Student Name: _____

PHYSICS

Unit 4 – Written examination 2

2008 Trial Examination

Reading Time: 15 minutes
Writing Time: 1 hour and 30 minutes

QUESTION AND ANSWER BOOK

Structure of Book

Section	*Number of Questions*	*Number of Marks*
A – Core Areas of Study		
1. Electric Power	17	40
2. Interactions of Light and Matter	10	24
B – Detailed Studies		
1. Synchrotron and applications	13	26
OR		
2. Photonics	13	26
OR		
3. Sound	13	26
	Total 90	

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, and rulers, up to 2 pages of pre written notes and an approved **scientific calculator**.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape, graphics calculators

Materials supplied
- Question and answer book of 34 pages.

Instructions
- Print your name in the space provided on the top of this page.
- All written responses must be in English.

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

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Instructions for Section A
Answer **all** questions for **both** Areas of Study in this section of the paper.

Area of Study 1 – Electric Power

Question 1
Sketch field lines around the two bar magnets shown in **Figure 1**

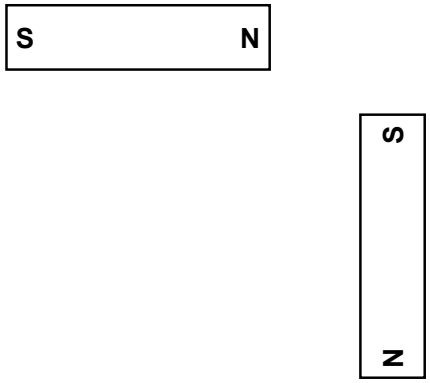

Figure 1

2 marks

Question 2
Which of the following best describes the direction of the magnetic field at **A** due to the current carrying wire shown in **Figure 2**?

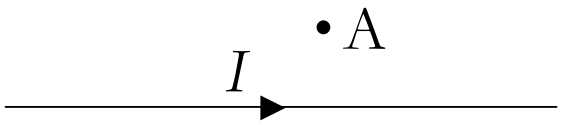

Figure 2

A	B	C	D	E
→	←	Into page	Out of page	Up

2 marks

SECTION A – AREA OF STUDY 1 – continued

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Figure 3 shows a basic DC motor.

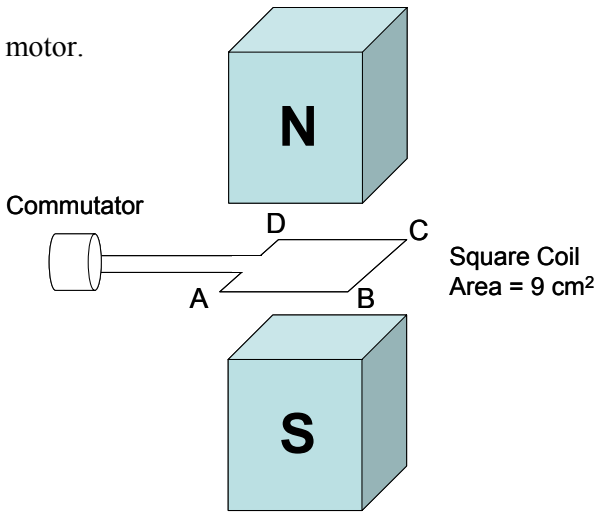

Figure 3

In the position shown, a force of $8.1\times10^{-2}\,N$ acts on side **AB**. The field strength due to the uniform field created by the magnets is 0.3 T and the current is 100 mA.

Question 3
Determine the number of loops that must be in the coil of the DC motor shown in **Figure 3.**

2 marks

Question 4
Complete **Table 1** by inserting the option which correctly describes the **changes in magnitude** of the forces and current that act on the coil when it is rotated 90^{o} from horizontal (as in **Figure 3**) to a vertical position.
(Use terminology: INCREASED / DECREASED / NO CHANGE)

Changes to the coil as it rotates from horizontal to vertical

FORCE on SIDE AB	FORCE on SIDE BC	CURRENT in SIDE AB

Table 1

3 marks

SECTION A – AREA OF STUDY 1 – continued
TURN OVER

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Brian has been given a rechargeable torch, which uses electromagnetic induction to charge a small capacitor and power an LED. A simplified sketch of the casing, coil and magnet is shown in **Figure 4**.

- A small, but strong magnet (B = 0.4 T) is shaken up and down within a circular coil (diameter = 3 cm) which is connected to a secondary circuit.
- You may assume the magnet takes 0.04 s to enter the coil moves at a constant speed.
- After 0.16 sec, the magnet has fully exited the coil.
- Flux is zero at either end (i.e. magnet clear of the coil)

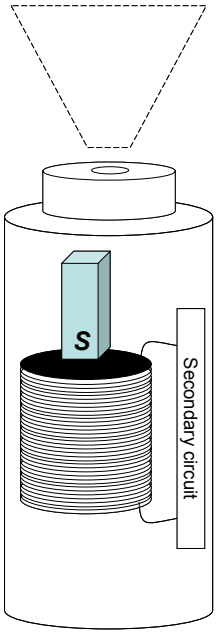
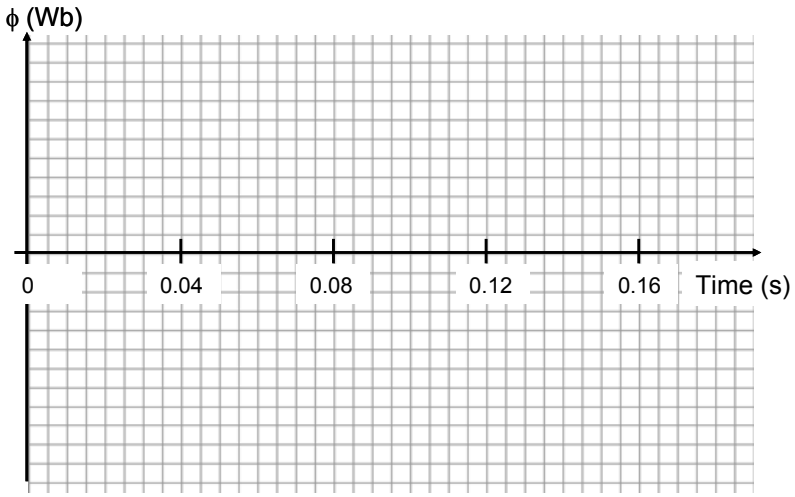


