VCE Physics 2013–2016
Written examination

Examination specifications

Overall conditions

The examination will be sat at a time and date to be set annually by the Victorian Curriculum and Assessment Authority.

There will be 15 minutes reading time and 2 hours 30 minutes writing time.

VCAA examination rules will apply. Details of these rules are published annually in the *VCE and VCAL Administrative Handbook.*

The examination will be marked by a panel appointed by the VCAA.

The examination will contribute 60 per cent to the Study Score.

Content

All outcomes in Units 3 and 4 will be examined. All the key knowledge that underpins the outcomes in Units 3 and 4 and the set of key skills listed on page 12 of the study design are examinable.

Questions will require students to apply Physics knowledge and skills that are related both to Unit 3 and/or Unit 4.

Format

The examination paper will consist of two sections. Examination questions will be presented in a question and answer book.

- **Section A** will cover Area of study 1 and Area of study 2 of Units 3 and 4: Motion in one and two dimensions; Electronics and photonics; Electric power; and Interactions of light and matter. This section will be out of 128 marks. Answers to Section A are to be provided in the question and answer book.

  All questions in Section A will be compulsory. Questions in Section A will be a mix of short answer questions and questions requiring numerical calculations.

  Some questions in both Section A and Section B may be built around a scenario or experiment. There may be a limited number of multiple-choice questions in Section A of the examination. Should there be multiple-choice questions in Section A of the examination, they will be answered in the question and answer book.

  The marks for each area will be allocated across areas of study in approximately the following way.

  – Motion in one and two dimensions: 30–40 marks
  – Electronics and photonics: 20–30 marks
  – Electric power: 30–40 marks
  – Interactions of light and matter: 20–30 marks

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- **Section B** will cover Area of study 3 of Units 3 and 4: the Detailed studies. Students will have to respond to only one Detailed study.
  - Einstein's special relativity

  OR
  - Materials and their use in structures

  OR
  - Further electronics

  OR
  - Synchrotron and its applications

  OR
  - Photonics

  OR
  - Sound

This section will comprise 11 multiple-choice questions worth two marks each, with a total of 22 marks. Answers to Section B will be recorded in pencil on a multiple-choice answer sheet.

The total for the examination will be 150 marks.

A formula sheet will be provided in the examination.

Approved materials and equipment

Calculators

A scientific calculator is allowed in this examination.

Notes

Students will be allowed to bring into the examination **one folded A3 sheet** OR **two A4 sheets bound together by tape** of pre-written notes that may be single- or double-sided. These notes may be typed or handwritten. They may be from any source. Commercially available materials are acceptable.

Advice

During the 2013−2016 accreditation period for VCE Physics, examinations will be prepared according to the examination specifications above. Each examination will be an interpretation of these specifications and will test a representative sample of the key knowledge and skills.

A sample paper is published in order to exemplify the new structure.

Selected questions from previous examination papers from 2004–2012 are indicative of the type and scope of questions that may be expected.

Answers to multiple-choice questions are provided on page 80. Answers to other questions are not provided.
The following documents should be referred to in relation to the VCE Physics examination.

- *VCE Physics Study Design 2013–2016*
- *VCAA Bulletin, VCE, VCAL and VET*

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
Year

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures									Letter
Words									

PHYSICS
Written examination

Day Date

Reading time: **. ** to **.** ** (15 minutes)**
Writing time: **. ** to **.** ** (2 hours 30 minutes)**

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A – Core studies	24	24	128
	Number of detailed studies	*Number of detailed studies to be answered*	*Number of marks*
B – Detailed studies	6	1	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 book of 77 pages. A formula sheet.
- Answer sheet for multiple-choice questions.

Instructions
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- 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 book.

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

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 (4 marks)

Ranjiv, who has a mass of 80 kg, is running with a speed of 4.0 m s^{-1} as he steps onto a stationary trolley of mass 40 kg as shown in Figure 1. Ranjiv holds on to the trolley. Ranjiv and the trolley then move forward together in the same direction.

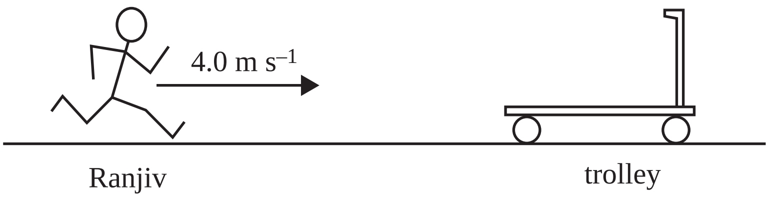


Figure 1

a. What is the speed of the trolley as soon as Ranjiv is on board? 2 marks

m s^{-1}

b. Is this collision between Ranjiv and the trolley elastic or inelastic? Justify your answer with a calculation. 2 marks

Question 2 (2 marks)

A motorcyclist is riding around a circle of radius of 100 m. The surface is flat and horizontal. The motorcyclist is travelling at a constant speed of 32.0 m s^{-1}. The motorcycle with rider has a mass of 250 kg.

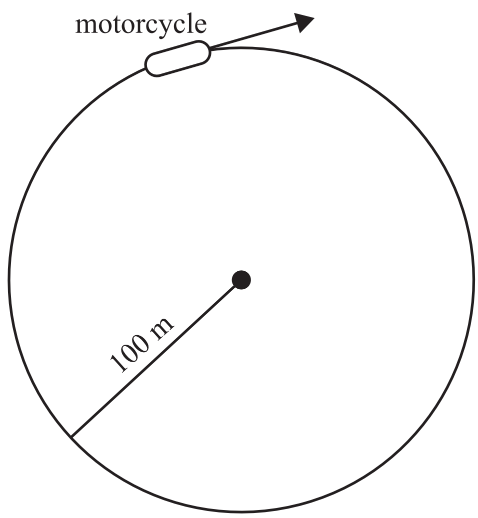


Figure 2

What is the magnitude of the net force on the motorcycle with rider? Give your answer to 3 significant figures.

N

Question 3 (4 marks)

A block of mass 0.20 kg is held at point A against a spring that has been compressed by 10 cm as shown in Figure 3.

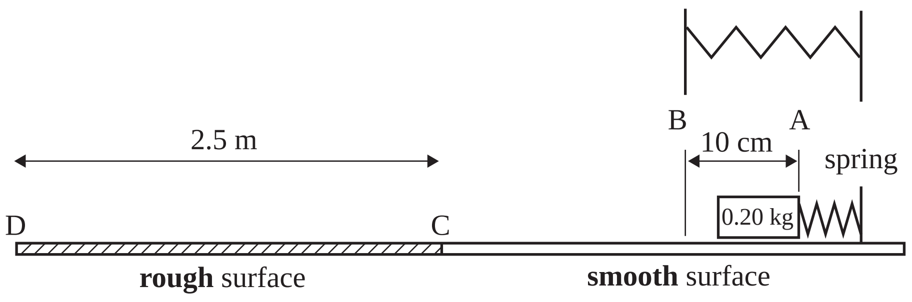


Figure 3

The block is released, and is pushed by the spring across a smooth surface. When the block leaves contact with the spring at point B the block has a speed of 5.0 m s^{-1}.

a. Calculate the spring constant, *k*, of the spring. 2 marks

N m^{-1}

b. At point C the block still has a speed of 5.0 m s^{-1}. At point C the block encounters a rough surface that provides a constant friction force that brings it to rest at point D. The distance C to D is 2.5 m.

Calculate the magnitude of the friction force. 2 marks

N

Question 4 (7 marks)

A ride in an amusement park allows a person to free fall without any form of attachment. A person on this ride is carried up on a platform to the top.

At the top, a trapdoor in the platform opens and the person free falls. Approximately 100 m below the release point, a net catches the person. A diagram of the ride is shown in Figure 4.

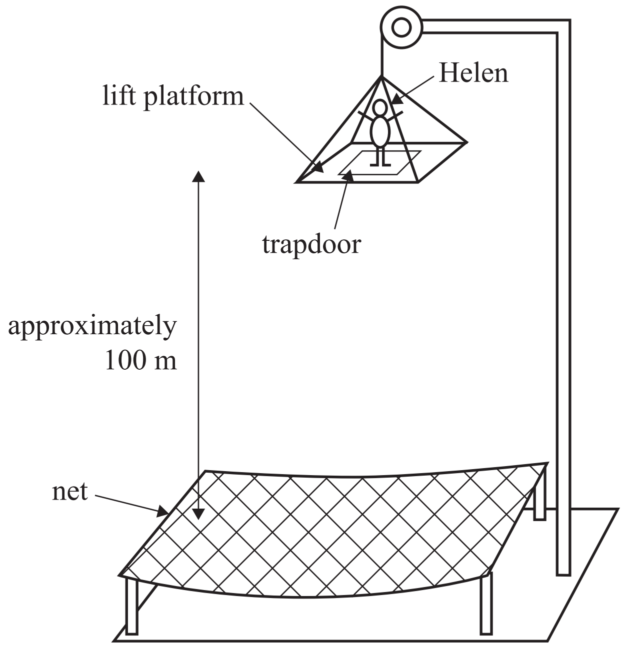


Figure 4

Helen, who has a mass of 60 kg, decides to take the ride and takes the lift platform to the top. The lift platform travels vertically upward at a constant speed of 5.0 m s^{-1}.

a. State Helen's apparent weight as she travels up. 1 mark

N

b. As the platform approaches the top, it slows to a stop at a uniform rate of 2.0 m s^{-2}.

Calculate Helen's apparent weight as the platform slows to a stop. 3 marks

N

c. Helen next drops through the trapdoor and free falls. Ignore air resistance. During her fall, Helen experiences ‘apparent weightlessness’. In the space below explain what is meant by ‘apparent weightlessness’. You should make mention of gravitational weight force and normal or reaction forces. 3 marks

Question 5 (6 marks)

Max hits a ball from the edge of a cliff.

The ball has an initial speed of 60 m s^{-1} at an angle of 30° to the horizontal as shown in Figure 5. Ignore the effects of air resistance.

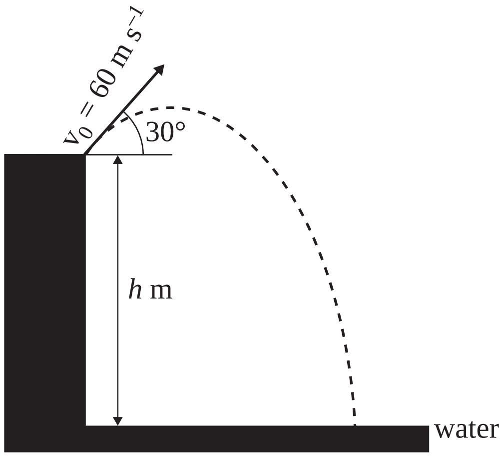


Figure 5

a. Calculate the height above the top of the cliff that the ball rises to. 3 marks

m

b. The ball takes 9.0 s from the time that Max hits it until it strikes the water.

Calculate the height h of the cliff. 3 marks

m

Question 6 (6 marks)

A rocket of mass 0.50 kg is set on the ground, pointing vertically up, as shown in Figure 6. When ignited, the gunpowder burns for 1.5 s, and provides a constant force on the rocket of 22 N. The mass of the gunpowder is very small and can be ignored, as can air resistance.

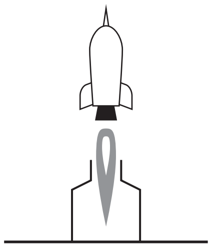


Figure 6

a. Calculate the magnitude of the resultant force on the rocket while the gunpowder is burning. 2 marks

N

b. Calculate the impulse of the force provided by the burning gunpowder on the rocket. 2 marks

N

c. Calculate the height of the rocket above the ground after 1.5 seconds. 2 marks

m

Question 7 (3 marks)

On a roller coaster, a loop in the track has a radius of 7.0 m, as shown in Figure 7.

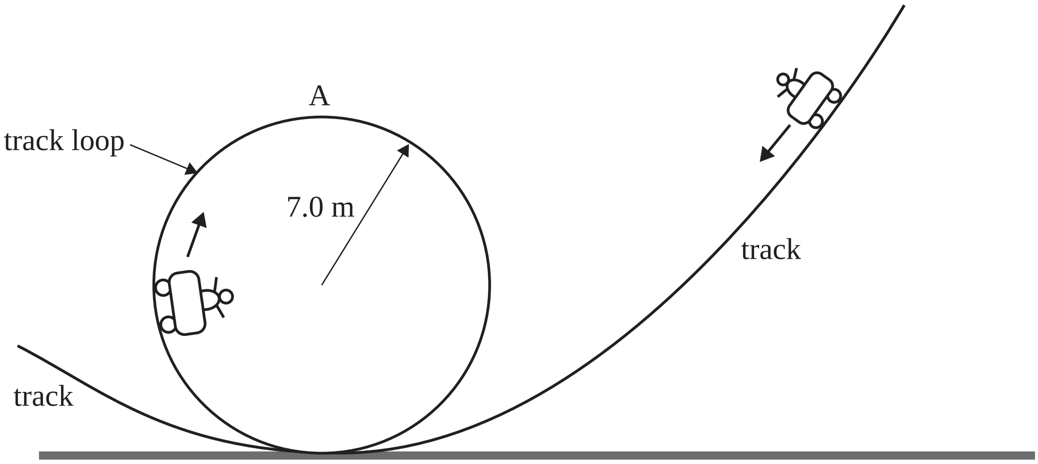


Figure 7

On a particular occasion, the mass of the trolley and riders is 600 kg. To go around the loop safely, the trolley wheels must not leave the rails at point A.

Calculate the minimum speed that the trolley must have at point A so that it does not leave the rails. You must include a clear outline of your reasoning.

______

______

______

______

m s^{-1}

Question 8 (6 marks)

The *Jason 2* satellite reached its operational circular orbit of radius 1.35×10^7 m in 2008 and then began mapping Earth's oceans.

DATA: mass of Earth = 5.98×10^{24} kg; mass of *Jason 2* = 525 kg; $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}

a. On Figure 8, draw one or more labelled arrows to show the direction of any force(s) acting on the satellite *Jason 2* as it orbits Earth. You can ignore the effect of any astronomical bodies other than Earth. 1 mark

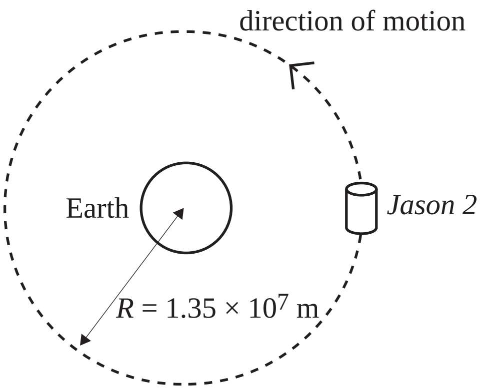


Figure 8

b. Calculate the period of orbit of the *Jason 2* satellite. 3 marks

s

c. Calculate the speed of the *Jason 2* satellite. 2 marks

m s^{-1}

Area of study – Electronics and photonics

Question 9 (7 marks)

Janelle sets up the circuit shown in Figure 9. The circuit consists of a 14 V battery and two resistors, $R_1 = 40\ \Omega$ and $R_2 = 30\ \Omega$.

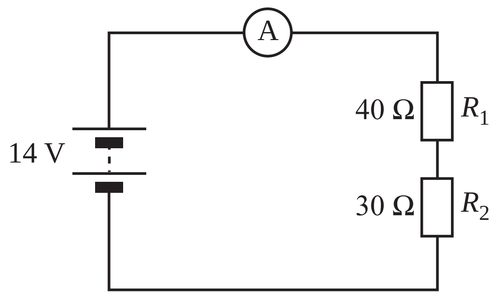


Figure 9

a. Calculate the potential difference (voltage drop) across R_2. 2 marks

V

b. Calculate the power dissipated in R_1. 2 marks

W

Janelle now adds a third resistor, $R_3 = 20\ \Omega$, as shown in Figure 10.

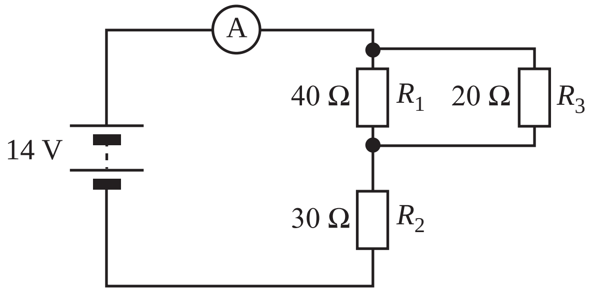


Figure 10

c. Calculate the current through the ammeter A now. Give your answer in mA. 3 marks

mA

Question 10 (4 marks)

Richard is conducting experiments with six identical light-emitting diodes (LEDs). The *I*–*V* characteristics of these diodes are shown in Figure 11, together with the symbol for an LED.

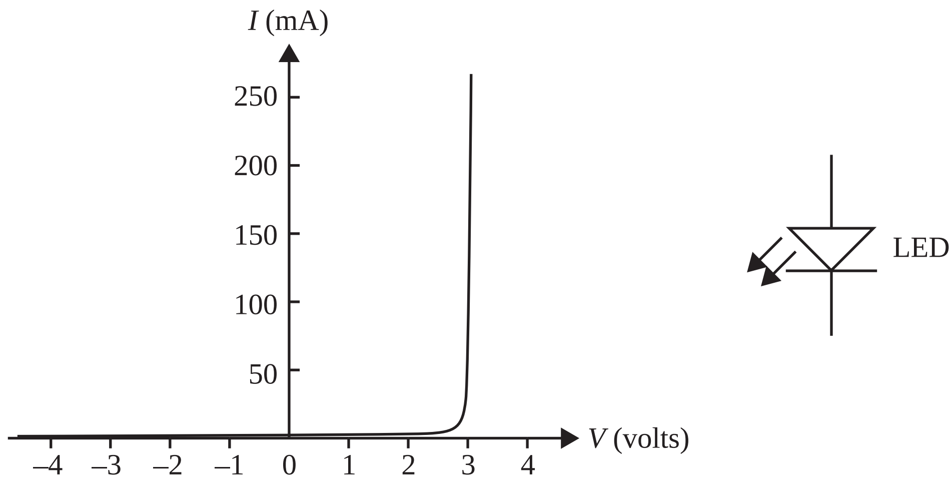


Figure 11

Richard sets up a circuit involving the six identical LEDs as shown in Figure 12.

