**Student Name:** ____________________

# PHYSICS

## Unit 4 – Written examination 2

## 2009 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 | 12 | 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 35 pages (including a multiple choice answer sheet for **Section B**).

**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.**

## SECTION A – Core

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

## Area of Study 1 – Electric Power

Figure 1 shows a single loop of wire powered by a battery.

**Question 1**
Use appropriate symbols to indicate the direction of the magnetic field. Be sure to clearly indicate the field both inside **and** outside of the loop.

3 marks

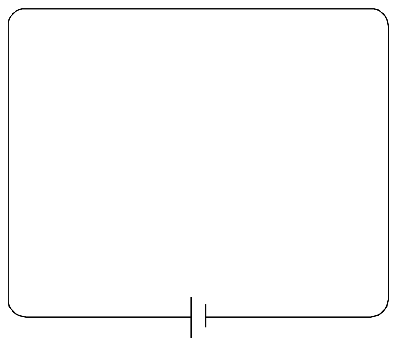


**Figure 1**

Jacky places a section of current carrying wire adjacent to the loop as shown in Figure 2. The current through the new section is 2.5 A and it is 4 cm in length. The magnitude of the field in the region of the wire is $2.0 \times 10^{-2}$ T.

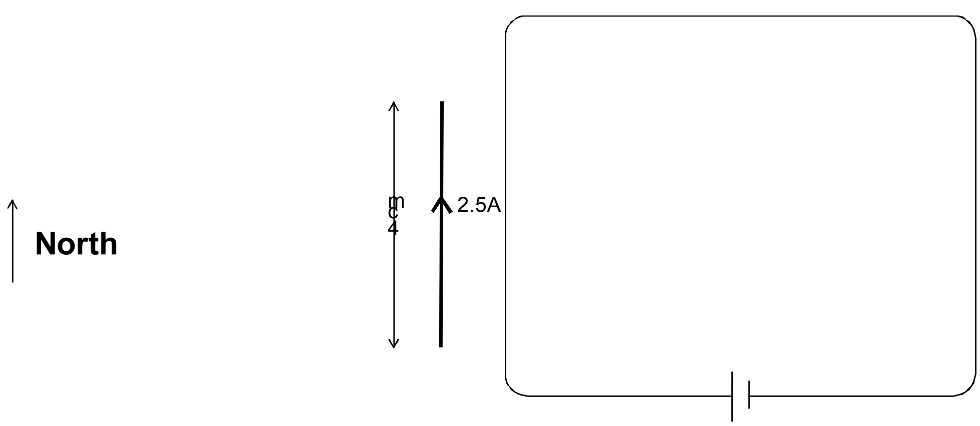



**Figure 2**

**SECTION A – AREA OF STUDY 1** – continued

**Question 2**
Determine the magnitude and direction of the force acting on the wire.

| N | **Direction:** |
|---|---|

2 marks

Emma now rotates the wire 90°, so that the current is now directed into the page as shown in Figure 3.

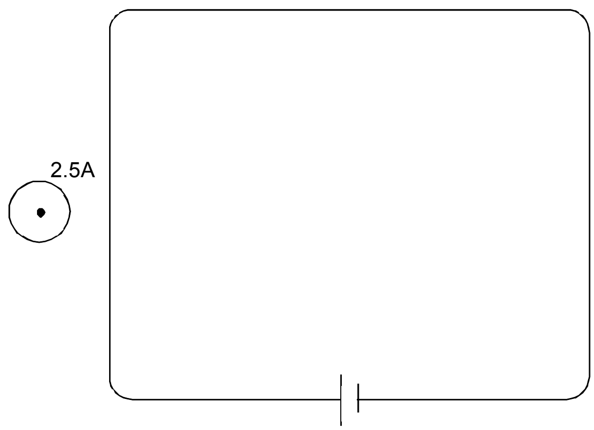



**Figure 3**

**Question 3**
Determine the magnitude of the force on the wire.

| N |
|---|

2 marks

**SECTION A – AREA OF STUDY 1** – continued
**TURN OVER**

Winston has constructed a DC motor as shown in Figure 4. He wants it to rotate **clockwise** as shown.

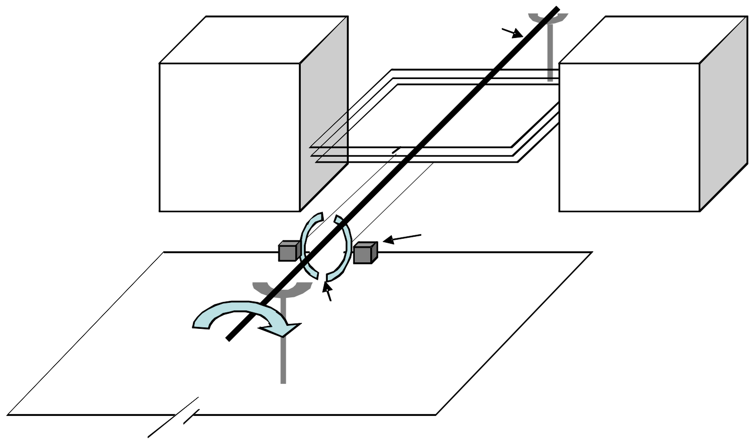


**Figure 4**

**Question 4**

If the current flows clockwise around the coil (as viewed from above), determine which of the magnets A and B should be the North and South poles.

| **A:** | **B:** |
|---|---|
| | |

2 marks

**Question 5**

Explain why a **commutator** is essential for the effective operation of a DC motor.

3 marks

**SECTION A – AREA OF STUDY 1** – continued

Dean now rearranges the setup **by** removing the battery and replacing it with a CRO. He measures the coil to be 5cm x 5cm and measures the magnetic field as 3.0 x $10^{-2}$ T. There are 20 turns in the coil. The resulting generator is shown in Figure 5.

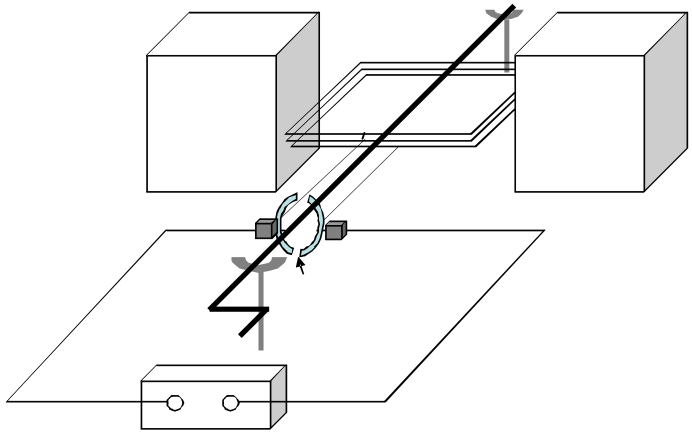


**Figure 5**

**Question 6**
Calculate the magnitude of the flux through the coil while positioned as shown in Figure 5.

| **Wb** |
|---|

2 marks

Dean now rotates the coil 90° in an anti-clockwise direction, taking 0.5 sec.