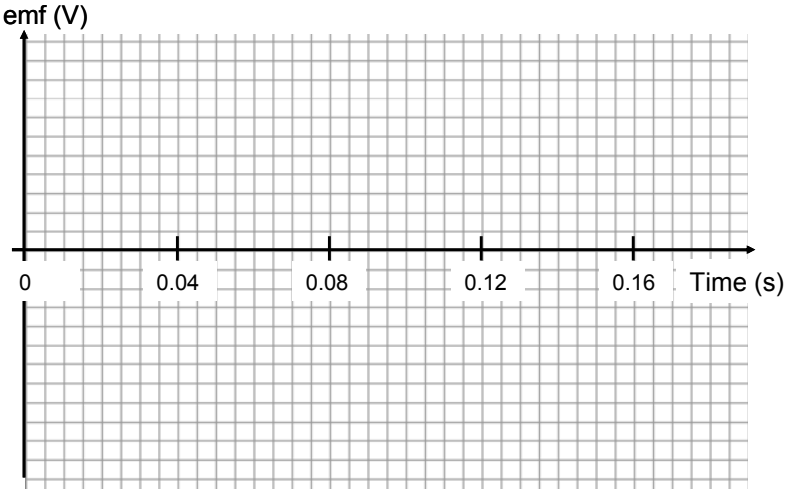
Figure 4

Question 5
Using the axes provided below, sketch a graph of flux over time as the magnet moves from the **top to the bottom** of the torch. Specify a vertical scale.



3 marks

Question 6
For the same movement from top to bottom of the coil, sketch a graph of induced voltage (emf) over time. No vertical scale is required.



2 marks

SECTION A – AREA OF STUDY 1 – continued

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As the magnet first enters the coil, the average emf over the 0.04 sec interval is 0.353 V.

Question 7
Which of the following options best approximates the number of loops in the coil?

A. 2
B. 20
C. 50
D. 250

2 marks

Question 8
Describe what would happen to the **flux** and the **emf** if the torch were shaken **more** rapidly and thus the magnet moved up and down faster inside the coil.

2 marks

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A wind turbine is modelled as a coil rotating within a magnetic field, as shown in **Figure 4**. Assume an observer is positioned at **P** and current is flowing from **A** to **B** as shown.
(NOTE: For reference purposes, a feint line indicates what the coil would look like in a vertical position)

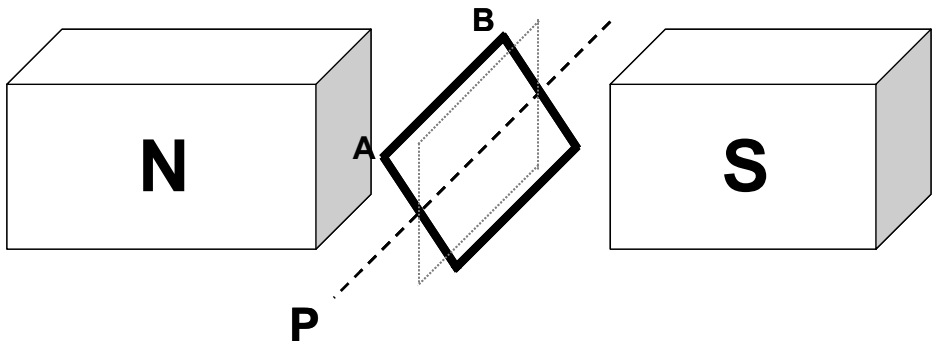

Figure 4

Question 9
Is the turbine spinning **clockwise** or **anticlockwise**? Justify your answer with reference to the principle of electromagnetic induction.

4 marks

SECTION A – AREA OF STUDY 1 – continued

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The turbine's coil is connected to an output circuit via **slip rings**.

Question 10
Explain the purpose of **slip rings** in such a circuit.

2 marks

Question 11
Is this setup an **alternator** or **generator**? Explain your answer and be sure to distinguish between these two terms.

3 marks

SECTION A – AREA OF STUDY 1 – continued
TURN OVER

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Question 12
The output circuit from the turbine leads to a step down transformer. Explain, in terms of induction, why **alternating current** is preferable to **direct current** in this situation.

2 marks

At one point, the turbine produces 2.5 kW at 400 V AC RMS. It is connected, via transmission cables (R = 4 Ω) and a step down transformer, to a small shack located 5 km away. **Figure 5** shows a basic outline of the setup.

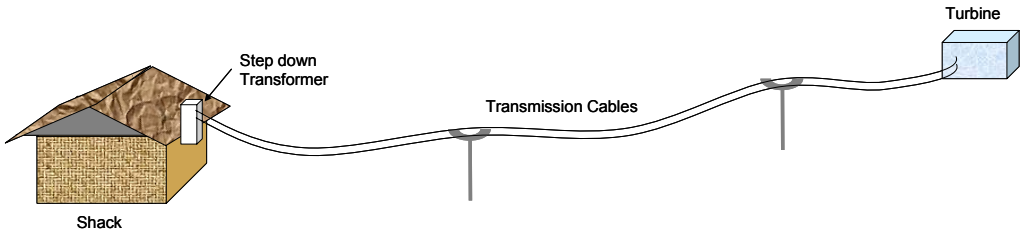

Figure 5

Question 13
Determine the value of V_{peak} at the turbine

V

2 marks

SECTION A – AREA OF STUDY 1 – continued

Question 14
Determine the value of $I_{peak\text{-}peak}$ at the turbine

A	2 marks

Question 15
Determine the voltage drop in the cables.

