Insight Publications

INSIGHT

Trial Exam Paper

2006

PHYSICS

Written examination 2

STUDENT NAME:

QUESTION AND ANSWER BOOK

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

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	10	10	25
B – Detailed studies			
1. Synchroton and its applications	10	10	25
OR			
2. Photonics	10	10	25
OR			
3. Sound	10	10	25
		Total	90

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

Materials provided

- The question and answer book of 31 pages with a separate data sheet.

Instructions

- Write your **name** in the box provided.
- Remove the data sheet during reading time.
- Answer all questions in the spaces provided.
- **Always** show your working where space is provided as marks may be awarded for this working.
- You must answer the questions in English and in the space provided.

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

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

Questions 1 to 3 refer to the following information.

As part of a Year 12 Physics experiment the following apparatus (Figure 1), consisting of two coils, a 6 V battery, a switch S, and a 200 Ω resistor is assembled.

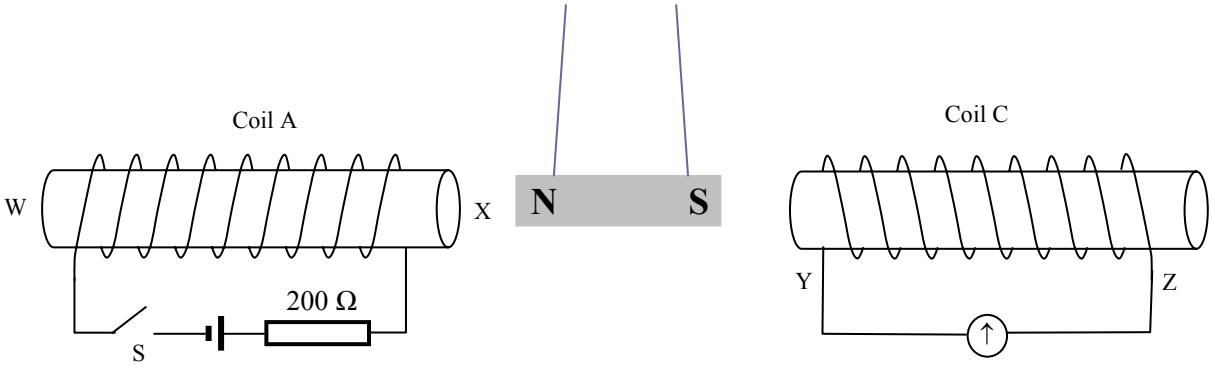


Figure 1

Coil A has a soft iron core inside of it. Nearby, coil C is wound around a thin plastic tube and has a sensitive galvanometer attached to it. Between the two coils a bar magnet is suspended as shown.

Question 1

When the switch S is first closed the magnetic field inside coil A

A. is non-existent because the current is not AC.
B. is in the direction from W to X.
C. is in the direction from X to W.
D. remains unchanged.

2 marks

Question 2

Explain what effect closing switch S would have on the suspended bar magnet and coil C.

3 marks

Question 3

When switch S is closed the needle of the galvanometer attached to coil C will

A. move right.
B. move left.
C. move right then return to the neutral position.
D. move left then return to the neutral position.
E. not move.

2 marks

Question 4

Sally and Ben are discussing the construction of a DC motor. Sally claims that they need to use a commutator, but Ben thinks that slip rings are the correct component to use. Who is correct and why?

3 marks

Question 5

Sally decides to build her design as shown below in Figure 2. Describe what happens when she closes the switch. Justify your answer.

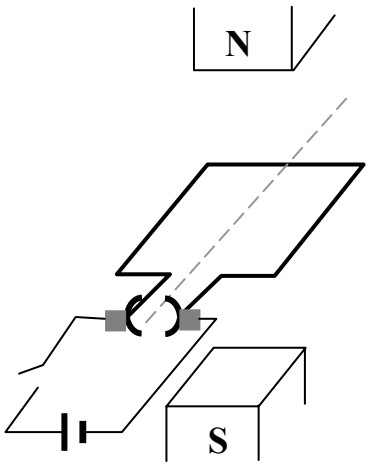


Figure 2

3 marks

Ishmael's train set is constructed on a large table in the centre of the room. His train set uses a transformer to convert the mains AC supply from 240 V RMS to 12 V RMS. Ishmael is tired of tripping over the extension lead running from the wall socket to the transformer so he decides to connect the transformer to the wall socket and run two long wires up the wall and across the roof to his train set. The wires are each 5 metres long and have a resistance of 0.001 Ω per metre.