**Question 7**
Calculate the magnitude of the flux through the coil in the **new** position.

| **Wb** |
|---|

2 marks

**Question 8**
Calculate the magnitude of the average emf generated in the coil as it rotates through 90° in an anti-clockwise direction. Give your answer in millivolts.

| **mV** |
|---|

2 marks

**SECTION A – AREA OF STUDY 1** – continued
**TURN OVER**

**Question 9**
Explain, using appropriate principles and referring to Points **X** and **Y** on Figure 5, which direction the current will initially flow as Dean rotates the coil $90^o$ **anti-clockwise**.

3 marks

**SECTION A – AREA OF STUDY 1 -** continued

Dean now rotates the coil continuously and observes the output on the CRO.

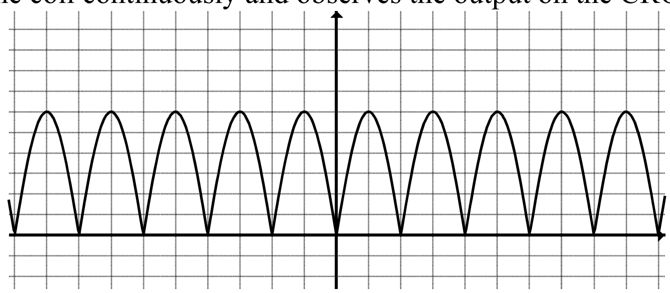
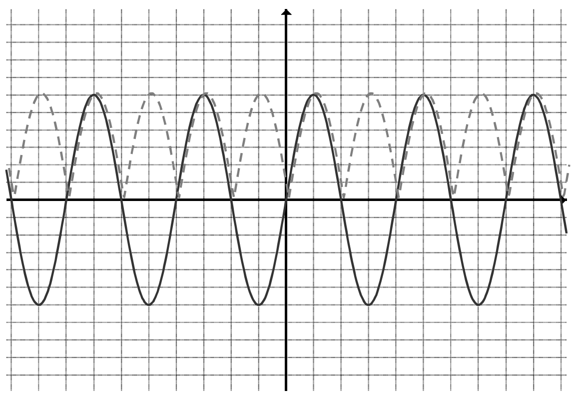
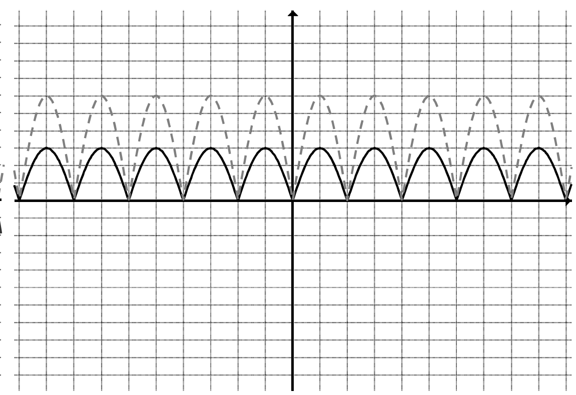


**Figure 6**

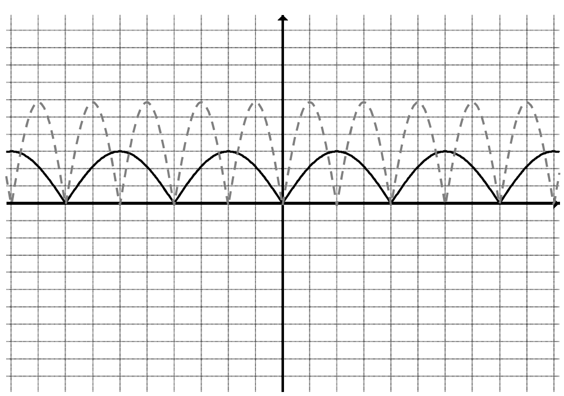
**Options A-D** show four alternate plots, with the original plot shown dashed.



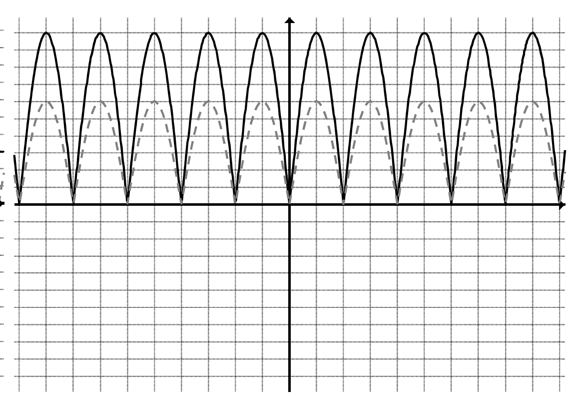
**Plot A**



**Plot B**



**Plot C**



**Plot D**

**Question 10**

Match the appropriate plot with the action listed in the table below

| Action | Resulting Plot |
|---|---|
| Commutator replaced by slip rings | |
| Coil rotated at half original speed | |
| Number of loops in coil increased | |

3 marks

**SECTION A – AREA OF STUDY 1** – continued

**TURN OVER**

Figure 7 shows Justin's solenoid, which is connected to a DC power supply. When looking into the solenoid from point **A**, the current is moving anticlockwise as shown. A single copper ring is positioned between **A** and the solenoid.

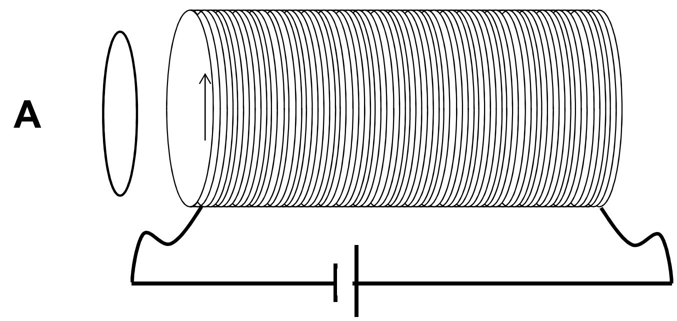



**Figure 7**

**Question 11**
Determine the direction of the induced current in the ring (as viewed from A) if the power supply is disconnected. Explain your answer using Lenz's law.