V	2 marks

The owner of the shack wants a 110 V AC RMS output after the step-down transformer.

Question 16
Which of the following is the most likely ratio of *primary turns : secondary turns* in the step down transformer?
A. 22 : 75
B. 541 : 110
C. 400 : 110
D. 75 : 22

	2 marks

SECTION A – AREA OF STUDY 1 – continued
TURN OVER

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The owner of the shack is disappointed to find that, when several large appliances are operating and the current in the shack is increased, the voltage falls below 110 V. Assume an ideal transformer is being used.

Question 17
Explain why the voltage drops below 110 V, despite the use of an ideal transformer.

3 marks

END AREA OF STUDY 1
SECTION A – continued

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Area of Study 2 – Light and Matter

Question 1
Choose the correct descriptors to complete **Table 1.**

Source of Light	Spectrum (Continuous/Discrete)	Nature of Phase (Coherent/Incoherent)	Electron behaviour (Thermal motion / Quantised energy level)
LASER			
Candle			
Metal Vapour Lamp			
Incandescent Globe			

Table 1

4 marks

Figure 1 shows the results of a double slit experiment, where monochromatic blue laser light is directed through a pair of closely spaced, narrow slits.

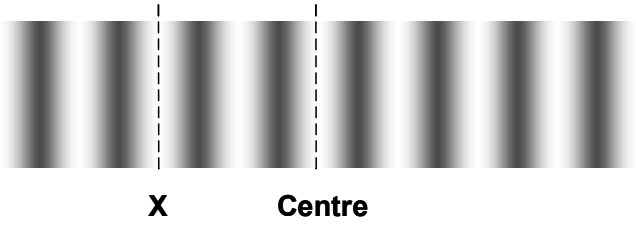

Figure 1

Question 2
Despite there being only two slits, multiple lines appear in the patter. Explain how the bright band at **X** is formed.

2 marks

SECTION A – AREA OF STUDY 2 – continued
TURN OVER

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The gap between the pair of slits is now decreased and the light is changed from **blue** to **red**.

Question 3
Which of the following best describes the **direction** that the bright band labelled **X** would appear to shift?
A. Left
B. Right
C. No shift
D. Impossible to tell

2 marks

Edward conducts an experiment to measure the diffraction of an electron beam and also X-Rays through a narrow slit. The results of his experiment are shown in **Table 2**.

Source	Extent of Diffraction
200 keV electron beam	Moderate
X-Rays (λ = 110 pm)	Significant

Table 2

Question 4
Which of the following best approximates the width of the slit being used in the experiment?
A. $1.6\times10^{-36}\,m$
B. $5\times10^{-21}\,m$
C. $2\times10^{-12}\,m$
D. $2\times10^{-10}\,m$

2 marks

SECTION A – AREA OF STUDY 2 – continued

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Question 5
In the paragraph below, circle the correct option to complete each sentence.

One of the key points of difference between the particle and wave models for light is the prediction associated with the photoelectric effect.

- According to the wave model, electrons will be ejected from the surface of a metal surface for **[some / all / none]** of the frequencies used, with **[longer / shorter]** delay for high frequencies.
- The wave model predicts an increase in the light intensity to be associated with an increase in [**electron energy / photocurrent]** and an **[increased / decreased / unchanged]** stopping voltage magnitude. This is because the energy of the wave is most related to its **[amplitude / frequency]**.
- According to the preferred particle model, an increase in the maximum photocurrent is associated with an increase in **[intensity / wavelength / frequency]**.
- The particle model also accurately predicts the existence of a threshold frequency, below which the energy of the incoming photons is **[more / less]** than the work function of the metal. The interaction of photons and electrons is a **[one-to-one / one-to-many]** event.

8 x 0.5 = 4 marks

Brian supervises a basic experiment to investigate the photoelectric effect. A violet light source (λ = 380 nm) illuminates a metal surface and photocurrent is generated. Brian records a stopping voltage of 1.3 V.

Question 6
Determine the momentum of a photon of the violet light in Jsm^{-1}.

Jsm^{-1}

2 marks

SECTION A – AREA OF STUDY 2 – continued
TURN OVER

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Question 7

Determine the momentum of the most energetic electron ejected from the metal in $kgms^{-1}$.

$kgms^{-1}$

2 marks

Question 8

Determine the threshold frequency for the metal surface in hertz.

Hz

2 marks

SECTION A – AREA OF STUDY 2 – continued

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Figure 2 is a simplified depiction of the energy levels for mercury. High voltage is applied across mercury vapour, causing its electrons to become excited.

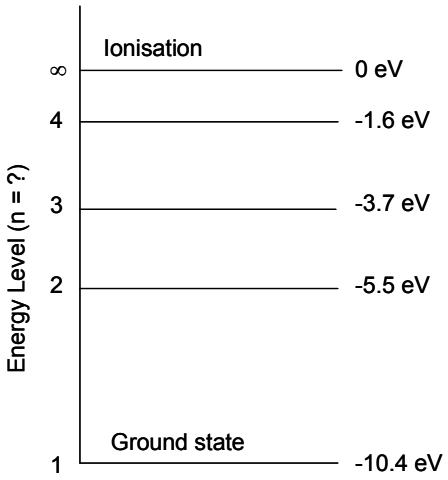

Figure 2

Question 9
Which **one or more of** the following wavelengths may be observed within the emission spectrum for the mercury?
A. 776 nm
B. 591 nm
C. 185 nm
D. 226 nm

2 marks

Question 10
Explain, with reference to **standing waves**, why there is no energy level at -4.5 eV.