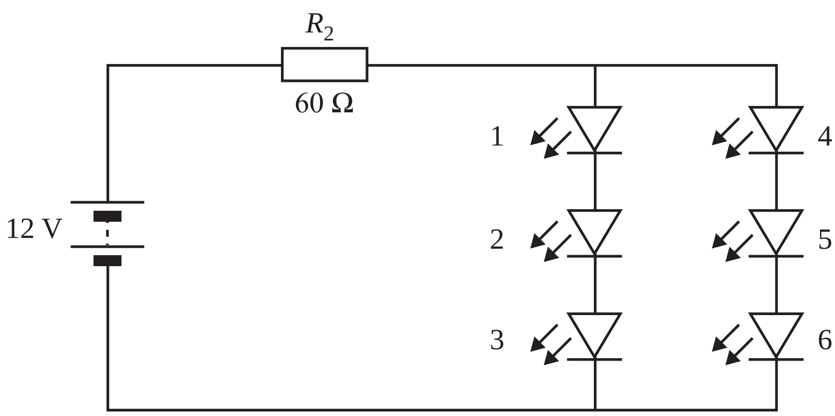


Figure 12

a. Calculate the value of the current through R_2. Give your answer in mA. 2 marks

mA

b. Later, Richard sets up the same circuit again but makes a mistake and connects LED 2 reversed, as shown in Figure 13.

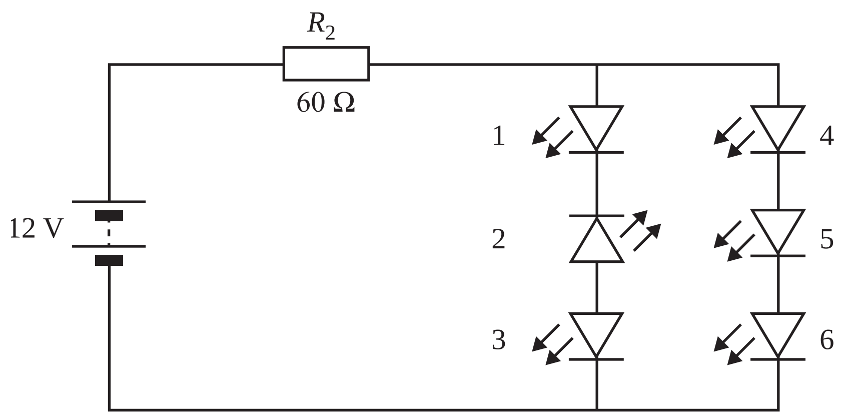


Figure 13

Indicate in the boxes below which of the six LEDs are ON and which are OFF. 2 marks

LED 1	LED 2	LED 3	LED 4	LED 5	LED 6

Question 11 (6 marks)

The characteristics of an amplifier are shown in Figure 14.

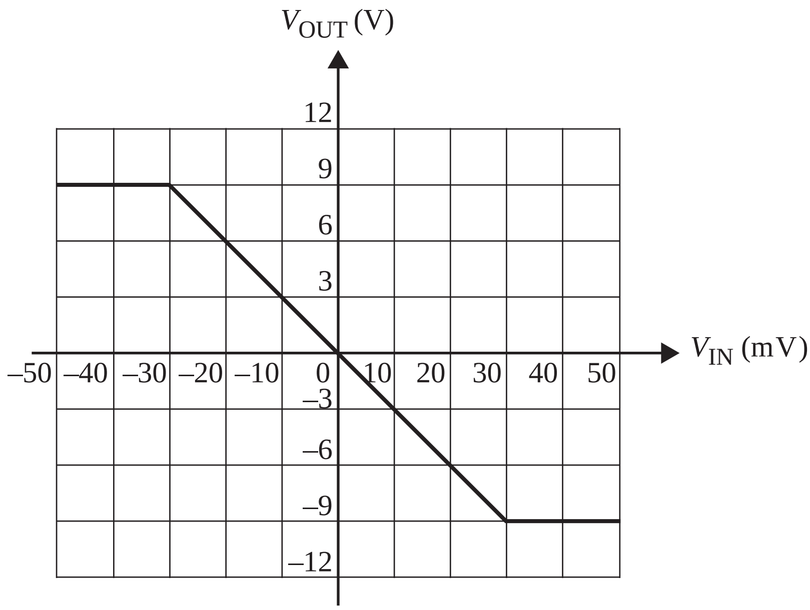


Figure 14

a. Calculate the voltage gain of the amplifier in the linear region (input up to ±30 mV). Indicate whether the amplifier is inverting, non-inverting or neither by ticking (✓) the appropriate box. 3 marks

voltage gain

☐ inverting ☐ non-inverting ☐ neither

The input signal to the amplifier is shown in Figure 15.

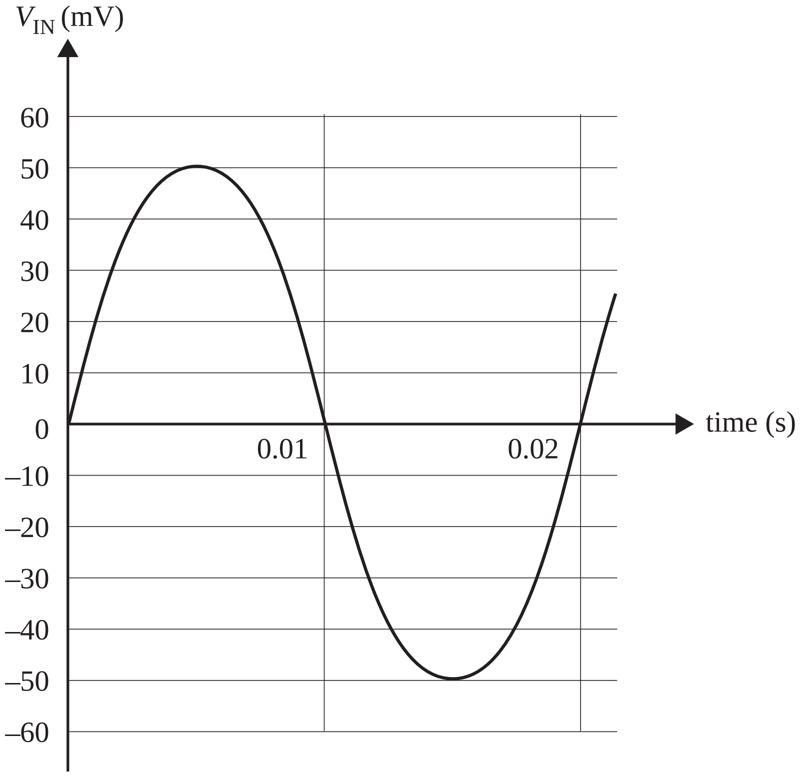


Figure 15

b. On the axes shown in Figure 16, sketch the output signal of the amplifier (V_{OUT}) and assign a scale to the vertical axis. 3 marks

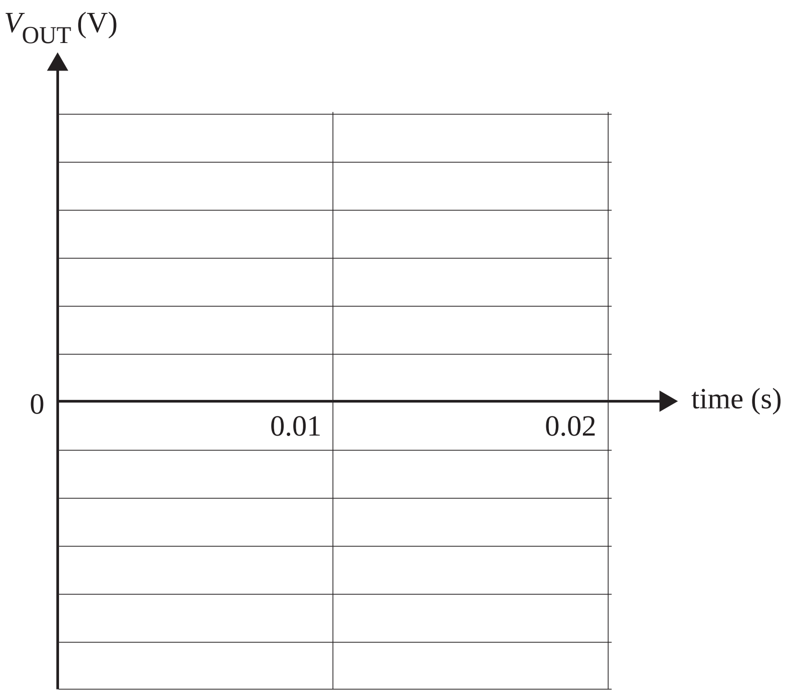


Figure 16

Question 12 (2 marks)

In certain large concert venues, it is common to use a modulated radio signal to link the sound from the microphone of the performer on stage to the audio amplifier system for the venue. A diagram for such a modulation/demodulation system is shown in Figure 17.

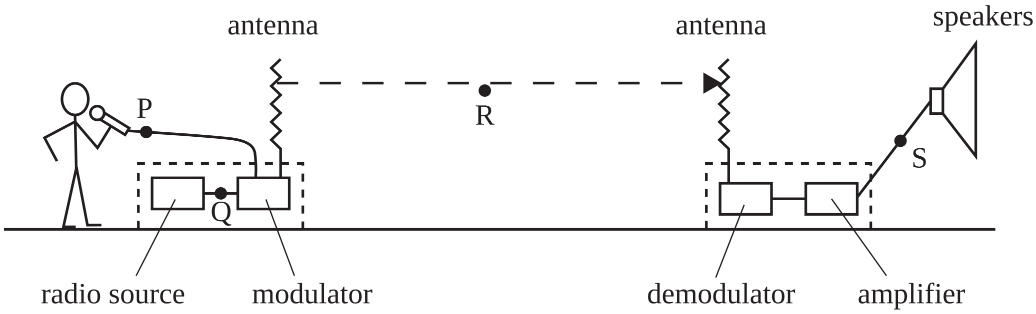
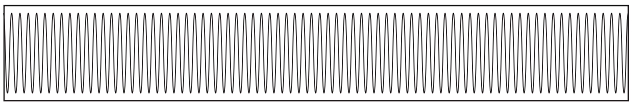


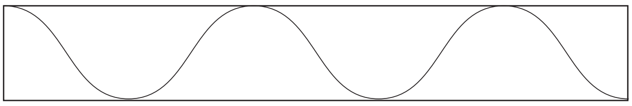
Figure 17

Figure 18 shows three signals, A, B, C, that might be observed at locations P, Q, R or S in the preceding diagram.

A



B



C

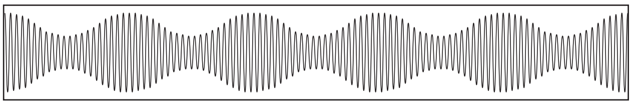


Figure 18

In the grid below, state the letter of the waveform (A, B or C) that you would expect to find at the locations P, Q, R and S.

Location	P	Q	R	S
Waveform				

Question 13 (7 marks)

The temperature-resistance characteristics of a thermistor are shown in Figure 19.

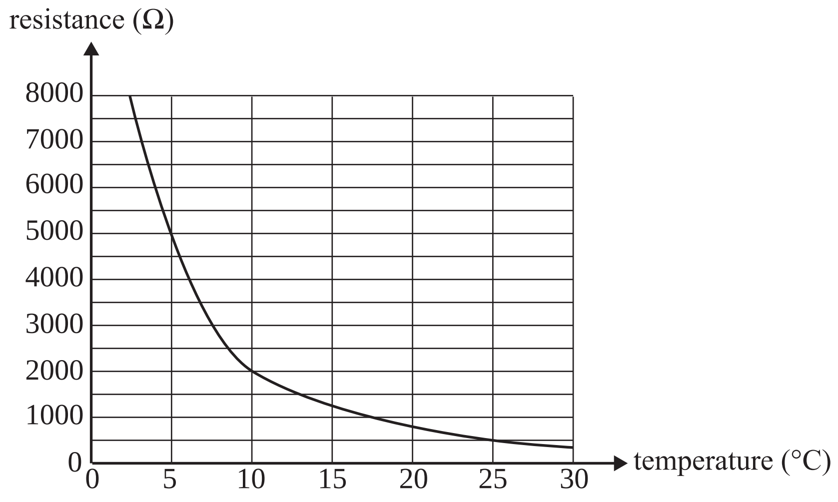


Figure 19

a. What is the resistance of the thermistor when the temperature is 5 °C? 1 mark

kΩ

The thermistor is incorporated into a circuit to control an air conditioner. The circuit is shown in Figure 20.

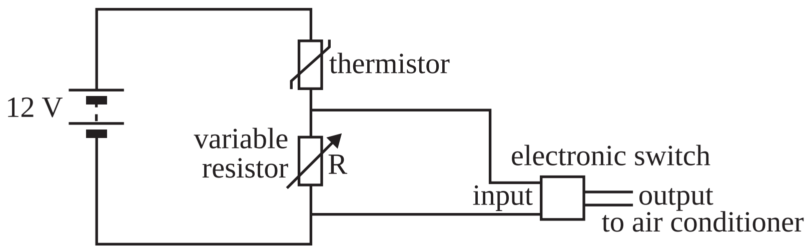


Figure 20

The electronic switch turns the air conditioner on when the voltage across the input of the switch reaches 8 V, and switches it off when the voltage falls below 8 V.

The air conditioner needs to come on when the temperature rises to 25 °C.

b. Calculate the required resistance of the variable resistor R. 3 marks

Ω

The air conditioner now needs to come on at a lower temperature.

c. State whether the variable resistor R should be increased or decreased to achieve this. Explain your answer. 3 marks

Area of study – Electric power

Question 14 (9 marks)

Figure 21 shows a solenoid and a battery.

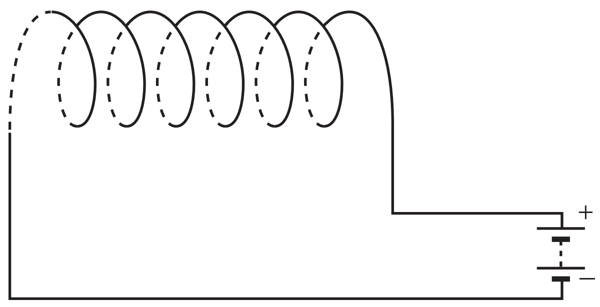


Figure 21

a. On Figure 21, draw **three** magnetic field lines, with arrows to show direction, to indicate the magnetic field produced both inside and outside the solenoid. 2 marks

A rectangular loop of wire, PQRS, of sides PQ = 4.0 cm and QR = 8.0 cm, is placed inside the solenoid as shown in Figure 22.

The loop has three turns of wire. A current of 4.0 A flows in the loop, in the direction indicated by the arrow. The uniform magnetic field strength inside the solenoid is 5.0×10^{-2} T. (Ignore any magnetic field produced by connecting wires outside the solenoid.)

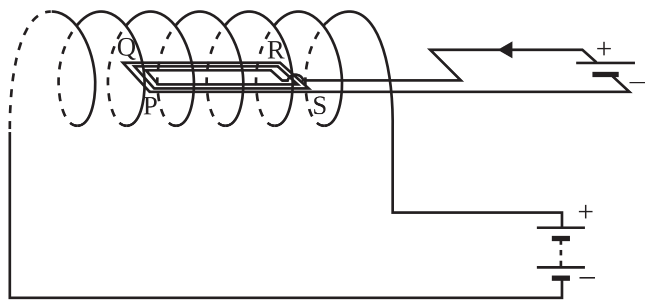


Figure 22

b. Calculate the magnetic flux from the solenoid's field threading the rectangular loop. Show your reasoning. 2 marks

Wb

c. Draw an arrow on Figure 22 indicating the direction of the force on the side PQ. 1 mark

d. Calculate the magnitude of the force on the side PQ. 2 marks

N

e. Calculate the force (magnitude and direction) on the side QR due to the magnetic field from the solenoid. Show your reasoning. 2 marks

N

direction:

Question 15 (5 marks)

Emily and Gerry have been studying DC generators and AC alternators. They have constructed the device shown in Figure 23. The rectangular coil is a single loop that has an area of 9.0×10^{-4} m^2. It is rotated in the direction shown in a uniform magnetic field with a direction indicated by B. The coil is completely contained in the magnetic field. The connections at P and Q are *slip rings*.

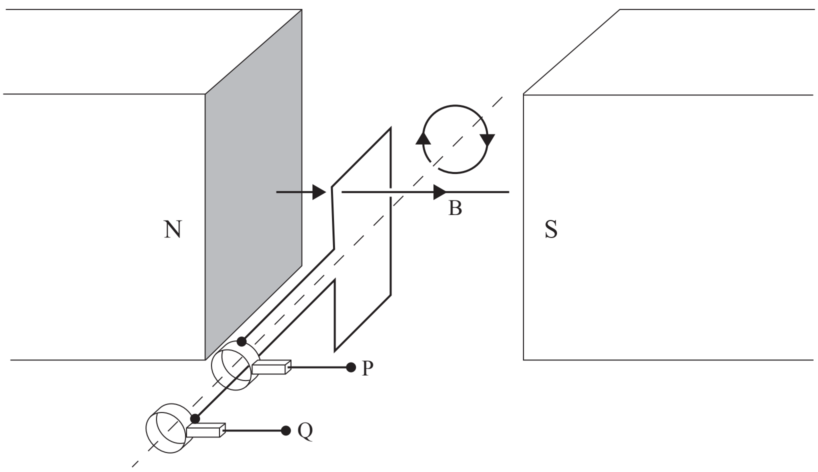


Figure 23

They tested the device by first connecting an oscilloscope between the terminals P and Q, and then rotating the coil at a constant rate, in the uniform field B, in the direction shown. The graphs in Figure 24 show the magnitudes of the voltage across the terminals and the magnetic flux through the coil, both as a function of time.

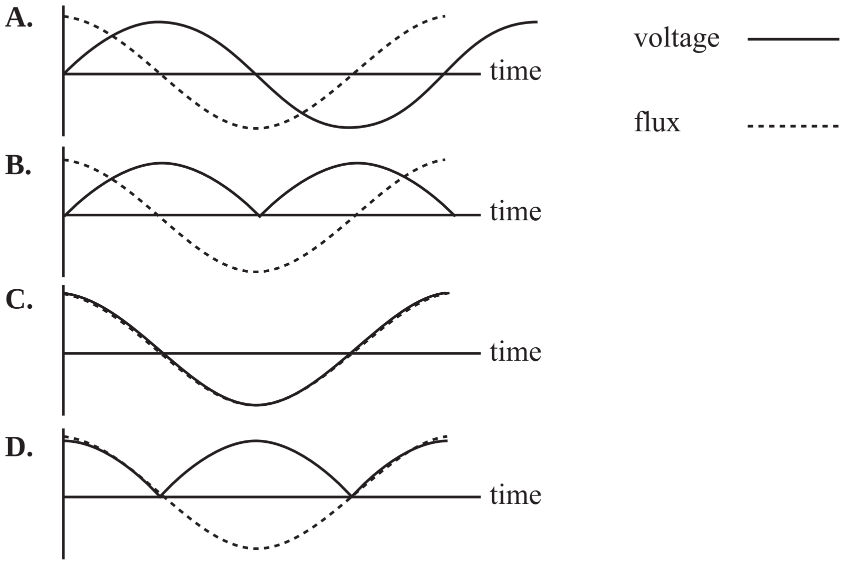


Figure 24

a. Which one of the graphs (**A.–D.**) shown above best represents the voltage observed on the oscilloscope? 2 marks

b. Explain the difference in function between a s*plit-ring commutator* and *slip rings*. Describe the situations in which a split-ring commutator and slip rings could be used. 3 marks

Question 16 (8 marks)

Figure 25 shows an experiment where the voltage induced in a coil by a time-dependent magnetic field is measured. The voltmeter measures the voltage induced in the coil as a function of time. The coil has 120 turns.

