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Student name

PHYSICS
Unit 4
Trial Examination

QUESTION AND ANSWER BOOK

Total writing time: 1 hour 30 minutes

Structure of book

Section		Number of questions	Number of marks
	A – Core areas of study		
	1. Electric Power	18	40
	2. Interactions of light and matter	13	25
	B – Detailed studies		
	1. Synchrotron and its applications	10	25
OR	2. Photonics	12	25
OR	3. Sound	12	25
		Total	**90**

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and an approved scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

- Question and answer book of 34 pages, with a detachable formula sheet in the centrefold.

Instructions

- Detach the formula sheet from the centre of this book during reading time.
- Write your **name** in the space provided above on this page.
- Answer all questions in this question and answer book where indicated.
- Always show your working where space is provided and place your answer(s) to multiple-choice questions in the box provided.
- All written responses should be in English.

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SECTION A – Core

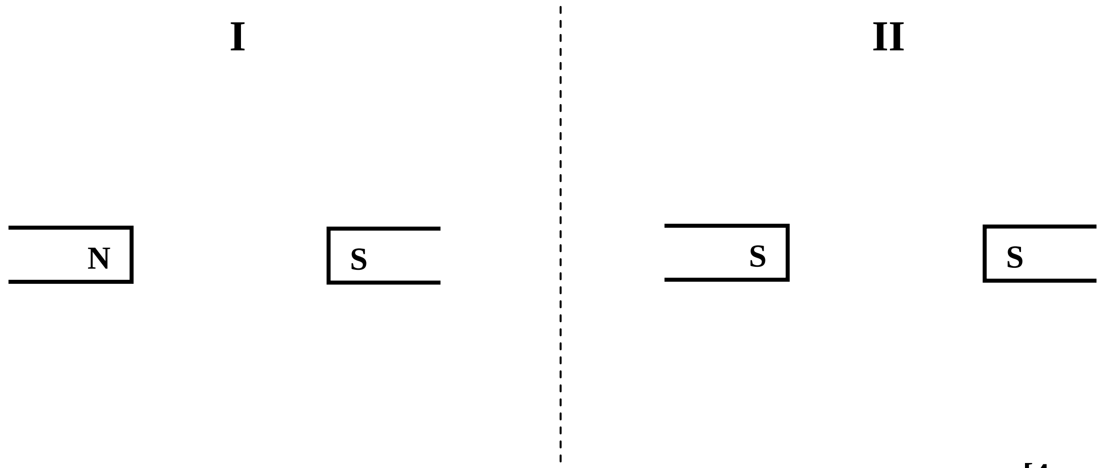
Instructions for Section A

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

AREA OF STUDY 1 – Electric power

Question 1

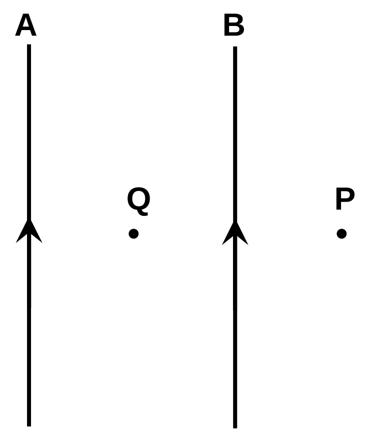
For the following two diagrams (I and II), showing pairs of bar magnets, carefully draw four magnetic field lines for **each** situation.



[4 marks]

Questions 2 & 3 relate to the following information.

Two wires, A and B, carry currents in the directions indicated by the arrows as shown in the diagram below. The current in wire B is twice the current in wire A ($I_B = 2\ I_A$).



The point Q is midway between wires A and B and the points P and Q are equal distances from wire B.

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Question 2

Which of the following best indicates the direction of the resultant magnetic field at point **Q** due to both currents?

A Up

B Down

C To the right

D To the left

E Into the page

F Out of the page

G zero

[2 marks]

Question 3

Which of the following best indicates the direction of the resultant magnetic field at point **P** due to both currents?

A Up

B Down

C To the right

D To the left

E Into the page

F Out of the page

G zero

[2 marks]

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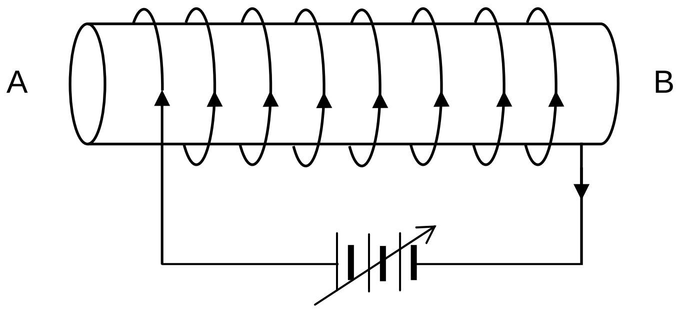
Questions 4 & 5 relate to the following information.

The diagram below shows a solenoid made by winding a current carrying wire around a cardboard cylinder. The direction of the current is indicated by the arrows.



Question 4

Which end of the solenoid, A or B, is the magnetic **South** Pole of the solenoid?

[2 marks]

Question 5

Give two ways in which the strength of the magnetic field of the solenoid could be increased?

Method One

____

____

Method Two

____

____

[2 marks]

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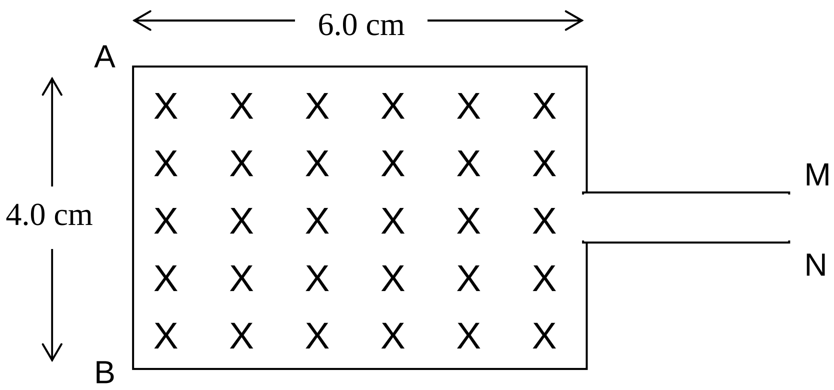
Questions 6 to 10 relate to the following information

A rectangular loop of wire measuring 6.0 cm by 4.0 cm is placed in a magnetic field of strength 2.3 x 10^{-3} Tesla directed into the page. This is shown in the diagram below.



