VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

# Victorian Certificate of Education 2009

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Figures | | | | | | | | | Letter |
| Words | | | | | | | | | |

# PHYSICS

## Written examination 2

### Wednesday 11 November 2009

**Reading time: 11.45 am to 12.00 noon (15 minutes)**
**Writing time: 12.00 noon to 1.30 pm (1 hour 30 minutes)**

## QUESTION AND ANSWER BOOK

**Structure of book**

| *Section* | *Number of questions* | *Number of questions to be answered* | *Number of marks* |
|---|---|---|---|
| **A – Core – Areas of study** | | | |
| 1. Electric power | 16 | 16 | 35 |
| 2. Interactions of light and matter | 12 | 12 | 29 |
| **B – Detailed studies** | | | |
| 1. Synchrotron and its applications | 13 | 13 | 26 |
| **OR** | | | |
| 2. Photonics | 13 | 13 | 26 |
| **OR** | | | |
| 3. Sound | 13 | 13 | 26 |
| | | | Total 90 |

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) 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 39 pages. The question and answer book has a detachable formula sheet in the centrefold.
- Answer sheet for multiple-choice questions.

**Instructions**
- Detach the formula sheet from the centre of this book during reading time.
- 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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## SECTION A – Core

### Instructions for Section A

Answer **all** questions **for both** Areas of study in this section in the spaces provided.
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.

**Areas of study** **Page**

## Area of study 1 – Electric power

*The following information relates to Questions 1–3.*

Emily and Gerry are studying generators and alternators. They have constructed the device shown in Figure 1.

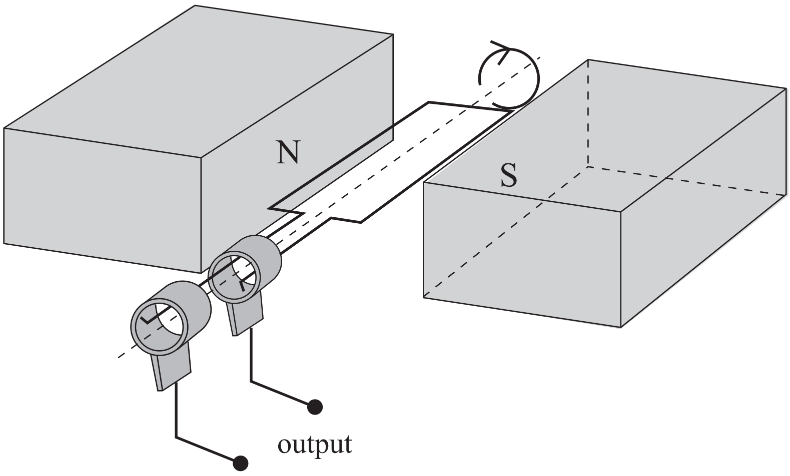


**Figure 1**

**Question 1**

Indicate, with an explanation, whether this device is a DC generator or an AC generator (alternator).

2 marks

The coil is a single rectangular loop of effective area $9.0 \times 10^{-4}$ m$^2$. The coil can be rotated about an axis as shown, in a uniform magnetic field, **B**, larger in area than the coil.

**Question 2**

The maximum magnetic flux that passes through the coil is $7.2 \times 10^{-6}$ Wb.
What is the magnitude of the uniform magnetic field?

T

2 marks

In an interval of 0.020 s the coil is rotated by one quarter turn (90°) from the orientation shown in Figure 1.

**Question 3**

What is the magnitude of the **average** voltage generated?

V

3 marks

**Question 4**

A coil of wire is placed around an iron bar. The coil is connected to a DC battery.

This is shown in Figure 2.

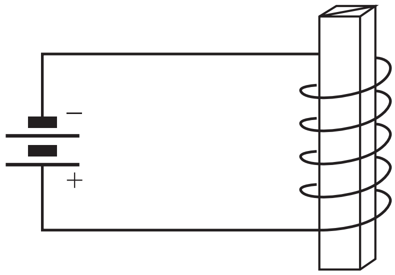


**Figure 2**

On the diagram in Figure 2, draw **four** lines, each with an arrow indicating direction, that show the magnetic field in the region around the iron bar.

2 marks

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*The following information relates to Questions 5–8.*

Figure 3 below shows a diagram of a simple DC motor. The single square loop coil **TUVW**, of side 0.0090 m, is free to rotate about the axis XY. Current is supplied from a battery via the split-ring commutator.

The two permanent magnets provide a uniform magnetic field **B** of magnitude 0.25 T in the region of the coil.

The current flowing in the coil is 2.0 amp.

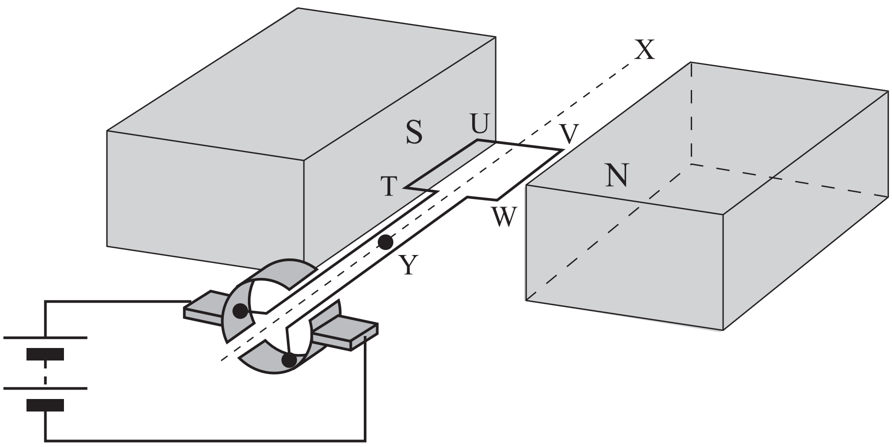



**Figure 3**

**Question 5**

Indicate with an arrow the direction of the force on side **TU** of the coil in Figure 3.

2 marks

**Question 6**

Calculate the magnitude of the force on the side **TU** of the coil. Show your working.

N

2 marks

**Question 7**

What is the magnitude of the force acting on side **UV** of the coil when in the position shown in Figure 3?

N

2 marks

**Question 8**

Explain the purpose of the split-ring commutator.

3 marks

*The following information relates to Questions 9–15.*

A diesel-powered portable DC generator is used to power lights on a light tower at an isolated football ground. The generator produces a constant 500 V DC. The generator is approximately 500 m from the light tower, and a two wire transmission line connects the generator to the lights. **Each** of the wires in the transmission lines has a resistance of 5.00 Ω. Ignore the resistance of the other connecting wires.

The system is shown in Figure 4.

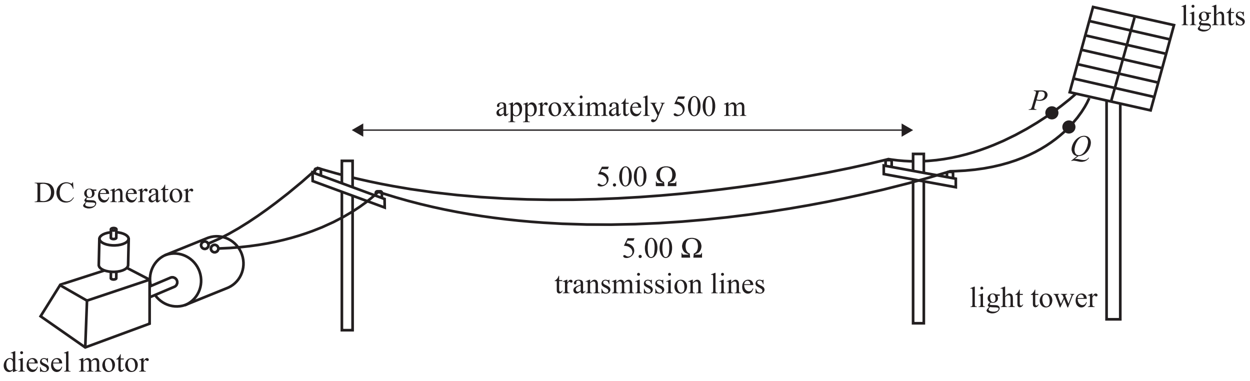



**Figure 4**

With the lights on, the generator has an output of 20.0 A.