2 marks

END AREA OF STUDY 2
TURN OVER

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SECTION B – Detailed Studies

Instructions for Section B

Choose **one** of the following **Detailed Studies**. Answer **all** the questions on the detailed study you have chosen, using the multiple choice answer sheet provided.

Detailed Study 1 – Synchrotron and applications

Question 1

Which of the following best describes the purpose and basic operation of the **electron gun** in a **linear accelerator**?

A. The electron gun is a device that provides free electrons for a linear accelerator. It consists of a hot wire filament with a current supplied by a very high-voltage source.

B. The electron gun is a device that provides free electrons for a linear accelerator. It consists of a ceramic resistor with a current supplied by a low-voltage source.

C. The electron gun is a device that provides free electrons for a linear accelerator. It consists of a hot wire filament with a current supplied by a low-voltage source.

D. The electron gun is a device that provides free electrons for a linear accelerator. It consists of a cold wire filament with a current supplied by a low-voltage source.

2 marks

Question 2

Which of the following best matches the voltage required to accelerate an electron to 6% of the speed of light. Ignore any relativistic effects.

A. $921\ V$

B. $1.02\times10^{-14}\,V$

C. $256\ \text{k}V$

D. $2.46\times10^{-15}\,V$

2 marks

DETAILED STUDY 1 – continued

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Question 3
Choose the answer **A-D** which isolates the terms in their correct order as you read through the paragraph below.

Electrons in the storage ring of the Synchrotron produce radiation for use in the **[linac / beamlines / booster ring]**. In **[straight / curved / all]** sections of the storage ring, electrons are accelerated by adding energy to compensate for losses when the electrons **[emit radiation / collide with remaining air particles / collide with the walls]**

A. Beamlines, straight, collide with the walls
B. Beamlines, all, emit radiation
C. Booster ring, straight, collide with air particles
D. Beamlines, straight, emit radiation
E. Linac, curved, emit radiation

2 marks

Sara is operating a small scale experiment, deflecting an electron beam with magnets. She accelerates the beam to 1% of the speed of light. The magnetic field can be assumed to be perpendicular to the path of the electrons.

Question 4

Which of the following best describes the field strength required to generate a radius of 2.1mm?

A. $2.7\times10^{-11}\,T$
B. $8.1\times10^{-3}\,T$
C. $8.1\,T$
D. $0.81\,T$

2 marks

Question 5
Which of the following best estimates the magnitude of the force on a single electron in the beam?
A. $3.9\times10^{-15}\,\text{N}$
B. $2.44\,\text{N}$
C. $3.9\times10^{-13}\,\text{N}$
D. None of the above

2 marks

DETAILED STUDY 1 – continued
TURN OVER

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In order for the Synchrotron to be applied to a range of different scientific and industrial applications, its **beamlines** must act as a **tuneable** source of radiation.

Question 6
Which of the following best describes the terms **tuneable** in the context of the **beamlines** in the Synchrotron?

A. **Tuneable** implies that researchers are able to use the monochromator to select radiation of various frequencies (i.e. energies) as applications of the Synchrotron require different photon energies.
B. **Tuneable** implies that researchers are able to use the beamlines to select radiation of a specific frequency (i.e. energy) as various applications of the synchrotron require different photon energies.
C. **Tuneable** implies that researchers are able to use the monochromator to select radiation of a specific frequency (i.e. energy) as all applications of the synchrotron require the same photon energy
D. **Tuneable** implies that researchers are able to use the monochromator to select radiation of a specific frequency (i.e. energy) as various applications of the synchrotron require different photon energies.

2 marks

Precisely cut silicon crystals are used in monochromators to diffract incoming X-rays at different angles. The crystals are spaced at 543.09 nm and the X-rays can be assumed to be at 1.5 keV.

Question 7
Choose the answer that best matches the glancing angle (θ) at which the X-rays would leave the crystal (assuming first order Bragg Diffraction)

A. 8.74×10^{-20}
B. 7.62×10^{-40}
C. 4.37×10^{-20}
D. 1.52×10^{-40}

2 marks

DETAILED STUDY 1 – continued

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Table 1 briefly explains one advantage for three characteristics of Synchrotron radiation.

#	Characteristic	Advantage when compared to regular X-Rays
1		Allows shorter exposure time or allows selection of a monochromatic beam (which is bright enough alone) for clearer images.
2		Eliminates interference effects associated with multiple photons out of phase.
3		Remains very accurate – a sharp spot on the target.

Table 1

Question 8
Identify the correct characteristics that best matches the advantages described for Item 1 in **Table 1**
A. Extremely bright
B. Coherent
C. Low divergence
D. Tuneable

2 marks

Question 9
Identify the correct characteristics that best matches the advantages described for **Item 2 in Table 1**
A. Extremely bright
B. Coherent
C. Low divergence
D. Tuneable

2 marks

DETAILED STUDY 1 – continued
TURN OVER

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The following information refers to Questions 10, 11 & 12

Table 2 lists several characteristics of X-ray scattering.

Item	Characteristics
1	Scattered photons have longer wavelength and lower energy
2	Direction of scattering is determined by Bragg's Law
3	Diffraction pattern is broadened due to increased temperature
4	Momentum is conserved during the scattering process

Table 2

Question 10
Which of the following correctly matches the items in **Table 2** with **Compton Scattering?**
A. 1, 3 & 4
B. 1 & 2
C. 2 & 3
D. 1 & 4

2 marks

Question 11
Which of the following correctly matches the items in **Table 2** with **Diffuse Scattering?**
A. 2, 3 & 4
B. 1, 2 & 4
C. 1, 2 & 3
D. 1, 3 & 4

2 marks

Question 12
Which of the following correctly matches the items in **Table 2** with **Thomson Scattering?**
A. 2 & 4
B. 1, 2 & 4
C. 1, 2 & 3
D. 2, 3 & 4

2 marks

DETAILED STUDY 1 – continued

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Ben is trying to replicate Arthur Compton's 1922 work with X-rays and graphite. An X-ray of frequency 2.5 x 10^{18} Hz is directed towards the graphite and rebounds with frequency of $2.34 \times 10^{18}\ Hz$.