Question 6

The primary coil of the transformer has 1800 turns. How many turns must the secondary coil possess in order to convert from 240 V RMS to 12 V RMS?

2 marks

Question 7

Ishmael finds that his trains are not moving as quickly as before. A possible reason for this is that

A. the transformer is connected with the secondary coil attached to the mains supply.
B. Ishmael has fewer trains than normal on the track at one time.
C. the wires connecting the transformer to the train set are too short.
D. the wires connecting the transformer to the train set are too long.

2 marks

Question 8

Ishmael measures the current out of the secondary coil of the transformer as being 100 A RMS. What is the power of the transformer?

W

2 marks

Question 9

Find the peak voltage across the secondary coil of the transformer at this time.

V

2 marks

Question 10

How much power is being lost in the wires?

W

3 marks

The orientation of the rectangular coil in an AC generator is compared with the flux passing through each turn of the coil. The coil has 100 turns. Figure 3 shows the coil orientation whilst Figure 4 shows the magnetic flux through the coil at the same point in time.

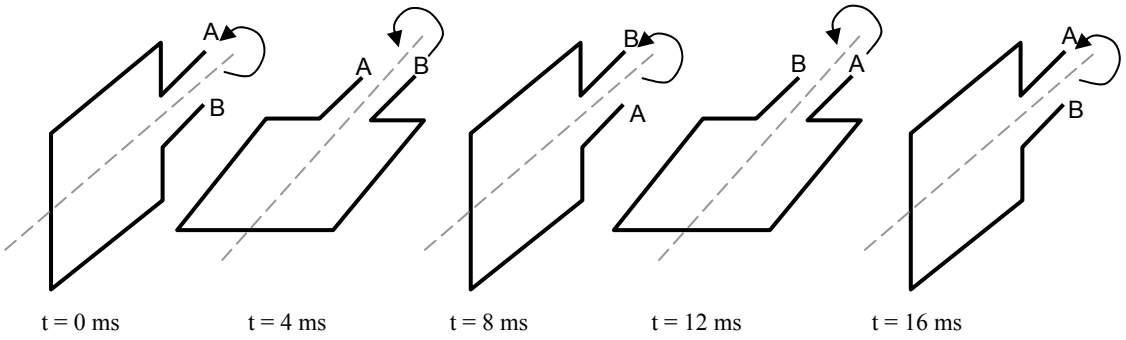


Figure 3

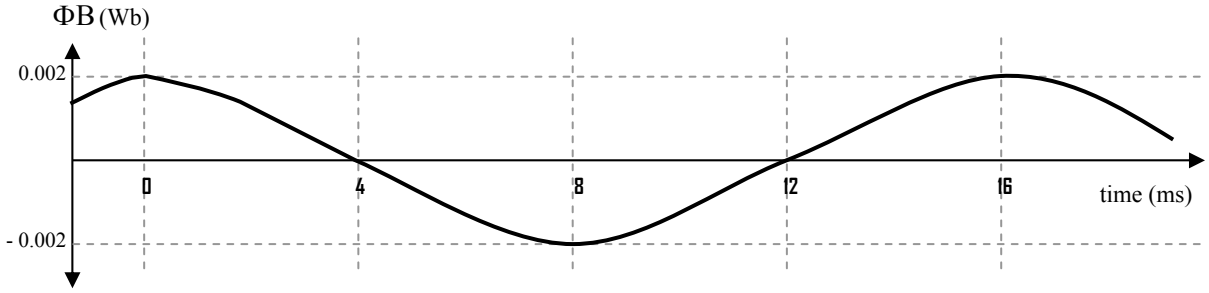


Figure 4

Question 11

From the above information, calculate the average EMF generated.

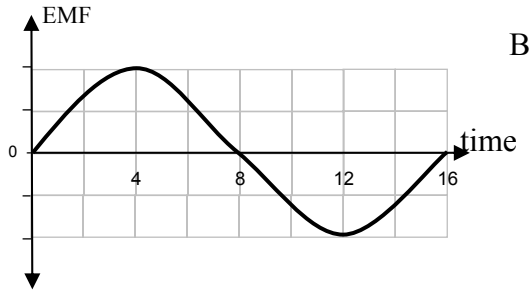
V

3 marks

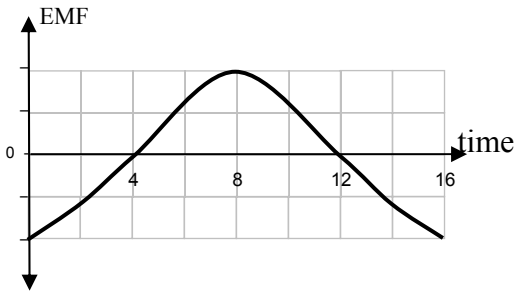
Question 12

Over the same time period, which graph best represents the induced EMF?