**Question 9**

What is the power output of the generator?

| W |
|---|

2 marks

**Question 10**

What is the **total** power loss in the transmission lines?

| W |
|---|

2 marks

**Question 11**

What is the voltage (potential difference) across the terminals (*PQ*) of the light tower?

| V |
|---|

3 marks

The players find the lights too dim. They call in an electrician.

She suggests the following.

- retain the diesel motor
- replace the DC generator with an AC alternator producing 500 $V_{RMS}$
- insert a 1:10 step-up transformer between the alternator and the power lines, and a 10:1 step-down transformer between the power lines and the light tower

The transformers can be considered ideal.

The arrangement is shown in Figure 5.

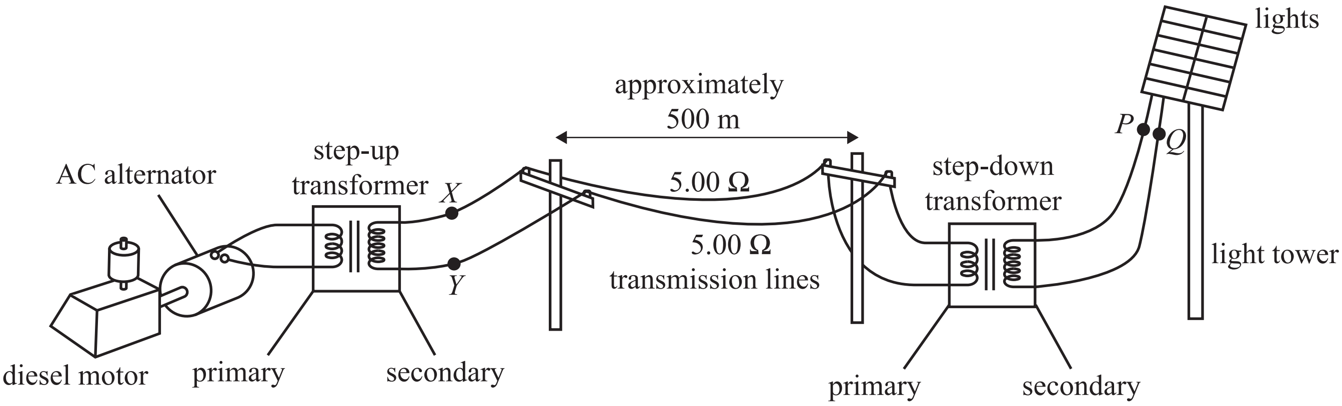



**Figure 5**

The lights are on.

The resistance of each wire in the transmission lines is still 5.00 Ω. Ignore the resistance of the other connecting wires.

The output of the alternator is 20.0 $A_{RMS}$.

(The generator output was 20.0 A DC.)

**Question 12**

What will the RMS voltage (potential difference) now be at the input to the transmission lines (at point *XY*) at the alternator end?

| V |
|---|

2 marks

**Question 13**

The primary of the step-down transformer has 4800 turns. How many turns are in the secondary winding?

1 mark

**Question 14**

What will be the power loss in the transmission lines now?

W

2 marks

**Question 15**

What will be the voltage at the output of the step-down transformer? Give your answer correct to three significant figures.

V

3 marks

**Question 16**

An AC alternator is rotating at a steady 50 revolutions per second. The output voltage, as measured on an oscilloscope, is shown below in Figure 6.

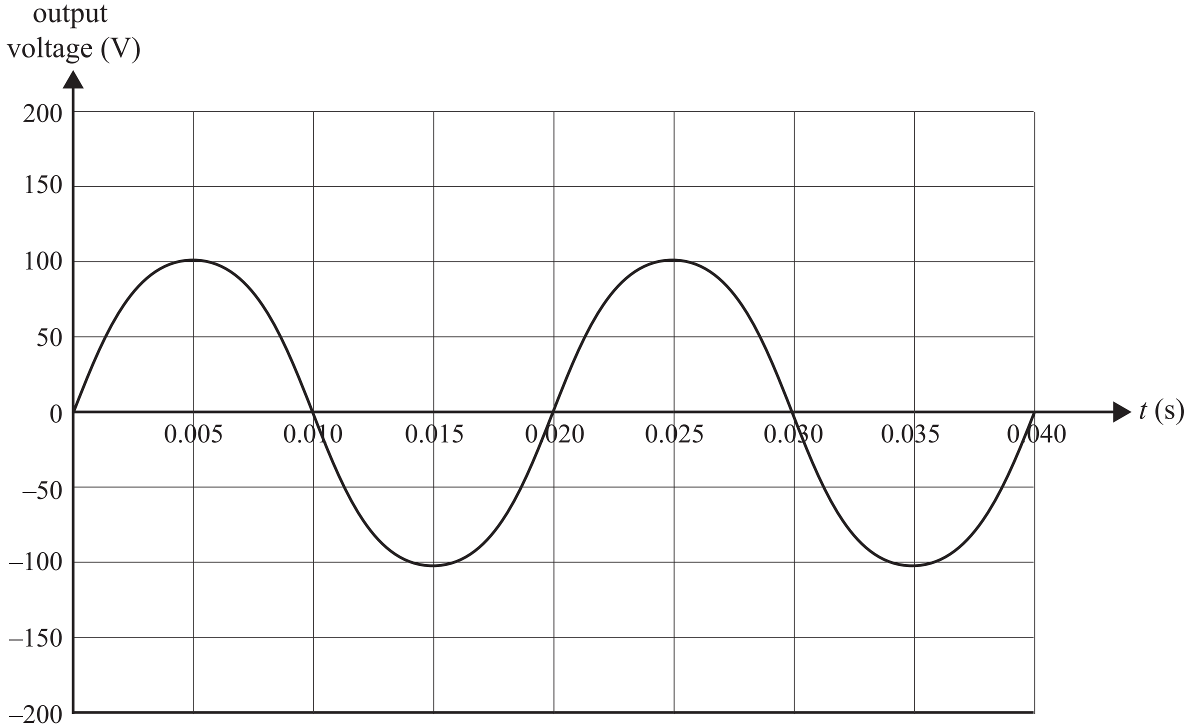
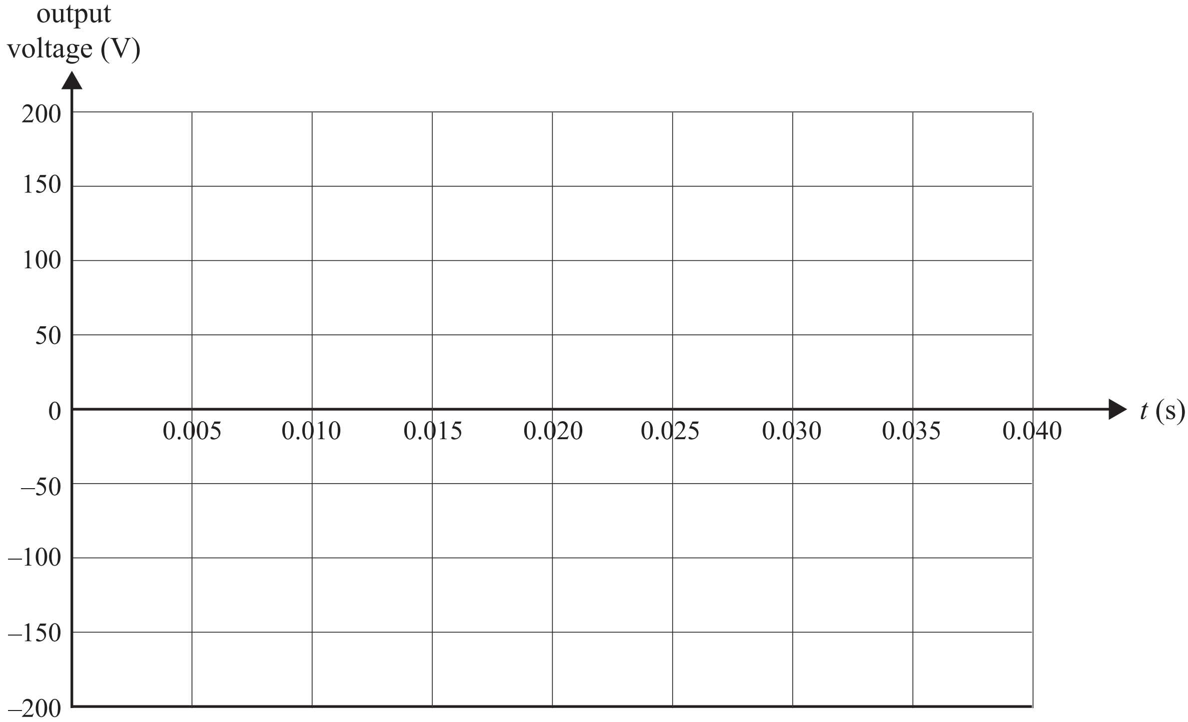



**Figure 6**

The rate of rotation of the alternator is now reduced to 25 revolutions per second.

