Neap:

Trial Examination 2015

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		5	5	24
Electric power		6	6	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, one folded A3 sheet or two A4 sheets of notes and one scientific calculator.

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

Materials supplied

Question and answer booklet of 51 pages.

Formula sheet of 4 pages.

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 book 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.

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2015 VCE Physics Units 3&4 Written Examination.

Table of Contents

SECTION A

SECTION B

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 (8 marks)

Figure 1 shows Chris, a mountain bike rider of mass 50 kg, heading downhill on a 30° slope. She is travelling at a constant speed of 12 m s^{-1}. The friction force acting on Chris is shown as $\boldsymbol{F}_R$, while the normal reaction force is shown as $\boldsymbol{F}_N$.

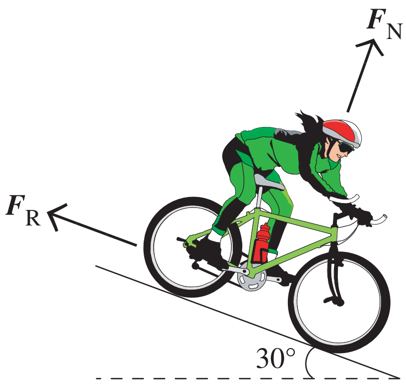

Figure 1

a. Calculate the sum of the total forces acting on Chris. 1 mark

N

b. Calculate the size of $\boldsymbol{F}_{\mathrm{R}}$. 3 marks

N

c. Calculate the size of $\boldsymbol{F}_{\mathrm{N}}$. 2 marks

N

Chris comes to a steeper section of the downhill course, where the angle of the slope is now 40° instead of 30°.

d. Which one of the following statements is true if the $\boldsymbol{F}_{\mathrm{R}}$ acting on Chris remains the same? 2 marks

A. Chris' speed will increase and $\boldsymbol{F}_{\mathrm{N}}$ will stay the same.
B. Chris' speed will stay the same and $\boldsymbol{F}_{\mathrm{N}}$ will also stay the same.
C. Chris' speed will stay the same and $\boldsymbol{F}_{\mathrm{N}}$ will decrease.
D. Chris' speed will increase and $\boldsymbol{F}_{\mathrm{N}}$ will decrease.
E. Chris' speed will increase and $\boldsymbol{F}_{\mathrm{N}}$ will increase.

Question 2 (2 marks)

Juana walks from her home to the hardware shop at a speed of 2 m s^{-1} and jogs back at a speed of 4 m s^{-1}. Calculate her average speed for the whole journey.

m s^{-1}

Question 3 (6 marks)

A car of mass 1.2 tonne travelling at 72 km h^{-1} west crashes into a large immovable tree. The car comes to a complete stop after the collision.

a. Calculate the momentum, $\boldsymbol{p}$, of the car before the collision. 2 marks

N s	direction:

After the crash, the car has no momentum.

b. Explain what has happened to the car's momentum as a result of the collision. 2 marks

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After the crash, the car has no kinetic energy.

c. Explain what has happened to the car's kinetic energy as a result of the collision. 2 marks

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Question 4 (4 marks)

Two Physics students set up an experiment to study motion using two masses, m_A (2.0 kg) and m_B (3.0 kg), as shown in Figure 2. m_A hangs off a pulley and is connected to m_B, which is on a table. m_B has a frictional force, $\boldsymbol{F}_R$, of 10 N acting on it as shown. Assume that the mass of the string is negligible and the pulley is frictionless.

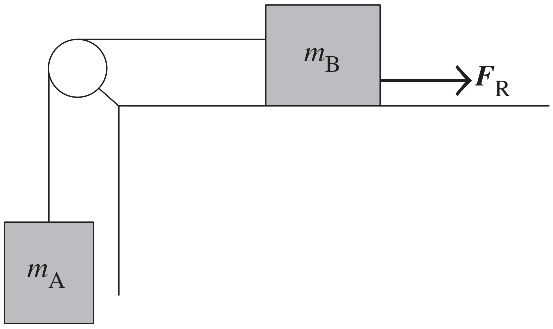

Figure 2

a. Calculate the acceleration of mass m_A. 2 marks

m s^{-2}

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

N

Question 5 (4 marks)

A projectile is projected at a constant speed, but a variety of different angles, in 15° increments from 15° through to 75°. Figure 3 shows the vertical distance travelled (h) and the range (R) as a function of the angle of projection. Air resistance is assumed to be negligible.

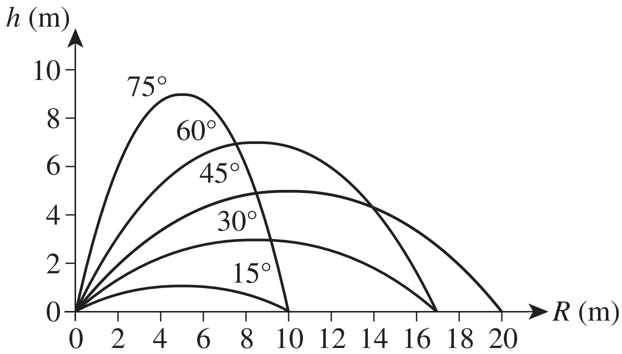

Figure 3

a. Calculate the initial speed of projection of the projectile shown in the graph when it is projected at an angle of 45° and achieves a range of 20 m. 2 marks

m s^{-1}

b. Using the appropriate projectile motion equations, prove that the range (R) is the same for a projectile that is projected at an angle of either 30° or 60° at a constant speed. 2 marks

Question 6 (4 marks)

Sam performs in a circus as an aerial acrobat. One of his acts involves hanging onto a rope with his teeth and swinging around in a conical pendulum, as shown in Figure 4. Sam has a mass of 50 kg, the radius of the circle is 6.0 m and he swings around at a constant speed of 4.0 m s^{-1}.

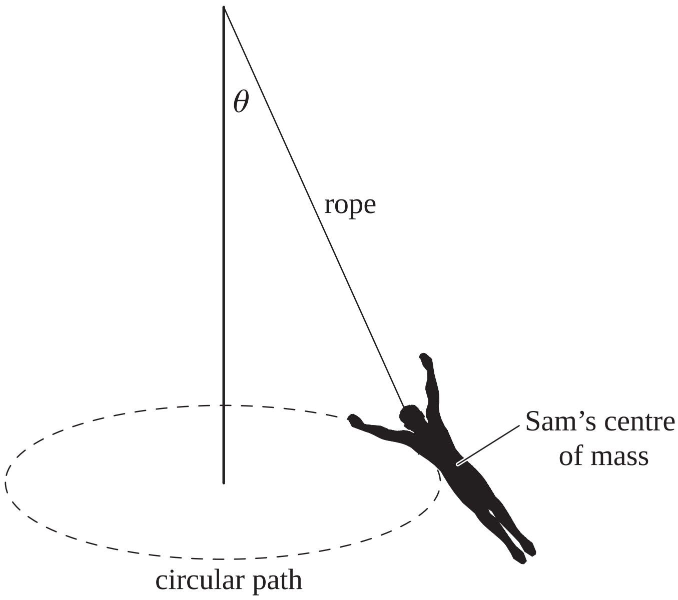

Figure 4

a. Calculate the angle θ that the rope makes with the vertical. 2 marks

$^\circ$

b. Calculate the tension in the rope. 2 marks

N

Question 7 (5 marks)

A spring of natural length 20 cm (equilibrium position) has a mass (*m*) of 0.5 kg hung on it which extends the spring by 10 cm, as shown in Figure 5.

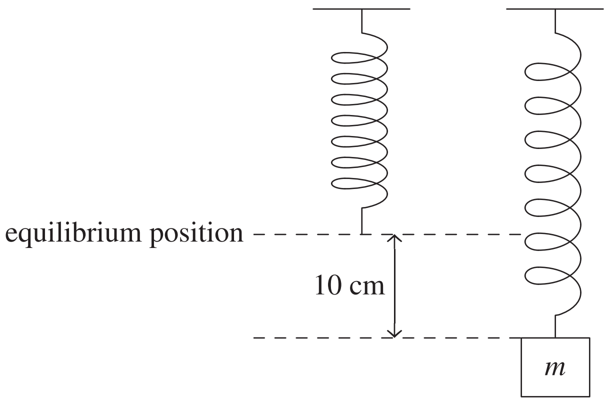

Figure 5

a. Calculate the spring constant for the spring. 1 mark

N m^{-1}

b. Calculate the extension of the spring when another mass of 0.5 kg is added. 1 mark

m

c. On Figure 6 below, draw the graph of the potential energy stored (in joules) in the spring (PE_S) versus the extension, x (in metres), for no mass, 0.5 kg and 1.0 kg. Ensure that you place numerical values on the axes. 3 marks

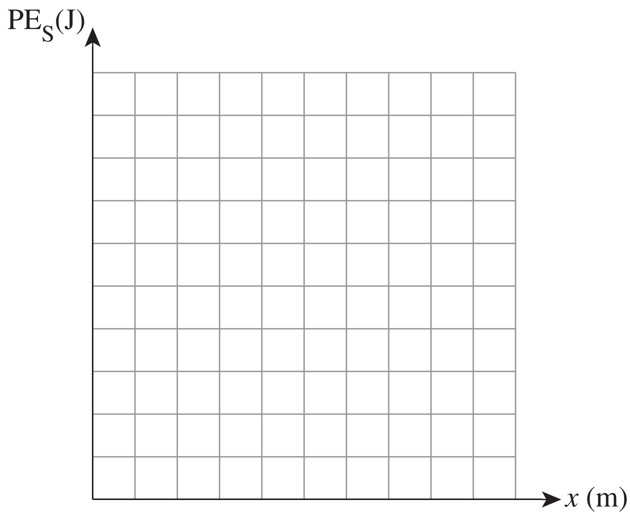

Figure 6

Question 8 (7 marks)

The Moon orbits the Earth with a period of 27.3 days. The mass of the Earth is 5.98×10^{24} kg. The mass of the Moon is 7.35×10^{22} kg.

a. Calculate the radius of orbit of the Moon around the Earth. You must show your working. 3 marks

m

b. Calculate the magnitude of the acceleration of the Moon towards the Earth. You must show your working. 2 marks

$m\ s^{-2}$

When astronauts visit the Moon they put their spacecraft into a circular orbit around it. Television footage of this event beamed back to Earth shows the astronauts 'floating' around inside the cabin of their spacecraft.

c. Explain why the astronauts are 'floating' around inside the cabin of the spacecraft. 2 marks

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Area of Study – Electronics and photonics

Question 9 (3 marks)

Figure 7 shows a circuit with four resistors: 48 Ω, 48 Ω, 40 Ω and 10 Ω.