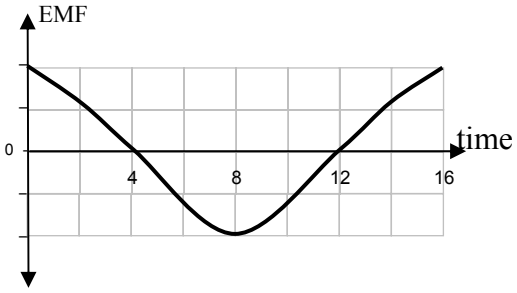
A.



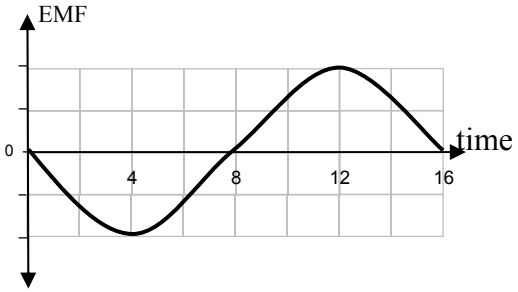
B.



C.



D.



2 marks

Question 13

Describe how the above EMF waveform would change if the rotational speed of the coils was halved.

_____

_____

_____

_____

_____

2 marks

Question 14

The dimensions of the coil are 40 cm × 20 cm. Find the size of the magnetic field inside the coil.

	T

3 marks

A small bar magnet is suspended by a spring above a solenoid as shown in Figure 5.

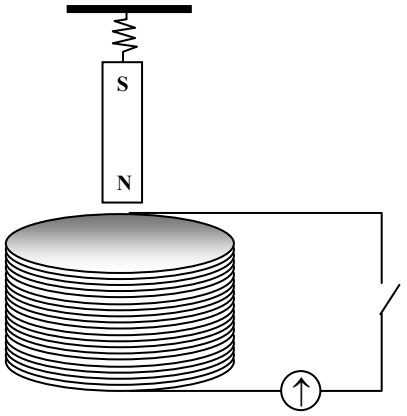


Figure 5

Use the following key to answer questions 15 to 17. (One or more answers may be given.)

KEY:

A. The needle experiences no change.
B. The needle moves to the left.
C. The needle moves to the right.
D. The needle moves left then right.
E. The needle moves right then left.
F. The needle does not deflect.

Initially the magnet is stationary.

Question 15

Use the above key to describe what happens to the needle of the galvanometer when the switch is first closed.

2 marks

Question 16

The spring is now stretched slowly so that the magnet approaches the solenoid. During this time, what happens to the needle?

2 marks

Question 17

The spring is now released, and the magnet moves up and down repeatedly. Use **one** of the keys A to F to describe the motion of the needle during this time.

2 marks

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

AREA OF STUDY 2 – Interactions of light and matter

Use the following key to answers questions 1 and 2.

Light source

A. Laser
B. Sodium vapour lamp
C. Incandescent light globe
D. Blue LED

Question 1

Which of the above light sources produces coherent light?

2 marks

Question 2

Which **one or more** of the above light sources produce photons of discrete wavelengths?

2 marks

Andre is investigating the photoelectric effect by varying the frequency of light incident upon a sodium metal cathode. The apparatus is shown in Figure 1.

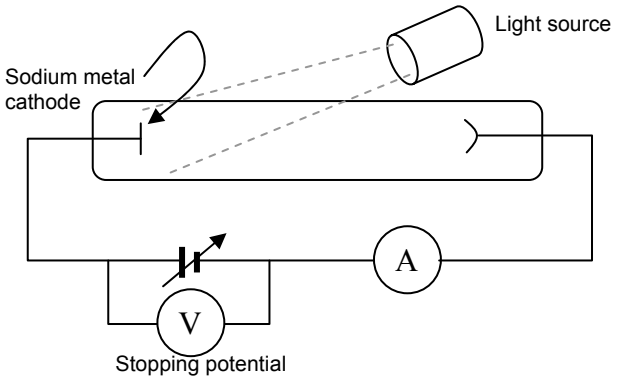


Figure 1

For each frequency, the stopping potential V_s is recorded by Andre.