On the axes provided below, sketch how the output will now appear.




2 marks

**END OF AREA OF STUDY 1**

## Area of study 2 – Interactions of light and matter

**Question 1**

At the time of Young's double-slit experiment there were two competing models of the nature of light.

Explain how Young's experiment supported one of these models compared with the other.

3 marks

**Question 2**

Einstein's explanation of the photoelectric effect reopened the question about the nature of light.

Explain briefly how the results of the photoelectric effect experiment supported a competing model to the one supported by Young's experiment.

3 marks

*The following information relates to Questions 3 and 4.*

Louise and Thelma set up the apparatus shown in Figure 1. It consists of a laser providing light of a single wavelength, which passes through two narrow slits and produces a pattern of bright and dark bands on a screen some distance away.

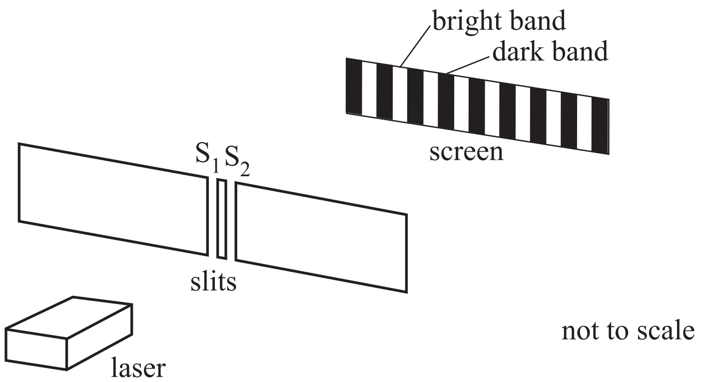



**Figure 1**

**Question 3**

Before doing the experiment, Louise believes that the central band (the one exactly opposite the centre point between the two slits) is a dark band. Thelma believes that this is a bright band.

Who is correct? Outline your reasoning clearly.

3 marks

**Question 4**

The pattern of bright and dark bands is shown in Figure 2 below.


**Figure 2**

Precision measurement shows that the **path difference** to the middle of dark band **A** (that is, the distance $AS_2 – AS_1$) is greater than the path difference to the middle of dark band **B** by 496 nm. From this information, determine the wavelength of the laser. You may include a diagram.

nm

2 marks

*The following information relates to Questions 5–7.*

The photoelectric effect occurs when photons falling on a metal surface cause the emission of electrons. Einstein's equation for the photoelectric effect can be written as follows.

$$E_{K\,max} = hf - W$$

Kristy and Adrian have set up an experiment to study the energy of photoelectrons emitted from a potassium plate. Their apparatus consists of

- a light source
- a set of filters, each of which allows through only one wavelength
- an evacuated tube containing a potassium plate onto which the light falls, and a collector electrode.

A variable DC source allows a voltage (stopping voltage) to be applied between the potassium plate and the collector electrode. A voltmeter ($V_s$) measures this voltage, and a microammeter (A) reads the current.

Their apparatus is shown in Figure 3.

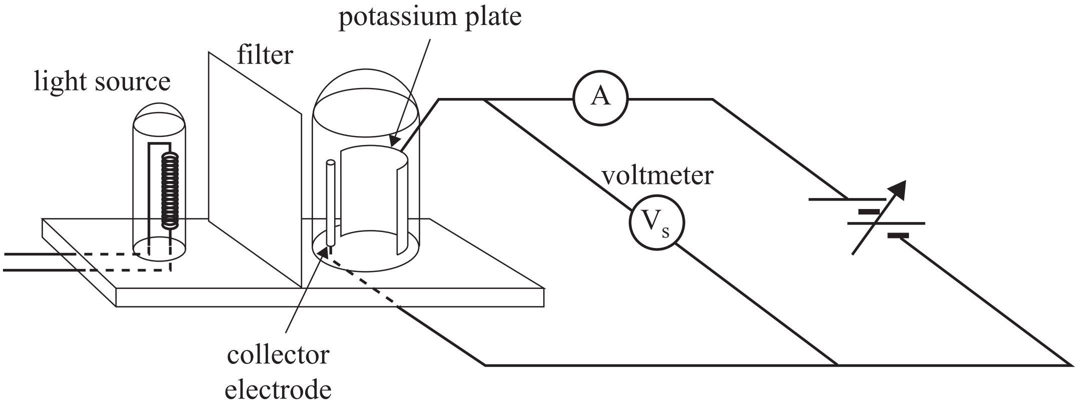



**Figure 3**

**Question 5**

Explain **in words** the physical meaning of the terms $E_{K\,max}$, $f$, and $W$ in the equation above. Your explanation must show how each term relates to the experiment in Figure 3.

$E_{K\,max}$

$f$

***W***

3 marks

The graph in Figure 4 shows the stopping voltage as a function of the frequency.

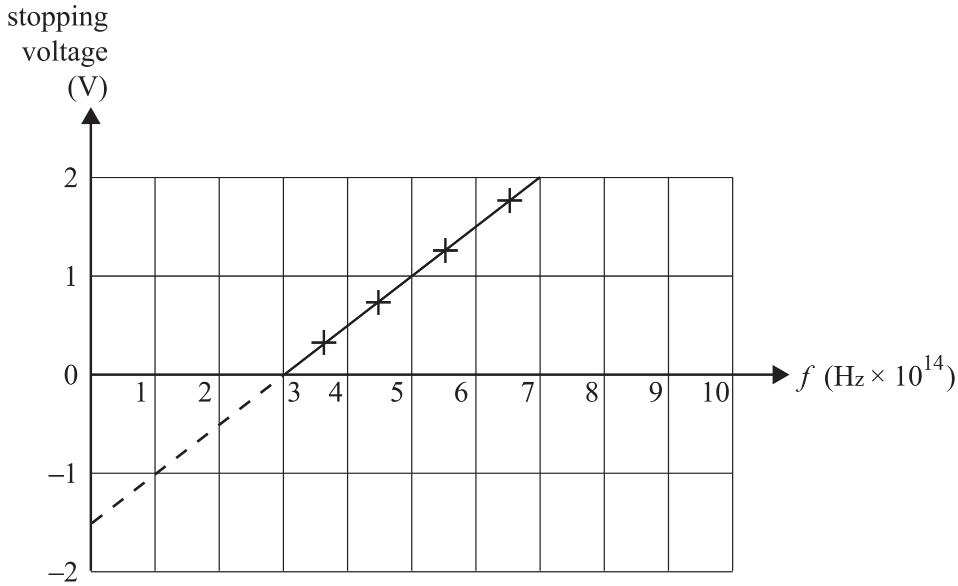



**Figure 4**

**Question 6**

**From the data on the graph** (Figure 4), determine the values Kristy and Adrian would obtain for Planck's constant, $h$, and the work function of the metal. Show your working.

Planck's constant

| |
|---|
| eV s |

Work function

| |
|---|
| eV |

3 marks

**Question 7**

With the filter for a particular frequency ($8.0 \times 10^{14}$ Hz), Kristy and Adrian now double the intensity of the light from the light source.