Question 6

What is the magnitude of the magnetic flux passing through the wire loop?

Wb

[2 marks]

Question 7

The loop is totally removed from the magnetic field by pulling it to the right in 0.1 seconds.
The direction of the induced current in the side A-B is:

A A to B

B B to A

C A to B then B to A

D B to A then A to B

E No current is induced as the circuit is not closed

[2 marks]

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Question 8

What is the average *emf* produced across the terminals M and N when the loop is withdrawn from the magnetic field in 0.1 s?

A 5.5 μV **B** 55 μV

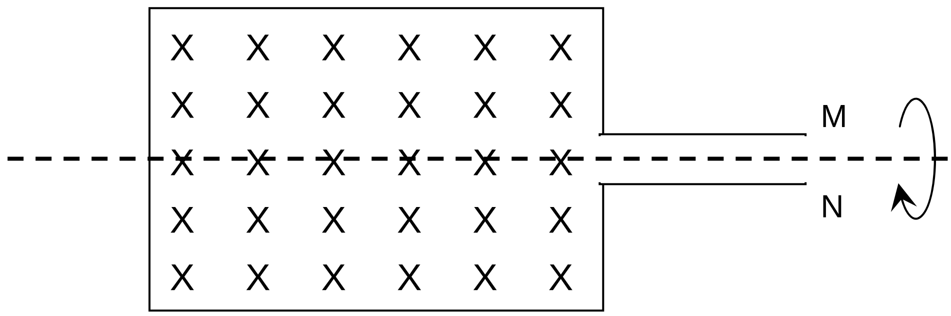
C 5.5 mV **D** 0.55 V

E No voltage is produced as the circuit is not closed

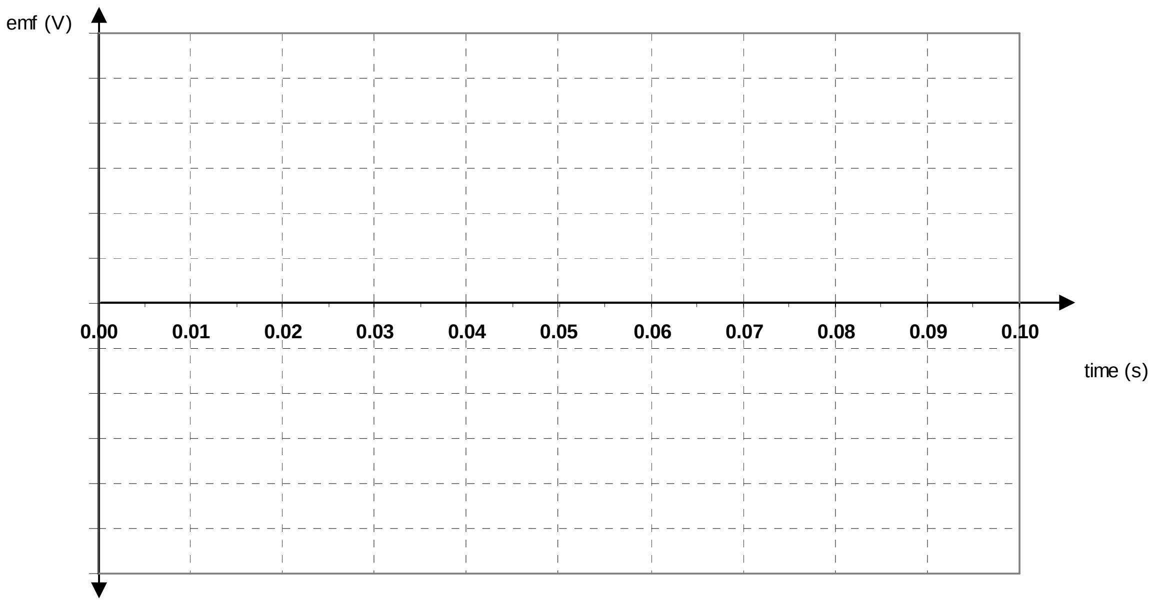
[2 marks]

Question 9

The loop is positioned in the magnetic field again and it is now rotated about the dashed axis making a full revolution in 0.1 second.



On the following set of axes carefully draw a graph of the induced *emf* across the terminals M and N. Values for the induced *emf* do NOT need to be included.



[2 marks]

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Question 10

The single loop is now replaced by 10 loops of identical size connected in series. These 10 loops are now completing a full rotation in 0.05 seconds.

These changes will affect both the amplitude and the period of the graph drawn in Question 9. Complete the table below stating what each of these changes will be. (For example, double would be an **increase** change by a factor of **× 2**).

Quantity	Change (increase, decrease, no change)	Factor of change (× or ÷ then a number)
Amplitude		
Period		

[4 marks]

Question 11

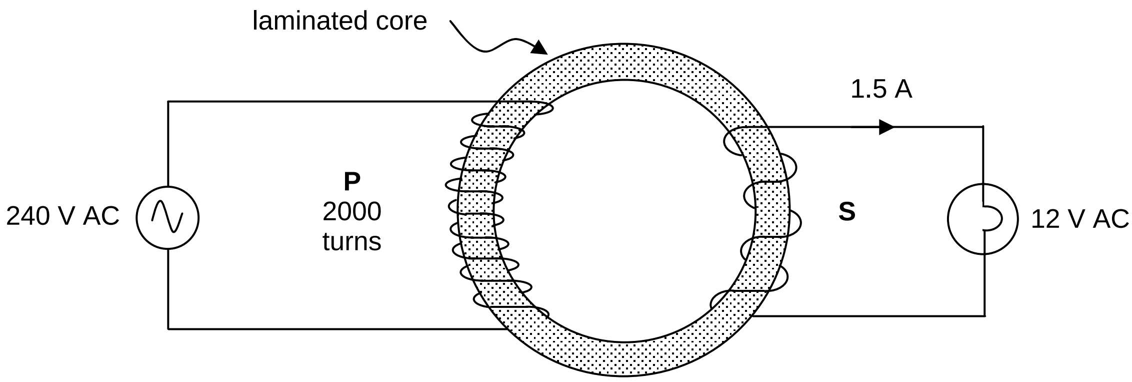
A 12 volt DC power supply is delivering 36 Watts of power to a circuit. What is the peak voltage from an AC power supply that would deliver an equivalent amount of power?

