Neap:

Trial Examination 2016

VCE Physics Units 3&4

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Student's Name: ______________________________

Teacher's Name: ______________________________

Structure of Booklet

Section		*Number of questions*	*Number of questions to be answered*	*Number of marks*
A – Motion in one and two dimensions		8	8	40
Electronics and photonics		4	4	24
Electric power		5	5	36
Interactions of light and matter		6	6	28
	Number of detailed studies	*Number of detailed studies to be answered*	*Number of questions to be answered*	*Number of marks*
B – Detailed studies	4	1	11	22
				Total 150

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, pre-written notes (one folded A3 sheet or two A4 sheets bound together by tape) and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer booklet of 58 pages. A formula sheet.

Answer sheet for multiple-choice questions.

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

All written responses must be in English.

At the end of the examination:

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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Table of Contents

SECTION A

SECTION B

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SECTION A – CORE STUDIES

Instructions for Section A

Answer **all** questions in this section in the spaces provided. Write using black or blue pen.

Where an answer box has a unit printed in it, give your answer in that unit.

You should take the value of g to be 10 m s^{-2}.

Where answer boxes are provided, write your final answer in the box.

In questions worth more than 1 mark, appropriate working should be shown.

Unless otherwise indicated, diagrams are not to scale.

Area of study – Motion in one and two dimensions

Question 1 (7 marks)

Figure 1 shows a parked car of mass 1200 kg on an inclined road. The angle of the incline is 15°.

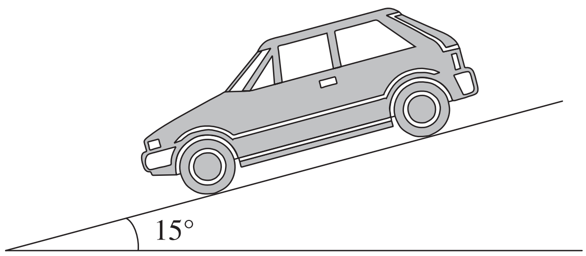

Figure 1

a. Using labelled arrows, draw on Figure 1 the following forces acting on the car: the weight force (W), the reaction force (R) and the frictional force (F_R). 3 marks

b. Calculate the size of the frictional force, F_R. 2 marks

N

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c. Calculate the size of the reaction force *R*. 2 marks

N

Question 2 (2 marks)

Jean leaves Melbourne for an around-the-world trip. She travels a total distance of 40 000 km in a time of six days before arriving back in Melbourne.

a. Calculate Jean's average speed for her journey. 1 mark

$m\ s^{-1}$

b. Calculate Jean's average velocity for her journey. 1 mark

$m\ s^{-1}$

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Question 3 (6 marks)

A car of mass 1000 kg travelling at 15 m s^{-1} crashes into a stationary truck of mass 4000 kg. After the collision, the car and truck move off together as one single mass.

a. Calculate the magnitude of the momentum of the car before the collision. 1 mark

kg m s^{-1}

b. Calculate the speed with which the combined car and truck move off together after the collision. 2 marks

m s^{-1}

c. Calculate the loss of kinetic energy that occurs in this collision and explain what happens to this lost kinetic energy. 3 marks

J

Question 4 (5 marks)

Two masses, m (2 kg) and M (2 kg), are connected by a frictionless pulley system and a string as shown in Figure 2. Mass M is on an inclined plane of 45°. Assume the inclined plane is smooth and friction is negligible.

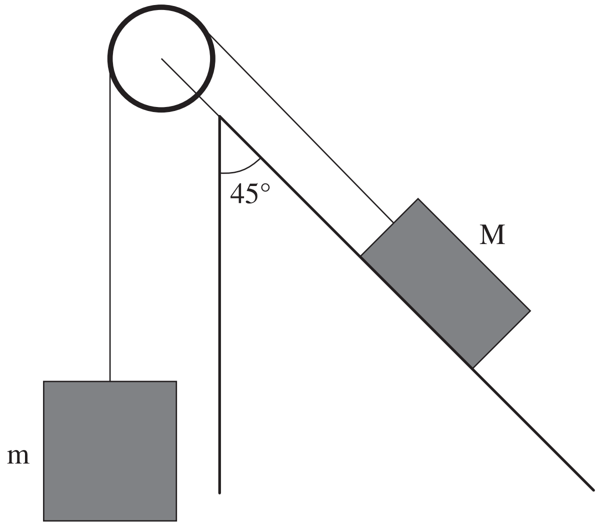

Figure 2

a. Calulate the acceleration of mass m and circle whether it moves up or down. 3 marks

m s^{-2}	up / down

b. Calculate the magnitude of the tension in the string joining the two masses. 2 marks

N

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Question 5 (6 marks)

The world record for the javelin throw is 104.8 m. Most javelin throwers release the javelin at an angle of 40°. Assume air resistance is negligible for your calculations.

a. Calculate the initial speed of projection of a javelin thrown 104.8 m at an angle of 40°. 2 marks

m s^{-1}

b. Calculate the time that the javelin is in the air. 2 marks

s

c. Calculate the maximum height reached by the javelin. 2 marks

m

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Question 6 (4 marks)

Figure 3 shows a motorbike racer, Ana, going around a corner which has a radius of 100 m. Ana is at an angle of **50° to the vertical** and is travelling at a speed of 144 km h^{-1}. The combined mass of Ana and the motorbike is 120 kg.

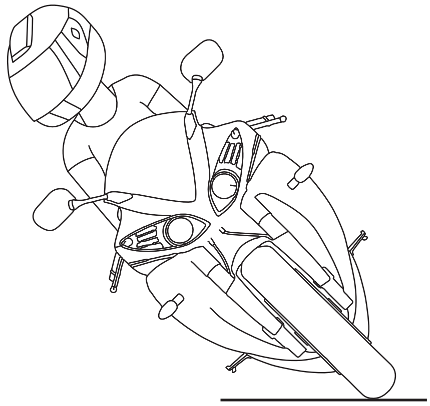

Figure 3

Calculate the magnitude and the direction (circle left or right below in the answer box) of the frictional force provided by the road on the motorbike's tyre.

N	left / right

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Question 7 (4 marks)

Figure 4 shows two springs, A (length 10 cm) and B (length 4 cm), arranged to absorb energy.

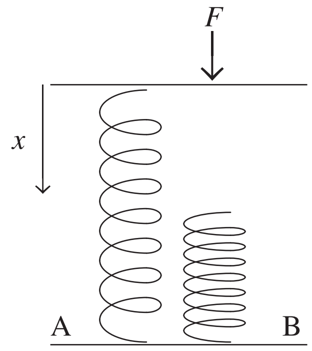

Figure 4

Figure 5 shows the graph of the force versus compression for the set of two springs.

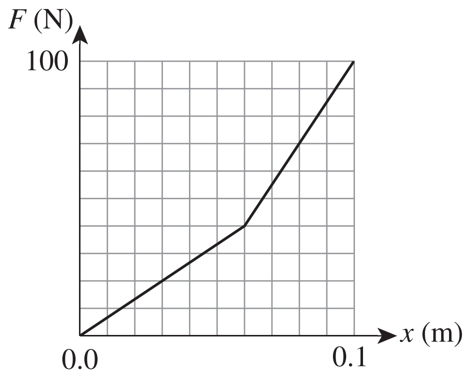

Figure 5

a. Determine the spring constants for both spring A and spring B. 2 marks

A: N m^{-1}	B: N m^{-1}

b. Calculate the total amount of energy absorbed by the spring system when the spring system is compressed 0.1 m. 2 marks

J

Question 8 (6 marks)

Skylab is orbiting 235 km above the Earth's surface. The mass of the Earth is 5.98×10^{24} kg and the radius of the Earth is 6.378×10^{6} m.

a. Calculate the period of the orbit of Skylab around the Earth. You must show your working. 3 marks

min

Television footage beamed back to Earth shows the astronauts 'floating' around inside Skylab's cabin.

b. Explain, using the terms *weight*, *true weightlessness* and *apparent weightlessness*, why the astronauts are 'floating' around inside the cabin of the spacecraft. 3 marks

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Area of study – Electronics and photonics

Question 9 (6 marks)

Figure 6 shows a circuit with four resistors: 20 Ω, 30 Ω and two identical resistors of unknown value R Ω. The two potentials 18 V and 9 V are shown. The point X is shown by the dot (●) and the potential at X is 15 V.

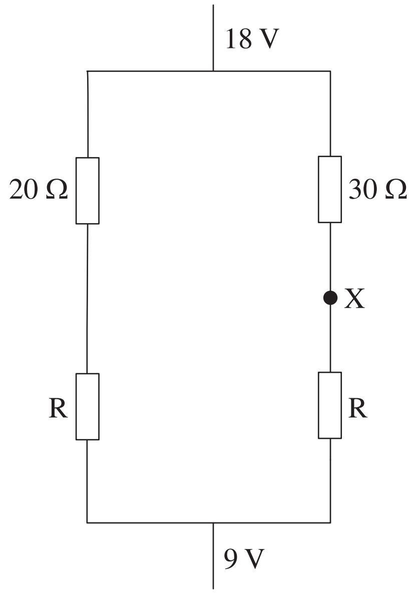

Figure 6

a. Determine the potential difference across the 30 Ω resistor. 1 mark

V

b. Determine the value R. 3 marks

Ω

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c. Determine the power developed in the resistor R that is connected to point X. 2 marks

W

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Question 10 (7 marks)

Figure 7 shows the transfer characteristic of an amplifier.

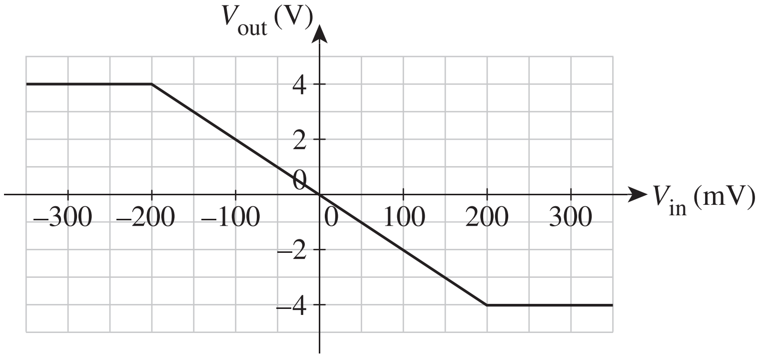


Figure 7

Figure 8 shows the input voltage to the amplifier.