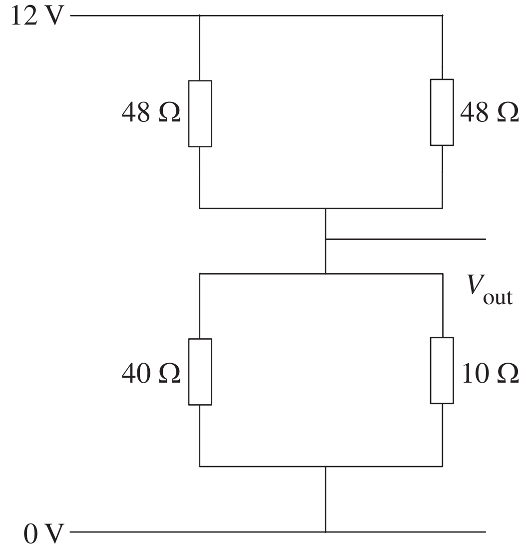

Figure 7

Determine the V_{out}.

V

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Question 10 (3 marks)

Figure 8 shows the transfer characteristics of an amplifier.

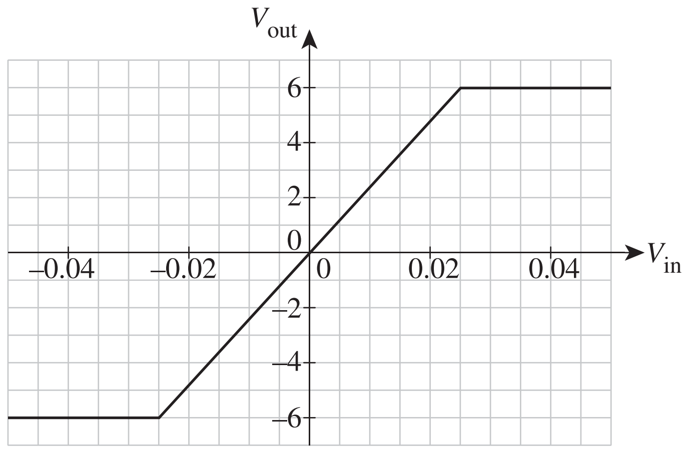

Figure 8

Figure 9 shows the input voltage variation with time that is applied to the amplifier.

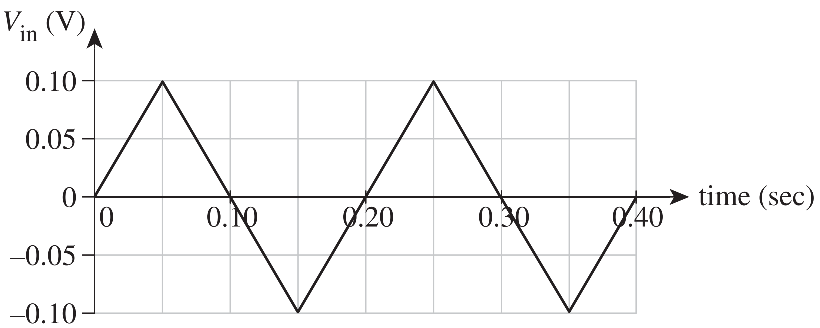

Figure 9

Sketch the output voltage of the amplifier with time on the graph in Figure 10 for the time interval 0–0.3 seconds.

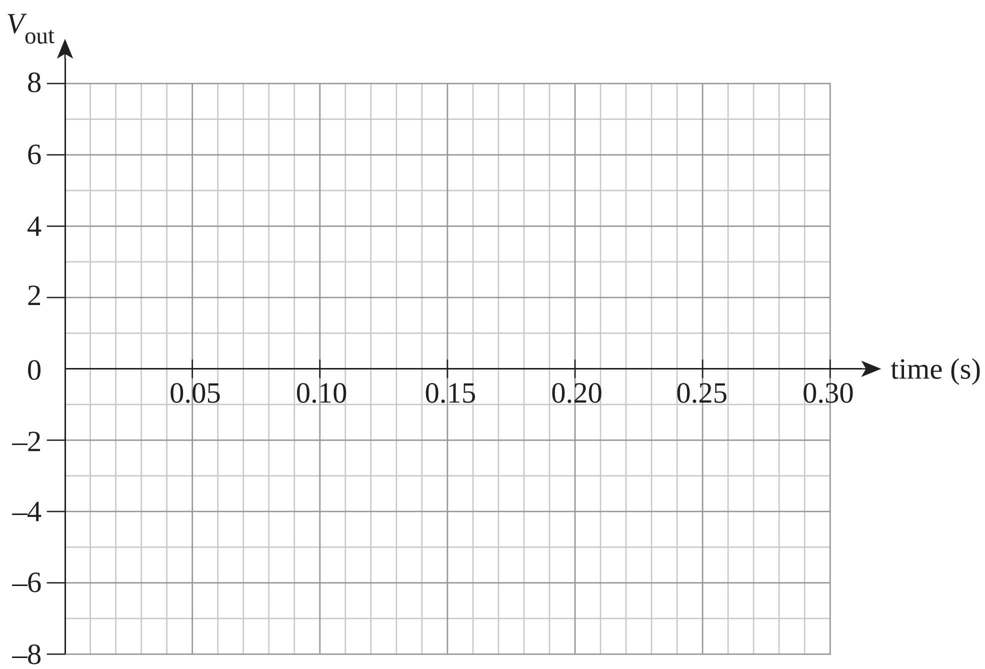

Figure 10

Question 11 (8 marks)

A thermistor is used in conjunction with a variable resistor and a 9 V power supply as shown in Figure 11. A cooling switching control and the cooling unit are also shown connected. The cooling unit, when switched ON, provides cool air to a location.

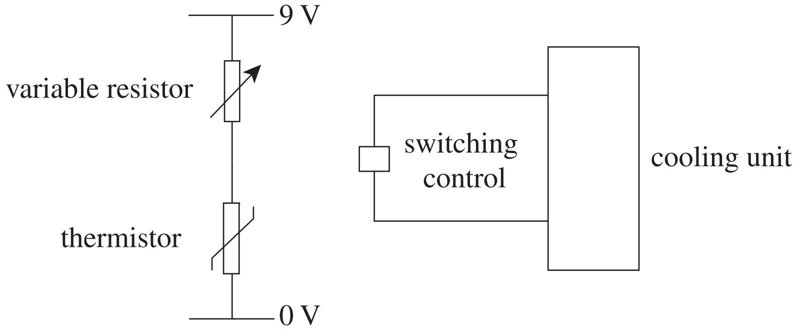

Figure 11

The resistance of the thermistor (in kΩ) is dependent on the temperature (°C) of the environment. The graph of resistance is shown in Figure 12.

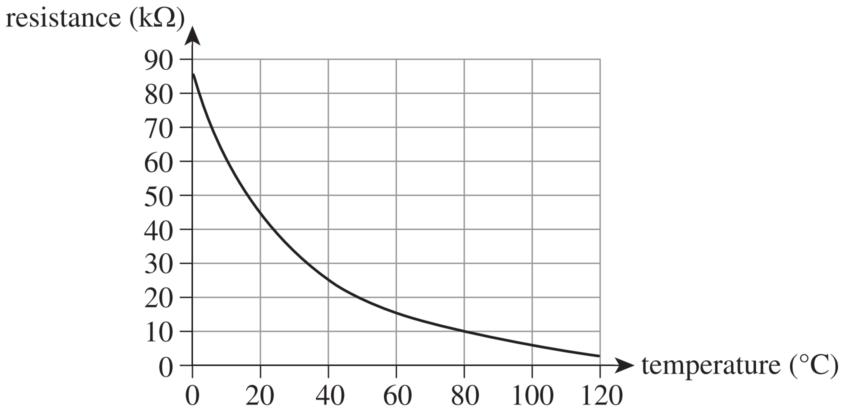

Figure 12

The switching control turns the cooling unit ON as soon as the temperature rises to 25°C. The cooling switching control needs to be at a minimum of 5.0 V in order to switch the cooling unit ON.

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

kΩ

b. Draw wiring into Figure 11 above to show how the switching control and cooling unit are to be connected so that the unit serves the purpose of providing cool air as the temperature rises to and beyond 25°C. 1 mark

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c. Determine the variable resistor value, in kΩ, such that the cooling switch control unit receives 5 V at a surrounding temperature of 25°C. 3 marks

kΩ

d. It is desired that the switching control now operates the cooling unit only when the temperature reaches 30°C. The cooling switch control unit still operates at a minimum of 5 V.

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

Question 12 (8 marks)

An alarmed security system employs an LED circuit that emits invisible light when activated. The invisible light is received by the photodiode in its own circuit, which then activates the alarm system. Figure 13 shows the two circuits.