Question 13

Which of the following is the best estimate of the speed of the electron which is knocked forward by the X-ray?

A. $1.4 \times 10^{8}\ \text{ms}^{-1}$

B. $2.34 \times 10^{14}\ \text{ms}^{-1}$

C. $1.53 \times 10^{7}\ \text{ms}^{-1}$

D. $1.39 \times 10^{8}\ \text{ms}^{-1}$

2 marks

END OF DETAILED STUDY 1
SECTION B – continued
TURN OVER

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Detailed Study 2 – Photonics

Question 1
Which of the following best explains the difference between the **valence** and **conduction** band of a material.

A. The valence band is the lowest natural energy band of a material. The conduction band is the level at which electrons are able to flow as current. The energy or band gap is the difference in energy between these two bands.
B. The valence band is the lowest natural energy band of a material. The conduction band is the level at which electrons are able to flow as current. The energy or band gap is the sum of the energy between these two bands.
C. The valence band is the highest natural energy band of a material. The conduction band is the level at which protons are able to flow as current. The energy or band gap is the difference in energy between these two bands.
D. The valence band is the highest natural energy band of a material. The conduction band is the level at which electrons are able to flow as current. The energy or band gap is the difference in energy between these two bands.

2 marks

Question 2
Which of the following best estimates the wavelength of a 1.34 eV indium phosphide LED?

A. 927 nm
B. 9.27 nm
C. 224 nm
D. 1.48 nm

2 marks

Question 3
Which of the following is **LEAST** affected by modal dispersion?

A. Large diameter, step-index, multimode fibre
B. Large diameter, graded-index, single-mode fibre
C. Small diameter, graded-index, multimode fibre
D. Small diameter, graded-index, single-mode fibre

DETAILED STUDY 2 – continued

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Question 4

Which of the following best explains the process of amplification as used in a LASER source?

A. **Amplification** (also called stimulated emission) is the process where atoms are stimulated to release their energy (as photons) by interacting with a photon of different energy. The term amplification is used because one photon produces many identical photons.

B. **Amplification** (also called stimulated emission) is the process where atoms are stimulated to release their energy (as photons) by interacting with a photon of the same energy. The term amplification is used because one photon produces a photon of considerably larger energy.

C. **Amplification** (also called stimulated emission) is the process where atoms are stimulated to release their energy (as photons) by interacting with a photon of the same energy. The term amplification is used because one photon produces many identical photons.

D. **Amplification** (also called stimulated emission) is the process where photons are stimulated to release their energy (as photons) by interacting with a photon of the same energy. The term amplification is used because one photon produces a photon of considerably larger energy.

2 marks

The following information refers to Questions 5 & 6

Figure 1 shows a simplified schematic diagram for a section of optic fibre.

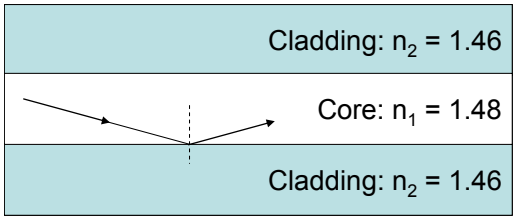

Figure 1

Question 5

Which of the following best approximates the critical angle (i_c) for the fibre?

A. 43.2°

B. 1.4°

C. 80.6°

D. Undefined – there is no critical angle for this section.

2 marks

DETAILED STUDY 2 – continued
TURN OVER

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The designers of the fibre shown in **Figure 1** wish to **change the core** to a **new** refractive index of 1.46.

Question 6

If the acceptance angle must be 14°, which of the following best estimates the numerical aperture?

A. 0.241
B. 0.242
C. 0.990
D. 4.096

2 marks

Question 7

If the acceptance angle must be 14°, which of the following would be the most appropriate new refractive index for the cladding?

A. 2.07
B. 1.44
C. 1.46
D. 1.89

2 marks

Question 8

Which of the following best describes the difference between a **coherent** and **incoherent** bundle of optic fibre?

A. A **coherent** and a **incoherent** bundle are both arranged carefully so that clear images can be transmitted and received, however a **coherent** bundle uses much brighter light.
B. A **coherent** and an **incoherent** bundle are both arranged carefully so that clear images can be transmitted and received, but the incoherent bundle uses less pure glass and is less efficient.
C. A **coherent** bundle is arranged carefully so that clear images can be transmitted and received, while an **incoherent** bundle simply carries a light source to illuminate a dark space – no images are required
D. An **incoherent** bundle is arranged carefully so that clear images can be transmitted and received, while an **coherent** bundle simply carries a light source to illuminate a dark space – no images are required

2 marks

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Question 9

Which of the following best describes how a coherent and incoherent optic fibre bundle could both be used during the investigation of a collapsed building.

A. In the case of a collapsed building, the incoherent bundle could provide the light source for a coherent bundle to be used to transmit and identify images of objects that may be hard to reach by rescuers

B. In the case of a collapsed building, the coherent bundle could provide the light source for a incoherent bundle to be used to transmit and identify images of objects that may be hard to reach by rescuers

C. In the case of a collapsed building, both bundles could be used to transmit images of objects that might be hard to reach by investigators.

D. In the case of a collapsed building, neither bundles could be used to transmit images of objects that might be hard to reach by investigators, but laser light sources would provide good working conditions for the rescuers.

2 marks

Question 10

Which of the following best explains why **single** mode fibres are preferred to **multi-mode** fibres for long distance telecommunication applications?