3 marks

A power station generates an AC voltage of 50 Hz with a magnitude of 15 kV RMS

**Question 12**
Calculate the peak voltage of the generator.

kV

1 mark

**SECTION A – AREA OF STUDY 1** – continued

At one point in its operation a power demand of 30 MW is recorded.

**Question 13**
Calculate the peak-to-peak current provided by the generator at this point

| A |
|---|

2 marks

The generator is now connected via a basic transmission system to a small town called Knox. On one ordinary Wednesday, the Knox townsfolk demand a total of 20 kA. A simplified diagram of the system is shown in Figure 8.

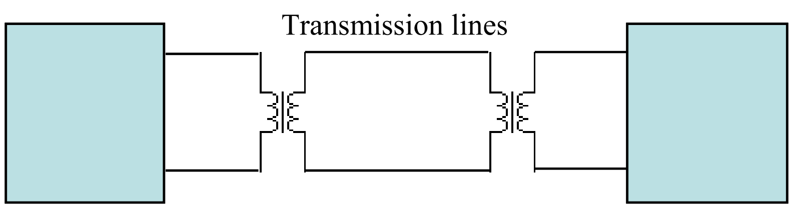



**Figure 8**

**Question 14**
Determine the power loss in **the transmission lines**, which have a **total** resistance of 2.5 Ω

| MW |
|---|

3 marks

**Question 15**
Determine the voltage available at the town of Knox.

| kV |
|---|

2 marks

**SECTION A – AREA OF STUDY 1** – continued
**TURN OVER**

**Question 16**
Explain why the step-up transformer at the generator site would **not** function correctly if the generator was producing smooth DC instead of AC.

2 marks

On a particularly hot Tuesday, the electricity demands of the town of Knox increase. The current increases to 25 kA.

**Question 17**
Would the voltage at the town **increase, decrease** or **stay the same**? Explain your answer with the aid of a calculation.

3 marks

**END AREA OF STUDY 1**
**SECTION A –** continued

## Area of Study 2 – Light and Matter

Figure 1 shows an interference pattern generated by a laser directed at a pair of narrow slits, similar to Young's experiment. The light used has a wavelength of 560 nm.

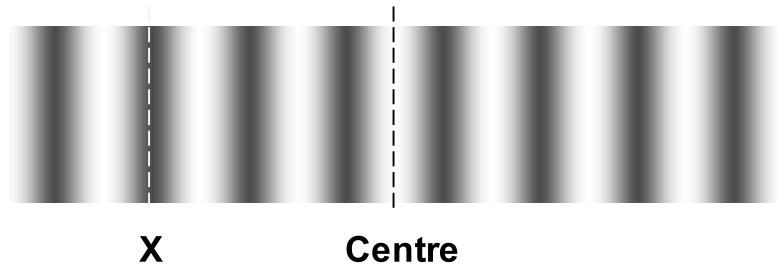



**Figure 1**

**Question 1**
Determine the path difference to **Point X**. Give your answer in nanometres.

| nm |
|---|

2 marks

**Question 2**
Describe the effect of **increasing** the gap between the two slits

2 marks

**SECTION A – AREA OF STUDY 2** - continued
**TURN OVER**

The experiment is now modified so that a single slit is used instead of the pair. The slit has a width of 1.5 mm. The 560 nm laser is used again.

**Question 3**
Explain, with the aid of an appropriate calculation, whether there would be significant diffraction.

2 marks

Nirav is undertaking an experiment to observe and measure the photoelectric effect. He constructs a photocell and circuit, which is shown in simplified form below in Figure 2

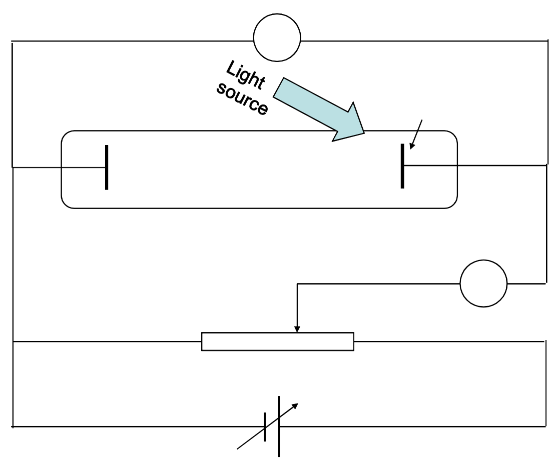



**Figure 2**

When using a light source of 450 nm, Nirav records a stopping voltage of 0.6 V

**Question 4**
Determine the energy of a single photon from the light source in eV
(h = $4.14 \times 10^{-15}$ eVs = $6.63 \times 10^{-34}$ Js)

| eV |
|---|

2 marks

**SECTION A – AREA OF STUDY 2** – continued

**Question 5**
Determine the threshold frequency of the metal in the photocell.
(h = 4.14 x $10^{-15}$ eVs = 6.63 x $10^{-34}$ Js)

| Hz |
|---|

2 marks

Using light of a particular frequency, Nirav collects a series of data points and constructs a graph of stopping voltage vs. photocurrent. This is shown below in Figure 3.

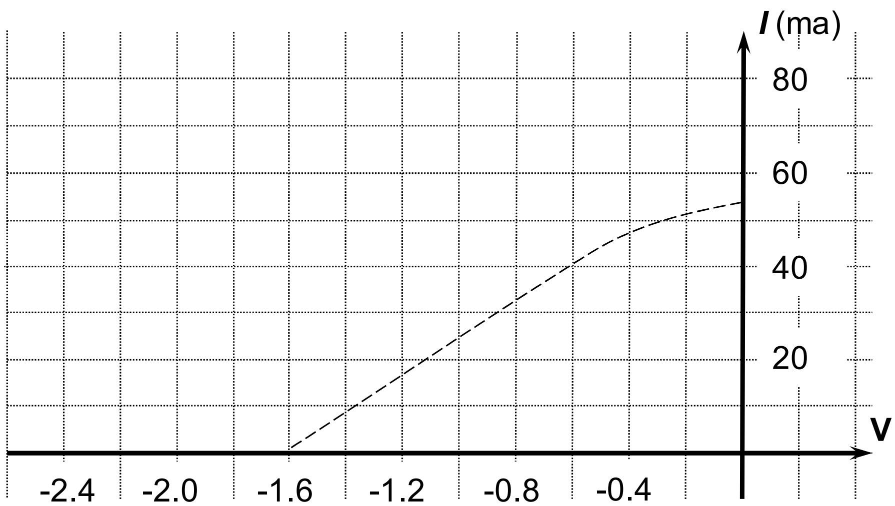



**Figure 3**

Nirav changes the light source to a brighter, but lower frequency source.