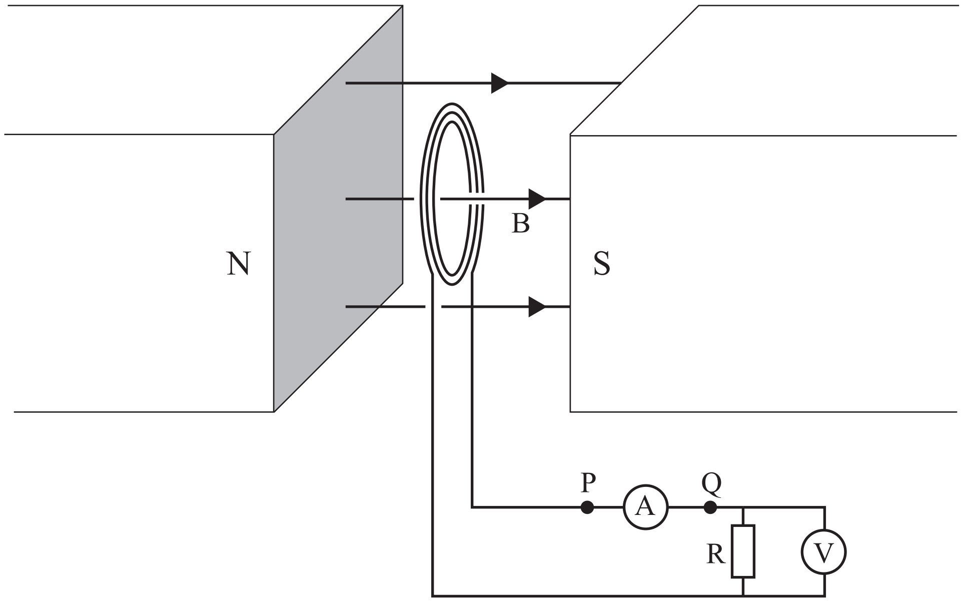


Figure 25

The magnetic field varies with time as shown in Figure 26.

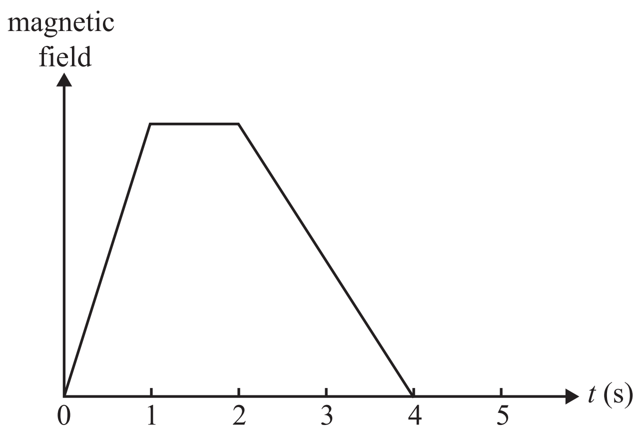
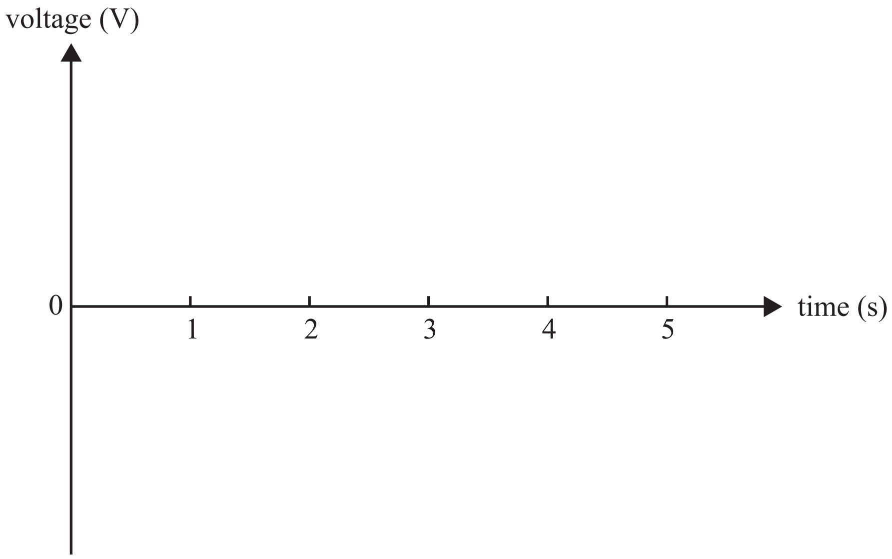


Figure 26

a. On the grid below, sketch a graph of voltage against time as measured by the voltmeter. 2 marks



b. Identify the physical law (or laws) that you used in constructing your graph. 1 mark

c. At another time, the magnetic flux through the 120 turn coil is a constant 3.0×10^{-4} Wb. The magnetic field is now reduced to zero over a period of 0.012 s.

Calculate the average emf induced in the coil during that 0.012 s interval. 2 marks

V

d. As the field is being reduced, in which direction (P→Q or Q→P) will the current flow through the ammeter A in Figure 25? Give clear reasons for your answer. 3 marks

Question 17 (4 marks)

The output of an AC alternator is shown in Figure 27.

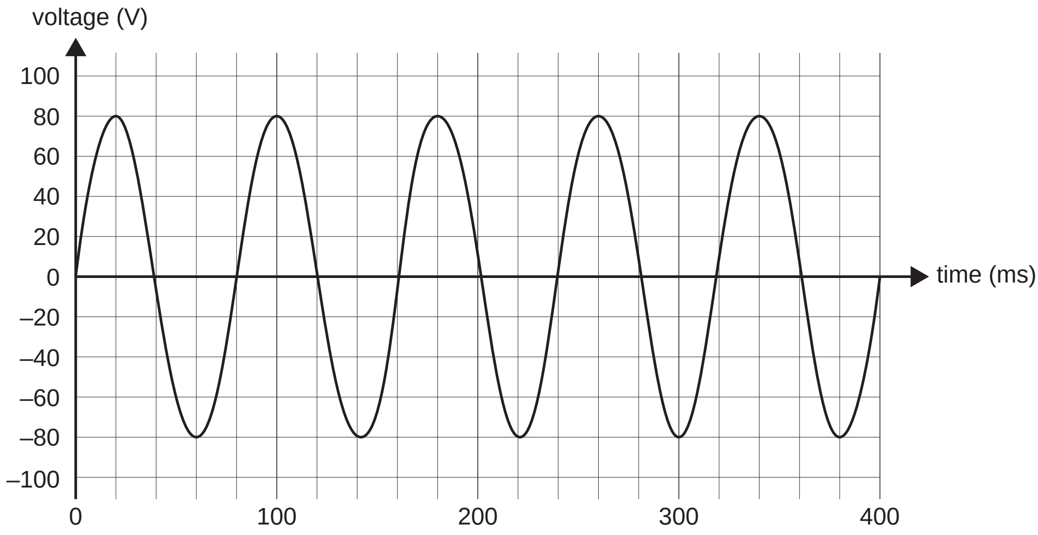


Figure 27

a. Calculate the frequency of rotation of the alternator. 2 marks

Hz

b. Calculate the value of the ratio 2 marks

$$\frac{\text{RMS voltage output}}{\text{peak-to-peak voltage output}}$$

Question 18 (14 marks)

Students are using a model to study power and voltage loss in transmission lines. This model consists of two wires, *each* of constant resistance 2.5 Ω. As a load they use a 5.0 W globe that operates at 5.0 W when there are 2.0 V across it.

The experimental arrangement is shown in Figure 28. The connecting wires from the power supply to the transmission lines and from the transmission lines to the globe have negligible resistance.

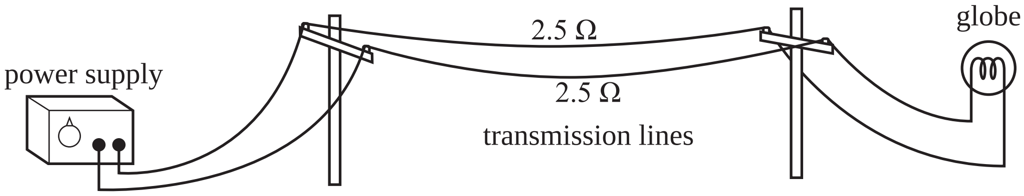


Figure 28

a. Initially the power supply is set on a voltage of 2.0 V DC. They find that the globe does not glow as brightly as they expected from a 5.0 W globe.

Explain why. 2 marks

b. The voltage setting of the power supply is then set so that the globe operates at 5.0 W as designed. Calculate the required voltage setting of the power supply. 2 marks

V

c. Calculate the power loss in the transmission lines when the globe is operating at 5.0 W as designed. Show your working. 2 marks

W

d. One of the students, Catherine, says that in the real situation that they are attempting to model, this fractional power loss would be unacceptable. She observes that AC, rather than DC, is often used for long-distance electric power transmission systems.

Explain how using AC for long-distance electric power transmission can reduce power losses. 3 marks

To model such an AC transmission system, the students modify their experiment as shown in Figure 29. They set the output of the AC power supply to 21.25 V_{RMS} AC. They use a 10:1 step-down transformer at the other end. The output of the transformer is connected to the globe. The globe is operating at 2.0 V and 5.0 W. The transformer is ideal.

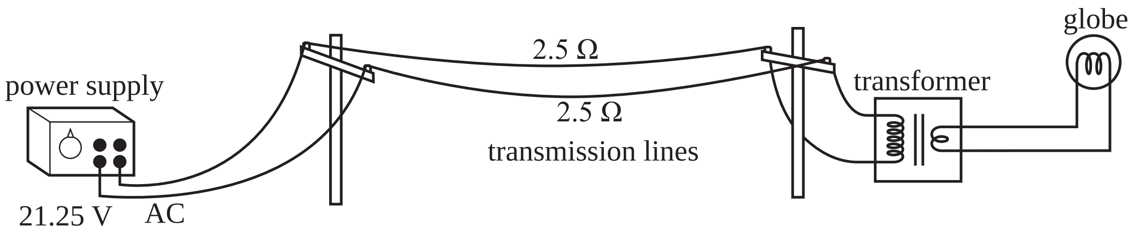


Figure 29

Before connecting the system, the students test the power supply by connecting it to an oscilloscope as shown in Figure 30.

Figure 30

e. Which of the following (**A.–D.**) best describes the voltage that they will observe on the oscilloscope? 1 mark

A. 21.25 V_{peak}

B. 21.25 $V_{peak\text{-}to\text{-}peak}$

C. 30.05 $V_{peak\text{-}to\text{-}peak}$

D. 60.10 $V_{peak\text{-}to\text{-}peak}$

f. The input coil of the 10:1 step-down transformer has 1460 turns.

Calculate the number of turns in the secondary coil. 1 mark

turns

g. Calculate the power loss in the model transmission lines when the experiment is set up as in Figure 29. 3 marks

W

Area of study – Interactions of light and matter

Question 19 (3 marks)

Over the last few centuries, scientists have proposed two conflicting models to explain the nature of light, as follows.

- the wave model
- the particle model

Name a historical experiment that supports the wave model rather than the particle model. Explain how the experiment supports the wave model rather than the particle model.

Question 20 (3 marks)

The photoelectric experiment supports the particle model of light rather than the wave model of light. The following are observed during a photoelectric effect experiment.

Observation 1: The number of emitted electrons (the photocurrent) depends on the intensity of the incident light.

Observation 2: The energy of the emitted electrons depends only on the frequency of the incident light and is independent of the intensity.

Observation 3: The energy of the emitted electrons depends on the metal surface involved.

The particle model can account for all the above three observations. The wave model can explain two of them but not a third one.

Select the observation that the wave model *cannot* explain. Explain how the particle model satisfactorily explains this observation.

observation number

Question 21 (4 marks)

Two students are studying interference of light. They use laser light of wavelength 580 nm.

a. Calculate the energy of one photon of the light from the laser. 2 marks

J

The students set up the laser, two slits, S_1 and S_2, and a screen on which an interference pattern is observed, as shown in Figure 31. The pattern that they observe on the screen is also shown, to the right of the diagram of the experimental setup. The point C indicates the centre of the screen.

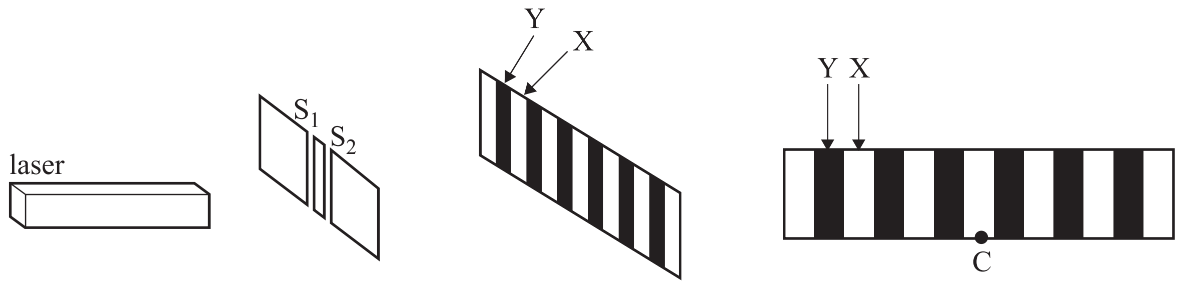


Figure 31

X is at the centre of a bright band. Y is at the centre of the dark band next to X and further away from the centre of the pattern. The path difference $S_2X - S_1X$ is 1160 nm.

b. Calculate the path difference $S_2Y - S_1Y$. 2 marks

m

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Question 22 (3 marks)

Students set up the apparatus shown in Figure 32 to study the photoelectric effect. They have a number of photocells with different metal plates in them.

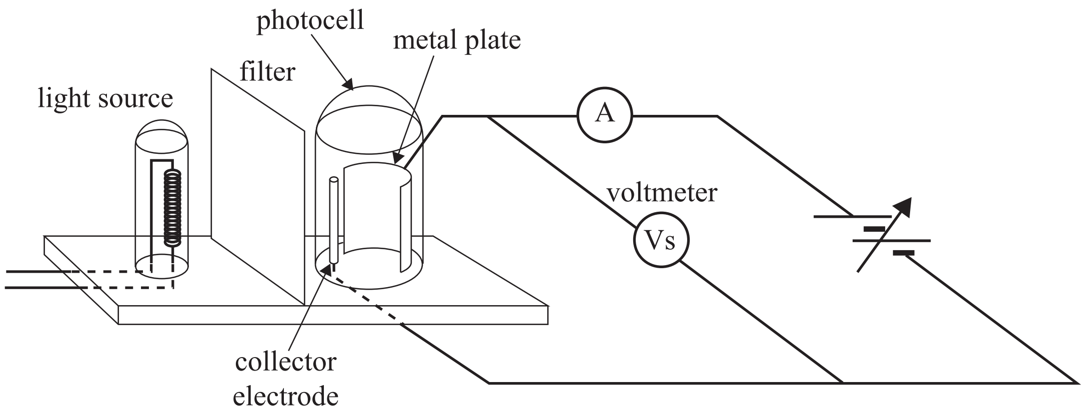


Figure 32

With a selenium plate in place, and using their data, the students draw a graph of the maximum kinetic energy of the photoelectrons versus the frequency of light incident on the selenium plate, as shown in Figure 33.

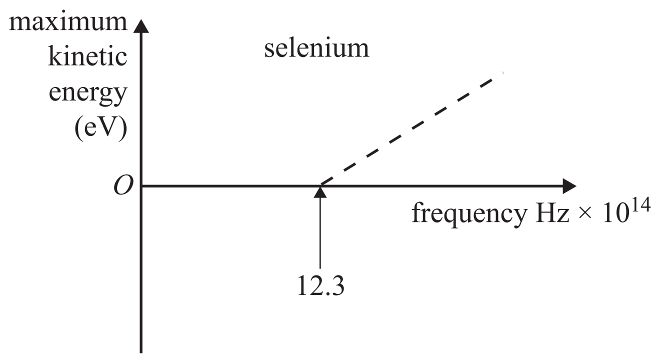


Figure 33

a. The students then double the intensity and repeat the experiment.
Identify the graph in Figure 34 which now best shows their results. 1 mark

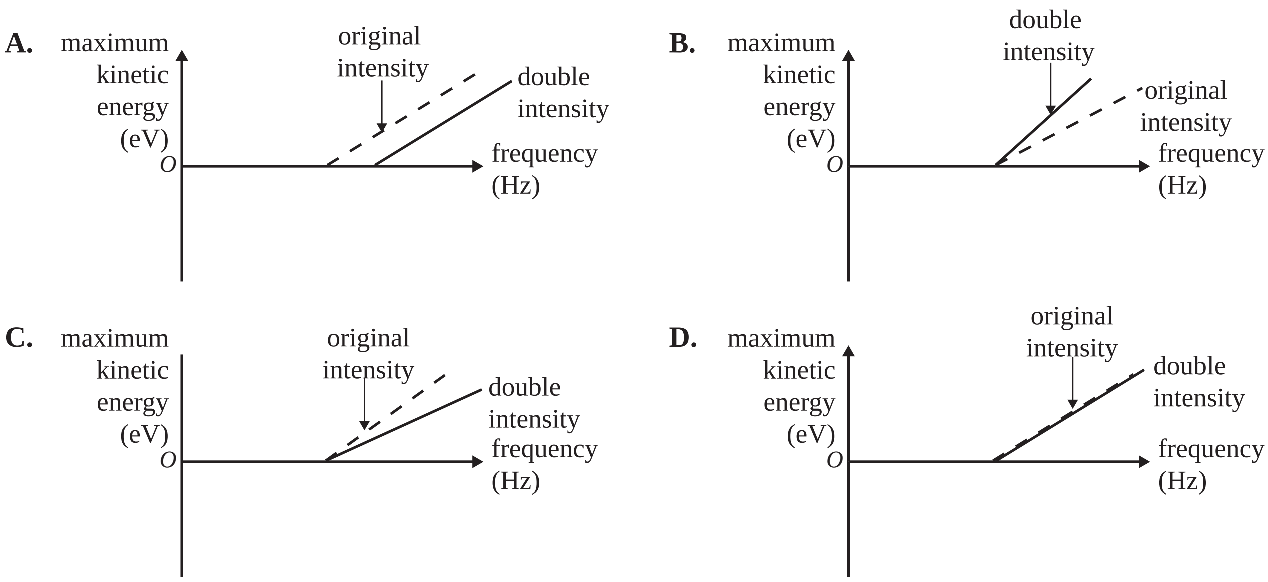


Figure 34

The students now use a photocell with a magnesium plate. The work function of magnesium (3.7 eV) is less than that of selenium (5.1 eV).

