TSSM
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2010 Trial Examination

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STUDENT NUMBER

Figures									Letter
Words									

PHYSICS

Unit 4 – Written examination 2

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

QUESTION AND ANSWER BOOK

Structure of Book

Section	*Number of Questions*	*Number of questions to be answered*	*Number of Marks*
A – Core Areas of Study			
1. Electric Power	16	16	37
2. Interactions of Light and Matter	12	12	27
B – Detailed Studies			
1. Synchrotron and applications	13	13	26
OR			
2. Photonics	13	13	26
OR			
3. Sound	13	13	26
			Total 90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, 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 37 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

Instructions for Section A

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

Areas of study **Page**

SECTION A - continued

Area of Study 1 – Electric Power

Questions 1 to 3 refer to the following information

Two current carrying cables hang vertically as shown in Figure 1. The direction of current in cable A is known, but the current direction in cable B is unknown.
Point **P** is a random point adjacent to Cable A and we will consider a 10 cm length of the cables in the following questions.

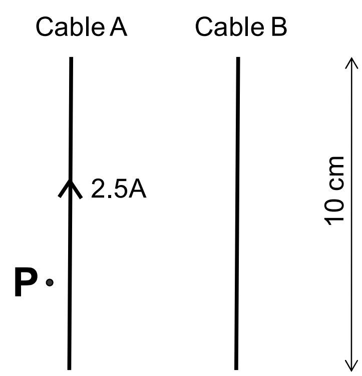


Figure 1

Question 1
Which of the following best describes the direction of the magnetic field created by the current in Cable A at Point **P**?
A. Into the page
B. Out of the page
C. Left
D. Right

2 marks

SECTION A – Area of study 1 – continued
TURN OVER

Cable B is known to generate a magnetic field in the vicinity of Cable A. This leads to a force of 0.12 N acting on Cable A as shown in Figure 2.

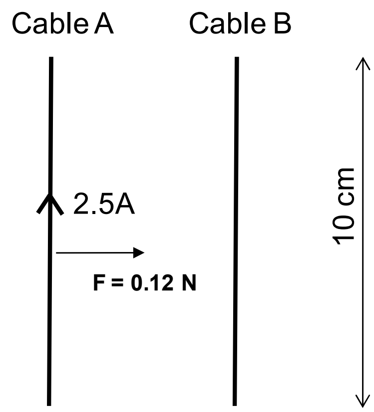


Figure 2

Question 2
Determine the size and direction of the magnetic field acting on Cable A. You must show your working.

Size: T	Direction:

2 + 1 = 3 marks

Question 3
Would Cable B be **attracted towards** or **repelled from** Cable A? Explain your answer.

2 marks

SECTION A – Area of study 1 – continued

Questions 4 to 6 refer to the following information

A single square copper loop (side length 3 cm) is connected to a DC supply and placed between two magnets as shown in Figure 3. The magnetic field between the two poles is 0.2 T At time t = 0, the DC supply is connected and a current of 1.5 A flows through the loop.

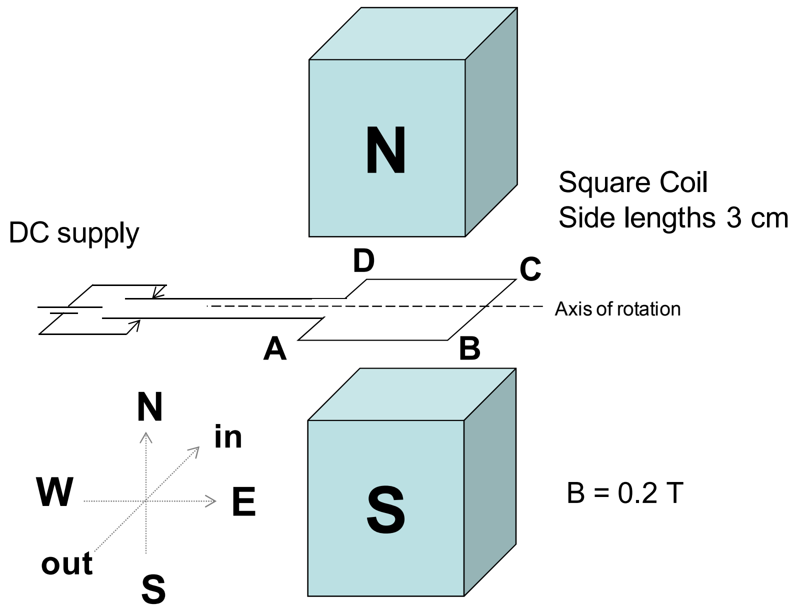


Figure 3

Question 4
Determine the size and direction of the force on side BC, when the switch is initially closed. Refer your direction to the axes provided in Figure 3. You must show your working.

Size: N	Direction:

2 marks

SECTION A – Area of study 1 – continued
TURN OVER

The motion of the loop is now observed from its initial position at t = 0.

Question 5
Which of the following best describes the magnetic force acting on side CD as the loop is rotated by 90 degrees to a vertical position.
A. The force decreases in magnitude, but maintains the same direction.
B. The force decreases in magnitude and changes to the opposite direction.
C. The force increases in magnitude, but maintains the same direction.
D. The force maintains the same magnitude and direction.

2 marks

In the vertical position the loop is set free.
After a few seconds, the loop comes to rest in a horizontal position.
Two students argue about how the device can be modified to ensure continuous rotation. One suggests adding a **commutator**, whilst the other suggests **slip-rings**.

Question 6
Explain which choice would be most appropriate to ensure continuous rotation of the loop.
Circle the preferred option below and refer to appropriate physics principles in your answer.

Commutator / Slip-rings

2 marks

SECTION A – Area of study 1 – continued

Questions 7 and 8 refer to the following information

James is experimenting with a modified transformer, where he has replaced the AC supply with a DC supply and a switch, as shown in Figure 4.
The switch is initially open, so no current is flowing in the primary coil.
There is a secondary coil, load resistor which is linked to the primary coil by an iron core.
James then closes the switch, which completes the primary circuit in 0.05 s
You may assume that the only interaction between the coils is via the iron core.

