PHYSICS

UNITS 1 & 2

2018

Name: ______________________________

Teacher: ___________________________

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work:	Ten minutes
Working time for the paper:	Three hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:

- This Question/Answer Booklet; Formula and Constants sheet

To be provided by the candidate:

- Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.
- Special items: Calculators satisfying the conditions set by the SCSA for this subject.

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short answer	12	12	50	54	30
Section Two: Extended answer	7	7	90	90	50
Section Three: Comprehension and data analysis	2	2	40	36	20
			Total	180	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 11 Information Handbook 2017.* Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

3. When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

   When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

4. You must be careful to confine your responses to the specific questions asked and follow any instructions that are specific to a particular question.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Refer to the question(s) where you are continuing your work.

Section One: Short response **30% (54 Marks)**

This section has **twelve (12)** questions. Answer **all** questions. Write your answers in the space provided. Suggested working time for this section is 50 minutes.

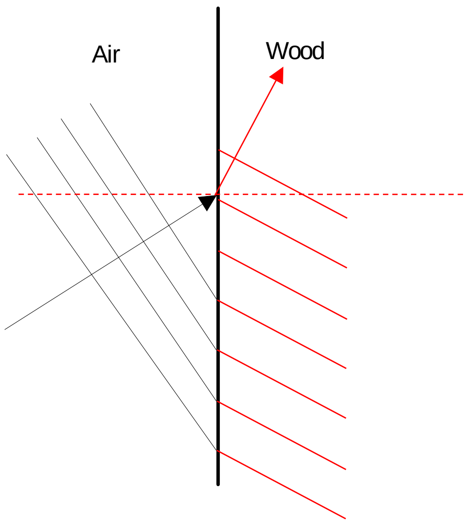
Question 1 **(4 marks)**

a) Determine the wavelength of a sound that is produced at 5.00 kHz when the speed in air is 340 ms^{-1}.

$$\lambda = \frac{v}{f} = \frac{340}{5000}(1) = 0.068\,m\,(1)$$

Answer:_______________________

b) Sound waves can also transmit through a solid medium. If the 5.0 kHz sound wave reached the wooden barrier, show how the sound path and wavefronts would change as it moved into the faster wood medium.



(1) ray bends away from normal and normal is drawn in
(1) wavelength increases

Question 2 **(4 marks)**

100 g of ice is taken from a freezer where it is kept at -6.00°C. It is heated until it becomes steam at 1.10 x 10^2 °C. Calculate how much energy it has absorbed.

$$Q=(0.1\times 2100\times 6)+(0.1\times 3.34\times 10^5)+(0.1\times 4180\times 100)+(0.1\times 2.26\times 10^6)+(0.1\times 2000\times 10)\,(3)$$
$$Q=3.04\times 10^5\,J\,(1)$$

Answer:________________________

Question 3 **(4 marks)**

A 0.10 kg hockey puck is at rest. A force of 20.0 N acts on it for 0.20 s, which sets it in motion. Over the next 2.00 s it encounters an average of 0.40 N frictional force. Lastly, a force of 24.0 N acts for 0.05 s in the direction of motion. Calculate the puck's final speed.

$$0-0.2\,s\;a=\frac{20}{0.1}=200\,m\,s^{-2}$$
$$v=0+200\times 0.2=40\,m\,s^{-1}\,(1)$$
$$0.2-2.2\,s\;a=\frac{-0.4}{0.1}=-4\,m\,s^{-2}$$
$$v=40\pm 4\times 2=32\,m\,s^{-1}\,(1)$$
$$2.2-2.25\,s\;a=\frac{24}{0.1}=240\,m\,s^{-2}$$
$$v=32+240\times 0.05=44\,m\,s^{-1}\,(2)$$
$$¿\Delta p=Ft$$

Answer:______________________

Question 4 **(4 marks)**

Devil's Lair is a small cave near Margaret River, South of Perth. Its name comes from the Tasmanian Devil remains found amongst other bones in the cave. Artefacts from the cave show that aboriginal people have been living in the area for up to 5.0 x 10^4 years. A sample of petrified wood from a spear shaft has a measured carbon-14 decay rate of 6.00 counts per minute per gram. The decay rate of carbon-14 in fresh wood today is 13.6 counts per minute per gram. Calculate the age of the spear shaft, in years. The half-life of C-14 is 5730 years.

$$\frac{A}{A_0}=(0.5)^n$$

$$\frac{6}{13.6}=(0.5)^n (1)$$

$$\log\frac{6}{13.6} ¿ n\log 0.5 (1)$$

$$n=\frac{\log\frac{6}{13.6}}{\log 0.5}$$

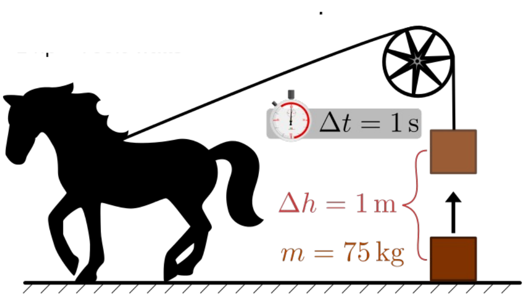
$$n=1.1806 (1)$$

$$t=nt_{1/2}=1.1806\times 5730=6760\, years\,(1)$$

Answer:______________________

Question 5 **(4 marks)**

Horsepower (hp) is an old unit to measure Power, the rate at which work is done. The diagram below shows that 1.00 hp is needed to lift a 75.0 kg mass by 1.00 metre in 1.00 second.



a) Show by calculation that 1.00 hp = 735 W. (2 marks)

$$W=Fs=75\times 9.8\times 1=735\,J\in 1\,s=735\,W$$

Answer:_______________________

b) If a 12.5 hp air conditioner is working for 2 minutes 15 seconds, calculate how much work has been done. (2 marks)

$$W = 12.5 \times 735 \times 135 (1)$$
$$W = 1.24 \times 10^6 J (1)$$

Answer:_______________________

Question 6 **(4 marks)**

A stone is dropped into a still pool of water. It generates 20 waves that spread out a distance of 10.0 m from where it entered the water. The outer wave covers the 10.0 m in a time of 5.00 s and the average height of the waves is 10.0 mm (crest to trough).

a) Determine the wavelength and velocity of the waves. (2 marks)

$$\lambda = \frac{10}{20} = 0.5 m (1)$$

Wavelength:_____________________

$$v = \frac{s}{t} = \frac{10}{5} = 2 m s^{-1}$$

Velocity: _______________________

b) Calculate the period of the water waves. (2 marks)

$$f = \frac{v}{\lambda} = \frac{2}{0.5} = 4 s (1) T = \frac{1}{f} = 0.25 s (1)$$

Answer:________________________

Question 7 **(6 marks)**

Sophie is drying her hair with a hair dryer. During this period the hair dryer drew a current of 5.50 A from a 240 V supply.