The dotted line on each graph shows the original graph for selenium.

b. Which one of the graphs in Figure 35 will now best show the results? Explain your answer. 2 marks

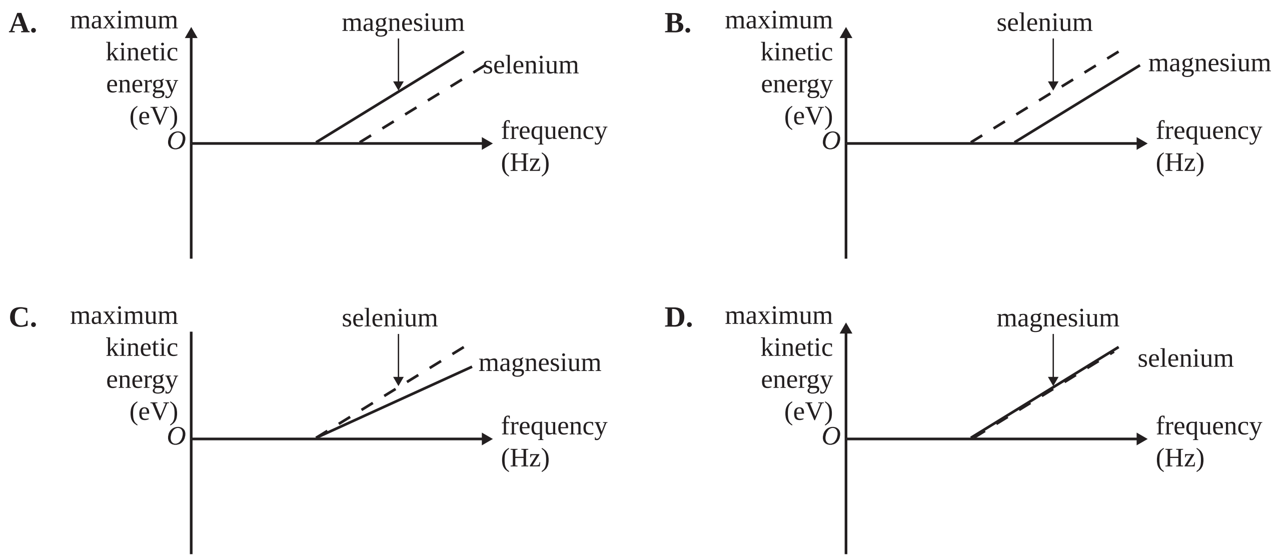


Figure 35

Question 23 (9 marks)

Students study diffraction of electrons by a crystal lattice. The apparatus is shown in Figure 36.

In the apparatus, electrons of mass 9.1×10^{-31} kg are accelerated to 1.5×10^{7} m s^{-1}.

The electrons pass through the crystal, and the diffraction pattern is observed on a fluorescent screen. The observed pattern is shown in Figure 37.

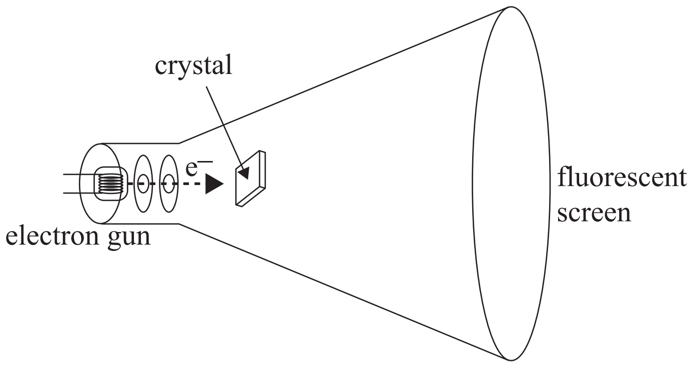


Figure 36

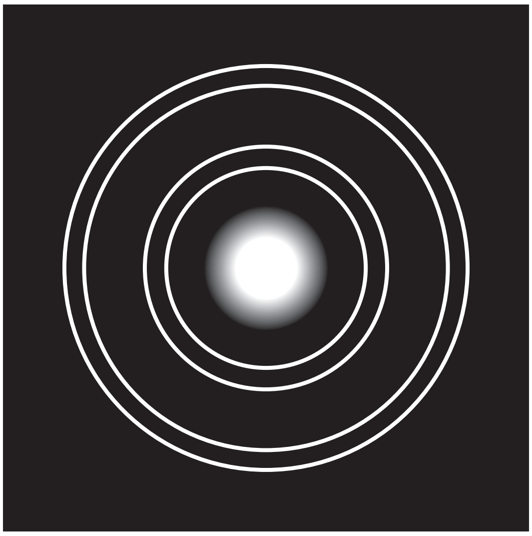


Figure 37

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

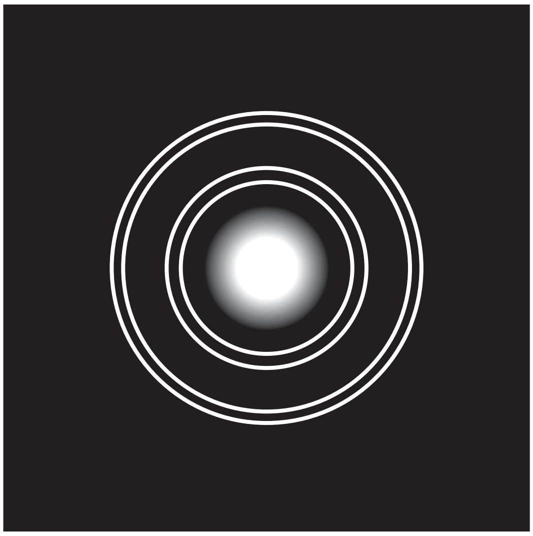
____

____

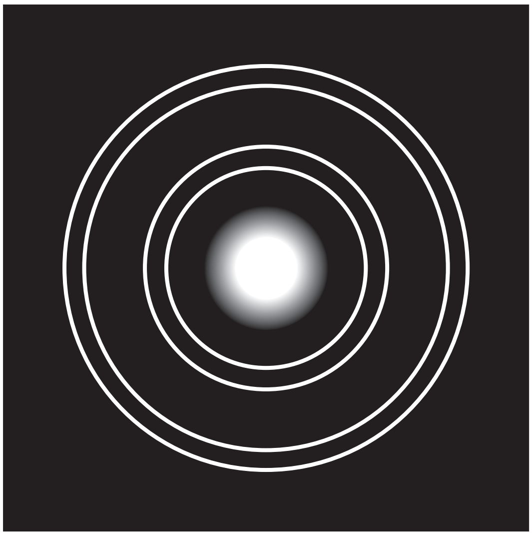
____

m

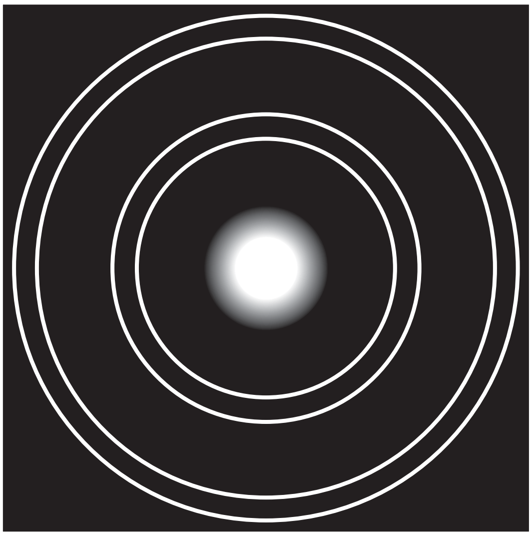
The students now increase the accelerating voltage and hence the speed of the electrons.



Option A



Option B (identical to original pattern)



Option C

Figure 38

b. Identify the option in Figure 38 that best shows the pattern that they will now observe on the screen (Option B is identical to the pattern on the previous page.) Explain your answer. 2 marks

SECTION A – Core studies – Question 23 – continued

The *left-hand* diagram in Figure 39 shows a new diffraction pattern with electrons of 500 eV.

When the students replace the electron gun with an **X-ray source** they observe the pattern shown in the *right-hand* diagram in Figure 39.

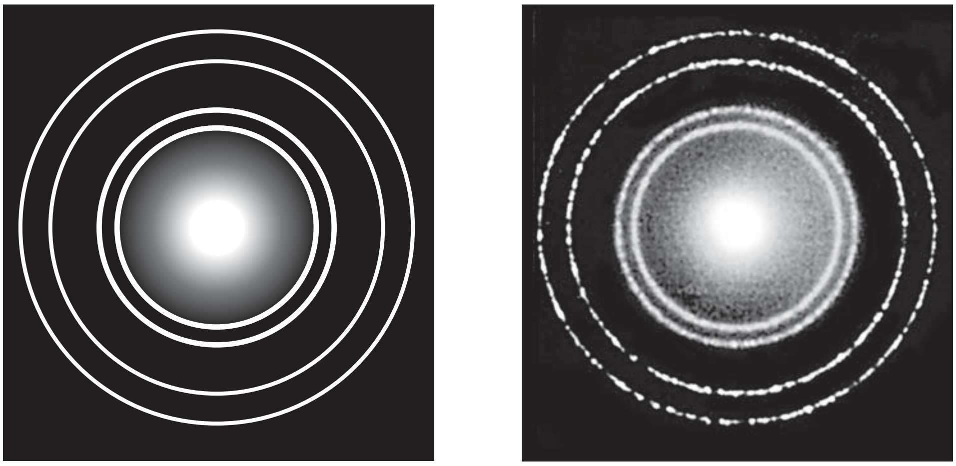


Figure 39

c. Explain why the electrons and the X-rays produce a pattern with very similar spacing. 2 marks

d. Estimate, using calculations, the energy, in keV, of a single photon of these X-rays. Show your working. 3 marks

keV

Question 24 (2 marks)

Figure 40 shows the energy levels of the hydrogen atom.

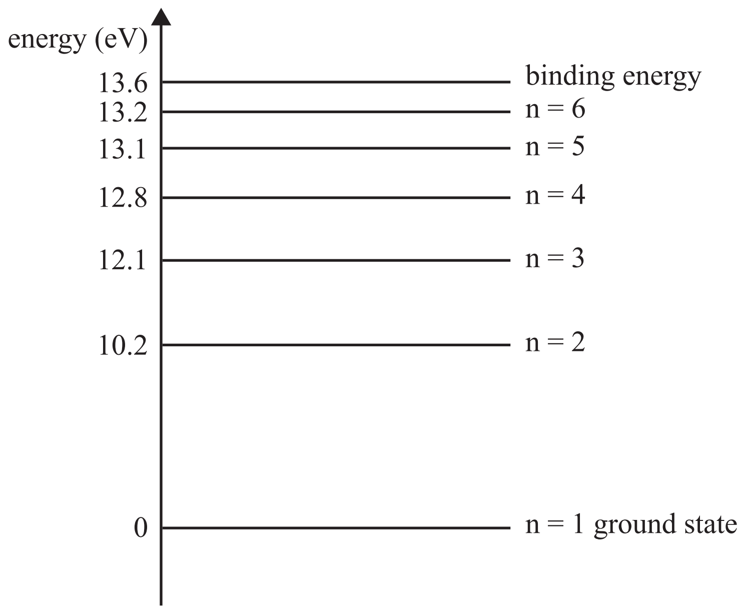


Figure 40

A photon of wavelength 478 nm is emitted from an excited hydrogen atom. This emerging photon is caused by a transition between two energy states.

Draw an arrow on Figure 40 that shows this transition from the initial to the final energy state.

END OF SECTION A

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SECTION B

Instructions for Section B

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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

Use the following information to answer Questions 1–3.

A racing car is moving at high speed (0.9*c*) along a straight track. It is heading straight for a post. Jim is standing next to the post. The situation is shown in Figure 1.

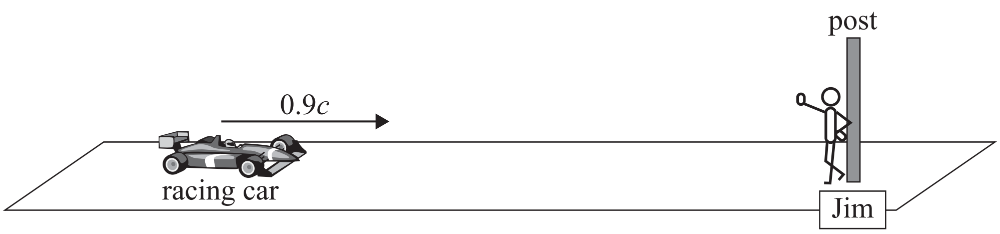

Figure 1

When the racing car is 1.00 km from the post (as measured by Jim), the driver sends a flash of light from the car.

Question 1

Which one of the following is the closest to the time that the flash of light takes to reach the post (as measured by Jim)?

A. 1.5 microseconds

B. 1.8 microseconds

C. 3.3 microseconds

D. 3.7 microseconds

The driver of the racing car, Susanna, measures the distance between herself and the post at exactly the same time that she sends the flash of light.

Question 2

Which one of the following is closest to the distance that she measures?

A. 0.44 km

B. 0.90 km

C. 1.00 km

D. 2.29 km

On another occasion, Vicky observes the racing car. She is standing exactly midway between two posts, A and B. At the instant that the car passes her, the driver sends simultaneous flashes of light forwards and backwards towards the posts. The car is travelling at $0.9c$ towards post B. The arrangement is shown in Figure 2.

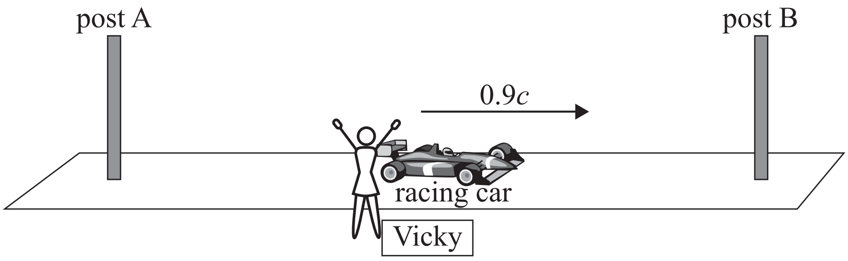

Figure 2

Question 3

Which one of the following best describes when the flashes of light reach the posts, as observed by Vicky?

A. Post A receives the flash of light first.

B. Post B receives the flash of light first.

C. Posts A and B receive a flash of light at the same time.

D. It is not possible to predict which receives a flash of light first.

Question 4

Which one of the following is the best description of the *proper length* of an object travelling with constant velocity?

A. the length when measured by any observer at the same location

B. the length when measured by an observer at rest relative to the object

C. the length when both ends of the object are measured at the same time

D. the length when measured with a proper measuring stick

Question 5

In a particle accelerator, an alpha particle of mass 6.64424×10^{-27} kg is accelerated from rest to high speed. The total work done on the alpha particle is equal to 1.0754×10^{-9} J.

Which one of the following is closest to its final speed?

A. $0.85c$

B. $0.93c$

C. $0.94c$

D. $0.95c$

Use the following information to answer Questions 6–8.

A robot is heading radially towards the surface of a planet at a constant speed of 0.85*c*. Observers on the surface of the planet observe it at a time when it is a distance *x* above the surface in their reference frame. The observers calculate the time that the robot will take to reach the surface of the planet as 784 microseconds. The situation is shown in Figure 3.

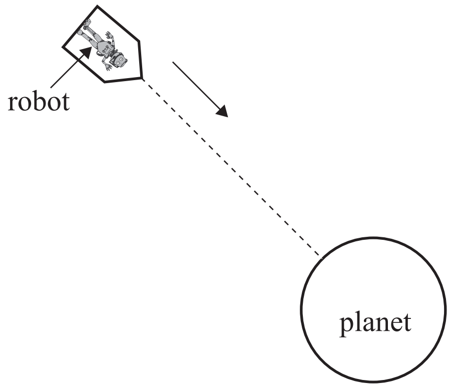

Figure 3

Question 6

Which one of the following is closest to the distance *x*?

A. 105 km

B. 200 km

C. 235 km

D. 380 km

Question 7

Which one of the following is the best estimate of the time, as measured by the *robot,* for it to reach the surface of the planet?

A. 413 microseconds

B. 666 microseconds

C. 784 microseconds

D. 1488 microseconds

Question 8

Which one of the following best describes the time of the robot's descent to the planet surface as measured by the robot, and the time measured by the observers on the surface of the planet?

A. They are both measurements of proper time in their own reference frames.

B. Neither are measures of proper time.

C. Only the observers measure the proper time.

D. Only the robot measures the proper time.

Question 9

Which one of the following best describes what follows directly from the measurements of the Michelson–Morley experiment?

A. The speed of light near the surface of Earth depends on the direction in which it is measured travelling.

B. The speed of light near the surface of Earth is the same in all directions

C. Earth travels through a stationary ether.

D. The ether may exist, but it is not detectable.

Question 10

Muons and antimuons are anti-particles of each other. They have the same mass. When a muon meets an antimuon, both are destroyed and two photons (gamma rays) are formed. If the two particles are effectively stationary, then the two photons have a *total* energy of 3.38×10^{-11} J.

Using this data, which one of the following is closest to the mass of a single muon?

A. 3.76×10^{-28} kg

B. 1.88×10^{-28} kg

C. 1.13×10^{-19} kg

D. 5.64×10^{-19} kg

Question 11

A conservation scientist is using a stun dart from a rifle to tranquillise a kangaroo to tag it for conservation research. He is travelling in a specially designed vehicle at a speed V in a straight line. He fires a dart from his rifle straight ahead. The dart has a speed U relative to the rifle. At the same time, a flash of light is emitted from the laser sight mechanism on his rifle. This is shown in Figure 4.

