angle of elevation 48.0˚. In answering the questions ignore air-resistance.

(a)　On the diagram below, sketch the flight of the ball.　(1 mark)

Tee

35 m

Green

Question 3 continues.

Question 3 (continued)

(b) (i) Show that the vertical component of the velocity of the ball as it lands is approximately 42.0 m s^{-1}. (2 marks)

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(ii) Hence or otherwise, show that the total time of flight of the ball is approximately 7.8 s. (2 marks)

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(c) What horizontal distance would you expect the ball to travel before it lands? (1 mark)

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(d) Calculate the maximum height of the ball relative to where it lands. (2 marks)

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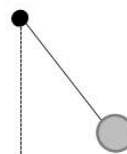
/8

Question 4

There is a 75.0 g ornament suspended by a thread from the rear-view mirror of a car. As the car accelerates northwards, the driver notices the ornament hangs at 11.0˚ from the vertical.

(a)   Add vectors to each of the diagrams below to show the forces on the ornament:

(2 marks)

      (i)   before the car moved

      (ii)   as the car accelerates

← North

(b)   Show that the magnitude of acceleration of the car in part (a) (ii) is approximately 2 m s^{-2}.

(2 marks)

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Question 4 continues.

Question 4 (continued)

Later, the car rounds a bend to the west while travelling at a constant speed of 15.0 m s^{-1}. The driver notices that the ornament hangs at the same angle of 11.0° from the vertical.

(c)   Explain why this occurs even though the car is travelling at a constant speed.

(2 marks)

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(d)   Calculate the radius of the bend in the road.   (2 marks)

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Question 5

In 2011, the space vehicle 'Dawn' became the first man-made object to orbit an asteroid when it went into orbit around the asteroid Vesta.

Dawn's orbit had a radius of 943 km and period of 6.86 hours. Assume Vesta is spherical, with a radius of 263 km.

In this question, ignore any gravitational effects of the Sun or other objects.

(a)   Show that the mass of Vesta is approximately 8×10^{20} kg.   (2 marks)
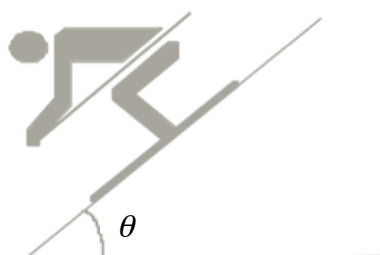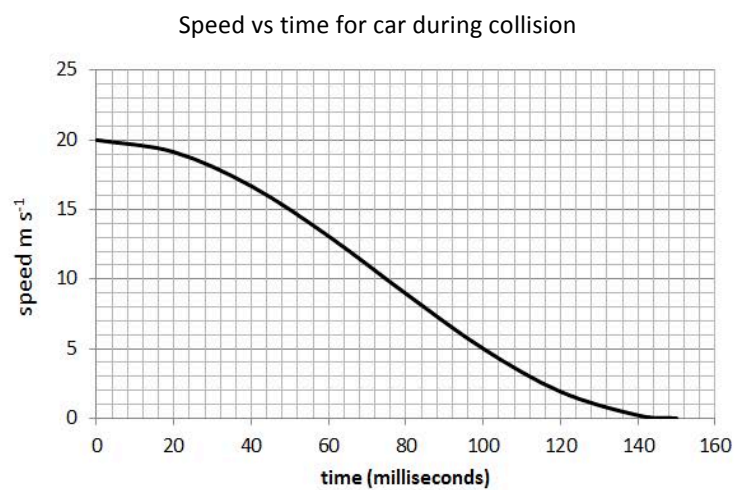
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(b)   Calculate the value of the acceleration due to gravity at the surface of Vesta.   (2 marks)

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SPARE DIAGRAMS

Question 1 (a)

Question 2 (d)

Speed vs time for car during collision

SPARE DIAGRAMS

Question 3 (a)

Tee

35 m

Green
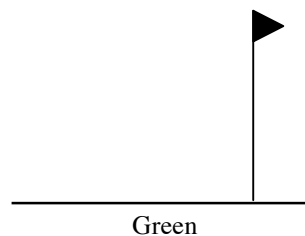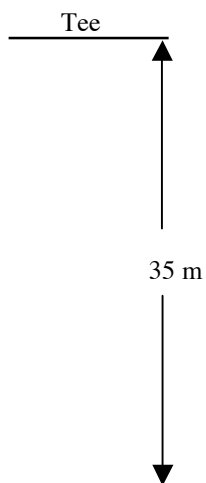
Question 4 (a)

(i) before the car moved
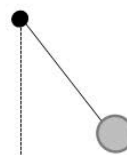
(ii) as the car accelerates

North

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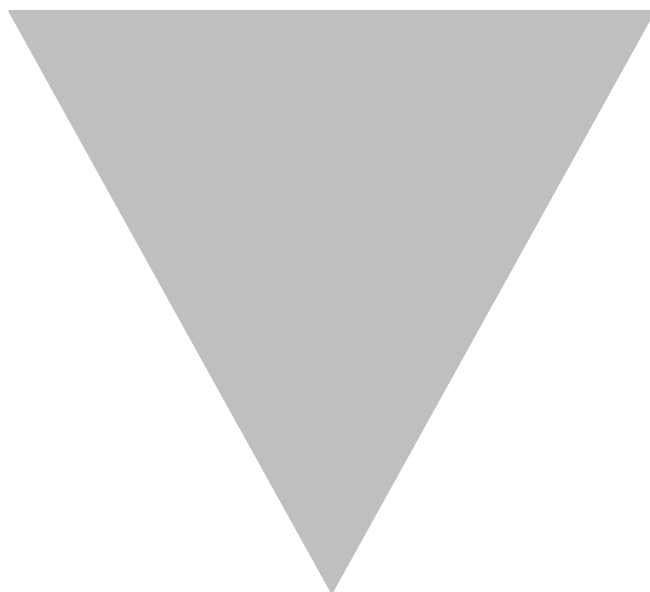
Tasmanian Certificate of Education

PHYSICS

Senior Secondary

Subject Code: PHY315114

External Assessment

2014

Part 2

Time: approximately 45 minutes

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

Criterion 6   Demonstrate knowledge and understanding of principles and theories of electricity and magnetism.

Section Total
/40

CANDIDATE INSTRUCTIONS

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Question 6

In a linear motor, a freely-moving conductor is connected to two long rails. A magnetic field creates a force on the conductor.

