Neap:

Trial Examination 2011

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	40
2. Interactions of light and matter	11	11	26
B Detailed studies			
1. Synchrotron and its applications	12	12	24
OR			
2. Photonics	12	12	24
OR			
3. Sound	12	12	24
			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 27 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 2011 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. 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}.

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

Unless otherwise indicated, diagrams are not to scale.

Areas of study **Page**

Area of study 1 – Electric power

Figure 1 shows a loudspeaker magnet from above.

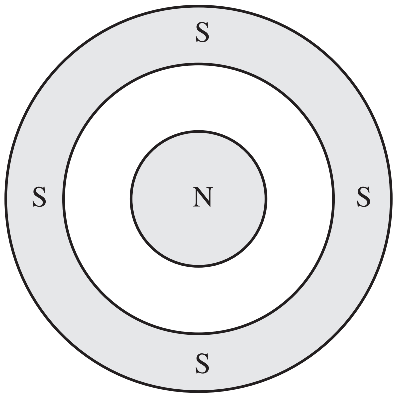


Figure 1

Question 1

On Figure 1, draw the magnetic field lines between the poles of a bass loudspeaker magnet.

1 mark

A current carrying wire (shown as a dotted line) of 200 turns is placed in the magnetic field as shown in Figure 2. This is attached to the speaker cone. The direction of the current is clockwise as shown by the arrows.

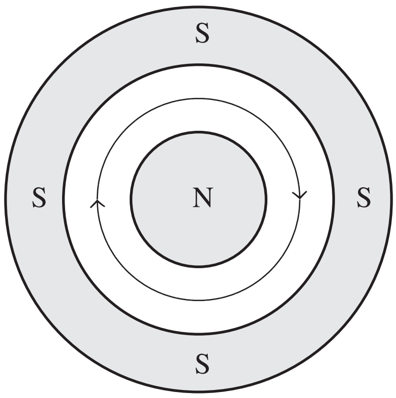


Figure 2

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

Question 3

Calculate the magnitude of the total force acting on the 200 coils of wire if the diameter of the coil shown in Figure 2 is 60 mm, the current in the wire is 0.1 A and the magnetic field is 1.0 T. Show your working.

N

3 marks

The designer of the bass loudspeaker requires a larger force to act on the speaker cone.

Question 4

Which one (or more) of the following changes would achieve this?

A. increase the current in the coil

B. increase the number of turns of wire

C. increase the strength of the magnetic field

2 marks

Chris is using a 240 VAC RMS 2400 W electric kettle to boil some water for her cup of coffee.

Question 5

Calculate the RMS current being drawn by the electric kettle. Show your working.

A

2 marks

Question 6

Calculate the resistance of the electric kettle. Show your working.

Ω

2 marks

Figure 3 shows a simplified diagram of a small working model of a DC motor consisting of 30 coils of wire connected in a rectangle shape (*PQRS*) to a 12 V DC battery. The total resistance of the coils of wire is 2.0 Ω. The length of side *PQ* = 10.0 cm and the length of side *QR* = 5.0 cm. The strength of the magnetic field is 1.0 T and runs from left to right as shown by the arrows. The design incorporates curved magnets, brushes and a split-ring commutator.

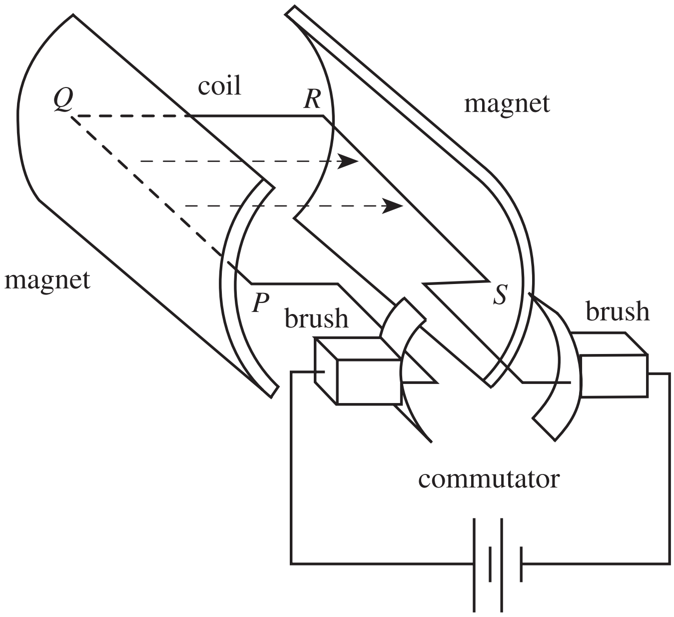


Figure 3

Question 7

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

N

2 marks

Question 8

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

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

2 marks

Question 9

Explain what function the brushes have in the DC motor.

2 marks

The DC motor shown in Figure 3 has curved magnets.

Question 10

Explain the purpose of the curved magnets in the DC motor.