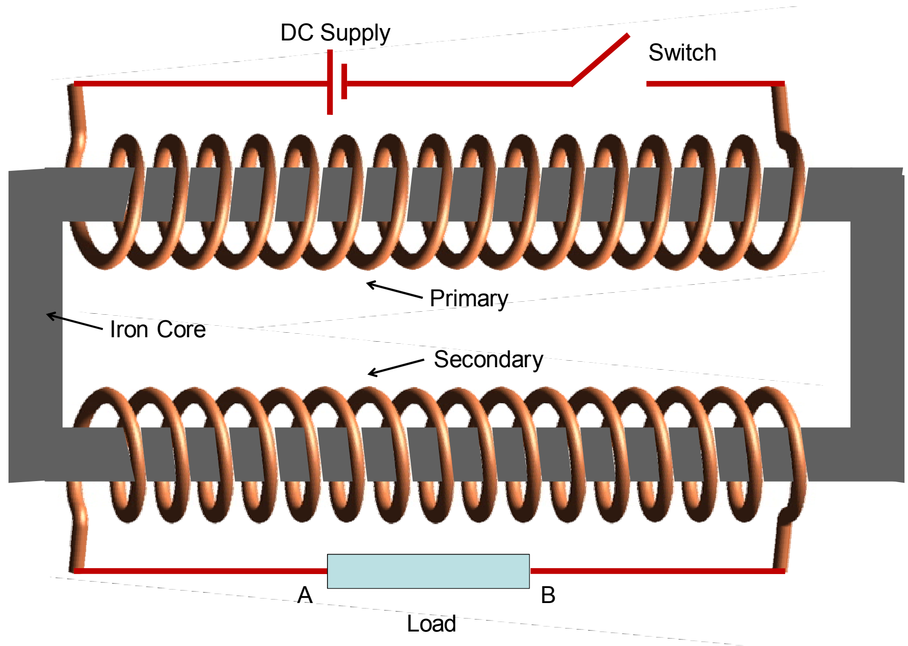


Figure 4

Question 7
Which of the following best describes the observations that James would make of the load resistor.

A. No current would flow at all in the secondary coil as the power source is DC in nature
B. Once the switch has been connected, continuous DC would flow from B to A across the load.
C. As the switch is connected, a short pulse of current would flow from A to B across the load
D. As the switch is connected, a short pulse of current would flow from B to A across the load
E. Once the switch has been connected, continuous AC would flow across the resistor

2 marks

SECTION A – Area of study 1 – continued
TURN OVER

Question 8
Explain your answer to Question 7, referring specifically to Lenz's Law.

3 marks

SECTION A – Area of study 1 – continued

Questions 9 to 14 refer to the following information

An engineer is modelling the electricity supply system for a remote factory, which received power from a small generator located some distance from the site. The simplified circuit diagram is shown in Figure 5.
Unfortunately, the engineer leaves some specifications and circuit parameters missing, so you have been asked to complete the analysis.

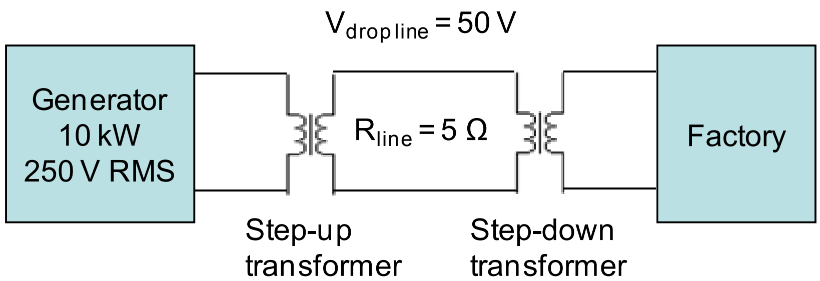


Figure 5

Question 9
Use the information available to determine the current in the transmission lines. You must show your working.

A

2 marks

There are 1200 turns on the secondary side of the step-up transformer.

Question 10
Determine the turns required on the primary side of the step-up transformer. You must show your working.

turns

3 marks

SECTION A – Area of study 1 – continued
TURN OVER

Question 11
Determine the voltage that would be available at the factory site, after the step-down transformer (ratio 4:1). You must show your working.

V

2 marks

Once the factory is constructed and the generator installed, the engineer observes that the voltage at the factory site is less than his modelling predicted.

Question 12
Which **one or more** of the following could have occurred to lead to this observation?

A. Reduced resistance in the transmission lines
B. Increased turns ratio (that is, greater step-up) at the generator site
C. Reduced current demand at the factory site
D. Increased current demand at the factory site

2 marks

At one point during its operation, the generator is recorded as having an output of 10 kW at 250 V RMS

Question 13
Determine the peak-to-peak voltage that would be observed. You must show your working.

V

2 marks

SECTION A – Area of study 1 – continued

Question 14

Determine the peak-to-peak current that would be observed. You must show your working.

A

3 marks

A copper loop is positioned adjacent to a 0.4 T magnetic field directed into the page, as shown in Figure 6.

Starting a time t = 0, the loop is then pulled across the magnetic field at a constant speed until it reaches the position outlined in the figure.

The movement of the loop takes 0.4 sec.