In an industrial process, the conductor is a small metal rod, which is being accelerated to a high speed towards the right.

metal rod

Battery

6.00 cm
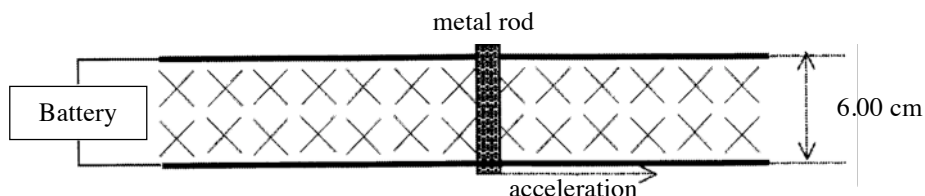
acceleration

(a)   On the diagram show the direction of the current causing this acceleration of the metal rod.   (1 mark)

(b)   If the magnetic field strength is 2.50 T and the current is 20.0 kA, calculate the force on the moving rod.   (1 mark)

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(c)   (i)   The rod accelerates to a speed of 400 m s^{-1}. Calculate the maximum value of the emf induced in the moving rod and indicate its direction.   (2 marks)

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       (ii)   What instantaneous power must be provided to overcome this induced emf?
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Question 7

(a) Two straight parallel wires, **X** and **Y**, are carrying currents of 100 A and 200 A respectively in opposite directions. The wires are separated by a distance of 20.0 cm.

   (i)   Calculate the force per metre between the wires.   (2 marks)

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   (ii) Sketch the likely **B**-field pattern in the region around the wires.   (2 marks)

Question 7 continues.

Question 7 (continued)

(b)   A physicist is standing 14.0 m north of a cable running east-west. The cable is carrying 1200 A of current towards the west.

⊗
                                                      north ⟶

(i)   Calculate the magnetic field strength due to the current where the physicist is standing. On the diagram above clearly indicate the direction of the field.

(2 marks)

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(ii)   The physicist knows that the Earth's magnetic field where he is standing is 60.0 μT horizontally, towards the north.

Evaluate the resultant magnetic field strength at his position.   (2 marks)

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Question 8

Two equal charges Q_1 and Q_2 of $+5.00 \times 10^{-8}$ C are fixed in position as shown. A point **P** is vertically above the mid-point of Q_1 and Q_2.
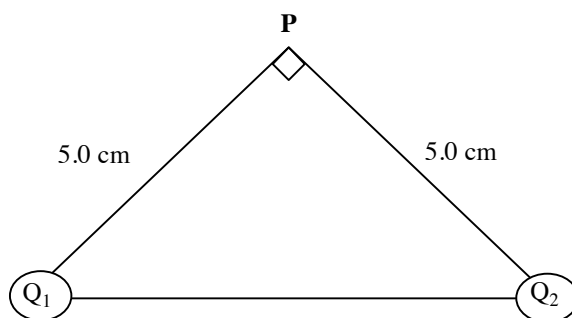
(a)   On the diagram above, sketch the resultant E-field around the two charges.   (1 mark)

(b)   (i)   Determine the E-field at **P** due to Q_1.   (2 marks)

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(ii)   Hence, show that the resultant E-field at **P** has a magnitude of approximately 3×10^5 SI units.   (2 marks)

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Question 8 (b) continues.

Question 8 (b) (continued)

(iii) A small particle of charge $+1.50 \times 10^{-9}$ C is then placed at **P**. This particle remains stationary at **P**.

Determine the mass of this particle. (2 marks)

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Question 9

If a 'live' electrical transmission line falls and makes contact with a point on the ground, it creates an electric field in the ground around the point of contact. The following graph shows the potential difference between such a live line and points on the ground at increasing distance from the line.

Potential difference Vs distance from line
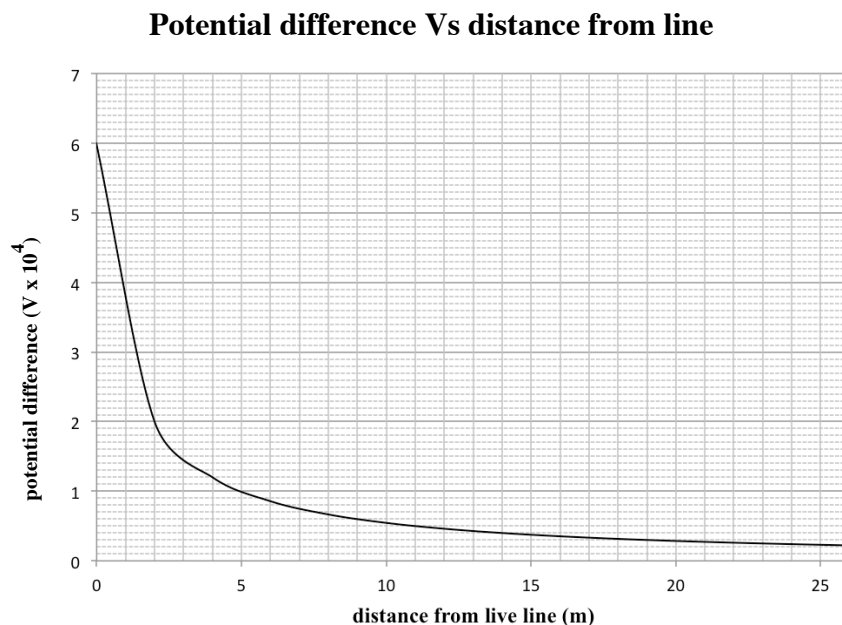
(a) What is the 'voltage' of the line, relative to ground a long distance from the line?

(1 mark)

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(b) Advice from an electrical power company includes the following:

When there is a live power line on the ground near a car you are in (for example, after a collision with a power pole), you should stay inside the car if you can. If you cannot stay in the car, put your feet together and kangaroo-hop away from the live line.

By referring to the information in the paragraph, discuss the possible hazard of moving directly away from the power line by taking normal (~ 1 m) walking strides instead of kangaroo-hopping.

(2 marks)

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Question 9 continues.

Question 9 (continued)

(c)   A person is at risk of lethal electric shock if 20.0 mA passes through the body. Suppose a particular person presents an electrical resistance of 100.0 kΩ and has a stride length of 1.00 m and walks directly away from the live line.