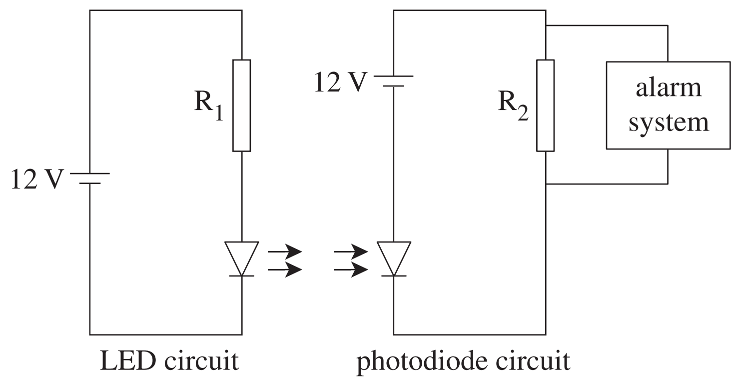

Figure 13

R_1 and R_2 are two fixed resistances. The current–voltage characteristics of the LED are shown in Figure 14.

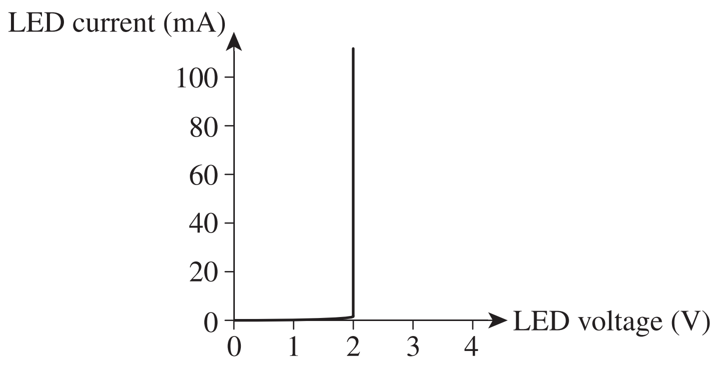

Figure 14

Figure 15 shows the current–voltage characteristics of the photodiode for different powers of light (in mW) falling on it.

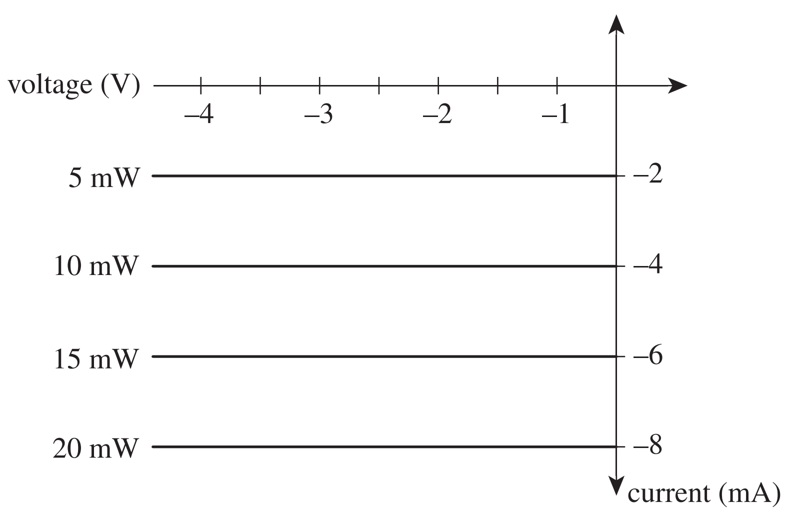

Figure 15

The resistor R_1 has a value of 100 Ω.

a. Determine the current passing through the LED. 2 marks

mA

b. The LED irradiates the photodiode with 20 mW of light. The alarm system requires 4 V to operate.

Determine the value of resistor R_2 that will enable the alarm system to operate under these conditions. 3 marks

Ω

c. If R_1 is now increased, explain what must happen to R_2 (decrease, increase, stay the same in value) for the alarm to continue operating at 4 V. In your answer make reference to any relevant electrical quantities in the LED circuit and the photodiode circuit. 3 marks

Question 13 (2 marks)

Figure 16 shows electronic equipment with an input light signal and an output light signal.

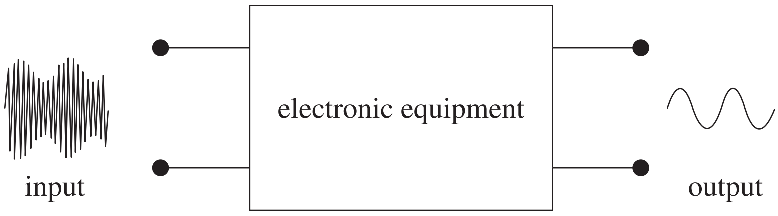

Figure 16

Explain the process carried out by the electronic equipment.

Area of study – Electric power

Question 14 (2 marks)

Figure 17 shows a coil placed next to a straight wire. The coil and the wire both carry a constant DC current, as shown by the arrows. Point Z is a point on the wire directly above the coil and on the central axis of the coil.

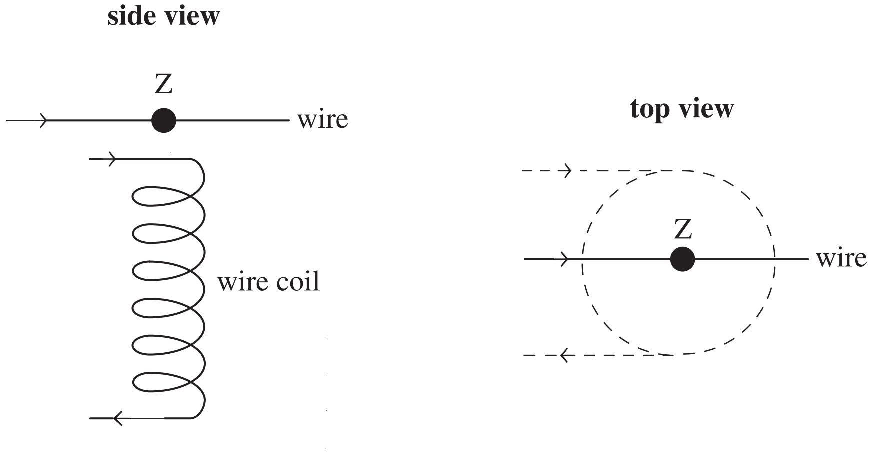

Figure 17

a. Which one of the following best describes the direction of the **magnetic field of the coil** at point Z, **according to the side view**? 1 mark

A. left
B. right
C. up
D. down
E. into the page
F. out of the page

b. Which one of the following best describes the direction of the **force on the wire** at point Z, **according to the side view**? 1 mark

A. left
B. right
C. up
D. down
E. into the page
F. out of the page

Question 15 (8 marks)

Figure 18 shows a single loop of wire that lies between two poles of two different magnets. The poles are labelled N (north) and S (south). The loop is not connected to any other component and is initially stationary.

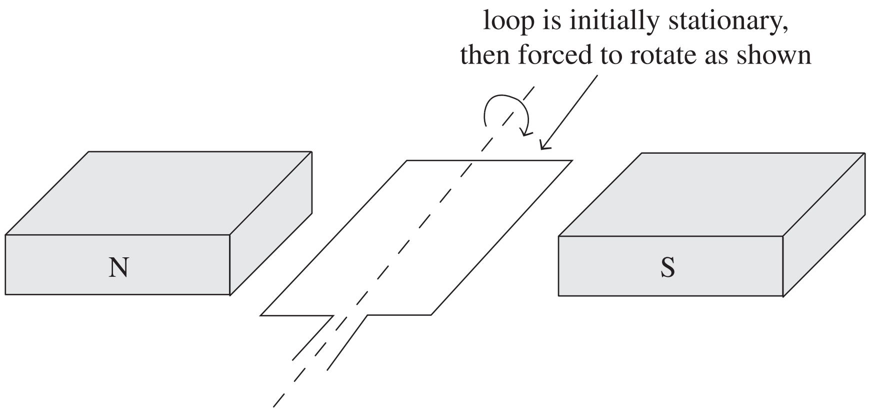

Figure 18

a. Indicate on Figure 18 the direction of the flow of conventional electric current by drawing an arrow on the coil immediately after the coil is forced to rotate in the direction shown. 1 mark

b. Explain the reasoning behind why a current flows in the circuit as soon as it is forced to turn from the position shown. 2 marks

c. Explain the direction of the conventional electric current as given by your answer to part **a.** 2 marks

The rectangular loop has dimensions 4.0 cm by 3.0 cm and an electrical resistance of 0.01 Ω. The magnetic field strength in the region of the loop is 0.10 T. The loop is forced to make a quarter of a turn in 0.50 seconds.

d. Determine the size of the average current induced in the loop over the quarter turn. 3 marks

A

Question 16 (4 marks)

A transformer is shown in Figure 19 with the input and output sections labelled. The transformer is assumed to be ideal and the number of turns of wire is shown for both the input and output.

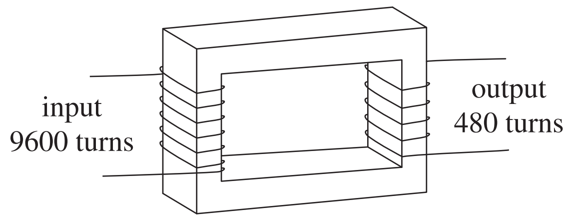

Figure 19

The input current graph is shown in Figure 20 below.

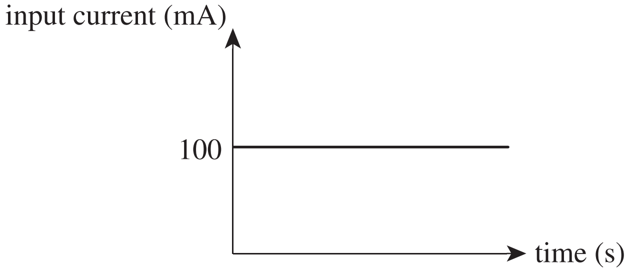

Figure 20

a. Using the graph in Figure 20, determine the RMS output current from the transformer and, by calculation or explanation, indicate how you arrived at your answer. 2 marks

mA

The input current is now altered to be that shown by the graph in Figure 21.