Trial no.	**Frequency ($\times 10^{14}$ Hz)**	**V_s (V)**
1	3.0	0.0
2	4.0	0.0
3	5.0	0.0
4	6.0	0.2
5	7.0	0.5
6	8.0	1.1
7	9.0	1.4

Question 3

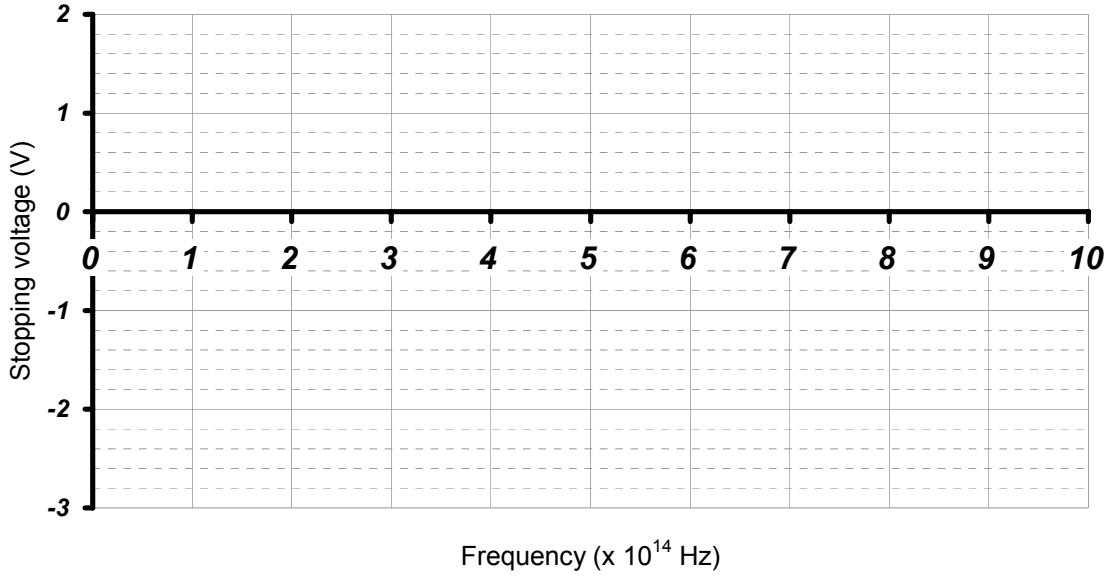
What is the maximum energy a photoelectron can possess as it leaves the cathode if the incident light used has a frequency of 9×10^{14} Hz?

	eV

2 marks

Question 4

Plot Andre's data on the axes provided and hence or otherwise justify the statement that the work function for sodium is 2.4 eV.



3 marks

Question 5

From your graph calculate Planck's constant.

eVs

3 marks

Andre now fixes the frequency at 7×10^{14} Hz, and records the current flowing through the circuit for various stopping potentials. He then plots his results to obtain the graph labelled X below in Figure 2.

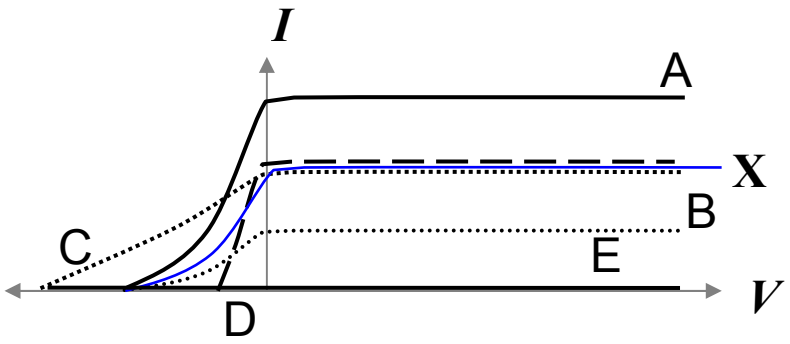


Figure 2

Andre then repeated this experiment with a piece of thick cardboard covering half of the light source.

Question 6

Which **one** of the graphs A to E is most likely to indicate the results of this repeated experiment?