	V

[2 marks]

Questions 12 to 15 relate to the following information.

The diagram below shows the structure of a simple transformer. The primary coil, (P) consists of 2000 turns of insulated copper wire connected to a 240 V AC mains supply. The secondary coil, (S) supplies a current of 1.5 A at 12 V AC to a small light globe. The transformer can be assumed to be 100% efficient.



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Question 12

What material is usually used for the laminated core of a transformer?

[1 mark]

Question 13

Explain the purpose of the core of a transformer.

[2 marks]

Question 14

How many turns are there on the secondary coil of this transformer?

turns

[2 marks]

Question 15

What is the power supplied by the mains supply voltage?

W

[2 marks]

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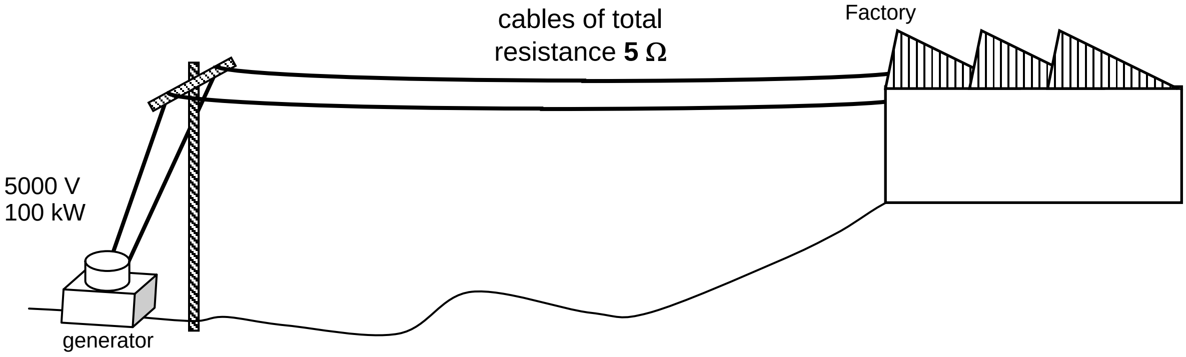
Questions 16 to 18 relate to the following information.

A generator producing 100 kW of power is connected to a factory by cables that have a ***total resistance*** of 5 Ω.

The generator produces the power at a voltage of 5000 V.



Question 16

What is the size of the current in the cables between the generator and the factory?

	A

[2 marks]

Question 17

What amount of power is delivered to the factory?

	W

[3 marks]

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Question 18

What is the voltage supplied to the factory?

V

[2 marks]

End of Area of Study 1

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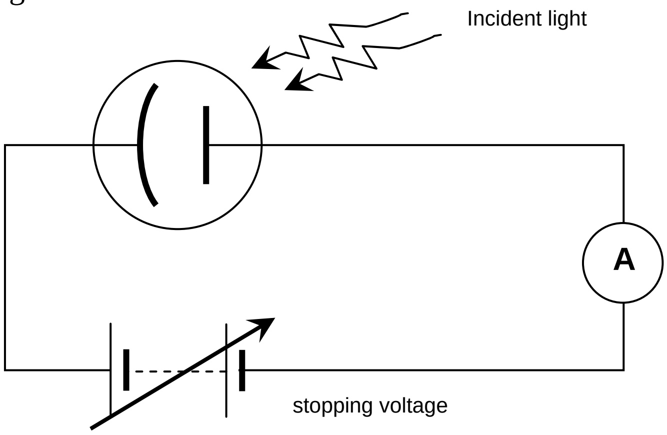
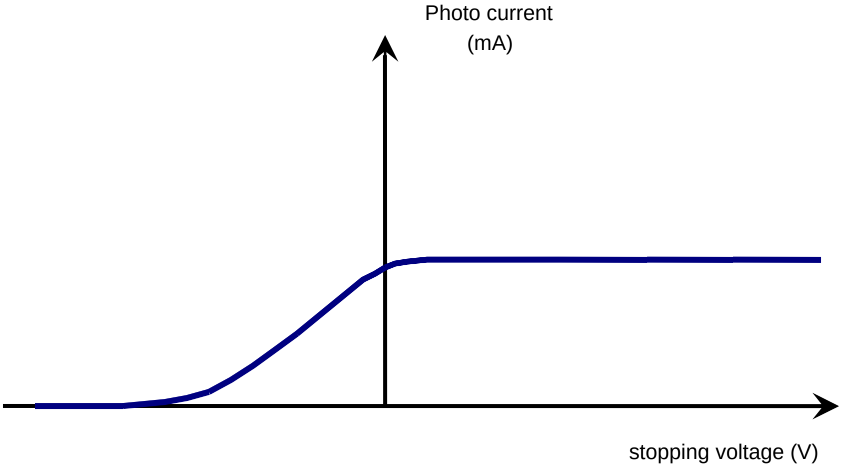
AREA OF STUDY 2 – Interactions of light and matter

Questions 1 to 5 relate to the following information.

A sodium light source of wavelength 589 nm is shone onto the photocathode of a photocell. This is shown in the diagram below.



The following relationship between the photoelectric current and the stopping voltage is obtained as shown.



Question 1

What is the energy of a photon of wavelength 589 nm?