a) **Estimate** how much charge passed through the hair dryer in the time it took to dry her hair. (3 marks)

$$Estimate: 10\,minutes\,(1)$$
$$Q = ¿ = 5.5 \times 600\,(1) = 3300\,C\,(1)$$

Answer:________________________

b) Calculate the resistance of the heating coil of the hair dryer. (1 mark)

$$R = \frac{V}{I} = \frac{240}{5.5} = 43.6\,\Omega\,(1)$$

Answer:________________________

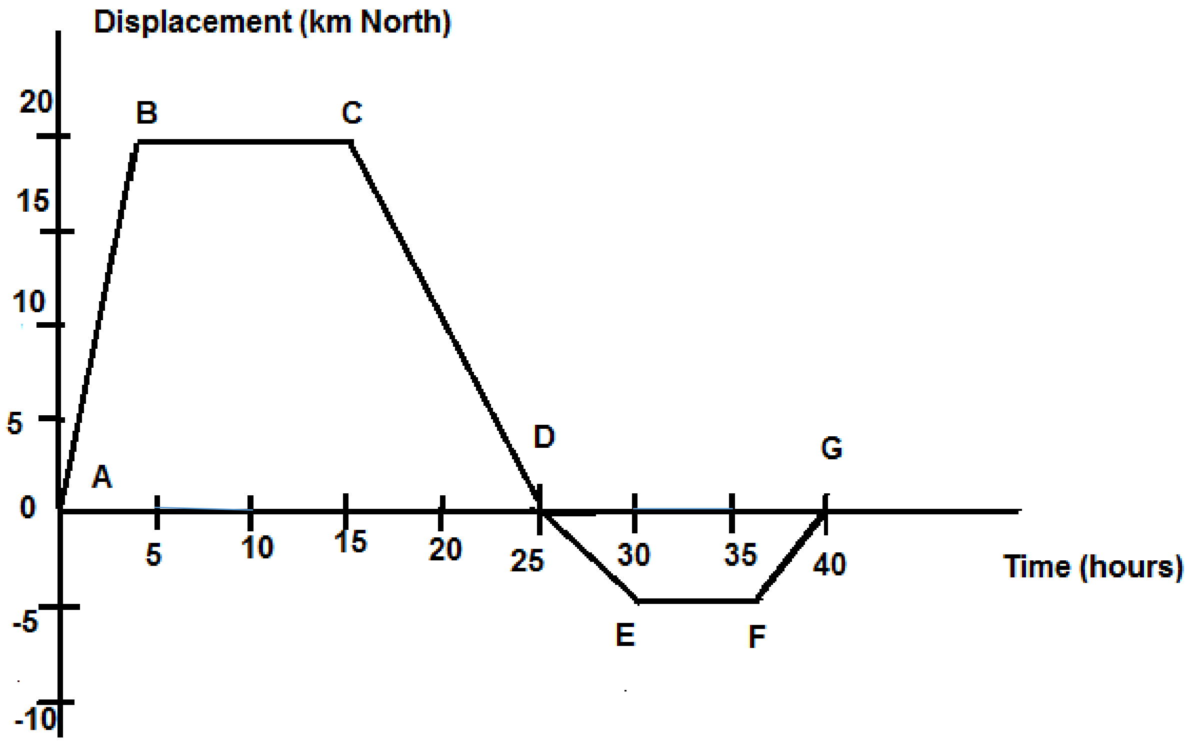
c) Calculate the power rating of the hair dryer. (2 marks)

$$P = VI = 240 \times 5.5 = 1320\,W\,(1)$$

Answer:________________________

Question 8 **(5 marks)**

A keen bushwalker went for an extended hike as shown by the following graph.



Use the graph to determine the following information:

a) How far did the hiker walk? (1 mark)

$$50\,km\,(1)$$

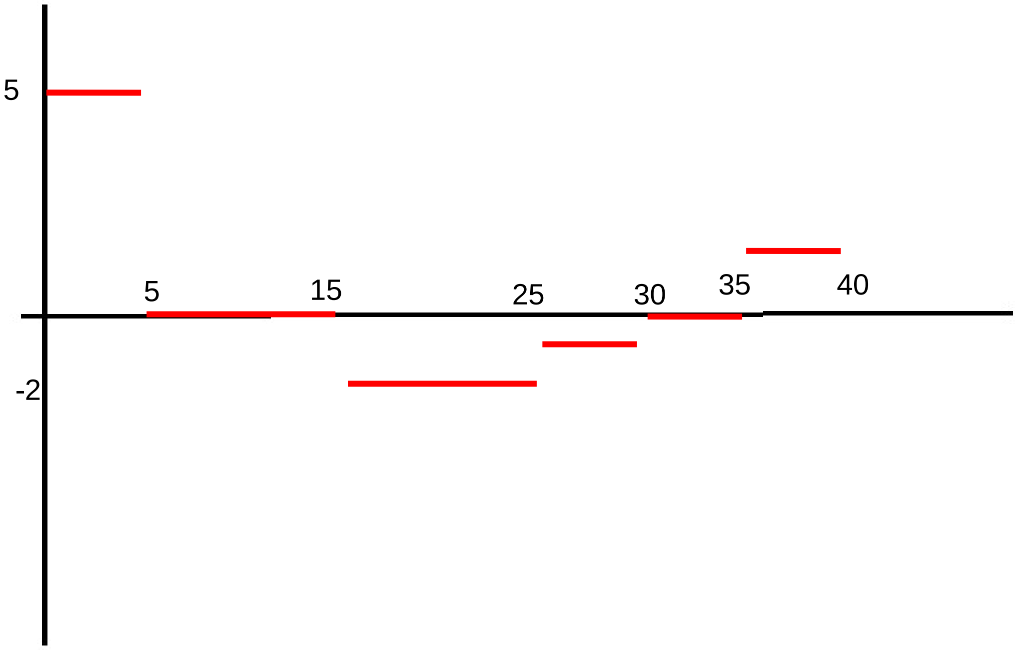
Answer:_________________________

b) Calculate the velocity (km h^{-1}) in the segment CD. (2 marks)