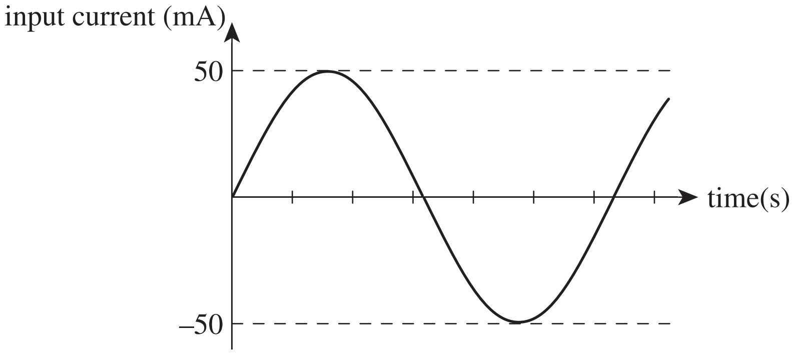

Figure 21

b. Determine the RMS output current from the transformer when its input current is that shown by Figure 21. 2 marks

mA

Question 17 (11 marks)

A student sets up the circuit shown in Figure 22, which consists of a 12 V battery, long identical wires, a fixed resistance and an ammeter.

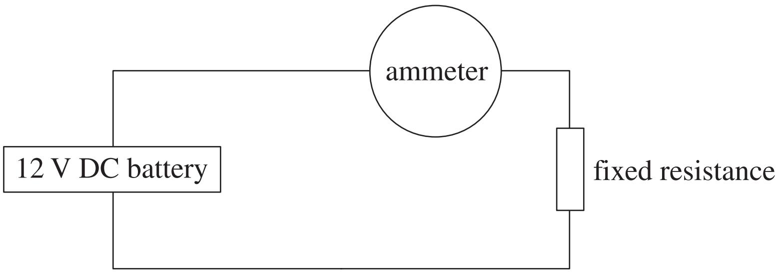

Figure 22

The ammeter is of negligible resistance but the wiring has a total resistance of 2.0 Ω. The ammeter reads 0.60 A.

a. Determine the voltage in the wiring of the circuit. 1 mark

V

b. Calculate that power that is dissipated in the fixed resistance. 3 marks

W

The student now wants the variable resistance to have a voltage of 8.0 V.

c. What should be the resistance value for the fixed resistance? 2 marks

Ω

The student has just learnt that the fixed resistance can achieve 8.0 V, but can receive a greater power than the circuit shown in Figure 22 by the use of a 12 V AC battery. The fixed resistance has the same value as determined in part **c.**

d. Draw a new circuit diagram below that shows the modifications which need to be made to the circuit in Figure 22. Do not include the ammeter. Also briefly explain the purpose for each of the modifications. 5 marks

Question 18 (5 marks)

A model motor is shown in Figure 23. The coil consists of 50 turns. The sides XY and WZ are of length 30 cm and the sides YW and XZ are of length 20 cm. The magnetic field strength is 0.20 T and the current in the coil is 0.80 A. The positive (+) and negative (–) terminals of a DC battery are shown.

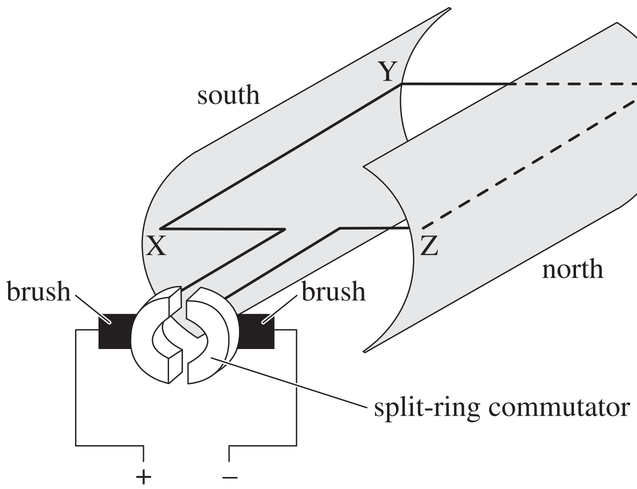

Figure 23

a. On Figure 23, show the direction of the force on side WZ. 1 mark

b. Calculate the size of the force on side WZ. 2 marks

N

The coil now turns from the position shown in Figure 23 through a quarter of a revolution so that the plane of the coil is now vertical.

c. Explain how the force on side WZ of the coil when it is in the vertical position compares to the force on side WZ when the coil is in the position shown in Figure 23. Provide a reason for any differences in the sizes of the forces. 2 marks

Question 19 (6 marks)

Harold experiments with electricity generation and sets up two circuits, A and B, as shown in Figure 24.

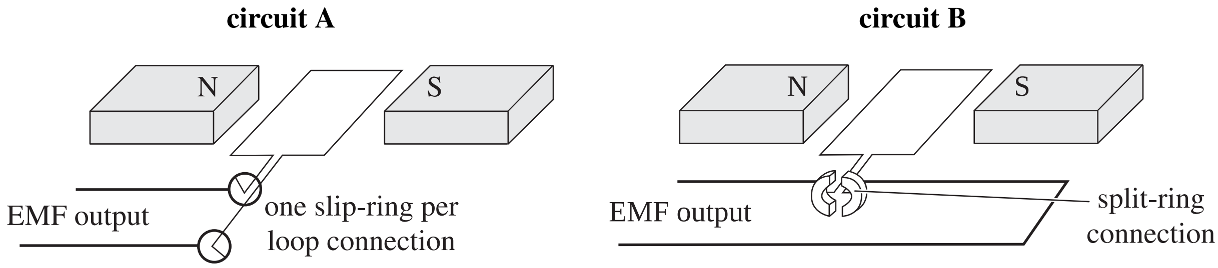

Figure 24

In both circuits the magnets and the coil are identical. The circuits differ in their connection at the EMF output. For circuit A, Harold spins the coil at 4.0 Hz. For circuit B, Harold spins the coil at 2.0 Hz.

Figure 25 below shows the output voltage with time for circuit A. X represents the value of the time, as indicated by the dotted vertical line.

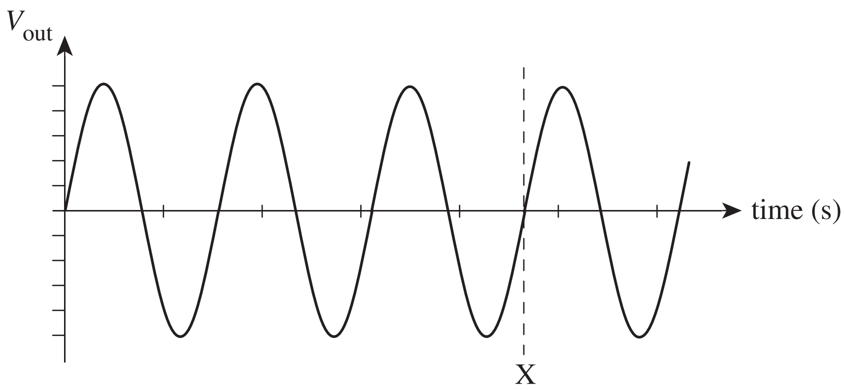

Figure 25

a. Determine the value of X in seconds. Express your answer to one significant figure. 3 marks

s

b. On Figure 25 above, sketch the output for circuit B up to the time mark X. 3 marks

Area of study 2 – Interactions of light and matter

Question 20 (6 marks)

Figure 26 shows the interference pattern created by a green laser beam of wavelength 530 nm going through two slits.

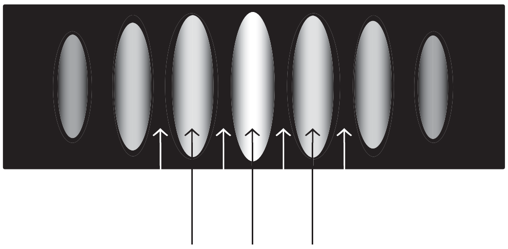

Figure 26

a. On Figure 26, label the following under the appropriate arrows: the central maximum (M), the first anti-nodal line to the right of the central maximum (A_1) and the second nodal line to the left of the central maximum (N_2). 2 marks

b. Fill in the table below with the correct path difference, in nm, for each label from part **a**. 2 marks

Label	M	A_1	N_2
Path difference (nm)			

c. Explain which model of light the interference experiment described above supports and what aspects of that model are demonstrated. 2 marks

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Question 21 (7 marks)

Blue light of frequency 6.3×10^{14} Hz is shone onto the photocathode of a sodium photocell. The graph of the photoelectric current (I) versus voltage (V) is shown in Figure 27. The value of the cut-off voltage, V_0, is –0.3 V.

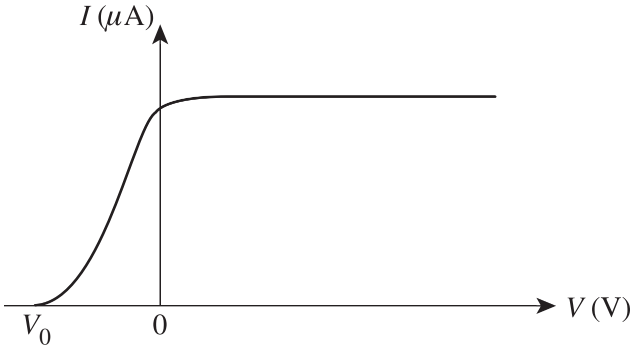

Figure 27

a. Explain the concept of threshold frequency in the photoelectric effect. 2 marks

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b. Calculate the threshold frequency for sodium. Show your working. 3 marks

Hz

c. On Figure 27 above, sketch the curve expected if ultraviolet light of a higher intensity is used in the experiment instead of the blue light. 2 marks

Question 22 (5 marks)

Figure 28 shows part of the energy level diagram for hydrogen, with four distinct energy levels and the ionisation level.