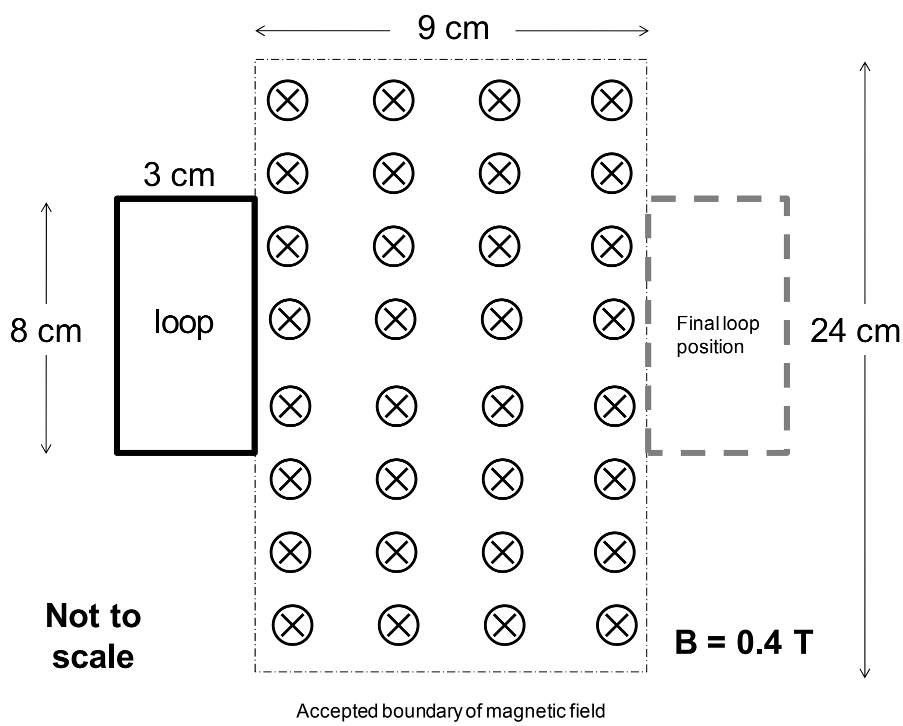
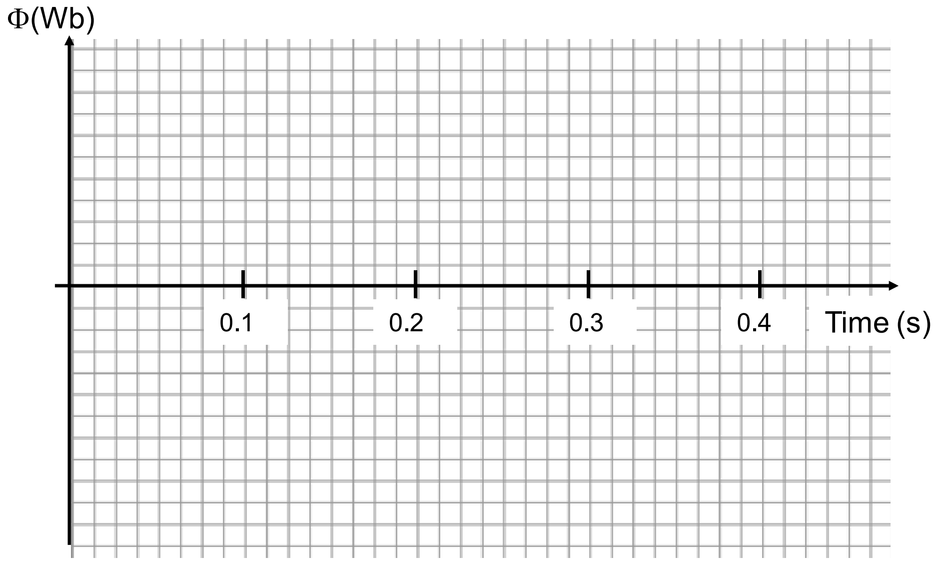


Figure 6

SECTION A – Area of study 1 – continued
TURN OVER

Question 15
Using the axes provided, sketch a graph of the flux through the loop. Show a vertical scale.
Note: Positive flux is defined as into the page.



3 marks

Question 16
Determine the magnitude of the maximum emf generated in the loop. You must show your working.

V

2 marks

END OF AREA OF STUDY 1
SECTIONA - continued

Area of Study 2 – Interactions of Light and Matter

Questions 1 to 3 refer to the following information

A red laser of wavelength 625 nm is directed through a pair of narrow slits to generate a distinct pattern on a screen as depicted in Figure 1.
Point C is at the centre of the pattern and Point A is located 2.5 μm **further** from Slit 1 than Slit 2.

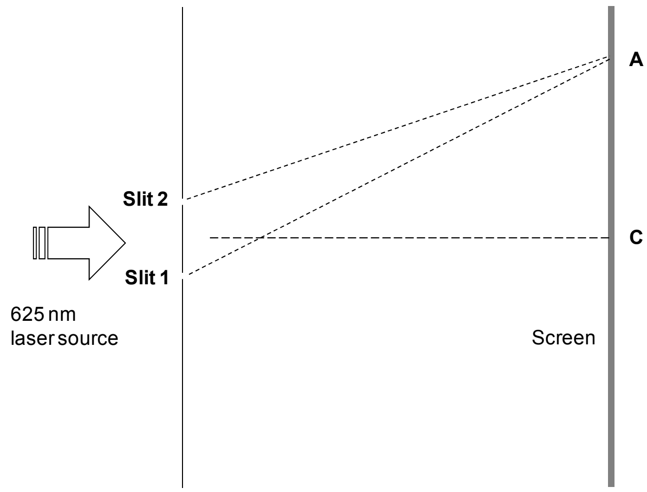


Figure 1

Question 1
Starting from Point C and moving directly to Point A, how many dark bands would be crossed? You must show your working.

2 marks

Question 2
Use appropriate physics principles to explain the existence of the dark bands within the pattern.

SECTION A – Area of study 2 – continued
TURN OVER

Adjustments are made to the experimental setup, which leads to a narrower pattern of dark and light bands.

Question 3
Which **one or more** of the following may have occurred?
A. The laser was changed from red to green
B. The pair of slits were moved closer together
C. The screen was moved closer to the slits
D. The intensity of the red laser was reduced

2 marks

Questions 4 and 5 refer to the following information

Figure 2 shows a simplified version of the energy level diagram of an atom.
An atom begins in the third excited state.

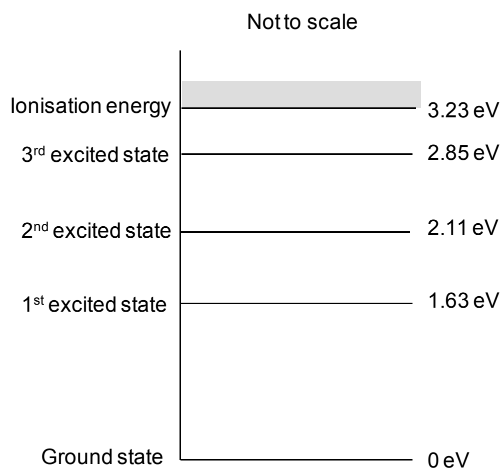


Figure 2

Question 4
Which of the following photons could NOT be emitted by the atom?
A. 0.38 eV
B. 0.48 eV
C. 0.74 eV
D. 2.11 eV

2 marks

SECTION A – Area of study 2 – continued

Now in its ground state, the atom is exposed to photons of various energies.

Question 5
Which photons with the wavelengths below could NOT be absorbed by the atom?

A. 762 nm
B. 510 nm
C. 436 nm
D. 325 nm

2 marks

Question 6
Explain how the existence of discrete energy levels is evidence for the wavelike nature of electrons in the atom.

3 marks

SECTION A – Area of study 2 – continued
TURN OVER

Questions 7 to 9 refer to the following information

When directed through a polycrystalline metallic foil, both x-rays and electrons can exhibit similar diffraction patterns, as shown in Figure 3.