A. Single mode fibres eliminate material dispersion by restricting the light to one path only. In contrast, multi-mode fibres suffer from considerable material dispersion as different paths lead to delays in signals arriving over longer distances and thus reduced bandwidths for telecommunication systems. Thus, single mode fibres are preferred.

B. Single mode fibres eliminate material dispersion by restricting the light to one path only. Multi-mode fibres suffer from less material dispersion, but are far too expensive over longer distances. Thus, single mode fibres are preferred.

C. Single mode fibres eliminate modal dispersion by restricting the light to one path only. In contrast, multi-mode fibres suffer from considerable modal dispersion as different paths lead to delays in signals arriving over longer distances and thus reduced bandwidths for telecommunication systems. Thus, single mode fibres are preferred.

D. Single mode fibres eliminate modal dispersion by restricting the light to one path only. Multi-mode fibres suffer from less modal dispersion as there many different paths increase the potential bandwidth of the system. However, material dispersion is far greater for multi-mode fibres, so single mode fibres are preferred.

2 marks

DETAILED STUDY 2 – continued
TURN OVER

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The following information refers to Question 11, 12 & 13

Figure 2 shows a graph of attenuation versus wavelength for a particular optic fibre design.

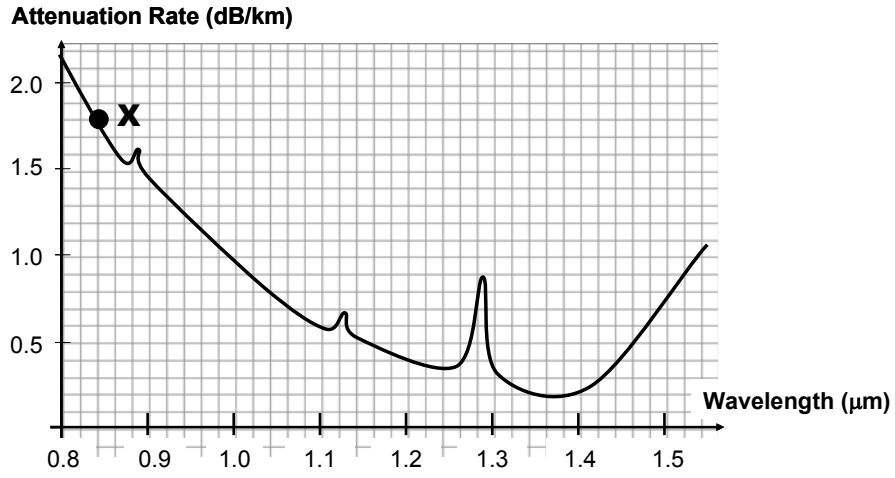

Figure 2

Question 11
Which type of losses is more significant **at Point X** on **Figure 2**?
A. Rayleigh Scattering
B. Absorption
C. Both Rayleigh Scattering and Absorption are equally significant
D. The attenuation is purely random

2 marks

Question 12
Which of the following best approximates the total optical loss for a 10 km section of fibre carrying laser light where the photons have energy of 1.04 eV?
A. 0.4 dB
B. 10 dB
C. 4 dB
D. Insufficient data given on the graph to make an estimate.

2 marks

DETAILED STUDY 2 – continued

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Question 13
Which of the following best explains the difference between attenuation due to **Rayleigh Scattering** compared to **Absorption**?

A. **Rayleigh scattering** is the attenuation effect caused by the scattering of light from small core imperfections. It is more pronounced for shorter wavelengths. **Absorption** is the attenuation due to the absorption of optical energy by impurities in the fibre (e.g. metal ions and hydroxyl ions). This is most significant at longer wavelengths, where the resonance of silicon dioxide molecules is particularly evident.
B. **Absorption** is the attenuation effect caused by the scattering of light from small core imperfections. It is more pronounced for shorter wavelengths. **Rayleigh scattering** is the attenuation due to the absorption of optical energy by impurities in the fibre (e.g. metal ions and hydroxyl ions). This is most significant at longer wavelengths, where the resonance of silicon dioxide molecules is particularly evident.
C. **Rayleigh scattering** is the attenuation effect caused by the scattering of light from small core imperfections. It is more pronounced for longer wavelengths. **Absorption** is the attenuation due to the absorption of optical energy by impurities in the fibre (e.g. metal ions and hydroxyl ions). This is most significant at shorter wavelengths, where the resonance of silicon dioxide molecules is particularly evident.
D. Both **Rayleigh scattering** and **absorption** are attenuation effects caused by the scattering of light from small core imperfections. Rayleigh scattering is most significant at shorter wavelengths, where the energy of the laser light is lower. Absorption is more significant at longer wavelengths where there are fewer impurities.

2 marks

END OF DETAILED STUDY 2
SECTION B – continued
TURN OVER

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Detailed Study 3 – Sound

A lit candle is placed a short distance in front of a speaker which is delivering a constant signal of 40 Hz, as shown in **Figure 1**.

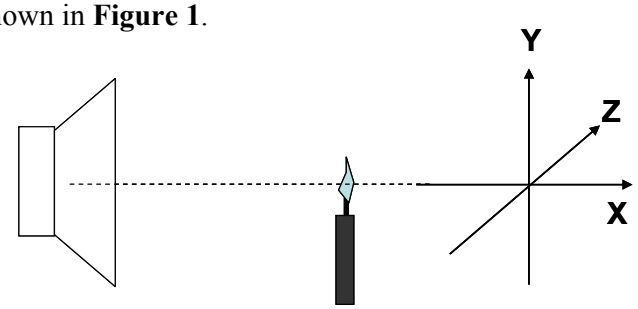

Figure 1

Question 1

Which of the following best describes the motion of the flame as the speaker operates?

