Student Name: _____

Physics
Written examination 2

2006 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 questions to be answered*	*Number of marks*
A-Core-Areas of study			
1. Electric power	17	17	40
2. Interactions of light and matter	11	11	25
B- Detailed studies			
1. Synchrotron and its applications	11	11	25
OR			
2. Photonics	9	9	25
OR			
3. Sound	12	12	25
			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 and/ or a graphics calculator.

Materials supplied
- Question and answer book of 27 pages.

Instructions
- Print your name in the space provided on the top of this page.
- All written responses must be in English.
- Write your answers in the spaces provided.
- **A**lways show working out where space is provided, marks may be awarded for working out.

Students are NOT permitted to bring mobile phones and/or any other electronic communication 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

Magnetic field associated with the circular magnet shown in **Figure 1**

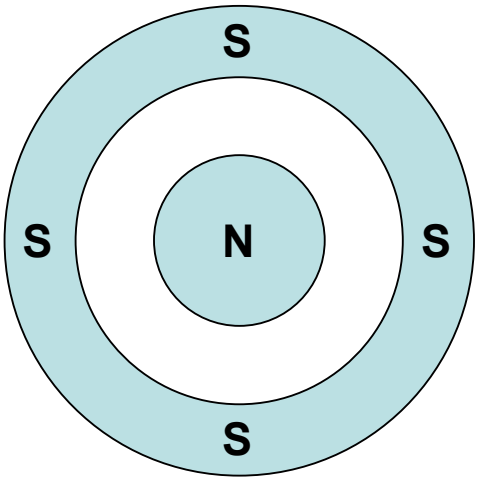


Figure 1

Question 1
Indicate on the diagram the *direction of the magnetic field* due to the arrangement in **Figure 1.**

2 marks

A coil of wire is placed between the magnets as shown in **Figure 2**. Current flows clockwise through the coil as shown, such that a force acts on the coil

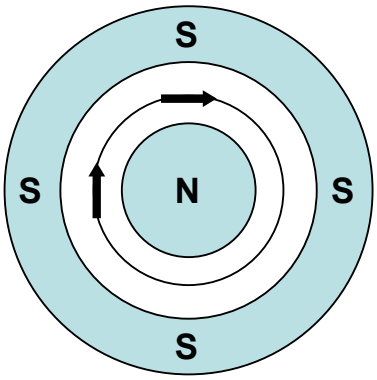
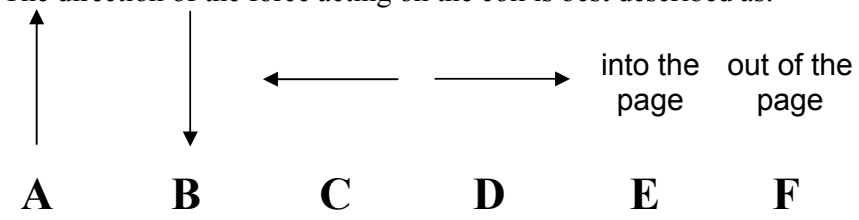


Figure 2

SECTION A- AREA OF STUDY 1- continued

Question 2
The direction of the force acting on the coil is best described as:



2 marks

The coil consists of 10 loops. If the current is set at 2A DC and the magnetic field is 0.25T, the force on the wire is 0.6N.

Question 3
Calculate the length of wire in each loop that is being affected by the magnetic field interactions.

m

2 marks

An alternating current of 10Hz now replaces the direct current through the coil.

Question 4
Describe the effect that this would have on the coil

_____

_____

_____

_____

2 marks

Lucy has constructed a basic generator circuit, as shown in Figure 3. The coil consists of 30 loops. Side lengths: AD = 10cm, AB = 15cm. The magnetic field strength between the poles is 0.4T

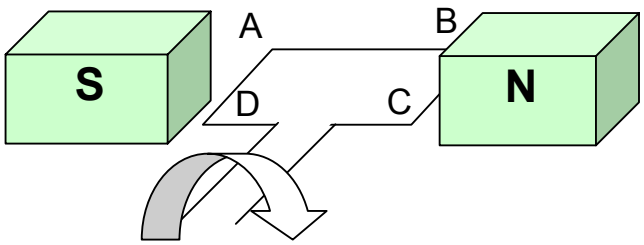


Figure 3

Question 5
Determine the direction of the current that would flow through the coil

2 marks

Lucy now rotates the coil at a rate of five revolutions per second.