   (i)   Determine if there is a lethal risk to this person when the person is at a distance of 3.00 m from the live line to which the graph refers.   (2 marks)

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   (ii)   Determine the approximate minimum safe distance from the line for this person. Show your reasoning.   (3 marks)

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Question 10

In the production of fluorine-18, a proton $\left(^1_1\text{H}\right)$ is fired at high speed at the nucleus of oxygen-18 $\left(^{18}_8\text{O}\right)$. In this question, assume that all particles are spherical.

(a) What is the charge, in coulombs, for: (1 mark)

  (i) the proton? ....

  (ii) the oxygen nucleus? ....

In order for a nuclear reaction to occur, the centres of the proton and nucleus must approach within 4.35×10^{-15} m of each other.

(b) Calculate the electric force between the proton and nucleus at this distance. (2 marks)

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Question 10 continues.

Question 10 (continued)

The increase in electrical potential energy as the proton approaches the nucleus can be calculated using the formula:

$$E_P = \frac{kq_1q_2}{r}$$

(c)   With the assistance of this formula, show that the minimum initial kinetic energy which the approaching proton needs in order to react with the oxygen nucleus is approximately 4×10^{-13} J .   (2 marks)

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(d)   Suppose the proton were fired from a linear accelerator. Calculate the required potential difference within the accelerator.   (2 marks)

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/7

Question 11

A bar magnet is **dropped** into a loop of conducting wire.

(a) (i) On the diagram show the direction of current induced in the loop when the magnet is moving at the instant shown. (1 mark)

Direction of motion

N

clockwise
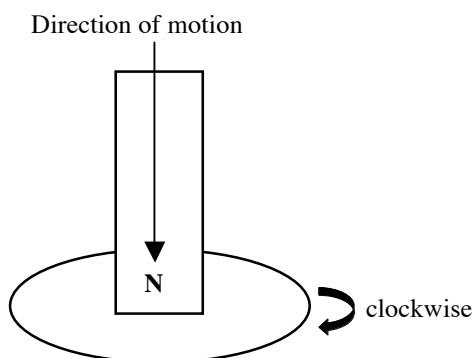
(ii) Explain your reasoning in determining the direction of current at this instant. A diagram may assist in your answer. (2 marks)
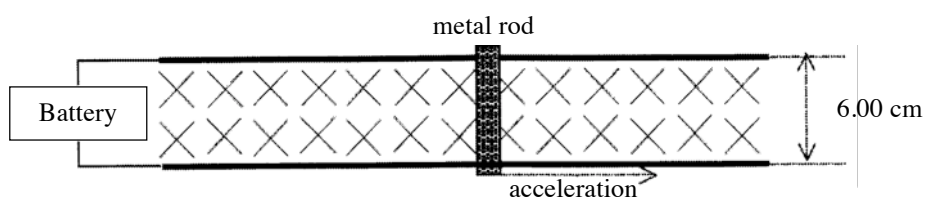
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(b) On the axes below, sketch the expected graph of the current against time as the magnet **accelerates** *all the way* through the loop, starting from a distance above the loop and finishing a distance below it. (2 marks)

current
clockwise

time

SPARE DIAGRAMS

Question 6 (a)
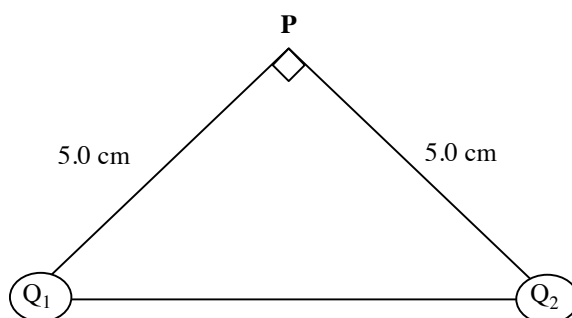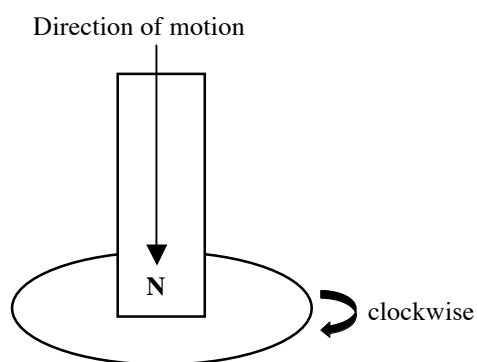
metal rod

Battery

6.00 cm

acceleration

Question 7 (a)(ii)

X

Y

Question 7 (b)(i)

X

north

SPARE DIAGRAMS

Question 8 (a)

P

5.0 cm   5.0 cm

Q₁   Q₂

Question 11 (a) (i)

Direction of motion

N

clockwise

Question 11 (b)

current
clockwise

time

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Tasmanian Certificate of Education

PHYSICS

Senior Secondary

Subject Code: PHY315109
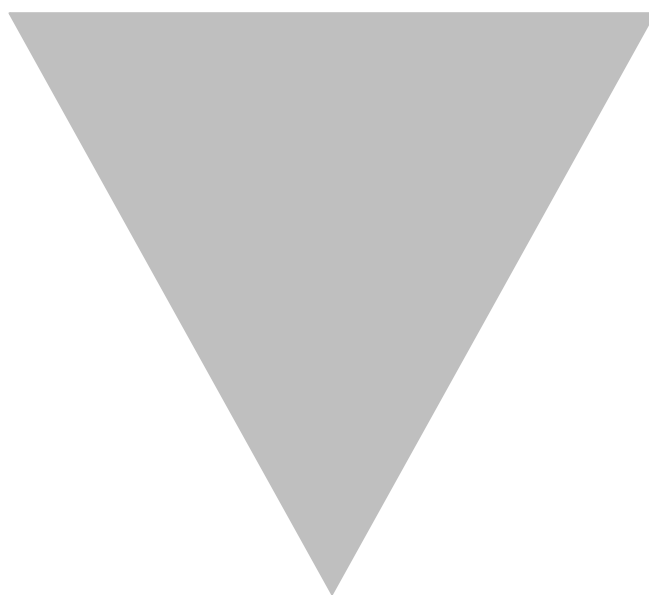
External Assessment

2014

Part 3

Time: approximately 45 minutes

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

Criterion 7   Demonstrate knowledge and understanding of general principles of wave motion.