**Question 6**
Sketch the expected I-V characteristic curve on Figure 3.

2 marks

**SECTION A – AREA OF STUDY 2** – continued
**TURN OVER**

**Question 7**
It is said that the photoelectric effect "provides evidence for the particle-like nature of light" but also that "the wave model of light cannot account for the experimental photoelectric effect results".
Explain how these statements can be true, providing examples to justify your explanation.

3 marks

Vinay is discussing two similar diffraction patterns. One has been generated by high speed electrons fired through a crystal, the other by X-Rays also directed towards the same crystal. Figure 4 shows the two patterns aligned, demonstrating the matching node and antinode points.

**Figure 4**

**Question 8**
If the energy of the X-Rays is known to be 451 keV, determine their wavelength.
($h = 4.14 \times 10^{-15}$ eVs = $6.63 \times 10^{-34}$ Js)

| m |
|---|

2 marks

**SECTION A – AREA OF STUDY 2** – continued

**Question 9**
Calculate the momentum of one electron in the experiment.
(h = 4.14 x $10^{-15}$ eVs = 6.63 x $10^{-34}$ Js)

| **$kgms^{-1}$** |
|---|

2 marks

Figure 5 shows a simplified energy level diagram for an atom.

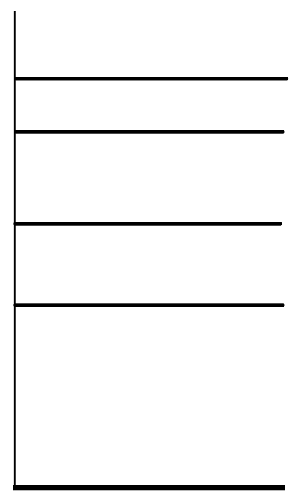


**Figure 5**

**Question 10**
Determine the energy of a photon emitted when an electron drops from the 3rd excited state (n = 4) to the ground state.
(1 eV = 1.6 x $10^{-19}$ J).

| **J** |
|---|

1 mark

**SECTION A – AREA OF STUDY 2 -** continued
**TURN OVER**

**Question 11**
Determine the longest wavelength photon that could be emitted by an electron in this atom as it drops from one energy level to another.
(h = $4.14 \times 10^{-15}$ eVs = $6.63 \times 10^{-34}$ Js)

**nm**

2 marks

**Question 12**
Explain how the existence of discrete energy levels as shown in **Figure 5** provides evidence of the "dual nature of matter".

2 marks

**END OF SECTION A**

## 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.
Each question is worth 2 marks.

## Detailed Study 1 – Synchrotron and applications

**Question 1**
Which of the following best describes the **production** of synchrotron radiation?

**A.** That electromagnetic radiation is produced when the direction of motion of an electron changes since the changing electric field produces another changing electric field
**B.** That electromagnetic radiation is produced when the direction of motion of an electron changes since the changing electric field produces a changing magnetic field
**C.** That electromagnetic radiation is produced when the speed of an electron changes since the changing electric field produces a changing magnetic field
**D.** That electromagnetic radiation is produced when the speed of an electron changes since the changing magnetic field produces a changing electric field

**Question 2**
Which of the following reasons best illustrates why synchrotron radiation is preferred to laser and x-ray tube radiation?

**A.** Synchrotron radiation has high divergence, which makes it easier to direct
**B.** Synchrotron radiation is less intense, so it can travel further
**C.** Synchrotron radiation has a very long wavelength, so it diffracts readily
**D.** Synchrotron radiation is tuneable, so users are able to choose from a broad range of wavelengths.

An electron is accelerated by voltage of 139 kV.

**Question 3**
Ignoring relativistic effects, the speed of the electron would be closest to:

**A.** $2.2 \times 10^6$ ms$^{-1}$
**B.** $2.2 \times 10^8$ ms$^{-1}$
**C.** $2.2 \times 10^4$ ms$^{-1}$
**D.** $5.5 \times 10^6$ ms$^{-1}$

**SECTION B – DETAILED STUDY 1** – continued
**TURN OVER**

An electron travels through a magnetic field as shown in Figure 1. Assume the field is parallel between the two poles.

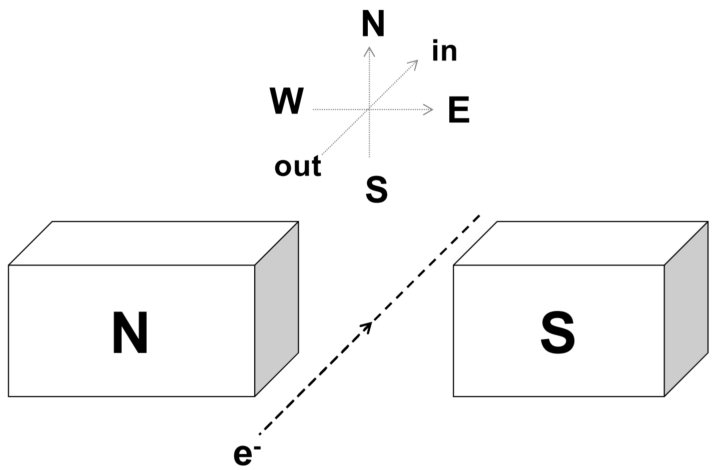



**Figure 1**

**Question 4**
Which of the following best describes the direction of the force acting on the electron?

**A.** North
**B.** South
**C.** East
**D.** West

The electron in Figure 1 is travelling at $8 \times 10^{6}$ $ms^{-1}$ and the radius of its path is $3 \times 10^{-4}$ m

**Question 5**
Which of the following is closest to the magnetic field strength it is experiencing?

**A.** $1.5 \times 10^{-1}$ T
**B.** 1.5 T
**C.** $1.2 \times 10^{6}$ T
**D.** 3.9 T

**Question 6**
The size of the force acting on the electron is closest to

**A.** 1.9 N
**B.** $1.9 \times 10^{-13}$ N
**C.** $2.4 \times 10^{-20}$ N
**D.** 2.4 N

**SECTION B – DETAILED STUDY 1** – continued

**Question 7**
Which of the following percentages best estimates the fraction of light speed to which the **electron gun** in the Australian synchrotron accelerates electrons?