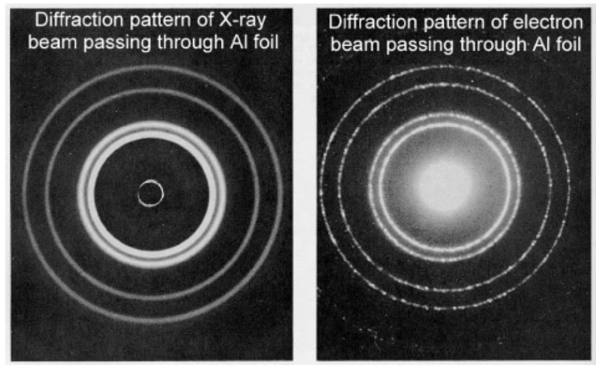


Figure 3

Question 7
Explain why both electrons and x-rays could form a similar diffraction pattern, despite the obvious differences between them.

3 marks

The electrons used in the diffraction experiment discussed above had been accelerated by a voltage of 600 V.

Question 8
Determine the wavelength of the electrons. You must show your working.

nm

3 marks

SECTION A – Area of study 2 – continued

Question 9
Given the similar diffraction patterns in Figure 3, determine the energy of the x-rays used in the experiment. Give your answer in joules. You must show your working.

J

2 marks

Questions 10 and 11 refer to the following information

Figure 4 shows a circuit diagram for an experiment into the photoelectric effect.

For a light source of 500 nm, a stopping voltage of 1.7 V is just sufficient to ensure no current is recorded on the ammeter.

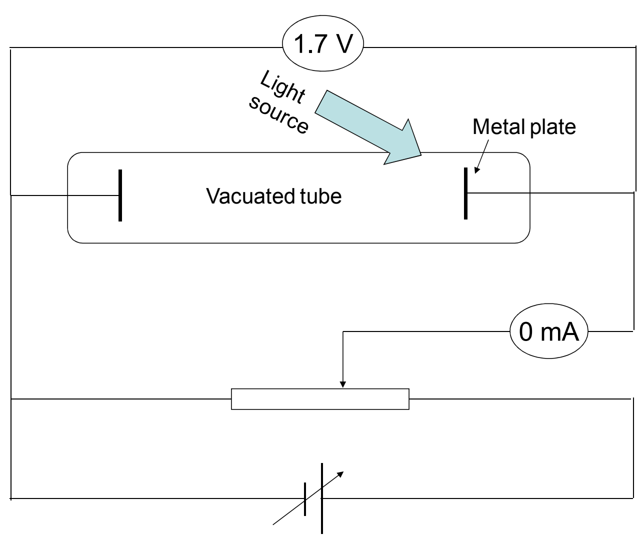


Figure 4

SECTION A – Area of study 2 – continued
TURN OVER

Question 10
Determine the speed of the fastest electron as it is ejected from the metal surface. You must show your working.

m s^{-1}

2 marks

Question 11
Determine the threshold frequency for the experiment. You must show your working.

Hz

2 marks

Question 12
Which **one or more** of the following observations are correctly used to justify the particle model for light during the photoelectric effect?

A. Increasing the intensity of the light source used will increase the energy of the electrons being ejected.

B. Increasing the frequency of the light source will reduce the time taken for electrons to be emitted.

C. Increasing the frequency of the light source will increase the energy of the electrons being emitted.

D. Decreasing the intensity of the light source will decrease the current recorded by the ammeter.

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 and record your answer on the accompanying answer sheet.
Each question is worth 2 marks.

Detailed study **Page**

SECTION B – continued
TURN OVER

Detailed Study 1 – Synchrotron and applications

Question 1
Which of the following reasons best illustrates why x-ray tube radiation is inferior to synchrotron radiation?
A. X-rays have lower divergence, which makes harder to direct
B. X-rays are more intense, so they cannot travel as far
C. X-rays have a much longer wavelength, so they diffract more readily
D. X-rays are inherently more tuneable, so users are better able to choose an appropriate wavelength to work with

An electron is accelerated to a speed of 2.2×10^7 m s^{-1}

Question 2
Ignoring relativistic effects, the accelerating voltage of the electron would be closest to:
A. 0.0125 V
B. 138 V
C. 1.25 kV
D. 1.38 kV

Questions 3 to 5 refer to the following information

An electron travels through a magnetic field as shown in Figure 1. Assume the field is parallel between the poles, although the exact orientation of the poles is unknown (shown as X and Y instead)
When the field strength is 0.15 T, the electron experiences a force of 1.9×10^{-13} N, directed into the page.

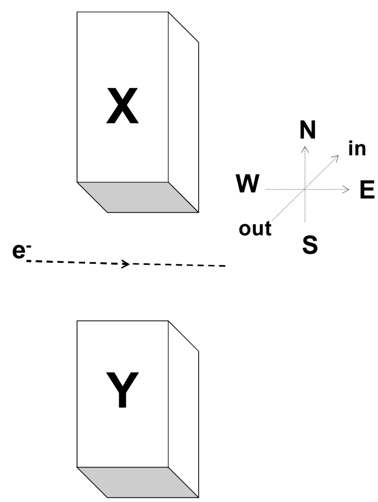


Figure 1

Question 3
Which of the following describes the direction of the magnetic field?
A. X to Y
B. Y to X
C. West to East
D. East to West

SECTION B – Detailed study 1 – continued

Question 4
Which of the following is closest to the speed at which the electron is moving?
A. 8×10^8 m s^{-1}
B. 8×10^6 m s^{-1}
C. 8×10^3 m s^{-1}
D. 8 m s^{-1}

Question 5
The radius of the path along which the electron travels is closest to:
A. 3.0 m
B. 1.1×10^{-2} m
C. 3.0×10^{-3} m
D. 3.0×10^{-4} m

Question 6
Which of the following percentages best estimates the fraction of light speed and the accelerating voltage that is provided by the synchrotron linear accelerator?
A. 90% light speed, achieved by 100 kV
B. 95% light speed, achieved by 100 MV
C. 99% light speed, achieved by 100 kV
D. 99.995% light speed, achieved by 100 MV

Question 7
Which of the following best describes the characteristics of the circular booster (booster ring) within the synchrotron facility?
A. Increases the energy of the electrons to approximately 3 GeV and due to relativistic effects, most of this change is to the speed of the electrons.
B. Increases the energy of the electrons to approximately 3 GeV, although due to relativistic effects, most of this change is to the mass of the electrons.
C. Where electrons, now at maximum possible speed, produce radiation for use in the beamlines.
D. The line along which the radiation passes to reach the target

Question 8
Which of the following gives the correct order in which electrons travel through the synchrotron?
A. Linac, Electron gun, booster ring, storage ring, beamline
B. Electron gun, Linac, booster ring, storage ring, beamline
C. Linac, Electron gun, storage ring, booster ring, beamline
D. Linac, Electron gun, beamline, booster ring, storage ring

SECTION B – Detailed study 1 – continued
TURN OVER

Question 9
Which of the following best describes the direction that radiation is emitted from fast moving charges, moving in a circular path in a magnetic field?
A. Radiation is emitted progressively along a tangent to the circular path
B. Radiation is emitted progressively, perpendicular to the circular path
C. Radiation is emitted in one burst, perpendicular to the direction of travel
D. Radiation is emitted progressively, in the opposite direction to the motion of the electron.

