Neap:

Trial Examination 2010

VCE Physics Unit 4

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: ______________________________

Teacher's Name: ______________________________

Structure of Booklet

Section	Number of questions	Number of questions to be answered	Number of marks
A Core – Areas of study			
1. Electric power	20	20	38
2. Interactions of light and matter	11	11	26
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 pieces of paper and/or white out liquid/tape.

Materials supplied

Question and answer booklet of 25 pages with a detachable data sheet in the centrefold.

Answer sheet for multiple choice questions.

Instructions

Detach the data sheet from the centre of this booklet during reading time.

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

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

All written responses must be in English.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2010 VCE Physics Unit 4 Written Examination.

SECTION A

Instructions for Section A

Answer **all** questions **for both** Areas of study in this section of the paper 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 $10\ \text{m s}^{-2}$.
In questions where more than one mark is available, appropriate working should be shown.

Area of study 1 – Electric power

Figure 1 shows a schematic diagram of a strong physics laboratory magnet.

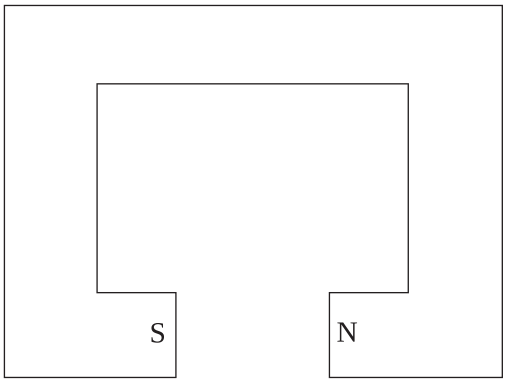

Figure 1

Question 1

On Figure 1 draw the magnetic field lines between the poles of the magnet.

1 mark

A current-carrying wire 10 cm long is placed in the magnetic field between the poles of the magnet as shown in Figure 2. The current is coming out of the page.

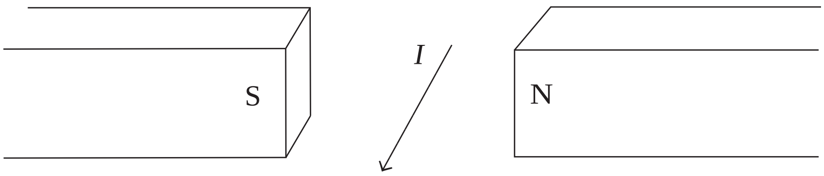

Figure 2

Question 2

Which one of the following best represents the direction of the magnetic force acting on the current-carrying wire as shown in Figure 2?

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

2 marks

The magnetic field strength of the magnet is 1.2 T and the current in the wire is 5.0 A.

Question 3

Calculate the size of the magnetic force acting on the 10 cm of wire that is between the poles of the magnet.

N

2 marks

Yelda is using a 240 V AC 2400 W cordless kettle to boil some water for a cup of coffee.

Question 4

Calculate the RMS current being drawn by the kettle.

A

2 marks

Question 5

Calculate the peak voltage for the kettle.

V

1 mark

Question 6

Calculate the resistance of the kettle’s heating element.

Ω

2 marks

Figure 3 shows a schematic diagram of a DC motor.

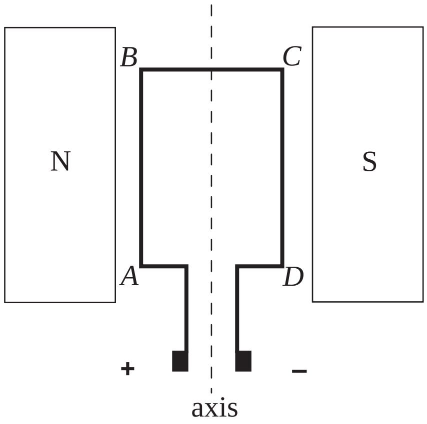

Figure 3

The electric motor is made using 200 coils of wire. The current in the wire is 2.0 A. The length of side *AB* is 10.0 cm and the length of side *BC* is 5.0 cm. The strength of the magnetic field is 1.0 T.

Question 7

Calculate the magnitude of the force acting on side *AB*. Show working.

N

2 marks

Question 8

Which one of the following best indicates the direction of the force acting on side *BC*?

A. up
B. down
C. left
D. right
E. into the page
F. out of the page
G. no force

2 marks

Question 9

Which one of the following statements is correct regarding the DC motor shown schematically in Figure 3?