J

[2 marks]

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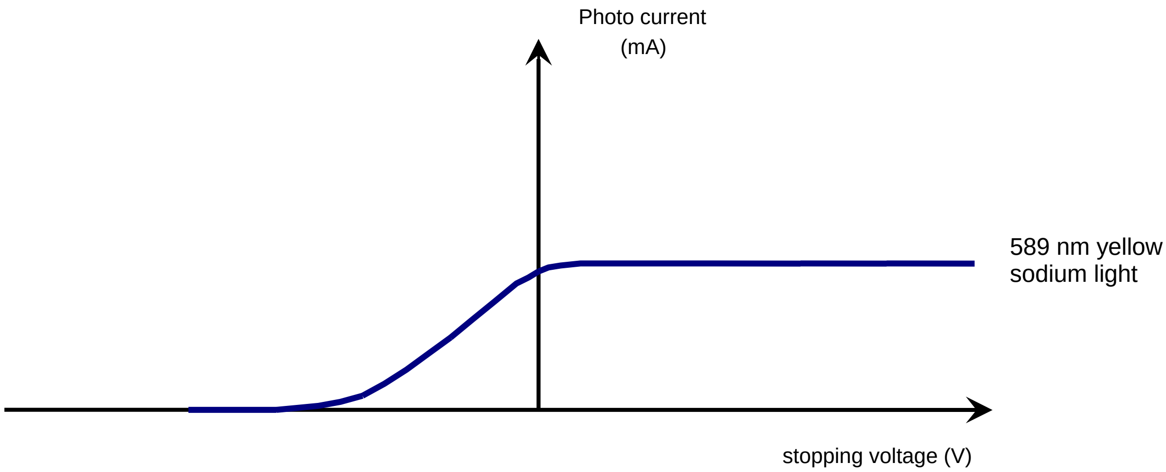
Question 2

On the following diagram sketch the approximate curve expected if the sodium light source is replaced by an ultraviolet light of twice the intensity.



[2 marks]

Question 3

An ultraviolet photon of energy 5.7×10^{-19} J shines on the metal cathode which has a work function of 3.1×10^{-19} J. What is the maximum kinetic energy of a photo emitted electron?

	J

[2 marks]

Question 4

The source of the incident ultraviolet light is reduced in intensity by 20%. What is the maximum kinetic energy of a photo emitted electron now?

	J

[2 marks]

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Question 5

Give two ways in which the maximum kinetic energy of the photo emitted electrons could be increased.

Method One

___

___

Method Two

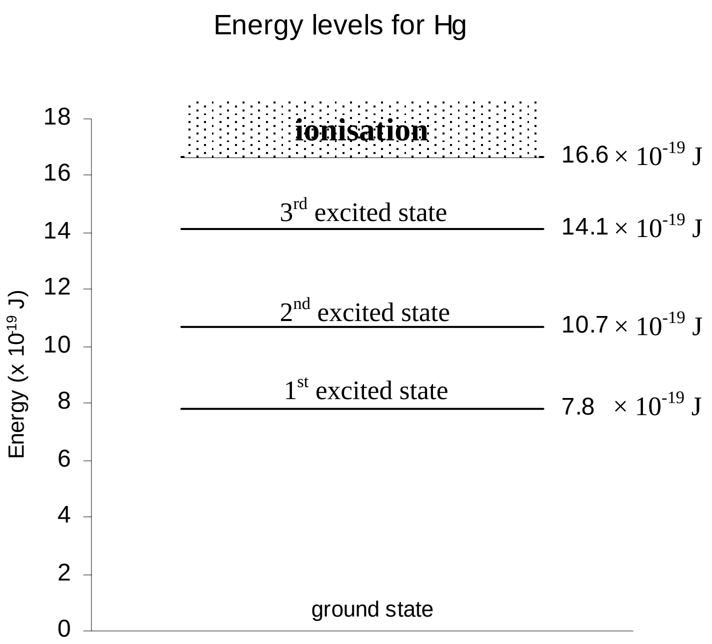
___

___

[2 marks]

Questions 6 to 8 relate to the following information.

Niels Bohr in 1913 proposed the theory that a photon is emitted when an electron 'jumps' from one energy level in an atom to another energy level of lower energy. The diagram below represents some possible energy levels for an electron in a Mercury atom.



Question 6

What is the ionisation energy of Mercury in eV?

eV

[2 marks]

Question 7

When mercury vapour is bombarded by photons of the "correct" energy the photons are absorbed. Which of the following photon energies could be absorbed by the mercury vapour? (one or more answers)

A 3.4×10^{-19} J

B 6.4×10^{-19} J

C 10.7×10^{-19} J

D 10.9×10^{-19} J

E 13.9×10^{-19} J

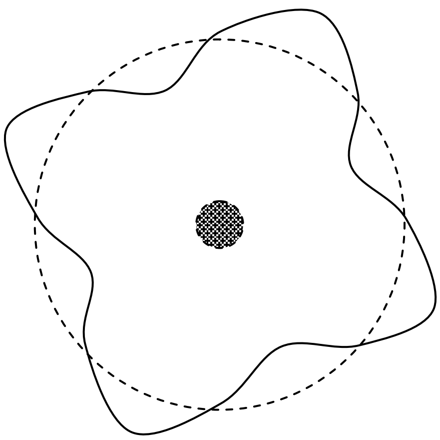
F 19.2×10^{-19} J

G None of the above are possible

[2 marks]

Question 8

Bohr's model of the atom used the idea of 'fitting' electrons into certain radius orbits around the nucleus according to their de Broglie wavelength. What is the principal quantum number represented by the following diagram?



n =

[2 marks]

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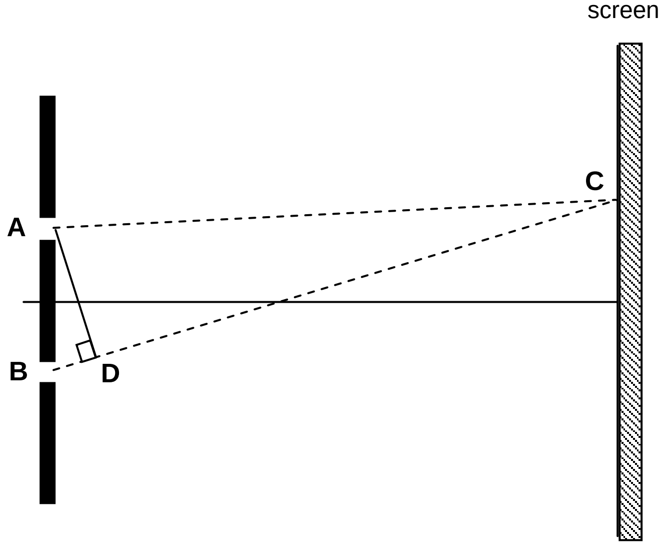
Questions 9 and 10 relate to the following information.

A sodium vapour lamp emits light of wavelength 589 nm. In an experiment, this light was passed through 2 slits; **A** and **B**. Point **C** represents the position of the second nodal line on a screen.