Section Total
/40

Pages: 16
Questions: 6

TASMANIAN QUALIFICATIONS AUTHORITY

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Question 12

A violin has strings of length of 325 mm. Its 'E' string is tuned to play a note with a fundamental frequency of 660 Hz.
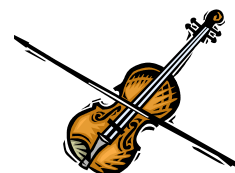
(a)   Show that the speed of a wave down the 'E' string is approximately 430 m s^{-1}.

(2 marks)

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(b)   The 'E' string has a linear mass density of 3.83×10^{-4} kg m^{-1}.

Show that the tension in the string is approximately 70 N.   (2 marks)

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(c)   The 'G' string is tuned to a fundamental frequency of 196 Hz. What are **two** ways in which this lower fundamental frequency can be achieved?   (2 marks)
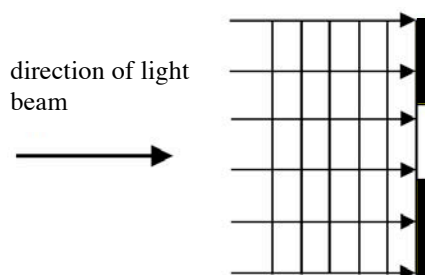
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Question 13

(a)   The following diagram shows both rays and wavefronts for a parallel beam of light incident on a slit in an opaque screen. Complete the diagram to show both rays and wavefronts for the light **after** it has passed through the slit in the screen.   (2 marks)

direction of light beam

(b)   A person has neighbours who live on the other side of a high wall. Despite the high wall, the person still hears the sound of a jazz band when it practises in the neighbours' home.

(i)   Explain why the sounds are still heard despite the wall. Include a diagram in your answer.   (2 marks)

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Question 13 (b) continues.

Question 13 (b) (continued)

  (ii) Assume that the bass drum and trumpet were played at the same volume.

    Which of the two would the person hear more clearly — the low frequencies of the bass drum or the high frequencies of the trumpet? Justify your answer.

                     (2 marks)

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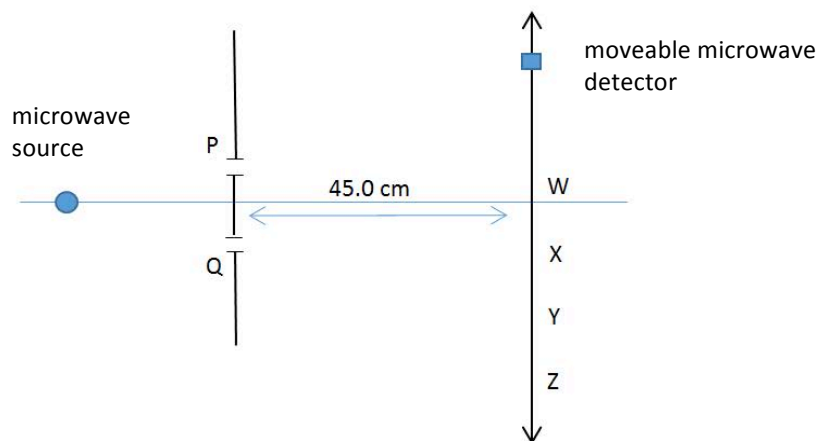
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Question 14

A teacher demonstrated the principles of Young's Double Slit experiment using a microwave source and detector as shown in the diagram below.

The microwaves used had a wavelength $\lambda = 2.70$ cm.

On the centre-line, a maximum of intensity was observed at **W**; when the detector was moved, a minimum of intensity was noticed at **X**, a second maximum at **Y**, 22.0 cm from the centre-line, and then a second minimum at **Z**.

(a)   Explain carefully what causes the first minimum of intensity.   (2 marks)

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(b)   Calculate the path difference between two rays travelling through slits **P** and **Q** to **Z**.
                                                                                       (1 mark)

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(c)   Show that the separation of the two slits **P** and **Q** is approximately 6 cm.   (2 marks)

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Question 14 continues.

Question 14 (continued)

The teacher obtained a rectangular slab of hard wax. In the microwave spectrum, the wax has a refractive index of 1.50.

(d)   Calculate the wavelength of the microwave radiation after it enters the wax.   (1 mark)

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(e)   The slab of wax was placed in front of slit **Q**. When the experiment was then repeated, a **minimum** intensity was observed at **W**.   (3 marks)

   (i)   Explain this change from a maximum in the original demonstration to a minimum.

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   (ii)   Calculate the minimum thickness of the wax slab.

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Question 15

In an experiment in the laboratory to measure the speed of sound, a student placed a thin hollow tube in a deep container of water as shown.

When a 512 Hz tuning fork was set vibrating at the open mouth of the tube, a loud resonant sound was heard at several different lengths, as the tube was raised out of the water. The shortest length for resonance was L = 0.166 m; it also occurred at 0.500 m and 0.833 m.

L
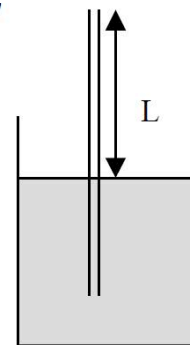
(a) Sketch a standing wave pattern within each tube to explain the three different resonant lengths. Show the water level within the tube. (3 marks)
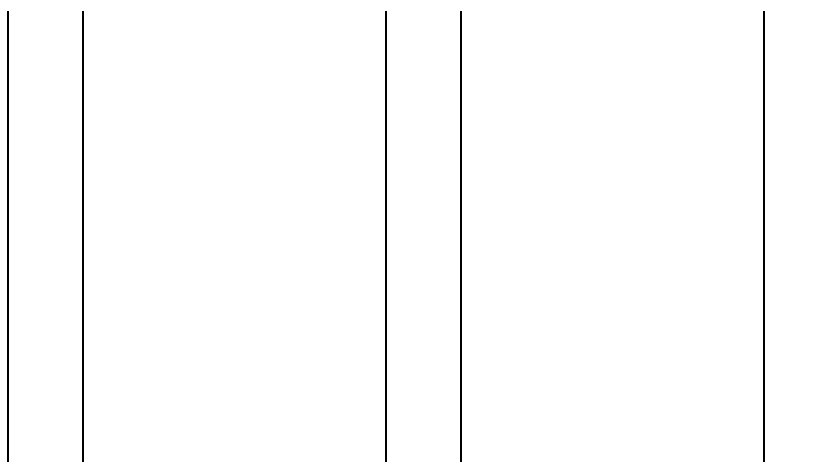
(b) Determine the speed of sound from these observations.

