

2012 Trial Examination

STUDENT NUMBER

Figures

Words

Letter

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PHYSICS

Unit 4 – Written examination 2

Reading Time: 15 minutes

Writing Time: 1 hour and 30 minutes

QUESTION & ANSWER BOOK

Structure of Book

<i>Section</i>	<i>Number of Questions</i>	<i>Number of Marks</i>
A – Core Areas of Study		
1. Electric Power	16	38
2. Interactions of Light and Matter	12	28
B – Detailed Studies		
1. Synchrotron and its applications	12	24
OR		
2. Photonics	12	24
OR		
3. Sound	12	24
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 34 pages (including a multiple choice answer sheet for **Section B**).
- Formula sheet.

Instructions

- Print your name in the space provided on the top of this page.
- All written responses must be in English.

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

SECTION A – Core

Instructions for Section A
 Answer **all** questions for **both** Areas of Study in this section of the paper.
 Assume $g = 10 \text{ Nkg}^{-1}$, near the Earth's surface.

Area of Study 1 – Electric Power

Questions 1 to 3 refer to the following information

A solenoid and bar magnet are positioned as shown in Figure 1. A DC battery powers the solenoid.

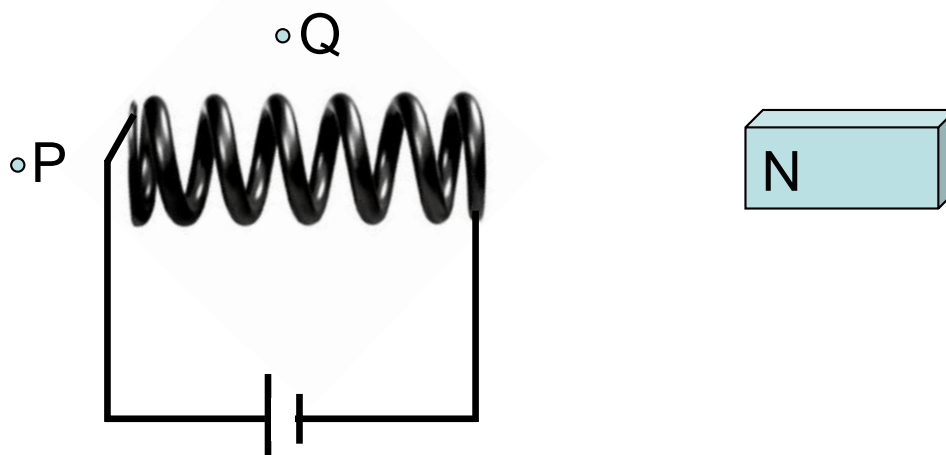


Figure 1

Question 1

Using Figure 1 as a template, sketch three field lines for both the bar magnet and the solenoid to indicate the magnetic field pattern that would be produced.

2 marks

SECTION A – Area of Study 1 – continued

Question 2

Which of the following best describes the direction of the magnetic field at Point Q (Figure 1)?

- A. Left
- B. Right
- C. Up
- D. Down
- E. Into the page
- F. Out of the page

Direction:

1 mark

A copper wire is positioned so that it runs perpendicular to the page at point P (see Figure 1). When the solenoid carries current, 4 cm of wire experiences a force of 0.08 N upwards. The magnetic field strength of the solenoid is 0.6 T in the vicinity of the wire.

Question 3

Determine the magnitude and direction of the current through the copper wire.

A

Direction:

3 marks

SECTION A – Area of Study 1 – continued
TURN OVER

Brian is analysing the operation of a basic electric motor, working sketches for which are shown in Figure 2a and Figure 2b.

The area of the square coil is 0.04 m^2 , the current 0.6 A and there are 20 turns. Side AB experiences a force of peak magnitude 0.3 N .

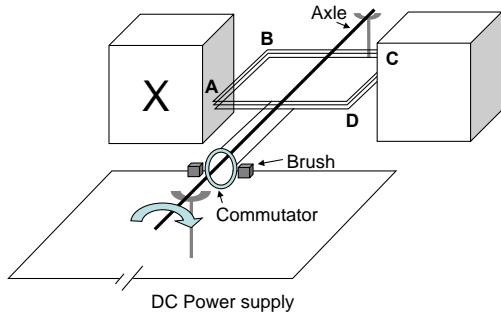


Figure 2a

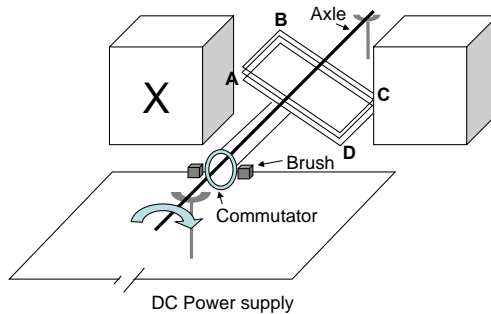


Figure 2b

Question 4

Determine the size and direction of the magnetic field (circle appropriate) required for clockwise rotation of the coil as indicated in Figure 2a.