Question 6
Calculate the magnitude of the average emf induced in the coil for a quarter turn from horizontal to vertical position

V

3 marks

SECTION A- AREA OF STUDY 1- continued

Lucy connects a cathode ray oscilloscope (CRO) to the coil and the output is shown in Figure 4.

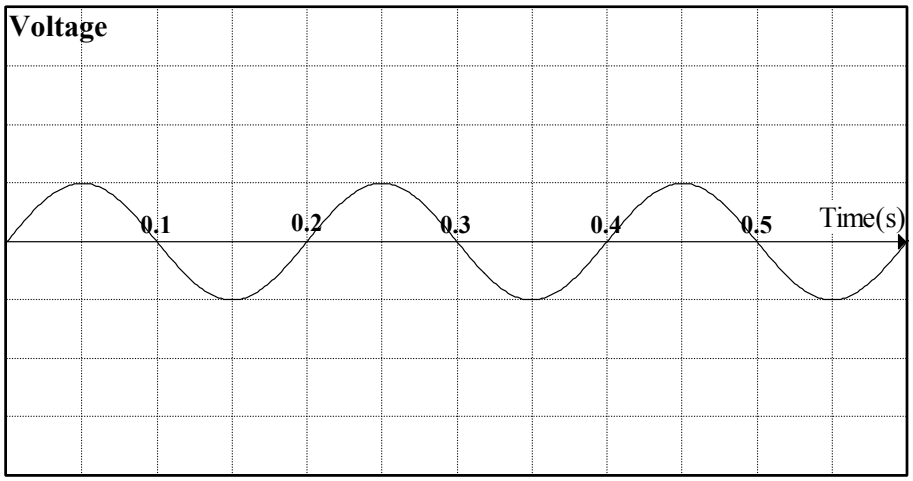


Figure 4

Lucy now doubles the speed of rotation to 10 revolutions per second.

Question 7
Sketch the output you would expect to see on the CRO (you can draw on **Figure 4**)

2 marks

Question 8
Justify your sketch for **Question 7** referring to appropriate physics principles

_____

_____

_____

_____

3 marks

A particular wind powered turbine and generator produces a peak output of 100kW at 600V AC RMS. The device is located some distance from a small sewage pumping station, which uses the electricity to run some auxiliary systems. Transmission lines connecting the station to the wind turbine have a combined resistance of 0.4Ω. A step down transformer at the station converts the supply voltage to 240V AC RMS.

Question 9
Calculate the peak-peak voltage of the generator prior to transmission

V

2 marks

Question 10
Calculate the power loss (in watts) using this transmission system

W

3 marks

A small step-up transformer is installed at the turbine site, increasing the voltage from 600V to 3.5kV.

Question 11
Calculate the current in the transmission lines

2 marks

A

Question 12
Calculate the voltage on the primary side of the step-down transformer at the station site.

V

3 marks

Question 13
For this scenario, calculate the turns ratio required to effectively step down the voltage at the station

2 marks

Two loops of wire are positioned as shown in Figure 5. Current is passed through the upper loop in the direction shown.

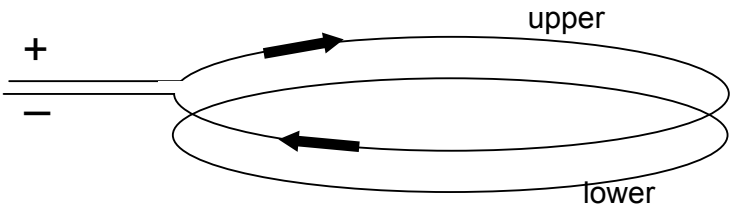


Figure 5

Question 14
Which of the following best describes the effect of switching ON the current in the upper loop, ***when viewed from above.***

A. Current flows clockwise in the lower loop
B. Current flows anticlockwise in the lower loop
C. There is no current flow in the lower loop
D. Impossible to say given the information provided

2 marks

Question 15
Explain your reasoning behind your answer to **Question 14.**

3 marks

Question 16
Explain the purpose of a commutator in a DC motor

_____

_____

_____

_____

_____

3 marks

Question 17
Outline one similarity and one difference between an alternator and a generator

_____

_____

_____

_____

2 marks

END OF AREA OF STUDY 1
SECTION A- continued

Area of Study 2 - Interactions of Light and Matter

Kevin sets up an experiment in which monochromatic green light of wavelength 525nm passes through two narrow slits, which are parallel and separated by 2mm. He observes a regular pattern of alternating dark and light bands cast on a screen some distance from the slits.