A. Oscillations at 40 Hz parallel to the X-axis, which is evidence of the transverse nature of sound waves.

B. Oscillations at 40 Hz parallel to the Y-axis, which is evidence of the transverse nature of sound waves.

C. Oscillations at 40 Hz parallel to the Z-axis, which is evidence of the longitudinal nature of sound waves.

D. Oscillations at 40 Hz parallel to the X-axis, which is evidence of the longitudinal nature of sound waves.

E. Oscillations at 40 Hz parallel to the Y-axis, which is evidence of the longitudinal nature of sound waves.

2 marks

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Svetlana connects a signal generator to an amplifier and a small loudspeaker, as well as a Cathode Ray Oscilloscope (CRO) to obtain a visual representation of the sound. The CRO display is shown in **Figure 2.** Assume the speed of sound is 340 ms^{-1} in the testing lab.

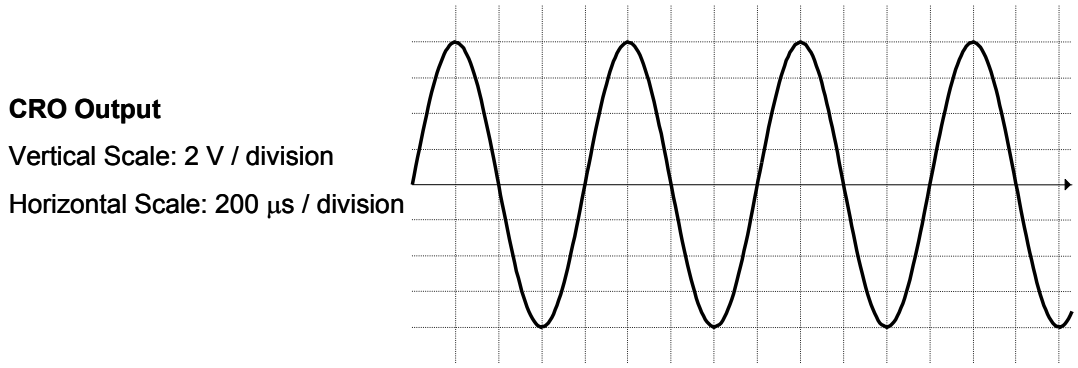

Figure 2

Question 2
Referring to the CRO Output from **Figure 2**, which of the following best estimates the frequency of the source?
A. 1250 Hz
B. 800×10^{-6} Hz
C. 0.27 Hz
D. 3.7 Hz

2 marks

Question 3
Referring to the CRO output from **Figure 2** and lab conditions, which of the following is the best estimate for the wavelength of the source in air.
A. 1250 m
B. 2.7×10^{5} m
C. 0.27 m
D. 3.7 m

2 marks

DETAILED STUDY 3 – continued
TURN OVER

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Svetlana now adjusts the signal generator to a frequency of 3900 Hz and positions the speaker behind a barrier with a small gap (0.15 m) cut in it, as shown in **Figure 3**. The dotted lines indicate the centre of the speaker and a semi-circle centred at the gap. Points A and B are equidistant from the centre of the gap and an observer records the loudness of the sound to be greater at A than at B.

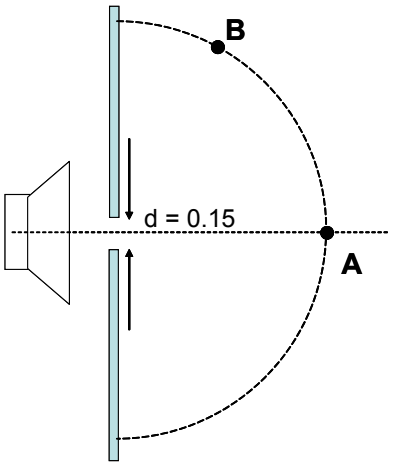

Figure 3

Question 4

Which of the following is the most likely observation of the loudness at A and B?

A. The observer will record the sound as louder at Point B than at Point A
B. The observer will record the sound as louder at Point A than at Point B
C. The observer will record the same loudness at Point B and Point A
D. Impossible to predict with the information given

2 marks

Question 5

Which of the following best explains the variations in loudness between A and B?

A. The observation of reduced loudness at A is due to a lack of diffraction through the gap. The test ratio of λ/w is greater than 1, so there would only be moderate diffraction of the sound wave through the gap and thus less intense sound at A.
B. The observation of reduced loudness at B is due to a lack of diffraction through the gap. The test ratio of λ/w less than 1, so there would only be moderate diffraction of the sound wave through the gap and thus less intense sound at B.
C. The observation of reduced loudness at B is due to significant diffraction through the gap. The test ratio of λ/w is less than 1, so there would only be significant diffraction of the sound wave through the gap and thus less intense sound at B.
D. Diffraction through the gap is not significant and thus there would be no observable difference in sound intensity level at A and B

2 marks

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The following information refers to Questions 6 to 8

A string vibrates above a semi-filled bottle of water as shown in **Figure 4**. The water level is adjusted until the bottle resonates. A nearby frequency analyser records a fundamental frequency of 560 Hz.

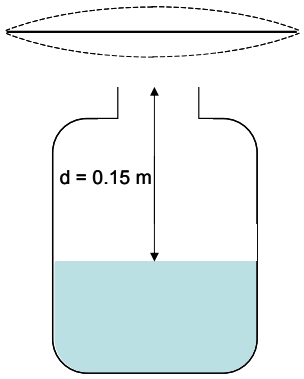

Figure 4

Question 6

Which of the following best describes the resonance that is occurring inside the bottle?

A. Sound waves from the string enter the bottle and refract at the water surface. As they return, they interact (superimpose) with further incoming pulses. If the wavelength (top of bottle to water) is suitable, a moving wave will result. The amplitude of this wave is half that of the original waves and thus a louder *resonant frequency* is heard.

B. Sound waves from the string enter the bottle and reflect off the water surface. If the amplitude of the incoming wave is large enough, a resonant frequency is heard.