**A.** 0.6%
**B.** 6%
**C.** 60%
**D.** 96%

**Question 8**
Which of the following best describes the characteristics of the **beamline** within the synchrotron facility?

**A.** Provides initial acceleration for the electrons which ultimately produce synchrotron radiation
**B.** Provides secondary acceleration to bring the electrons to the requisite energy levels to produce synchrotron radiation
**C.** Path followed by radiation. Monochrometers within the section select (tune) a wavelength for use
**D.** Curved ring where electrons give off synchrotron radiation due to rapid acceleration

Emission of light by insertion devices is due to magnetic fields causing the electrons to accelerate and emit synchrotron radiation

**Question 9**
Choose the correct statement that completes the following sentence:
Insertion devices...

**A.** are located in the curved sections of the storage ring
**B.** are located in the straight sections of the storage ring
**C.** cause electrons to accelerate rapidly in the direction they are moving
**D.** guide electrons with electric fields

An incident photon is observed to scatter an electron (which can be assumed to be initially stationary). This interaction is an example of Compton scattering.

**Question 10**
Which of the following is true about the interaction?

**A.** Momentum is not conserved, however total kinetic energy remains constant
**B.** The scattered photon will have a higher frequency than the incident radiation
**C.** The interaction is an example of elastic scattering
**D.** The scattered photon will have a longer wavelength than the incident photon

**SECTION B – DETAILED STUDY 1** – continued
**TURN OVER**

Coherent X-Rays of wavelength 0.2 nm are directed towards a crystal as shown in Figure 2. The crystal is rotated to vary the angle θ until constructive interference is achieved.

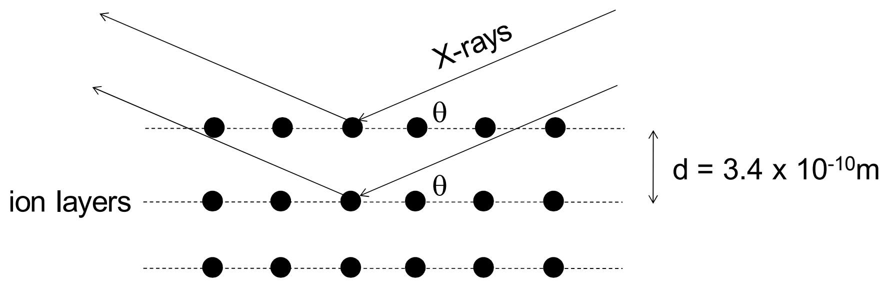



**Figure 2**

**Question 11**
Use your understanding of Bragg diffraction to determine the value of the first angle which would cause constructive interference due to the path difference between layers in the lattice

**A.** $1.7^{o}$
**B.** $17^{o}$
**C.** $73^{o}$
**D.** $0.78^{o}$

**Question 12**
Referring to Figure 2, how many angles between 0 and $90^{o}$ would be expected to yield constructive interference?

**A.** 5
**B.** 6
**C.** 1
**D.** 3

Synchrotron radiation is increasingly being used in the process of **photoemission**, where it is preferred to regular light sources.

**Question 13**
The best reason for the preference for synchrotron radiation is

**A.** Other light sources, such as lasers, cannot be coherent
**B.** The high energy of synchrotron radiation enables electrons to be ejected from a wide range of surfaces, enabling more effective and detailed understanding of atomic structures
**C.** Synchrotron radiation is highly incoherent and thus more electrons are ejected and surfaces can be more readily analysed
**D.** Synchrotron radiation has primarily wavelike properties when being used for photoemission

**END OF DETAILED STUDY 1**
**SECTION B -** continued

## Detailed Study 2 – Photonics

**Question 1**
Which of the following statements is true of LEDs?

**A.** LEDs emit light when electrons move from the valence band to lower energy levels
**B.** A bright blue LED would produce more photons than a dimmer blue LED
**C.** A bright red LED would produce photons of a higher energy than a dimmer red LED
**D.** Blue LEDs have an energy gap which is less than a red LED

An LED emits light of wavelength 490 nm

**Question 2**
The energy of an emitted photon in joule would be closest to

**A.** $4.1 \times 10^{-19}$ J
**B.** 2.56 J
**C.** $9.7 \times 10^{-32}$ J
**D.** $3.25 \times 10^{-40}$ J

**Question 3**
The best explanation for the coherent nature of laser light is

**A.** Photons are produced by stimulated emission from excited atoms. All the photons are out of phase.
**B.** All the photons have a similar wavelength, except for the stimulating photon
**C.** Photons are produced by stimulated emission from excited atoms. All the photons are in phase with the photon that stimulated their emission
**D.** Laser is due to destructive interference of emitted photons.



A simplified diagram of a fibre optic wave guide is shown in Figure 1. The critical angle at the core-cladding boundary is $80.1^o$ as shown (i.e. the light only emerges from the core at angles of incidence less than $80.1^o$).
Assume the light source initially enters the core from air (n = 1.00)

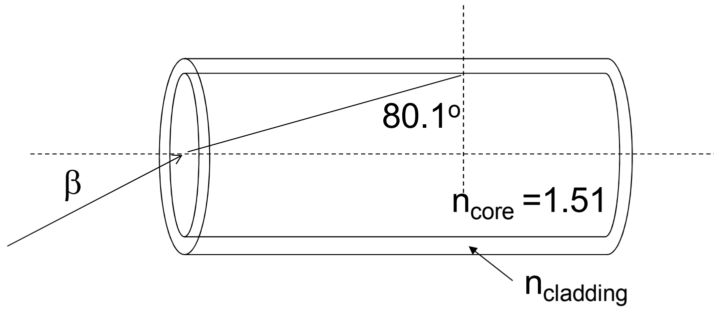



**Figure 1**

**Question 4**
The value for the refractive index of the cladding, $n_{cladding}$, is closest to:

**A.** 1.51
**B.** 1.53
**C.** 0.66
**D.** 1.49

**Question 5**
The angle of acceptance, β is closest to

**A.** $15^o$
**B.** $80.1^o$
**C.** $9.9^o$
**D.** $75^o$

**SECTION B – DETAILED STUDY 2** – continued

Figure 2 shows a graph of optical loss (attenuation) versus wavelength for a sample of optical fibre.