2 marks

A laser is used as the light source for a demonstration of Young's 'Double Slit' experiment as shown in Figure 3.

S_1 and S_2 are slits through which the laser light passes, and the dotted lines represent wave fronts. Boxes A to L are parallel sections of the screen onto which the light falls.

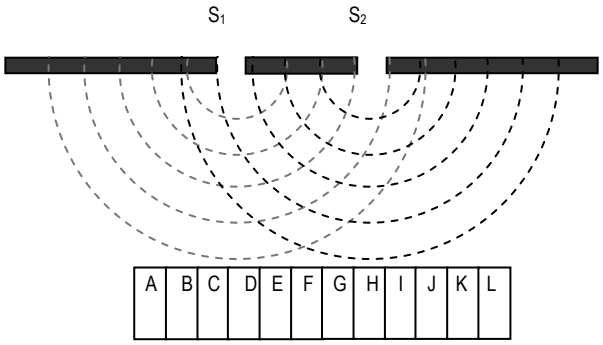


Figure 3

Question 7

Shade in any of the boxes A to L which represent regions on the screen which will appear bright.

3 marks

Question 8

Two students who observe the demonstration are discussing whether the same effect would be observed if the slits were removed and two identical lasers were used instead. Brad thinks the interference pattern will change. Amy thinks the pattern will not. Who is correct and why?

_____

_____

_____

_____

_____

_____

_____

3 marks

An electron in an excited energy level of a mercury atom emits a photon of wavelength 175 nm as it changes energy levels, as shown in Figure 4.

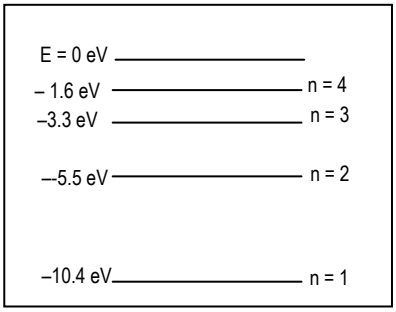


Figure 4

Question 9

What energy level was the electron in before it emitted the photon?

3 marks

Question 10

Which of the following wavelengths is not possible for an emitted photon from this atom?

A. 565 nm
B. 318 nm
C. 253 nm
D. 226 nm

2 marks

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

Use the diagram and key shown in Figure 1 to answer questions 1 to 3.

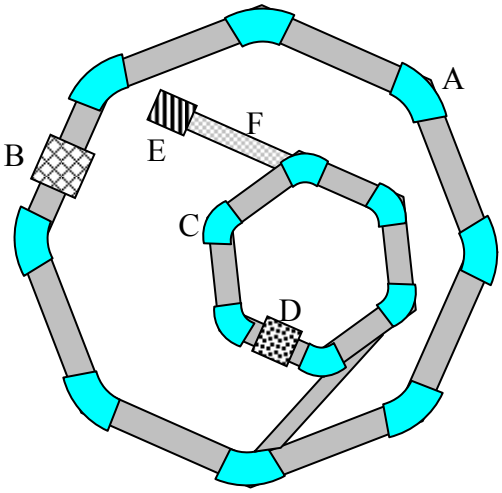


Figure 1

Question 1

At which of the points A to F would a wiggler be found?

2 marks

Question 2

Where are bending magnets located in the above diagram?

2 marks

Question 3

Indicate at which points from A to F radio frequency (RF) cavities could be located.

2 marks

Question 4

In a small synchrotron, it is planned to use bending magnets which produce a field strength of 0.5 T to contain the electron beam in a curve of radius 14 m. What momentum must the electrons possess to maintain this radius?

kg m s^{-1}

2 marks

Question 5

The electrons are initially accelerated from 0 ms^{-1} by an electron gun. The potential difference across the plates of the electron gun is 6000 V. With what energy does each electron leave the electron gun? Give your answer in joules.

2 marks

Question 6

Explain why a linac is constructed using progressively longer drift tubes.

_____

_____

_____

_____

_____

_____

_____

3 marks

Question 7

Circle the correct word in bold to make the following sentences correct.

> Conventional X-rays are not as useful as light from a synchrotron of similar wavelength for diagnostic purposes because synchrotron light is **[collimated / pulsed / wide spectrum]**. Conventional X-rays are always **[coherent / incoherent / adherent]** and **[lower / equal / higher]** intensity than synchrotron light.

3 marks

Question 8

A photon of energy 6.5 eV collides with an electron, and 2.3 eV of energy is transferred to the electron. Calculate the initial and final momentum of the photon.