2 marks

Figure 4 shows a schematic diagram of an alternating current (AC) generator. It is being rotated at 50 Hz. The strength of the magnetic field B between the poles is 1.5 T and the area of the coil is $1.2\ \text{m}^2$.

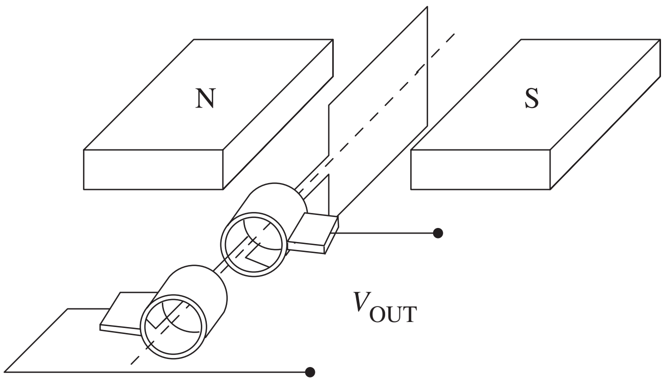


Figure 4

Question 11

Calculate the magnetic flux Φ_B for the instant shown in Figure 4. Show working and give a unit in your answer.

2 marks

Question 12

Explain the purpose of the slip-rings in an AC generator as shown in Figure 4.

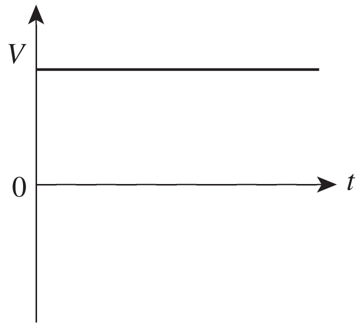
2 marks

A cathode ray oscilloscope (CRO) is attached at V_{OUT} .

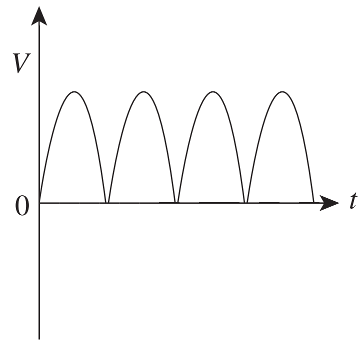
Question 13

Which of the following graphs best depicts the voltage variation of the AC generator as seen at V_{OUT} ?

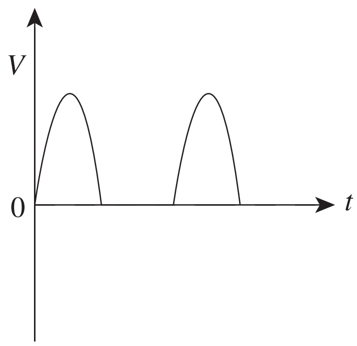
A.



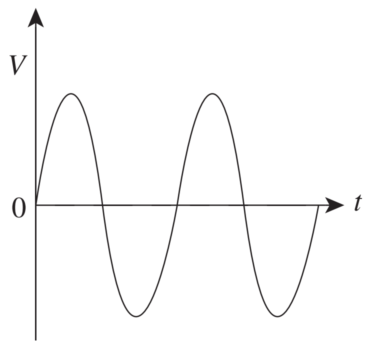
B.



C.



D.



2 marks

The two slip-rings in Figure 4 are replaced with a single split-ring commutator.

Question 14

Which of the graphs (**A**–**D**) above best depicts the voltage variation of the generator with a single split-ring commutator as seen at V_{OUT} ?

2 marks

Modern single bed electric blankets use a carbon fibre wire and work on 24 V AC. They are connected to the mains 240 V AC via a transformer. They have three different heat settings (High, Medium and Low) with the maximum power used being 60 W for maximum heating, 30 W for medium heating and 15 W for low heating. Assume the transformer is ideal.

Question 15

Calculate the current through the carbon fibre wire when the electric blanket is set on maximum heat. Show your working.

A

2 marks

Question 16

Calculate the current drawn from the mains electricity when the electric blanket is set on maximum heat. Show your working.

A

2 marks

Question 17

Calculate the total resistance of the carbon fibre wire when the electric blanket is set on maximum heat. Show your working.

Ω

2 marks

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Question 18

Yao turns his electric blanket down from the maximum heat setting (High) to the lowest heat setting (Low).

This is best achieved when the total resistance of the carbon fibre wire

A. decreases by a factor of two.

B. decreases by a factor of four.

C. increases by a factor of two.

D. increases by a factor of four.

2 marks

Transmitting electrical power over long distances involves the use of step-up and step-down transformers. Typically for a 500 MW electrical power system, the voltage used for transmission is 500 kV after it has been generated at 10 kV.

Question 19

Calculate the current in the transmission wires for a 500 MW system transmitting at 500 kV. Show your working.

kA

2 marks

Jim, an electrical engineer, suggests that the electrical power could be transmitted at 250 kV rather than 500 kV.

Question 20

Compare the power–loss ratio if the 500 mW electrical power is transmitted at 250 kV rather than 500 kV. Show your working.