You should ensure that you use **all** of the given data. Do **not** ignore end-effect. (3 marks)
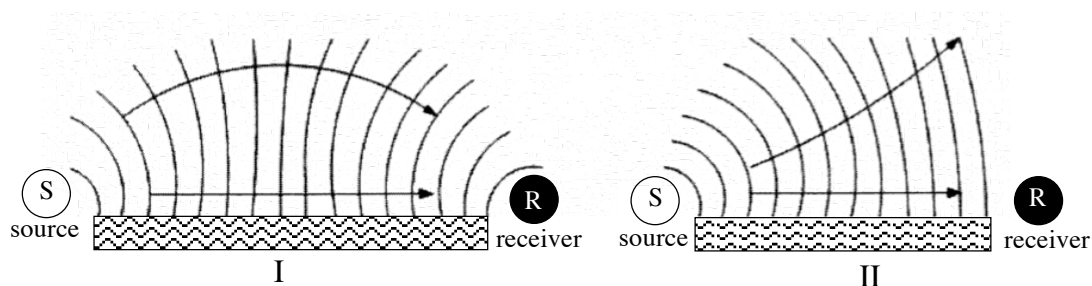
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Question 16

Sound travels more slowly in cold air than in warmer air.

During the daytime the ground is often warmer than the air above it, while at night the ground may be the colder. This causes a temperature gradient from hot → cold.

Change in speed can cause a 'bending' of the sound wave that can alter the distance noises appear to travel.

(a) (i) Which of the diagrams above, I or II, represents the situation at night? (1 mark)

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(ii) Justify your answer. (2 marks)

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(b) Explain why distant noises are often easier to hear at night. (1 mark)

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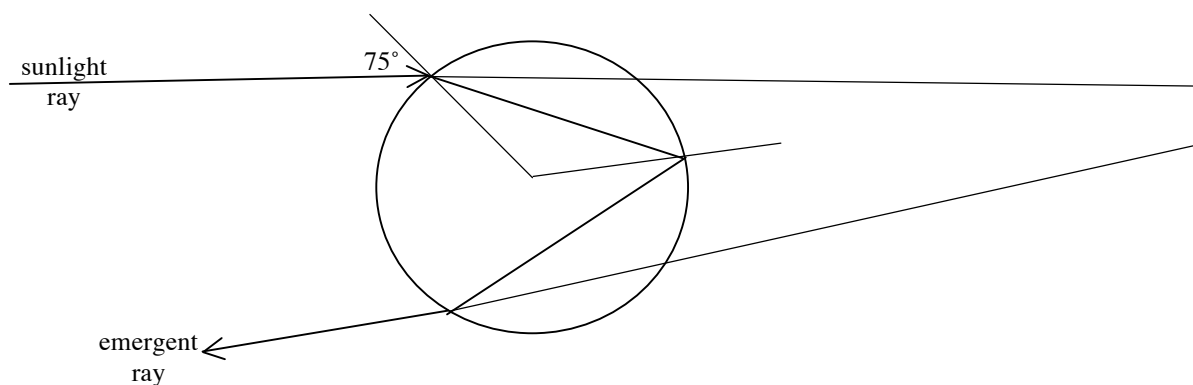...

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Question 17

Rainbows are caused by a combination of refraction and reflection of visible light in raindrops in the atmosphere.

The diagram below shows a ray of sunlight on a raindrop assumed to be spherical.

Part (a) focuses on the blue light and part (b) on the red light components of the sunlight ray.

(a)   The refractive index for blue light in water is 1.34.

   (i)   If the angle of incidence of a ray of blue light onto the front of a droplet is 75.0°, calculate the angle of refraction.   (2 marks)

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   (ii)   Calculate the critical angle for blue light in water.   (2 marks)

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Question 17 (a) continues.

Question 17 (a) (continued)

    (iii)   Internal reflection occurs as the light ray strikes the far side of the raindrop, but is this internal reflection total? Justify your answer.   (2 marks)
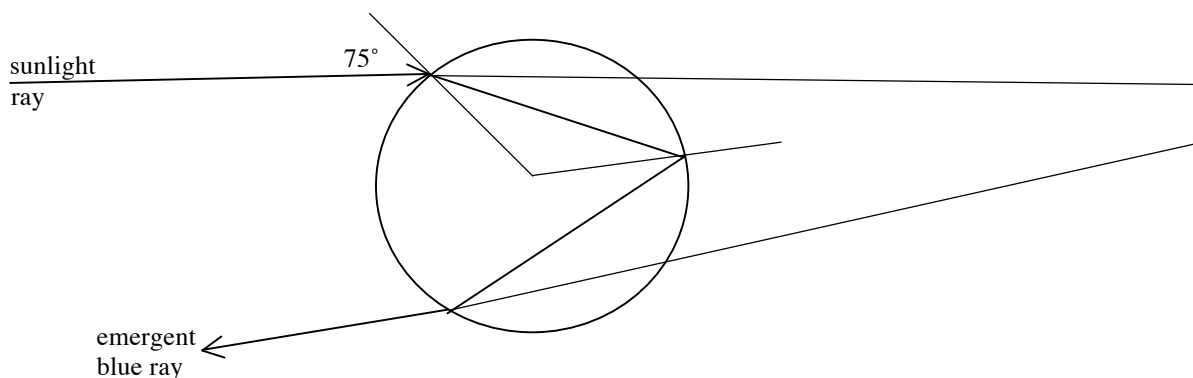
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(b)   Red light has a refractive index of 1.32. Sketch carefully the expected path, after first striking the drop, of the ray of red light compared to the shown path of the blue ray.
   (2 marks)

sunlight ray

75°

emergent blue ray

(c)   Why is it not possible to take a single photographic image of a rainbow and the sun?
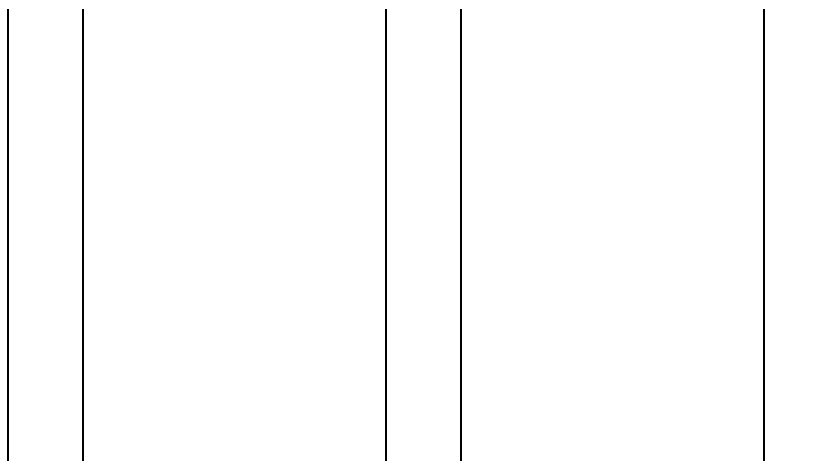   (1 mark)