$P_{initial}$ = kg m s^{-1}	P_{final} = kg m s^{-1}

3 marks

An unknown crystalline sample is subjected to X-rays of wavelength 150 pm during Bragg diffraction analysis. The graph shown in Figure 2 was faxed to a researcher but unfortunately some data was obscured.

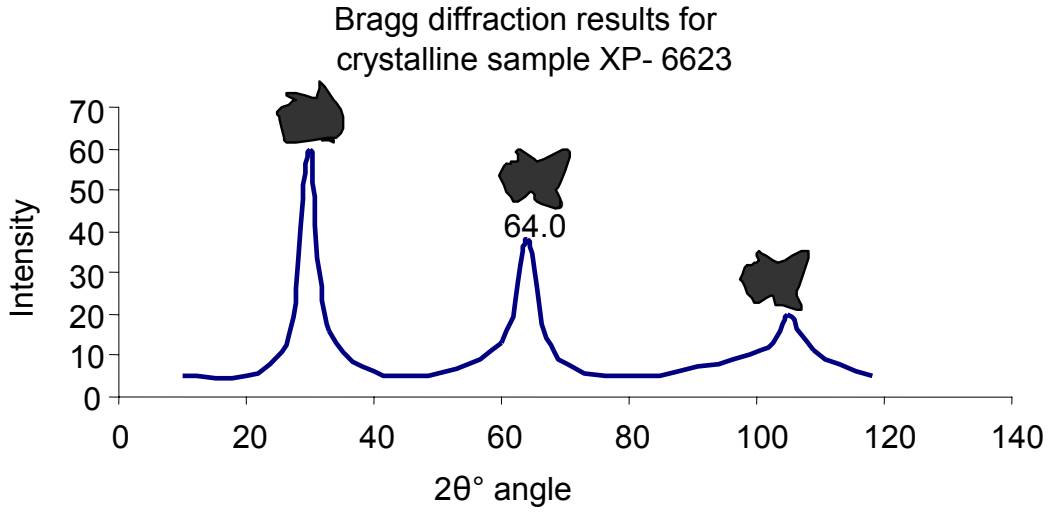


Figure 2

Question 9

Use the above information to find the crystal layer spacing.

	m

3 marks

Question 10

Calculate the exact values of the first and third peaks which have been obscured on the graph above.

First peak =	Third peak =

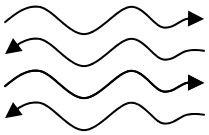
3 marks

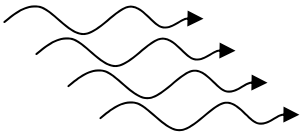
END OF DETAILED STUDY 1
SECTION B – continued
TURN OVER

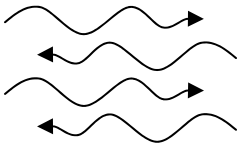
DETAILED STUDY 2 – Photonics

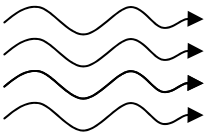
Question 1

Which of the following diagrams best represents light emitted from a laser?

A. 

B. 

C. 

D. 

2 marks

A laser beam is shone into the core of a step index fibre with a core refractive index of 1.45 and a cladding refractive index of 1.30, as shown in Figure 1.

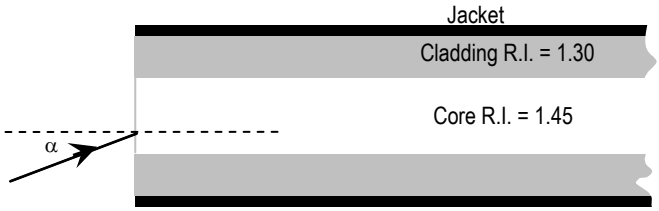


Figure 1

Question 2

What is the minimum angle at which a light ray can strike the core–cladding boundary and not enter the cladding?

2 marks

Question 3

What is the greatest value for angle α that will still allow the light beam to remain inside the core?

3 marks

Question 4

LEDs all have a 'band gap'. Describe what the band gap is and what characteristic of the LED it determines.

4 marks

Question 5

A red LED emits light of an average wavelength of 605 nm. While a blue LED emits light of an average wavelength of 470 nm. Find the ratio

$$\frac{\text{Band gap energy of red LED}}{\text{Band gap energy of blue LED}}$$

2 marks

Question 6

Circle the correct physics term in bold to make the following paragraph correct.