State what effect this will have on

i. the maximum kinetic energy of the emitted electrons

ii. the number of electrons emitted per second as indicated by the microammeter.

2 marks

A source is designed to produce X-rays with a wavelength of $1.4 \times 10^{-10}$ m.

**Question 8**

What is the energy, in units of eV (electron-volt), of one photon of these X-rays?

eV

2 marks

**Question 9**

What is the momentum of one of these X-ray photons?

kg m $s^{-1}$

2 marks

*The following information relates to Questions 10 and 11.*

Figure 5 shows the energy level diagram of an atom.

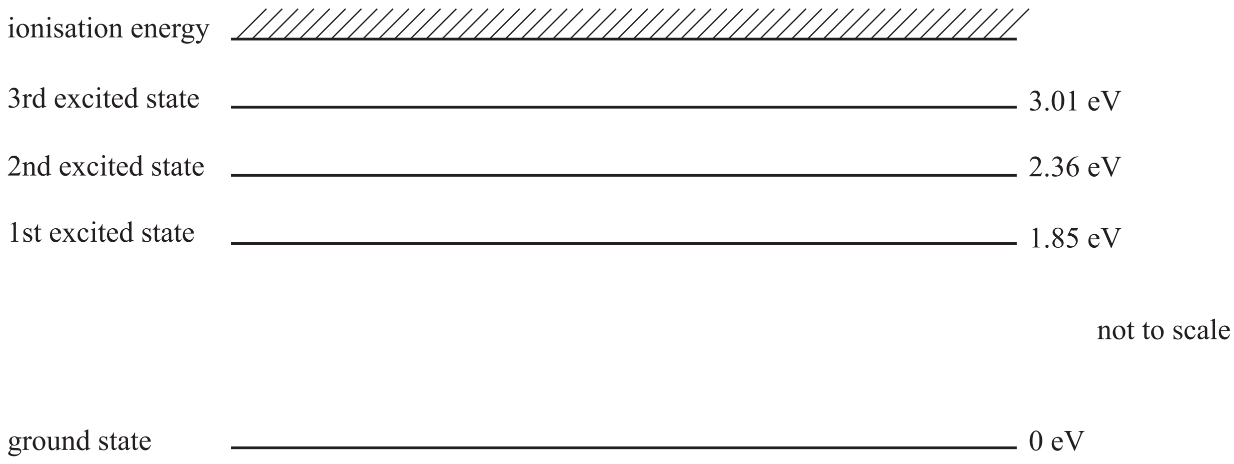



**Figure 5**

**Question 10**

When an atom is in the third excited state, it can emit photons with six different values of energy.

Use arrows on the diagram above to show the transitions that produce these six possible photon energies.

2 marks

**Question 11**

In an experiment with a large number of these atoms, virtually all of the atoms are in one particular excited state. Photons with a range of energies are directed at the atoms in order to produce an **absorption spectrum**. It is found that the atoms strongly absorb photons of 0.51 eV and 1.16 eV.

Determine the initial excited state of the atoms. Show your reasoning clearly and relate your explanation to the energy level diagram in Figure 5.

| Initial excited state |
|---|

2 marks

**Question 12**

De Broglie suggested that the quantised energy states of the atom could be explained in terms of electrons forming standing waves.

Describe how the concept of standing waves can help explain the quantised energy states of an atom. You may include a diagram.

2 marks

**END OF SECTION A**

## SECTION B – Detailed studies

### Instructions for Section B

Select **one** Detailed study.

Answer **all** questions from the Detailed study, in pencil, on the answer sheet provided for multiple-choice questions.

Write the name of your chosen Detailed study on the multiple-choice answer sheet **and** shade the matching box.

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.

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

**Detailed study** **Page**

## Detailed study 1 – Synchrotron and its applications

Mass of the electron = $9.1 \times 10^{-31}$ kg

Charge on the electron = $-1.6 \times 10^{-19}$ C

Speed of light = $3.0 \times 10^{8}$ m s$^{-1}$

**Question 1**

X-rays are produced in the storage ring and pass into the beamlines of a synchrotron when

**A.** X-rays are deflected out of the storage ring into the beamlines by magnets.

**B.** electrons are accelerated in the linear sections of the storage ring.

**C.** electrons are deflected around circular sections of the storage ring by magnets.

**D.** electrons are deflected out of the storage ring into the beamlines by magnets.

**Question 2**

Which one of the following gives the correct order in which electrons pass through the synchrotron?

**A.** booster ring, storage ring, beamline

**B.** linac, booster ring, storage ring

**C.** linac, storage ring, booster ring

**D.** storage ring, booster ring, beamline

---

*The following information relates to Questions 3 and 4.*

The first stage of the electrons' path through the synchrotron is the electron-gun injector, in which stationary electrons are initially accelerated by an electric field, E.

In a particular synchrotron, the electric field in the injector is 200 kV m$^{-1}$.

**Question 3**

Which one of the following best gives the force on a single electron while it is in the field of the injector?

**A.** $9.1 \times 10^{-31}$ N

**B.** $1.6 \times 10^{-19}$ N

**C.** $3.2 \times 10^{-14}$ N

**D.** $1.8 \times 10^{-25}$ N

As the electrons leave the injector, they are moving at a speed of $8.4 \times 10^{7}$ m s$^{-1}$.

**Question 4**

Which one of the following best gives the length of the accelerating section of the electron-gun?

**A.** 0.01 m

**B.** 0.1 m

**C.** 1.0 m

**D.** 2.0 m

---

*The following information relates to Questions 5 and 6.*

As they leave the injector, the electrons (travelling at $8.4 \times 10^7$ m s$^{-1}$) are deflected by a magnetic field of $2.4 \times 10^{-4}$ T through a curved path of constant radius. Ignore any relativistic effects.

**Question 5**

Which one of the following best gives the force on an electron while in this magnetic field?

**A.** $3.2 \times 10^{-7}$ N

**B.** $1.3 \times 10^{-11}$ N

**C.** $3.2 \times 10^{-15}$ N

**D.** $1.8 \times 10^{-26}$ N

**Question 6**

Which one of the following best gives the radius of the path of an electron while in this magnetic field?

**A.** 0.20 m

**B.** 0.50 m

**C.** 1.0 m

**D.** 2.0 m

---

Electrons are travelling in the storage ring of a synchrotron at close to the speed of light.

They are directed from a straight section into a curved section of the storage ring, as shown in Figure 1.

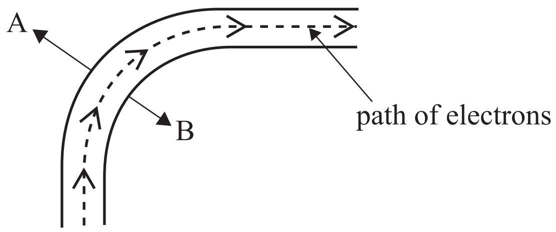



**Figure 1**

**Question 7**

Which one of the following best gives the direction that the magnetic field must have to keep the electrons in this curved path?

**A.** direction A on the diagram

**B.** direction B on the diagram

**C.** out of the page

**D.** into the page

---

**Question 8**

A wiggler is used in a part of the storage ring to produce very short wavelength X-rays.

The wiggler produces these because

**A.** it has a steady magnetic field in a constant direction which is much stronger than the field of the bending magnets.

**B.** it causes the electrons to follow a wavy path, and hence emit electromagnetic radiation.

**C.** the magnetic field of the wiggler slows the electrons, hence they decelerate and emit electromagnetic radiation.

**D.** it causes the electrons to increase their speed, hence accelerate and emit electromagnetic radiation.

**Question 9**

An undulator is best described as

**A.** a single very powerful magnet in the storage ring.

**B.** a row of magnets with alternating polarity in the beamline.

**C.** a row of magnets with alternating polarity in the storage ring.

**D.** a row of magnets in the storage ring with a magnetic field which is constant in direction but sharply undulating in magnitude.