Question 10
The design and purpose of the wigglers is to:
A. Produce a wide, powerful beam of radiation through the use of magnets with alternating polarity
B. Produce a narrow, powerful beam of radiation through the use of magnets with alternating polarity.
C. Produce a narrow, powerful beam of radiation through the use of magnets with identical polarity.
D. Produce a wide, powerful beam of radiation through the use of magnets with identical polarity.

A 0.9 nm photon is incident on a stationary electron.
After the interaction, the scattered photon has a wavelength of 1.1 nm, whilst the electron moves with a velocity of 9.4×10^6 m s^{-1}.

Question 11
Which of the following statements about the interaction is true?
A. The interaction is an example of Thomson scattering, because kinetic energy is conserved and the wavelength of the photon decreases
B. The interaction is an example of Compton scattering, because energy is conserved and the wavelength of the photon increases
C. The interaction is an example of Thomson scattering, because momentum is conserved, but kinetic energy is lost
D. The interaction is an example of Compton scattering, because momentum is conserved, but kinetic energy is gained

SECTION B – Detailed study 1 – continued

Questions 12 and 13 refer to the following information

Coherent x-rays of wavelength 0.2 nm are directed towards a crystal lattice as shown in Figure 2. The crystal is rotated, until the x-rays interact to form an observable pattern

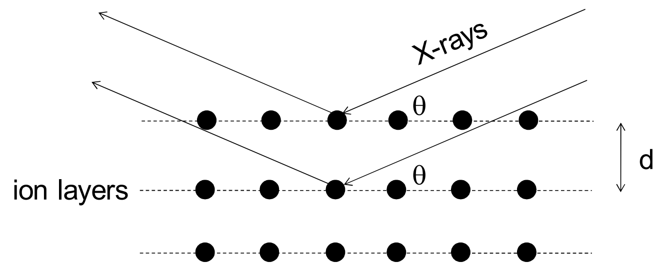


Figure 2

Question 12
Which of the following best describes the reason for this pattern?
A. The x-rays diffract as they pass through the lattice and this pattern is readily observed.
B. The path difference due to gap between the layers in the lattice leads to constructive and destructive interference, which can be readily observed as the x-rays reflect from the crystal
C. Electrons are ejected from the ion layers and these interact with the x-rays to form a pattern
D. There is no path difference due to gap between the layers in the lattice, which leads to constructive and destructive interference.

As the crystal is rotated, multiple angles yield a similar pattern. The third of these angles is 51^o

Question 13
Based on the angle information and wavelength of the x-rays, use your understanding to determine which of the following distances best approximates the distance between layers, d.
A. 3.86×10^{-10} m
B. 7.72×10^{-10} m
C. 1.28×10^{-9} m
D. 1.03×10^{-1} m

END OF DETAILED STUDY 1
SECTION B – continued
TURN OVER

Detailed Study 2 – Photonics

Question 1
Which of the following statements regarding LEDs is FALSE?
A. LEDs emit light when electrons move from the conduction to the valence band
B. A bright blue LED would produce more photons than a dimmer blue LED
C. A bright red LED would produce photons of greater energy as a dimmer red LED
D. Blue LEDs have an energy gap which is more than a red LED

An LED emits light of wavelength 600 nm

Question 2
The energy of an emitted photon (in eV) would be closest to:
A. 2.1×10^{-19} eV
B. 6.0×10^{-9} eV
C. 2.1 eV
D. 3.3 eV

Question 3
Which of the following is the best explanation for the incoherent nature of an incandescent light source?
A. Photons are produced by the stimulated emission of photons from excited atoms. All photons are out of phase.
B. Photon emission is due to discrete jumps of outer shell electrons. Photons are predictable in frequency and timing, so the light is out of phase.
C. Photon emission is due to random collisions between outer shell electrons. Photons are random in frequency and their timing is also unpredictable, so the light is out of phase.
D. All of the photons produced in a incandescent source have a similar wavelength and are thus in phase.

SECTION B – Detailed study 2 – continued

Questions 4 and 5 refer to the following information

A simplified diagram of a fibre optical wave guide is shown in Figure 1. The critical angle at the boundary between the core and cladding materials is 82^o.
The refractive index of the cladding material is 1.470.
Assume the light initially enters from air (n = 1.000)

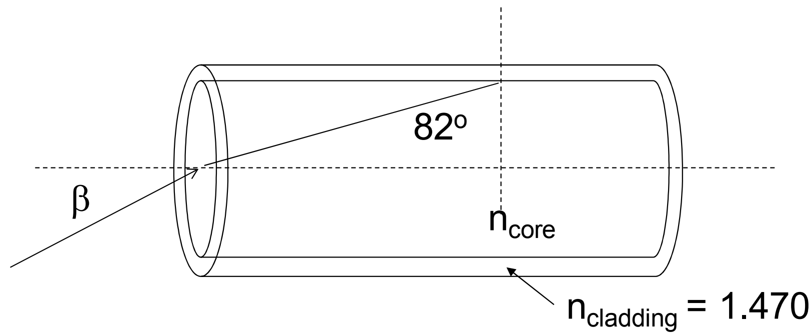


Figure 1

Question 4
The value for the refractive index of the core, n_{core}, is closest to:
A. 1.470
B. 1.484
C. 1.490
D. 1.500

The optical fibre is now immersed in a bucket, so that the light source now enters the guide from water rather than air.
Assume n_{water} = 1.333

Question 5
Which of the following statements best describes the effect that this change in surrounding medium would have on the acceptance angle, β?
A. β would increase marginally
B. β would decrease
C. β would stay constant
D. β would increase significantly

SECTION B – Detailed study 2 – continued
TURN OVER

Questions 6 to 8 refer to the following information

Figure 2 shows a graph of optical loss versus wavelength for a sample of optic fibre