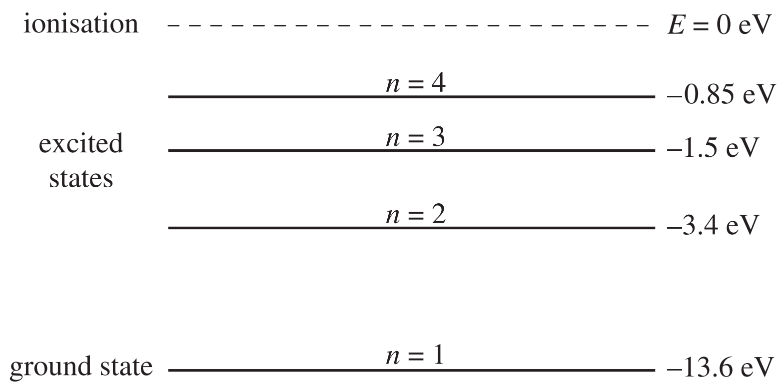

Figure 28

a. Using labelled arrows, draw clearly on Figure 28 the transition involved with the emission of the following:

- a 1.90 eV photon (label **A**)
- a 2.55 eV photon (label **B**)
- a 10.20 eV photon (label **C**)

3 marks

b. Calculate the longest wavelength photon that is emitted by hydrogen in the transitions that occur between the four energy levels shown in Figure 28. 2 marks

m

Question 23 (6 marks)

One cornerstone of modern physics is de Broglie's model concerning the wave nature of matter.

Jo hits a tennis ball of mass 50 g with a speed of 40 m s^{-1}.

a. Calculate the de Broglie wavelength of the tennis ball. 2 marks

m

b. Circle the correct bolded options for the following sentence:

'The de Broglie wavelength of the tennis ball is **unobservable / observable** because it is **possible / impossible** to create appropriate diffraction gratings for tennis balls.' 1 mark

Jo then goes to the laboratory, where she accelerates electrons to a speed of 6000 km s^{-1}.

c. Calculate the de Broglie wavelength of the electrons. 2 marks

m

d. Circle the correct bolded options for the following sentence:

'The de Broglie wavelength of the electron is **unobservable / observable** because it is **possible / impossible** to create appropriate diffraction gratings for electrons.' 1 mark

Question 24 (2 marks)

Calculate the momentum of a photon having a wavelength of 30.0 nm.

N s

Question 25 (2 marks)

Figure 29 shows an interference pattern in a Physics textbook.

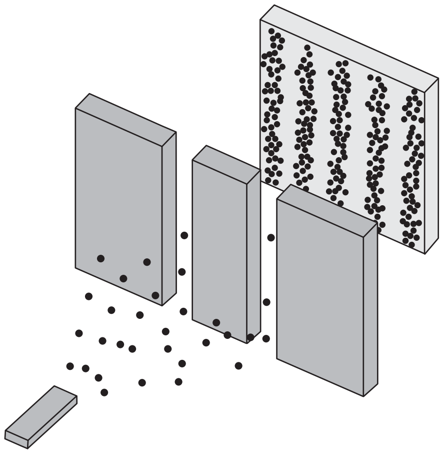

Figure 29

Which one or more of the following statements regarding Figure 29 is/are correct?

A. The black dots could represent photons.

B. The black dots could represent electrons.

C. The black dots could represent protons.

D. The black dots could represent neutrons.

SECTION B

Instructions for Section B

Select **one** Detailed study and answer **all** questions within that Detailed study in pencil on the answer sheet provided for multiple-choice questions.

Show the Detailed study you are answering by shading the matching box on your multiple-choice answer sheet and writing the name of the Detailed study in the box provided.

Choose the response that is **correct** for the question.

A correct answer scores 2, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

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

An inertial frame of reference is an important idea in special relativity.

A frame of reference that is described as non-inertial

A. is at rest relative to an inertial frame of reference.
B. undergoes an acceleration relative to an inertial frame of reference.
C. travels at constant velocity relative to an inerial frame of reference.
D. does not obey Newton's first law of motion in relation to inertia.

Question 2

One of the most important experiments in the history of relativity physics is that performed by Michelson and Morley.

Which of the following statements regarding the Michelson–Morley experiment is correct?

A. It did not show a difference in the speed of light when light travels tangentially along the same path as the Earth through space, and when light travels perpendicular to the motion of the Earth through space.
B. It was designed to determine the speed of light through space.
C. It was designed to determine the speed of light relative to the Earth.
D. It was concluded that a more accurate design of the experiment was needed to achieve more precise results, given the magnitude of the speed of light.

Use the following information to answer Questions 3–8.

Two astronauts, Yuri and Valentina, travel separately in two identical spacecraft, both of length 100 m. They travel in opposite directions past each other as shown in Figure 1. Each spacecraft travels at a speed of $0.8c$ relative to the other.

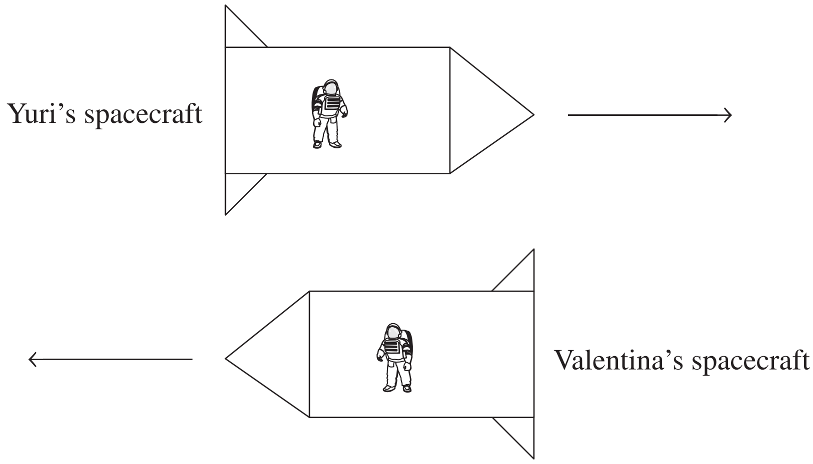

Figure 1

Question 3

What is the value of the Lorentz factor, γ?

A. 1.67

B. 0.6

C. 2.24

D. 5.00

Question 4

The proper length of Valentina's spacecraft as the astronauts travel past each other can be measured by

A. any observer moving past at any speed.

B. either Yuri or Valentina.

C. only Yuri.

D. only Valentina.

Question 5

The two spacecraft now travel at $0.6c$ relative to each other.

What is the length of Valentina's spacecraft as observed by Yuri?

A. 100 m

B. 80 m

C. 64 m

D. 40 m

Question 6

Yuri moves to one end of the craft and places a mirror in a fixed position relative to the other end of the craft. At the other end there is a laser light source. This is shown in Figure 2.

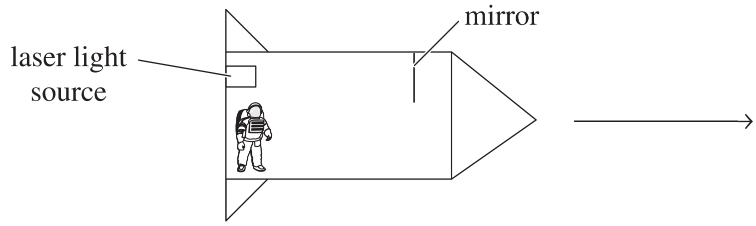

Figure 2

Yuri measures the distance from the laser light source to the mirror to be 70 m.

How long does it take the laser light to return to the source after reflection from the mirror?

A. 667 ns
B. 467 ns
C. 333 ns
D. 233 ns

Question 7

On a different occasion, Yuri changes the position of the mirror. He now measures the time taken for the laser light to travel from the laser light source to the mirror to be 300 ns.

Valentina's spacecraft travels past at 0.6*c* and also measures the time taken for the light to travel this path in Yuri's spacecraft.

What is the time taken for the motion of the laser light as measured by Valentina?

A. 750 ns
B. 474 ns
C. 469 ns
D. 375 ns

Question 8

Valentina now steers her spacecraft so that it travels in the same direction as Yuri's. Both spacecraft are now travelling directly toward Earth. Yuri's spacecraft travels at $0.3c$ toward Earth and Valentina's spacecraft travels at $0.7c$ toward Earth, both speeds relative to an observer on Earth. This is shown in Figure 3.

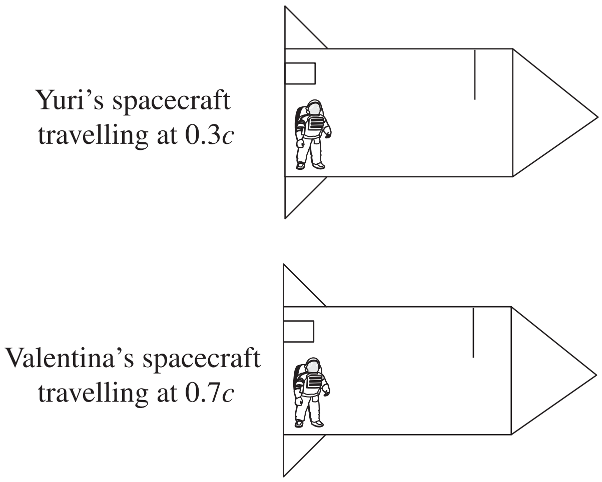

Figure 3

A radio signal from Mission Control on Earth strikes the two spacecraft simultaneously as they are side-by-side, and the signal reflects back towards Mission Control.

Which one of the following statements is correct of the radio signals returning to Mission Control on Earth?

A. The radio signal reflected from Valentina's spacecraft arrives at Mission Control first.

B. The two reflected radio signals both arrive at Mission Control at the same time.

C. The radio signal reflected from Yuri's spacecraft cannot arrive at Mission Control first, as his spacecraft was travelling slower than Valentina's when the radio signals struck them.