T

<i>Polarity of X: N or S</i>

3 marks

Question 5

Circle the correct descriptor to indicate the change in the force on sides **AB** and **BC** as the motor moves **from** Position 1 (Figure 2a) **to** Position 2 (Figure 2b)?

Change in Force from Position 1 to Position 2

Force on side AB: Increases / Decreases / Constant

Force on side BC: Increases / Decreases / Constant

2 marks

SECTION A – Area of Study 1 – continued

Question 6

Using Figure 3 as a template, draw in a commutator in its correct orientation (showing the split) for the position of the coil (horizontal). Explain why the commutator must be in this position.

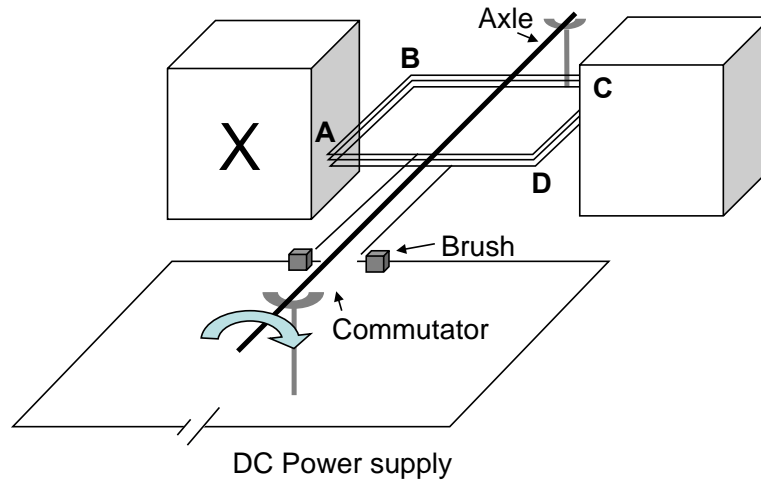


Figure 3

3 marks

**SECTION A – Area of Study 1 – continued
TURN OVER**

Figure 4 shows a coil of 10 turns as a basic generator positioned horizontally between a pair of bar magnets, which provide a constant magnetic field strength of 0.4 T. The coil has an area of 0.3 m^2 and can be assumed to be immersed in the field of the bar magnets at all times.

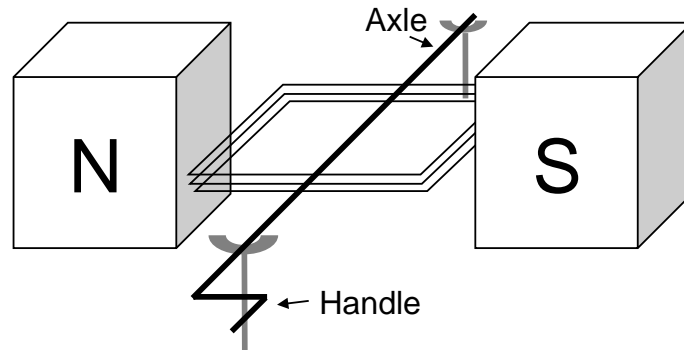


Figure 4

Question 7

Determine the size of the magnetic flux through the coil as shown in Figure 4.

Wb

2 marks

The coil is now rotated clockwise through a quarter of one revolution. The average voltage generated during the movement is 4 V.

Question 8

Determine the time interval required to generate an average of 4 V in a quarter turn.

s

2 marks

SECTION A – Area of Study 1 – continued

Figure 5 shows a solenoid, which is connected to a variable voltage supply and positioned near a circular copper loop (area = 0.3 m^2). The voltage in the solenoid is initially zero. You may assume that the magnetic field from the solenoid varies directly with the voltage, with 4V corresponding to 0.4 T.

From $t = 0$, the voltage is adjusted according to the graph shown in Figure 6.