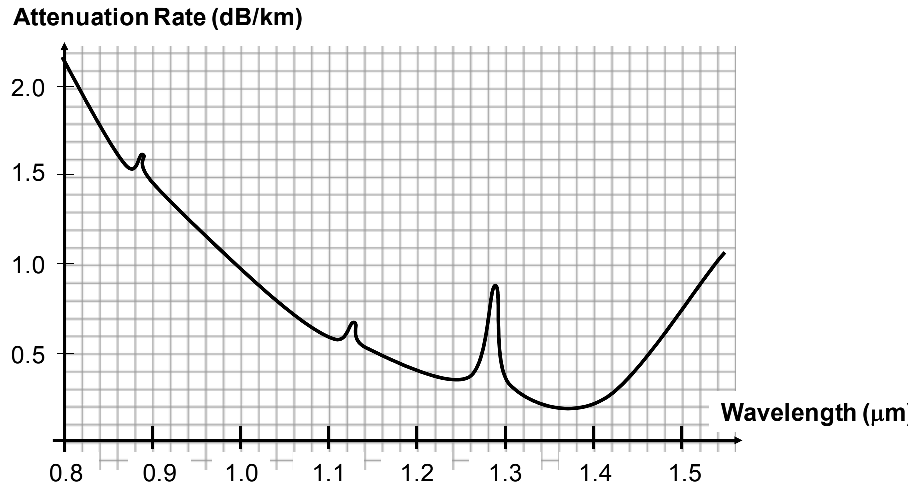


Figure 2

Question 6
For which wavelength is Rayleigh scattering most significant?
A. 0.8 μm
B. 0.9 μm
C. 1.29 μm
D. 1.36 μm

Question 7
If a designer wished to minimise energy losses, which of the following wavelengths would NOT be used for long distance telecommunications applications?
A. 0.9 μm
B. 1.24 μm
C. 1.36 μm
D. 1.40 μm

Question 8
The best explanation for the rapid increase in losses for wavelengths less than 0.9 μm would be:
A. Higher absorption due to impurities in the fibre
B. Absorption due to resonance in the fibre
C. Increased Rayleigh scattering
D. Leakage from the fibre due to imperfect total internal reflection.

SECTION B – Detailed study 2 – continued

Question 9
The light produced by a laser source can best be described as:
A. Incoherent, polychromatic, high divergence
B. Incoherent, monochromatic, low divergence
C. Coherent, polychromatic, high divergence
D. Coherent, monochromatic, low divergence

An engineer in considering upgrading a system from an existing network of:
- Multimode, step index
- Using monochromatic red laser to transmit information to a distant receiver.

Question 10
Which of the following would best decrease the amount of modal dispersion in a fibre?
A. Using a larger diameter fibre
B. Using a green laser source instead of a red laser source to transmit the information
C. Increase the length of the fibre
D. Using graded-index multimode fibre.

The engineer is also considering options for a single-mode fibre which operates with a red LED source.

Question 11
Which of the following would best decrease the amount of material dispersion?
A. Using a larger diameter fibre
B. Using a white light source instead of a red LED source to transmit the information
C. Using a red laser instead of the red LED.
D. Using a multimode graded-index fibre.

Question 12
Which of the following would be LEAST affected by modal dispersion?
A. Large diameter, step-index, multimode fibre.
B. Small diameter, step-index, multimode fibre.
C. Large diameter, graded-index, multimode fibre.
D. Small diameter, graded-index, multimode fibre.

Question 13
Which of the following statements about the illuminating and imaging fibre bundles used in key-hole surgery is FALSE?
A. Neither bundles need to be coherent to enable effective operation of the system.
B. Only illuminating bundles need to be coherent.
C. Only imaging bundles need to be coherent.
D. Both bundles will operate with polychromatic light sources.

END OF DETAILED STUDY 2
SECTION B – continued
TURN OVER

Detailed Study 3 – Sound

Questions 1 to 4 refer to the following information

A speaker mounted on a vertical wall vibrates with a period of 2 ms.
Assume that sound in the vicinity of the speaker travels at 340 m s^{-1}

Question 1
Which of the following best approximates the frequency of the speaker source?
A. 2 Hz
B. 170 Hz
C. 500 Hz
D. 680 Hz

Question 2
Which of the following best approximates the wavelength of the source?
A. 0.68 m
B. 1.47 m
C. 2 m
D. 1.7 m

A candle is placed in front of the speaker and its motion observed.
The speaker has a diameter of 0.25 m
When answering Question 3, refer to the axis orientation in Figure 1.

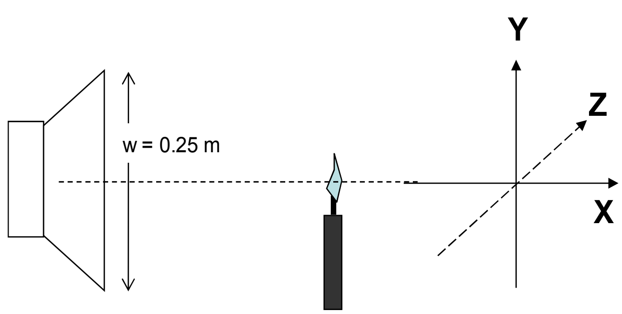


Figure 1

Question 3
Which of the following best describes the way in which the candle moves as the speaker is operating?
A. The candle will oscillate along horizontal x-axis, perpendicular to the wall
B. The candle will oscillate along vertical y-axis, parallel to the wall
C. The candle will oscillate along horizontal z-axis, parallel to the wall.
D. The candle will move away from the wall and stay at an angle until the source is switched off.

SECTION B – Detailed study 3 – continued

The sound from the speaker in Figure 1 is directed through a gap of width 0.2 m.
An operator reduces the period of the signal to 1 ms.

Question 4
Comparing the 1 ms and 2 ms period sources, which of the following statements would be most correct?
A. Diffraction of the source through the gap would be increased for the 1 ms source, but still remain minimal
B. Diffraction of the source would be decreased for the 1 ms source, but remain significant.
C. Diffraction of the source would be decreased for the 1 ms source and now be unnoticeable to an observer on the other side of the gap.
D. The change in period would have no effect on the extent of diffraction.

Figure 2 shows a set of phon curves, typical for a human ear.