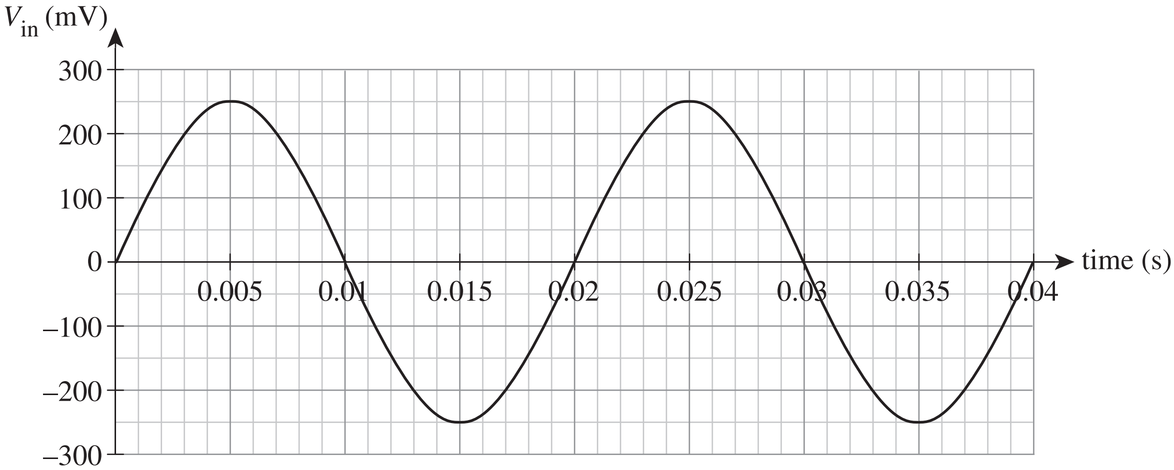
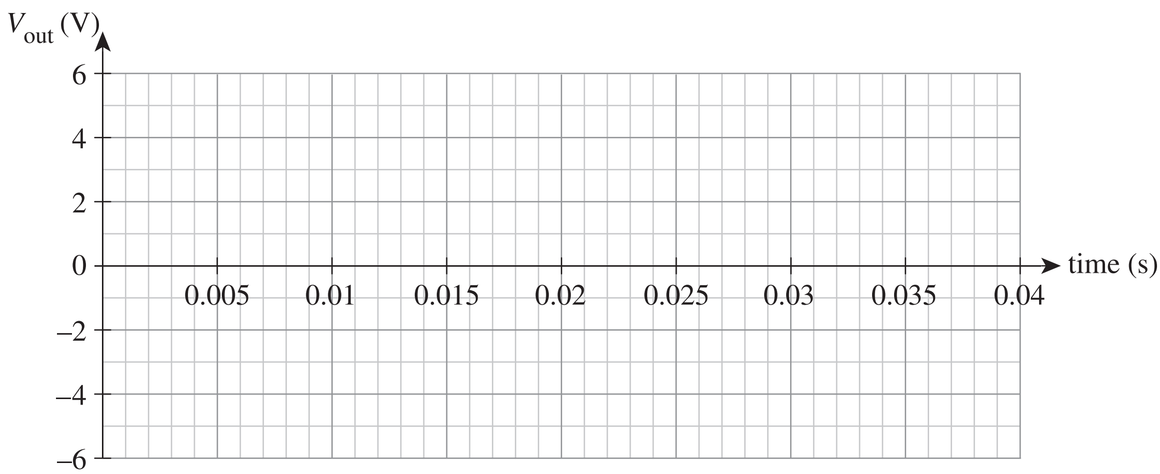


Figure 8

a. Sketch the output voltage of the amplifier with time on the axes below from $t = 0$ seconds to $t = 0.04$ seconds. 3 marks



b. Determine the magnitude of the gain of the amplifier input. 2 marks

It is desired for the output voltage to be as shown in Figure 9.

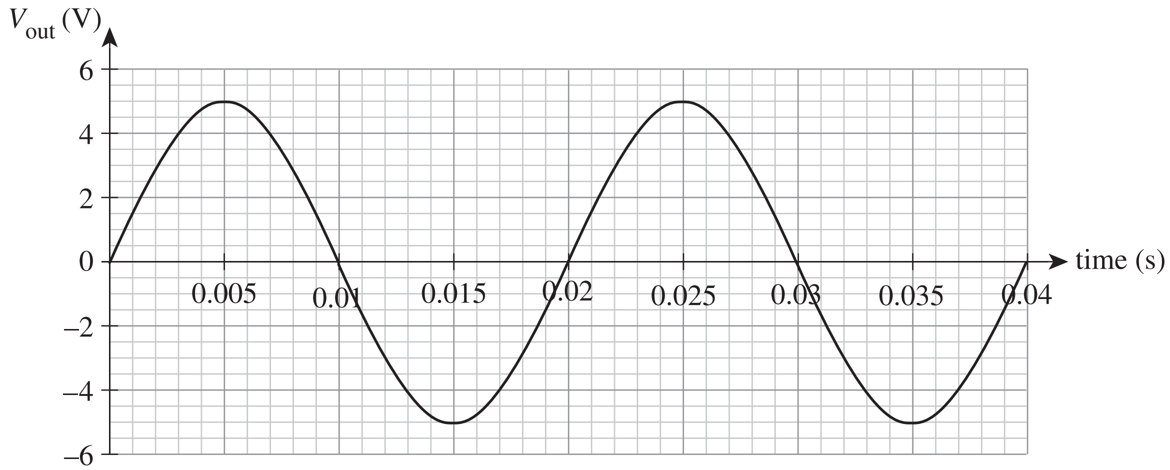
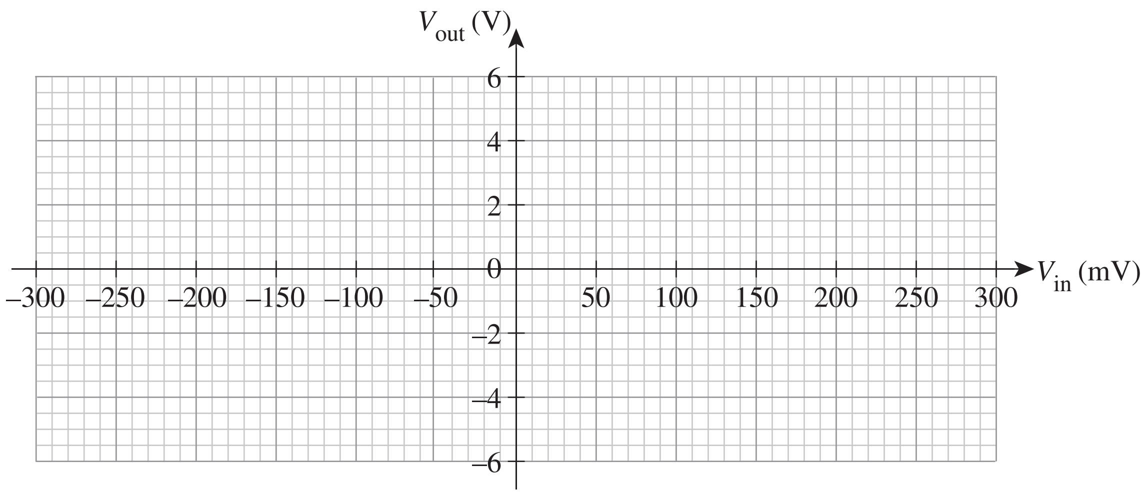


Figure 9

c. Plot the voltage characteristic of the amplifier V_{out} versus V_{in} using the axes provided below so that the V_{out} has the voltage variation as shown in Figure 9 for the input voltage shown in Figure 8. 2 marks



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Question 11 (5 marks)

Figure 10 shows three signal forms: A, B and C.

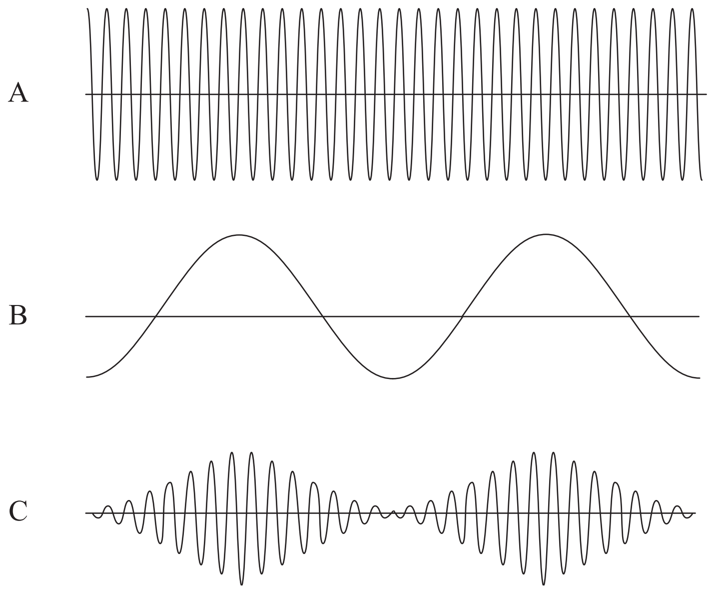


Figure 10

The pathway of a radio signal from the air through the electronics through to the listener's ear is shown by the block diagram in Figure 11. The points X, Y and Z are indicated by dots (●).

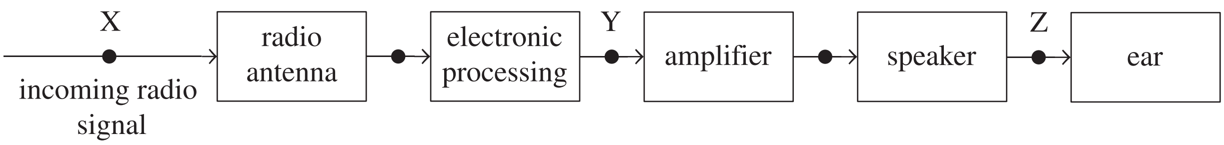


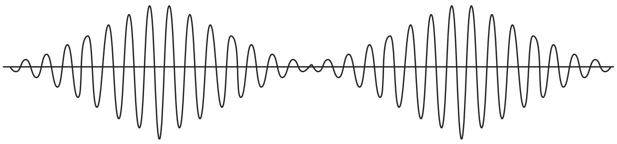
Figure 11

a. In the table below, fill in the signal form (A, B or C) that is present at each of the positions X, Y and Z in the pathway as a result of the incoming radio signal and its processing. 3 marks

Position	Signal form
X	
Y	
Z	

Figure 12 shows the original signal C and a new signal, D.