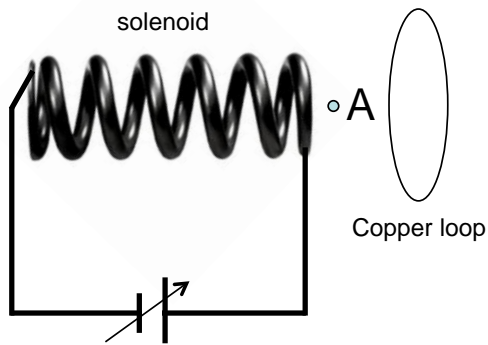


Figure 5

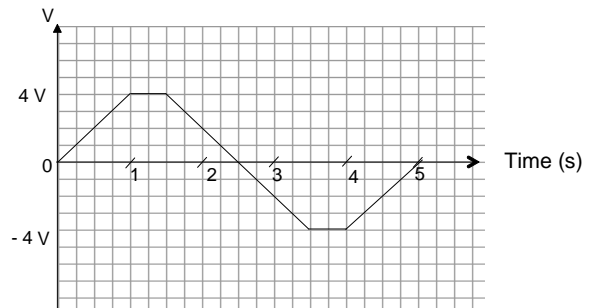


Figure 6

Question 9

Determine the direction of the current induced in the copper loop over the first 1 second, as viewed from Point A (Figure 5). Explain how you arrived at your answer.

Direction: Clockwise / Anticlockwise

3 marks

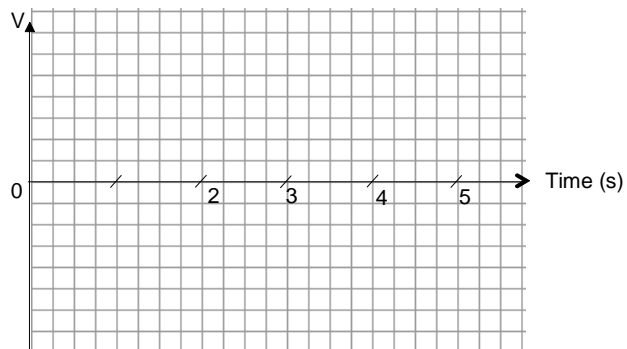
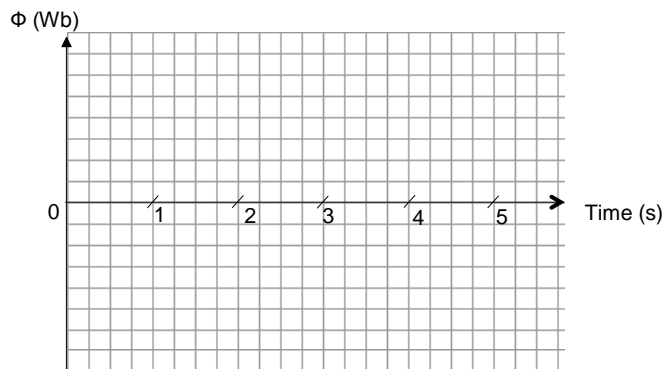
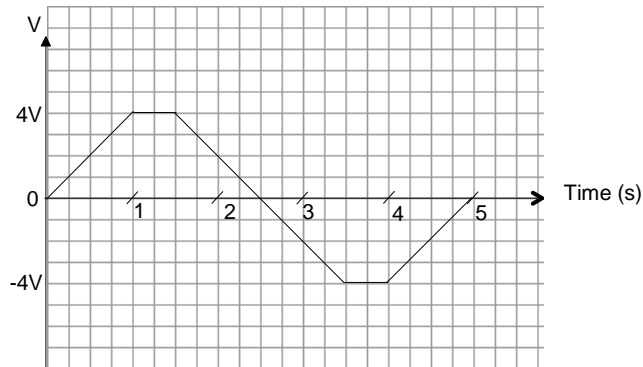
**SECTION A – Area of Study 1 – continued
TURN OVER**

Question 10

Using the axes provided below, sketch a graph of flux and emf in the loop as the voltage in the solenoid varies. Label the vertical axes with appropriate scales.

The original voltage vs. time graph has been included for reference purposes.

4 marks



Questions 11 to 14 refer to the following information.

A generator, operating a 5 kV AC RMS, delivers power to a distant school. At a given point in time, the equipment at the school consumes 22.34 kW of power. The transmission lines linking the generator and the school have a total resistance of 8Ω and are carrying 4.5 A RMS current. A transformer is located adjacent to the school. The setup is shown below in Figure 5.