---

**Question 10**

X-rays of wavelength 0.150 nm from a beamline are incident on a crystalline material. The crystal is rotated so as to vary the incident angle, $\theta$, between the X-ray beam and the crystal planes. A sharp peak in the intensity of the scattered beam from the crystal planes first occurs at an incident angle of 15°.

Which one of the following best gives the spacing between the crystal planes of the crystal?

**A.** 0.075 nm

**B.** 0.29 nm

**C.** $2.9 \times 10^{-6}$ nm

**D.** $2.9 \times 10^{-10}$ nm

**Question 11**

The frequency of the incident X-rays is decreased.

Which one of the following best gives the effect of this change?

**A.** The incident angle at which this peak occurs increases.

**B.** The incident angle at which this peak occurs decreases.

**C.** No change in the incident angle at which this peak occurs, but intensity of the peak increases.

**D.** No change in the incident angle at which this peak occurs, but intensity of the peak decreases.

---

*The following information relates to Questions 12 and 13.*

A beam of X-rays with energy 22 keV is scattered by a metal foil, and the energy of emerging X-rays is measured.

**Question 12**

Which one of the following is the best estimate of the energy of the scattered X-rays which have undergone Thomson scattering?

**A.** 0 keV

**B.** 20 keV

**C.** 22 keV

**D.** 24 keV

**Question 13**

Which one of the following is the best estimate of the energy of the scattered X-rays which have undergone Compton scattering?

**A.** 0 keV

**B.** 20 keV

**C.** 22 keV

**D.** 24 keV

**END OF DETAILED STUDY 1**

## Detailed study 2 – Photonics

### Question 1

The spectra of light from three different light sources are shown in Figure 1. The dashed lines indicate the range of visible wavelengths.

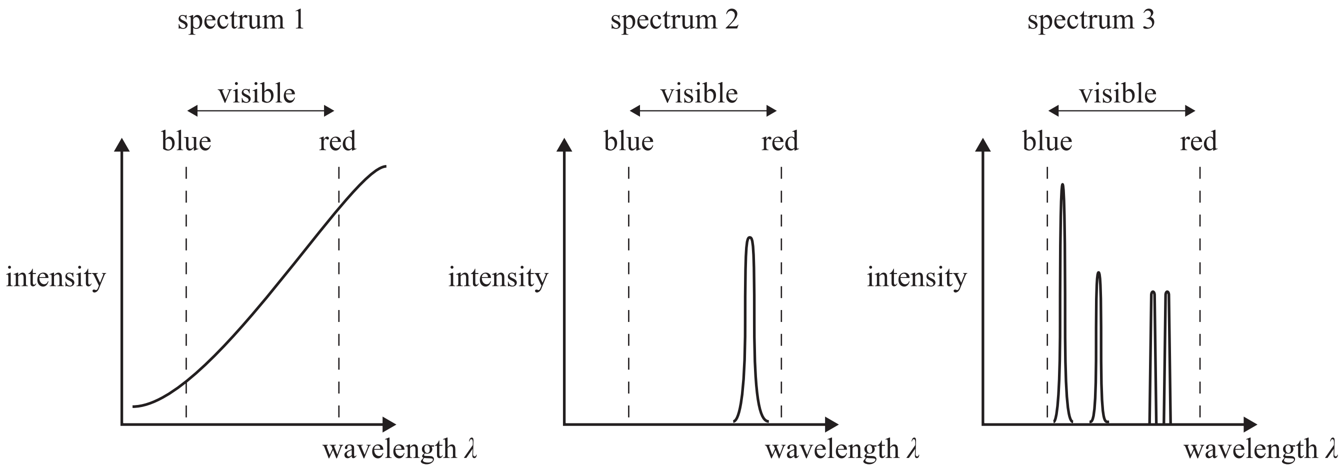



**Figure 1**

Five possible light sources are listed below.

- mercury vapour lamp
- red laser
- 100 W incandescent globe
- LED (light-emitting diode)
- sunlight

Which one of the options (A–D) below correctly identifies the light source for each spectrum?

| | spectrum 1 | spectrum 2 | spectrum 3 |
|---|---|---|---|
| **A.** | mercury vapour lamp | red laser | sunlight |
| **B.** | 100 W incandescent globe | mercury vapour lamp | LED |
| **C.** | 100 W incandescent globe | LED | mercury vapour lamp |
| **D.** | sunlight | red laser | LED |

### Question 2

Which one of the following statements best describes the production of light in an incandescent light bulb?

**A.** stimulated emission of photons by electrons in the electric current

**B.** transition of excited valence electrons back to lower energy states

**C.** acceleration of electrons in random thermal collisions

**D.** emission of electromagnetic radiation (light) by electrons accelerated by the applied voltage

**Question 3**

Which one of the following statements best describes the production of light in an LED (light-emitting diode)?

**A.** movement of electrons from the conduction band to the valence band

**B.** movement of electrons from the valence band to the conduction band

**C.** movement of electrons from the valence band to lower energy bands

**D.** movement of ground state electrons to higher energy bands

**Question 4**

Which one of the following is the best statement about laser light compared to light from an LED?

**A.** Light from a laser is of higher frequency (energy) than light from an LED.

**B.** Lasers can switch on and off rapidly, but LEDs cannot.

**C.** Laser light is incoherent, but light from an LED is coherent.

**D.** Laser light has a narrower spread of frequencies than light from an LED.

*The following information relates to Questions 5 and 6.*

A variable DC power supply is used to investigate the operation of an LED of band gap energy 2.30 eV. The voltage of the power supply is increased slowly. At a potential of 2.30 V across it, the LED emits light. A current of 4.0 mA is now flowing through the LED.

The circuit used is shown in Figure 2.

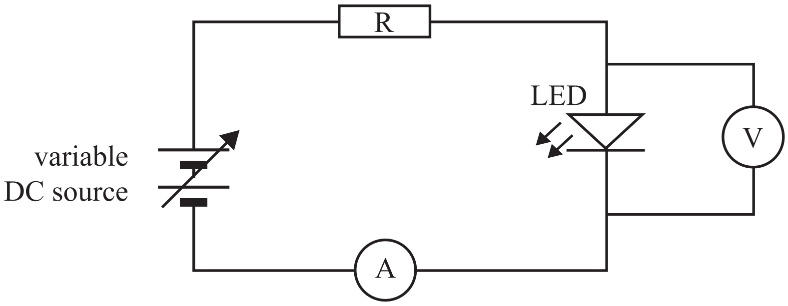



**Figure 2**

**Question 5**

Assuming an ideal diode, which one of the following best gives the wavelength of light emitted by the LED?

**A.** 284 nm

**B.** 540 nm

**C.** 865 nm

**D.** $8.65 \times 10^{-17}$ nm

**Question 6**

The power supply voltage is now increased.

Which one of the following statements is true?

**A.** The wavelength of the light emitted decreases and the current increases.

**B.** The wavelength of the light emitted and the current both stay the same.

**C.** The wavelength of the light emitted stays the same and the current increases.

**D.** The wavelength of the light emitted increases and the current increases.

*The following information relates to Questions 7–10.*

Figure 3 shows a step-index fibre-optic waveguide, with a ray of light entering it.

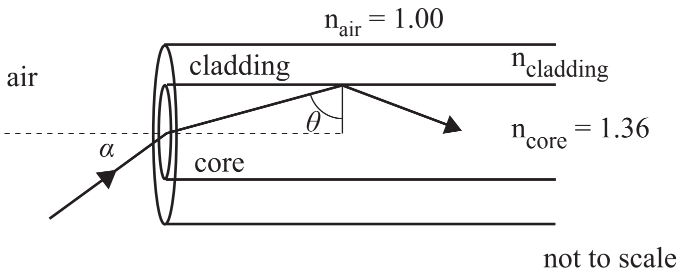



**Figure 3**

**Question 7**

The critical angle for total internal reflection at the interface between the cladding and the core of the waveguide is found to be 80°.

Which one of the following is the best estimate of the refractive index, $n_{cladding}$, of the cladding material?

**A.** 1.32

**B.** 1.34

**C.** 1.36

**D.** 1.38

**Question 8**

Which one of the following best gives the value of the limiting acceptance angle, $\alpha$, for the waveguide to operate correctly?