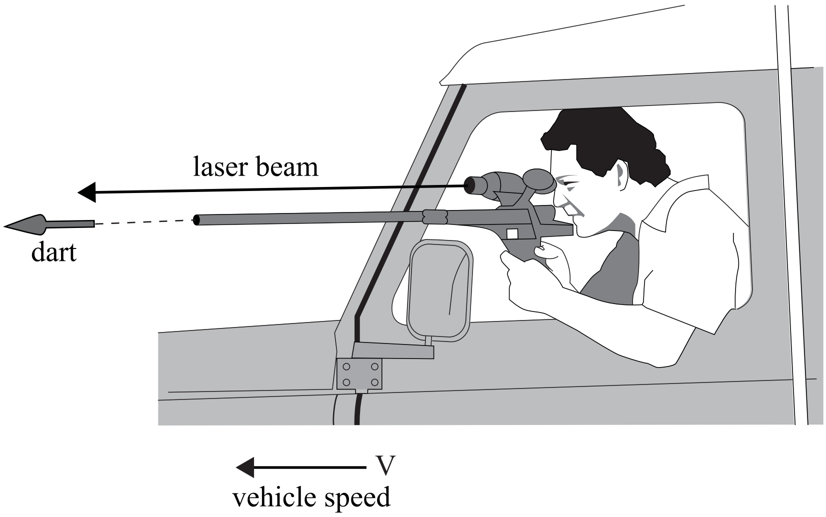

Figure 4

Which one of the following choices is the best estimate of the speed of the dart and the light flash, as measured by a stationary observer on the ground?

	Speed of *dart* relative to stationary observer	Speed of *light flash* relative to stationary observer
A.	$U + V$	c
B.	$U + V$	$V + \sqrt{\frac{V^2}{c^2}}$
C.	$U - V$	$V + c$
D.	U	c

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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 1–7.

The mechanical properties of steel depend on how it is produced. The graph in Figure 1 shows the stress-strain graphs for *hard steel* and *soft steel* under tension.

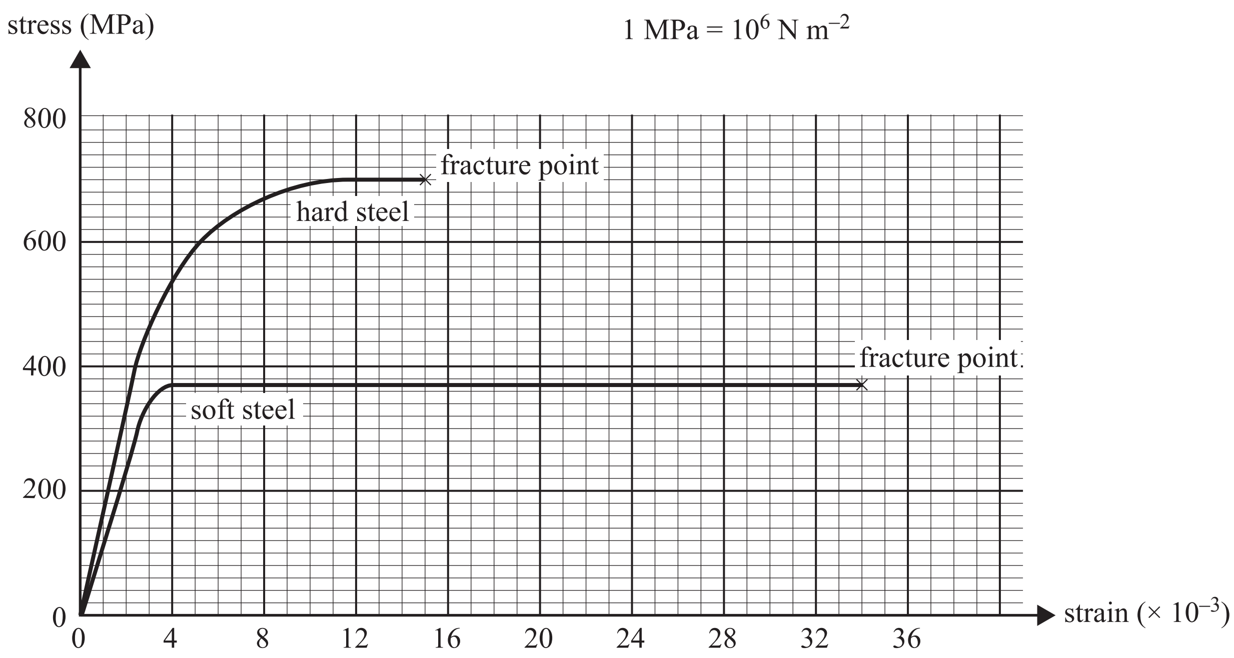


Figure 1

Question 1

From the graph, compared to hard steel, soft steel can best be described as

A. stiff.

B. strong.

C. brittle.

D. ductile.

Question 2

Which one of the following statements best indicates that hard steel is stiffer than soft steel?

A. Hard steel undergoes less plastic deformation than soft steel.

B. A greater stress is needed to fracture hard steel than soft steel.

C. The area under the graph is greater for hard steel than soft steel.

D. The gradient of the stress-strain curve is greater for hard steel than soft steel.

Question 3

Which one of the following statements about toughness is correct?

A. Soft steel is tougher than hard steel.

B. Hard steel is tougher than soft steel.

C. Both hard steel and soft steel are equally tough.

D. To decide which steel is tougher, the volume of both must be known.

A rod of soft steel, of initial length 10.000 m, is placed under a tensile stress. The strain produced by this stress is 1.000×10^{-3}.

Question 4

Which one of the options below is the best estimate of the length of this rod under this stress?

A. 9.990 m

B. 9.999 m

C. 10.001 m

D. 10.010 m

Question 5

Which one of the options below is the best estimate of Young's modulus for *hard steel* under tension?

A. 1.2×10^{11} N m^{-2}

B. 1.6×10^{5} N m^{-2}

C. 1.6×10^{8} N m^{-2}

D. 1.6×10^{11} N m^{-2}

A cylindrical rod of length 2.0 m and cross-sectional area 8.0×10^{-5} m^2 is made of *hard steel*. The rod is placed under a tensile stress of 200 MPa.

Question 6

Which one of the following is the best estimate of the force that must be applied to this hard steel rod to provide this stress?

A. 8.0×10^{3} N

B. 1.6×10^{4} N

C. 1.6×10^{10} N

D. 2.5×10^{12} N

A stress of 200 MPa applied to the *hard steel* cylindrical rod described above produces a strain of 1.25×10^{-3}.

Question 7

Which of the following best gives the strain energy per unit volume stored in the cylindrical rod?

A. 1.0×10^{1} J m^{-3}

B. 1.3×10^{5} J m^{-3}

C. 7.8×10^{8} J m^{-3}

D. 1.6×10^{9} J m^{-3}

Use the following information to answer Questions 8 and 9.

Figure 2 shows a mass of 100 kg hanging from the end of a 1.20 m uniform beam **PS** of mass 20 kg.

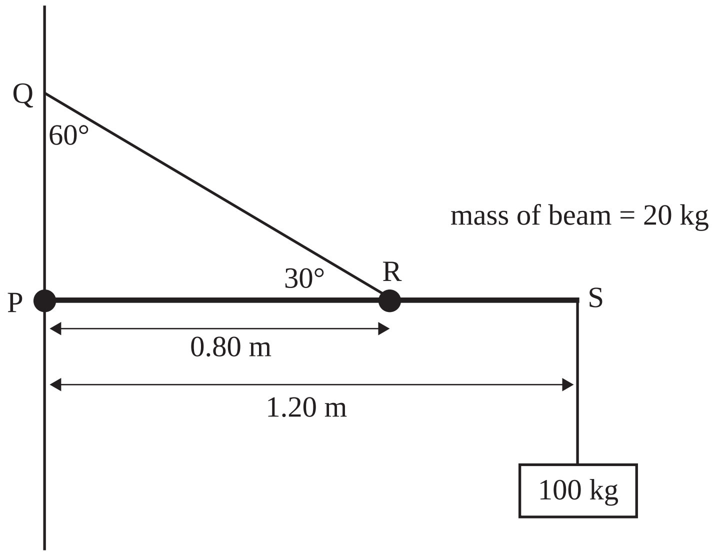


Figure 2

The beam is pivoted at the point P, with a freely rotating link. The beam is supported by a cable of negligible mass, connected at the point R. The point R is 0.80 m from P. The cable makes an angle of 30° to the horizontal (60° to the wall).

Question 8

Which one of the following best gives the magnitude of the torque on the beam about the point P due to the weight of the 100 kg mass?

A. 60 N m

B. 120 N m

C. 600 N m

D. 1200 N m

Question 9

Which one of the following best gives the tension in the cable RQ?

A. 120 N

B. 1320 N

C. 1905 N

D. 3300 N

Question 10

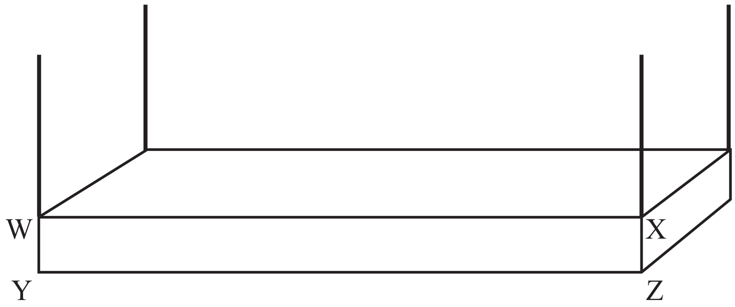
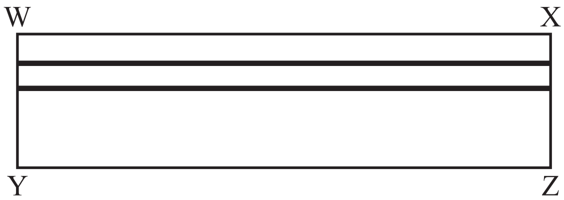


Figure 3

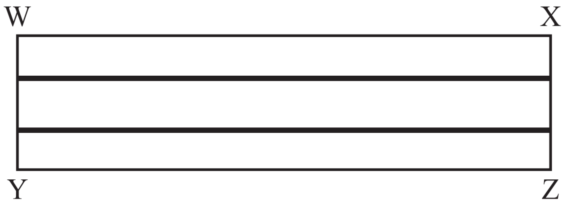
Figure 3 shows a suspended concrete walkway. The walkway is supported by cables from above.

Which one of the sketches below shows the best placement of reinforcing steel rods (represented by the pairs of thick black lines) in order to provide maximum strength for concrete in the walkway?

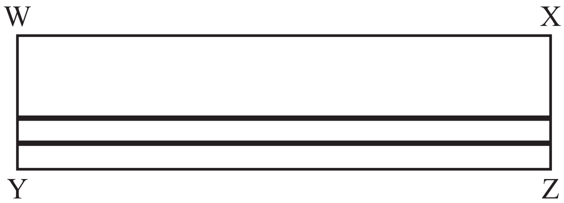
A.



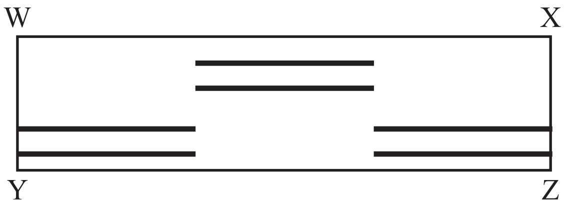
B.



C.



D.



Question 11

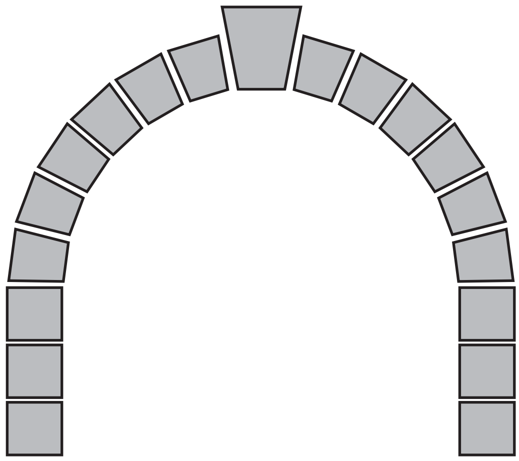


Figure 5

Figure 5 shows a stable stone arch. It is made of suitably shaped stone blocks. There is no cement or other adhesive between the blocks to bind them together.

Stone is used in this arch because this arch requires a material that is

A. strong under shear stress.

B. strong under tensile stress.

C. strong under compressive stress.

D. ductile under compressive stress.

SECTION B

Instructions for Section B

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Detailed study 3 – Further electronics

Use the following information to answer Questions 1–5.

Jenny is building an AC to DC regulated smoothed power supply. She sets up the first part of the circuit, as shown in Figure 1.

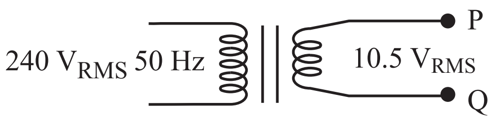


Figure 1

The input of the transformer is 240 V_{RMS} AC, 50 Hz, and the output 10.5 V_{RMS} AC.

Question 1

Assuming an ideal transformer, which one of the following best gives the ratio of turns in the primary (N1) to turns in the secondary (N2)?

A. 210 : 4800

B. 300 : 4800

C. 4800 : 300

D. 4800 : 210

Jenny connects an oscilloscope across the output terminals, PQ, of the transformer. The vertical scale of the oscilloscope is set on 5 V/cm, and the horizontal scale on 5 ms/cm.

Question 2

Which one of the displays in Figure 2 will she observe?

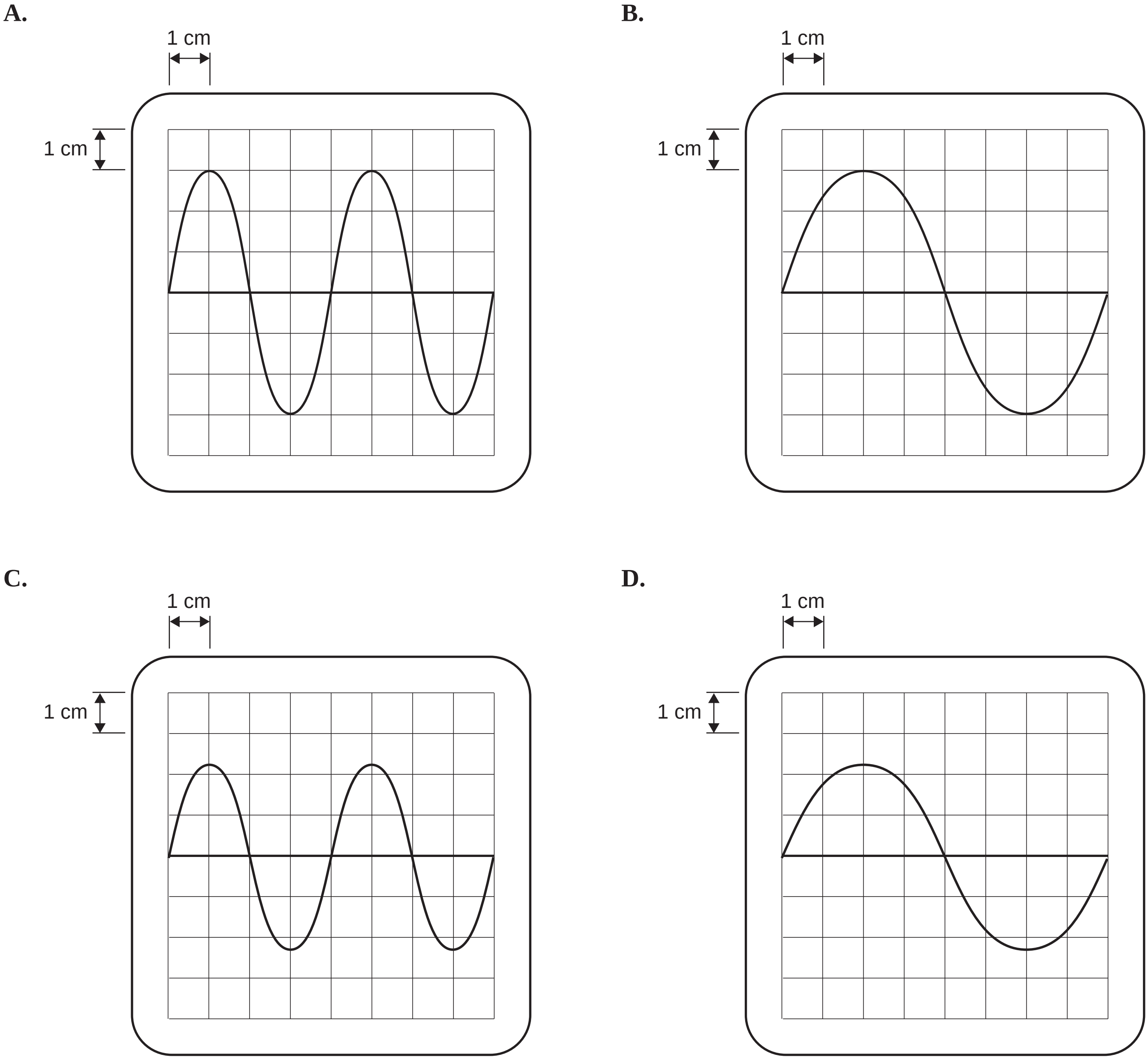


Figure 2

Jenny next adds a full-wave diode bridge rectifier, a 10 μF capacitor and a 500 Ω load resistor, as shown in Figure 3.

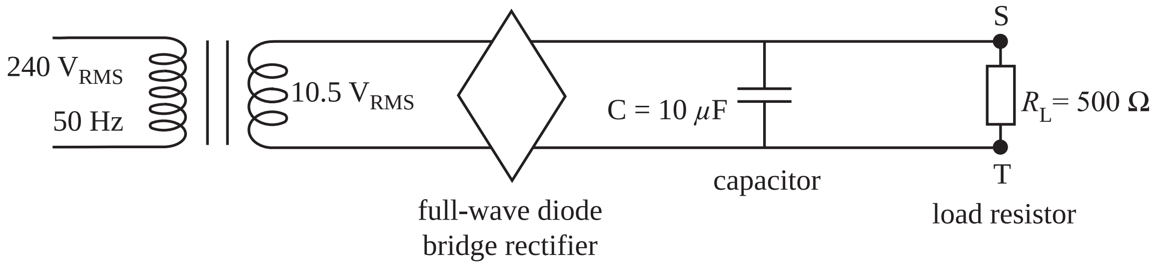


Figure 3

Jenny connects the oscilloscope across the load resistor (ST). The output as measured by the oscilloscope is shown in Figure 4.