An endoscope is a device used by surgeons to view inside the body during keyhole surgery. Light is transmitted through bundles of **[incoherent / coherent / linear]** optic fibres to the operational end of the endoscope. This light undergoes **[reflection / refraction / total internal reflection]** inside the body cavity. Some of this light then passes through a focusing **[mirror / lens / prism]** before entering a set of **[incoherent / coherent / linear]** optic fibres which transmit the light using the principal of **[reflection / refraction / total internal reflection]** to the viewing eyepiece as an accurate **[picture / reflection / image]** of the body cavity.

3 marks

Question 7

Modal dispersion causes signal attenuation because

A. shorter wavelengths travel slower inside the optic fibre.
B. some light signals will travel a longer path than others due to the angle at which they enter the optic fibre and so take more time to reach the end.
C. impurities in the fibre slow down some wavelengths more than others.
D. longer wavelengths travel more slowly inside the optic fibre.

2 marks

Question 8

Modal dispersion is a significant problem in optic fibres classified as

A. single mode.
B. step index multimode.
C. graded index multimode.
D. all of the above.

2 marks

A light signal is to be transmitted down an optic fibre with an attenuation curve as shown in Figure 2.

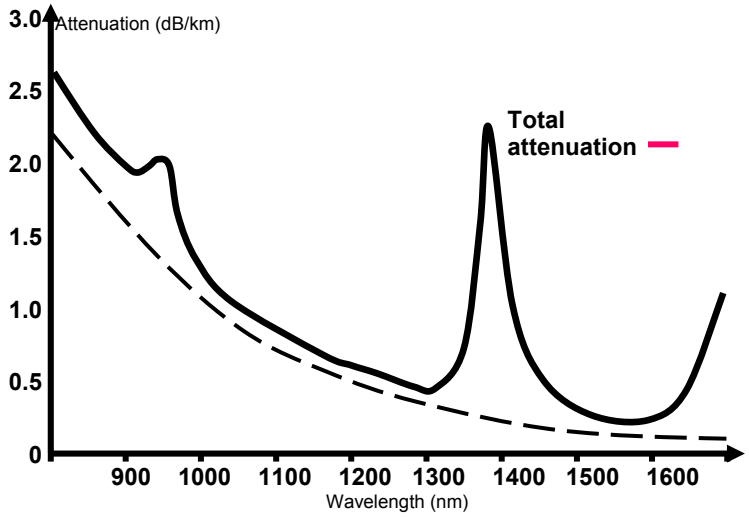


Figure 2

Question 9

Indicate the range of wavelengths which would be best for transmitting data between Melbourne and Sydney along an optic fibre of roughly 1000 km in length.

Minimum wavelength Maximum wavelength

2 marks

Question 10

The dotted line represents a form of attenuation. Name this type of attenuation and explain why its effect is dependent on the wavelength of the light being transmitted.

_____

_____

_____

_____

_____

_____

3 marks

END OF DETAILED STUDY 2
SECTION B – continued

DETAILED STUDY 3 – Sound

Question 1

A microphone uses a thin ribbon of aluminium suspended in a magnetic field to detect vibrations in the air and convert them into electrical signals. This type of microphone is called (one or more answers)

A. velocity.
B. dynamic.
C. ribbon.
D. moving coil.
E. electret-condenser.
F. crystal.

2 marks

While hiking one day Simone notices she can hear an echo from a cave. Her map indicates the cave is 462 m long. Simone uses the stopwatch function on her watch to record the delay. It takes on average 2.67 seconds for the echo of her 3800 Hz whistle to be heard when she stands at the mouth of the cave.

Question 2

What is the speed of sound inside the cave?

2 marks

Question 3

What is the wavelength of the sound as it travels inside the cave?

2 marks

Question 4

A siren located at the top of a tower is struck once. At a distance of 35 m from the siren, the sound level is recorded at 75 dB. At what distance from the siren is the sound level only 50 dB?