**A.** 10.0°

**B.** 13.7°

**C.** 46.4°

**D.** 80.0°

The waveguide is now immersed in water (refractive index 1.33).

**Question 9**

Which one of the following best describes the effect of this immersion on the critical angle, $\theta$?

**A.** $\theta$ will increase.

**B.** $\theta$ will remain the same.

**C.** $\theta$ will decrease.

**D.** There will be no critical angle $\theta$.

**Question 10**

Which one of the following best describes the effect of this immersion on the limiting acceptance angle, $\alpha$?

**A.** $\alpha$ will increase.

**B.** $\alpha$ will remain the same.

**C.** $\alpha$ will decrease.

**D.** There will be no suitable acceptance angle $\alpha$.

*The following information relates to Questions 11–13.*

Melanie and Max are discussing the best options for long-distance transmission using a fibre-optic waveguide.

**Question 11**

Melanie and Max want to minimise **material dispersion**.

Melanie argues that a laser would be a better light source than an LED to minimise material dispersion.

The best reason for this would be that

**A.** lasers are more intense than LEDs.

**B.** lasers emit light with a narrower range of wavelengths than LEDs.

**C.** lasers operate at higher frequencies (shorter wavelengths) than LEDs.

**D.** laser light is coherent, but light from an LED is incoherent.

**Question 12**

Which one of the following would reduce **modal dispersion** in the optic waveguide?

**A.** use of a higher refractive index cladding

**B.** use of a lower refractive index cladding

**C.** use of a larger diameter core

**D.** use of a smaller diameter core

**Question 13**

Max and Melanie decide to use a step-index fibre for the waveguide.

Compared with a step-index fibre, a graded-index optical fibre is superior because it is more likely to reduce transmission difficulties caused by

**A.** modal dispersion.

**B.** material dispersion.

**C.** Rayleigh scattering.

**D.** absorption.

---

**END OF DETAILED STUDY 2**

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## Detailed study 3 – Sound

**Question 1**

The operation of the crystal microphone depends on

**A.** electromagnetic induction.

**B.** piezo-electric effect.

**C.** capacitance.

**D.** electrical resistance.

**Question 2**

A stretched spring, attached to two fixed ends, is compressed on the right end and then released, as shown in Figure 1. The resulting wave travels back and forth between the two fixed ends until it comes to a stop.

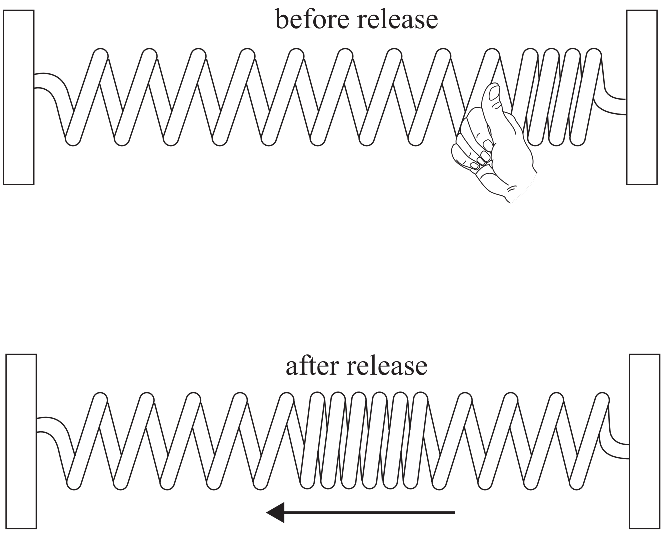



**Figure 1**

This wave is best seen as an example of

**A.** a transverse wave.

**B.** a longitudinal wave.

**C.** diffraction.

**D.** an electromagnetic wave.

*The following information relates to Questions 3 and 4.*

A loudspeaker is emitting sound of a fixed intensity which travels equally in all directions. Figure 2 below shows the pressure variation plotted against distance from the loudspeaker, at a particular instant of time. Take the speed of sound to be 333 m $s^{-1}$.

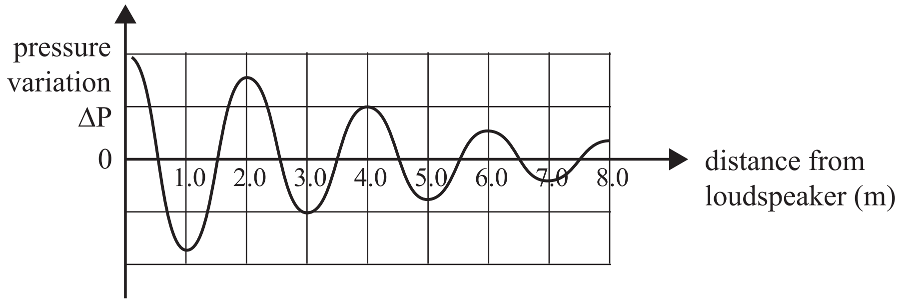



**Figure 2**

**Question 3**

The frequency of the sound emitted is closest to

**A.** 111 Hz

**B.** 133 Hz

**C.** 167 Hz

**D.** 333 Hz

**Question 4**

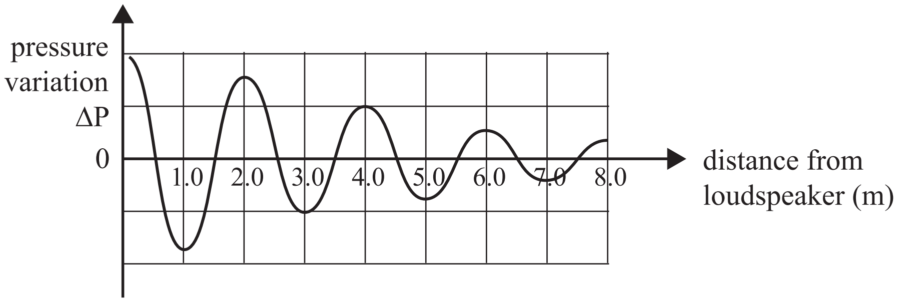
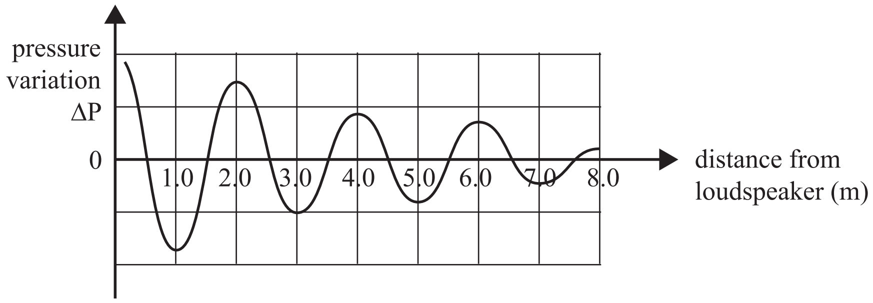


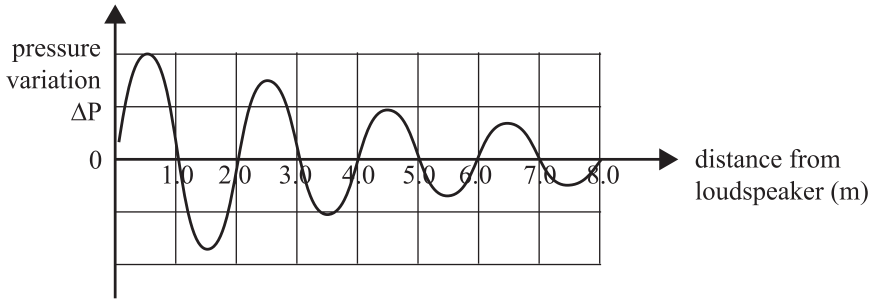

**Figure 2 (repeated)**

Which one of the graphs shows the pressure variation as a function of distance from the loudspeaker, at a time that is a quarter of a period later than shown in Figure 2?