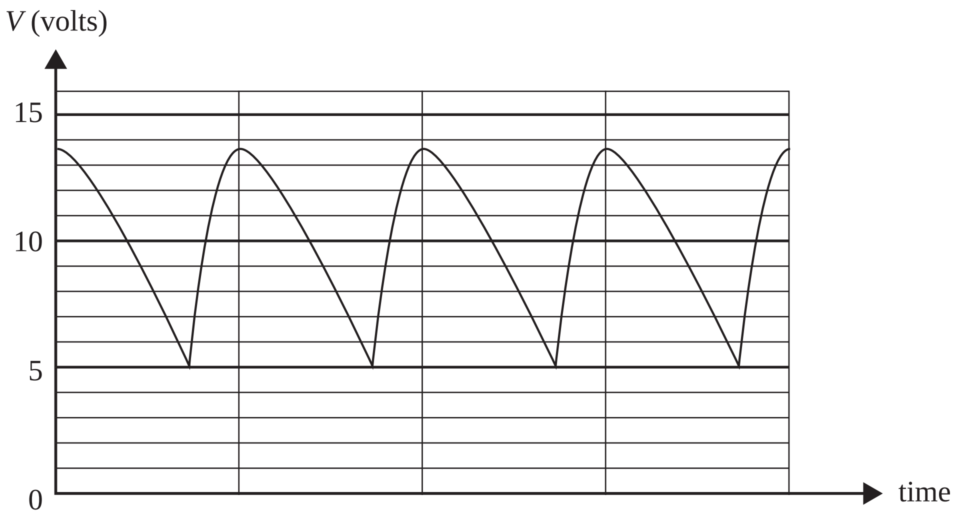


Figure 4

Question 3

Which one of the following is the best estimate of the average power dissipated in the 500 Ω load resistor?

A. 0.02 W

B. 0.2 W

C. 0.4 W

D. 5000 W

Question 4

Which one of the following is the best estimate of the peak-to-peak ripple voltage?

A. 0.5 V

B. 5.0 V

C. 8.5 V

D. 13.5 V

Jenny now adds a voltage regulator circuit consisting of a resistor, R_1, of 100 Ω and a 6.0 V Zener diode. The circuit is now set up as shown in Figure 5.

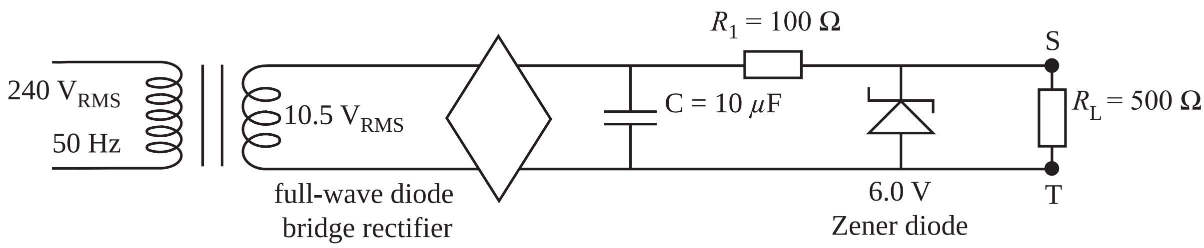


Figure 5

Jenny now connects the oscilloscope across the load resistor R_L.

Question 5

Which one of the graphs in Figure 6 best shows the output she will observe?

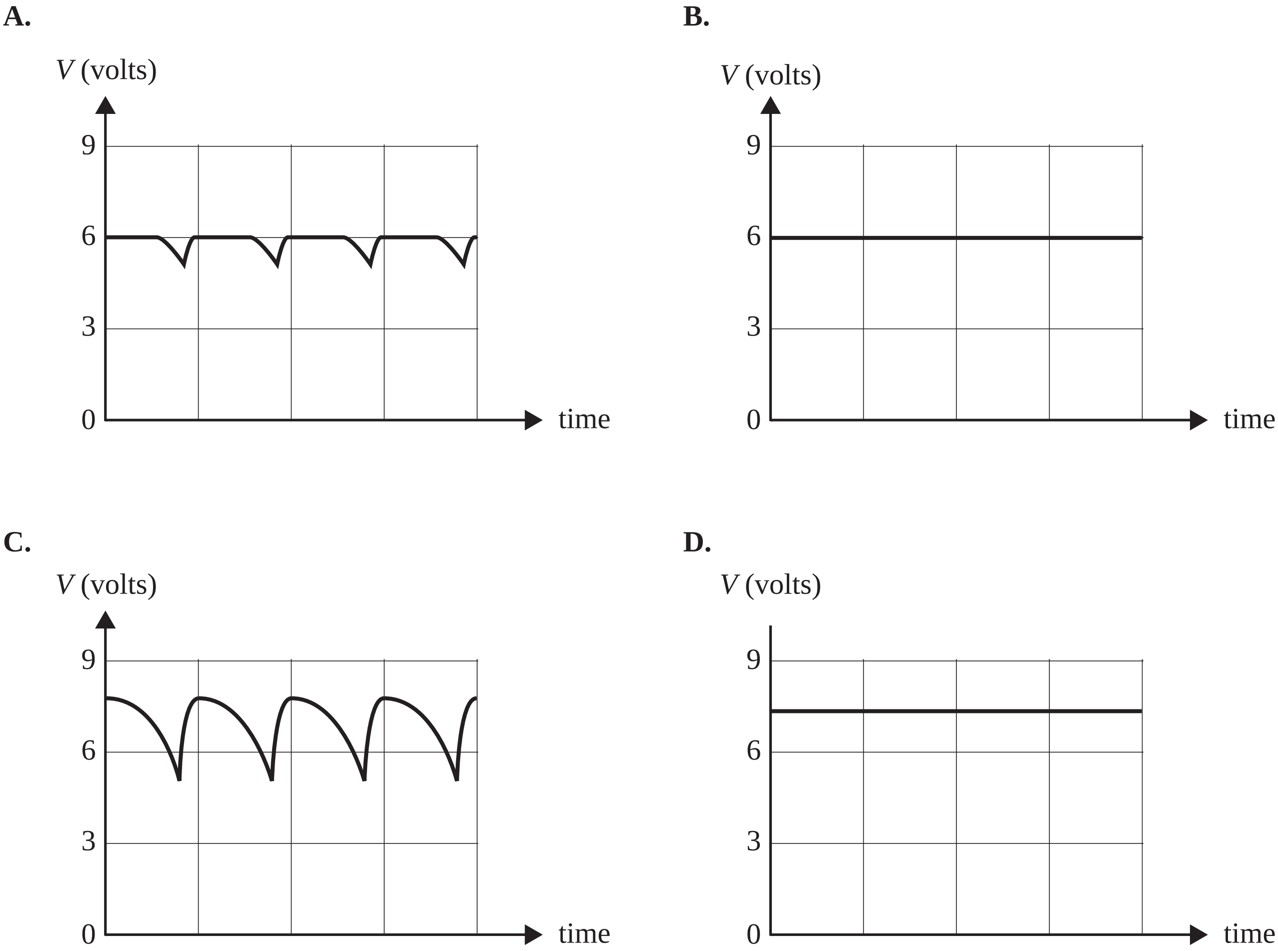


Figure 6

Use the following information to answer Questions 6 and 7.

Jenny tests an RC circuit. The circuit is shown in Figure 7.

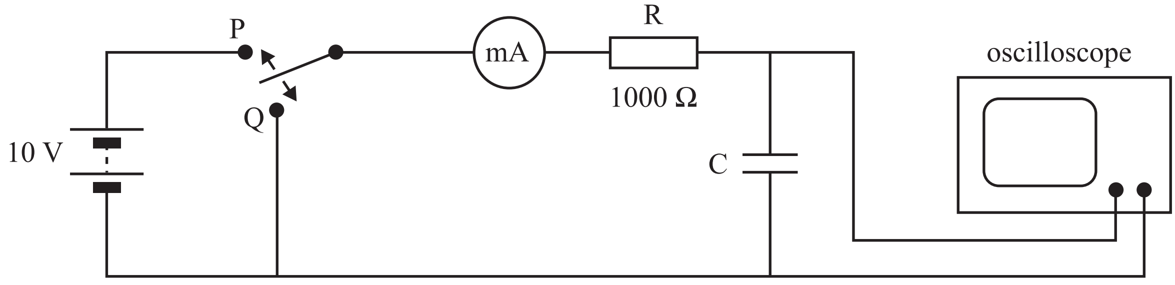


Figure 7

With the capacitor discharged, the switch is moved to position P at time $t = 0$. The voltage across the capacitor, C, as measured by the oscilloscope is shown in Figure 8.

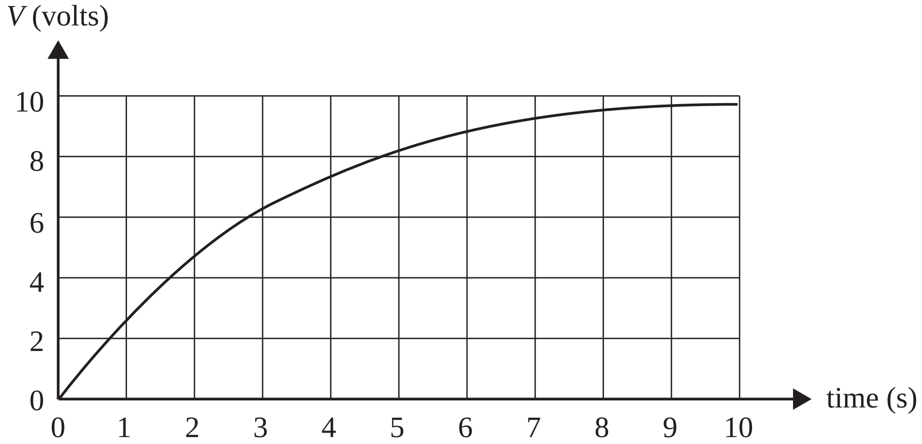


Figure 8

Question 6

Which one of the following is the best estimate of the value of the capacitor C?

A. 3 μF

B. 1000 μF

C. 3000 μF

D. 10 000 μF

After 60 s the switch is moved to position Q.

Question 7

Which one of the following best gives the *initial* current flowing through the milliammeter?

A. 0 mA

B. 6.3 mA

C. 10 mA

D. 10 A

Question 8

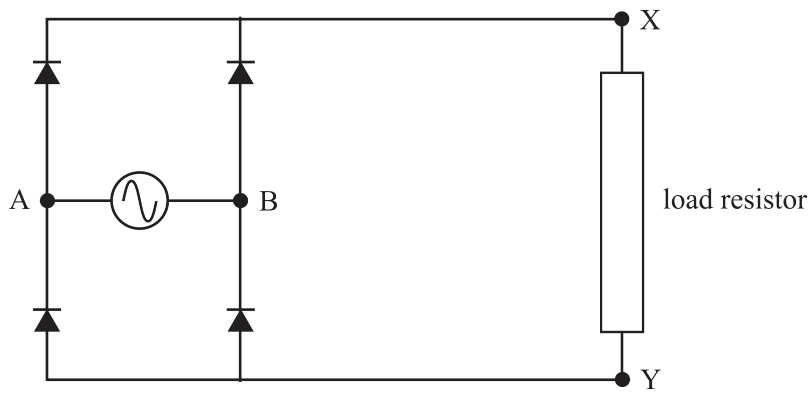


Figure 9

A circuit containing an AC power source, four diodes and a load resistor is shown in Figure 9.
Sally connects an oscilloscope across the load resistor, that is, across XY.
Which one of the outputs in Figure 10 best shows the resulting display of the oscilloscope?

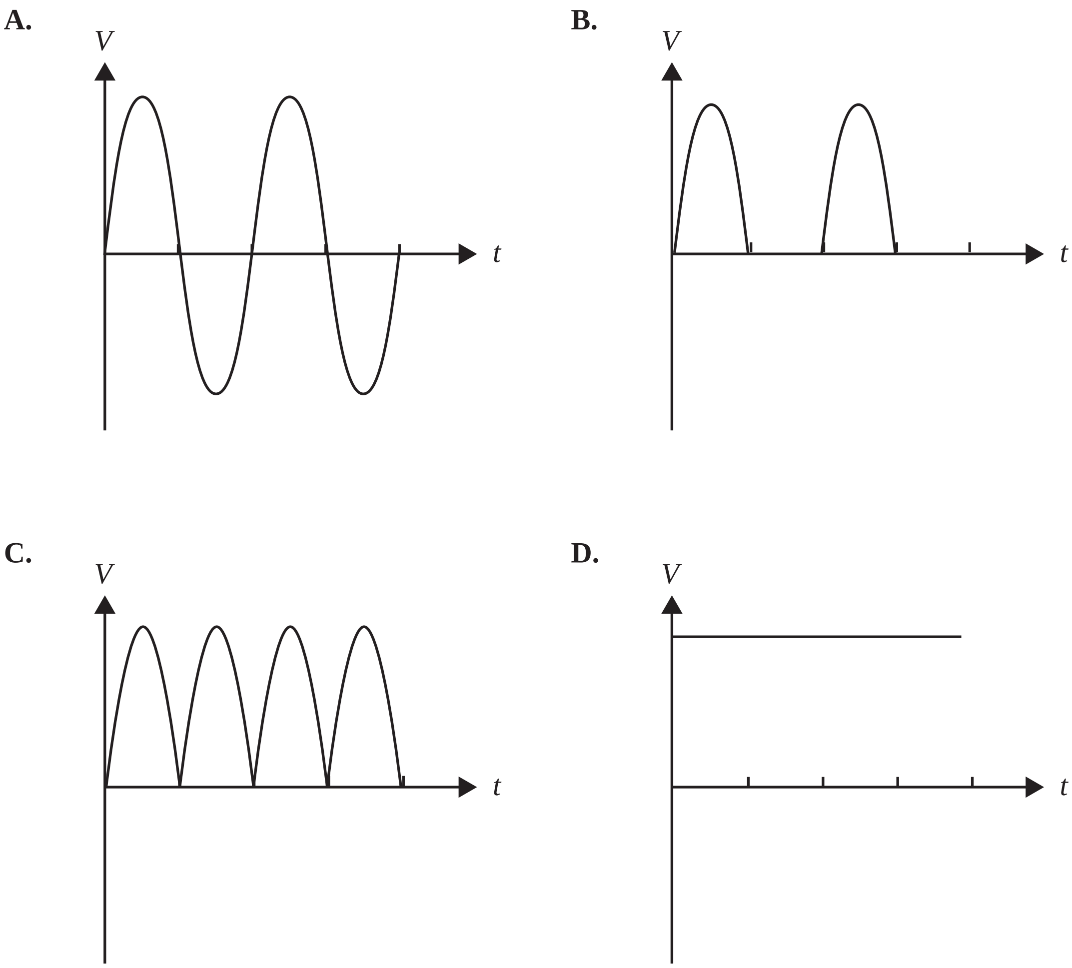


Figure 10

Question 9

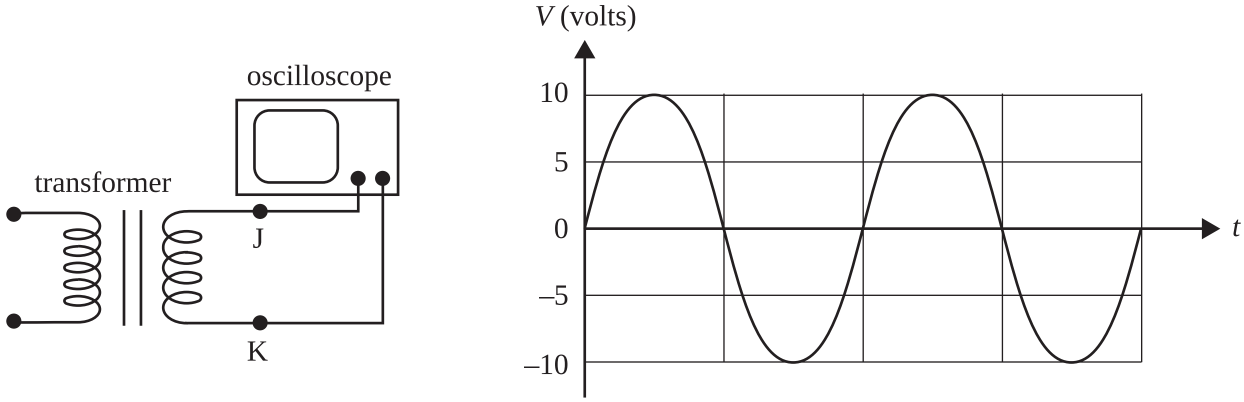


Figure 11

Michael has a transformer connected to an oscilloscope. The circuit and the output of the transformer are shown in Figure 11.

Michael now connects a multimeter set on AC volts across the terminals, JK, of the transformer.

Which one of the following best gives the reading he will observe on the multimeter?

A. 7 V

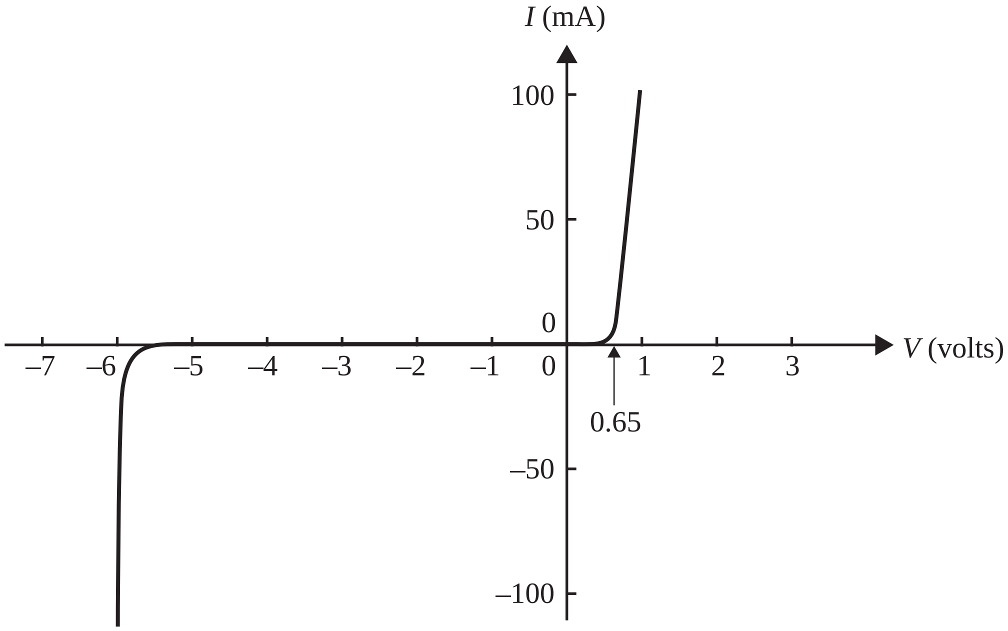
B. 10 V

C. 14 V

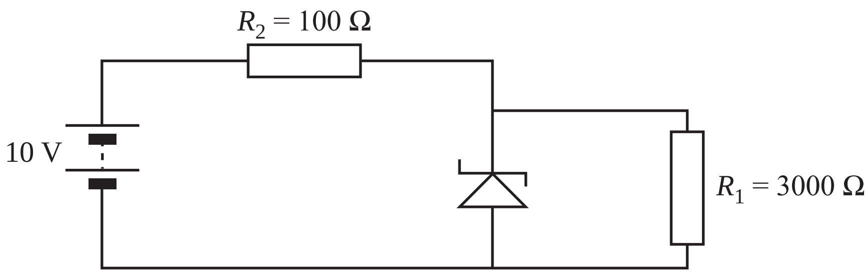
D. 20 V

Use the following information to answer Questions 10 and 11.