A. It uses a slip-ring commutator to work properly.
B. It uses a split-ring commutator to work properly.
C. It uses an alternator to work properly.
D. It uses a generator to work properly.

2 marks

A rectangular loop of wire measuring 10 cm by 4 cm is placed in a magnetic field of strength 15 mT as shown in Figure 4 below.

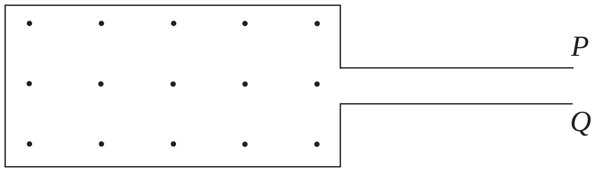

Figure 4

Question 10

Which one of the following best indicates the direction of the magnetic field passing through the loop?

A. up
B. down
C. left
D. right
E. into the page
F. out of the page
G. no force

1 mark

Question 11

What is the magnitude of the magnetic flux passing through the loop?

Wb

2 marks

The loop is pulled completely out of the magnetic field in 200 ms.

Question 12

Calculate the magnitude of the average emf produced across the terminals *P* and *Q* as the loop is pulled out.

V

2 marks

Question 13

As the loop is pulled out of the magnetic field, the direction of the induced current runs

A. from *P* to *Q*.

B. from *Q* to *P*.

C. from *P* to *Q* then from *Q* to *P*.

D. from *Q* to *P* then from *P* to *Q*.

2 marks

Figure 5 shows the output of an alternator used to generate electricity. The generator is rotating at 40 Hz and produces 12 V RMS.

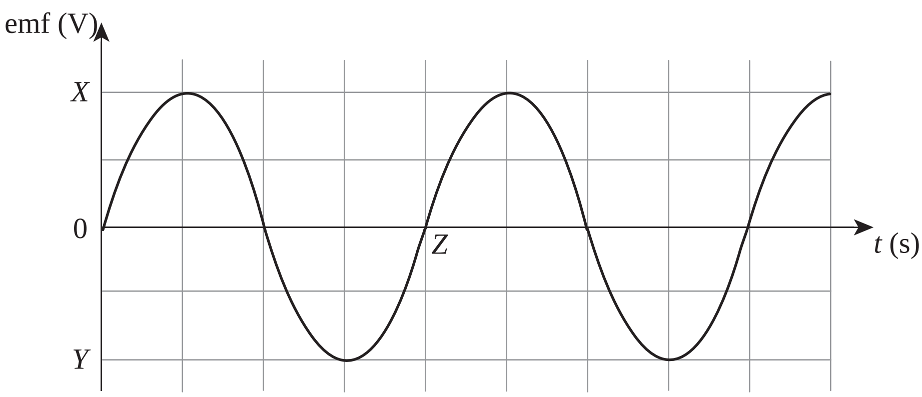

Figure 5

Question 14

Is the output voltage shown in Figure 5 AC or DC? Explain your answer.

2 marks

Question 15

Fill out the table below with the correct numerical value for the points *X*, *Y* and *Z* shown on Figure 5.

X		Volts
Y		Volts
Z		seconds

3 marks

Figure 6 shows a schematic diagram of a transformer used to transform 240 V AC to 12 V AC for a notebook computer. Assume for Questions 16 and 17 that it is an ideal transformer.

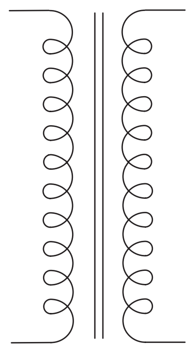

Figure 6

Question 16

The primary coil which is connected to the main electricity has 500 turns on it.

Calculate how many turns there are on the secondary coil. Show your working.

2 marks

The power drawn by the secondary circuit is 12.0 W.

Question 17

Calculate the current flowing in the primary circuit. Show your working.

A

2 marks

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A student feels the insulated casing surrounding the notebook transformer and notices that it is quite warm. She reasons that the transformer **must not be ideal**.

Question 18

Which one of the following best explains why the transformer is warm?

A. $P_{\text{primary}} > P_{\text{secondary}}$

B. $P_{\text{primary}} = P_{\text{secondary}}$

C. $P_{\text{primary}} < P_{\text{secondary}}$

D. cannot be determined from the information given

2 marks

A generator producing 200 kW of power at 5.0 kV for a factory is connected by two cables that have a total resistance of 5.0 Ω.