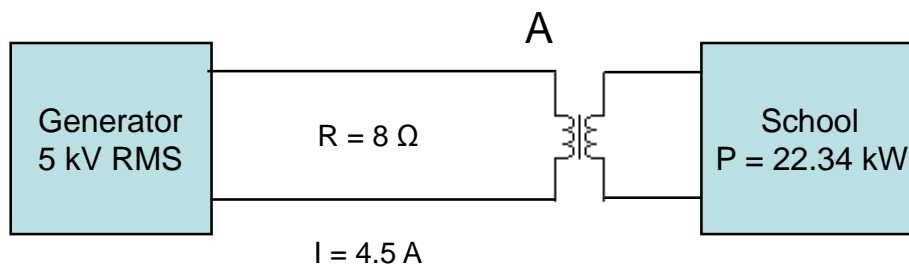


Figure 5

Question 11

Determine the power lost in the transmission lines.

2 marks

Question 12

Determine the voltage at the primary side of the transformer, labelled as Point A in Figure 5.

2 marks

SECTION A – Area of Study 1 – continued
TURN OVER

Question 13

Which of the following turns ratios would be most appropriate for the transformer (*Primary : Secondary*)?

- A. 20 : 400
- B. 20 : 1
- C. 20 : 20000
- D. 20000 : 20

Justify your choice with a sample calculation.

Ratio:

3 marks

The operator of the school now installs some additional equipment, effectively placing it in parallel circuit with the original equipment.

Question 14

Complete the table below, indicating the effect on the parameter with a descriptor: Increases, Decreases, Remains Constant.

Parameter	Effect of new equipment
Voltage at school	
Current in transmission line	
Total power supplied to school	
Total power at generator site	

2 marks

SECTION A – Area of Study 1 – continued

Julian is experimenting with an unusual generating device, which consists of a large drum with a permanent magnet through its central axis. A mass on a line is wound around the drum and can be released, spinning the drum as it falls.

A copper rod (AB) is fixed to the end of the drum, directed radially and connected to a CRO via a central wire at A and making contact with a fixed ring at B. As the drum rotates, the connection at B is maintained and thus a circuit is achieved.

The setup is shown in Figure 6.

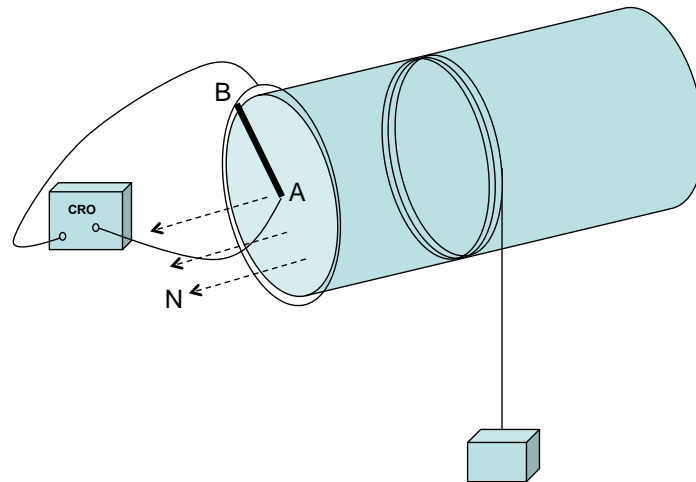


Figure 6

The mass is allowed to fall.

Initially it accelerates at a constant rate, but due to friction it reaches a constant speed after 2 seconds and continues until $t = 4$ seconds, at which point it stops quickly.

Question 15

As the drum rotates clockwise, which of the following best describes the effect on the copper rod?

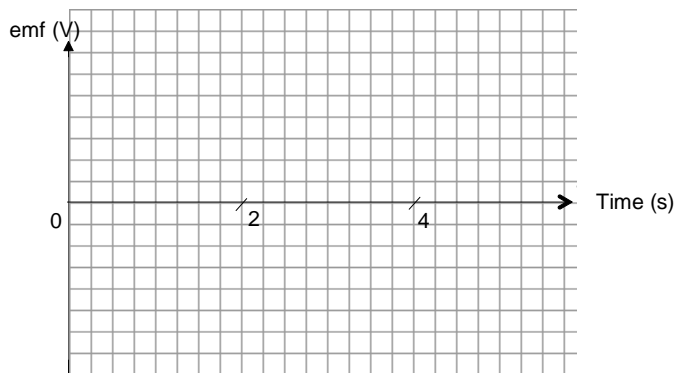
- A. The copper rod near Point A will develop a positive potential relative to Point B.
- B. The copper rod near Point A will develop a negative potential relative to Point B.
- C. The copper rod near Point A will develop a varying potential (positive then negative etc).
- D. The copper rod near Point A will not develop a potential relative to Point B.

2 marks

**SECTION A – Area of Study 1 – continued
TURN OVER**

Question 16

On the axes provided, draw a plot of the voltage vs. time in the rod at Point A. No vertical scale is required.