Question 9

What is the distance **BD** in nm?

nm

[2 marks]

Question 10

Explain how this experimental observation supports the wave model for light.

____

____

____

____

____

____

[2 marks]

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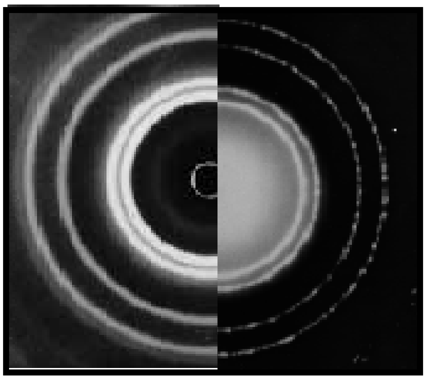
Questions 11 to 13 relate to the following information.

In 1927 Davisson and Germer investigated the scattering of electrons by a Nickel crystal. They compared their results with the diffraction pattern created by X-rays of wavelength 1.65×10^{-10} m in the same Nickel crystal and found a very strong similarity. This similarity is illustrated by the following side by side representation of their results.



X-rays **Electrons**

Question 11

What was the De Broglie wavelength of the electrons used by Davisson and Germer?

m

[1 mark]

Question 12

What was the momentum of the X-rays used by Davisson and Germer?

kg m s^{-1}

[2 marks]

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Question 13

This experiment was considered to be strong evidence of the existence of matter waves.

Explain why this was so.

[2 marks]

End of Area of Study 2

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SECTION B – Detailed studies

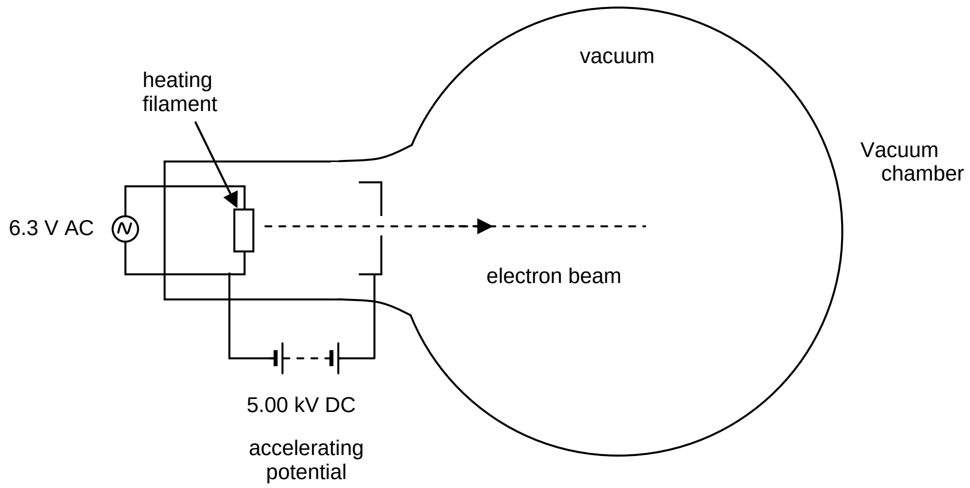
Instructions for Section B

Choose **one** of the following **Detailed studies**. Answer **all** questions on the Detailed study you have chosen.

DETAILED STUDY 1 – Synchrotron and its applications

Questions 1 to 4 relate to the following information.

An electron gun is a simple particle accelerator. It consists of a hot filament and an accelerating potential, all sealed inside a vacuum chamber as shown in the diagram below. It is assumed the electrons are emitted from the heated filament with zero kinetic energy and that the accelerating potential is 5.00 kV.



Question 1

Calculate the kinetic energy (in eV) of an electron as it passes through the hole in the positive plate of the accelerating potential.

eV

[2 marks]

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Question 2

Show by calculation that the speed of an accelerated electron is 4.2×10^{7} ms^{-1} as it passes through the hole in the positive plate.

[4 marks]

Question 3

The heating element is replaced by a source of protons. Give two changes that would need to be made to the rest of the particle accelerator to produce a beam of protons moving at a speed of 4.20×10^{7} ms^{-1} as they exit the accelerating potential.

(mass of proton = 1.67×10^{-27} kg)

Change One

____

____

Change Two

____

____

[2 marks]

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Question 4

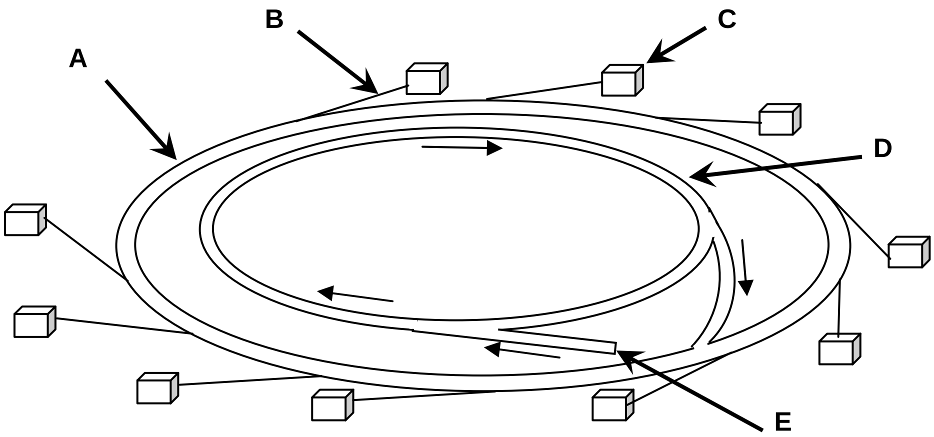
The electrons from the original particle accelerator enter a magnetic field travelling at a speed of 4.20×10^7 ms^{-1}. What strength magnetic field is needed to cause the electrons to deflect in a circle of radius 6.0 cm?

	T

[2 marks]

Question 5

The Australian Synchrotron design includes a LINAC (linear electron accelerator), a booster ring, a storage ring, beam lines and experiment stations. The following schematic shows a simplified diagram of the Australian Synchrotron.



Place a the correct letter (**A – E**) from the above diagram next to the following list of components.:

LINAC		**Booster ring**	
Storage ring		**Beam Line**	
Experiment station			

[5 marks]

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Questions 6 & 7 relate to the following information.

A synchrotron uses both magnetic field and electric fields to control the motion of the electron beam around the booster ring.