Question 19

Calculate the current in the cables connecting the generator to the factory.

A

2 marks

Question 20

Calculate the amount of power lost in the transmission line. Show your working.

W

2 marks

END OF AREA OF STUDY 1

Area of study 2 – Interactions of light and matter

In 1801 Thomas Young performed a famous experiment. He passed monochromatic light through two slits in order to produce a series of light and dark bands on a screen, as shown in Figure 7.

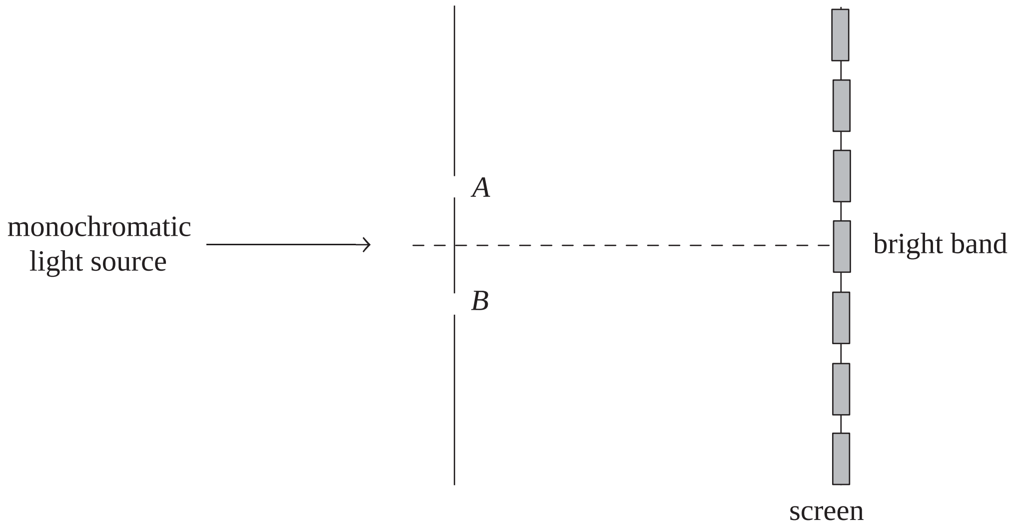


Figure 7

To replicate this experiment, Sarah and Sam use a red laser which produces light of wavelength 700 nm.

Question 1

When light passes through each of the slits, the first phenomena that occurs is

A. dispersion.
B. diffraction.
C. interference.
D. polarisation.

2 marks

Question 2

The phenomena in Question 1 will be maximised if

A. the slit width is much greater than the wavelength of the light.
B. the slit width is approximately equal to the wavelength of the light.
C. the distance between the two slits is approximately equal to the wavelength of the light.
D. the slit width is much smaller than the wavelength of the light.

2 marks

At a particular point *X* on the screen in Figure 7, the path difference (distance *BX* – distance *AX*) is found to be 1750 nm.

Question 3

Mark the location of point *X* on the screen in Figure 7, and explain your answer.

3 marks

Question 4

The light and dark bands produced on the screen in Young's experiment provided vital support for the wave model of light.

Describe how the wave model explains the light and dark bands and why the particle model does not.

3 marks

Nearly 100 years after Young's experiment confirmed the wave nature of light, Heinrich Hertz discovered the photoelectric effect. In this experiment, light of varying frequencies is shone on a metal surface. When the frequency of light is higher than a particular value known as the threshold frequency for that metal, electrons are ejected from the surface of the metal.

For a particular metal, the threshold frequency is found to be 6.0×10^{14} Hz.

Question 5

Calculate the work function of the metal described above. Give your answer in eV.

eV

2 marks

Blue light of frequency 7.0 x 10^{14} Hz is now shone on the same metal and the current–voltage graph shown in Figure 8 is obtained.