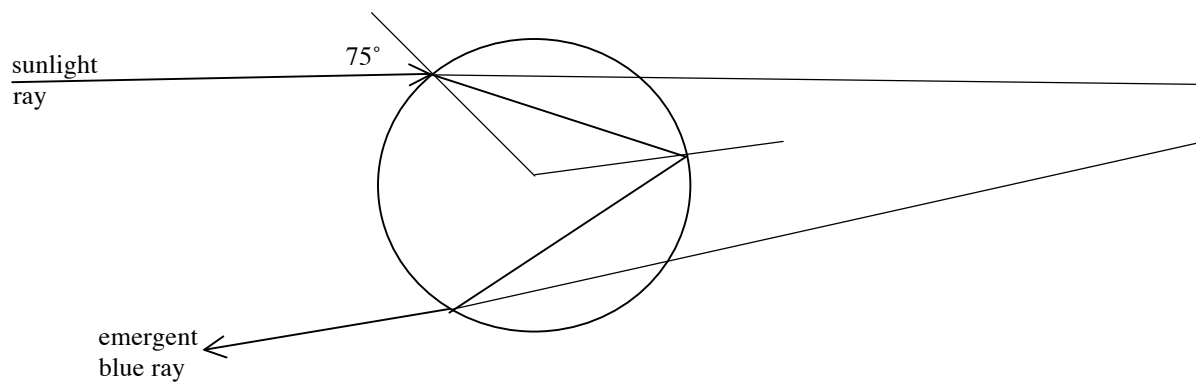...

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SPARE DIAGRAMS

Question 13 (a)

direction of light
beam
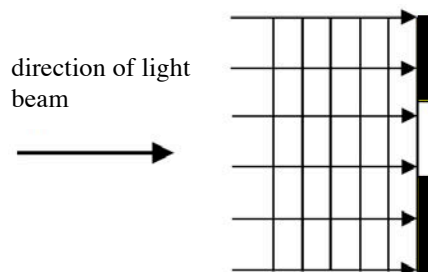
Question 14 (a)

Question 17 (b)

sunlight
ray

75°

emergent
blue ray

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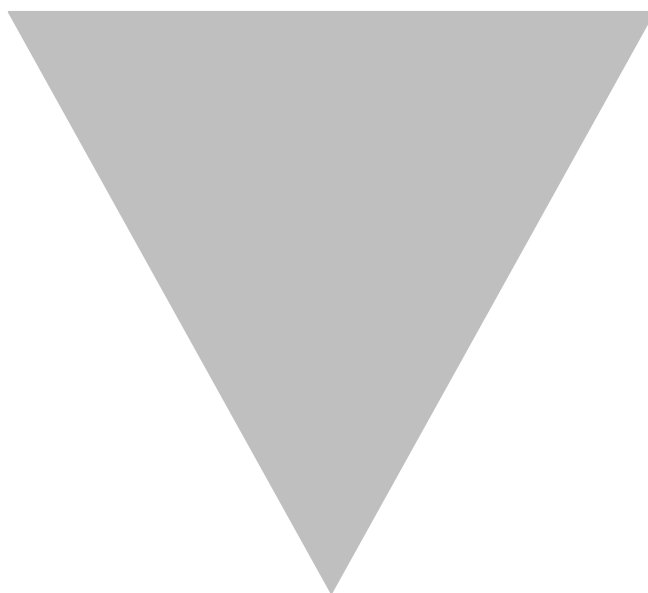
Tasmanian Certificate of Education

PHYSICS

Senior Secondary

Subject Code: PHY315109

External Assessment

2014

Part 4

Time: approximately 45 minutes

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

Criterion 8   Demonstrate knowledge and understanding of the particle nature of light, and atomic and nuclear physics.

Section Total
/40

Pages: 12
Questions: 6

CANDIDATE INSTRUCTIONS

You **MUST** make sure that your responses to the questions in this examination paper will show your achievement in the criteria being assessed.

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

Note:

When candidates are asked to 'show that' an answer to a question is 'about' a numerical value given to one or two significant figures:

- A candidate should provide their own answer to three significant figures (unless told otherwise in that question).

- A candidate whose answer rounds off to the given answer should continue to use their own three significant figure answer in any subsequent questions requiring this answer.

- A candidate whose answer is **significantly** different from that given by the examiner should use the one or two significant figure answer given by the examiner in answering subsequent questions.

This examination is 3 hours in length. In total it is recommended that you spend approximately 45 minutes answering the questions in this part.

The 2014 External Examination Information Sheet for Physics can be used throughout the examination.

No other written material is allowed into the examination.

All written responses must be in **English**.

Question 18

(a)   Calculate the minimum wavelength of X-rays from a Coolidge tube producing
175 keV electrons.   (2 marks)

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The spectrum from a typical Coolidge X-ray tube has two distinct features:

•   continuous spectrum
•   characteristic spectrum

(b)   Explain, briefly, the origins of each of these parts of the spectrum: (3 marks)

(i)   continuous ....

....

....

(ii)   characteristic ....

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(c)   Sketch a typical Intensity (I) ~ wavelength (λ) spectrum for an X-ray tube, labelling **all**
important features.   (2 marks)

/7

Question 19

The electron in the hydrogen atom can have different energies, depending on the quantum number of the orbital occupied by the electron. The following table shows the energies of the electron in the first five orbitals.

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

(a) An electron jumps from the $n = 4$ orbital to the $n = 2$ orbital

   (i) What is the change in energy of the electron and has it lost or gained energy?