2 marks

END OF AREA OF STUDY 1

Area of study 2 – Interactions of light and matter

In order to replicate Thomas Young's famous experiment investigating the interference of light, a scientist sets up an apparatus with a coherent monochromatic light source of frequency 7.8×10^{14} Hz. The light is passed through two narrow slits and the resultant interference pattern is detected on a photographic plate.

Question 1

Calculate the momentum of a photon of light of frequency 7.8×10^{14} Hz.

kg m s^{-1}

2 marks

The pattern produced on the photographic plate is shown in Figure 1. Four points on the pattern, A, B, C and D, are marked. Note that the shaded sections correspond to bright bands in the interference pattern.

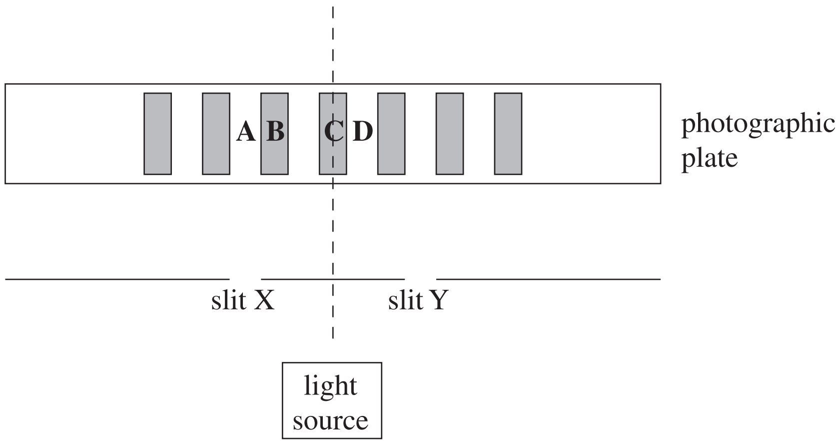


Figure 1

Question 2

At which of the points labelled, A, B, C or D, on the pattern shown in Figure 1, would the path difference (the difference in the distance from each of the slits to the point on the pattern) be equal to 5.8×10^{-7} m ? Show your working.

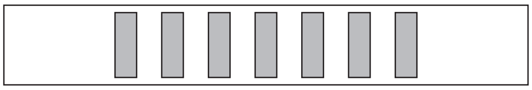
3 marks

The scientist now reduces the intensity of the monochromatic light so that only one photon is travelling between the slits and the screen at any time. The apparatus is left for a period of time until a pattern is produced on the photographic plate.

Question 3

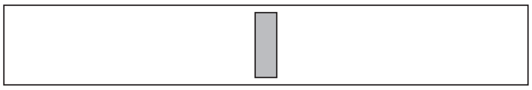
With only one photon in the apparatus at any time, which of the following patterns would you expect to be produced?

A.

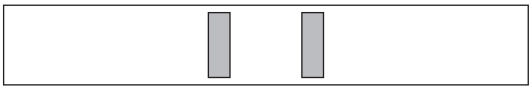


B.

C.



D.



1 mark

Question 4

Explain the reason for your choice in Question 3, referring to the appropriate model of light (wave or particle) in your explanation.

3 marks

The same light source (frequency = 7.8×10^{14} Hz) is then used to investigate another famous experiment known as the photoelectric effect. The light is incident on the surface of potassium metal, as shown in Figure 2.

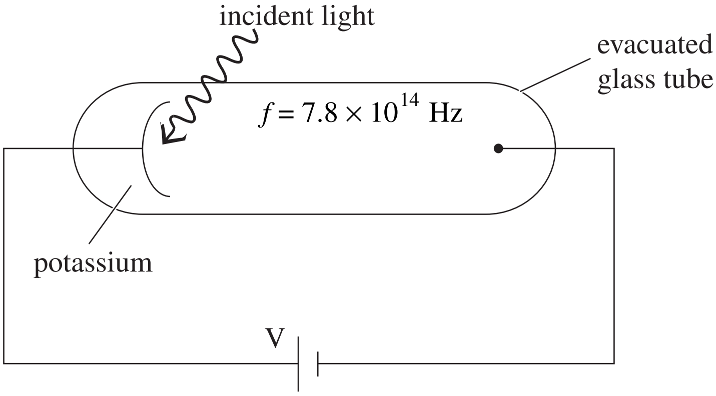


Figure 2

Photoelectrons are ejected from the potassium. In order to stop the most energetic photoelectrons, a voltage of 1.0 V is applied at V.

Question 5

Use the data provided to calculate the threshold frequency for potassium. Show your working.

Hz

3 marks

Question 6

If the frequency of the light is unchanged but the intensity is increased, would the stopping voltage increase, decrease or remain the same? Explain your answer.

3 marks

X-ray photons of a particular wavelength are passed through a crystal in order to produce a diffraction pattern, which is shown in Figure 3.