2 marks

Area of Study 2 – Interactions of Light and Matter

Questions 1 to 3 refer to the following information.

Brian is investigating Young's famous double-slit experiment.

Using a laser source to improve the clarity of the pattern, he recreates the setup and manages to achieve a similar light and dark pattern, as shown in Figure 1.

C represents a point equidistant from both sources.

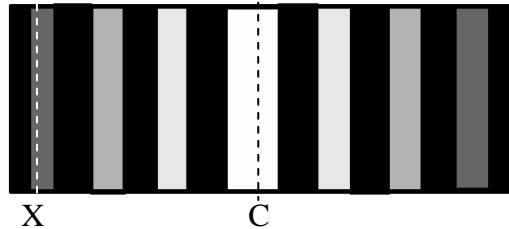


Figure 1

Question 1

If the path difference for point X on Brian's pattern is known to be 1.5×10^{-6} m, calculate the wavelength of the laser source.

m

2 marks

Brian now makes some adjustments to the apparatus.

In summary:

- The source is changed to a laser of double the original wavelength
- The slits are brought closer together, so the gap d is halved.
- The screen upon which the pattern forms is moved further from the slits, so the length L is doubled.

Question 2

Which of the following would best describe the overall effect of these changes?

- A. The spacing between bright bands would be increased.
- B. The spacing between bright bands would be decreased.
- C. The pattern would be fuzzy and there would be a single bright band only.
- D. It would be impossible to predict the overall effect as each factor has a different effect on the width of the pattern.

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2 marks

**SECTION A – Area of Study 2 – continued
TURN OVER**

Question 3

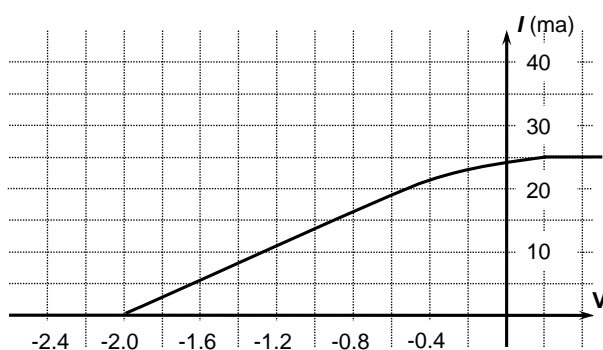
Explain why Young's (and Brian's) double-slit experiment supports the wave but not the particle model for light.

3 marks

Not satisfied with his investigations on the double-slit experiment, Brian now turns his hand to the photoelectric effect.

He obtains some data from a previously conducted experiment and plots a graph of the stopping voltage (V) vs. photocurrent (I), as shown in Figure 2.

Brian notes that the light used in the original experiment had a wavelength of 490 nm.

**Figure 2****Question 4**

Determine the value of the maximum kinetic energy of the fastest moving electron ejected by the 490 nm source.

J

2 marks

SECTION A – Area of Study 2 – continued

Question 5

Determine the value of the work function, W for the photocell that Brian is investigating.

J

3 marks

Brian is now considering the effect of some adjustments to the setup and pondering the effect on the curve in Figure 2 (repeated below).

Question 6

Sketch an estimate for a new curve which correctly models the results for a source of lower frequency (but still above threshold level) whilst retaining the same overall power.

Use Figure 3 as a template and justify your answer in the space provided.

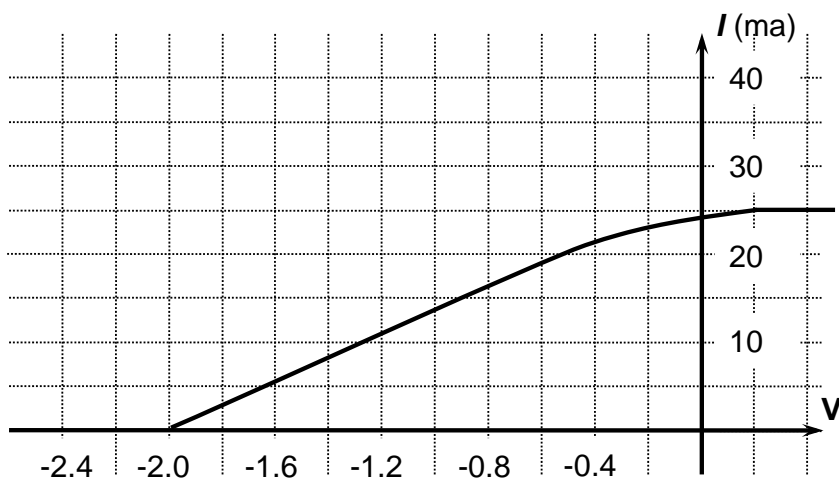


Figure 3

3 marks

**SECTION A – Area of Study 2 – continued
TURN OVER**

2012 PHYSICS EXAM 2

Students are investigating diffraction patterns generated by x-rays and electrons directed through a fine mesh.