$$v=\frac{0-20}{10}=-2\,km\,h^{-1}\,North$$

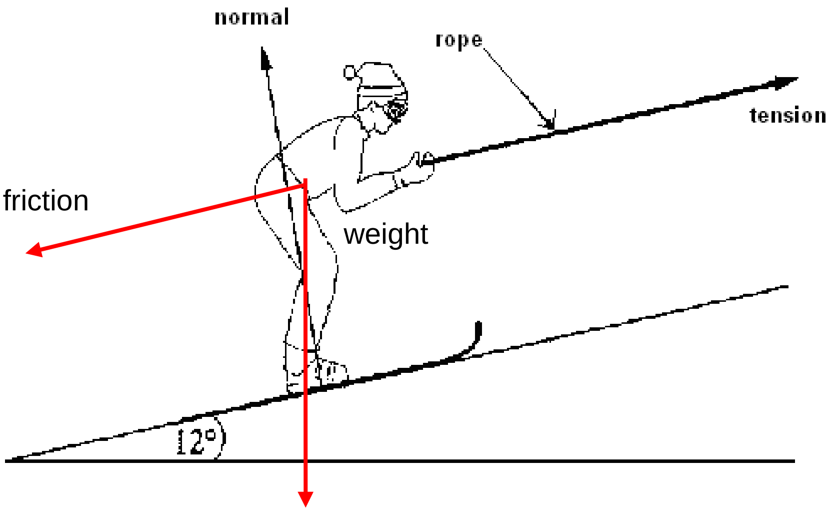
Answer:________________________

c) Sketch a graph of velocity versus time for the bushwalker's hike. (2 marks)



Question 9 **(4 marks)**

The figure below shows a skier being pulled by rope up a hill of incline 12.0° at a <u>constant speed</u>. The total mass of the skier is 85.0 kg. Two of the forces acting on the skier are already shown.



Mark with **arrows** and **label** on the diagram above a further **two (2)** forces that are acting on the skier. (1 mark)

b) Calculate the minimum tension in the rope pulling on the skier. (3 marks)

$$0 = tension + friction + weight_{¿}(1)$$
$$0 = tension + 0 \pm 85 \times 9.8 \sin 12 (1)$$
$$tension = 173\,N \text{ } assuming \text{ } 0 \, friction (1)$$

Answer:________________________

Question 10 **(7 marks)**

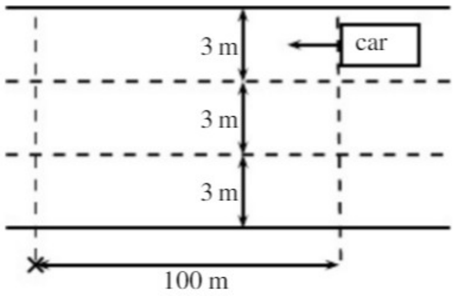
On the way to school, a student decides not to use the pedestrian bridge to cross a busy road, and decides instead to run across the road. He sees a car 100 m away travelling towards him, and is confident that he can cross in time.

a) The car is travelling at 105 kmh^{-1} and the student can run at 10.0 kmh^{-1}, calculate their respective speeds in ms^{-1}. (2 marks)

$$v_{car} = \frac{105}{3.6} = 29.2\,m\,s^{-1}\quad v_{student} = \frac{10}{3.6} = 2.78\,m\,s^{-1}$$

Car____________________ Student ____________________

b) If the road has 3 lanes, and each lane is 3 m wide, how long will it take for the student to cross all three lanes, from kerb to kerb?



$$t_{student} = \frac{9}{2.78} = 3.24\,s$$

Answer:________________________ (2 marks)

c) If the car is travelling in the furthermost lane from the student, will he be able to cross all **3** lanes of the road safely? Justify your answer with a calculation. (3 marks)

Answer: _______________________

Calculation:

$$t_{car} = \frac{100}{29.2} = 3.43\,s$$

$$t_{car} > t_{student}\ so\ the\ student\ crosses\ safely$$

Question 11 **(5 marks)**

A 240 V electric kettle is used to heat 2.80 x 10^2 mL of water initially at 22.0 ^{0}C. The heating element draws a current of 1.80 A, and is left on for 3 minutes. Determine the final temperature of the water, assuming 85% efficiency.

$$E = VIt = 240 \times 1.8 \times 180 = 77760\,J\,(2)$$
$$Q = 0.85E = 66096 = 0.28 \times 4180\,\Delta T\,(1)$$
$$\Delta T = 56.5\,(1)$$
$$T_f = 56.5 + 22 = 78.5\,°C\,(1)$$

Answer:________________________

Question 12 **(3 marks)**

In a game of 10-pin bowling, a person bowls a 10.5 kg bowling ball so that it hits the last remaining 1.0 kg bowling pin at 2.4 ms^{-1} and continues after the collision at 1.94 ms^{-1}. Calculate the speed of the pin immediately after the collision.

$$10.5 \times 2.4 + 1 \times 0 = 10.5 \times 1.94 + 1 \times v_{pin}\,(2)$$
$$v_{pin} = 4.83\,ms^{-1}\,same\,direction\,as\,the\,ball\,(1)$$

Answer:______________________

End of Section One

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Section Two: Problem-solving **50% (90 Marks)**

This section has **seven (7)** questions. You must answer **all** questions. Write your answers in the space provided. Suggested working time for this section is 90 minutes.

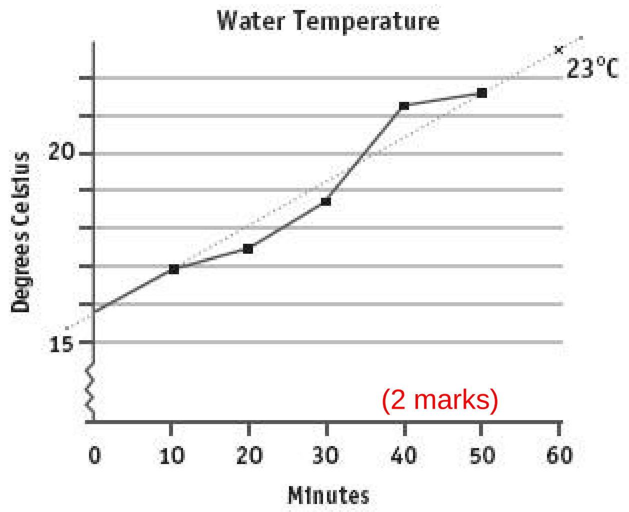
Question 13 **(16 marks)**

A solar camp shower is a device to heat water for a shower when other sources of energy are unavailable. The bag is simply hung in a sunny spot for a period of time. A typical camp shower would hold 20.0 litres of water.

a) Explain why the bag is black in colour. (1 mark)

To increase the absorption of solar radiation and thus the rate of water heating.

b) Examine the graph to the right, which shows how on a certain day, the temperature of water changes with time.



i. State and briefly explain **one** reason why the temperature of the water is not increasing at a constant rate.
Variation in wind cooling the bag
OR
Variation in sunlight heating the bag due to shifting position of the sun or cloud cover

(2 marks)

ii. Use the graph's line of best fit to calculate the average rate at which the water is heated. Express your answer in $^{o}C\ min^{-1}$.