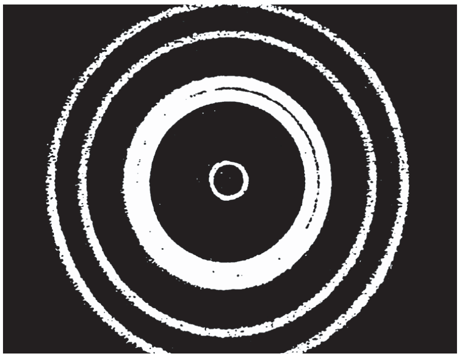


Figure 3

A 1.2 keV electron beam is then passed through the same crystal and found to produce a similar diffraction pattern.

Question 7

Calculate the speed of the electrons (ignore relativistic effects) which are incident on the crystal.

$m\ s^{-1}$

2 marks

Question 8

Calculate the wavelength of the X-ray photons used to produce the original diffraction pattern.

m

2 marks

Question 9

If the energy of the electrons was **decreased**, which of the following would be correct?

A. The wavelength of the electrons would increase so the amount of diffraction would increase.
B. The wavelength of the electrons would increase so the amount of diffraction would decrease.
C. The wavelength of the electrons would decrease so the amount of diffraction would increase.
D. The wavelength of the electrons would decrease so the amount of diffraction would decrease.

2 marks

The energy levels for a sodium ion are shown in Figure 4.

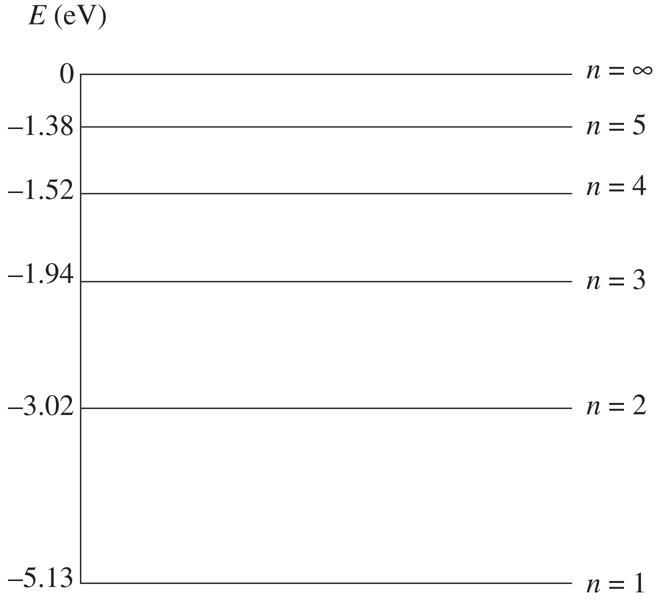


Figure 4

Question 10

Explain why a sodium ion, initially in the ground state, could not absorb a photon of light with wavelength of 3.5×10^{-7} m. Support your answer with calculations.

3 marks

Question 11

A sodium ion in an excited state emits a 1.08 eV photon.

What was the original excited energy state of the ion?

$n =$

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** 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}.

Unless indicated, diagrams are not to scale.

Detailed study **Page**

Detailed study 1 – Synchrotron and its applications

Question 1

In the Australian Synchrotron, synchrotron radiation is produced when an electron

A. accelerates in a straight line.
B. is stopped suddenly by a metal target.
C. changes direction.
D. collides with another electron.

In order to accelerate electrons in an electron gun, electrons pass between two plates 20 cm apart. The potential difference between the plates is 2000 V.

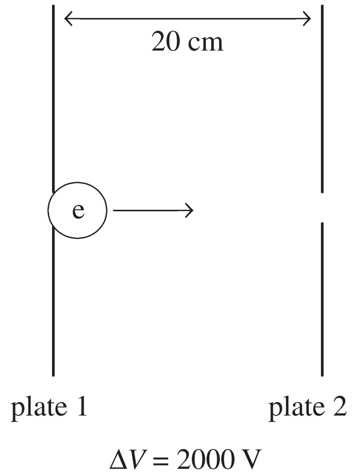


Figure 1

Question 2

The acceleration of an electron travelling between the plates in Figure 1 would be

A. 1.8×10^{7} m s^{-2}
B. 1.8×10^{13} m s^{-2}
C. 1.8×10^{15} m s^{-2}
D. 1.1×10^{34} m s^{-2}

Question 3

The electric field between the plates is equal to

A. 1.0×10^{-4} N C^{-1}
B. 100 N C^{-1}
C. 400 N C^{-1}
D. 10000 N C^{-1}

Question 4

In the Australian Synchrotron, an electron gun fires electrons into the

A. beamline.

B. booster ring.

C. linac.

D. storage ring.

Question 5

Which of the following components of the Australian Synchrotron primarily contains electromagnetic radiation rather than electrons?

A. beamline

B. booster ring

C. linac

D. storage ring

An electron travelling at 2.0×10^6 m s^{-1} to the left is placed in a magnetic field of strength 0.3 T, as shown in Figure 2. The direction of the magnetic field is to the right of the page.