C. Sound waves from the string enter the bottle and reflect off the water surface. If the amplitude of the reflected wave is large enough, a resonant frequency is heard.

D. Sound waves from the string enter the bottle and reflect off the water surface. As they return, they interact (superimpose) with further incoming pulses. If the wavelength (top of bottle to water) is suitable, a standing wave will result. The amplitude of this standing wave is double that of the original waves and thus a louder *resonant frequency* is heard.

2 marks

Question 7

Assuming 560 Hz is the fundamental frequency, which of the following is the best estimate of the speed of sound in the air within the bottle?

A. 0.6 ms^{-1}

B. 933 ms^{-1}

C. 330 ms^{-1}

D. 336 ms^{-1}

2 marks

DETAILED STUDY 3 – continued
TURN OVER

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Question 8
Which **one or more** of the following frequencies could also resonate with the water at the same level?
A. 280 Hz
B. 1120 Hz
C. 1680 Hz
D. 2800 Hz

2 marks

Question 9
Which of the following describes the operation of a velocity (ribbon) microphone?

A. A velocity microphone transforms sound into an electrical signal using the variation in resistance caused by pressure changes on a small sample of carbon dust.
B. A velocity microphone transforms sound into an electrical signal using the induced voltages created when a coil (attached to a cone) moves within a radial magnetic field.
C. A velocity microphone transforms sound into an electrical signal using the induced voltages across a metal ribbon, which vibrates due to the motion (velocity) of air particles. The metal ribbon is very thick and inflexible to allow for sensitive response to vibrations.
D. A velocity microphone transforms sound into an electrical signal using the induced voltages across a metal ribbon, which vibrates due to the motion (velocity) of air particles. The metal ribbon is very thin a flexible to allow for sensitive response to vibrations.

2 marks

The following information refers to Questions 10 & 11

A decibel meter located 1.5 m from an emergency siren atop a fire station tower records a sound intensity level of 127 dB

Question 10
Which of the following is the best estimate for the sound intensity 1.5 m from the siren.
A. 1.27 Wm^{-2}
B. 3.2 Wm^{-2}
C. 5 Wm^{-2}
D. 1.5 Wm^{-2}

2 marks

DETAILED STUDY 3 – continued

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Barry sits comfortably in his banana lounge in a garden adjacent to the fire station. His decibel meter records a sound intensity level of 105 dB.

Question 11
Which of the following best matches the straight line distance that Barry must be from the siren?
A. 19 m
B. 23.5 m
C. 1.8 m
D. 11 m

2 marks

Question 12
Which of the following best explains how the inclusion of an **enclosure** will improve the **fidelity** of a loudspeaker?
A. An enclosure reduces the constructive interference effects that occur when out of phase sound waves interact at the edge of a speaker. Reducing this constructive interference improves the fidelity of the speaker by allowing it to more accurately reproduce the original sound as intended by the input signal.
B. An enclosure reduces the destructive interference effects that occur when out of phase sound waves interact at the edge of a speaker. Reducing this destructive interference improves the fidelity of the speaker by allowing it to more accurately reproduce the original sound as intended by the input signal.
C. An enclosure reduces the destructive interference effects that occur when in phase sound waves interact at the edge of a speaker. Reducing this destructive interference decreases the fidelity of the speaker by allowing it to more accurately reproduce the original sound as intended by the input signal.
D. An enclosure reduces the constructive interference effects that occur when out of phase sound waves interact at the edge of a speaker. Reducing this constructive interference improves the fidelity of the speaker by allowing it to less accurately reproduce the original sound as intended by the input signal.

2 marks

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Figure 5 shows a set of phon curves for a typical adult.

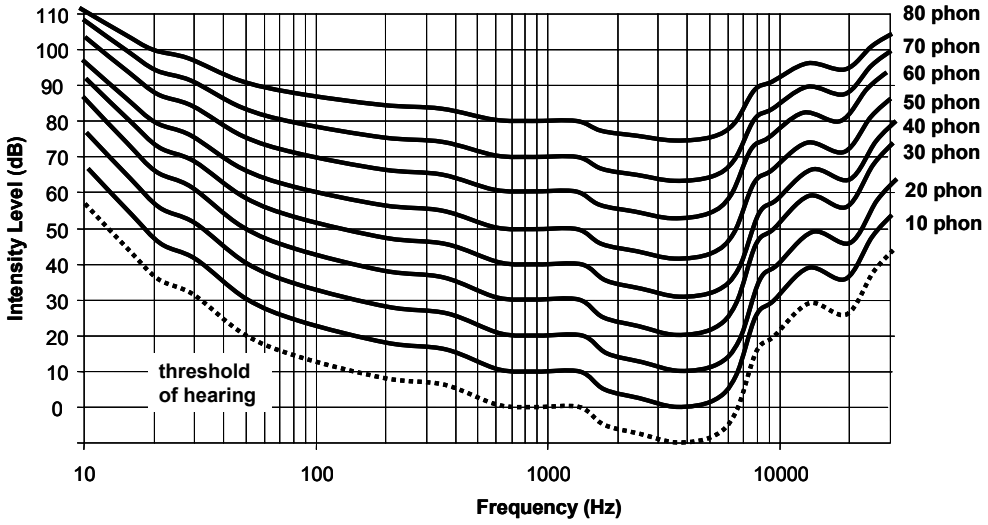

Figure 5

Question 13

According to **Figure 5**, which of the following pairs of points would sound equally loud?

A. (60 dB at 30 Hz) and (40 dB at 700 Hz)
B. (60 dB at 30 Hz) and (42 dB at 30 Hz)
C. (70 dB at 40 Hz) and (70 dB at 100 Hz)
D. (80 dB at 80 Hz) and (70 dB at 900 Hz)

2 marks

END OF QUESTION AND ANSWER BOOK

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