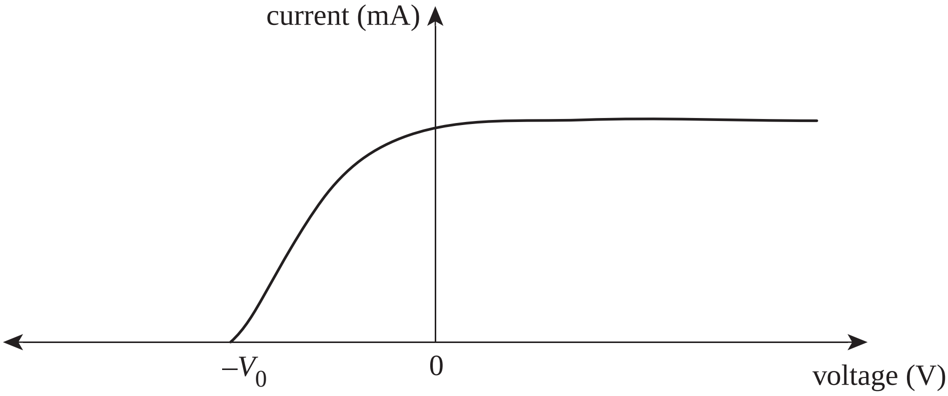


Figure 8

Question 6

Explain what is meant by the value V_0 on the graph in Figure 8, and how this value relates to the photoelectrons ejected from the metal.

2 marks

Question 7

Calculate the de Broglie wavelength of the most energetic photoelectrons ejected by the incident blue light (f = 7.0 x 10^{14} Hz).

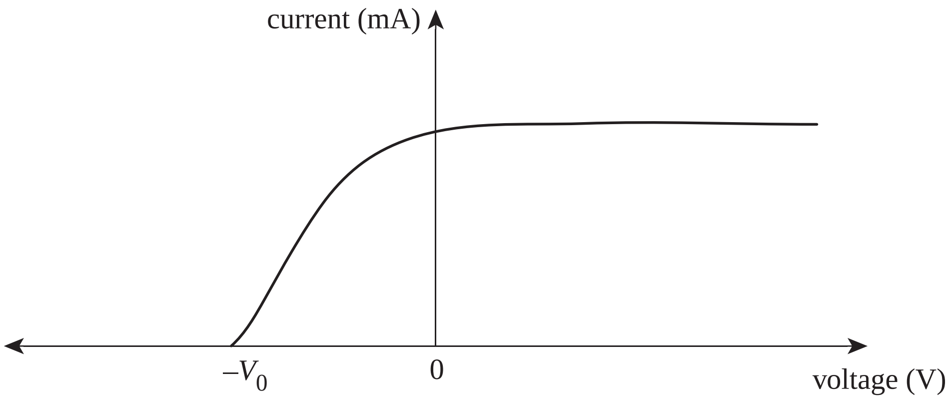
m

4 marks

The blue light is now replaced with a violet light with much lower intensity than the blue light.

Question 8

On the copy of Figure 8 given below, sketch the current–voltage graph that would be obtained using the dimmer violet light for the same metal.



Copy of Figure 8

2 marks

The energy levels for atomic mercury are shown in Figure 9.

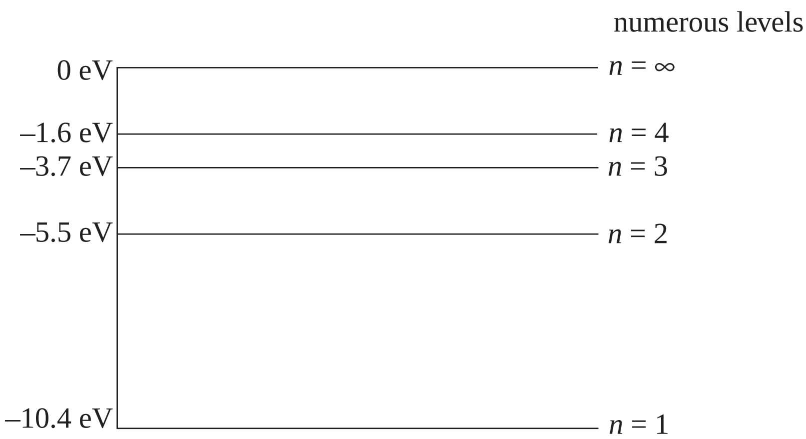


Figure 9

Question 9

Calculate the wavelength of a photon emitted when an electron in the 3rd excited state ($n = 4$) falls to the 1st excited state ($n = 2$).

m

2 marks

Question 10

Calculate the momentum of the photon described in Question 9.

kg m s^{-1}

2 marks

Question 11

Explain what would happen to the mercury atom if a photon of energy 12.0 eV was incident on the mercury atom with a valence electron in the ground state $(n = 1)$.

2 marks

END OF AREA OF STUDY 2

SECTION B – Detailed studies

Instructions for Section B

Select **one** Detailed study.