Question 1
Which one of the following best describes the pattern Kevin would observe if he were to change the green light to red light (λ = 680nm)

A. The spacing between the bright bands would increase
B. The spacing between the bright bands would decrease
C. There would be no change to the spacing of the pattern
D. Impossible to say given the information provided

2 marks

Kevin replaces the double-slits with a second pair, this time with a separation of 3mm

Question 2
Which one of the following correctly summarises the results in order of **increasing band spacing**

A. Green-2mm, Green-3mm, Red-2mm
B. Red-2mm, Green-2mm, Green-3mm
C. Green-3mm, Green-2mm, Red-2mm
D. Red-2mm, Green-3mm, Green-2mm

2 marks

Question 3
Explain how the bright and dark bands were formed

_____

_____

_____

_____

_____

3 marks

Figure 1 shows a circuit that Bill has constructed to investigate the photoelectric effect. A metal plate is illuminated with light of various frequencies and the stopping voltage (V_0) of the emitted photoelectrons is measured. The stopping voltage is used to measure the maximum kinetic energy of the photoelectrons and is observed using the voltmeter. The voltmeter also measures the potential difference between Y and X. A milliammeter is used to record the photocurrent.

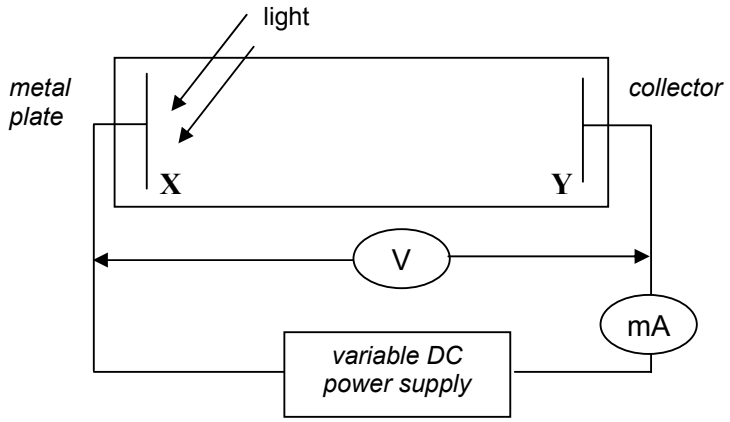


Figure 1

With the light source set to green (525nm), Bill records results of photocurrent (I) vs. Potential difference between Y and X ($V_{Y\text{-}X}$)

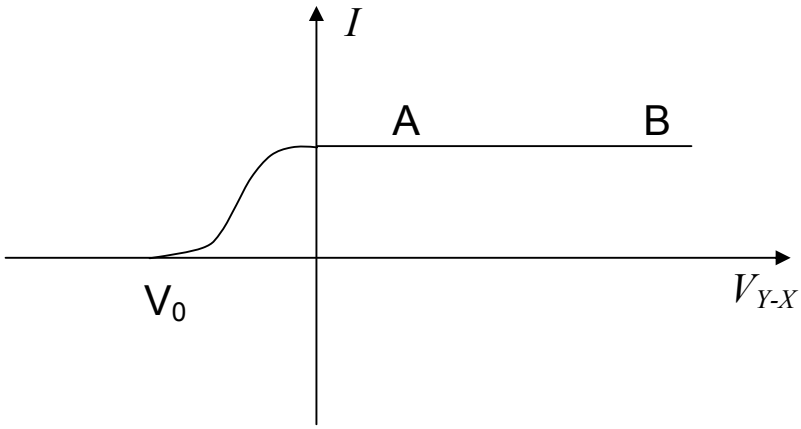


Figure 2

SECTION A- AREA OF STUDY 2- continued

Question 4
Explain why the current in the circuit is constant between points A and B, while the potential between Y and X increases