The pattern formed by electrons that have been accelerated by a pair of 400 V plates is very similar to that observed by a separate x-ray source.

Question 7

Determine the wavelength of the electrons used in the experiment.

2 marks

Question 8

Determine the energy of a single photon of the x-ray source required for the matching diffraction patterns.

2 marks

SECTION A – Area of Study 2 – continued

Figure 4 shows an energy level diagram for an element which can absorb and emit photons in its gaseous state.

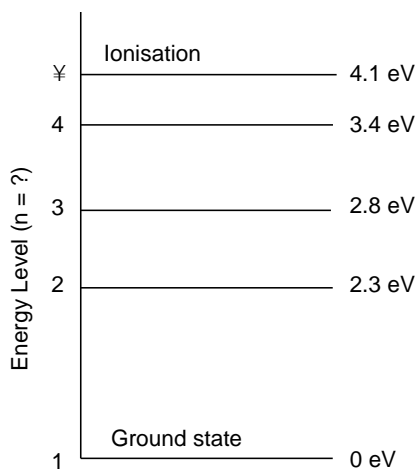


Figure 4

Question 9

Determine the wavelength of a photon required to send an electron from ground state to the excited state corresponding to $n = 4$.

nm

2 marks

Question 10

Which of the following photon energies could be observed as the electron returns to ground state from $n = 4$? There may be more than one answer.

- A. 0.5 eV
- B. 0.7 eV
- C. 2.3 eV
- D. 3.4 eV

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2 marks

SECTION A – Area of Study 2 – continued
TURN OVER

Question 11

Explain how the existence of electrons transitioning discrete energy levels supports both the wave and particle model for matter.

3 marks

Question 12

Draw a diagram to show how an electron can be modelled in the state $n = 3$.

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.

Synchrotron and its applications

p. 19

Photonics

p. 23

Sound

p. 27

Detailed Study 1 – Synchrotron and its applications

Question 1

Which of the following is the best description of the purpose of the **booster ring** at the Australian Synchrotron?

- A. To focus the electron beam for injection into one of the beam lines.
- B. To maintain the energy of the electrons at their maximum value.
- C. To store the high energy X-rays for experiments.
- D. To increase the energy of the electrons to their maximum value.

Question 2

Which of the following is the best description of a **beam line** at the Australian Synchrotron?

- A. Where the electrons, now at maximum possible speed, produce radiation for use in experiments.
- B. Path along which synchrotron radiation passes to reach the experimental target.
- C. Row of magnets with alternating polarity used to produce radiation
- D. Series of chambers designed to accelerate electrons, using 100 MV.

Question 3

Which of the following is the best approximation for the voltage required to accelerate a slow moving electron (you may assume $v = 0$) to $1.2 \times 10^7 \text{ ms}^{-1}$?

- A. 41 V
- B. 410 V
- C. $2.6 \times 10^5 \text{ V}$
- D. $3.4 \times 10^5 \text{ V}$

SECTION B – Detailed Study 1 – continued
TURN OVER

Question 4

Which of the following is the best estimate of the speed of the electron that would be required for a radius of curvature of 0.1 m within a magnetic field of 4.2×10^{-3} T?

- A. $7.4 \times 10^6 \text{ ms}^{-1}$
- B. $3 \times 10^8 \text{ ms}^{-1}$
- C. $1.35 \times 10^8 \text{ ms}^{-1}$
- D. $7.4 \times 10^7 \text{ ms}^{-1}$

Question 5

If the electron referred to in Question 4 were to move in a clockwise circular path (in the plane of this page), which direction would the magnetic field need to be directed?

- A. Clockwise
- B. Anticlockwise
- C. Into the page
- D. Out of the page

Consider the following three X-ray sources:

1. A laser
2. An X-ray tube
3. Entering from the storage ring of the synchrotron

Question 6

Which of the following best ranks the **intensity** of the sources from lowest to highest?

- A. $1 < 2 < 3$
- B. $2 < 1 < 3$
- C. $3 < 2 < 1$
- D. $3 < 1 < 2$

Undulators are rows of magnets with alternating polarity, that force electrons into a snaking path.

Question 7

Radiation is emitted as the electrons

- A. change direction
- B. decrease in speed
- C. increase in speed
- D. collide with sensors in the surrounding walls

X-rays of energy 3.6 keV are used in single crystal diffraction

Question 8

Which of the following is closest to the wavelength of the X-rays?