Answer **all** the 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** or that **best answers** 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

An electron gun is used to initially accelerate electrons in a synchrotron. In one such synchrotron, the potential difference across the plates in the electron gun is 500 kV and the plates are 40 cm apart.

Question 1

The increase in kinetic energy of the electrons in the electron gun is equal to

A. 8.0×10^{-17} keV

B. 200 keV

C. 500 keV

D. 1250 keV

Question 2

The average acceleration of electrons in the electron gun is equal to

A. 2.0×10^{-13} m s^{-2}

B. 1.3×10^{6} m s^{-2}

C. 2.2×10^{17} m s^{-2}

D. 1.4×10^{36} m s^{-2}

Question 3

The linear accelerator (linac) in a synchrotron uses

A. magnetic fields to maintain the speed of electrons initially accelerated by the electron gun.

B. electric fields to maintain the speed of electrons initially accelerated by the electron gun.

C. magnetic fields to increase the speed of electrons initially accelerated by the electron gun.

D. electric fields to increase the speed of electrons initially accelerated by the electron gun.

Bending magnets in the booster ring are used to change the path of fast moving electrons.
An electron travelling at 1.5×10^{8} m s^{-1} enters a magnetic field as shown in Figure 1.

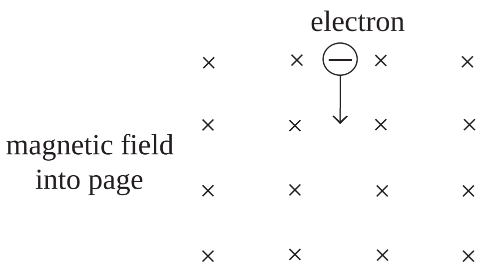


Figure 1

Question 4

The direction of the force on the electron in Figure 1 will be

A. to the left of the page.

B. to the right of the page.

C. up the page.

D. down the page.

Once the electron enters the magnetic field it travels in a circular arc of radius 10 cm.

Question 5

The magnitude of the magnetic field is equal to

A. 8.5×10^{-5} T

B. 8.5×10^{-3} T

C. 1.2 T

D. 120 T

Question 6

The acceleration of the electron under the effect of the magnetic field is

A. 2.0×10^{-23} m s^{-2}

B. 1.5×10^{7} m s^{-2}

C. 2.3×10^{17} m s^{-2}

D. 1.5×10^{9} m s^{-2}

In a synchrotron, useful electromagnetic radiation known as ‘synchrotron radiation’ is produced.

Question 7

Most of the synchrotron radiation is produced in the

A. linac.

B. booster ring.

C. storage ring.

D. beamline.

Question 8

Synchrotron radiation is produced when electrons

A. are stopped suddenly by a metal target.

B. travel in a straight line close to the speed of light.

C. are accelerated by a series of electric fields in tubes of increasing length.

D. are accelerated by a magnetic field perpendicular to their direction of travel.

Question 9

The use of insertion devices known as ‘wigglers’ enables the synchrotron to produce synchrotron X-rays which are much more

A. intense than those produced in a traditional X-ray machine.

B. monochromatic than those produced in a traditional X-ray machine.

C. coherent than those produced in a traditional X-ray machine.

D. collimated than those produced in a traditional X-ray machine.

X-rays of wavelength 1.3×10^{-10} m are used to investigate the atomic spacing of a crystal by producing Bragg diffraction.

Question 10

First order diffraction is observed at an angle of 15.7°.

The spacing between layers of atoms in the crystal is equal to

A. 8.3×10^{-12} m

B. 2.4×10^{-10} m

C. 4.8×10^{-10} m

D. 9.6×10^{-10} m

Question 11

Second order diffraction would be detected at an angle of

A. 7.9°

B. 31.4°

C. 32.7°

D. Second order diffraction would not be able to be detected.

X-ray photons of energy 1.0×10^{3} eV are incident on the surface of a metal and undergo scattering.

Question 12

Which of the following statements is correct?

A. Photons that have undergone Thompson scattering will have a longer wavelength than those that have undergone Compton scattering.

B. Photons that have undergone Thompson scattering will have a shorter wavelength than those that have undergone Compton scattering.

C. Photons that have undergone Thompson scattering will have the same wavelength as those that have undergone Compton scattering.

D. Photons that have undergone Thompson scattering will be completely absorbed by the metal, whereas photons that have undergone Compton scattering will have the same wavelength as the incident photons.

Question 13

In which of the following phenomena is all the energy of a photon transferred to an electron?