_____

_____

_____

_____

_____

3 marks

The intensity of the light is increased and the source is changed to blue (470nm)

Question 5
Sketch the expected result on **Figure 2**

2 marks

Question 6
With the source still blue, a stopping voltage of 1.9V is recorded. Determine the maximum kinetic energy of the ejected electrons in joule

J

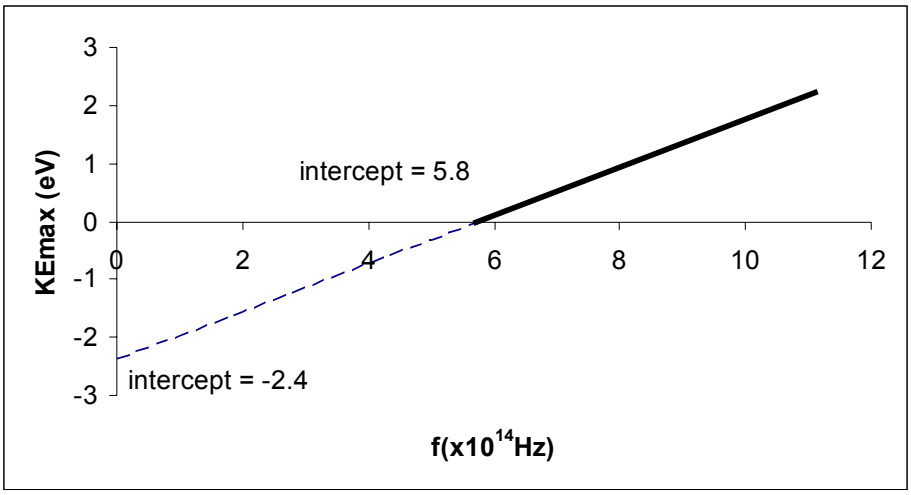
2 marks

Question 7
Determine the threshold frequency for the metal plate

Hz

2 marks

Bill now substitutes the metal plate for an alternate one and proceeds to plot the KE_{max} of the electrons vs. frequency for the new setup.



Question 8
For a light source of 375nm, use the graph to estimate the stopping voltage required

V

2 marks

Question 9
Calculate the de Broglie wavelength of an electron which is travelling at 6.7×10^5 ms^{-1}

m

2 marks

A beam of electrons travelling at 6.7×10^5 ms^{-1} will exhibit a similar diffraction pattern to that of X-rays when passed through thin foil onto a photographic film

Question 10
Calculate the frequency of X-rays required to yield a similar pattern

Hz

2 marks

SECTION A- AREA OF STUDY 2- continued

Question 11
Explain which model of light and matter is supported by these observations of X-rays and electrons

_____

_____

_____

_____

3 marks

Working space

END OF SECTION A
TURN OVER

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.

Detailed study 1 - Synchrotron and its Applications

Barry has engineered an electron beam, using a simple electron gun as shown in the schematic **Figure 1.**

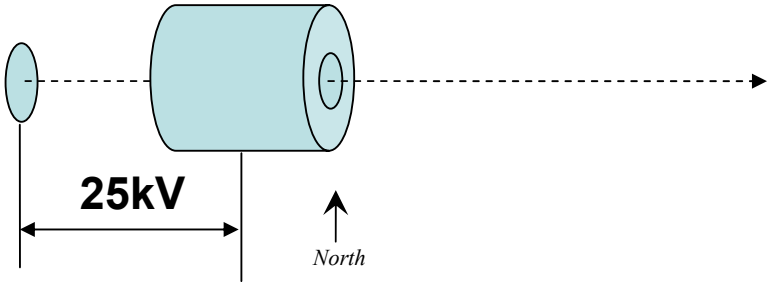


Figure 1

Question 1
Calculate the kinetic energy of an electron as it exits the gun

eV

2 marks

Question 2
Calculate the velocity of an electron as it leaves the gun

ms^{-1}

2 marks

Barry wishes to deflect the electron beam in a southerly direction (as per key in **Figure 1**) via a magnetic field

Question 3
Using appropriate field line conventions, indicate the direction of the magnetic field that Barry would need to employ (Draw on **Figure 1**)

2 marks

The size of the magnetic field is observed to be 1.4T.