- A. 0.345 nm
- B. 3.45 nm
- C. 3.45 m
- D. 3.45×10^{-10} nm

The following information applies to Questions 9 and 10

Bragg diffraction is observed for a spacing of 4 nm. The first angle observed is 21° .

Question 9

Which of the following best approximates the wavelength of the radiation involved in the diffraction?

- A. 14 nm
- B. 28 nm
- C. 28 m
- D. 2.8 nm

Question 10

Which of the following best approximates the next angle that would be observed?

- A. 45°
- B. 22°
- C. 10.5°
- D. There is no second angle observed.

Compton scattering is observed with an incoming photon of wavelength 0.2 nm and an exiting electron at $1.1 \times 10^7 \text{ ms}^{-1}$.

Question 11

Which of the following is the best estimate for the frequency of the deflected photon?

- A. $1.5 \times 10^{18} \text{ Hz}$
- B. $1.42 \times 10^{18} \text{ Hz}$
- C. $1.58 \times 10^{18} \text{ Hz}$
- D. $1.36 \times 10^{18} \text{ Hz}$

SECTION B – Detailed Study 1 – continued
TURN OVER

A photon is scattered without the loss of any energy (ie. it exits the interaction with the same energy as it arrived).

Question 12

Which of the following statements best summarises the event?

- A. An example of Thomson scattering, with an increase in the frequency of the photon.
- B. An example of Thomson scattering, with no change in the frequency of the photon.
- C. An example of Compton scattering, with no change in the frequency of the photon.
- D. An example of Compton scattering, with a decrease in the frequency of the photon.

Detailed Study 2 - Photonics

Question 1

Light from a red LED source would best be described as:

- A. Wide spectrum and coherent
- B. Narrow spectrum and incoherent
- C. Wide spectrum and incoherent
- D. Narrow spectrum and coherent

Question 2

Which of the following best describes the production of light by a mercury gas discharge tube?

- A. Light is emitted as electrons fall to lower energy states. Multiple wavelengths are emitted if the electrons absorb sufficient energy to take them several energy levels above ground state.
- B. Thermal motion of electrons.
- C. Transition of electrons from conduction band to ground state.
- D. Transition of electrons from conduction band to valence band.

An LED has a band gap of 2.4 eV.

Question 3

Which of the following is the best estimate for the wavelength of photons emitted by the LED?

- A. 5.18 nm
- B. 5.18 m
- C. 518 nm
- D. 193 nm

Question 4

Which of the following correctly lists LED colours in terms of **increasing** band gap?

- A. Red, Blue, Green
- B. Green, Blue, Red
- C. Red, Green, Blue
- D. Blue, Green, Red

SECTION B – Detailed Study 2 – continued
TURN OVER

The following information applies to Questions 5 to 7

Consider the following circuit, comprising an LED, resistor and DC supply, as shown in Figure 1. $V_{\text{LED}} = 2.1 \text{ V}$ under normal forward bias conditions.

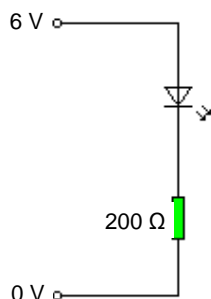


Figure 1

Question 5

Which of the following best estimates the current through the LED?

- A. 2 mA
- B. 3 mA
- C. 20 mA
- D. 30 mA

Question 6

Which of the following best estimates the power dissipated by the LED?

- A. 41 mW
- B. 41 W
- C. 4.1 W
- D. 410 mW

A second similar LED is now added in parallel, as shown in Figure 2.

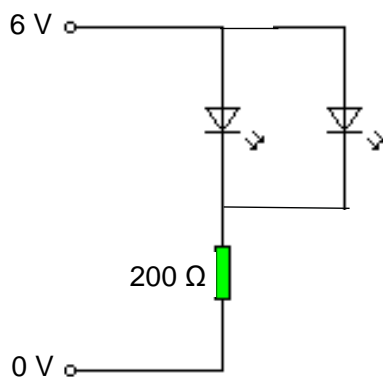


Figure 2

SECTION B – Detailed Study 2 – continued

Question 7

Which of the following best describes the effect on the brightness of the original LED?

- A. Increased by a factor of two
- B. Increased by a factor of four
- C. Decreased
- D. No change

The following information applies to Questions 8 and 9

A particular optic fibre has a core with a refractive index of 1.45 and critical angle between core and cladding of 80.5° .

Question 8

Which of the following best estimates the refractive index of the cladding?