C



D

Figure 12

b. Explain how the new signal D is different to signal C by way of the information it represents. 2 marks

____

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____

____

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Question 12 (6 marks)

A thermistor is used in conjunction with a variable resistor and a 9 V power supply. A cooling switching control unit is also connected, as shown in Figure 13.

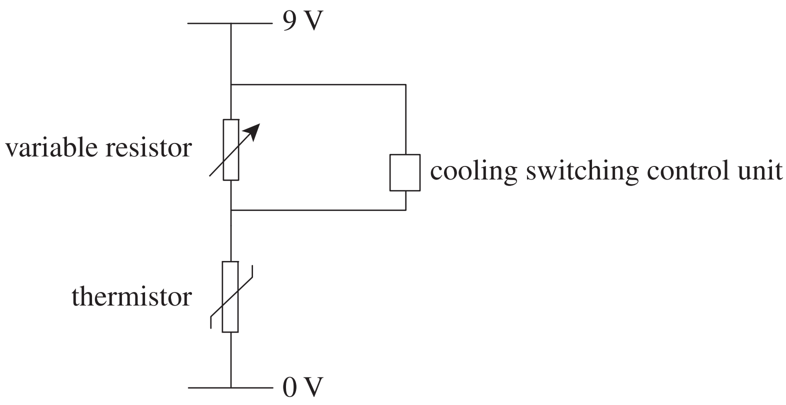

Figure 13

Figure 14 shows the dependence of the resistance of the thermistor (in kΩ) on temperature (°C) of the environment.

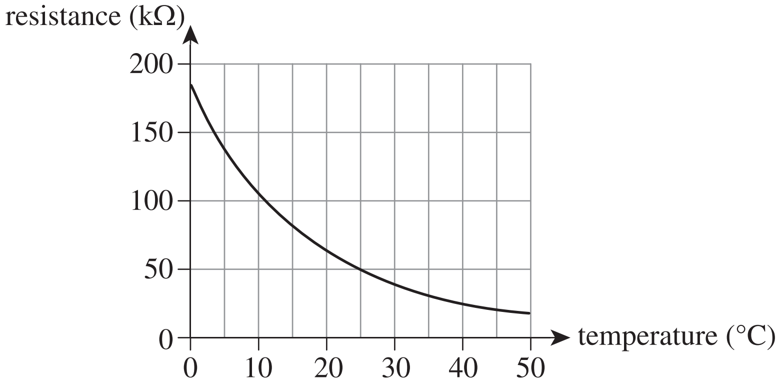

Figure 14

The cooling switching control unit will operate to provide cool air when it receives a minimum voltage of 5 V, which is to occur at 25°C.

a. What is the resistance of the thermistor at 25°C? 1 mark

kΩ

b. Determine the variable resistor value required such that the cooling switch control unit is to receive 5 V at 25°C surrounding temperature. 2 marks

kΩ

It is desired for the cooling switch control unit to now operate when the temperature rises to 30°C. The cooling switch control unit still operates at a minimum of 5 V.

c. Explain whether the value of the variable resistor needs to increase or decrease. In your answer, make reference to the resistance of the thermistor, as well as the voltages of the thermistor and variable resistor. 3 marks

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Area of study – Electric power

Question 13 (3 marks)

A student turns a wire so that she produces a conical coil of wire as shown in Figure 15. The student organises for a positive DC current to enter the solenoid. Two points, Y and Z, are also shown near the solenoid.

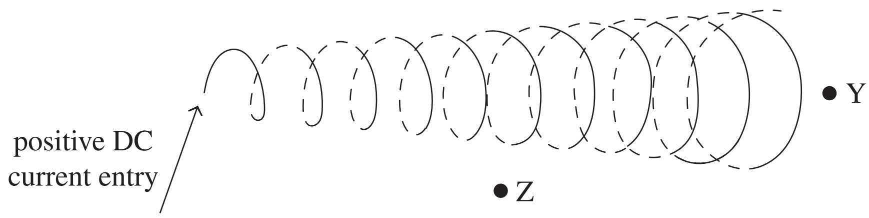

Figure 15

a. Draw a line with an arrow through each of the points Y and Z in Figure 15 to indicate the direction of the magnetic field due to the conical coil of wire. If the resulting field is zero then write ZERO at that point; if it is into the page, draw an X; or if it is out of the page, draw a ●. 2 marks

The student now connects the original conical coil to another identical conical coil as shown in Figure 16. The entry of positive DC current is in the same direction as in Figure 15.

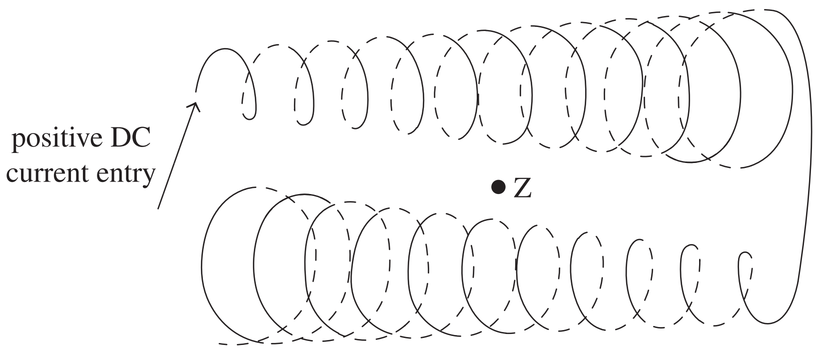

Figure 16

b. Draw a line with an arrow through point Z in Figure 16 to indicate the direction of the resultant magnetic field due to the conical coils of wire. If the resulting field is zero then write ZERO at that point; if it is into the page, draw an X; or if it is out of the page, draw a ●. 1 mark

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Question 14 (9 marks)

A student builds a model DC motor. A simplified diagram of the motor is shown in Figure 17.

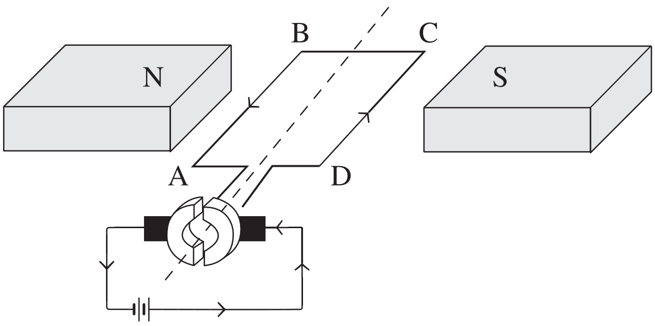

Figure 17

a. Draw arrows on the diagram to show the direction of the forces on sides AB and BC of the coil when the plane of the coil is as shown in Figure 17. If the force on either side is zero, then label that side 'zero force'. 2 marks

The rectangular coil of the motor has 75 turns of wire and the magnetic field acting is 0.080 T. The length of the side CD of the coil is 4.0 cm. The side CD experiences 0.48 N force.

b. Calculate the magnitude of the current in the coil. 2 marks

	A

The commutator connection has two splits in the ring section of the assembly.

c. Explain the importance of the splits in the ring in relation to the operation of the motor. 3 marks

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d. Explain the effect on the operation of the motor if the ring was solid, without the splits. 2 marks

Question 15 (11 marks)

A student is investigating the induction of voltage in a coil by the relative motion of a magnet near it. He sets up the equipment as shown in Figure 18.

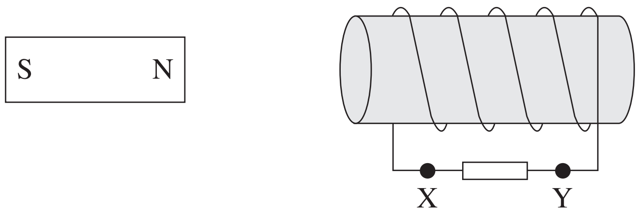

Figure 18

a. On Figure 18, draw the direction of the induced magnetic field (if one exists) in the coil when the **magnet is pulled towards the coil**. Provide an explanation for your answer. 3 marks

b. Explain the direction of the current induced in the coil, either from X through the resistor to Y or from Y through the resistor to X (if one exists), when the **magnet is pulled towards the coil**. 2 marks

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Figure 19 shows the variation of the magnetic flux (Wb) with time (s) in the middle loop of wire as the magnet is slowly brought towards and then pulled away from the coil over a time interval of four seconds. At the two-second mark into the motion, the magnetic flux value is 0.0005 Wb.

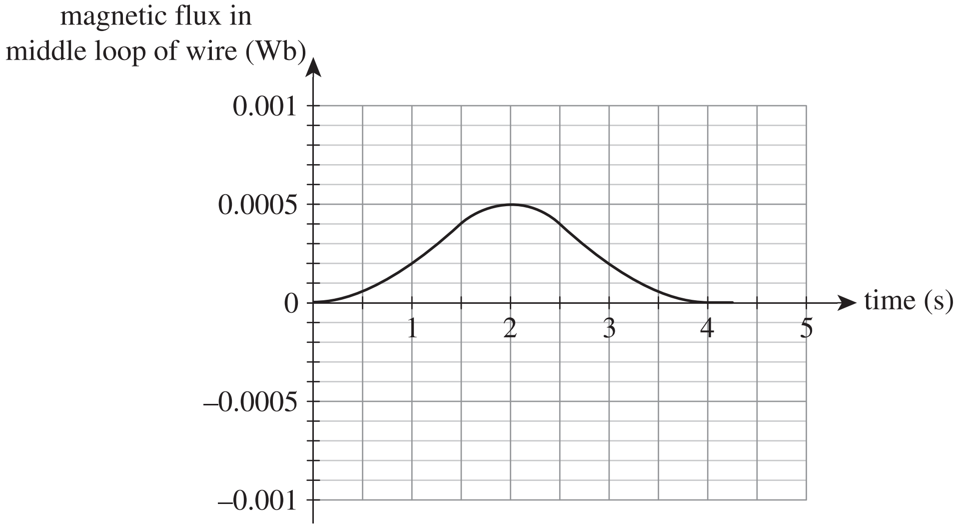

Figure 19

c. Determine the magnitude of the average induced voltage through the middle loop of the coil in the first two seconds of its motion. 2 marks

V

d. On Figure 19, sketch the variation of the magnetic flux (Wb) with time (s) in the middle loop of wire as the magnet is slowly brought towards and then pulled away from the coil in a time of two seconds. 2 marks

Figure 20 shows the variation of the induced voltage in the middle loop of the coil (V) with time (s) as the magnet is slowly brought towards and then pulled away from the coil over a time interval of four seconds.