Question 4
Calculate the size of the force on a single electron

N

2 marks

The experiment is now repeated for a new accelerating voltage and the radius of curvature is observed to be 9×10^{-5} m. The magnetic field remains at 1.4T

Question 5
Determine the momentum of an electron which follows this arc.

$kgms^{-1}$

2 marks

SECTION B- DETAILED STUDY 1- continued
TURN OVER

Question 6
Explain the function of the following synchrotron components

Booster ring

_____

_____

_____

_____

Beamline

_____

_____

_____

_____

2+2 = 4 marks

Question 7
Explain three ways in which X-rays can interact with atoms and electrons, exhibiting both wave and particle like behaviours

_____

_____

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_____

3 marks

When X-rays of an appropriate energy level are fired at a crystal, they are scattered by each atom in the lattice, spreading out from the atom and interacting with each other to form and interference pattern.
X-rays of 8.3keV are fired at a crystal with plane spacing 0.28nm

Question 8
Calculate the angle of reflection for n = 3 as per Bragg's Law.

o

2 marks

SECTION B- DETAILED STUDY 1- continued
TURN OVER

Question 9
Show that there will only be three angles of reflection exhibited for this crystal

2 marks

Various interactions are examined in a synchrotron using X-rays of various energies as indicated in **Figure 2**

Interaction	Incident X-ray Energy (MeV)	Scattered X-Ray Energy (MeV)
P	0.03	0.03
Q	0.07	0.04
R	0.15	None

Figure 2

Question 10
Which of the following best describes the interactions A, B and C

A. P = Compton Scattering, Q = Thomson Scattering, R = Diffuse Scattering
B. P = Photoelectric Effect, Q = Compton Scattering, R = Thomson Scattering
C. P = Compton Scattering, Q = Photoelectric Effect, R = Thomson Scattering
D. P = Thomson Scattering, Q = Compton Scattering, R = Photoelectric Effect

2 marks

Question 11
Calculate the wavelength of the scattered X-rays in Interaction Q

m

2 marks

END OF DETAILED STUDY 1
SECTION B- continued

Detailed study 2 - Photonics

Question 1
Explain and contrast the production of light by the following incoherent sources

Light bulb:

_____

_____

_____

_____

Metal vapour lamp:

_____

_____

_____

_____

4 marks

Question 2
Describe the method of producing light using a LASER and comment on the differences between it and the two incoherent sources discussed above.

_____

_____

_____

_____

4 marks

SECTION B- DETAILED STUDY 2 continued
TURN OVER

Question 3
Explain how light is emitted from an LED

_____

_____

_____

_____

_____

_____

2 marks

Question 4
Use the data in **Figure 1** to calculate the wavelength of the photons emitted by a common LED

h	4.14×10^{-15} eVs
c	3×10^{8} ms^{-1}
E_g	2.1eV

Figure 1

nm

2 marks

Figure 2 shows an optical fibre used in telecommunication

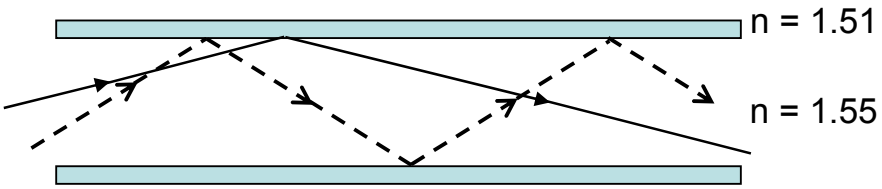


Figure 2

Question 5
Which of the following best describes the design of the fibre in **Figure 2**

A. Single-mode step index
B. Multi-mode step index
C. Single-mode graded index
D. Multi-mode graded index

2 marks

SECTION B- DETAILED STUDY 2- continued

Question 6
Calculate the numerical aperture for the fibre shown in **Figure 2**

2 marks

Question 7
Explain and contrast the cause of **material** and **modal** dispersion in optical fibre AND describe one way in which each can be reduced.

4 marks

Question 8
Explain the difference between a **coherent** and **non-coherent** fibre optic imaging bundle. Provide an example of where each could be used.