Question 6

Explain the purpose of the electric fields in the booster ring.

[2 marks]

Question 7

Explain the purpose of the magnetic fields in the booster ring.

[2 marks]

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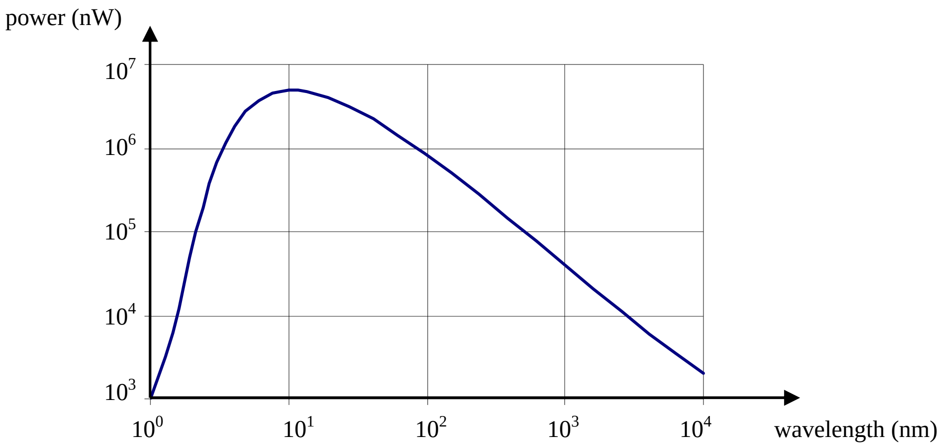
Question 8

The radiation emitted by a synchrotron is created over a range of wavelengths and at varying intensities. The following graph shows how the power (nW) varies with wavelength (nm) when the synchrotron beam energy is 340 MeV.



What is the frequency of the peak power radiation coming from this 340 MeV beam?

Hz

[2 marks]

Question 9

Compton scattering occurs when an X-ray photon collides with a stationary electron. After the collision the scattered X-ray photon has which of the following characteristics?

	Wavelength	Energy	Speed
A	Longer	Less	Unchanged
B	Shorter	Higher	Slower
C	Unchanged	Unchanged	Unchanged
D	Longer	Higher	Unchanged
E	Shorter	Less	Slower
F	Unchanged	Unchanged	Faster

[2 marks]

Question 10

Thomson scattering occurs when an X-ray photon is scattered by an atom. This occurs in Bragg Diffraction. After the collision the scattered X-ray photon has which of the following characteristics?

	Wavelength	Energy	Speed
A	Longer	Less	Faster
B	Shorter	Higher	Slower
C	Unchanged	Unchanged	Unchanged
D	Longer	Higher	Unchanged
E	Shorter	Less	Slower
F	unchanged	unchanged	Faster

[2 marks]

End of Detailed Study 1

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DETAILED STUDY 2 – Photonics

Questions 1 and 2 relate to the following information.

A LED is to be made using Gallium Arsenide which emits light in the near-infrared region with a peak wavelength (λ_{peak}) of 900 nm.

Question 1

What is the band gap energy for this Gallium Arsenide LED? Give your answer in eV and Joules.

eV	J

[3 marks]

Question 2

The light emitted by a simple LED typically contains a range of wavelength values. This range is typically of the order of:

A 1 – 5 nm

B 30 – 80 nm

C 1 – 5 μm

D 30 – 80 μm

[2 marks]

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Question 3

In a LASER the lasing medium can be a number of different materials.
Give an example of the lasing medium in a:

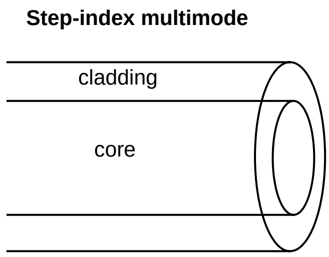
GAS laser:

Solid-State laser:

[2 marks]

Questions 4 and 5 relate to the following information.

Optical fibres can be made using step-index multimode fibre.
Such a fibre is represented in the diagram below.



Question 4

Explain the defining feature of a "step-index" optical fibre.

[2 marks]

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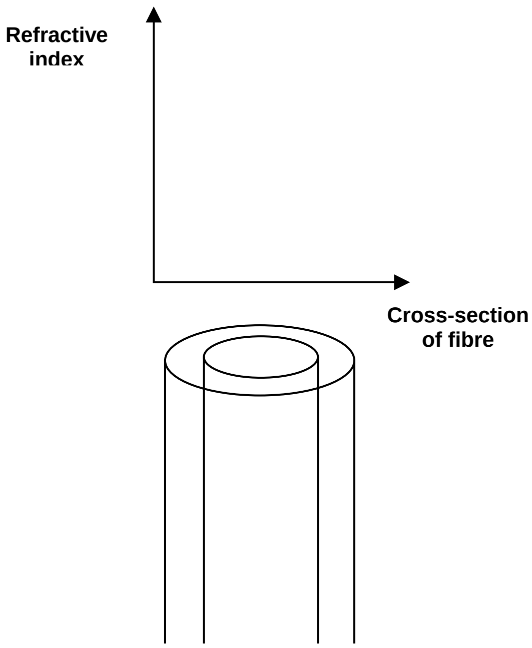
Question 5

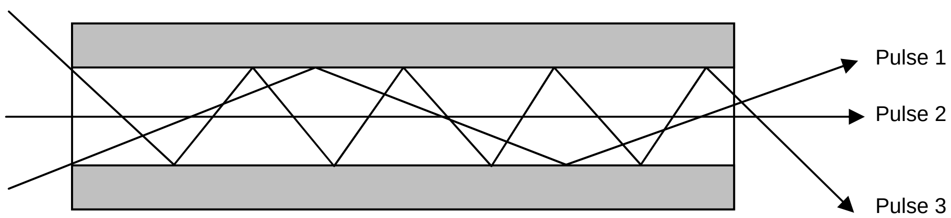
Sketch a graph on the axes below to illustrate the variation in refractive index for the cross-section of a step-index optical fibre. (No numbers are required on either axis).



[2 marks]

Question 6

A number of light pulses are sent along a step index optical fibre.