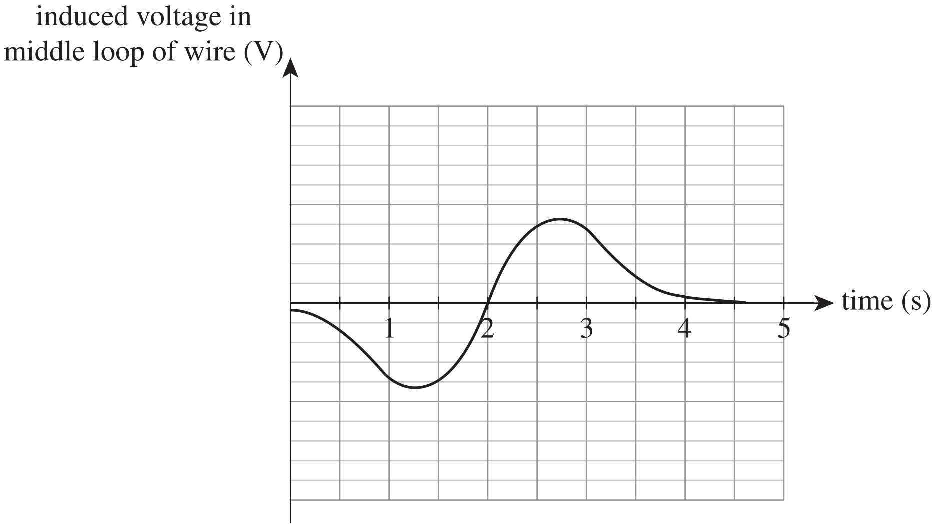

Figure 20

e. On Figure 20, sketch the variation of the induced voltage (V) in the middle loop of wire with time (s) as the magnet is slowly brought towards and then pulled away from the coil in a time of two seconds. 2 marks

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Question 16 (7 marks)

A student builds a generator and incorporates blades that can be turned by running water. The blades connect to the coil of the generator as shown in Figure 21. The generator uses two slip-rings as part of its assembly.

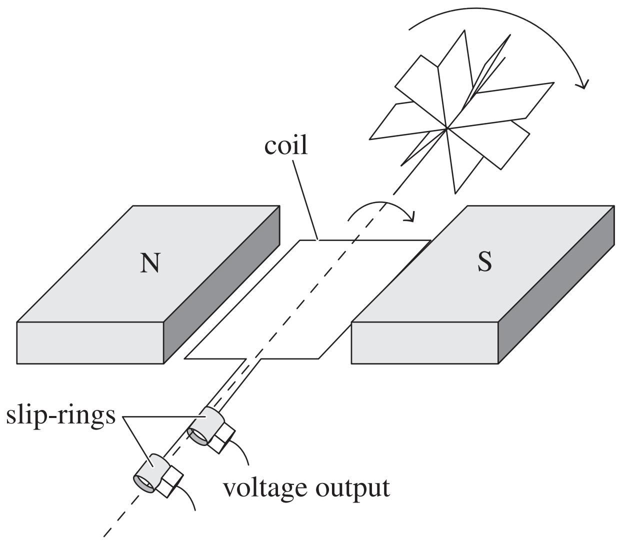

Figure 21

The voltage output is connected to a data logger, which records the output voltage as shown in Figure 22. No numerical scales are shown.

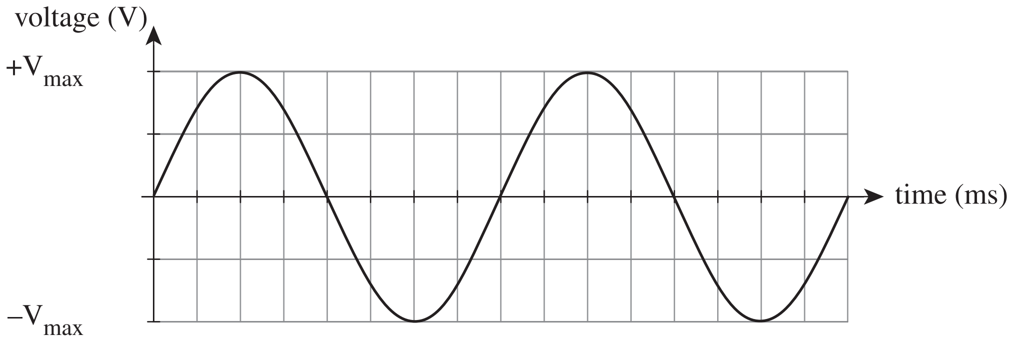

Figure 22

The slip-ring ends were then connected to a multimeter and the student measured the RMS voltage to be 0.40 V for the same rotation. The student measured the turning rate to be 2.5 turns per second.

a. On Figure 22, mark in the time scale in milliseconds (ms) and the values of $+V_{max}$ and $-V_{max}$ in volts (V). Show your working in the space below. 5 marks

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b. Explain the importance of the slip-rings in relation to the voltage output variation as shown in Figure 22. 2 marks

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Question 17 (6 marks)

Delivery of electric power from a power station to a city involves transmission at a number of different voltages. The generator of the power station produces energy at an AC voltage of 20 kV RMS.

In the adjacent switchyard this is stepped up to 500 kV RMS before transmission to the terminal station transformer in the outer suburban area. Figure 23 shows the switchyard transformer with long-distance lines (active and return) leading to a terminal station transformer.

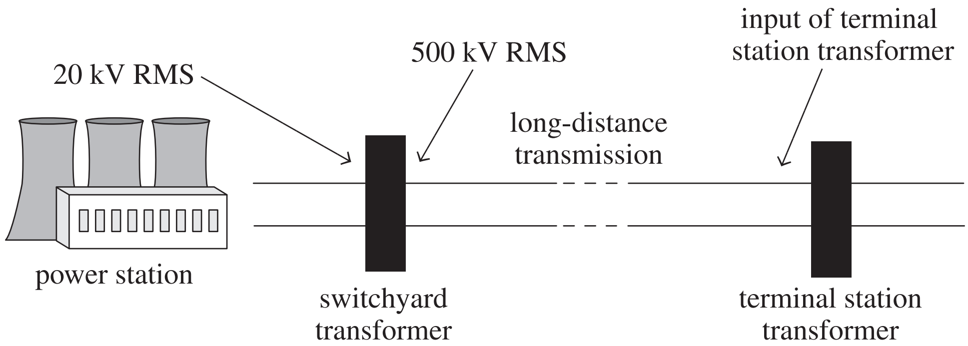

Figure 23

a. Calculate the ratio $\frac{\text{number of turns on the secondary coil of the switchyard transformer}}{\text{number of turns on the primary coil of the switchyard transformer}}$. 1 mark

At the secondary coil of the switchyard transformer where the voltage is 500 kV RMS, the power delivered is 400 MW.

b. Determine the peak current flowing in the secondary coil of the switchyard transformer. 2 marks

A

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The percentage power loss in the long-distance line is 1.6%.

c. Determine the resistance of the long-distance transmission lines (active and return). 3 marks

Ω

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Area of study – Interactions of light and matter

Question 18 (6 marks)

Figure 24 shows how an interference pattern can be created on a screen by a coherent monochromatic light source going through two slits (S_1 and S_2) which are a distance d apart.

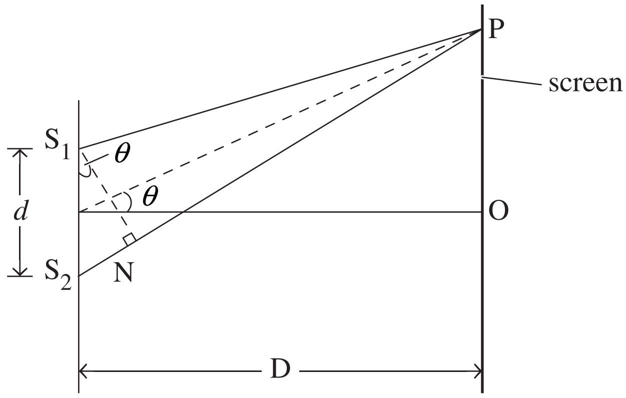

Figure 24

A blue laser of wavelength 400 nm is used as the coherent monochromatic light source.

a. Which one of the following best describes what you would expect to see at point O on the screen? 2 marks

A. a bright band due to constructive interference

B. a bright band due to destructive interference

C. a dark band due to constructive interference

D. a dark band due to destructive interference

Point P represents the third nodal line from the centre of the pattern on the screen.

b. Calculate the path difference $S_2P - S_1P$. 2 marks

nm

c. Explain what happens to the interference pattern on the screen if the distance d between the two slits is made smaller. 2 marks

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Question 19 (6 marks)

Figure 25 shows incoming light ejecting an electron from a metal. This is called the photoelectric effect.

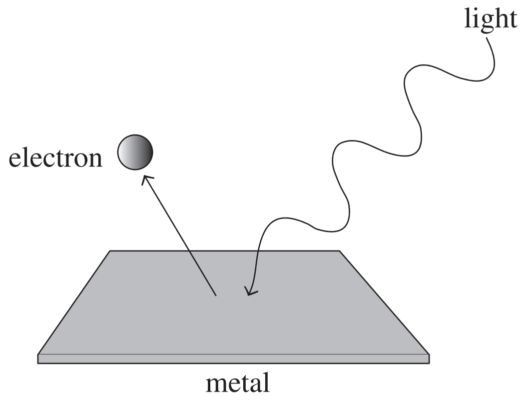

Figure 25

Albert Einstein won the Noble Prize in 1921 for his 'discovery of the photoelectric law'; that is, the maximum kinetic energy (KE_{max}) of the ejected electron was the difference between the incoming photon energy (hf) and the work function of the metal (W). Mathematically, $KE_{max} = hf - W$.

a. Explain why Einstein's formula refers to the maximum kinetic energy (KE_{max}) of the ejected electron. 2 marks

___

___

___

___

b. Potassium has a work function of 2.3 eV.

Calculate the threshold frequency for potassium. Show your working. 2 marks

Hz

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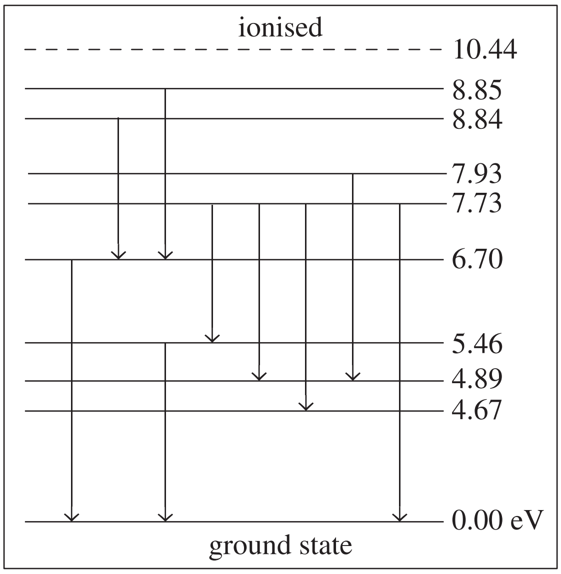
c. In an experiment using the potassium as the target metal, an electron is ejected with a maximum kinetic energy of 1.7 eV.