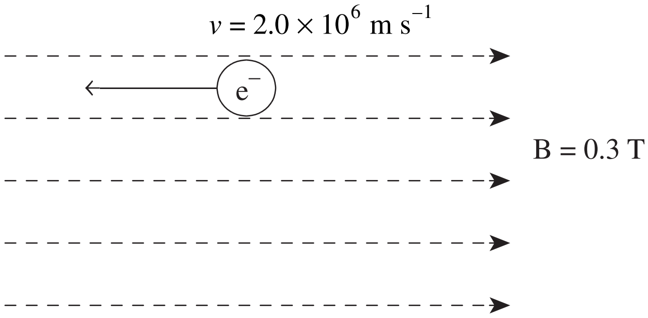


Figure 2

Question 6

The magnitude of the force on the electron due to the magnetic field is equal to

A. 0 N

B. 9.6×10^{-14} N

C. 0.3 N

D. 6.0×10^5 N

The magnetic field is now turned off and then rotated through 90°. When the field is turned back on, **the strength of the field is changed**. The electron still initially travels to the left at 2.0×10^{6} m s^{-1}.

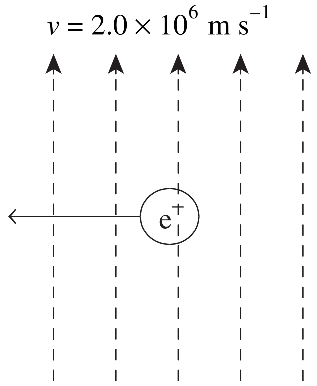


Figure 3

Once the field is turned on, the electron travels in a circular path of radius 0.15 m.

Question 7

The strength of the magnetic field is equal to

A. 0 T

B. 1.7×10^{-6} T

C. 7.6×10^{-5} T

D. 1.3×10^{4} T

Question 8

The direction of the force on the electron shown in Figure 3 is

A. down the page.

B. up the page.

C. into the page.

D. out of the page.

Question 9

Which of the following devices inserted into the storage ring would potentially produce the brightest synchrotron light?

A. bending (dipole) magnet

B. undulator

C. wiggler

D. monochromator

In an experiment to investigate the spacing between layers of atoms in a crystal, high energy X-rays produced in the Australian Synchrotron are incident on the crystal and undergo a process known as Bragg diffraction.

Question 10

For Bragg Diffraction to occur, the X-ray photons must

A. emerge from the crystal and undergo destructive interference.

B. emerge from the crystal and undergo constructive interference.

C. pass through the crystal and produce a diffraction pattern.

D. be absorbed by the crystal, which then emits photons of a different wavelength.

X-ray photons strike a crystal sample at an angle of 28° to the surface of the crystal. An intense beam of X-rays is detected emerging from the crystal, having undergone Bragg Diffraction.

Question 11

If the spacing between the atoms in the crystal is known to be 1.2×10^{-10} m, which of the following could **not** be the wavelength of the incident X-rays?

A. 2.8×10^{-11} m

B. 3.8×10^{-11} m

C. 5.6×10^{-11} m

D. All the wavelengths given in options **A**, **B** and **C**, could produce Bragg diffraction.

X-rays are incident on a material and undergo Thomson scattering.

Question 12

The X-rays which have undergone Thomson scattering will have

A. a longer wavelength than the incident X-rays.

B. a shorter wavelength than the incident X-rays.

C. the same wavelength as the incident X-rays.

D. a wavelength which could be either shorter or longer than the wavelength of the incident X-rays, depending on the angle at which they struck the target material.

END OF DETAILED STUDY 1

Detailed study 2 – Photonics

Figure 1 shows the spectrum for a particular light source.