D. It is not possible to predict which radio signal arrives at Mission Control first.

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Use the following information to answer Questions 9–11.

A proton is accelerated to an energy of 3.45×10^{-10} J as observed by a particle physicist. The mass of the proton when at rest is 1.67×10^{-27} kg.

Question 9

The energy of the proton in its inertial frame of reference is

A. 3.00×10^{-10} J

B. 1.50×10^{-10} J

C. 2.44×10^{-10} J

D. 1.22×10^{-10} J

Question 10

The kinetic energy of the proton in the frame of reference of the particle physicist is

A. 4.95×10^{-10} J

B. 3.45×10^{-10} J

C. 1.50×10^{-10} J

D. 1.95×10^{-10} J

Question 11

The proton was accelerated to a speed of

A. $0.98c$

B. $0.90c$

C. $0.82c$

D. $0.75c$

SECTION B

Instructions for Section B

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Detailed Study 2 – Materials and their use in structures

Use the following information to answer Questions 1–3.

Chris is creating some new types of materials in the engineering laboratory. The stress–strain graphs of a particular glass (sample P) and particular steel (sample Q) are shown in Figure 1. Failure of each of the materials is indicated by an asterisk (*).

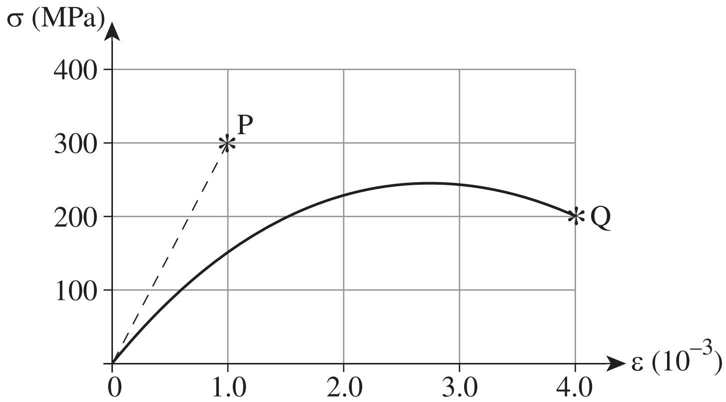

Figure 1

Question 1

Which one of the following best gives the value of Young's modulus for glass?

A. 300 N m^{-2}

B. 3.0×10^{5} N m^{-2}

C. 3.0×10^{8} N m^{-2}

D. 3.0×10^{11} N m^{-2}

Question 2

Which one of the following statements is **incorrect** concerning materials P and Q?

A. P is a stronger material than Q.

B. P is a tougher material than Q.

C. P shows brittle failure.

D. Q shows plastic behaviour.

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Question 3

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

A. 0.7 kJ m^{-3}

B. 0.6 MJ m^{-3}

C. 0.7 MJ m^{-3}

D. 0.7 GJ m^{-3}

Use the following information to answer Questions 4–7.

Figure 2 shows a concrete beam used in a bridge. These concrete beams are often reinforced with steel.

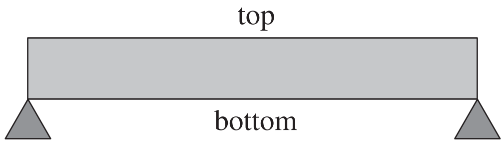

Figure 2

Figure 3 shows some steel reinforcing that could be used in the concrete beam.

_ _

Figure 3

Question 4

The main reason concrete is often reinforced with steel is because steel is

A. stronger in tension than concrete.

B. stronger in compression than concrete.

C. more ductile than concrete.

D. not brittle, while concrete is brittle.

Question 5

For the concrete beam used in the bridge shown in Figure 2, the steel reinforcement in Figure 3 would most likely be placed

A. near the top of the beam.

B. in the middle of the beam.

C. near the bottom of the beam.

D. near both the top and bottom of the beam.

Use the following information to answer Questions 6 and 7.

The concrete beam with the correctly placed steel reinforcing is now tested. The beam is 10 m long and weighs 10 tonnes. A load, L, of 4 tonnes is placed on the beam at a distance 4.0 m from point P as shown in Figure 4.

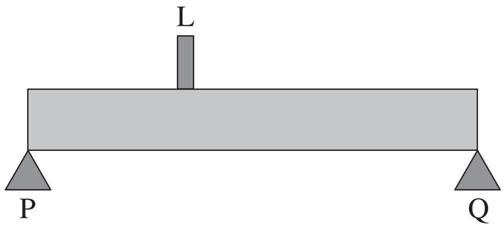

Figure 4

Question 6

Which one of the following best gives the total weight (W) of the bridge and load?

A. 14 tonnes

B. 1.4×10^4 N

C. 1.4×10^5 N

D. 1.4×10^6 N

Question 7

Which one of the following is closest to the value of the force acting upwards at point P?

A. 1.4×10^4 N

B. 6.6×10^4 N

C. 7.2×10^4 N

D. 7.4×10^4 N

Use the following information to answer Questions 8 and 9.

An overhead traffic light of mass 20 kg is connected by two wires at point R to two points, P and Q, at the angles shown in Figure 5.

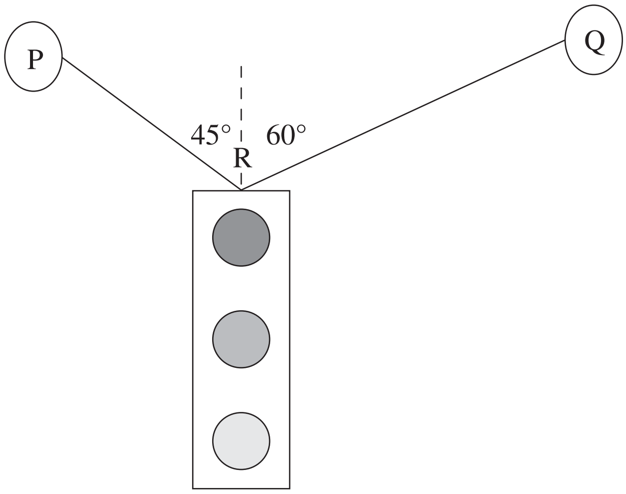

Figure 5

Question 8

Which one of the following best gives the magnitude of the tension in the wire connected to point P?

A. 141 N
B. 146 N
C. 176 N
D. 179 N

Question 9

Which one of the following statements best explains the relative sizes of the tension forces $\boldsymbol{T}_{\mathrm{P}}$ and $\boldsymbol{T}_{\mathrm{Q}}$?

A. $\boldsymbol{T}_{\mathrm{P}} = (0.82)\boldsymbol{T}_{\mathrm{Q}}$

B. $\boldsymbol{T}_{\mathrm{P}} = \boldsymbol{T}_{\mathrm{Q}}$

C. $\boldsymbol{T}_{\mathrm{P}} = (1.22)\boldsymbol{T}_{\mathrm{Q}}$

D. $\boldsymbol{T}_{\mathrm{P}} = (1.33)\boldsymbol{T}_{\mathrm{Q}}$

Question 10

A pair of scissors is used to cut paper as shown in Figure 6.

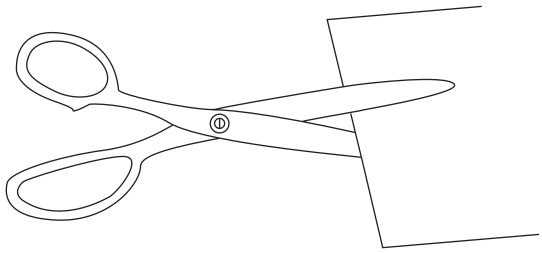

Figure 6

Which one of the following forces is associated with a pair of scissors cutting paper?

A. tension

B. compression

C. stress

D. shear

Question 11

Figure 7 shows a test cylinder of material being stressed. The diameter of the cylinder is 20 mm and the length is 100 mm. Under a tensile force of 2.0 kN the material shows a strain of 0.1%.

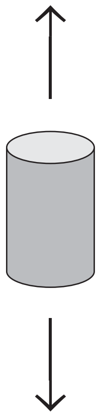

Figure 7

Which one of the following best gives the Young's modulus for this material?

A. 64 MPa

B. 1.6 GPa

C. 6.4 GPa

D. 64 GPa

SECTION B

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Detailed study 4 – Synchrotron and its applications

Use the following information to answer Questions 1–4.

A linear accelerator accelerates electrons in an evacuated chamber using a 20 kV potential difference between the cathode and the anode, as shown in Figure 1.

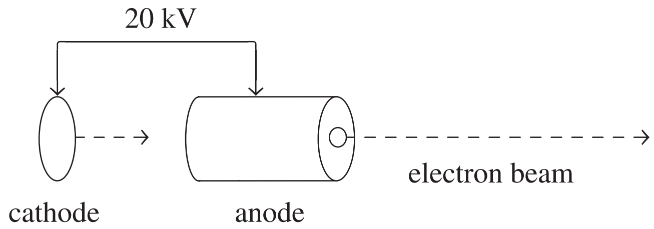

Figure 1

Question 1

Assuming the electrons have no kinetic energy when they are emitted at the cathode, the velocity of electrons leaving the anode is closest to

A. 8.4×10^6 m s^{-1}

B. 8.4×10^7 m s^{-1}

C. 3.0×10^8 m s^{-1}

D. 8.4×10^8 m s^{-1}

Question 2

Figure 2 shows another electron beam travelling to the right at a speed of 2.0×10^7 m s^{-1} and entering a region where there is a magnetic field of strength 2.0 T.

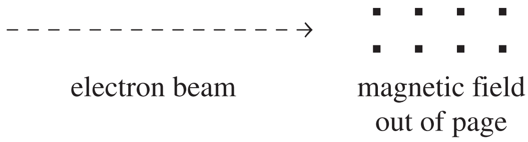

Figure 2

Which one of the following best describes the direction the electron beam will deflect when it enters the magnetic field?