(1 mark)

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

(2 marks)

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   (iii) Where in the EM spectrum does the emitted radiation lie?   (1 mark)

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(b) What is the minimum energy a photon needs, in electron volts, to ionise a hydrogen atom when the electron is in the $n = 3$ orbital?   (2 marks)
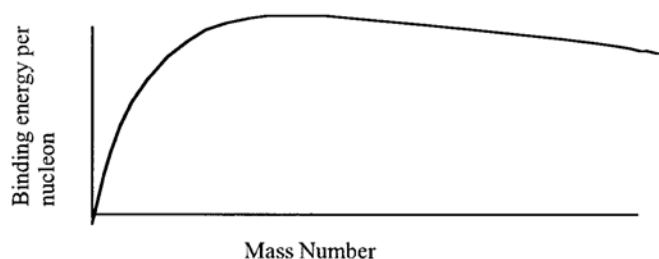
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Question 20

The graph below shows, in simplified form, the binding energy per nucleon as a function of mass number for different nuclides.

Use the graph to answer the following.

(a) Explain the difference between **nuclear fission** and **nuclear fusion**. (3 marks)

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(b) Explain why energy is released in these processes. (1 mark)

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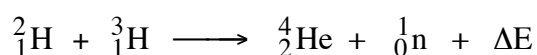**Question 21**

Nuclear fusion involves the combining of two low-mass nuclei to form a single nucleus, with energy being released.

The table below includes all masses that you will need to answer this question.

Isotope	Mass (amu)
^1_1H	1.007825
^2_1H	2.014102
^3_1H	3.016049
^3_2He	3.016029
^4_2He	4.002603
^1_0n	1.008665
^6_3Li	6.015123
^7_3Li	7.016003

Consider this fusion equation:

$$^2_1H \ + \ ^3_1H \ \longrightarrow \ ^4_2He \ + \ ^1_0n \ + \ \Delta E$$

(a) Calculate the energy released per fusion (ΔE), in joules. (4 marks)

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Question 21 (continued)

Deuterium is quite abundant, forming about one atom in 5000 of hydrogen in seawater. However, tritium is almost non-existent in the natural world, but can be produced from a variety of other nuclides.

One possible reaction producing tritium using the reasonably common lithium-7 is shown.

$$^{7}_{3}Li \ + \ ^{1}_{0}n \ (fast) \ \longrightarrow \ ^{3}_{1}H \ + \ X \ + \ 2^{1}_{0}n$$
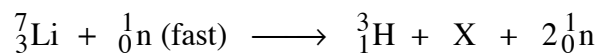
(b)   Identify particle X. (1 mark)

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(c)   In Australia, the electrical energy consumption over a person's lifetime is expected to be about 3.4×10^{12} J .

   Determine how many kilograms of lithium-7 would be needed to supply a person's lifetime electricity requirement using the two steps shown in the previous equations.

(4 marks)

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Question 22

The positron $\left(\begin{smallmatrix} 0 \\ +1 \end{smallmatrix}e\right)$ is the anti-particle of the electron.

In positron emission tomography (PET), a positron-emitter is attached to a particular molecule, which is then ingested by a patient. One widely used positron emitter is fluorine-18 $\left(\begin{smallmatrix} 18 \\ 9 \end{smallmatrix}F\right)$ which decays by emitting a positron and an isotope of oxygen.

(a) Write a balanced equation for this decay, showing all products. (1 mark)

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The rest energy of a positron and an electron are the same.

(b) Show that the value of this rest energy is approximately 0.5 MeV. (1 mark)

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(c) The positron emitted from the original decay quickly combines with an electron; they mutually annihilate producing a pair of identical photons.

(i) What is the energy of each photon produced? (1 mark)

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(ii) Show that the wavelength of each photon is approximately 2.5×10^{-12} m.
(1 mark)

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Question 22 (c) continues.

Question 22 (c) (continued)

(iii) Calculate the magnitude of the momentum of each photon. (1 mark)

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(iv) Explain **briefly** why the pair of photons produced will travel in opposite directions. (1 mark)

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Question 23

In medical diagnosis, PET scans often use Fluorine-18 (F-18). The F-18 can bond to a glucose molecule which goes to sites in the body of high metabolic activity. Since F-18 has a relatively short half-life, it is usually produced in the hospital where it is to be used.

The half-life of F-18 is 109.8 minutes.

(a)   State **two** benefits in medical diagnosis of using a radioisotope with a half-life of about this magnitude.   (2 marks)

(i)   ....

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(ii)   ....

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(b)   Determine the decay constant of F-18.   (2 marks)

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Question 23 continues.

Question 23 (continued)

(c) A patient is given a dose of glucose containing 0.102 ng of F-18.

    (i) Show that the activity of this dose of F-18 is approximately 360 MBq. (2 marks)

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    (ii) The F-18 was produced 60 minutes before being administered to the patient.

       Determine the mass of F-18 originally produced to provide the required 0.102 ng dose. (2 marks)
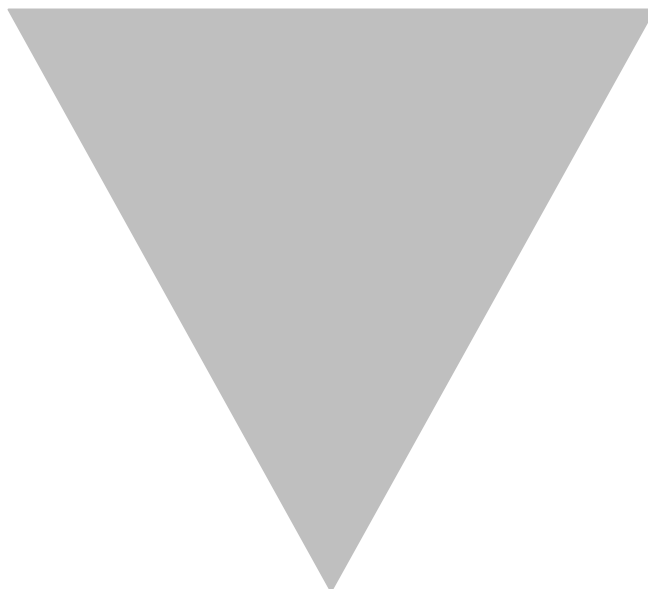
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Physics