Which of the pulses (1 – 3) best represents:

The lowest order mode ☐

The highest order mode ☐

[2 marks]

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Question 7

Modal dispersion is best described as:

A The spreading of pulses due to different modes taking different paths to reach the end of the fibre.

B The spreading of pulses due to the differing speeds of each wavelength that makes up the light beam.

C The spreading of pulses due to the different wavelengths travelling different distances to reach the end of the fibre.

D The spreading of pulses due to the differing speeds of each of the modes that makes up the light beam.

[2 marks]

Question 8

Material dispersion is best described as:

A The spreading of pulses due to different modes taking different paths to reach the end of the fibre.

B The spreading of pulses due to the differing speeds of each wavelength that makes up the light beam.

C The spreading of pulses due to the different wavelengths travelling different distances to reach the end of the fibre.

D The spreading of pulses due to the differing speeds of each of the modes that makes up the light beam.

[2 marks]

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Question 9

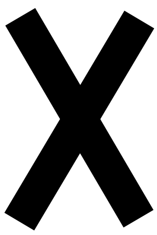
An endoscope is a flexible tube used for looking inside the body. Light from objects at the far end is carried to the viewing end by a coherent bundle of optic fibres so an accurate image is formed.
An endoscope can use light emitting diodes as a light source. One possible such light source is an indium gallium aluminium phosphide LED (IGAP). This particular LED has a band gap equal to 3.34×10^{-19} J. What is the wavelength of the light emitted by this type of LED?
Give your answer to the nearest nanometre.

nm

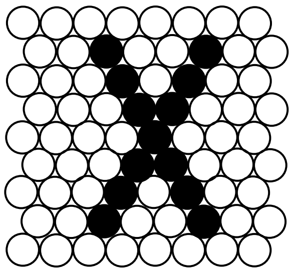
[3 marks]

Questions 10 & 11 relate to the following information.

The image of an X is formed by a bundle of fibre optics is shown below.



Object



Image

Question 10

How many pixels are there in this fibre optic bundle?

[1 mark]

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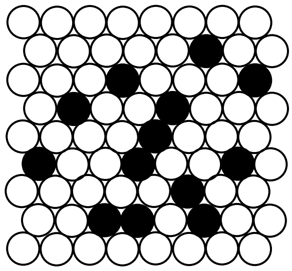
Question 11

A second bundle of fibre optics is used to view the same object and the following image was obtained. Explain why this image is different from the image originally obtained.



[2 marks]

Question 12

Lord Rayleigh, in 1871, found that the different wavelengths of light are scattered by different amounts for different colours (Rayleigh scattering). In fibre optics Rayleigh scattering occurs because:

A LASER light has a variation in wavelength of approximately 1 – 5 nm.

B the optical fibre absorbs the light energy and transforms it into heat.

C of the Fresnel-reflection losses.

D of small imperfections in the core of the optical fibre.

[2 marks]

End of Detailed Study 2

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DETAILED STUDY 3 – Sound

Question 1

At an outdoor concert the sound of the band is being investigated by a curious student. She starts her measurements at a distance of 400 m from the stage. The sound intensity at this distance is measured to be 2.0×10^{-7} Wm^{-2}.
What is this sound intensity level in dB?

dB

[2 marks]

Question 2

As the student approaches the stage with her portable sound level meter the sound intensity reading rises to 8.0×10^{-7} Wm^{-2}. How far from the stage is the student now?

m

[3 marks]

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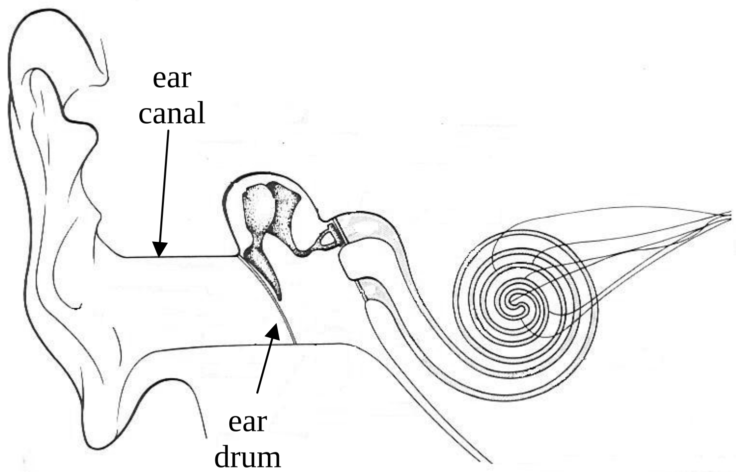
Questions 3 to 5 refer to the following information

Jenny is in her school physics laboratory doing some hearing tests. She is listening to sound from a signal generator and single speaker, set at a constant intensity level. Increasing the frequency slowly, Jenny notices that the sound oscillates between loud and soft as the frequency increases.

The ear canal can be modelled as a pipe closed at one end by the eardrum as shown in the diagram below.



Question 3

Although the intensity of the sound is not altered, the sound that Jenny hears appears to be louder for certain frequencies. Which of the following could best explain this effect?

A Refraction of the sound from the generator causes nodes and antinodes of sound.

B The eardrum reflects certain selected frequencies from the sound generator.

C Loss of the higher frequencies due to diffraction from the sound source.

D Certain frequencies produced by the generator are resonant frequencies of the ear canal.

E Certain frequencies form displacement antinodes at the eardrum

F Loss of the lower frequencies due to reflections from the side of the head

[2 marks]

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Question 4

Jenny notes that the sound first appears loudest at approximately 3.50 kHz. The speed of sound, at the temperature of the air in the ear, is 344 ms^{-1}. Using this information, calculate the length of Jenny's ear canal. Give your answer in cm.