Calculate the wavelength of the incoming light. 2 marks

m

Question 20 (4 marks)

Figure 26 shows part of the energy level diagram (in eV) for mercury, including the ionisation level.



energy levels for mercury

Figure 26

a. Calculate the value of highest frequency light emitted by mercury in one of the transitions shown in Figure 26. 2 marks

Hz

b. Calculate the value of the longest wavelength light that is emitted by mercury in one of the transitions shown in Figure 26. 2 marks

m

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Question 21 (4 marks)

Louis de Broglie proposed a model wherein matter has a wave nature.

In a linear accelerator, protons are accelerated to a speed of 2000 km s^{-1}. The mass of a proton is 1.673×10^{-27} kg.

a. Calculate the de Broglie wavelength of the protons. 2 marks

m

b. A proton has a mass that is 1836 times the mass of an electron.

The ratio of the de Broglie wavelength of a proton to an electron both travelling at the same speed is closest to 2 marks

A. $\frac{1}{1836}$

B. $\frac{1}{\sqrt{1836}}$

C. $\frac{\sqrt{1836}}{1}$

D. $\frac{1836}{1}$

Question 22 (5 marks)

Figure 27 shows the X-ray diffraction pattern created when an X-ray beam of wavelength 2×10^{-10} m passes through an aluminium foil, and Figure 28 shows the electron diffraction pattern created when a beam of electrons passes through the same aluminium foil.

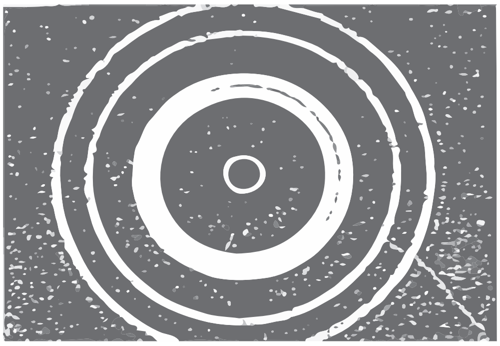

Figure 27

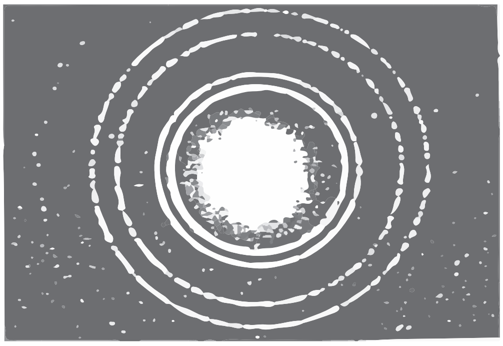

Figure 28

a. Calculate the momentum of the X-rays used to produce the diffraction pattern shown in Figure 27. 2 marks

kg m s^{-1}

b. Calculate the kinetic energy of the electrons that would produce the diffraction pattern shown in Figure 28. 3 marks

J

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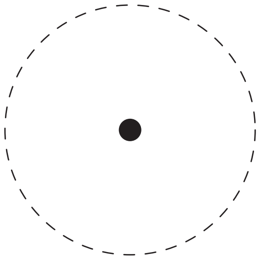
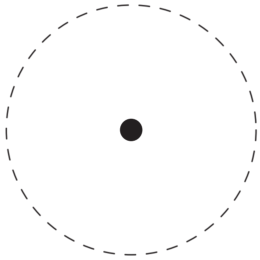
Question 23 (3 marks)

On the diagrams below, draw how the de Broglie wavelengths can be represented for 4.5λ and 5λ.



4.5λ



5λ

END OF SECTION A

SECTION B

Instructions for Section B

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Detailed study 1 – Einstein's special relativity

For all questions in this Detailed study you should take the value of g to be 10 m s^{-2}.

Question 1

Neil travels in a spacecraft and sunlight enters the craft. At the same time, light is passing through a vacuum tube inside the craft.

Which one of the following statements is true?

A. The speed of light is the same value for the sunlight in the air inside the spacecraft as for the light travelling through the vacuum tube, according to Einstein's second postulate for relativity.

B. The speed of the sunlight will be different to the speed of the light in the vacuum tube, due to the relative speed of the spacecraft to the Sun.

C. The speed of the light in the vacuum tube will be less than the speed of the sunlight inside the spacecraft, as the vacuum tube is a non-inertial frame of reference.

D. The speed of the sunlight inside the spacecraft is different to the speed of the light in the vacuum tube, as the electrical and magnetic properties of air and the internal chamber of the vacuum tube are different.

Question 2

A rocket ship is travelling away from the Sun at a speed of v relative to the Sun. Light from the Sun enters the rocket ship. The speed of light relative to the Sun is c.

In terms of the view held by classical physics in 1870 and the view held by modern physics today, respectively, which of the following is true regarding the speed of the sunlight relative to the rocket ship?

	Classical physics view (1870) of the speed of sunlight relative to rocket ship	Modern physics view (today) of the speed of sunlight relative to rocket ship
A.	$c - v$	c
B.	$c + v$	c
C.	c	$c - v$
D.	c	$c + v$

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Question 3

The conclusions drawn from the Michelson–Morley experiment of 1887 were important in assisting with the development of Einstein's special relativity.

Which of the following statements describes the most important conclusion drawn from the experiment?

A. The speed of light has a constant value in space.

B. The existence of the aether did not affect the speed of light value.

C. There is no difference in the speed of light travelling in two different directions through space relative to an observer.

D. The aether was more difficult to detect experimentally than previously thought.

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Use the following information to answer Questions 4–8.

Two spacecraft, SC16 and RS55, are travelling in opposite directions to each other and are near a space station. This is shown in Figure 1 below.

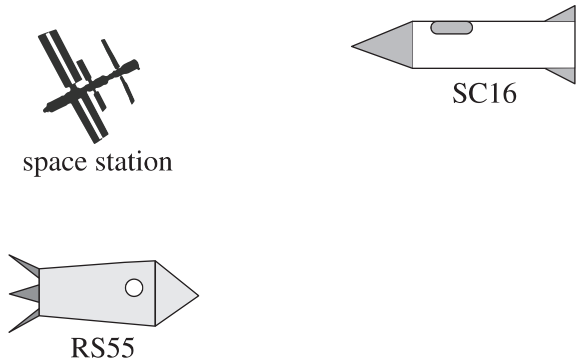

Figure 1

The astronauts in RS55 see the space station as stationary relative to their craft. The astronauts in SC16 see the space station moving past them.

Question 4

Which of the following is true about the measurement of the proper length of the space station?

A. The astronauts on RS55 and SC16 will both be able to measure the proper length.

B. Only the astronauts in RS55 will be able to measure the proper length, as they are at rest relative to the space station.

C. Only the astronauts in RS55 will be able to measure the proper length, as they have more time than the astronauts in SC16 to see the space station directly, allowing a more accurate measurement to be made.

D. Only the astronauts in SC16 will be able to measure the proper length of the space station as they are able to measure the endpoints of it simultaneously.

Question 5

The proper length of the space station is 300 m. A measurement of the space station length taken in one of the spacecraft is 198 m.

What is the value of the Lorentz factor?

A. 2.296

B. 1.515

C. 0.660

D. 0.436

Question 6

The same spacecraft now changes its motion and the measurement of the space station length is taken again. The Lorentz factor is calculated to be 1.25.

What is the speed of the space station relative to the spaceship?

A. 0.80*c*

B. 0.75*c*

C. 0.60*c*

D. 0.44*c*

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Question 7

The space station now begins to rotate. The astronauts from the two spacecraft communicate to measure the time of one revolution of the rotating space station using identical clocks. One of the spacecraft measures a revolution time of 4.5 minutes while the other measures the revolution time to be 7.5 minutes.

What is the speed of one of the spacecraft relative to the other?

A. $0.80c$

B. $0.64c$

C. $0.63c$

D. $0.40c$

Question 8

Which of the following is the correct reason that the astronauts from both spacecrafts measure the rotation time to be different?

A. The internal workings of the clocks vary with the spacecraft speeds.

B. The two sets of astronauts perceive the length of the space station to be different.

C. The speed of the spacecraft relative to the space station affects the time at which the light arrives at their eyes, which then influences the times for starting and stopping their clocks.

D. Light from the space station takes longer to arrive at the spacecraft that is furthest from it and so influences the starting and stopping of the clock on that spacecraft.

Question 9

A helium nucleus consists of 2 protons and 2 neutrons bound together. The binding of the protons and neutrons causes their combination to release energy of value 4.367×10^{-12} J. Let the total mass of the 2 protons and 2 neutrons prior to their combination be M_i.

The mass of the helium nucleus after the combination is

A. $(M_i + 4.367 \times 10^{-12})$ kg

B. $(M_i + 4.852 \times 10^{-29})$ kg

C. $(M_i - 4.367 \times 10^{-12})$ kg

D. $(M_i - 4.852 \times 10^{-29})$ kg

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Use the following information to answer Questions 10 and 11.

A spacecraft travels toward Earth at a speed of 0.7c. The rest mass of the spacecraft is M_0.

Question 10

The mass of the spacecraft relative to Earth is

A. M_0.

B. greater than M_0 by $0.4M_0$.

C. greater than M_0 by $0.7M_0$.

D. greater than M_0 by $0.83M_0$.

Question 11

The kinetic energy of the spacecraft relative to Earth is

A. $0.4M_0c^2$

B. M_0c^2

C. $1.4M_0c^2$

D. $2.4M_0c^2$

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SECTION B

Instructions for Section B

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Detailed study 2 – Materials and their use in structures

For all questions in this Detailed study you should take the value of g to be 10 m s^{-2}.

Use the following information to answer Questions 1 and 2.

Stone columns were used to build many temples in Greece. Figure 1 shows the stress versus strain graph for a particular type of stone. X indicates the point of failure.