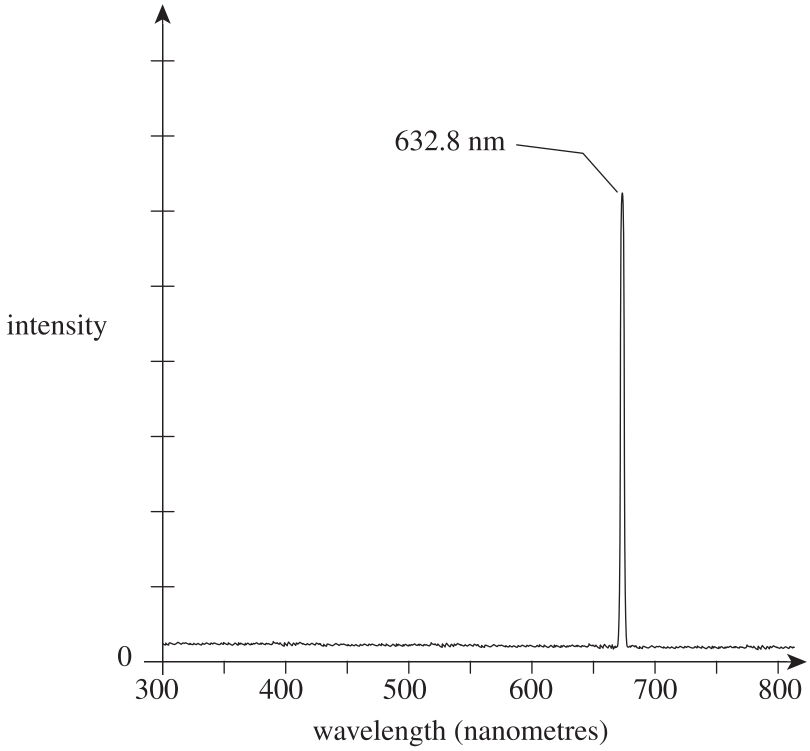


Figure 1

Question 1

The particular light source spectrum shown in Figure 1 is most likely to be produced by

A. an incandescent light bulb.

B. a fluorescent light bulb.

C. a laser.

D. the sun.

Question 2

The predominant colour produced by the particular light source spectrum shown in Figure 1 is

A. red.

B. green.

C. yellow.

D. blue.

Light-emitting diodes (LEDs) are used as light sources for bicycles. Red LEDs are used for the tail lights of a bicycle.

Question 3

Which of the following best explains how a red tail light LED produces its light?

A. spontaneous emission of electrons

B. spontaneous absorption of electrons

C. spontaneous emission of photons

D. spontaneous absorption of photons

The tail light LED is manufactured to produce light of frequency 4.62×10^{14} Hz.

Question 4

The energy gap for this tail light LED is

A. 1.84 eV
B. 1.91 eV
C. 2.24 eV
D. 2.51 eV

Optic fibres are used in international communication networks.

Question 5

Which one of the following best explains the physics principle of how an optic fibre works?

A. total internal reflection
B. total internal refraction
C. partial internal reflection
D. partial internal refraction

Question 6

Which one of the following best explains the difference between a low-order mode and a high-order mode?

A. A high-order mode makes very few internal reflections.
B. A high-order mode makes very few internal refractions.
C. A high-order mode makes many internal reflections.
D. A high-order mode makes many internal refractions.

A one step-index multimode optic fibre is made of glass of refractive index 1.51 with a cladding of refractive index 1.48.

Question 7

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

A. 68.3°
B. 76.8°
C. 78.6°
D. 89.7°

Question 8

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

A. 17.4°
B. 16.2°
C. 14.2°
D. 5.15°

Attenuation occurs in optical fibre communication systems.

Question 9

Attenuation in an optic fibre communication system is best explained as

A. the gain of optical power of the signal along the optical fibre.

B. how the signal is reflected along the optical fibre.

C. how the signal is transmitted along the optical fibre.

D. the loss of optical power of the signal along the optical fibre.

Optic fibres can be used for medical imaging.

Question 10

The purpose of a coherent optic fibre bundle as used for medical imaging is best explained as

A. the ability to allow laser light to travel through the optic fibre bundle.

B. the ability to create a precise image of the site under medical examination.

C. the ability to get light onto the site under medical examination.

D. None of the above.

Sometimes an optical fibre sensor is placed under such excessive unintentional stress that although it does not break, it has excessive bending. This can cause a significant loss of signal.

Question 11

The most likely reason for a significant loss of signal is that the optical fibre

A. cannot attenuate the light.

B. can no longer refract the light.

C. cannot totally internally reflect all of the light.

D. cannot scatter the light.

Question 12

A 633 nm laser has a power rating of 4.0 mW.

How many photons would the laser emit per second?

A. 6.4×10^{14}

B. 1.28×10^{15}

C. 1.28×10^{16}

D. 1.28×10^{17}

END OF DETAILED STUDY 2

Detailed study 3 – Sound

A 2500 Hz siren is sounded through a speaker to signal the commencement of a soccer game. Sarah, who is sitting 3.0 m from the speaker, measures the sound intensity of the siren to be 7.5×10^{-4} W m^{-2}. The speed of sound is 330 m s^{-1}. Assume that the speaker emits sound equally in all directions.

Question 1

The wavelength of the sound produced by the speaker is equal to

A. 1.2×10^{-3} m

B. 0.13 m

C. 4.4 m

D. 7.6 m

Question 2

If Sarah's sound intensity meter was to record the intensity in decibels rather than W m^{-2}, the reading on the meter would be

A. 8.9 dB

B. 31 dB

C. 75 dB

D. 89 dB

Joanne is sitting 1.0 m from the speaker which emits the sound produced by the siren.

Question 3

The sound intensity of the sound at Joanne's location is equal to

A. 8.3×10^{-5} W m^{-2}

B. 2.5×10^{-4} W m^{-2}

C. 2.3×10^{-3} W m^{-2}

D. 6.8×10^{-3} W m^{-2}

The loudspeaker used to transmit the siren sound can be modelled as a free moving cone attached to a coil of wire wrapped around a fixed magnet.