A. up
B. down
C. into the page
D. out of the page

Question 3

The magnitude of the magnetic force acting on an electron when it enters the magnetic field shown in Figure 2 is closest to

A. 4.0×10^{-10} N
B. 6.4×10^{-10} N
C. 6.4×10^{-12} N
D. 4.0×10^{7} N

Question 4

While the electrons are in the magnetic field shown in Figure 2 they follow a path which is an arc of a circle.

The radius of the arc of the electron beam is closest to

A. 1.9×10^{-6}m
B. 5.7×10^{-6} m
C. 1.9×10^{-5}m
D. 5.7×10^{-5} m

Use the following information to answer Questions 5 and 6.

Figure 3 shows a schematic diagram of the Australian synchrotron. The design includes a linac (an electron linear accelerator), a booster ring, a storage ring and beamlines. The booster ring contains straight sections as well as curved sections.

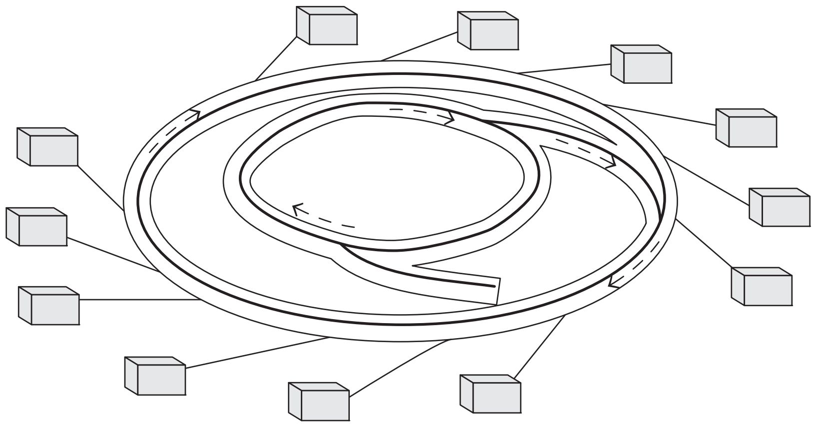

Figure 3

Question 5

The function of the curved sections of the booster ring in the synchrotron is to

A. accelerate particles from rest.

B. accelerate particles to higher energies.

C. guide particles around the booster ring.

D. decelerate particles.

Question 6

One term used in describing synchrotron radiation is the 'brightness' of the synchrotron beam.

Which one of the following best defines what is meant by the 'brightness' in this context?

A. the strength of the beam

B. the length of the pulse of the beam

C. the strength of the polarisation of the beam

D. the number of photons emitted per second within a specific narrow frequency range

Question 7

The main principle behind the use of X-rays to investigate the structure of matter in crystals is

A. diffraction.

B. reflection.

C. refraction.

D. dispersion.

Question 8

One experiment in the synchrotron involves a sample of silver being bombarded with X-rays of wavelength 8.0×10^{-10} m. The work function for silver is 4.7 eV.

The maximum kinetic energy of the ejected photoelectrons is

A. 4.7 eV
B. 1500 eV
C. 1548 eV
D. 1584 eV

Use the following information to answer Questions 9 and 10.

One specific crystal is examined in a synchrotron using X-rays of $\lambda = 8.4 \times 10^{-10}$ m. The X-ray radiation scattered back off the crystal is of $\lambda = 9.8 \times 10^{-10}$ m.

Question 9

The amount of energy lost in this collision is

A. 3.4×10^{-17} J
B. 4.0×10^{-17} J
C. 8.2×10^{-17} J
D. 1.6×10^{-19} J

Question 10

The form of scattering involved in this experiment is known as

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

Question 11

An X-ray beam of wavelength 0.30 nm is fired at a particular crystal which has an atomic plane spacing of 0.45 nm.

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

A. 15°
B. 30°
C. 42°
D. 60°

SECTION B

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Detailed study 6 – Sound

For all questions in this detailed study, the speed of sound in air is equal to 340 m s^{-1}.

Use the following information to answer Questions 1–5.

A bird sings a particular note. The amplitude–position graph of the note is shown in Figure 1. The wave represented in the graph is travelling to the right.

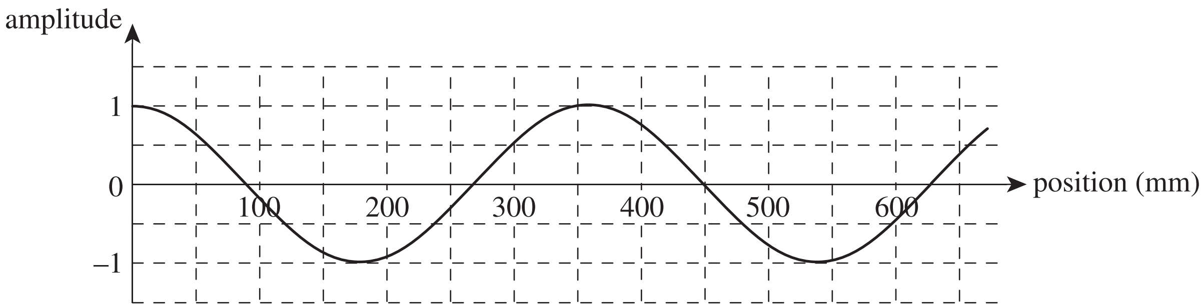


Figure 1

Question 1

What is the frequency of the note sung by the bird?

A. 360 Hz

B. 944 Hz

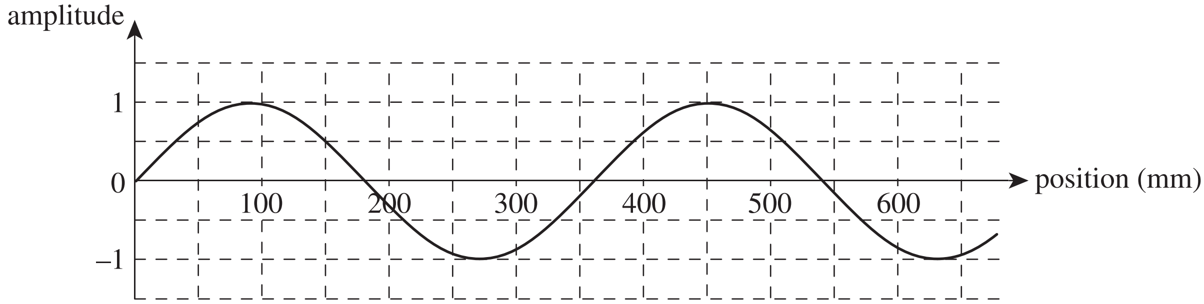
C. 720 Hz

D. 1888 Hz

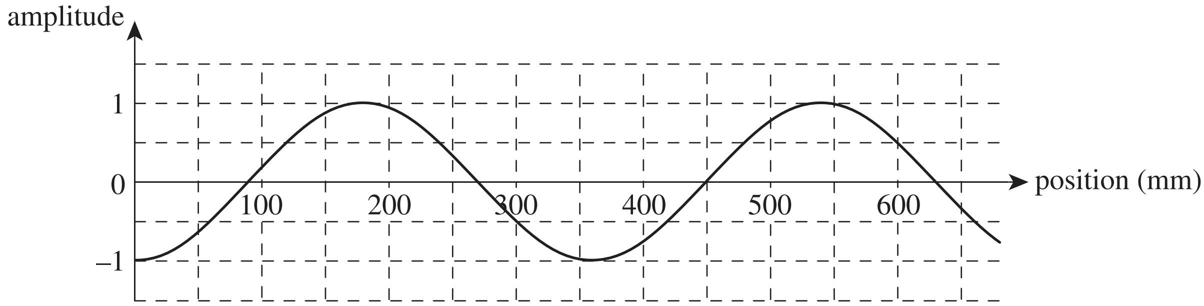
Question 2

Which of the graphs below shows the note three-quarters of a cycle later than in Figure 1?

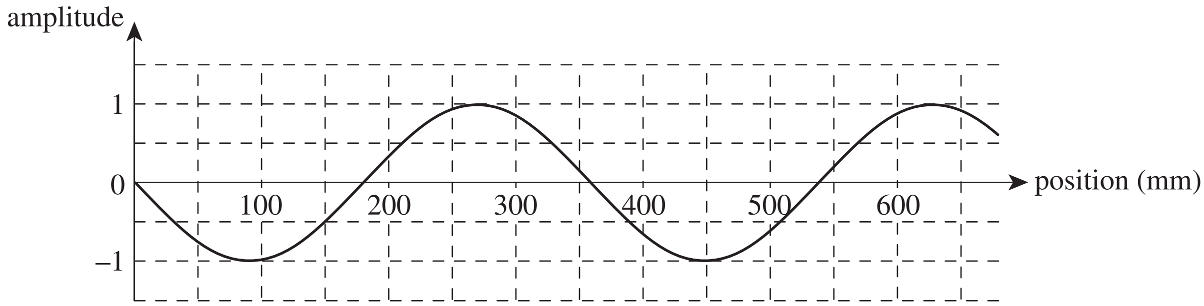
A.



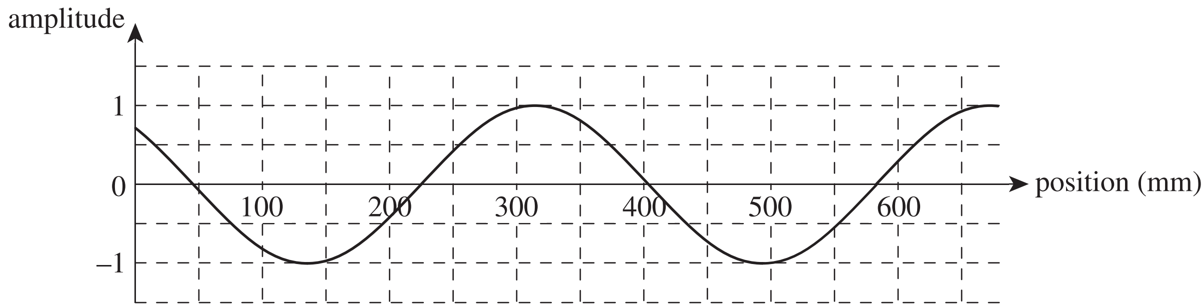
B.