4 marks

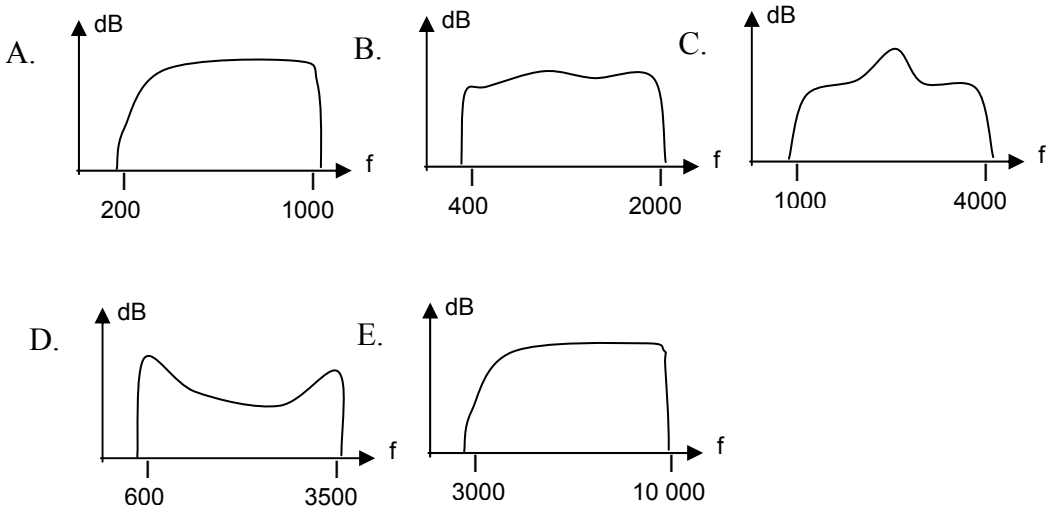
Question 5

Ken has a guitar string tuned to resonate at a fundamental frequency of 600 Hz. At which of the frequencies below will this string also resonate? (One or more answers may be given.)

A. 300 Hz
B. 900 Hz
C. 1200 Hz
D. 1800 Hz

2 marks

Ken plans to build his own speaker system for his guitar described in **Question 5**. He has the response curves for five possible drivers to use.



Initially Ken decides to use only driver A as a speaker by connecting it to his amplifier with two wires, but he finds the sound produced is very flat and he is disappointed.

Question 6

State **two** things that Ken could do to improve the sound from his speaker system. You must explain why the sound will improve.

4 marks

Question 7

The quality of sound from a single driver speaker is not as good as that from a multiple driver speaker because

A. diffraction effects are less noticeable in the multiple driver speaker.
B. diffraction effects are more noticeable in the multiple driver speaker.
C. refraction effects are less noticeable in the multiple driver speaker.
D. refraction effects are more noticeable in the multiple driver speaker.

2 marks

Question 8

Circle the correct option from those in bold to complete the following sentence.

A pipe which is closed at one end and is of length **[1.8 / 2.6 / 3.2]** metres will have a **[first / second / third]** harmonic with a wavelength of **[1.8 / 2.4 / 3.2]** metres.

3 marks

A police cadet's hearing is tested and the graph in Figure 2 shows the results.

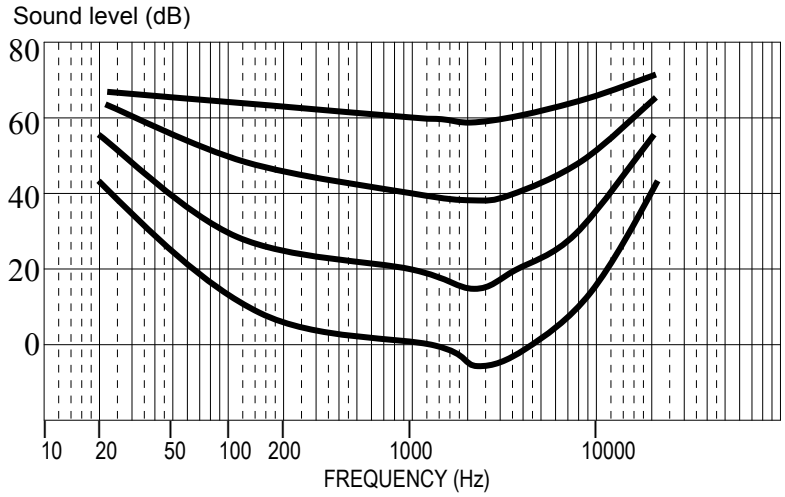


Figure 2

Question 9

What range of frequencies can the police cadet hear below 20 dB?

2 marks

Question 10

At what sound level does a 100 Hz sound need to be at to sound as loud as an 800 Hz sound at 40 dB?

2 marks

END OF QUESTION AND ANSWER BOOK