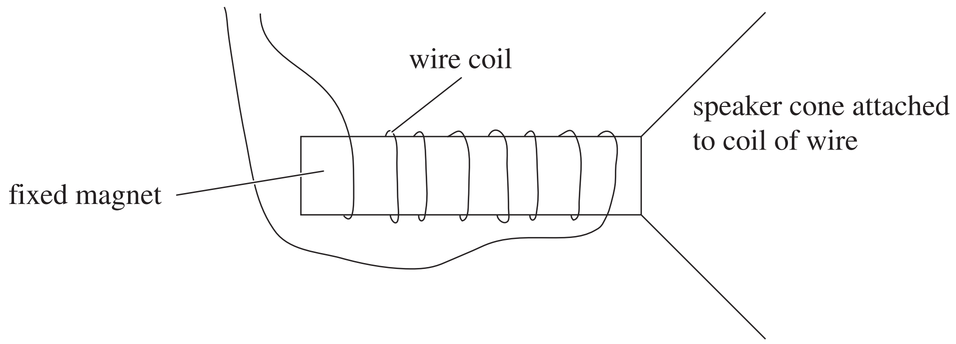


Figure 1

Question 4

The loudspeaker operates because

A. the vibration detected by the speaker cone induces a current in the coil of wire.

B. a changing magnetic field in the magnet induces a current in the coil which causes the cone to vibrate.

C. a changing current in the coil produces a magnetic field which interacts with the field of the fixed magnet, causing the coil and cone to move.

D. a constant current flowing in the coil produces a magnetic field in the magnet which attracts the coil and causes it to move.

The speaker emitting the siren sound is encased in a box (baffle) which has a small opening, sometimes called a port, in the front of it.

Question 5

The purpose of the port is to

A. enable destructive interference to occur for sound produced by the speaker at the same frequency as the resonant frequency of the baffle.

B. enable sound waves from the back of the speaker to interfere constructively with sound waves from the front of the speaker for a range of frequencies.

C. allow sound waves to diffract through the port in order to amplify the sound.

D. produce a pressure node at the front of the speaker to eliminate feedback.

Question 6

A radio commentator at the soccer match speaks into a velocity (ribbon) microphone.

This style of microphone operates due to the principles of

A. capacitance.

B. the piezoelectric effect.

C. electromagnetic induction.

D. inductance.

One of the soccer fans celebrates a goal by blowing into a 'Vuvuzela', which is a plastic horn that can be modelled as a pipe closed at one end and open at the other. The speed of sound is 330 m s^{-1} and the fundamental frequency produced by the Vuvuzela is equal to 130 Hz.

Question 7

The length of the Vuvuzela is equal to

A. 0.40 m
B. 0.63 m
C. 1.3 m
D. 2.5 m

Question 8

Which of the following frequencies could also be produced by the Vuvuzela described?

A. 65 Hz
B. 195 Hz
C. 260 Hz
D. 390 Hz

At a distance of 1.0 m from a Vuvuzela, the sound intensity level can be as high as 120 dB.

Question 9

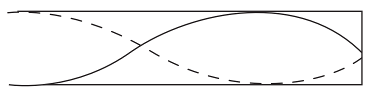
If four Vuvuzelas were played simultaneously and each instrument produced a sound of 120 dB, at a distance of 1.0 m from the instruments the sound intensity level would be

A. 126 dB
B. 129 dB
C. 240 dB
D. 480 dB

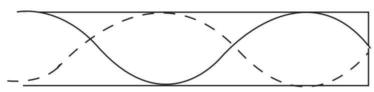
Question 10

Which of the following diagrams correctly shows the pressure variation in a Vuvuzela when the **2nd overtone** is produced?

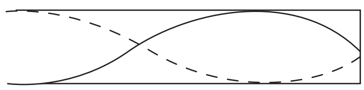
A.



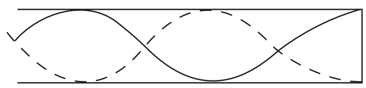
B.



C.



D.



During the soccer match, one of the teams' coaches sits in a coaching box immediately in front of the spectator stand. The coach's box is 2.5 m long. At the same, the scorer, who is in charge of the scoreboard, is located at one end of the soccer ground, as shown in Figure 2. Note that the diagram is not to scale.