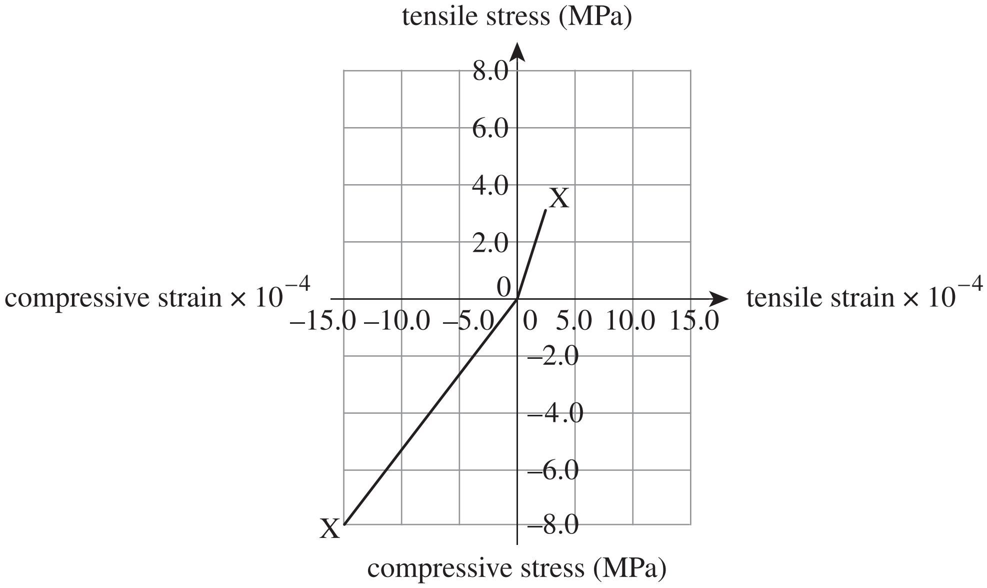

Figure 1

One such stone column was 20 m high and had a cross-sectional area of 2.0 m^2.

Question 1

Which one of the following gives the best estimate of the largest downward force such a column can withstand without breaking?

A. 8.0×10^4 N

B. 1.6×10^7 N

C. 8.0×10^7 N

D. 1.6×10^8 N

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Question 2

Lintels made of the same stone were placed on top of the columns as shown in Figure 2.

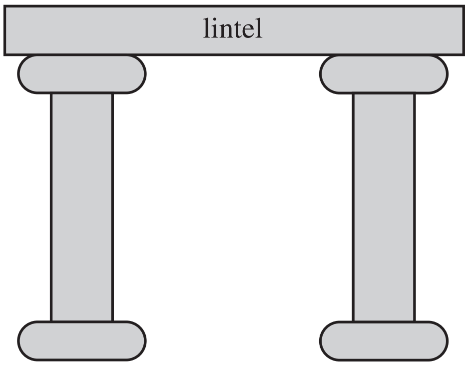

Figure 2

The Greeks found that the span of the lintel had to be very short because the bottom of the lintel cracked easily.

This was because

A. both the top and the bottom of the lintel were under compressive stress.

B. the top of the lintel was under compressive stress and the bottom of the lintel was under tensile stress.

C. both the top and the bottom of the lintel were under tensile stress.

D. the top of the lintel was under tensile stress and the bottom of the lintel was under compressive stress.

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Use the following information to answer Questions 3 and 4.

The stress versus strain graphs of two different materials (X and Y) are shown in Figure 3. Failure of each of the materials is indicated on the graph by an asterisk (∗).

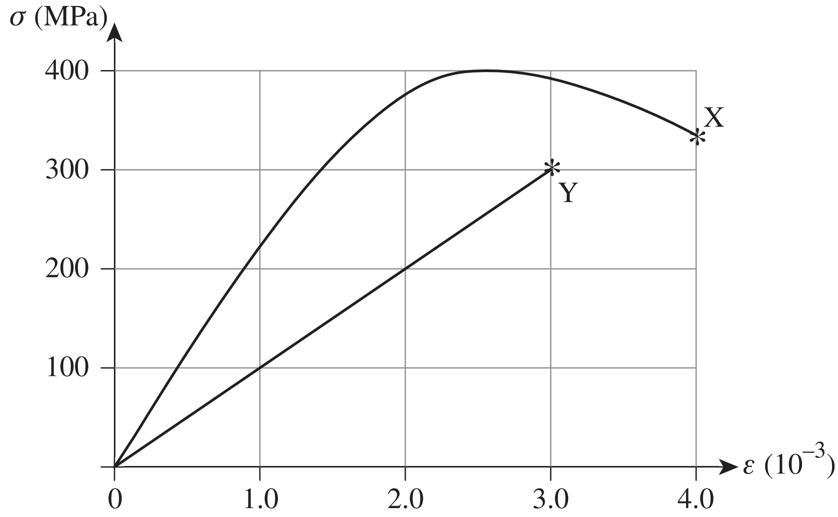

Figure 3

Question 3

Which one of the following statements is correct concerning materials X and Y?

A. X is a weaker material than Y.

B. Y shows plastic behaviour.

C. X shows brittle failure.

D. X is a tougher material than Y.

Question 4

Which one of the following is closest to the value of the toughness of material Y?

A. 0.45 kJ m^{-3}

B. 0.45 MJ m^{-3}

C. 0.9 MJ m^{-3}

D. 0.9 GJ m^{-3}

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Use the following information to answer Questions 5 and 6.

Figure 4 shows a simple seesaw. The distance between Bob on the left and Raz on the right is 4.5 m. Bob has a mass of 65 kg while Raz has a mass of 25 kg.

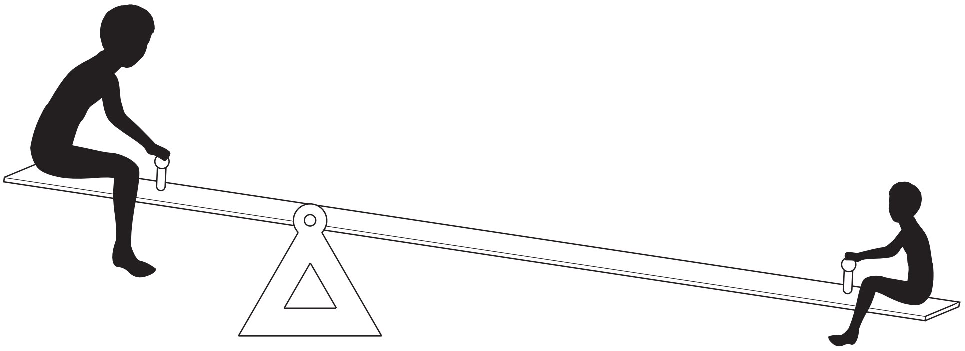

Figure 4

Question 5

Assuming the beam has a negligible mass, the distance of the fulcrum point from Bob is closest to

A. 1.25 m

B. 1.45 m

C. 2.00 m

D. 2.25 m

Question 6

If the beam actually had a mass of 20 kg, then the distance from Bob to the fulcrum point for the whole system to be in balance would be

A. closer to Bob than before.

B. the same as before.

C. further from Bob than before.

D. impossible to determine from the information given.

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Use the following information to answer Questions 7 and 8.

A simple equilateral triangle truss is made as shown in Figure 5. A vertical force of 20 kN acts down at point A.

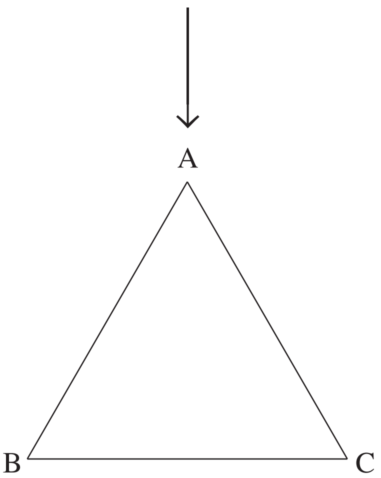

Figure 5

Question 7

Which one of the following tables regarding the type of stress acting in the various sections of the truss is correct?

A.

F_{AB}	F_{AC}	F_{BC}
tension	tension	tension

B.

F_{AB}	F_{AC}	F_{BC}
compression	compression	tension

C.

F_{AB}	F_{AC}	F_{BC}
tension	tension	compression

D.

F_{AB}	F_{AC}	F_{BC}
compression	compression	compression

Question 8

Which one of the following is closest to the magnitude of the force acting in section AB of the truss?

A. 10 kN
B. 11.6 kN
C. 20 kN
D. 23.2 kN

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Question 9

Peta, of mass 60 kg, is painting while standing on a plank of mass 100 kg and length 4 m, at a distance of 1 m from the support at P, as shown in Figure 6.

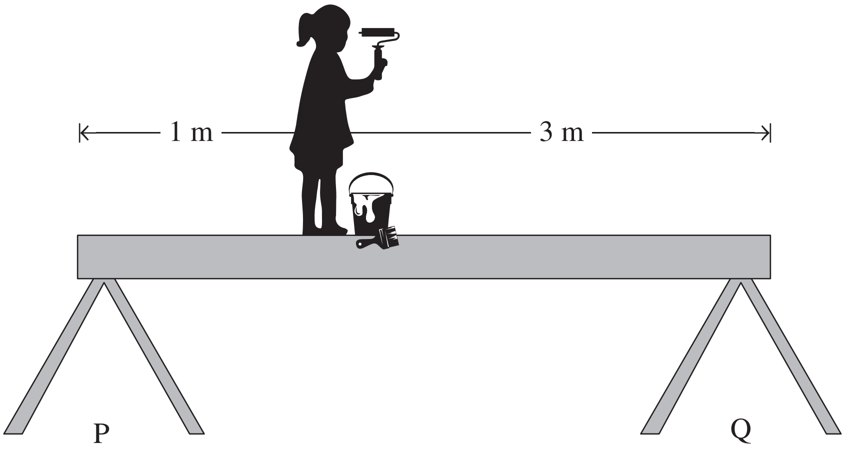


Figure 6

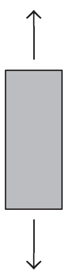
Which one of the following best gives the magnitude of the supporting force at point P?

A. 160 N
B. 650 N
C. 950 N
D. 1600 N

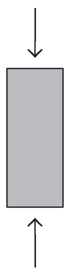
Question 10

Which one of the following diagrams shows a shear force?

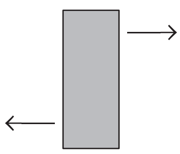
A.



B.



C.



D. none of these options

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Question 11

Cast-iron beams were once used in bridges as shown in Figure 7. In designing the cast-iron bridge beam engineers needed to take into account that cast iron is stronger in compression than in tension and that material costs should be kept to a minimum without compromising safety.