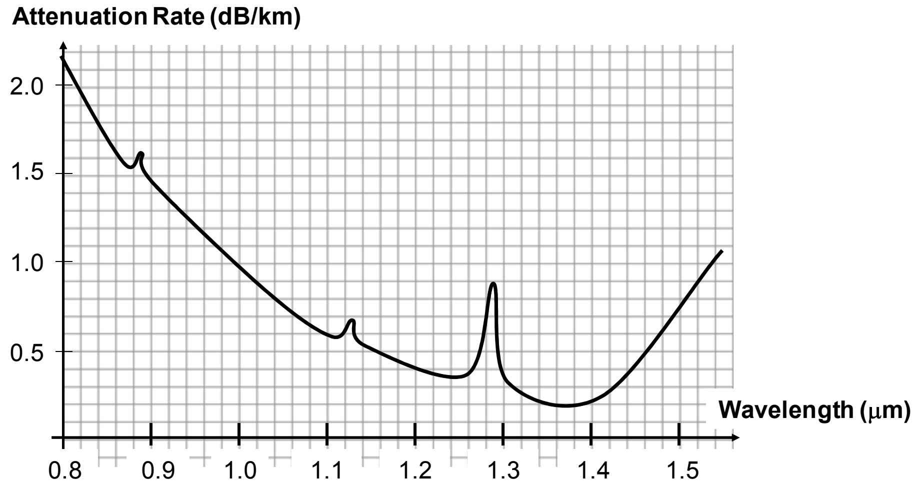



**Figure 2**

**Question 6**
In terms of losses, in can be said that

**A.** Rayleigh scattering is more significant at lower frequencies than higher frequencies
**B.** Rayleigh scattering is most significant at 1.29 μm
**C.** Rayleigh scattering decreases up to 1.37 μm, then rapidly increases
**D.** Rayleigh scattering is more significant at higher frequencies than lower frequencies

**Question 7**
If a designer wished to minimise energy losses, which of the following wavelengths would be preferred for long distance telecommunication applications?

**A.** 1.2 μm
**B.** 1.29 μm
**C.** 1.37 μm
**D.** 0.89 μm

**Question 8**
The best explanation for the rapid increase in losses for wavelengths beyond 1.4 μm is

**A.** Higher absorption due to impurities in the fibre
**B.** Absorption due to resonance in the fibre
**C.** Greater Rayleigh scattering
**D.** Leakage from the fibre due to imperfect total internal reflection

**SECTION B – DETAILED STUDY 2** – continued
**TURN OVER**

**Question 9**
Small diameter, **single-mode** optical fibres are used for long distance telecommunication. Which of the following is the best justification for this?

**A.** Single mode fibres reduce material dispersion
**B.** Single mode fibres reduce modal dispersion
**C.** The narrow diameter increase material dispersion
**D.** Multi-mode fibres are preferred, but material dispersion makes them impractical over long distances.

**Question 10**
Which of the following is correct about **material dispersion** in the single-mode fibre?

**A.** A pulse of red light will take longer to travel through a given section of the fibre than a pulse of green light
**B.** A pulse of green light will take longer to travel through a given section of the fibre than a pulse of blue light
**C.** A pulse of red light will take longer to travel through a given section of the fibre than a pulse of infrared light
**D.** All colours will suffer the same degree of material dispersion

**Question 11**
Which of the following is true about **illuminating** and **imaging** fibre bundles used in key-hole surgery?

**A.** The ends of the both fibre bundles must be coherent (in the same relative position) to enable effective operation of the system
**B.** Only illuminating fibre bundles need to be coherent
**C.** Only imaging fibre bundles need to be coherent
**D.** Neither type of bundle requires coherent ends, however they must both only use monochromatic light.

**Question 12**
Which of the following would be **MOST** 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

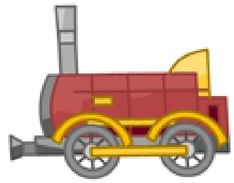
**Question 13**
The light produced by a **lighted candle (thermal) source** can best be described as

**A.** Coherent, monochromatic, includes all wavelengths in the visible spectrum
**B.** Incoherent, monochromatic, includes all wavelengths in the visible spectrum
**C.** Coherent, polychromatic, includes only discrete wavelengths in the visible spectrum
**D.** Incoherent, polychromatic, includes all wavelengths in the visible spectrum

**END OF DETAILED STUDY 2**
**SECTION B –** continued

## Detailed Study 3 – Sound

**Note: Assume the speed of sound is 340 ms$^{-1}$ for all questions in this section**



Phil the steam train is about to depart from his favourite station and sounds his deep horn to celebrate. The horn initially emits sound uniformly in all directions at a frequency of 170 Hz. Phil's driver Michael considers the motion of a dust particle one metre in front of the horn.

**Question 1**
Which one of the following statements correctly describes the motion of the dust particle?

**A.** The particle remains stationary.
**B.** The particle oscillates towards and away from the speaker, its motion parallel to its direction from the horn.
**C.** The particle oscillates in a horizontal plane, its motion perpendicular to its direction from the horn.
**D.** The particle oscillates in a vertical plane, its motion perpendicular to its direction from the horn

**Question 2**
The distance between successive air compressions corresponding to the sound wave from the horn is calculated to be

**A.** 0.5 m
**B.** 2.0 m
**C.** 170 m
**D.** $5.9 \times 10^{-3}$ m

Using his sound level meter, Michael takes a reading of 97 dB when standing 4.0 m from the horn.

**Question 3**
The sound intensity at this point would be closest to

**A.** 5.0 Wm$^{-2}$
**B.** $5.0 \times 10^{9}$ Wm$^{-2}$
**C.** $5.0 \times 10^{-3}$ Wm$^{-2}$
**D.** $2.0 \times 10^{-12}$ Wm$^{-2}$

**SECTION B – DETAILED STUDY 3** – continued
**TURN OVER**

Michael's assistant, Ben, is standing further away on the platform. He records a sound level of 91 dB.

**Question 4**
Ben's distance from the horn is closest to:

**A.** 4 m
**B.** 8 m
**C.** 10 m
**D.** 16 m

Michael notes that part of the horn consists of a tube which resonates to amplify the sound. The tube can be modelled as being open at both ends.

**Question 5**
Which of the following statements provides the best explanation for the phenomena of resonance that is occurring in the tube?

**A.** A longitudinal wave reflects and undergoes destructive interference, leaving a standing wave which can be heard at the resonant frequency.
**B.** The sides of the tube amplify the sound wave as it reflects off them, increasing in amplitude. At a resonant frequency, these transverse reflections are maximised.
**C.** A standing wave enters the tube and continuously reflects, increasing in amplitude.
**D.** A sound wave enters the tube and reflects from the open end. At a resonant frequency, the incident and reflected waves interfere constructively, generating a standing wave with a larger amplitude.