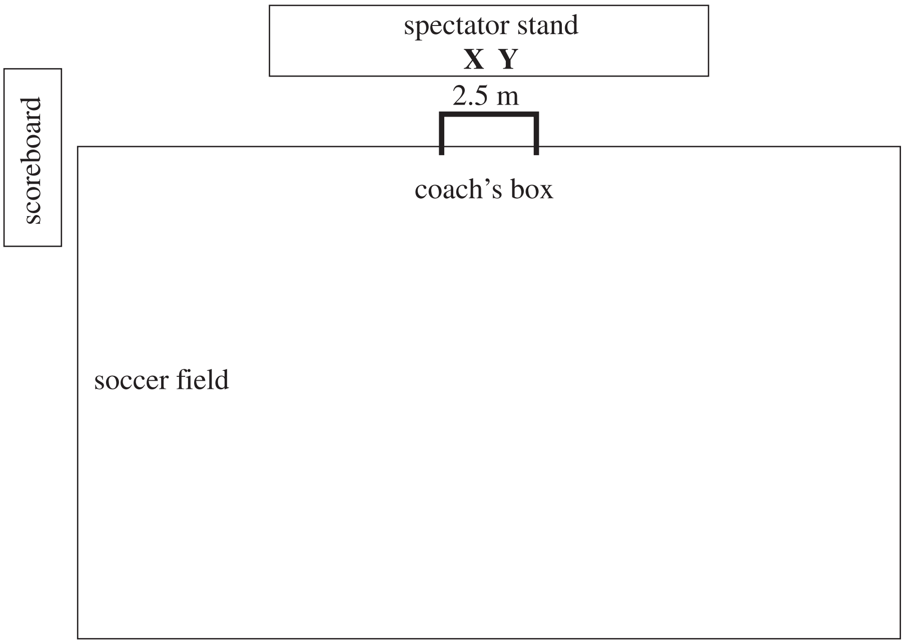


Figure 2

A spectator, at location X in the stand, uses a Vuvuzela to produce a sound of frequency 130 Hz. Immediately afterwards, the loudspeaker, in location Y, sounds the 2500 Hz siren for the end of the match. Assume that both sounds are of equal intensity.

Question 11

Which of the following best describes the relative loudness of the siren and the Vuvuzela as heard by the coach (in the coach's box) and the scorer (at the scoreboard)?

	Sounds heard by the coach	Sounds heard by the scorer
A.	The Vuvuzela and the siren will be of equal loudness.	The Vuvuzela will sound louder than the siren.
B.	The Vuvuzela will sound louder than the siren.	The siren will sound louder than the Vuvuzela.
C.	The siren will sound louder than the Vuvuzela.	The Vuvuzela will sound louder than the siren.
D.	The Vuvuzela will sound louder than the siren.	The Vuvuzela and the siren will be of equal loudness.

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Following the soccer match, Anton, a spectator, fears that he has suffered some hearing damage due to the loudness of the Vuvuzelas so he has a hearing test. Anton listens to a range of frequencies and indicates the minimum loudness at which he can detect each of the frequencies. The results of Anton's hearing test are shown in Figure 3.

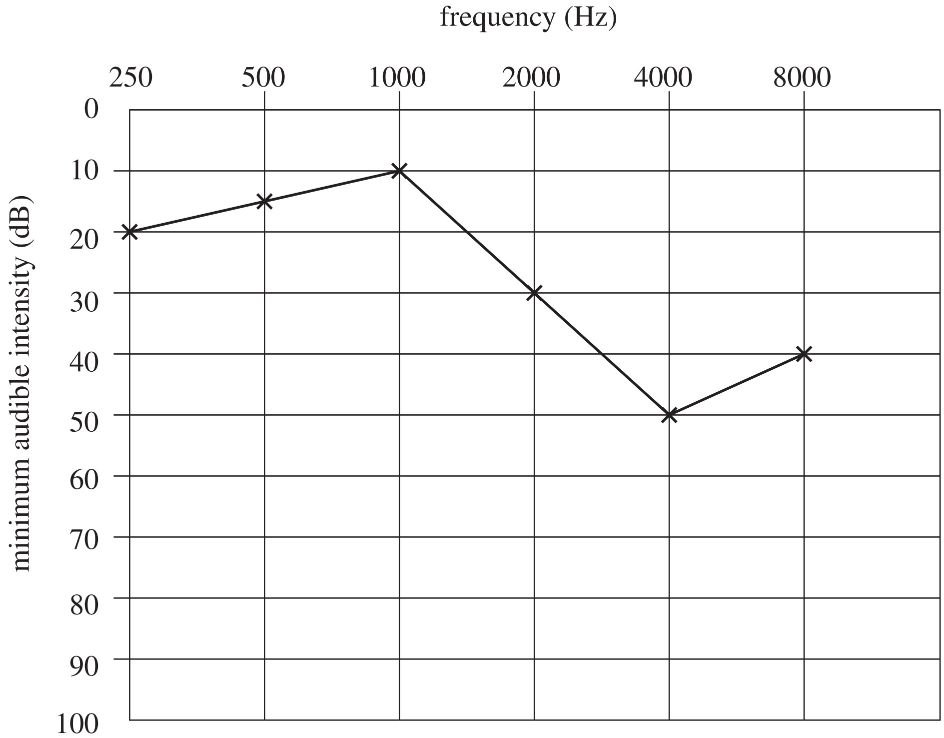

Figure 3

Question 12

Anton's hearing test indicates that he is most sensitive to sounds

A. between 250 and 1000 Hz.

B. between 1000 and 4000 Hz.

C. between 4000 and 8000 Hz.

D. less than 500 Hz and greater than 4000 Hz.

END OF QUESTION AND ANSWER BOOKLET