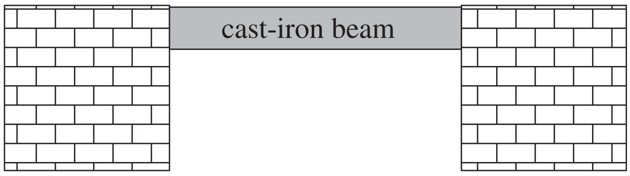
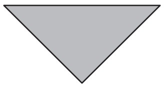
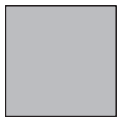
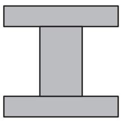


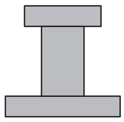
Figure 7

Which one of the following cross-sections would an engineer select as being the most appropriate for the cast-iron beam in the bridge?

A. 

B. 

C. 

D. 

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SECTION B

Instructions for Section B

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Detailed study 4 – Synchrotron and its applications

Use the following information to answer Questions 1 and 2.

A linear accelerator designed to accelerate electrons has a 10 kV potential difference between the cathode and the anode, as shown in Figure 1. Assume the electrons have no kinetic energy when they are at the cathode and ignore relativistic corrections.

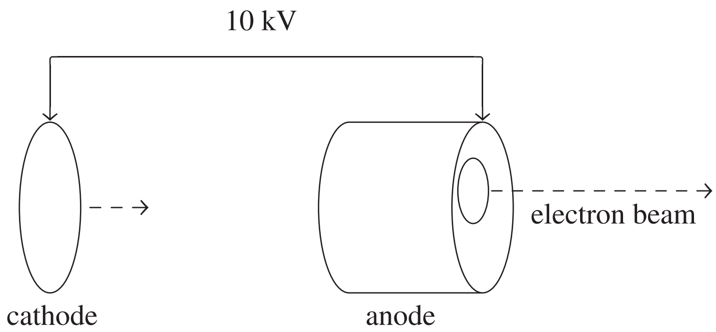

Figure 1

Question 1

The velocity of electrons leaving the anode is closest to

A. 1.0×10^6 m s^{-1}

B. 6.0×10^7 m s^{-1}

C. 1.0×10^8 m s^{-1}

D. 3.0×10^8 m s^{-1}

Question 2

If the 10 kV linear accelerator accelerated protons instead of electrons in the apparatus shown in Figure 1, then the speed of the protons leaving the anode compared to the speed of the electrons leaving the anode would be

A. smaller.

B. the same.

C. larger.

D. impossible to determine from the information given.

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Use the following information to answer Questions 3–5.

Figure 2 shows a proton beam travelling to the right at a speed of 1.0×10^{7} m s^{-1} and entering a region where there is a magnetic field of strength 2.0 T. The mass of a proton is 1.67×10^{-27} kg.

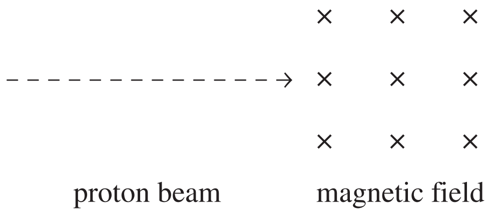

Figure 2

Question 3

Which one of the following best describes the direction of the force acting on the proton beam as a result of its interaction with the magnetic field shown in Figure 2?

A. up

B. into the page

C. down

D. out of the page

Question 4

The magnitude of the magnetic force acting on a proton as it enters the magnetic field is

A. 1.0×10^{-12} N

B. 1.6×10^{-12} N

C. 3.2×10^{-12} N

D. 1.0×10^{-8} N

Question 5

While the protons are in the magnetic field, they follow a path which is an arc of a circle.

The radius of the arc of the circle of the proton beam is closest to

A. 2.6×10^{-3} m

B. 5.2×10^{-3} m

C. 2.6×10^{-2} m

D. 5.2×10^{-2} m

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Use the following information to answer Questions 6 and 7.

Synchrotron radiation can be characterised by the **divergence** of the beam and the **brightness** of the beam.

Question 6

Which of the following statements best explains what is meant by the **divergence** of the beam?

A. the extent to which the frequency of the beam spreads
B. the extent to which the beam spreads out
C. the extent to which the photon energy spreads out
D. none of the above

Question 7

Which of the following statements best explains what is meant by the **brightness** of the beam?

A. the length of the pulse of the beam
B. the number of photons emitted per second within a specific narrow frequency range
C. the strength of the polarisation of the beam
D. the strength of the beam

Use the following information to answer Questions 8 and 9.

X-rays are used to investigate important properties of crystalline structures. One particular crystal is examined in a synchrotron using X-rays of wavelength 8.6×10^{-10} m. The X-ray radiation scattered back off the crystal is of wavelength 9.6×10^{-10} m.

Question 8

The amount of energy lost in this collision is

A. 1.0×10^{-17} J
B. 1.2×10^{-17} J
C. 2.4×10^{-17} J
D. 1.0×10^{-10} J

Question 9

The form of scattering involved in this experiment is

A. Compton scattering.
B. diffuse scattering.
C. Thomson scattering.
D. convergent scattering.

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Use the following information to answer Questions 10 and 11.

An X-ray beam of wavelength 0.50 nm is fired at a particular crystal which has an atomic plane spacing of 1.0 nm.

Question 10

The angle of reflection for $n = 2$ for this crystal is closest to

A. 2°
B. 5°
C. 30°
D. 60°

Question 11

The number of different angles of reflection this crystal can exhibit is

A. 1
B. 2
C. 3
D. 4

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SECTION B

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Detailed study 6 – Sound

Use the following information to answer Questions 1–4.

Tina is singing a note. P is a fixed point of distance 2.0 m in front of her. At the instant shown in Figure 1, P has a compression passing through it.

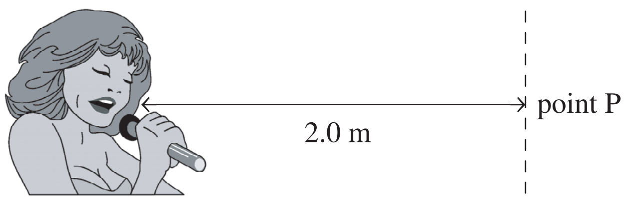

Figure 1

Figure 2 shows the variation of wave pressure at point P with time ($\times 10^{-6}$ seconds).

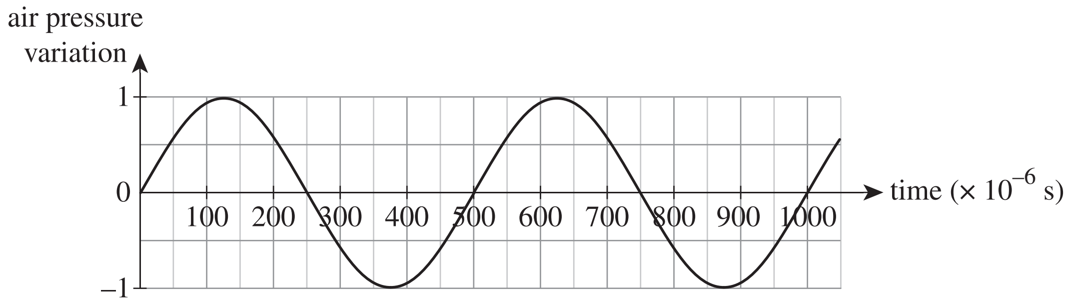

Figure 2

Figure 3 shows the variation of air pressure variation at some distance (cm) around the point P for a particular instant.

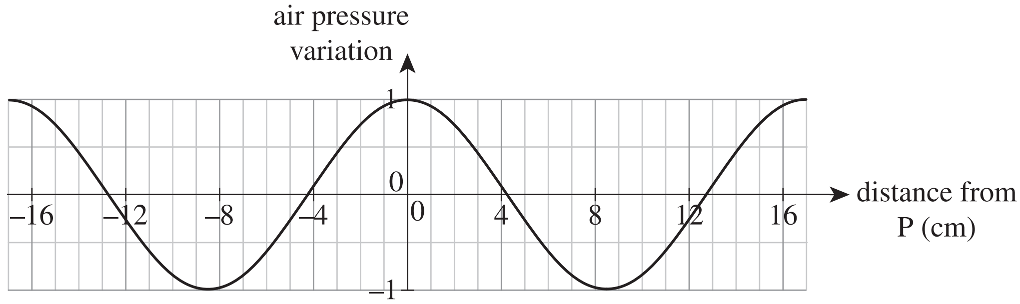

Figure 3

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Question 1

What is the distance between two consecutive compression centres?

A. 4.25 cm
B. 8.5 cm
C. 17 cm
D. 34 cm

Question 2

What is the frequency of the note sung by Tina?

A. 500 Hz
B. 1000 Hz
C. 2000 Hz
D. 4000 Hz

Question 3

The sound intensity level at point P is 80 dB.

What is the sound intensity (in $W\ m^{-2}$) at point P?

A. $8.0 \times 10^{-5}\ W\ m^{-2}$
B. $1.0 \times 10^{-4}\ W\ m^{-2}$
C. $8.0 \times 10^{-4}\ W\ m^{-2}$
D. $1.0 \times 10^{-3}\ W\ m^{-2}$

Question 4

If Tina continues to sing with the same power, which of the following best gives the sound intensity level at a distance of 6.0 m in front of her?

A. 9.0 dB
B. 70 dB
C. 75 dB
D. 80 dB

Question 5

Figure 4 is an equal-loudness curve showing the phon levels.