(2 marks)

$$gradient = \frac{23-17}{60-10}(1) = 0.12\,℃\,min^{-1}(1)$$

Answer:__________________________

iii. How long would it take to heat the water to 30.0 °C? (2 marks)

$$\Delta T = 30 - 15.8 = 14.2\,℃$$
$$t = \frac{14.2}{0.12} = 118\,minutes\,(2)$$

Answer:________________________

c) Calculate the amount of energy 20.0 litres of water needs to absorb to be heated from 15.8°C to 30.0°C.

(1 mark)

$$Q = 20 \times 4180 \times 14.2 = 1190000\,J \vee 1.19\,MJ$$

Answer:________________________

d) The average amount of solar radiation received at the Earth's surface is 1.37×10^3 Wm^{-2}. The camp shower bag has an absorbing area of 0.40 m^2.

i. Calculate the rate at which solar energy falls on the bag. (2 marks)

$$1370 \times 0.4 = 548\,W\,(2)$$

Answer:________________________

ii. If 100% of this energy was to go into heating water, how long would it take to heat 20.0 litres of water from 15.8°C to 30.0°C (3 marks)

$$\frac{1190000}{548}(2) = 2170\,s \vee 36.1\,minutes\,(1)$$

Answer:________________________

e) Calculate the efficiency of the camp shower at converting the solar energy it receives into thermal energy in the water. (3 marks)

$$(2)\,for\ any\ reasonable\ working\,(1)\,for\ answer$$
$$time\ efficiency = \frac{2166.277372}{7100} \times 100 = 30.5\,\%$$
$$rate\ efficiency = \frac{0.12 \times 4180 \div 60 \times 20}{548} \times 100 = 30.5\,\%$$
$$energy\ efficiency = \frac{1187120}{7100 \times 548} \times 100 = 30.5\,\%$$

Answer:________________________

Question 14 **(13 marks)**

Panpipes, or pan flutes, can be traced back to Greek, Mayan, Native American, and many other ancient cultures. Although the sizes and styles differ across cultures, the basic design is a series of closed-end tubes of varying length, fixed together.
The sound is produced by blowing into the pipes and setting the column of air inside into motion. Once the wave pattern is stabilized it is known as a standing wave.

a) Will the closed end of the tube always serve as a displacement node or an antinode? Briefly explain your answer in terms of interference of waves.
(2 marks)

Displacement node, (1) the wave and its reflection will be perfectly out of phase by 1/2λ so there will be permanent destructive interference. (1)

b) Determine the relationship between the wavelength of the **fundamental** frequency and the length of the tube. (1 mark)

$$\lambda = 4\,l$$

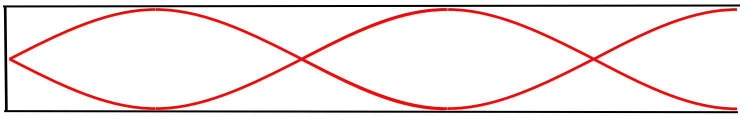
Answer:________________________

c) If a pipe of length 30.4 cm was made to resonate at its fundamental frequency, calculate the frequency of sound produced. (2 marks)

$$\lambda = 4 \times 0.304 = 1.216\,m\,(1)$$
$$f = \frac{346}{1.216} = 285\,Hz\,(1)$$

Answer:________________________

d) The tube is now vibrating with a standing wave pattern of three antinodes and three nodes. Draw a particle displacement diagram below and state which overtone this represents. your answer. (2 marks)



Overtone: 2nd

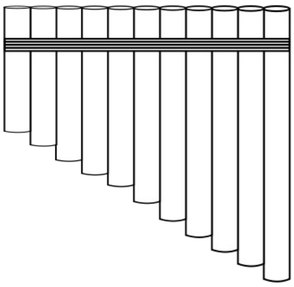
e) Explain how a standing wave forms and the conditions that are necessary. (2 marks)

A standing wave forms when two like waves moving in opposite directions through a medium interfere to create points of maximum amplitude and points of zero amplitude. One wave can be a reflection of the other. (1)

The frequency of the wave must be a resonant frequency, the two waves must have the same wavelength, speed and amplitude. (1)

f) An internet guide to making your own panpipe suggests that each pipe is 9/8 the length of the previous. One of the pipes resonates at its 3rd harmonic, producing an A note of 440 Hz.

Calculate the frequency of the fundamental note produced by the pipe 3 "steps" longer than this. (4 marks)



$$\lambda=\frac{v}{f}=\frac{346}{440}=0.7863636=\frac{4l}{2n-1}=\frac{4l}{3}$$

$$l=0.589772727\,m\,(1)$$

$$l_{+3\,steps}=0.589772727\times\left(\frac{9}{8}\right)^3=0.839734996\,m\,(1)$$

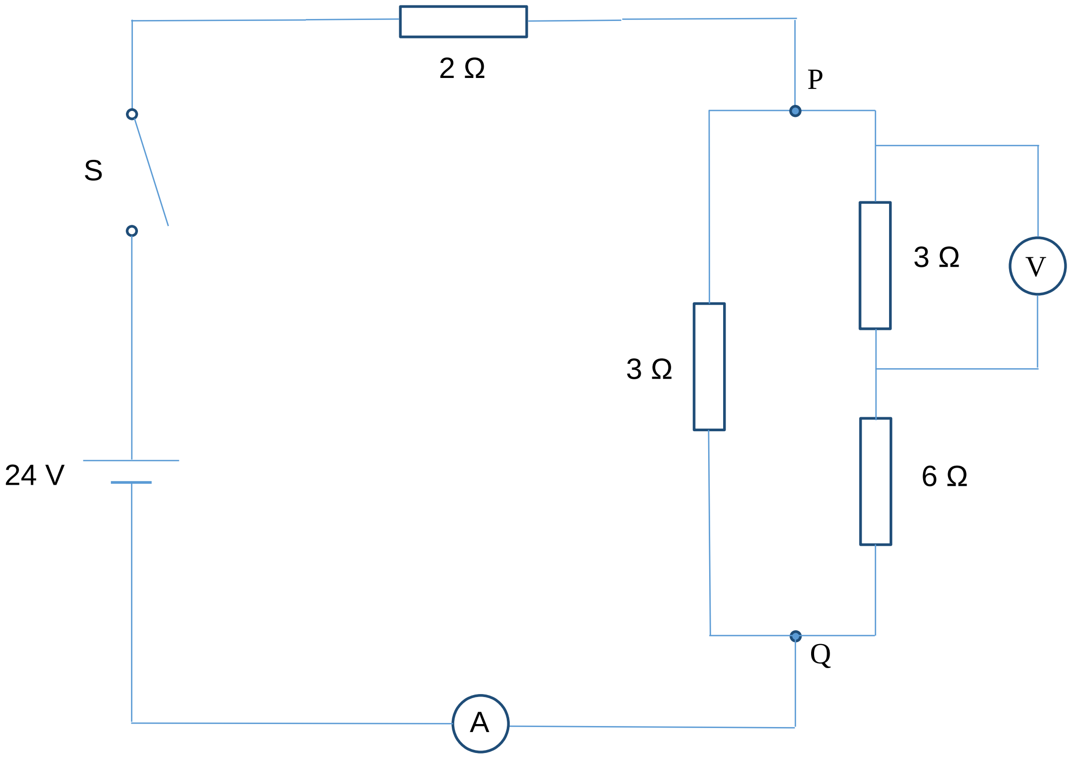
$$\lambda=\frac{4l}{2n-1}=\frac{4\times 0.839734996}{1}=3.358939986\,m\,(1)$$