Next, Michael adjusts the frequency of the horn in an attempt to find other pitches which sound loud. The lowest resonant frequency he can find is 170 Hz. In addition, he notices significant resonance at 340 Hz, 510 Hz and 680 Hz. In all cases, the tube can be modelled as open at both ends and the speed of sound taken as 340 $ms^{-1}$

**Question 6**
Which of the following is correct for the **third** harmonic of the system?

| Option | Wavelength | Tube length |
|---|---|---|
| **A** | 0.67 m | 0.67 m |
| **B** | 1.5 m | 1.0 m |
| **C** | 1.0 m | 1.5 m |
| **D** | 0.67 m | 1.0 m |

**SECTION B – DETAILED STUDY 3** – continued

Sitting in the station master's quarters adjacent to the platform, Sam announces the arrival of another train. Sam is not sure of the type of microphone he is using, but he knows that it relies on the principle of **electromagnetic induction**.

**Question 7**
Based on this information, which of the following combinations accounts for Sam's microphone?

**A.** Dynamic or Electret
**B.** Piezo-electric or Ribbon
**C.** Carbon or Piezo-electric
**D.** Dynamic or Ribbon

Sam's important announcements are broadcast to the passengers on the platform via a single dynamic loudspeaker.

**Question 8**
Which of the following best describes the operation of a basic dynamic loudspeaker?

**A.** The coil and moving cone of the loudspeaker move perpendicular to the direction of the current in the coil and creates compressions which propagate away from the speaker.
**B.** The current in the coil is DC and the cone moves due to electromagnetic induction.
**C.** The cone moves due to the vibrations of piezo-electric crystals, which result from varying the polarity of electrodes connected to them
**D.** The cone of the dynamic speaker resonates for discrete frequencies, predominantly those in the range of human speech.

**SECTION B – DETAILED STUDY 3** – continued
**TURN OVER**

To improve the operation of the loudspeaker, Sam has cut a hole in the wall so that the speaker fits snugly in wall as shown in Figure 1.

**Figure 1**

**Question 9**
Which of the following best describes the advantage of mounting the speaker in this way?

**A.** The wall prevents excessive diffraction from the rear of the speaker
**B.** The wall acts as a baffle, minimizing the destructive interference that would otherwise occur at the edges of an unmounted speaker
**C.** The wall ensures that sound waves from the front side of the speaker remain completely in phase with sound from the rear of the speaker
**D.** The wall improves the fidelity of the speaker by allowing it to cover a wider range of frequencies.

**SECTION B – DETAILED STUDY 3** – continued

Figure 2 shows the hearing response curve (phon) for Michael. As he adjusts the frequency of the horn (Question 6) he notices that aside from the resonant frequencies, some pitches seem louder to his ear than others.

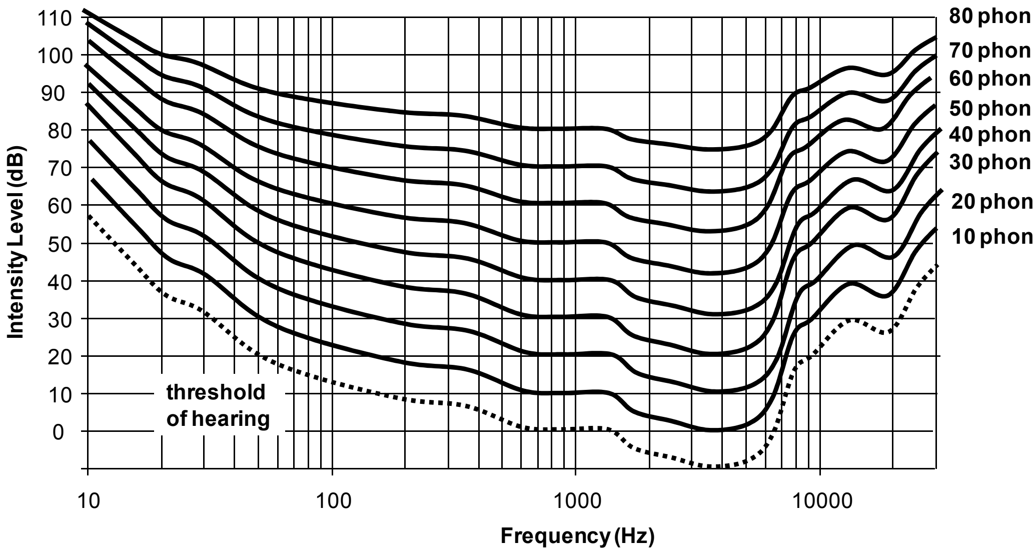



**Figure 2**

**Question 10**
Using the phon curves, which of the following **frequencies** would seem as loud as 70dB at 40Hz?

**A.** 80 Hz at 10dB
**B.** 1000 Hz at 70 dB
**C.** 110 Hz at 40dB
**D.** 800 Hz at 50 dB

Figure 3 shows the response curve for a loudspeaker.

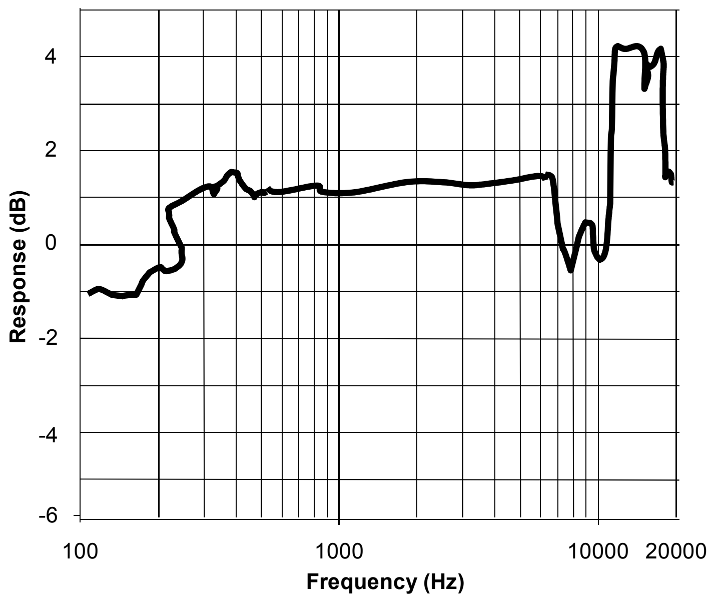



**Figure 3**

**Question 11**

Which of the following statements best describes the most appropriate application for the speaker and correctly justifies its selection?