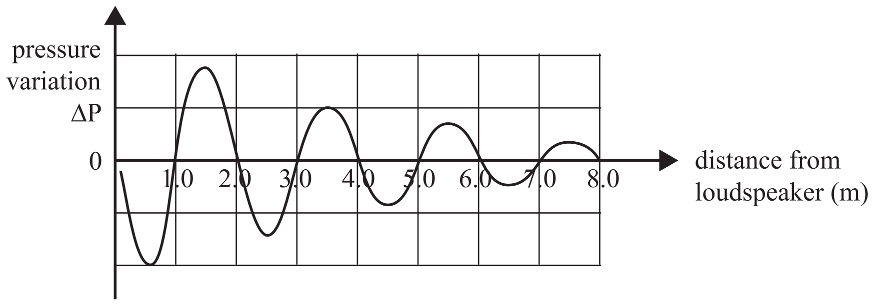
**A.**



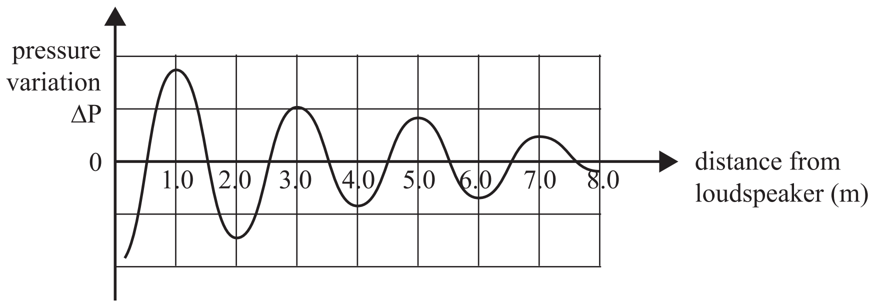

**B.**




**C.**




**D.**



*The following information relates to Questions 5 and 6.*

A teacher sets up a loudspeaker in the middle of a school oval at point P, as shown in Figure 3. The loudspeaker emits sound equally in all directions with a wavelength of 1.5 m.

Ignore reflections from the ground.

Take the speed of sound to be 333 m $s^{-1}$.

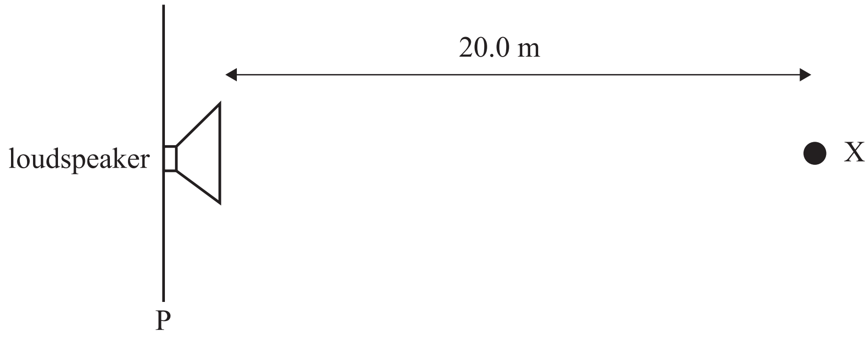



**Figure 3**

A student, Alex, stands at point X, 20.0 m from the loudspeaker, and measures the intensity of the sound to be $2.0 \times 10^{-7}$ W $m^{-2}$. Alex now moves to a different distance, and measures the intensity of the sound to be $5.0 \times 10^{-8}$ W $m^{-2}$.

**Question 5**

Which one of the following gives the best estimate of how far Alex is from the loudspeaker at this new position?

**A.** 5.0 m
**B.** 10.0 m
**C.** 40.0 m
**D.** 80.0 m

**Question 6**

By how many decibels (best estimate) has the intensity level of the sound changed between the two readings?

**A.** –2 dB
**B.** –3 dB
**C.** –4 dB
**D.** –6 dB

**Question 7**

Dan and Serena arrived at a rock concert that had already started. While waiting at point C in a queue outside the hall (Figure 4), Dan commented that the sound quality was poor. Dan and Serena were pleased to find the sound quality improved when they reached point D in front of the 2.0 m wide door to the hall.

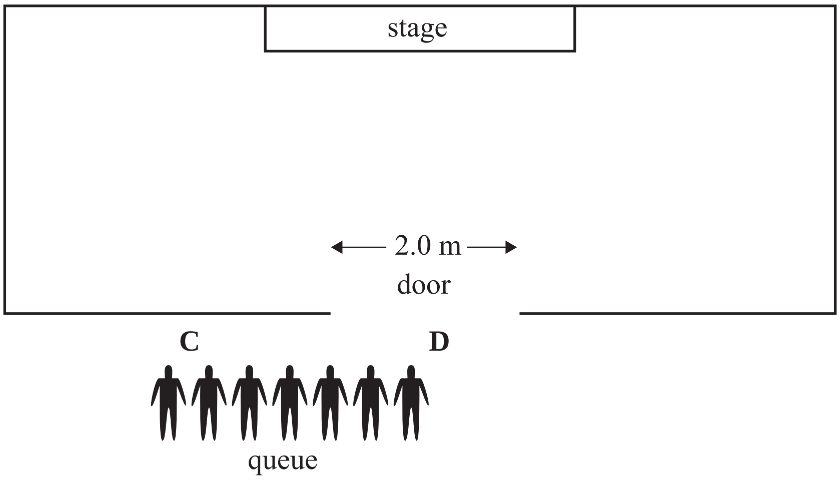



**Figure 4**

Which one of the following is the best explanation of the poor sound quality at C compared to D?

**A.** Low-frequency sound was heard with less intensity than high-frequency sound, due to diffraction effects.

**B.** Low-frequency sound was heard with less intensity than high-frequency sound, due to resonance effects.

**C.** High-frequency sound was heard with less intensity than low-frequency sound, due to diffraction effects.

**D.** High-frequency sound was heard with less intensity than low-frequency sound, due to resonance effects.

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*The following information relates to Questions 8 and 9.*

The graph in Figure 5 shows the relationship between sound intensity level (dB), frequency (Hz) and loudness (phon).

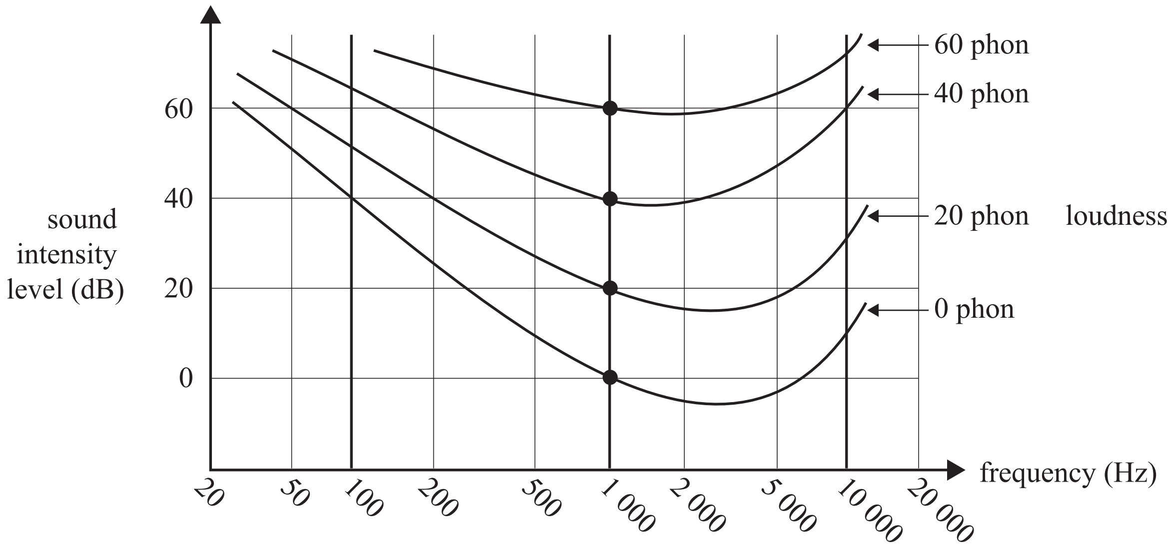



**Figure 5**

A frequency generator emits a sound of 200 Hz. The sound intensity level (dB) of this sound is measured at a particular point by a sound-level meter to be 40 dB.