3 marks

SECTION B- DETAILED STUDY 2- continued
TURN OVER

Figure 3 shows a chart of Optical Loss vs. Wavelength for two different forms of attenuation

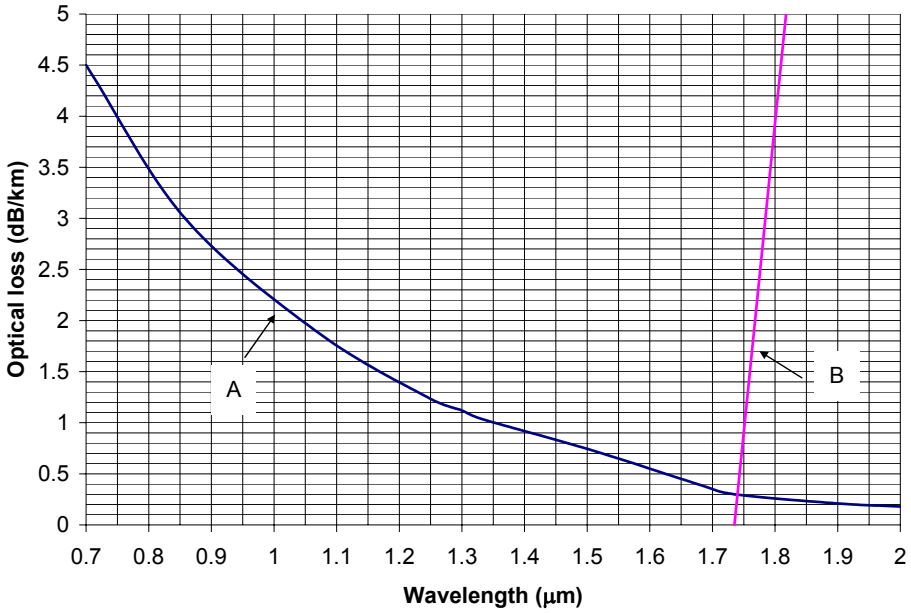


Figure 3

Question 9

Identify loss type B and describe the primary factor driving the rapid increase in optical loss for wavelengths greater than ~ 1.7μm

_____

_____

_____

_____

2 marks

END OF DETAILED STUDY 2
SECTION B- continued

Detailed Study 3 – Sound

Figure 1 shows variation in air pressure over time (in ms) at a point very near a loudspeaker

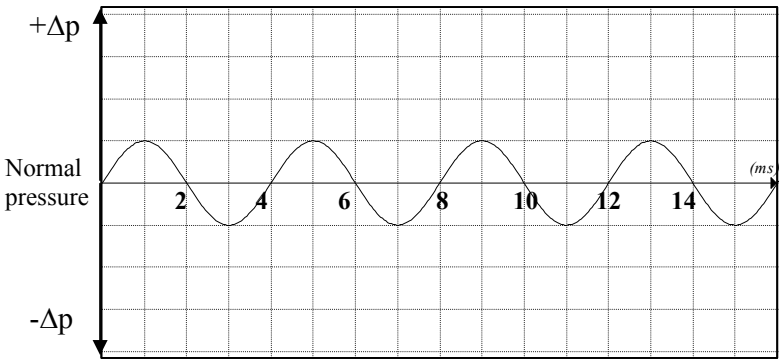


Figure 1

Question 1
Determine the period of the sound wave

s

2 mark

The speed of sound in the air near the loudspeaker is known to be 335 ms^{-1}

Question 2
Calculate the wavelength of the sound wave

m

2 marks

SECTION B- DETAILED STUDY 3- continued
TURN OVER

Question 3
Describe how the dynamic loudspeaker is able to convert electrical signals to an audible sound AND how this sound then travels through the air

_____

_____

_____

_____

_____

_____

_____

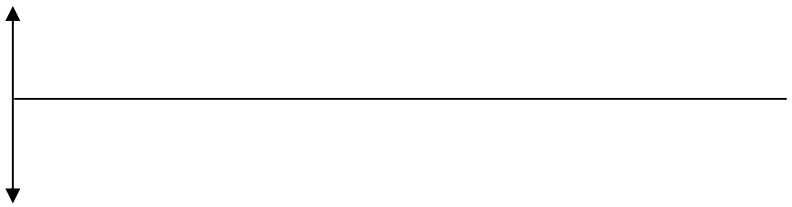
4 marks

A metal guitar string is plucked and the sound which is generated is analysed using a simple software program which identifies significant resonant frequencies. Figure 2 summarises the results of the test. Speed of sound in air is measured at 330 ms^{-1}