C.



D.



Question 3

At 1.0 m from the bird the sound level is 70 dB.

Which one of the following best gives the sound intensity at this distance from the bird?

A. 1.0×10^{-5} W m^{-2}

B. 7.0×10^{-5} W m^{-2}

C. 1.0×10^{-7} W m^{-2}

D. 7.0×10^{-7} W m^{-2}

Question 4

Which one of the following best gives the sound intensity level at 4.0 m from the bird?

A. 66 dB

B. 64 dB

C. 58 dB

D. 54 dB

Question 5

A birdwatcher listens to the bird, who now sings a new note of 3000 Hz. The sound intensity level of the bird at the position of the birdwatcher is now 40 dB. Figure 2 shows an equal-loudness curve for the human ear.

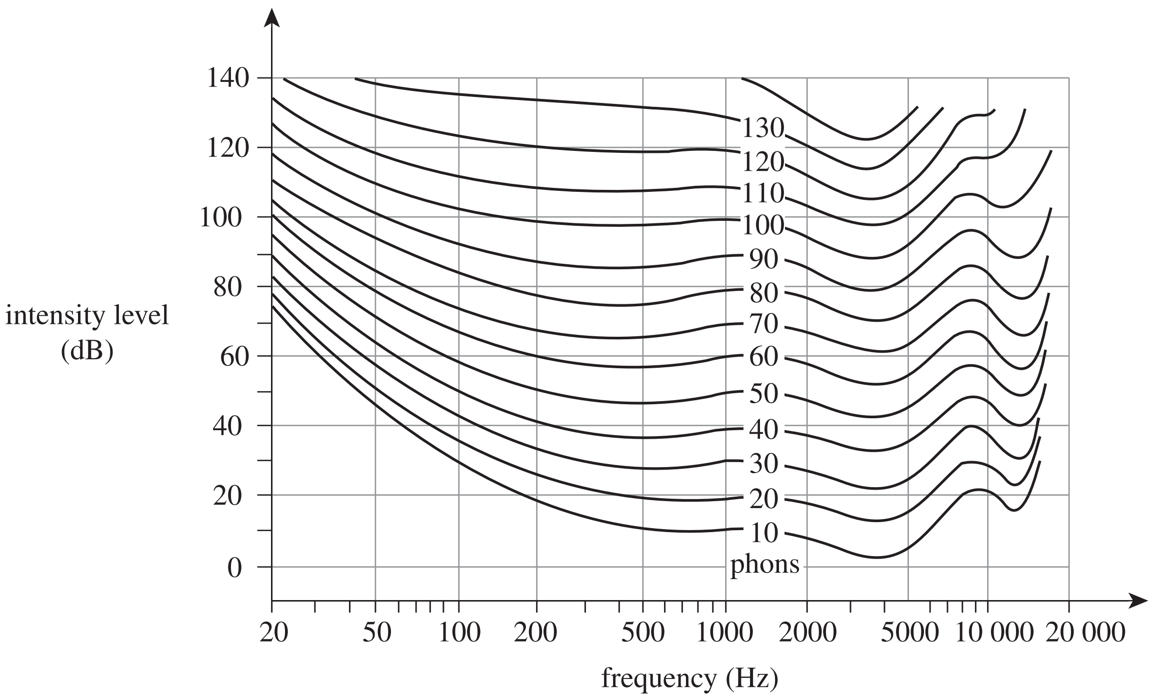


Figure 2

At what loudness does the birdwatcher hear the bird singing?

A. 30 phon

B. 40 phon

C. 45 phon

D. 50 phon

Use the following information to answer Questions 6–9.

In the pipe of a musical instrument, two waves of the same note are travelling in opposite directions according to Figure 3. The pipe is open at one end only. Two vertical planes, A and B, are shown across particular positions of the pipe.

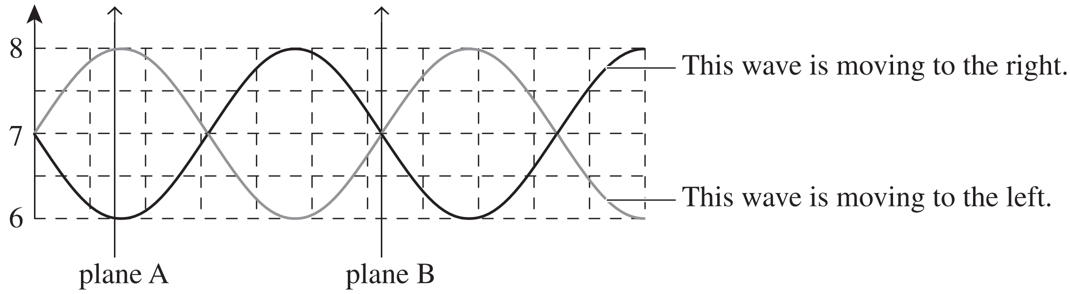


Figure 3

Four graphs (labelled 1–4) showing variations in sound intensity with time are given in Figure 4 below.

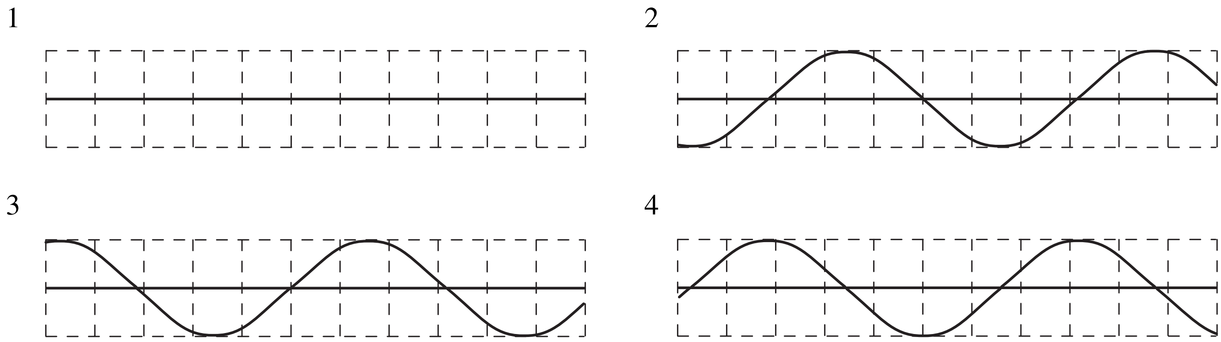


Figure 4

Question 6

Which of the graphs correctly shows the variation of sound intensity with time along plane A?

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

Question 7

Which of the graphs correctly shows the variation of sound intensity with time along plane B?

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

Question 8

The pipe is 0.85 m long and the speed of sound is 340 m s^{-1} in the pipe.

Determine the frequency of the note played by the instrument according to Figure 3.

A. 700 Hz
B. 500 Hz
C. 400 Hz
D. 300 Hz

Question 9

The pipe is now open at both ends and the speed of sound in the pipe remains at 340 m s^{-1}.

What are the three lowest resonant frequencies in the pipe?

A. 100 Hz, 200 Hz, 300 Hz
B. 100 Hz, 300 Hz, 500 Hz
C. 200 Hz, 400 Hz, 600 Hz
D. 200 Hz, 600 Hz, 1000 Hz

Question 10

A loudspeaker consists of a coil and cone assembly mounted into a closed wooden box.

The main purpose of the box is to

A. mount the coil and cone assembly.
B. enable sound to transmit through the wood of the box into the room as part of its sound transmission.
C. prevent the sound from the rear of the speaker from transmitting backwards.
D. prevent the sound from the rear of the coil diffracting around to the front of the speaker and interfering with the forward sound.

Question 11

A student performs an experiment where a loudspeaker is placed inside a doorway and two sound meters are placed at positions A and B, as shown in Figure 5.

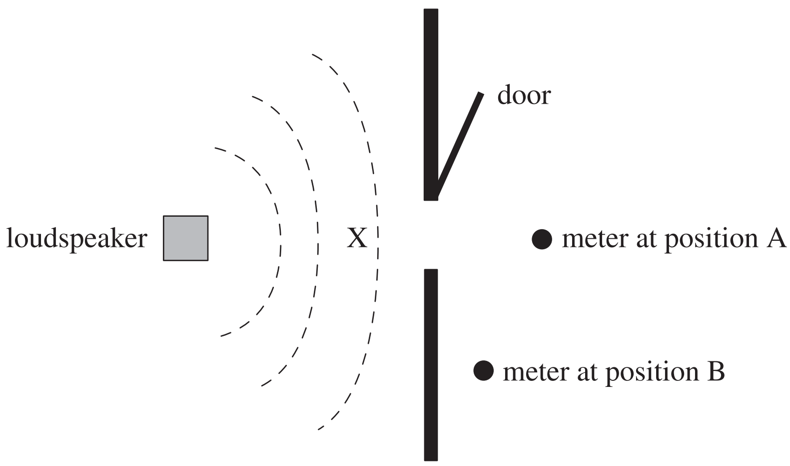


Figure 5

The distance of the meter positions A and B from the centre of the doorway, X, are equal. The student plays a note of 300 Hz and measures the sound intensity levels of the note at positions A and B. She then plays a second note of 3000 Hz, such that its sound intensity level at position A is the same as that of the 300 Hz sound.

Which of the following is true of the ratio $\frac{\text{sound intensity of 300 Hz at position B}}{\text{sound intensity of 3000 Hz at position B}}$?

A. The ratio is close to 0.1.
B. The ratio is 1.
C. The ratio is greater than 1.
D. The ratio is close to 10.

END OF QUESTION AND ANSWER BOOKLET