**A.** The speaker would be best used as a woofer because it demonstrates high fidelity across a useful range of low frequencies
**B.** The speaker would best be used as a mid-range speaker because it demonstrates flat response across a useful range of mid-range frequencies
**C.** The speak would be best used as a tweeter because its response is maximum in the high frequency range
**D.** The speaker could be used for low and mid frequencies because its response is above zero for these frequencies.

**SECTION B – DETAILED STUDY 3** – continued

Two passengers on a train platform, Annabel (**A**) and Barry (**B**), are standing behind a heavy barrier. Due to a 0.5 m gap in the barrier, Annabel has a clear view of a wall-mounted speaker, whilst Barry is positioned slightly off-centre, as shown in Figure 4. **Both are the same distance from the speaker.**
Annabel and Barry listen carefully while a broadcast of a series of high (3500 Hz) and low (165 Hz) tones occurs.
Assume that both Barry and Annabel are equally sensitive to both frequencies when they are standing directly next to the speaker (That is, they are on the same phon)

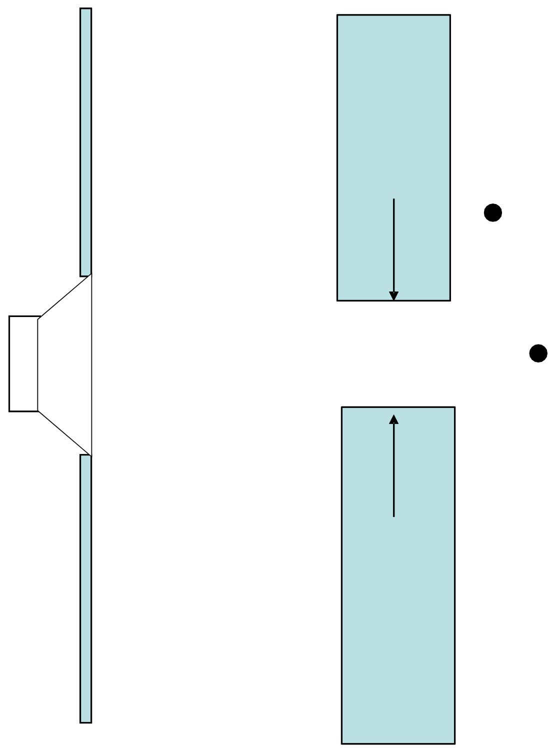


**Figure 4**

**Question 12**
Which of the following statements best describes the results of the test?

**A.** Both 165 Hz and 3500 Hz signal sound the same because the two are equidistant from the speaker.
**B.** Annabel and Barry will hear the 3500 Hz sound at close to the same intensity, but the 165 Hz sound will be at a higher intensity for Annabel
**C.** Annabel and Barry will hear the 165 Hz sound at close to the same intensity, but the 3500 Hz sound will be at a higher intensity for Annabel
**D.** Annabel and Barry will hear the 165 Hz sound at close to the same intensity, but the 3500 Hz sound will be at a higher intensity for Barry

**SECTION B – DETAILED STUDY 3** – continued
**TURN OVER**

**Question 13**
When analysing the intensity variation for Annabel and Barry, which of the following computations are most relevant?

**A.** $\frac{\lambda_{3500}}{w} = \frac{3500}{0.5} = 7500$ (significant diffraction), $\frac{\lambda_{165}}{w} = \frac{165}{0.5} = 330$ (significant diffraction)

**B.** $\frac{\lambda_{3500}}{w} = \frac{0.1}{0.3} = 0.33$ (minimal diffraction), $\frac{\lambda_{165}}{w} = \frac{2.1}{0.3} = 7$ (significant diffraction)

**C.** $\frac{\lambda_{3500}}{w} = \frac{0.5}{0.1} = 5$ (significant diffraction),, $\frac{\lambda_{165}}{w} = \frac{0.5}{2.1} = 0.25$ (minimal diffraction)

**D.** $\frac{\lambda_{3500}}{w} = \frac{0.1}{0.5} = 0.2$ (minimal diffraction), $\frac{\lambda_{165}}{w} = \frac{2.1}{0.5} = 4.2$ (significant diffraction)

**END OF QUESTION AND ANSWER BOOK**

## Data Sheet

**Area of Study 1 and 2 – Electric Power, Interactions of Light and Matter**

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

**Detailed study 3.1 - Synchrotron and its applications**

| | | |
|---|---|---|
| 17 | energy transformations for electrons in an electron gun (<100 keV) | $\frac{1}{2}mv^2 = eV$ |
| 18 | radius of electron beam | $r = \frac{p}{qB}$ |
| 19 | force applied to an electron beam | $F = qvB$ |
| 20 | Bragg's law | $n\lambda = 2d\sin\theta$ |
| 21 | electric field between charged plates | $E = \frac{V}{d}$ |

**Detailed study 3.2 - Photonics**

| | | |
|---|---|---|
| 22 | band gap energy | $E = \frac{hc}{\lambda}$ |
| 23 | Snell's Law | $n_1 \sin i = n_2 \sin r$ |
| 24 | acceptance angle | $\theta_A = \sin^{-1}\sqrt{(n_1^2 - n_2^2)}$ |
| 25 | numerical angle | $NA = \sin\theta_A$ |

**Detailed study 3.3 - Sound**

| | | |
|---|---|---|
| 26 | speed, frequency and wavelength | $v = f\lambda$ |
| 27 | intensity and levels | sound intensity level (in dB) $= 10\log_{10}\left(\frac{I}{I_0}\right)$ where $I_0 = 1.0 \times 10^{-12}$ W m$^{-2}$ |

**SECTION B – DETAILED STUDY ANSWER SHEET**

**Detailed Study Attempted – Please tick appropriate box**

| | |
|---|---|
| 1. Synchrotron and Applications | |
| 2. Photonics | |
| 3. Sound | |

**Answers – Circle ONE of A-D for each of the thirteen multiple choice questions.**

| Question | Answer | | | |
|---|---|---|---|---|
| 1 | A | B | C | D |
| 2 | A | B | C | D |
| 3 | A | B | C | D |
| 4 | A | B | C | D |
| 5 | A | B | C | D |
| 6 | A | B | C | D |
| 7 | A | B | C | D |
| 8 | A | B | C | D |
| 9 | A | B | C | D |
| 10 | A | B | C | D |
| 11 | A | B | C | D |
| 12 | A | B | C | D |
| 13 | A | B | C | D |