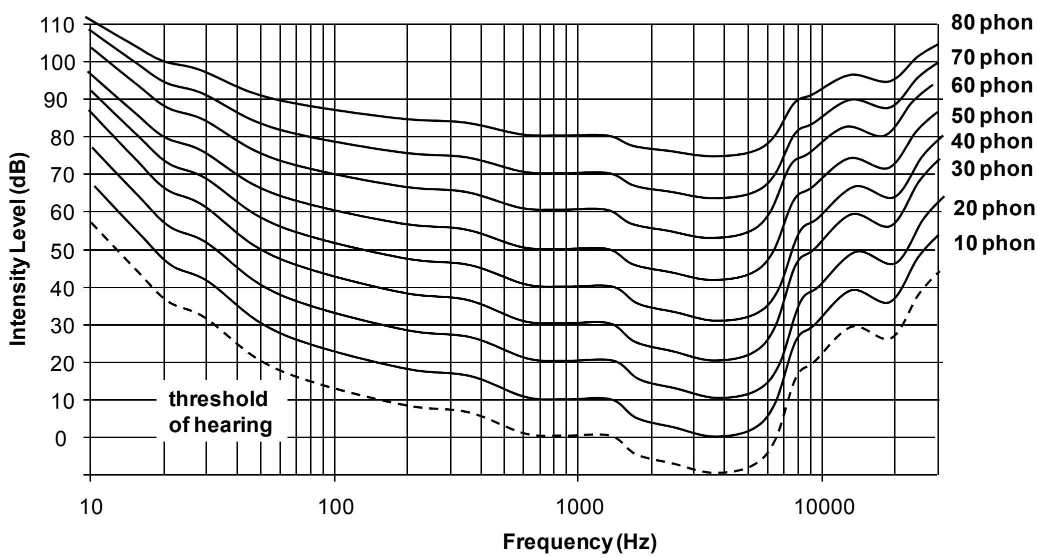


Figure 2

Question 5
Referring to Figure 2, which of the following statements is correct?
A. 60 dB at 30 Hz would be perceived as equally loud as 60 dB at 100 Hz
B. 70 dB at 100 Hz would be perceived as equally loud as 33 dB at 100 Hz
C. 70 dB at 40 Hz would be louder than 52 dB at 4000 Hz
D. 90 dB at 8000 Hz would be perceived as equally loud as 80 dB at 800 Hz

SECTION B – Detailed study 3 – continued
TURN OVER

Questions 6 and 7 refer to the following information

A siren is suspended from a cable high above the centre of a sporting field.
When the siren is switched on, at a height of 12 m above the ground, an intensity of 1.2×10^{-2} W m^{-2} is recorded.

Question 6
Which of the following best approximates the power of the sound source?
A. 1.2×10^{-2} W
B. 0.144 W
C. 1.81 W
D. 21.7 W

The siren is now lifted so that the sound level at ground level decreases by 6 dB.

Question 7
Which of the following is the best estimate for the new height of the siren?
A. 12.6 m
B. 18 m
C. 24 m
D. 36 m

Questions 8 and 9 refer to the following information

A teacher is demonstrating resonance with a long PVC tube, 10 cm in diameter, open at both ends. When placed above a Bunsen burner, a low frequency tone of 134 Hz is heard distinctly. This tone is the fundamental frequency.

Question 8
Using a different source, which of the following frequencies could also be heard?
A. 67 Hz
B. 201 Hz
C. 268 Hz
D. 469 Hz

Question 9
If the tube is 1.27 m long, which of the following is the best estimate for the speed of sound in the tube?
A. 333 m s^{-1}
B. 340 m s^{-1}
C. 343 m s^{-1}
D. 353 m s^{-1}

SECTION B – Detailed study 3 – continued

Questions 10 and 11 refer to the following information

A tube closed at one end is resonating at its second resonant frequency above the fundamental.
The tube is 2 m in length and the speed of sound can be taken as 340 m s^{-1}.
A teacher places a microphone at position X as shown in Figure 3.

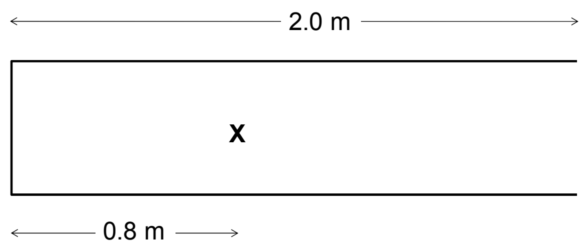
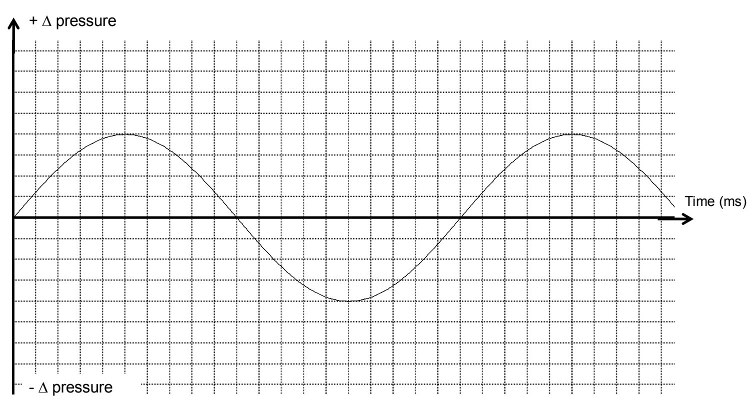


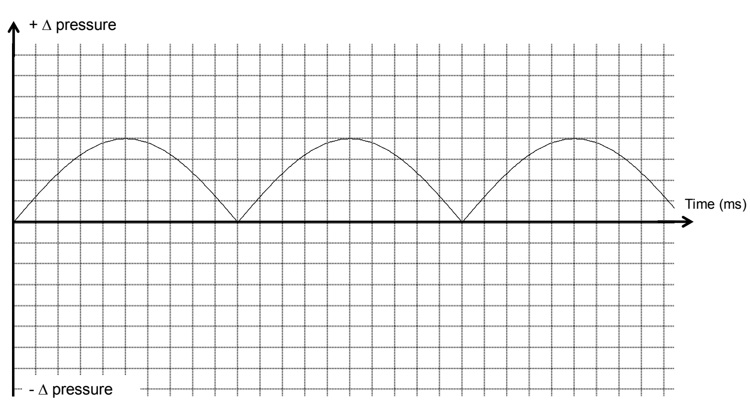
Figure 3

Question 10
Which of the following graphs of pressure vs. time best estimates the variation of pressure that would be recorded by the microphone?