$$f=\frac{v}{\lambda}=\frac{346}{3.358939986}=103\,Hz\,(1)$$

Answer:________________________

Question 15 **(14 marks)**

Alexia set up the electrical circuit shown below for her Physics investigation. The circuit is powered by a 24 V DC power source and has a single switch S.



a) **ON THE CIRCUIT DIAGRAM,** draw in the direction of conventional current flow.

(1 mark)

b) Calculate the total resistance of the circuit. (4 marks)

$$R_P = \left(\frac{1}{3} + \frac{1}{3+6}\right)^{-1} (1)$$
$$R_P = 2.25\,\Omega\,(1)$$
$$R_T = 2 + 2.25\,(1)$$
$$R_T = 4.25\,\Omega\,(1)$$

Answer: ______________________________

c) Calculate the current recorded by the ammeter when the switch is closed. (2 marks)

$$I=\frac{V}{R}=\frac{24}{4.25}(1)$$
$$I=5.65\,A(1)$$

Answer: ___________________________________

d) Assume the current measured by the ammeter is 5.65 A, calculate the electric charge delivered by the DC power source in 2 hours and 35 minutes. (3 marks)

$$t=(2\times 60+35)\times 60=9300\,s(1)$$
$$Q=¿=5.65\times 9300(1)$$
$$Q=52500\,C(1)$$

Answer: ___________________________________

e) If the voltage drop between P and Q is 12.7 V,

(i) Calculate the voltage drop recorded by the voltmeter. (2 marks)

$$V_{9\Omega}=12.7$$

$$V_{3\Omega}=12.7\times\frac{3}{3+6}(1)\vee other\,reasonable\,method$$

$$V_{3\Omega}=4.23\,V(1)$$

Answer: ___________________________________

(ii) Calculate the power consumed by the 6.00 Ω resistor. (2 marks)

$$V=12.7-4.23=8.466666\,V(1)\vee other\,reasonable\,method$$

$$P=\frac{V^2}{R}=\frac{8.4666666^2}{6}=11.9\,W(1)$$

Answer: ___________________________________

Question 16 **(12 marks)**

The La Quebrada Cliff Divers® are a group of professional high divers based in Acapulco, Mexico. They regularly dive head first from a height of 36.0 m into a narrow inlet of ocean water. The water depth varies from 1.80 m – 4.90 m as the ocean waves surge in and out of the inlet. The average depth is 3.60 m.

a) A diver jumped verically upwards from the cliff with an initial vertical velocity of 3.5 ms^{-1}. Calculate the kinetic energy of a 60.0 kg diver at the instant he reached the water.

$$v^2 = u^2 + 2as = 0 = 3.5^2 + 2(-9.8)s$$
$$s = 0.625\,m\,(1)$$
$$PE = mgh = 60 \times 9.8 \times (36 + 0.625)\,(1)$$
$$PE = 21535.5\,J\,(1)$$
$$KE = PE = 21500\,J\,(1)$$

(4 marks)

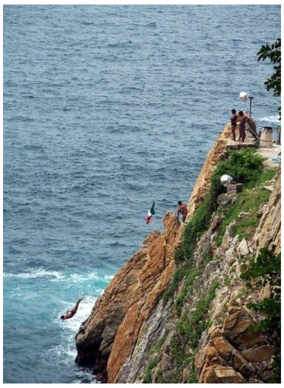
Answer:________________________

b) If he came to stop at a depth of 3.00 m, what average vertical force must the water exert on him? (2 marks)

$$F = \frac{W}{s} = \frac{21535.5}{3}\,(1)$$
$$F = 7180\,N\,upwards\,(1)$$

Answer:________________________

c) The divers time their dive by observing the waves at the entrance of the inlet, to their right. The aim is to land as the wave passes under them, hence the water is at a maximum depth. Calculate how far away from the landing zone a wave peak travelling at 12 ms^{-1} would need to be for the diver in part a) to hit the water when at its maximum depth. (4 marks)



$$s = ut + \frac{1}{2}at^2 = 36.625 = 0 + \frac{1}{2}9.8t^2\,(1)$$
$$t = 2.73395\,s\,(1)$$
$$s = vt = 12 \times 2.73395\,(1)$$
$$s = 32.8\,m\,(1)$$

4 marks)

Answer:_______________________

d) The rocks at the base of the cliff protrude horizontally 4m into the water from where the divers jump. Explain, in terms of forces, why a diver would be killed if they hit these rocks. (2 marks)

Hitting a rock the diver will experience a much larger force than hitting the water (1). When hitting the rock the diver will come to a near-instant stop, when hitting the water the the diver takes a longer time to stop. Since the momentum of the diver is the same in both scenarios, the impulse will be the same. $\Delta p = Ft$ so with Δp being constant, the much smaller time coming to a stop against the rock results in a much larger force. (1)

Question 17 **(11 marks)**

Nuclear Fusion is the process that powers our Sun and stars as smaller nuclei fuse together to form larger ones, and matter is converted into energy. When Hydrogen is heated to very high temperatures, its electrons are separated from the nuclei and the gas changes to a plasma. These high temperatures are also needed to overcome strong repulsive forces.

a) Describe the origin of the “strong repulsive forces” mentioned above. (2 marks)