A. Bragg diffraction

B. Compton scattering

C. Thompson scattering

D. Photoelectric effect

END OF DETAILED STUDY 1

Detailed study 2 – Photonics

Sunil is looking at a 20 W incandescent light globe as part of a VCE photonics physics practical and he analyses the light using a handheld spectrometer.

Question 1

Which of the following best explains what Sunil can deduce about the nature of the light when looking at the 20 W incandescent light globe with the hand held spectrometer?

A. The light emitted is monochromatic.
B. The light emitted is polychromatic.
C. The light emitted is in phase.
D. The light emitted is out of phase.

Simone, his physics teacher, tells Sunil that the light coming from the 20 W incandescent light globe is incoherent.

Question 2

Which of the following best explains what is meant by the term ‘incoherent’ when applied to the light emitted by a 20 W incandescent light globe?

A. The light emitted is monochromatic.
B. The light emitted is polychromatic.
C. The light emitted is in phase.
D. The light emitted is out of phase.

Red and green lasers are often used in physics laboratories for various experiments in photonics. Teachers often stress the need for extreme caution when using these lasers even though the laser light output might be only 2.0 mW.

Question 3

Which of the following best explains how a laser produces light?

A. thermal motion of electrons
B. stimulated emission of photons
C. spontaneous emission of photons
D. spontaneous absorption of photons

Question 4

Which of the following best explains the nature of laser light?

A. It is incoherent, polychromatic and out of phase.
B. It is incoherent, monochromatic and in phase.
C. It is coherent, polychromatic and in phase.
D. It is coherent, monochromatic and in phase.

Question 5

Which of the following best explains why teachers stress the need for extreme caution when using lasers in the physics laboratory?

A. The colour of the laser light (red and green) is dangerous for human eyes.

B. The intensity of the laser light is dangerous for human eyes.

C. The frequency of the laser light is dangerous for human eyes.

D. The wavelength of the laser light is dangerous for human eyes.

Light emitting diodes (LEDs) are used for various display applications in consumer electronic appliances. For example, red and green LED displays are often used to indicate when electronic appliances are off (red), or on (green).

Question 6

Which of the following is the best explanation of how an LED produces red light?

A. by the thermal motion of electrons

B. by an induced emission of photons

C. by a spontaneous emission of photons

D. by a spontaneous absorption of photons

Question 7

Which of the following best explains the differences between a red LED compared to a green LED?

A. The band energy gap is greater for a red LED compared to a green LED.

B. The band energy gap is smaller for a red LED compared to a green LED.

C. The frequency for a green LED is smaller compared to a red LED.

D. The wavelength is greater for a green LED compared to a red LED.

The green LED is manufactured to produce light of wavelength 515 nm.

Question 8

The energy gap required for the production of this green light from the LED is

A. 2.14 eV

B. 2.41 eV

C. 2.49 eV

D. 3.01 eV

A one step-index multimode optic fibre is made of glass of refractive index 1.52 with a cladding of refractive index 1.50.

Question 9

The critical angle for this one-step index multimode optic fibre is closest to

A. 45.0°

B. 80.6°

C. 80.7°

D. 89.7°

Question 10

The acceptance angle for this one-step index multimode optic fibre is closest to

A. 12.4°
B. 14.2°
C. 14.4°
D. 15.2°

Question 11

Rayleigh scattering in relationship to an optic fibre is best explained as

A. absorption of light due to variations in fibre density.
B. absorption of light due to variations in impurities in the fibre.
C. scattering of light due to variations in fibre density.
D. scattering of light due to variations in impurities in the fibre.

Optic fibres are used for medical imaging. Both incoherent and coherent bundles of optic fibre are used.

Question 12

Which of the following best explains what is meant by a 'coherent optic fibre bundle' as used for medical imaging purposes?

A. It only allows coherent light through it.
B. It only allows laser light through it.
C. The individual fibres at both ends of the bundle are in the same position relative to each other.
D. none of the above

A doctor, Sandra, has a choice of buying two different coherent optical fibre bundles both of 10 mm diameter. One has 100 optical fibres packed in the bundle, and the other one, although more expensive, has 400 optical fibres packed in the bundle.

Sandra chooses the coherent optical fibre bundle with 400 optical fibres in the bundle.

Question 13

Which of the following best explains why Sandra chooses the coherent optical fibre bundle with 400 optical fibres in the bundle for her medical imaging purposes?