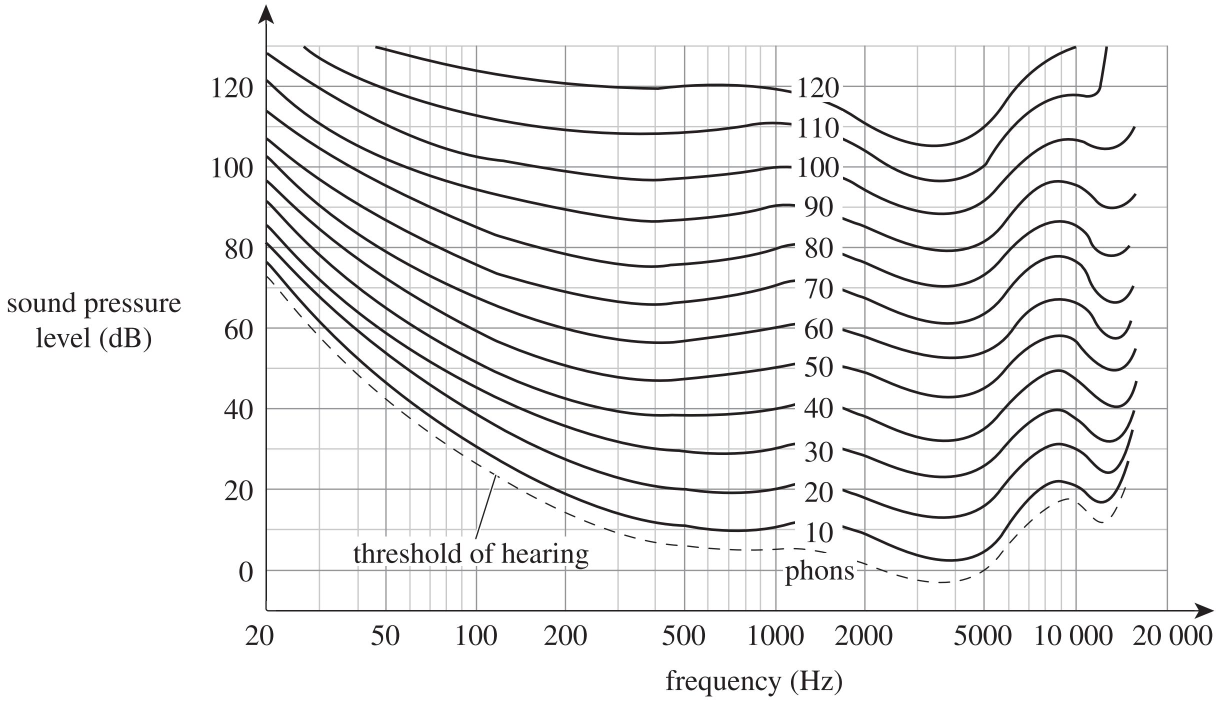

Figure 4

A speaker plays a note of 100 Hz and Mary uses a sound meter to measure the note where she stands. The meter measures the sound level to be 80 dB.

Which one of the following is the best estimate of the sound level with which Mary perceives the note?

A. 70 dB

B. 75 dB

C. 80 dB

D. 100 dB

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Question 6

Figure 5 shows two violinists sitting in different but identical rooms which are located off a corridor. The rooms have doorways of different width and the doorways are open and directly opposite each other. Point X is immediately in front of each doorway and point Y is a few metres down the corridor. The doorway of room A is 1.5 m wide. The doorway of room B is 0.80 m wide. The speed of sound is 330 m s^{-1} in the music rooms and corridor.

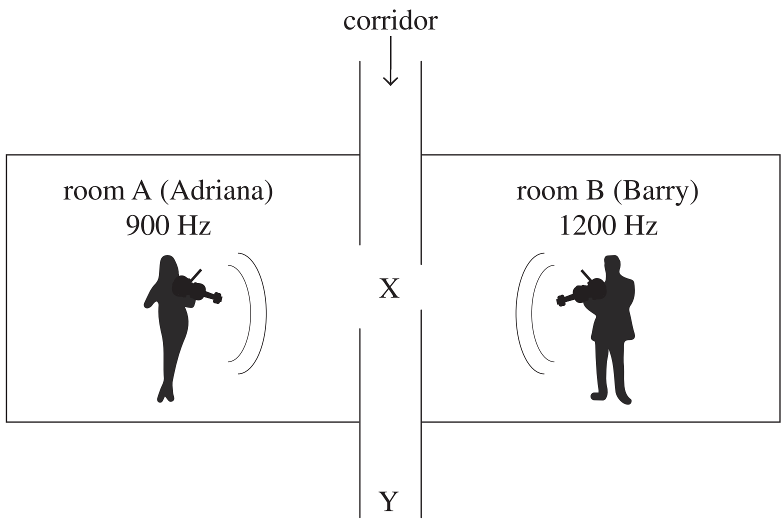

Figure 5

The teacher places a sound meter at point X. The teacher then asks the violinist, Adriana, in room A to play a note of 1200 Hz, and measures the sound intensity level with the sound meter. The teacher then asks the violinist, Barry, in room B to play a note of 800 Hz, and organises for Barry to play the note until the meter measures the sound level to be the same as that for the note played by Adriana.

The teacher now moves to point Y and places the sound meter there to take sound-level measurements for both sounds played at the strengths tested as for point X. The readings were not affected by walls or reflections.

Which of the following statements best describes the comparison of the two notes observed at position Y?

A. The note played by Barry will be louder because it diffracts more through the doorway than the note played by Adriana.

B. The note played by Barry will be softer because it diffracts more through the doorway than the note played by Adriana.

C. The note played by Adriana will be louder because it diffracts more through the doorway than the note played by Barry.

D. The note played by Adriana will be softer because it diffracts more through the doorway than the note played by Barry.

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Use the following information to answer Questions 7 and 8.

A group of students are investigating the sound variation within a pipe that is open at both ends when a speaker plays a sound of single frequency through one end of the pipe. They slide a microphone through the pipe that connects to a cathode-ray oscilloscope to observe sound intensity levels as voltage variations. Figure 6 shows the experiment.

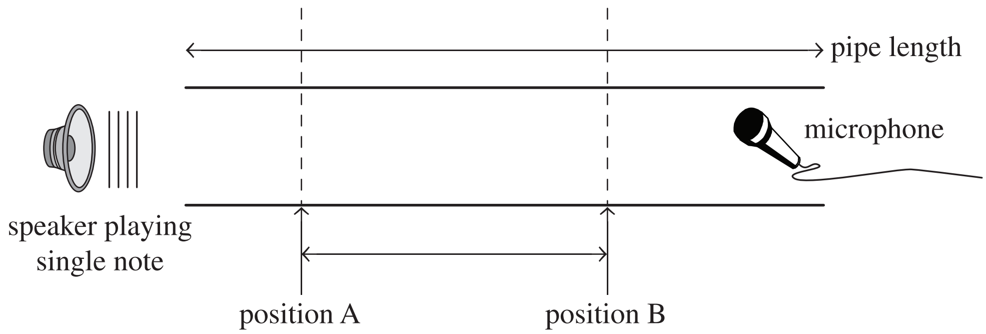

Figure 6

Two positions inside the pipe, A and B, have particularly interesting properties. The students discover that the intensity level of A, as displayed by the oscilloscope, is minimum in value, and as they move along to position B, the intensity level reaches a maximum. They record that:

- the speed of sound is 330 m s^{-1} in their laboratory
- the pipe has a length of 99.0 cm

Question 7

If λ represents the wavelength of the note played inside the pipe, then the distance between the two positions corresponds to

A. λ

B. $\frac{3}{4}\lambda$

C. $\frac{1}{2}\lambda$

D. $\frac{1}{4}\lambda$

Question 8

The first resonance occurs for a wavelength of 1.98 m.

The next three resonances occur for wavelengths of

A. 3.96 m, 5.94 m, 7.92 m

B. 99.0 cm, 66.0 cm, 49.5 cm

C. 66.0 cm, 39.6 cm, 28.3 cm

D. 5.94 m, 9.90 m, 13.86 m

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Question 9

Figure 7 below shows a diagram of a particular type of microphone.

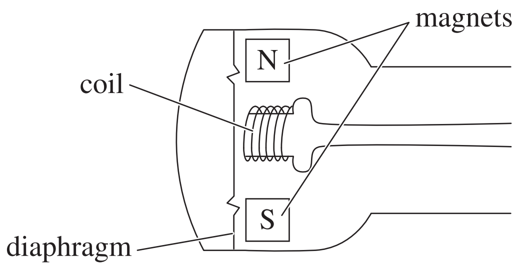

Figure 7

The microphone shown in Figure 7 works on which type of process?

A. piezoelectric effect
B. electromagnetic induction
C. electrostatic effect
D. sound amplification

Question 10

A particular microphone has the frequency response curve shown in Figure 8.

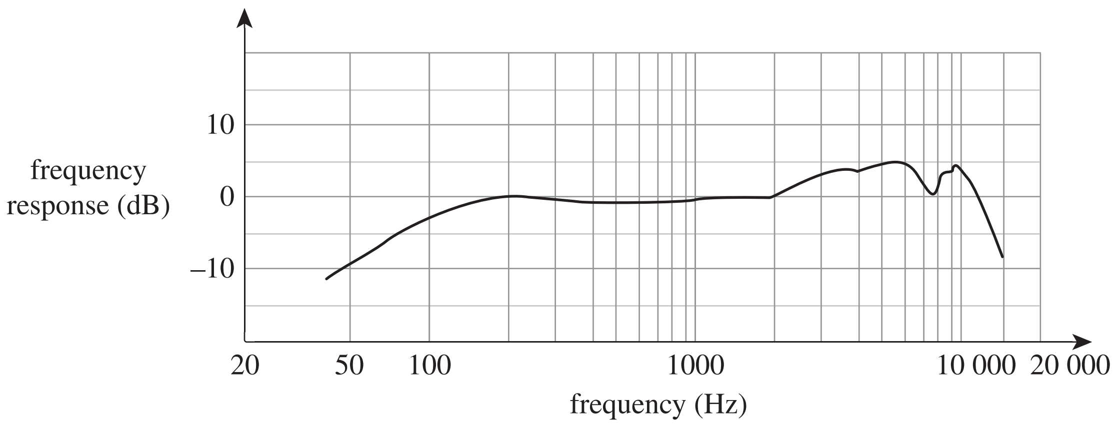

Figure 8

For which frequency or range of frequencies does the microphone operate with highest fidelity?

A. approximately 5300 Hz
B. between 200 Hz and 2000 Hz
C. between 2000 Hz and 8000 Hz
D. all frequencies mapped on the curve

Question 11

Figure 9 shows the front and side view of a typical speaker from a home sound system. The speaker is enclosed in a hard box.

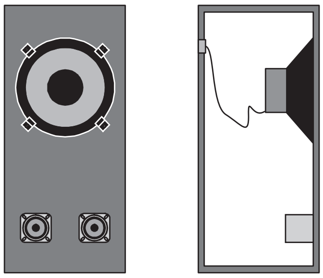

Figure 9

The purpose for enclosing the speaker in the hard box is to reduce the disruption of the desired sound from the speaker, by reducing

A. interference effects due to the sound from the rear of the speaker.

B. heat energy build-up around the speaker in altering the emitted sound.

C. the vibrational acoustic effects from the speaker in altering the emitted sound.

D. the contact of the speaker with the ground, where environmental ground vibrations can be conveyed to by the speaker and transmitted as unwanted sound.

END OF QUESTION AND ANSWER BOOKLET

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