Electrostatic repulsion, (1) protons are positively charged so will repel each other when brought close together. (1)

b) Write a nuclear equation for the fusion of a Deuterium ($^{2}_{1}H$¿ nucleus and a Tritium ($^{3}_{1}H$¿ nucleus to form a $^{4}_{2}He$ nucleus, one other particle and energy. (2 marks)

$$^{2}_{1}H+^{3}_{1}H=^{4}_{2}He+^{1}_{0}n+energy\,(1)\,neutron\,(1)\,remainder$$

c) Given the data below, determine the amount of energy (in J) released by the reaction in b). (5 marks)

m ($^{2}_{1}H$¿ = 2.01410178 u
m ($^{3}_{1}H$¿=¿ 3.01604927 u
m $\left(^{4}_{2}He\right)$ = 4.00260325 u

$$Mass\ of\ neutron=\frac{1.67\times10^{-27}}{1.66\times10^{-27}}=1.006024096\,(1)$$
$$Mass\ defect=2.01410178+3.01604927-4.00260325-1.006024096\,(1)$$
$$Mass\ defect=0.021523704\,u\,(1)$$
$$E=0.021523704\times931=20.03856842\,MeV\,(1)$$
$$E=20.03856842\times1000000\times1.6\times10^{-19}=3.21\times10^{-12}\,J\,(1)$$

Answer:________________________

d) Determine how much energy would be released by 1kg of hydrogen gas. (2 marks)
(Assume equal H-2 and H-3 in sample and all atoms fuse)

$$¿\,fusions=\frac{1\,kg}{mass\ of\ pair\ of\ hydrogens}=\frac{1}{(2.01410178+3.01604927)\times1.66\times10^{-27}}=1.197597513\times10^{26}\,fusions\,(1)$$
$$E=1.197597513\times10^{26}\times3.21\times10^{-12}=3.84\times10^{14}\,(1)$$

Answer:______________________

Question 18 **(8 marks)**

Fuses provide a way of helping to protect people against electrocution. They are generally a short length of wire which is designed to melt when the current in the circuit exceeds a certain amount.

a) Describe why the wire will melt when a high current passes through it. (2 marks)

The electrical energy converted to heat as a current passes through a wire can be approximated by $P=I^2R$. (1) As current increases the heating of the wire increases dramatically which will cause the wire to melt at a certain point. (1)

b) State what would have to happen to the resistance of a circuit for the current to increase. Under what conditions would this happen? (2 marks)

A decrease in total resistance would cause current to increase, (1) this is most common with a short-circuit, bypassing load on the circuit. (1)

c) In a house, a lighting circuit might use a 20.0 A fuse, whilst an oven would use 40.0 A. State which of these circuits would use a fuse with a thicker wire. (1 mark)

Answer oven

d) State **one (1)** disadvantage of fuses, compared to a residual current device (RCD). (1 mark)

Once a fuse is activated it is destroyed and must be replaced while an RCD can just be switched back and is ready to go again.

OR

RCDs respond faster than fuses.

OR

Fuses prevent fire but may not prevent electrocution in some situations where an RCD would

e) List **two (2)** other electrical safety devices or features commonly used in a home.(2 marks)

- Double insulation
- Earth wires
- Circuit breaker

Any 2, (1) each

Question 19 **(16 marks)**

When an object such as a metal rod is heated, its length will almost always increase. A measure of the rate at which this increases is called the coefficient of linear expansion α_L. It is the fractional change in length per degree of temperature change, and can be expressed as:

$$\frac{\Delta L}{L_o} \cdot \frac{1}{\Delta T} = \alpha_L$$

Where L_o is the initial length of the sample material, ΔL is the amount by which it has expanded and ΔT is the change in temperature.

This equation works well as long as the linear-expansion coefficient does not change much over the change in temperature and the fractional change in length $\frac{\Delta L}{L_o}$ is small. $\frac{\square}{\square}$

In an experiment to determine the coefficient of linear expansion of Aluminium, a sample of known length, $L_o =$ ¿ 6.00 x 10^2 mm was placed in a sealed chamber, and heated with steam at 1.00 x 10^2 °C, then allowed to cool. The length of the bar was recorded each drop of 2 °C until the temperature inside the chamber reached 50.0 °C.

a) Explain, using the Kinetic particle model of matter, why substances expand when heated. (3 marks)

As a substance is heated it gains kinetic energy causing the particles to move faster. (1) As they move faster they stretch their bonds, moving further apart, gaining potential energy. (1) Since the particles have moved further apart the substance expands. (1)

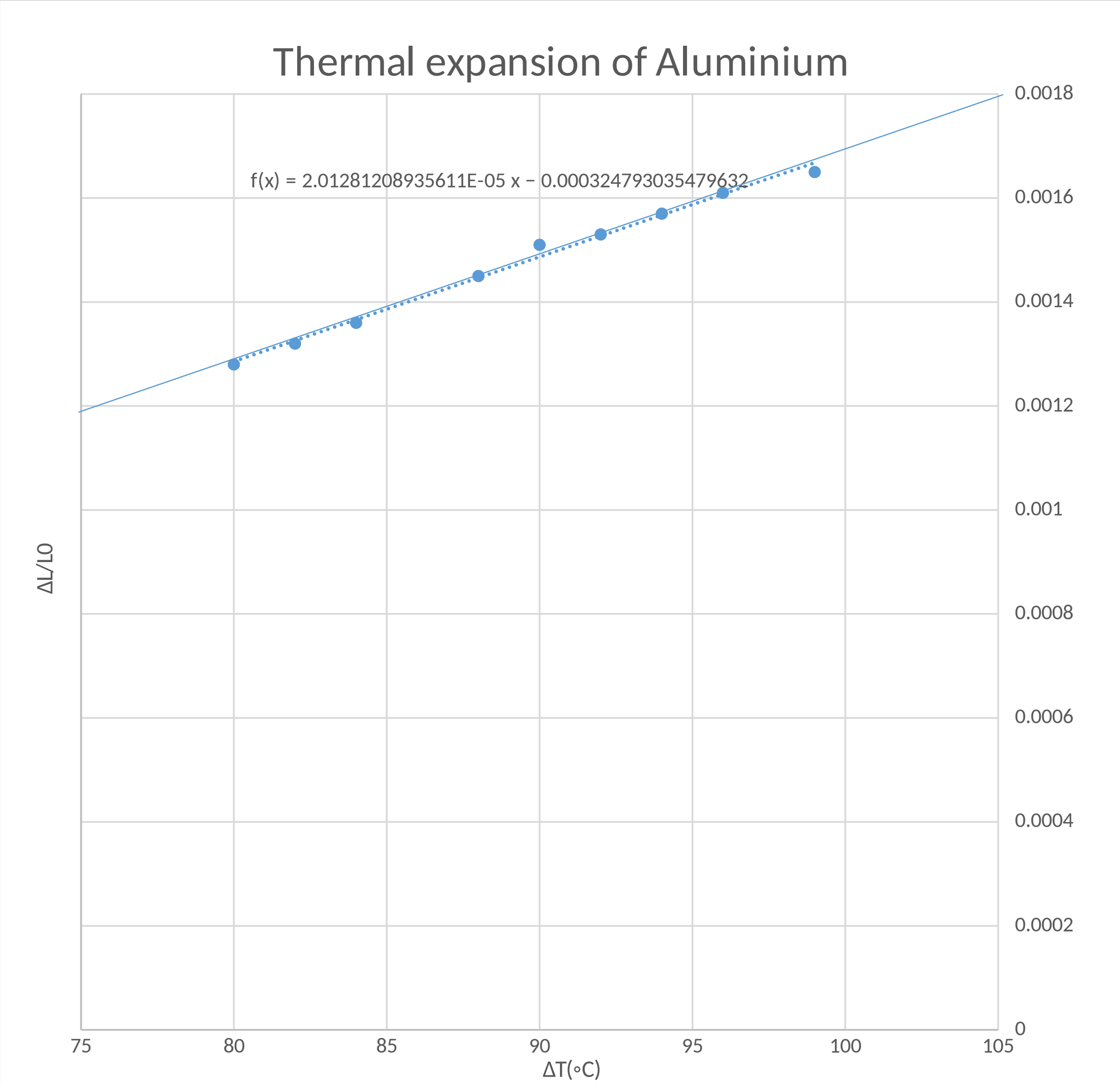
The results for the experiment are as follows:

ΔTemp (°C)	ΔL (mm)	$\frac{\Delta L}{L_o}$
99	0.99	0.00165
96	0.97	0.00161
94	0.94	0.00157 (0.5)
92	0.92	0.00153 (0.5)
90	0.9	0.00151
88	0.87	0.00145
84	0.82	0.00136
82	0.79	0.00132 (0.5)
80	0.77	0.00128 (0.5)

b) Complete the third column, $\frac{\Delta L}{L_o}$ in the table above. Some values are already done.

(2 marks)

c) On the graph paper provided, plot a graph of $\frac{\Delta L}{L_o}$ on the y-axis and ΔT on the x-axis. (A spare grid is supplied at the end of the paper) (4 marks)



Appropriate title (1)
Correct axis labels (1)
Correct axis scales (1)
Correct point plotting (1)

d) Draw the line of best fit for your data. (1 mark)

e) Using your line of best fit, calculate the coefficient of linear expansion for the sample used. Show **all** relevant calculations and working. (4 marks)

$$\alpha_L = gradient = \frac{\Delta y}{\Delta x} = \frac{0.0018 - 0.0012(1)}{105 - 76(1)} = 0.0000207\,℃^{-1} \vee other\ reasonable\ value(1)$$

$$Triangle\ drawn\ on\ graph(1)$$

f) The theoretical value of α_L for Aluminium is 23.8 x 10^{-6} $^oC^{-1}$. Calculate the percentage error in the experimental value obtained. (If you were unable to calculate a value for part f, use 23.0 x 10^{-6} $^0C^{-1}$). (2 marks)

$$\frac{0.0000207 - 0.0000238}{0.0000238} \times 100\,(1) = 13.0\,\%\,(1)$$

give full follow through

Answer:________________________

End of Section 2

Section Three: Comprehension **20% (36 Marks)**

This section contains **two (2)** questions. You must answer both questions. Write your answers in the spaces provided. Suggested working time for this section is 40 minutes.

Question 20 **(18 marks)**

The Great Eastern Japan Earthquake and Tsunami

On March 11, 2011 at 2:45 pm a massive earthquake occurred off the North East Coast of Japan. The hypocentre was at an underwater depth of approximately 29.0 km.

Less than an hour after the earthquake, the first of many tsunami waves hit Japan's eastern coastline. It is estimated that the Tsunami waves were travelling at about 340 kmh^{-1} with wavelengths averaging 280 km when they encountered the coastline. The tsunami waves reached run-up heights (how far the wave surges above sea level as it hits the land) of up to 39 metres at Miyako city and travelled inland as far as 10 km in some places.

The tsunami waves also travelled across the Pacific, reaching Alaska, Hawaii and Chile. In Chile, some 17,000 km distant, the tsunami waves were 2 metres high when they reached the shore. The earthquake produced a low-frequency rumble called infrasound, which travelled into space and was detected by the Goce satellite.

As well as the devastation from the Tsunami, several nuclear power stations were damaged, releasing significant amounts of radioactive material into the atmosphere. Some 55,000 households were displaced and evacuation zones of up to 100km from the reactors were established.

The following table is from reports released by Japan’s Atomic Energy Commission a year after the disaster, estimating the amount of various isotopes released into the atmosphere and the ocean:

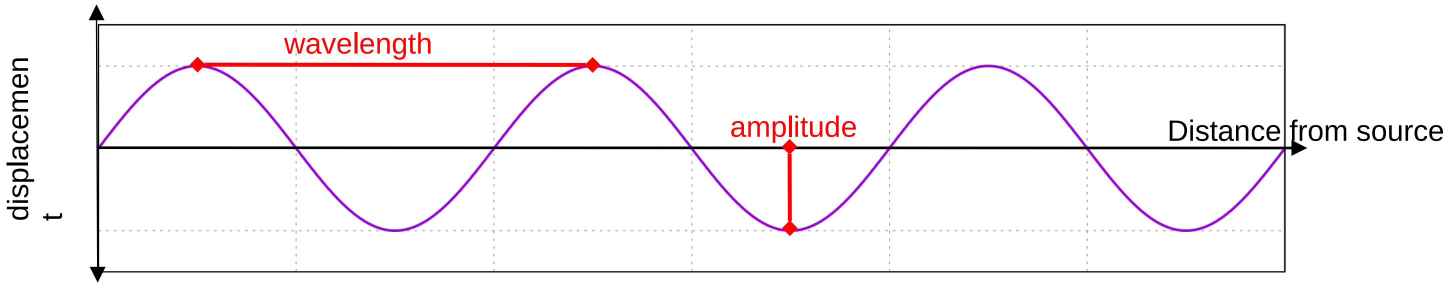
Isotope	Estimated amount released (TBq)
iodine-131	511,000
caesium-134	13,500
caesium-137	13,600
Strontium-90	8,300

- Iodine-131 is easily absorbed by the thyroid, so persons exposed to releases of I-131 have a higher risk of developing thyroid disease. Children are more vulnerable to I-131 than adults. I-131 decays by beta minus and gamma emissions with a short half-life at 8.02 days.
- Caesium-137 has a long, 30-year half-life. Internal exposure to Cs-137, through ingestion or inhalation, allows the radioactive material to be distributed in the soft tissues, especially muscle and lung tissue, exposing these tissues to the beta particles and gamma radiation.
- Strontium-90 behaves like calcium (20–30% of ingested Sr-90 is absorbed and deposited in the bone and bone marrow). It undergoes β− decay into Yttrium-90, with a half-life of 28.8y.