A. The 400 optical fibre bundle is more expensive therefore it must be better.
B. The 400 optical fibre bundle will allow more light through.
C. The 400 optical fibre bundle will give a more detailed image.
D. The 400 optical fibre bundle magnifies the image by a factor of four.

END OF DETAILED STUDY 2

Detailed study 3 – Sound

Question 1

Which of the following is the best description of the motion of the particles when a sound wave travels through a gas?

A. The particles vibrate at right angles to the direction of wave motion.
B. The particles travel in the opposite direction to the wave motion.
C. The particles travel in the same direction as the wave motion.
D. The particles vibrate parallel to the direction of wave motion.

Molly is learning to play the flute, which can be modelled as a tube open at both ends. The length of the tube can be changed by closing holes in the flute.

The speed of sound in the air in the flute is equal to 350 m s^{-1}.

Question 2

In order to produce a fundamental frequency of 880 Hz, the distance between open ends of the tube is equal to

A. 0.10 m
B. 0.20 m
C. 0.40 m
D. 0.80 m

Question 3

Which of the following frequencies could also be produced in the flute with this length of tube?

A. 220 Hz
B. 440 Hz
C. 2200 Hz
D. 3520 Hz

The sound Molly produces is measured to have a sound intensity level of 65 dB at a point 2.0 m away from the flute.

Question 4

The intensity of the sound at this point is equal to

A. $6.5 \times 10^{-12} \text{ W m}^{-2}$
B. $3.2 \times 10^{-7} \text{ W m s}^{-2}$
C. $3.2 \times 10^{-6} \text{ W m}^{-2}$
D. $1.0 \times 10^{-2} \text{ W m}^{-2}$

Molly now plays exactly the same note but the intensity is measured at a distance of 4.0 m away.

Question 5

The intensity level measured at this point will be closest to

A. 16 dB

B. 33 dB

C. 59 dB

D. 62 dB

The section of tube in the flute which produces this note is shown in Figure 1.

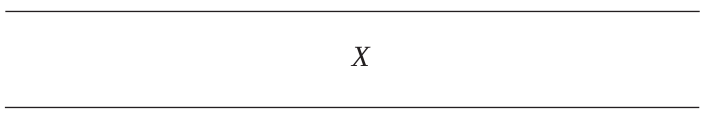


Figure 1

The point *X* is midway along the length of the tube.

Question 6

Which of the following correctly describes the pressure at point *X* in the tube?

A. The pressure is always at a lower value than the air pressure outside the tube.

B. The pressure varies between a value much higher than the air pressure outside the tube and a value much lower than the air pressure outside the tube.

C. The pressure is always at a higher value than the air pressure outside the tube.

D. The pressure remains the same as the air pressure outside the tube.

Question 7

Point *X* is best described as

A. a node where constructive interference is occurring.

B. a node where destructive interference is occurring.

C. an antinode where constructive interference is occurring.

D. an antinode where destructive interference is occurring.

Molly is practising in the study at home while her dad Chris stands in the hallway. Molly and Chris's locations are shown in Figure 2. The doorway is open.

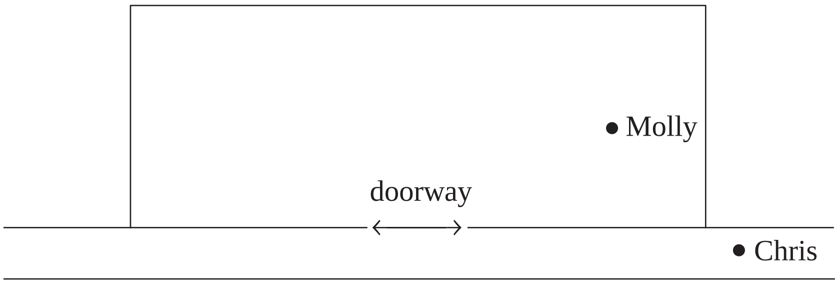


Figure 2

Question 8

If Chris can clearly hear Molly play the 880 Hz note, the width of the doorway must be

A. less than or equal to 0.4 m.

B. exactly equal to 0.4 m.

C. greater than or equal to 0.4 m.

D. greater than 2.5 m.

Data relating to a sound produced by a signal generator and transmitted through an unknown gas is shown in Figure 3.