Subject Code: PHY315114

2014 External Examination Information Sheet

Prefixes

T	— tera	10^{12}
G	— giga	10^{9}
M	— mega	10^{6}
k	— kilo	10^{3}
c	— centi	10^{-2}
m	— milli	10^{-3}
μ	— micro	10^{-6}
n	— nano	10^{-9}
p	— pico	10^{-12}
f	— femto	10^{-15}

Trigonometry Identities

$$\sin\theta = \frac{opposite}{hypotenuse} \qquad \cos\theta = \frac{adjacent}{hypotenuse}$$

$$\tan\theta = \frac{opposite}{adjacent}$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \qquad c^2 = a^2 + b^2 - 2ab\cos C$$

Motion in a Straight Line, Momentum, Force, Centripetal Force

$$v = u + at$$

$$s = ut + \tfrac{1}{2}at^2$$

$$2as = v^2 - u^2$$

$$p = mv$$

$$F_{net} = \frac{\Delta mv}{\Delta t} = ma$$

$$F_c = \frac{mv^2}{r} = \frac{4\pi^2 mr}{T^2}$$

$$a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$$

Work, Energy and Power

$$W = \Delta Energy = Fs\cos\theta$$

$$E_p = mgh \qquad E_K = \tfrac{1}{2}mv^2$$

$$P = \frac{W}{t}$$

Gravity, Kepler's Law

$$G = 6.67 \times 10^{-11} \ Nm^2kg^{-2}, \qquad g = 9.81 \ ms^{-2}$$

$$F_g = mg, \quad F_g = \frac{Gm_1 m_2}{r^2}$$

$$g \overset{def}{=} \frac{F}{m}, \quad g = \frac{GM}{r^2}$$

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

Electrostatics

$$k_E = 9.00 \times 10^9 \ Nm^2C^{-2}$$

$$e = 1.6 \times 10^{-19} \ C$$

$$m_e = 9.11 \times 10^{-31} \ kg, \quad m_p = 1.67 \times 10^{-27} \ kg$$

$$E \overset{def}{=} \frac{F_E}{q}, \quad E = \frac{k_E Q}{r^2}, \quad E = \frac{V}{d}$$

$$F_E = \frac{k_E q_1 q_2}{r^2}$$

$$V = \frac{\Delta E_p}{q}$$

Magnetism

$$k_B = 2 \times 10^{-7} \ NA^{-2}$$

$$F_B = I\ell B\sin\theta$$

$$F_B = qvB\sin\theta$$

$$B = \frac{k_B I}{r}$$

$$F_B = \frac{k_B I_1 I_2 \ell}{r}$$

$$r = \frac{mv\sin\theta}{qB}$$

$$v = \frac{E}{B}$$

Induction

$$emf = v\ell B\sin\theta$$

$$V = IR$$

$$P = VI$$

Oscillations, Waves

$c = 3.00 \times 10^8 \text{ ms}^{-1}$

Speed of sound in air at $20^0\text{C} = 344 \text{ ms}^{-1}$
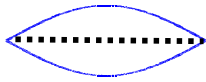
$f = \dfrac{1}{T}$

$v = \lambda f$

$\theta_i = \theta_r$

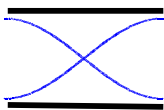$\dfrac{\sin \theta_i}{\sin \theta_r} = \dfrac{v_i}{v_r} = n$

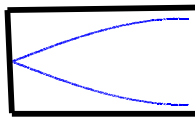$n_i \sin \theta_i = n_r \sin \theta_r$

$W = \dfrac{\lambda x}{d}$
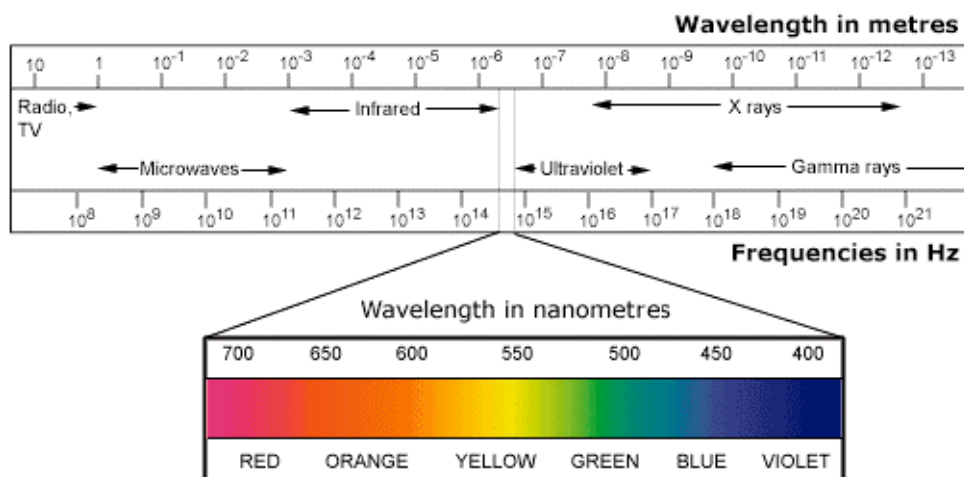
$v = \sqrt{\dfrac{T}{\mu}}$

$\lambda = 2\ell$

$\lambda = 2\ell$

$\lambda = 4\ell$

Quantum

$h = 6.63 \times 10^{-34} \text{ Js} = 4.14 \times 10^{-15} \text{ eVs}$

$e = 1.6 \times 10^{-19} \text{ C}$

$E = hf$

$E_K(\max) = eV = hf - W$

$p = \dfrac{h}{\lambda}$

Nuclear

$m_e = 9.11 \times 10^{-31} \text{ kg} = 0.000549 \text{ amu}$

$m_p = 1.67 \times 10^{-27} \text{ kg} = 1.007276 \text{ amu}$

$m_n = 1.67 \times 10^{-27} \text{ kg} = 1.008665 \text{ amu}$

Mass to energy conversion: $931 \text{ MeV} = 1 \text{ amu}$

$N_A = 6.02 \times 10^{26} \text{ (kg mole)}$

$E = mc^2$

$-\dfrac{dN}{dt} = \lambda N = A$

$\lambda = \dfrac{0.693}{T_{\frac{1}{2}}}$

$\dfrac{N}{N_O} = e^{-\lambda t} = \dfrac{A}{A_O} = \dfrac{\text{Count Rate}}{\text{Orig Count Rate}}$

$N = \dfrac{mN_A}{M}$

EM spectrum