Number	Frequency (Hz)
1	120
2	240
3	360
4	480

Figure 2

Question 4
Sketch a graph of the standing wave that represents the 3rd harmonic of the vibrating string



2 marks

SECTION B- DETAILED STUDY 3- continued

Question 5
Calculate the length of the guitar string

m

2 marks

Elif and Gill are discussing the operation of Gill's acoustic guitar. Gill asserts that the air in the body of the guitar is acting as a resonator, while the string is simply the principal vibrator. Elif disagrees, stating that the string acts as both resonator and vibrator

Question 6
Who is correct?

1 mark

Question 7
Justify your answer to Question 6, referring specifically to the principle of resonance

_____

_____

_____

_____

_____

_____

_____

2 marks

SECTION B- DETAILED STUDY 3- continued
TURN OVER

Figure 3 shows the equivalent detectable sound intensity levels for an average human ear

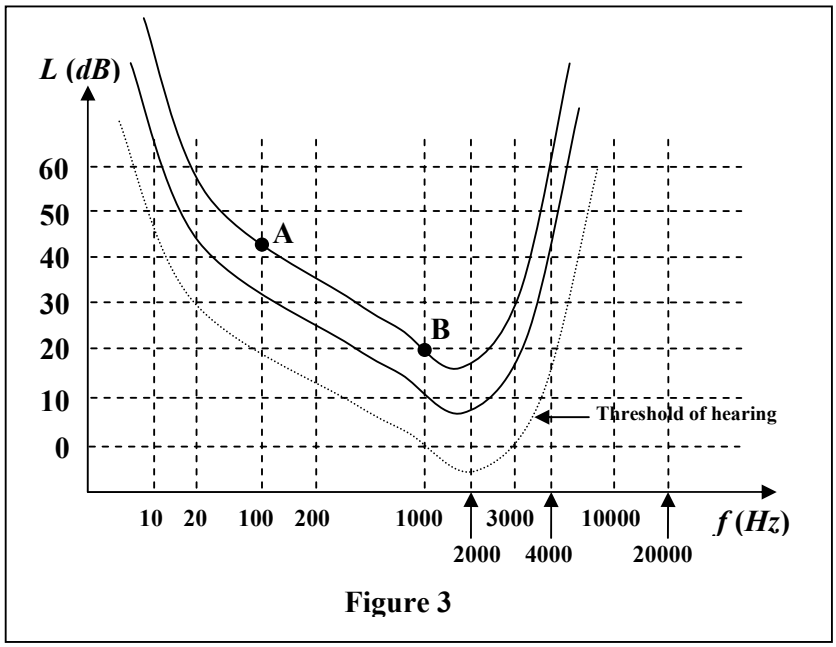


Figure 3

Question 8
Explain the term phon, referring specifically to points A and B in **Figure 3**.

_____

_____

_____

_____

_____

2 marks

A piercing safety alarm produces a 4000 Hz signal at 128dB – measured by a meter positioned 3m from the source

Question 9
Determine the distance you would need to be positioned from the source for the meter to read 122dB

m

2 marks

SECTION B- DETAILED STUDY 3- continued

In order to escape the noise of the safety alarm, Jim hides behind a 3m high brick wall. Suddenly the alarm alters in pitch to 200Hz.

Question 10
Would Jim notice any variation in loudness? Explain your answer

_____

_____

_____

_____

2 marks

High fidelity speaker systems use multiple speakers mounted on baffle boards.

Question 11
Why would multiple speakers be preferable to a single speaker. Refer specifically to **response curves** and the term **fidelity** in the context of the speaker system

_____

_____

_____

_____

2 marks

Some basic communication devices can use a single dynamic coil device which acts as both microphone and loudspeaker to both send and receive signals.

Question 12
Explain how the single moving coil device can act as both an audio-electro and electro-audio transducer

_____

_____

_____

_____

_____

_____

2 marks

END OF QUESTION AND ANSWER BOOK