**Question 8**

Which one of the following is the best estimate of the sound intensity of this sound in W $m^{-2}$?

**A.** $4.0 \times 10^{-12}$ W $m^{-2}$

**B.** $1.0 \times 10^{-4}$ W $m^{-2}$

**C.** $1.0 \times 10^{-8}$ W $m^{-2}$

**D.** $1.0 \times 10^{4}$ W $m^{-2}$

**Question 9**

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

**A.** 0 phon

**B.** 20 phon

**C.** 40 phon

**D.** 60 phon

*The following information relates to Questions 10–13.*

Students use a narrow tube, open at both ends, to model a flute. A frequency generator attached to a loudspeaker is placed near one end, as shown in Figure 6. The fundamental frequency is measured to be 385 Hz. Take the speed of sound to be 333 m s$^{-1}$.

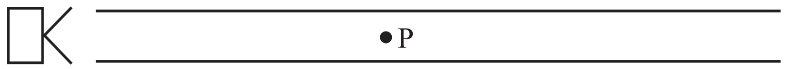



**Figure 6**

**Question 10**

The length of this tube is closest to

**A.** 0.144 m

**B.** 0.288 m

**C.** 0.432 m

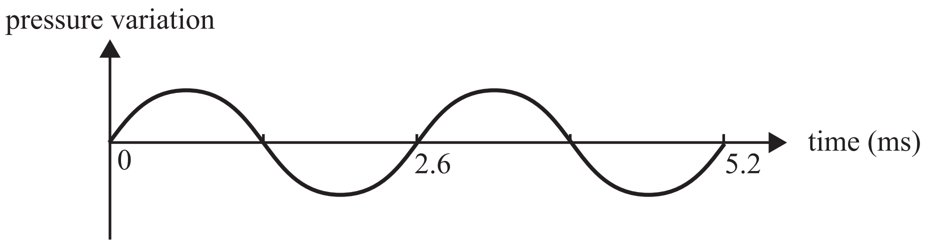
**D.** 0.864 m

**Question 11**

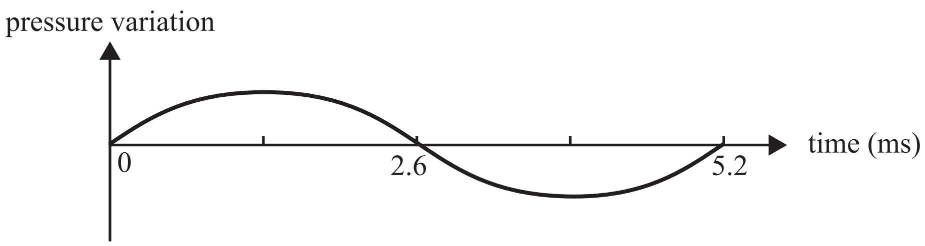
P is at the middle of the tube and the sound of 385 Hz is still being emitted.

Which one of the following graphs best shows the pressure variation at P as a function of time?

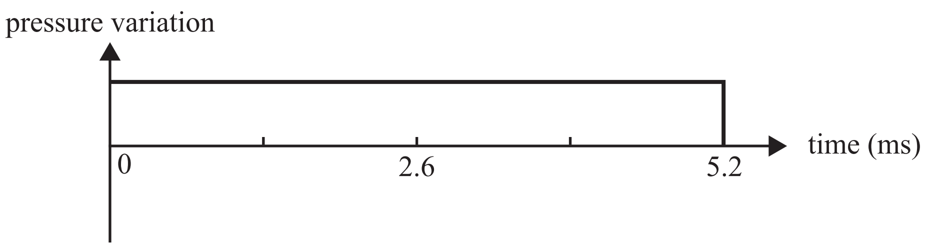
**A.**



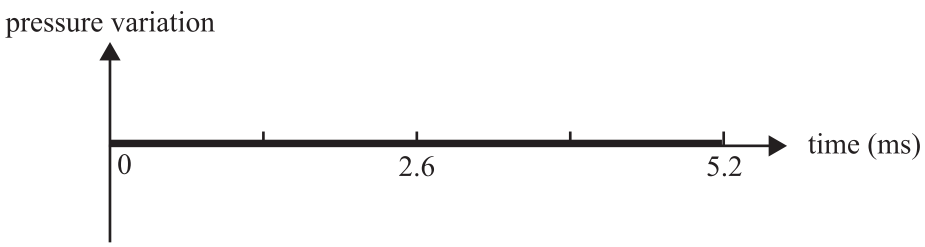

**B.**




**C.**




**D.**



**Question 12**

Which one of the following frequencies is **not** a resonant frequency of this tube?

**A.** 193 Hz

**B.** 770 Hz

**C.** 1155 Hz

**D.** 1540 Hz

**Question 13**

The students now cover the right-hand end of the tube (away from the loudspeaker) with a solid cover. The tube is now closed at one end.

Which one of the following now best gives the frequency at which they will hear the fundamental resonance?

**A.** 193 Hz

**B.** 385 Hz

**C.** 578 Hz

**D.** 770 Hz

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**END OF QUESTION AND ANSWER BOOK**

# PHYSICS

## Written examination 2

### FORMULA SHEET

**Directions to students**

| |
|---|
| Detach this formula sheet before commencing the examination. |
| This formula sheet is provided for your reference. |

| | | |
|---|---|---|
| 1 | photoelectric effect | $E_{K\max} = hf - W$ |
| 2 | photon energy | $E = hf$ |
| 3 | photon momentum | $p = \frac{h}{\lambda}$ |
| 4 | de Broglie wavelength | $\lambda = \frac{h}{p}$ |
| 5 | resistors in series | $R_T = R_1 + R_2$ |
| 6 | resistors in parallel | $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ |
| 7 | magnetic force | $F = I\,l\,B$ |
| 8 | electromagnetic induction | emf : $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ flux: $\Phi = BA$ |
| 9 | transformer action | $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ |
| 10 | AC voltage and current | $V_{RMS} = \frac{1}{\sqrt{2}}V_{peak}$ $I_{RMS} = \frac{1}{\sqrt{2}}I_{peak}$ |
| 11 | voltage; power | $V = RI$ $P = VI$ |
| 12 | transmission losses | $V_{drop} = I_{line}R_{line}$ $P_{loss} = I^2_{line}R_{line}$ |
| 13 | mass of the electron | $m_e = 9.1 \times 10^{-31}$ kg |
| 14 | charge on the electron | $e = -1.6 \times 10^{-19}$ C |
| 15 | Planck's constant | $h = 6.63 \times 10^{-34}$ J s<br>$h = 4.14 \times 10^{-15}$ eV s |
| 16 | speed of light | $c = 3.0 \times 10^8$ m s$^{-1}$ |
| 17 | Acceleration due to gravity at Earth's surface | $g = 10$ m s$^{-2}$ |

**Detailed study 3.1 – Synchrotron and applications**

| | | |
|---|---|---|
| 18 | energy transformations for electrons in an electron gun (<100 keV) | $\frac{1}{2}mv^2 = eV$ |
| 19 | radius of electron beam | $r = mv/eB$ |
| 20 | force on an electron | $F = evB$ |
| 21 | Bragg's law | $n\lambda = 2d\sin\theta$ |
| 22 | electric field between charged plates | $E = \frac{V}{d}$ |

**Detailed study 3.2 – Photonics**

| | | |
|---|---|---|
| 23 | band gap energy | $E = \frac{hc}{\lambda}$ |
| 24 | Snell's law | $n_1 \sin i = n_2 \sin r$ |

**Detailed study 3.3 – Sound**

| | | |
|---|---|---|
| 25 | speed, frequency and wavelength | $v = f\lambda$ |
| 26 | intensity and levels | sound intensity level (in dB) $= 10\log_{10}\left(\frac{I}{I_0}\right)$ where $I_0 = 1.0 \times 10^{-12}$ W m$^{-2}$ |

**Prefixes/Units**

p = pico = $10^{-12}$

n = nano = $10^{-9}$

$\mu$ = 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 DATA SHEET**