John is studying the operation of a Zener diode. The voltage-current characteristics of the Zener diode are shown in the diagram below.



John sets up the circuit shown below.



Question 10

Which one of the following best gives the voltage he will observe across R_2?

A. 0 V

B. 4 V

C. 6 V

D. 10 V

Question 11

Which one of the following best gives the current through the Zener diode?

A. 1 mA

B. 2 mA

C. 38 mA

D. 40 mA

SECTION B

Instructions for Section B

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Detailed study 4 – Synchrotron and its applications

Question 1

Synchrotron radiation is produced when an electron

A. travels close to the speed of light.

B. collides with other electrons.

C. collides with air molecules.

D. changes direction.

Question 2

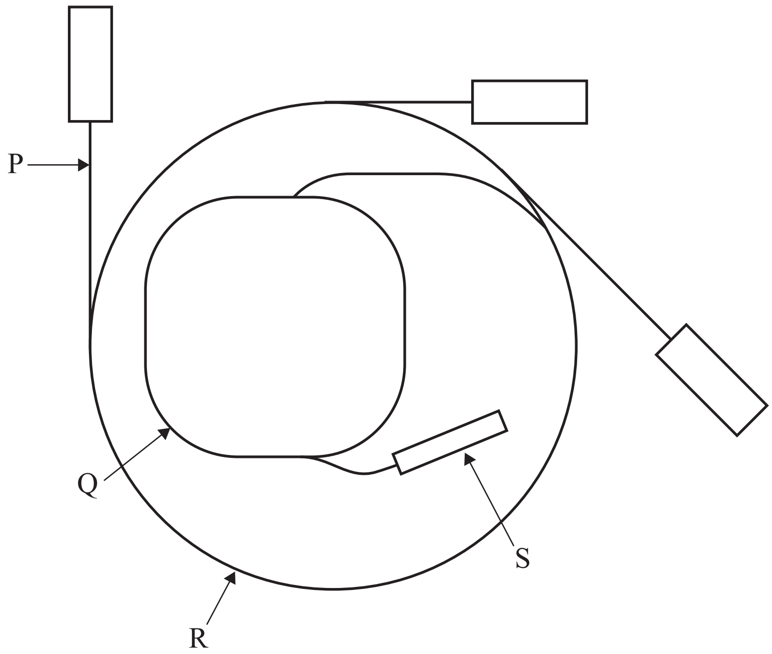

Figure 1

Figure 1 shows a schematic plan of the Australian Synchrotron. The Australian Synchrotron has four main components: beamline, booster ring, linac and storage ring. The arrows P, Q, R, S indicate these components (not in order).

Which option below best indicates to which of the components the arrows P, Q, R, S refer?

	P	Q	R	S
A.	linac	booster ring	storage ring	beamline
B.	linac	storage ring	booster ring	beamline
C.	beamline	booster ring	storage ring	linac
D.	beamline	storage ring	booster ring	linac

Question 3

Which option below best describes a key function of each component?

	Beamline	Booster ring	Linac	Storage ring
A.	photons move through	electrons are accelerated to 0.8*c*	photons are produced	electrons are accelerated to 0.9999*c*
B.	photons move through	electrons are accelerated to 0.9999*c*	electrons are accelerated to 0.8*c*	photons are produced
C.	photons are produced	electrons are accelerated to 0.9999*c*	electrons are accelerated to 0.8*c*	electrons are accelerated to 0.9999*c*
D.	electrons are accelerated to 0.8*c*	electrons are accelerated to 0.9999*c*	photons are produced	photons move through

Question 4

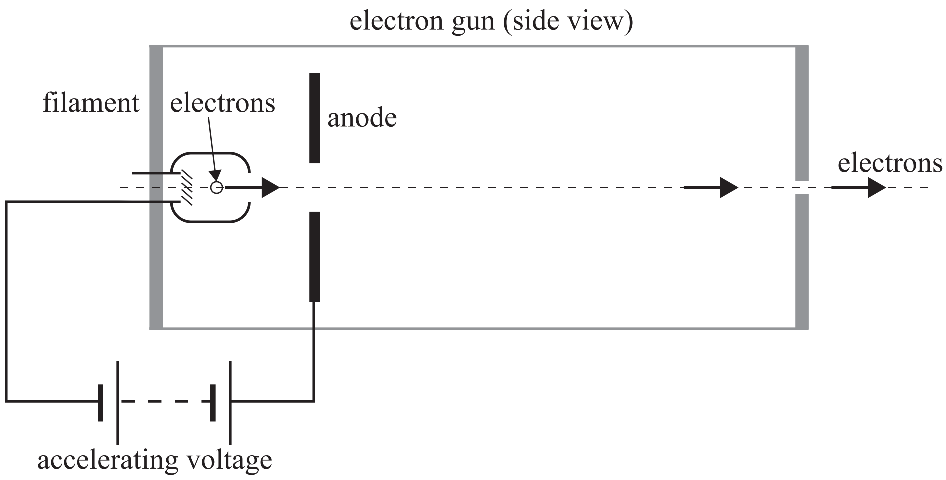

Figure 2

An electron gun is used to inject electrons into the linac of a synchrotron. A schematic diagram of the electron gun is shown in Figure 2. The accelerating voltage of the electron gun is adjusted so that the electrons reach a speed of 4.6×10^7 m s^{-1}.

Which of the following best gives the value of the accelerating voltage?

A. 600 V
B. 2600 V
C. 6000 V
D. 260 000 V

Use the following information to answer Questions 5 and 6.

An electron with a speed of 4.6×10^7 m s^{-1} enters a uniform magnetic field and moves in a circular path. The radius of the path is 0.40 m. This is shown in Figure 3.

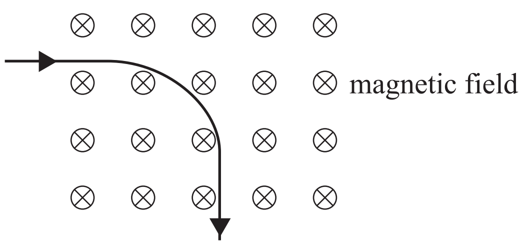

Figure 3

Question 5

Which of the following best gives the magnitude of the magnetic field required to achieve this path?

A. 4.2×10^{-3} T
B. 6.5×10^{-4} T
C. 1.5×10^{3} T
D. 3.0×10^{4} T

Question 6

The magnetic field is now adjusted to 5.0×10^{-4} T.

Which of the following best gives the magnetic force on the electron?

A. 4.80×10^{-17} N

B. 3.68×10^{-15} N

C. 2.40×10^{-14} N

D. 3.68×10^{-7} N

Question 7

In an experiment at the Australian Synchrotron, X-rays from a beamline are directed into a material being tested. The X-rays are scattered by collision with electrons, and are observed coming out at many angles, with the same wavelength as the incident X-rays.

This is an example of

A. Thomson scattering, because the energy of the X-rays is unchanged.

B. Thomson scattering, because the energy of the X-rays has decreased due to losses in collisions.

C. Compton scattering, because the energy of the X-rays is unchanged.

D. Compton scattering, because the energy of the X-rays has decreased due to losses in collisions.

Use the following information to answer Questions 8 and 9.

Synchrotron radiation consists of a range of wavelengths. Using Bragg scattering, a crystal of silicon can be used to select a specific wavelength for use in an experiment. Bragg's law gives the angles at which sharp peaks in the X-ray intensity are produced. Figure 4 shows the experimental arrangement, and the right-hand diagram shows a schematic diagram of a silicon crystal with a crystal-plane separation of 0.314 nm.

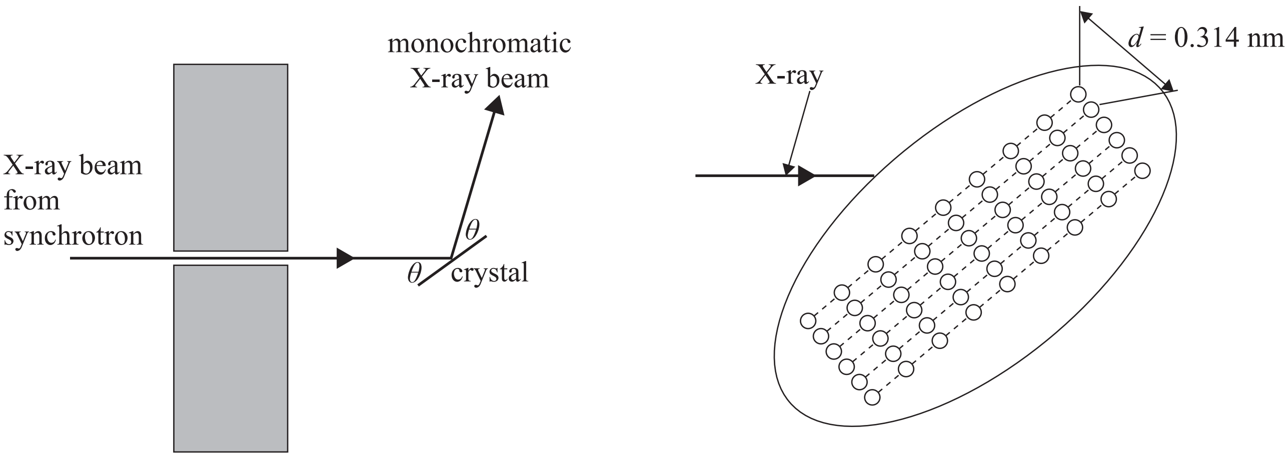

Figure 4

Question 8

To select the wavelength of the X-rays that are diffracted, the angle θ is varied. Consider only first order scattering ($n = 1$) from the planes shown.

Which of the following is closest to the wavelength of X-rays that are diffracted at an angle of 15°?

A. 0.163 nm

B. 0.314 nm

C. 0.408 nm

D. 0.607 nm

Question 9

In another experiment, the same crystal is irradiated with a monochromatic beam of X-rays of wavelength 0.200 nm. The angle of the incident beam on the crystal is varied from 0°–90°.

Consider *only* the peaks caused by scattering from the planes shown in the diagram above (0.314 nm spacing).

How many peaks will be observed?

A. 1

B. 2

C. 3

D. 4

Use the following information to answer Questions 10 and 11.

Undulators are insertion devices for synchrotrons. They consist of two rows of magnets with alternating north and south poles, as shown in the diagram below. A beam of electrons enters the undulator from the left, as shown in Figure 5.

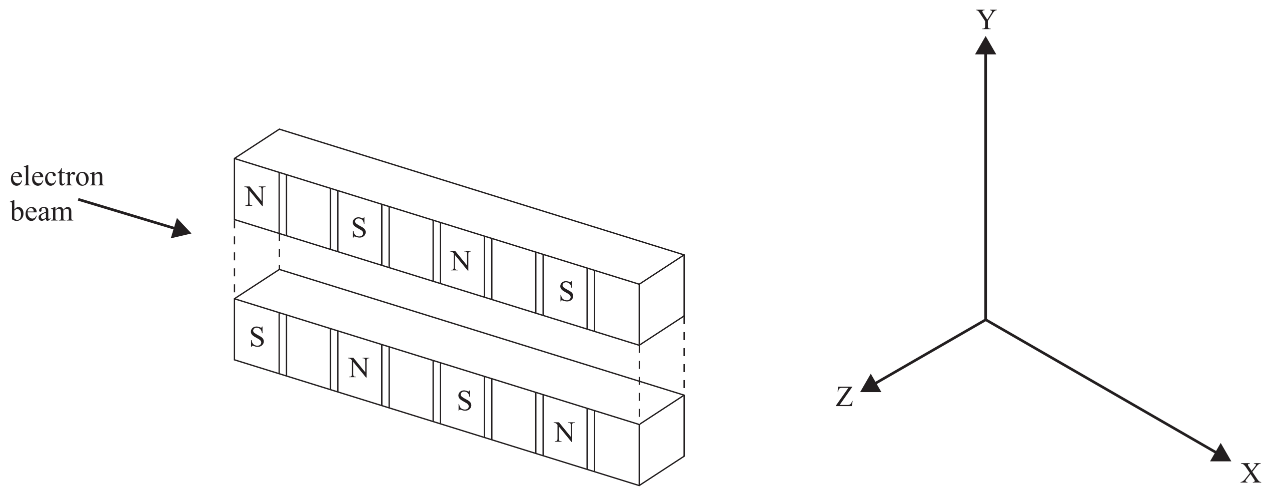

Figure 5

Question 10

Which statement best describes the path of the electrons?

A. The electrons continue to move in the X direction with a side-to-side movement in the Y direction.

B. The electrons continue to move in the X direction with a side-to-side movement in the Z direction.

C. The electrons move in a spiral around the X direction.

D. The electrons accelerate in the X direction.

Question 11

Where are undulators inserted in the Australian Synchrotron?

A. linac

B. beamline

C. booster ring

D. storage ring

End of Detailed study 4
SECTION B – continued
TURN OVER

SECTION B

Instructions for Section B

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Detailed study 5 – Photonics

Question 1

Which one of the following contains only sources that produce predominantly incoherent light?

A. incandescent globe, fluorescent tube, laser

B. laser, fluorescent tube, sun

C. sun, candle, incandescent globe

D. sun, candle, laser

Use the following information to answer Questions 2–4.

The characteristics of a red light-emitting diode (LED) are shown in Figure 1.

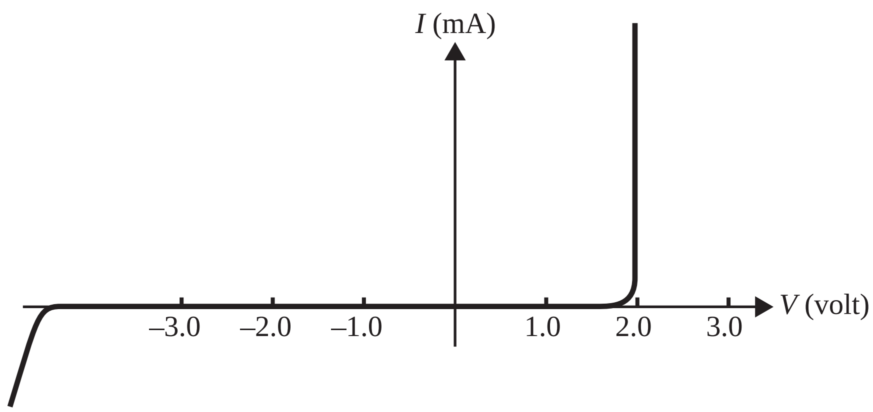

Figure 1

Question 2

Which of the following best gives the average wavelength of the light from this LED?

A. 9.94×10^{-17} nm

B. 62 nm

C. 621 nm

D. 994 nm

A student sets up the following circuit to test this LED, as shown in Figure 2. The (ideal) battery has a voltage of 12 V and the resistor has a resistance of 400 Ω.

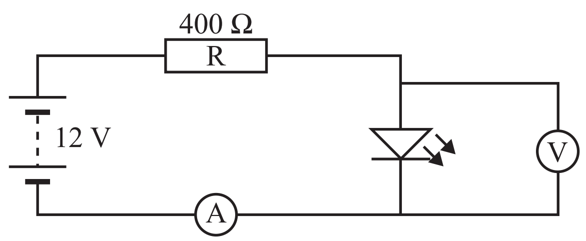

Figure 2

Question 3

Which of the following best gives the current through the ammeter?

A. 5 mA

B. 25 mA

C. 30 mA

D. 60 mA

Question 4

The red LED is replaced by a blue LED, using the same circuit.

Which of the following statements best describes the effect on the circuit?

A. The blue LED emits light, and the current through it is greater than the current through the red LED.

B. The blue LED emits light, and the current through it is the same as the current through the red LED.

C. The blue LED emits light, and the current through it is less than the current through the red LED.

D. The blue LED does not emit light, and the current through it is less than the current through the red LED.

Question 5

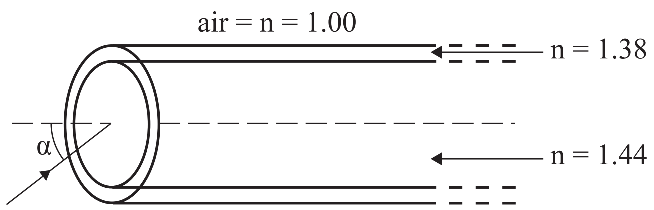

Figure 3

Figure 3 shows a step-index fibre-optic waveguide. The outer cladding has a refractive index of 1.38, and the inner core has a refractive index of 1.44.

Which of the following best gives the value of the critical angle for total internal reflection between the core and cladding?

A. 17°

B. 44°

C. 46°

D. 73°

Question 6

Which of the following best explains the cause of Rayleigh scattering in an optical fibre?

A. excessively sharp bending of the optical fibre

B. absorption at the interface of the core and cladding

C. small variations in density in the core of an optical fibre

D. refractive index of the cladding being too similar to the refractive index of the core

Use the following information to answer Questions 7 and 8.

Students are using a length of *flexible* plastic rod to investigate transmission of laser light through a fibre-optic waveguide. The plastic material has a refractive index of 1.20. The refractive index of air is 1.00. The situation is shown in Figure 4.

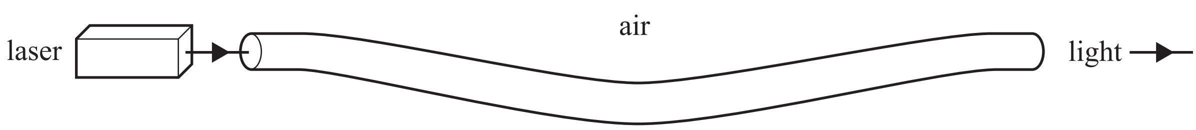

Figure 4

The students bend the rod more as shown in Figure 5.