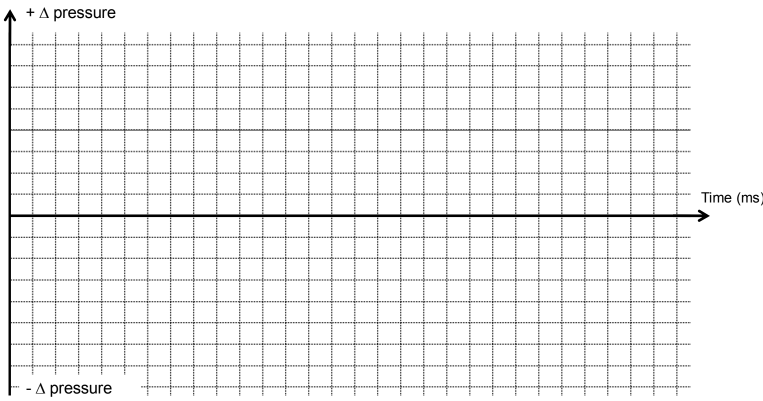
A.



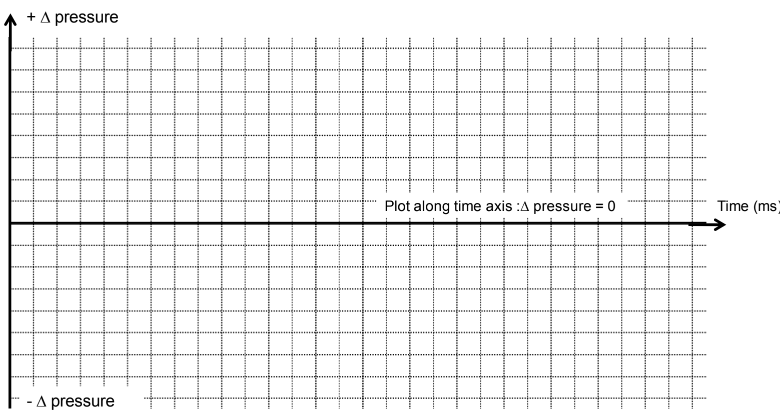
B.



C.



D.



SECTION B – Detailed study 3 – continued

Question 11
Which of the following is closest to the frequency of the tube as it resonates in Figure 3?
A. 43 Hz
B. 128 Hz
C. 213 Hz
D. 298 Hz

Question 12
Which of the following statements best describes how a baffle improves the performance and fidelity of a loudspeaker?
A. It increases destructive interference near the edges of the speaker cone
B. It decreases destructive interference near the edges of the speaker cone
C. It increases diffraction to allow greater spread of sound
D. It increases the power of the speaker by removing sound behind the speaker cone.

SECTION B – Detailed study 3 – continued
TURN OVER

Figure 4 shows a response curve for a proposed vocal microphone, designed to record human voice.

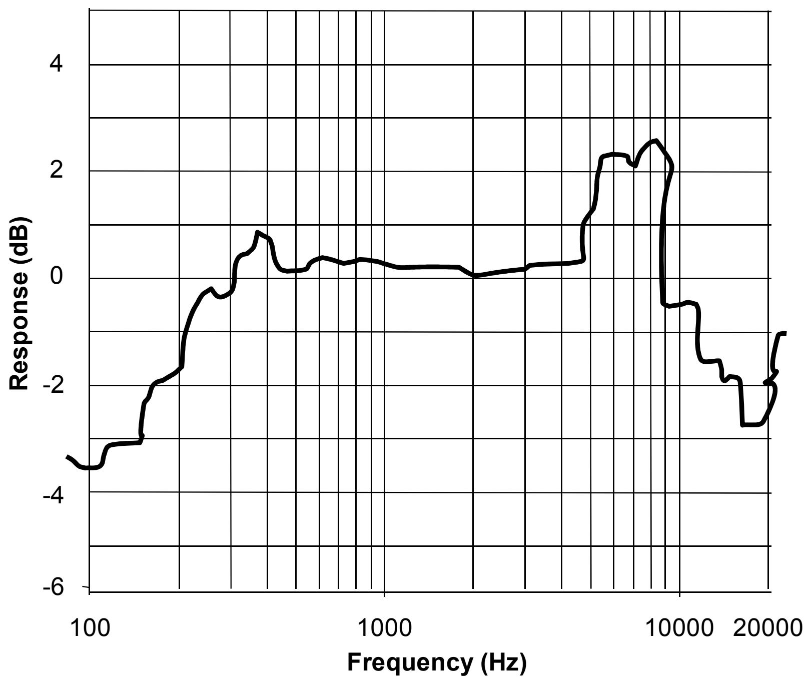


Figure 4

Question 13

Which of the following responses is incorrect?

A. The microphone is regarded as "high fidelity" within the vocal range as its response curve is flat between ~ 400 – 4000 Hz

B. The microphone is regarded as "low fidelity" within the vocal range as its response curve is flat between ~ 400 – 4000 Hz

C. The microphone is regarded as "high fidelity" within the vocal range as its response curve peaks at 8000 Hz, which is ideal for human speech

D. The microphone is regarded as "high fidelity" within the vocal range as it has a linearly increasing response from 100 – 400 Hz.

END OF QUESTION AND ANSWER BOOK

Data Sheet

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

1	photoelectric effect	$E_{\text{k max}} = hf - W$
2	photon energy	$E = hf$
3	photon momentum	$p = \frac{h}{\lambda}$
4	de Broglie wavelength	$\lambda = \frac{h}{p}$
5	resistors in series	$R_{\text{T}} = R_1 + R_2$
6	resistors in parallel	$\frac{1}{R_{\text{T}}} = \frac{1}{R_1} + \frac{1}{R_2}$
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	$V_{\text{RMS}} = \frac{1}{\sqrt{2}}V_{\text{peak}}$ $I_{\text{RMS}} = \frac{1}{\sqrt{2}}I_{\text{peak}}$
11	voltage; power	$V = RI$ $P = VI$
12	transmission losses	$V_{\text{drop}} = I_{\text{line}}R_{\text{line}}$ $P_{\text{loss}} = I_{\text{line}}^2 R_{\text{line}}$
13	mass of the electron	$m_{\text{e}} = 9.1 \times 10^{-31}$ 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 $h = 4.14 \times 10^{-15}$ 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	$\theta_\mathrm{A} = \sin^{=1}\sqrt{(n_1^2 - n_2^2)}$
25	numerical angle	$NA = \sin\theta_\mathrm{A}$

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}

Prefix/Units

p = pico = 10^{-12}
n = nano = 10^{-9}
μ = micro = 10^{-6}
m = milli = 10^{-3}
k = kilo = 10^{3}
M = mega = 10^{6}
G = giga = 10^{9}
t = tonne = 10^{3} kg

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