On 22 March, World Nuclear News reported that 6 workers had received over 100 mSv, and one of over 150 mSv. On 24 March, three workers required hospital treatment after radioactive water seeped through their protective clothes. The injuries indicated exposure of 2000 to 6000 mSv around their ankles, with whole body doses of about 170 mSv. They were not wearing protective boots, as their employing firm's safety manuals "did not assume a scenario in which its employees would carry out work standing in water at a nuclear power plant".

Questions:

a) As the Tsunami waves travel in deep water, they can be approximated as a sine wave. On the diagram below, clearly indicate the amplitude and wavelength of the wave. (2 marks)



b) Calculate the time between two successive waves hitting the Japanese coastline. (1 mark)

$$T=\frac{1}{f}=\frac{\lambda}{v}=\frac{280}{340}=0.824\,hours\vee 2960\,s\vee 49.4\,minutes$$

Answer:________________________

c) As a result of their long wavelengths, tsunamis act as shallow-water waves. A wave becomes a shallow-water wave when the wavelength is very large compared to the water depth. Shallow-water waves move at a speed, *c*, that is dependent upon the water depth and is given by the formula:

$$c=\sqrt{gH}$$

where *g* is the acceleration due to gravity and *H* is the depth of water, in metres.

i. Refer to the equation above to state what would happen to the speed of the tsunami wave as it approached the shore.

(1 mark)

The speed of the wave is proportional to the square root of the water depth, so as the wave approached shore it would slow as the water became shallower.

ii. Calculate how long after the earthquake the Tsunami wave would reach the shore of Chile if the average ocean depth is 3.00 km. (3 marks)

$$c=\sqrt{9.8\times 3000}=171.464282\,m\,s^{-1}(1)$$
$$t=\frac{17000000}{171.464282}(1)=99100\,s\vee 27.5\,hours(1)$$

Answer:________________________

iii. Explain why the wave height would only be around 2.00 m when it reached Chile. (2 marks)

$$I \propto \frac{1}{r^2} \text{ so as the radius increases the intensity is greatly decreased.}$$

$$\text{The energy is } \frac{\text{spread}}{a} \text{ much larger area so the amplitude is greatly reduced.}$$

$$\text{¿ other reasonable explanation}$$

d) The earthquake produced a low frequency rumble, called infrasound. By what factor would the intensity of the infrasound be at half the distance to the GOCE satellite? Justify your answer. (2 marks)

If radius increases by a factor of 2, intensity will increase by a factor of $2^2=4$ (1). So at halfway the intensity will be 4 times greater. (1)

Answer:________________________

e) Which of the isotopes mentioned would cause the most serious health risks in the first weeks after the incident? Explain your answer. (2 marks)

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f) Calculate the percentage of I-131 to the total fallout experienced. (1 mark)

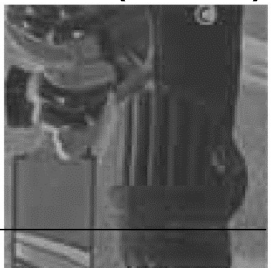
g) Calculate the amount (in TBq) of Iodine131 that remained 30.0 days after the accident. (2 marks)

Answer:________________________

h) Calculate how much energy would need to be absorbed by a 75.0 kg person for them to receive a whole body dose of 170 mSv. (2 marks)

Answer:______________________

Question 21 **(18 marks)**



In cricket, a batsman is judged 'out' if the ball is caught after hitting the bat.

The batsman is ‘not out’ if the ball is caught after hitting the batsman’s leg. A cricket umpire must sometimes decide whether the ball hit the bat, the batsman’s leg, or if both have been hit, which happened first. This can be tricky because the bat and the leg may be very close together, and the contact occurs over a very short time.

A technology called Hot Spot can be used to resolve this issue. Hot Spot is an infra-red imaging system, and is used to determine where, or what, the ball actually hit. There are two Hot Spot infra-red cameras, one at each end of the cricket ground. These measure and record the temperature of the bat and the batsman, before and after the ball makes contact. The infra-red images are then processed by a computer to show temperature differences between the ‘before’ and ‘after’ images.

The point is to show accurately whether the ball has hit the bat, the batsman’s glove, the batsman’s leg, or none of these. The black-and-white images produced by Hot Spot can potentially allow an umpire to precisely localise the ball’s point of impact, and so reduce the risk of making an incorrect decision.

a) Using the image above as a reference, which would have the higher temperature? (1 mark)

Circle the correct answer:

a light part **a dark part** **not enough information**

b) Explain how the infra-red cameras are able to ‘sense’ where the contact or collision point has occurred. (1 mark)

c) The increase in heat energy of the contact point only lasts for a short time. Explain one form of heat transfer that is likely to occur in this situation. (2 marks)

d) A 161 gram cricket ball moving at 25.0 m s^{-1} hits the edge of a stationary bat transferring 18.1 J of energy to the bat. Contact with the bat lasts 4.50 ***m***s. (milliseconds)

(i) Calculate the speed of the ball after the collision. (4 marks)

Answer:________________________

(ii) The cricket ball bounced off at a right angle to the direction it was originally moving. Determine the magnitude of the change in velocity of the cricket ball. Include a vector diagram. (4 marks)

Answer:________________________

(iii) Determine the magnitude of the force applied to the bat. (2 marks)

Answer:________________________

e) At the moment the photograph is taken, about 4.00 grams of wood absorb the 18.1 J of energy and increase in temperature. Determine the temperature increase of this portion of the bat, given that the specific heat of the bat is 2.25×10^3 J kg^{-1} K^{-1}. (3 marks)

Answer:________________________

(e) After the ball is struck, it rolls along the ground and comes to a stop. Explain, using Physics concepts. (2 marks)

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End of Questions

Additional working space

Spare grid for graph

End of examination

Acknowledgements

Question 5
Horsepower Diagram
Adapted from – http://commons.wikimedia.org/w/index.php?curid=35217113

Question 6
Ripples in Pond
CC0 Public Domain

Telstra vehicle Specs
Adapted from – https://www.flikr.com/photos/jurvetson/8273926700
https://en.wikipedia.org/wiki/Tesla Model S

Question 9
Indoor Skydiving
http://upload.wikimedia.org/wikipedia/commons

Question 14
Pan Pipes picture
https://commons.wikimedia.org
Line Drawing
https://en.wikipedia.ord

Question 16
Cliff Divers
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Question 17
Nuclear Fusion
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Thermal expansion coeffient data and diagram.-With permission from Hose Nanjaro Torres.
http://www.academia.edu/6905702/implementaion and Analysis of Linear Thermal Expansion

Question 20
Sine Wave
https://commons.wikimedia .org/wiki/File:Wave sine.svg

Question 21
Fukushima.Data on radiation exposure. https:wikipedia.org