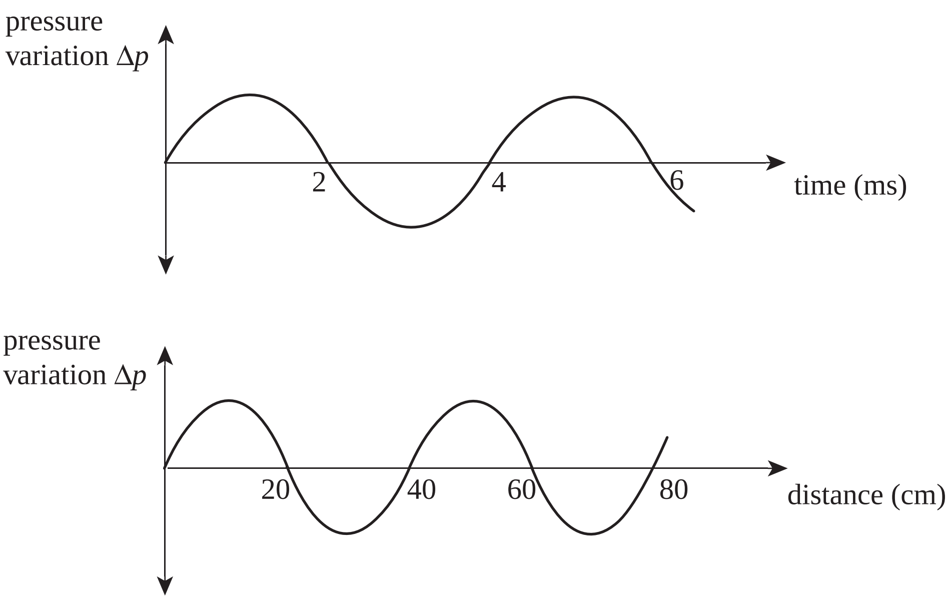


Figure 3

Question 9

The speed of sound in the unknown gas is equal to

A. 0.1 m s^{-1}

B. 10 m s^{-1}

C. 100 m s^{-1}

D. 1000 m s^{-1}

Question 10

Which of the following types of microphone operates on the principle of changing capacitance?

A. crystal

B. electret-condenser

C. velocity

D. dynamic

Question 11

In a moving coil loudspeaker, the movement of the speaker cone occurs because

A. a current is induced in the speaker coil.

B. a magnetic field is induced around the speaker coil.

C. the bar magnet inside the speaker coil is able to vary its magnetic field.

D. sound waves are incident on the cone causing it to vibrate.

A hearing test was conducted to investigate how a student responded to different frequencies of sound. The results are shown in Figure 4.

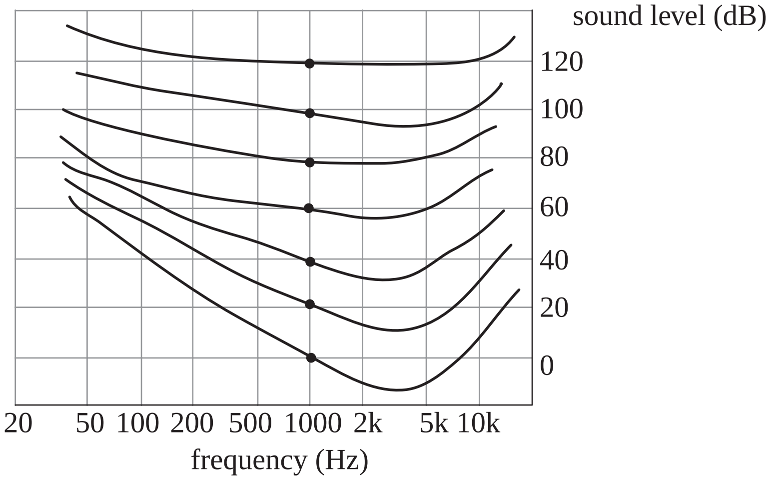


Figure 4

Question 12

The student is most sensitive to sounds with frequency

A. less than 50 Hz.

B. 1000 Hz.

C. between 2000 and 5000 Hz.

D. less than 1000 Hz and greater than 8000 Hz.

Question 13

Which of the following pairs of sounds does the student **not** identify as having the same apparent loudness?

A. 100 Hz at 40 dB and 1000 Hz at 40 dB.

B. 100 Hz at 40 dB and 50 Hz at 58 dB.

C. 50 Hz at 80 dB and 5000 Hz at 60 dB.

D. 1000 Hz at 0 dB and 8000 Hz at 0 dB.

END OF QUESTION AND ANSWER BOOKLET