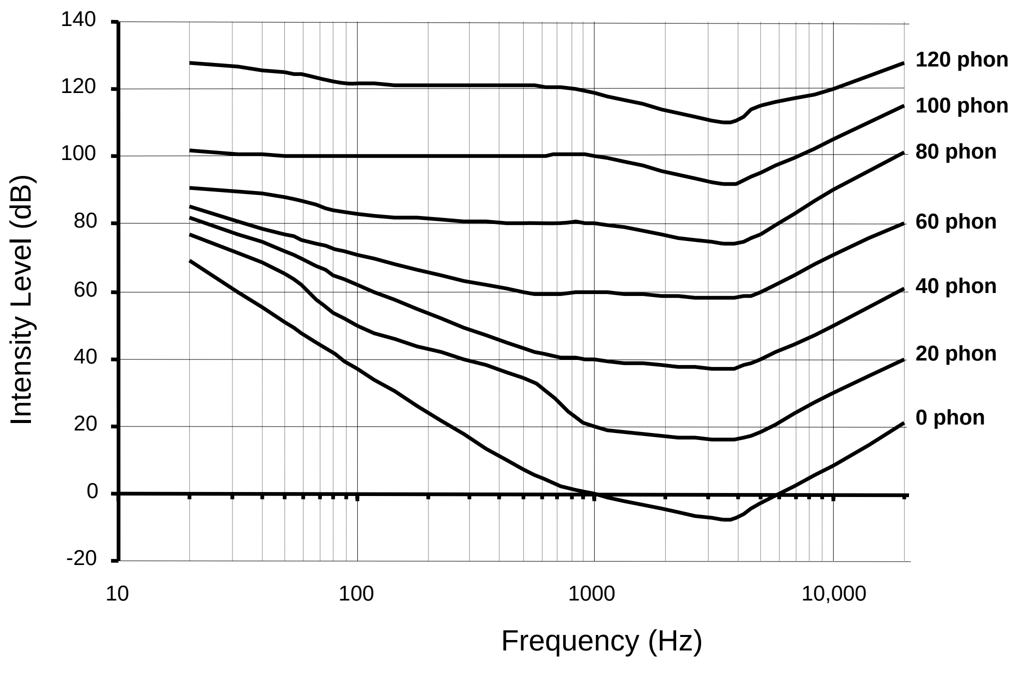
cm

[3 marks]

Questions 5 & 6 refer to the following information

The following is a Phon Level graph for the human ear showing seven equal loudness contour lines.

Human Ear Phon Levels



Question 5

Approximately what sound intensity level must a 100 Hz tone have to have a loudness of 20 Phon?

dB

[1 mark]

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Question 6

Use the Phone Level graph to complete this table showing equal loudness values at 60 phon.

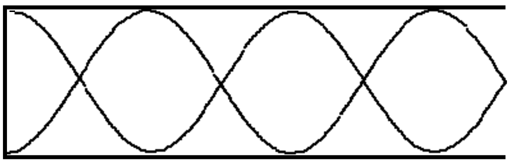
Frequency (Hz)	sound intensity level (dB)
10,000	70
2,000	
	62

[2 marks]

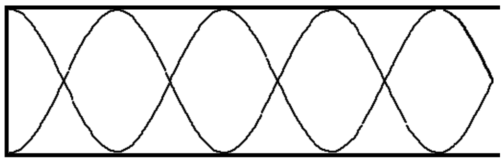
Questions 7 to 9 relate to the following information

The following diagrams show a series of closed pipes with standing sound waves inside them. Select the appropriate pipe, **A** – **E**, for each of the following questions.

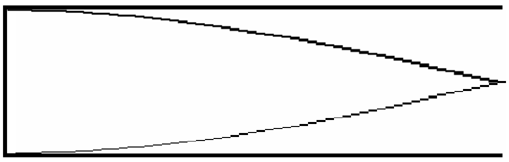
A



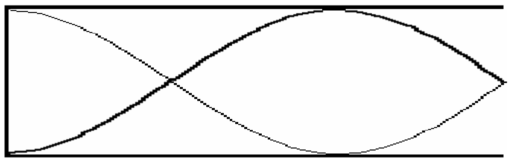
B



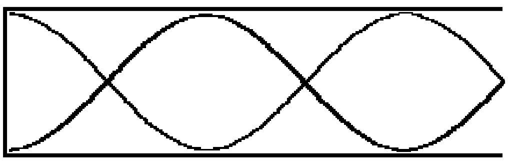
C



D



E



Question 7

Which diagram shows the pipe with the lowest pitch standing wave?

[2 marks]

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Question 8

Which pipe is resonating at three (3) times its fundamental frequency?

[2 marks]

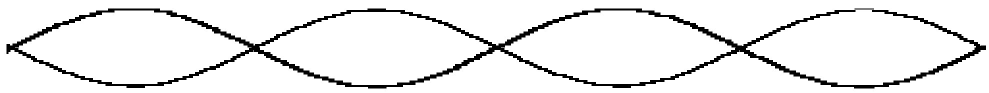
Question 9

Which pipe is resonating at its fifth harmonic?

[2 marks]

Question 10

A vibrating string is viewed under a stroboscopic light set at the slowest possible rate in order to obtain a "stationary" image. This image of the string is shown in the diagram below.



This string is vibrating in which of the following possible modes? (one or more answers)

A Fundamental **B** First overtone

C Second overtone **D** Third overtone

E Fourth overtone **F** First harmonic

G Second harmonic **H** Third harmonic

I Fourth harmonic **J** Fifth harmonic

[2 marks]

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Question 11

The microphones in old style home telephones use a simple diaphragm and variable resistance carbon block to convert sound into electrical signals. In general they are no longer used because newer microphones have better fidelity.
Explain the use of the word "***fidelity***" as used in this instance.

____

____

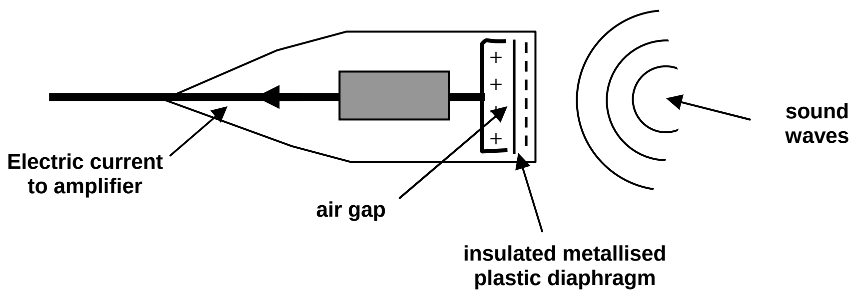
____

____

[2 marks]

Question 12

The following diagram shows the cross-section for a particular type of microphone.



From the following list of microphone types select the one which best describes the type of microphone illustrated.

A Electret-condensor **B** Velocity

C Crystal **D** Dynamic

[2 marks]

End of Detailed Study 3
END OF EXAMINATION

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