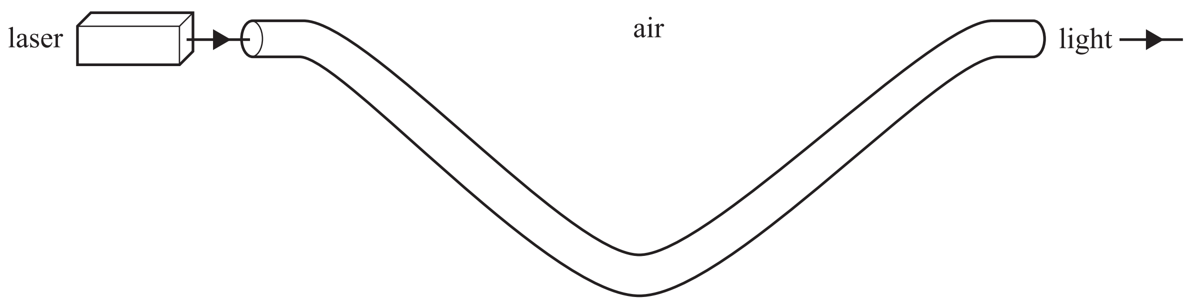

Figure 5

They find that the intensity of light emerging from the rod decreases significantly.

Question 7

Which of the following statements is the most likely explanation for this?

A. Material dispersion has caused this decrease.

B. The angle of incidence of the light ray on the side of the rod at some point has now become less than the critical angle for plastic to air.

C. The angle of incidence of the light ray on the side of the rod at some point has now become greater than the critical angle for plastic to air.

D. Modal dispersion has caused this decrease.

The bending of the plastic rod is now **reduced** back to the situation shown in Figure 4.

The students now immerse the plastic rod in water (refractive index 1.33), as shown in Figure 6.

This action results in the intensity of the light emerging from the rod once again decreasing significantly. The refractive index of water is 1.33.

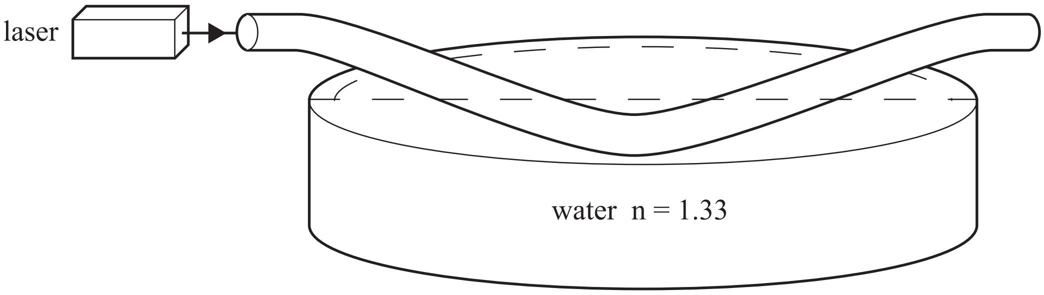

Figure 6

Question 8

Which of the following statements is the most likely explanation for this?

A. The critical angle for total internal reflection has increased.

B. Modal dispersion has reduced the light intensity reaching the end of the rod.

C. Total internal reflection cannot now occur.

D. Material dispersion has reduced the light intensity reaching the end of the rod.

Use the following information to answer Questions 9 and 10.

The graph in Figure 7 shows the attenuation (optical loss) for a particular material used in fibre-optic waveguides.

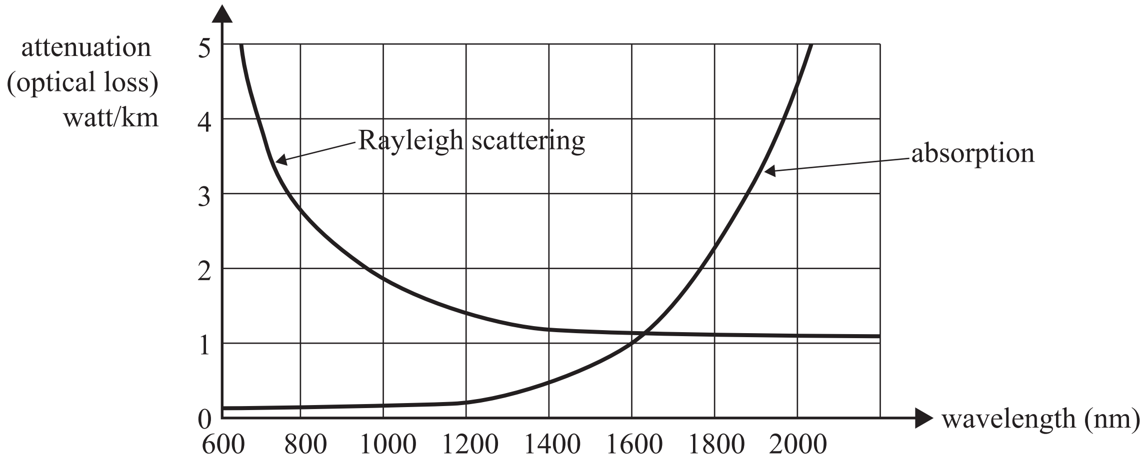

Figure 7

An infrared laser of wavelength 2000 nm is used.

Question 9

Which of the following would be the major cause of attenuation in the waveguide?

A. modal dispersion

B. material dispersion

C. Rayleigh scattering

D. absorption by material

A long-distance data link using this particular material is being planned. The designers wish to select the best wavelength to reduce signal loss in the system.

Question 10

Which of the following wavelengths will give the least signal loss?

A. 600 nm

B. 1000 nm

C. 1200 nm

D. 1600 nm

Question 11

Graded-index fibres, even though they are more expensive, are sometimes used in place of step-index fibres in optical transmission systems.

Graded-index fibres are used because they best reduce

A. material dispersion.

B. modal dispersion.

C. Rayleigh scattering.

D. attenuation due to absorption.

SECTION B

Instructions for Section B

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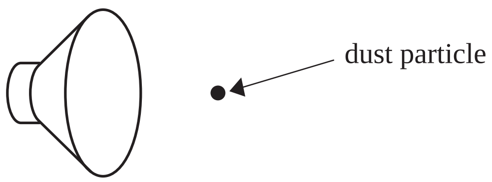
Detailed study 6 – Sound

Use the following information to answer Questions 1 and 2.

A particle of dust is floating at rest 10 cm directly in front of a loudspeaker. The loudspeaker is not operating. The loudspeaker then emits sound of frequency 10 Hz and with a speed of 330 m s^{-1}.



Question 1

Which one of the following statements best describes the motion of the dust particle?

A. It vibrates vertically up and down at 10 Hz remaining (on average) 10 cm in front of the loudspeaker.

B. It vibrates horizontally backwards and forwards at 10 Hz remaining (on average) 10 cm in front of the loudspeaker.

C. It travels away from the loudspeaker at 330 m s^{-1} while moving horizontally backwards and forwards at 10 Hz.

D. It remains at rest.

The loudspeaker now emits a sound of frequency 220 Hz.

Question 2

Which one of the following best gives the wavelength of sound from the loudspeaker?

A. 0.67 m

B. 1.5 m

C. 220 m

D. 7.3×10^4 m

Use the following information to answer Questions 3 and 4.

A siren emits a 3000 Hz sound uniformly in all directions. 20 m from the siren, the sound intensity is measured to be 1.7×10^{-3} W m^{-2}.

Question 3

Which one of the following best gives the sound intensity level (in dB) at this point?

A. 1.0×10^{-3} dB

B. 9.2 dB

C. 92 dB

D. 117 dB

Question 4

Which one of the following best gives the measured sound intensity (in W m^{-2}) 60 m from the siren?

A. 1.7×10^{-3} W m^{-2}

B. 1.9×10^{-4} W m^{-2}

C. 5.7×10^{-4} W m^{-2}

D. 5.1×10^{-3} W m^{-2}

Use the following information to answer Questions 5 and 6.

The graph in Figure 1 shows the relationship between sound intensity level (dB) and loudness (phon).

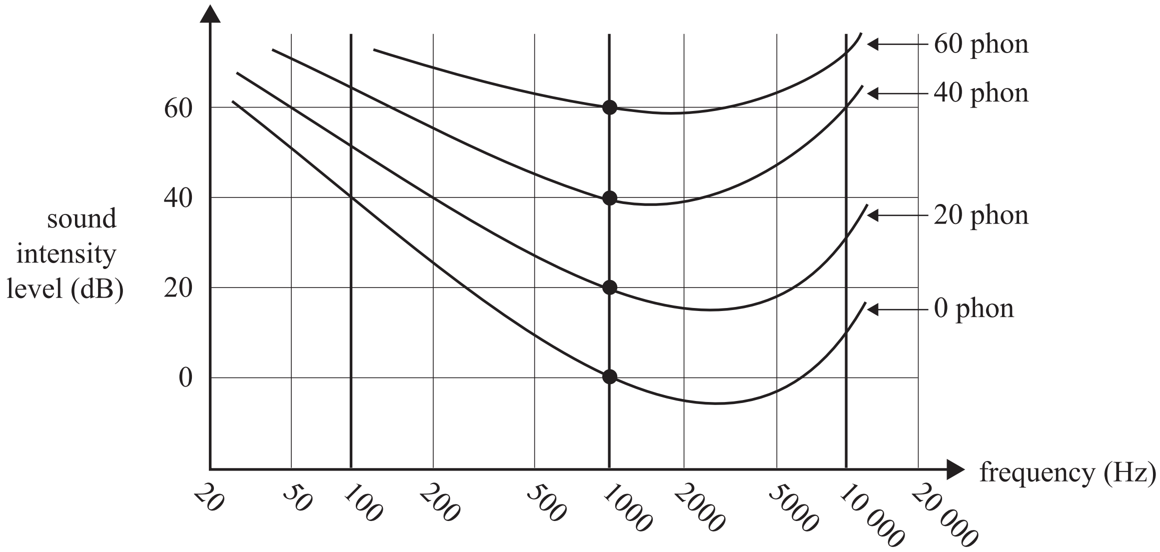


Figure 1

The sound intensity level (dB) of a note of 10 000 Hz is measured by a sound level meter to be 60 dB.

Question 5

Which one of the values below best gives the loudness in phon at this point?

A. 20 phon
B. 40 phon
C. 60 phon
D. 80 phon

Question 6

The loudness scale (phon) specifically takes account of which one of the following factors?

A. Intensity of sound, as perceived by human hearing, is inversely proportional to distance from the source.
B. The perception of sound by human hearing is logarithmic, rather than linear, compared to sound intensity.
C. The perception of the intensity of sound by human hearing varies with frequency.
D. Human hearing has a very limited range of frequencies.

Use the following information to answer Questions 7–10.

Roger is constructing and testing pipes for a pipe organ. The pipes are uniform tubes open at one end and closed at the other.

The speed of sound in air at the time of the test is 333 m s^{-1}. One pipe resonates at a fundamental frequency of 256 Hz.

Question 7

Which one of the following best gives the length of the pipe corresponding to this 256 Hz fundamental frequency?

A. 0.33 m
B. 0.65 m
C. 1.3 m
D. 2.6 m

Roger tests the pipe by placing a loudspeaker attached to an audio signal generator at one end of the pipe. He gradually increases the frequency.

He finds that, in addition to the fundamental frequency resonance at 256 Hz, there is a higher resonance (the third harmonic) at another frequency.

Question 8

At which one of the following frequencies will this third harmonic be observed?

A. 128 Hz
B. 512 Hz
C. 768 Hz
D. 1024 Hz

Question 9

Which one of the following best describes how Roger was able to identify the third harmonic?

A. At the frequency of the third harmonic a standing wave is set up in the tube. This absorbs sound energy, and the volume heard by Roger decreases.
B. At the frequency of this third harmonic the first harmonic is also heard, so when Roger hears this as well, he knows that the generator is at the third harmonic.
C. At the frequency of this third harmonic a standing wave is set up in the tube. This causes the volume heard by Roger to increase.
D. At the frequency of this third harmonic the fidelity of the note changes, and Roger is able to identify this.

Roger is later designing a different pipe, open at **both** ends, to give a fundamental frequency resonance with a wavelength of 0.325 m.

Question 10

Which one of the following lengths should Roger make the pipe?

A. 0.163 m
B. 0.325 m
C. 0.650 m
D. 1.30 m

Question 11

Two sound engineers are testing the acoustics of an outdoor performance area. The area consists of a covered stage and an open-air seating area, as shown in Figure 2. The stage opening is 4.0 m wide.

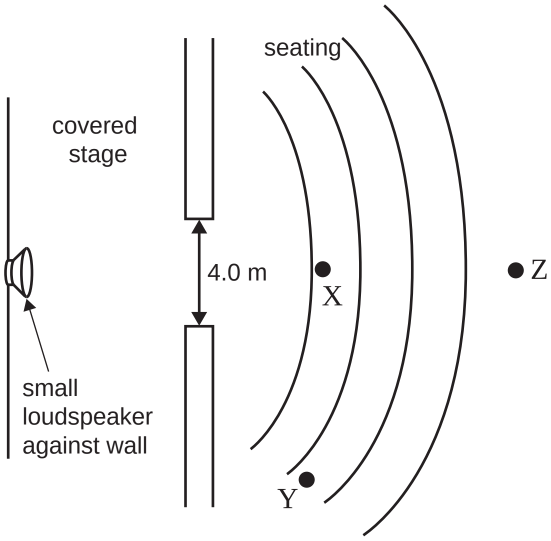


Figure 2

The sound engineers measure the sound intensity level of 200 Hz and 5000 Hz signals in turn at point Z, and find that the levels are the same. At the point Y, however, they are significantly different. Point Z and point Y are the same distance from the stage opening.

Which of the following statements best describes this difference?

A. The intensity of the 5000 Hz sound at point Y is likely to be much softer than its intensity at the point Z.

B. The intensity of the 200 Hz sound at point Y is likely to be much softer than at the point Z.

C. Both the 200 Hz and 5000 Hz sounds will be of similar intensities at the points Z and Y.

D. The 5000 Hz sound will always be louder than the 200 Hz sound at the point Y.

END OF QUESTION AND ANSWER BOOK

Answers to multiple-choice questions

Detailed study 1 – Einstein's special relativity

Question	1	2	3	4	5	6	7	8	9	10	11
Answer	C	A	C	B	B	B	A	D	B	B	A

Detailed study 2 – Materials and their use in structures

Question	1	2	3	4	5	6	7	8	9	10	11
Answer	D	D	A	D	D	B	B	D	D	C	C

Detailed study 3 – Further electronics

Question	1	2	3	4	5	6	7	8	9	10	11
Answer	D	A	B	C	A	C	C	C	A	B	C

Detailed study 4 – Synchrotron and its applications

Question	1	2	3	4	5	6	7	8	9	10	11
Answer	D	C	B	C	B	B	A	A	C	B	D

Detailed study 5 – Photonics

Question	1	2	3	4	5	6	7	8	9	10	11
Answer	C	C	B	C	D	C	B	C	D	C	B

Detailed study 6 – Sound

Question	1	2	3	4	5	6	7	8	9	10	11
Answer	B	B	C	B	B	C	A	C	C	A	A

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
Year

PHYSICS

Written examination

Day Date
Reading time: *. ** to *.** ** (15 minutes)**
Writing time: *. ** to *.** ** (2 hours 30 minutes)**

FORMULA SHEET

Directions to students

- A question and answer book is provided with this formula sheet.

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

1	velocity; acceleration	$v = \frac{\Delta x}{\Delta t}; \quad a = \frac{\Delta v}{\Delta t}$
2	equations for constant acceleration	$v = u + at$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2ax$ $x = \frac{1}{2}(v+u)t$
3	Newton’s second law	$\Sigma F = ma$
4	circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
5	Hooke’s law	$F = -kx$
6	elastic potential energy	$\frac{1}{2}kx^2$
7	gravitational potential energy near the surface of Earth	mgh
8	kinetic energy	$\frac{1}{2}mv^2$
9	Newton’s law of universal gravitation	$F = G\frac{M_1 M_2}{r^2}$
10	gravitational field	$g = G\frac{M}{r^2}$
11	acceleration due to gravity at Earth’s surface	$g = 10 \text{ m s}^{-2}$
12	voltage; power	$V = RI \qquad P = VI = I^2R$
13	resistors in series	$R_T = R_1 + R_2$
14	resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
15	transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2}$
16	AC voltage and current	$V_{RMS} = \frac{1}{\sqrt{2}}V_{peak} \qquad I_{RMS} = \frac{1}{\sqrt{2}}I_{peak}$
17	magnetic force	$F = I\,l\,B$

18	electromagnetic induction	emf : $\varepsilon = -N\dfrac{\Delta\Phi}{\Delta t}$ flux: $\Phi = BA$
19	transmission losses	$V_{drop} = I_{line} R_{line}$ $P_{loss} = I^2_{line} R_{line}$
20	mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
21	charge on the electron	$e = -1.6 \times 10^{-19}$ C
22	Planck's constant	$h = 6.63 \times 10^{-34}$ J s $h = 4.14 \times 10^{-15}$ eV s
23	speed of light	$c = 3.0 \times 10^8$ m s^{-1}
24	photoelectric effect	$E_{K\,max} = hf - W$
25	photon energy	$E = hf$
26	photon momentum	$p = \dfrac{h}{\lambda}$
27	de Broglie wavelength	$\lambda = \dfrac{h}{p}$
28	speed, frequency and wavelength	$v = f\lambda$
29	energy transformations for electrons in an electron gun (<100 keV)	$\frac{1}{2}mv^2 = eV$
30	radius of electron path	$r = \dfrac{mV}{eB}$
31	magnetic force on a moving electron	$F = evB$
32	Bragg's law	$n\lambda = 2d\sin\theta$
33	electric field between charged plates	$E = \dfrac{V}{d}$
34	band gap energy	$E = \dfrac{hc}{\lambda}$
35	Snell's law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
36	intensity and level	sound intensity level (in dB) $\mathrm{L} = 10\log_{10}\left(\dfrac{I}{I_0}\right)$ where $I_0 = 1.0 \times 10^{-12}$ W m^{-2}

37	Lorentz factor	$\gamma = \dfrac{1}{\sqrt{1-\dfrac{v^2}{c^2}}}$
38	time dilation	$t = t_o\gamma$
39	length contraction	$L = \dfrac{L_o}{\gamma}$
40	relativistic mass	$m = m_o\gamma$
41	total energy	$E_{total} = E_k + E_{rest} = mc^2$
42	stress	$\sigma = \dfrac{F}{A}$
43	strain	$\varepsilon = \dfrac{\Delta L}{L}$
44	Young's modulus	$E = \dfrac{\text{stress}}{\text{strain}}$
45	capacitors	time constant : $\tau = \mathrm{RC}$
46	universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
47	mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
48	radius of Earth	$R_E = 6.37 \times 10^6$ m
49	mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
50	charge on the electron	$e = -1.6 \times 10^{-19}$ C
51	speed of light	$c = 3.0 \times 10^8$ m s^{-1}

Prefixes/Units

p = pico = 10^{-12}

n = nano = 10^{-9}

μ = micro = 10^{-6}

m = milli = 10^{-3}

k = kilo = 10^3

M = mega = 10^6

G = giga = 10^9

t = tonne = 10^3 kg

END OF FORMULA SHEET