- A. 1.43
- B. 1.47
- C. 1.41
- D. 1.50

Question 9

Which of the following best estimates the acceptance angle for the fibre?

- A. 1.4°
- B. 14°
- C. 24°
- D. 0.24°

Question 10

Which of the following best describes when and why Rayleigh scattering is most significant?

- A. For blue light, because it has a higher frequency than red
- B. For red light, because it has a higher frequency than blue
- C. For red light, because it has a lower frequency than blue
- D. For blue light, because it has a lower frequency than red

Question 11

Which of the following best describes the use of multimode, step index fibres?

- A. For short distance computer networks, where modal dispersion will be less significant
- B. For long distance computer networks, where modal dispersion will be less significant
- C. For long distance telecommunication networks, where material dispersion will be less significant
- D. For long distance telecommunication networks, where modal dispersion will be less significant

SECTION B – Detailed Study 2 – continued
TURN OVER

4 km of optic fibre is subject to attenuation, so that an initial $10 \mu\text{W}$ signal is received with only $6 \mu\text{W}$ of power.

Question 12

Which of the following is the best estimate for the percentage loss of signal per kilometre?

- A. 12% per km
- B. 88% per km
- C. 15% per km
- D. 60% per km

Detailed Study 3 – Sound

Questions 1 to 5 refer to the following information

Figure 1 shows a displacement vs. time graph at the midpoint of a long string for a wave travelling along the string. The tension in the string causes the wave to travel at 240 ms^{-1} .

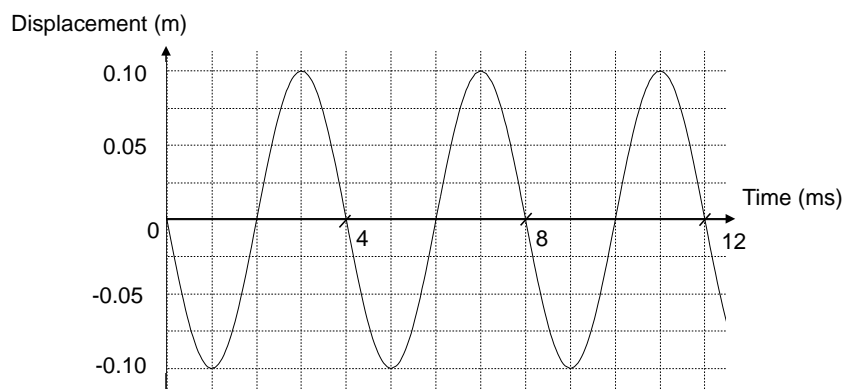


Figure 1

Question 1

Which of the following best estimates the wavelength of the wave?

- A. 0.68 m
- B. 0.96 m
- C. 1.36 m
- D. 0.004 m

Now consider a point 0.48 m from the midpoint, in the direction of the moving wave.

Question 2

At time $t = 2 \text{ ms}$, which of the following would best approximate the displacement of the string?

- A. 0 m
- B. -0.1 m
- C. $+0.1 \text{ m}$
- D. -0.05 m

SECTION B – Detailed Study 3 – continued
TURN OVER

Figure 2 shows the air pressure variation due to a 340 Hz source a considerable distance away.

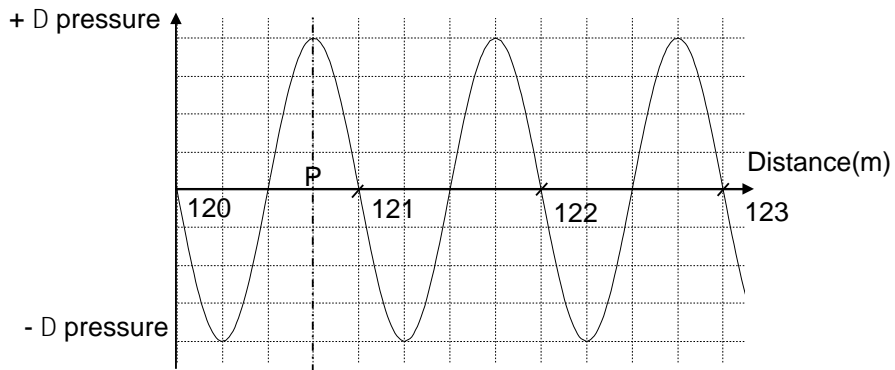


Figure 2

Question 3

2.5 ms later, an observer at Point P would experience which of the following?

- A. Compression
- B. Rarefaction
- C. Atmospheric pressure
- D. A minor increase in pressure, but not a full compression.

Figure 3 shows a set of phon curves for a standard human ear.

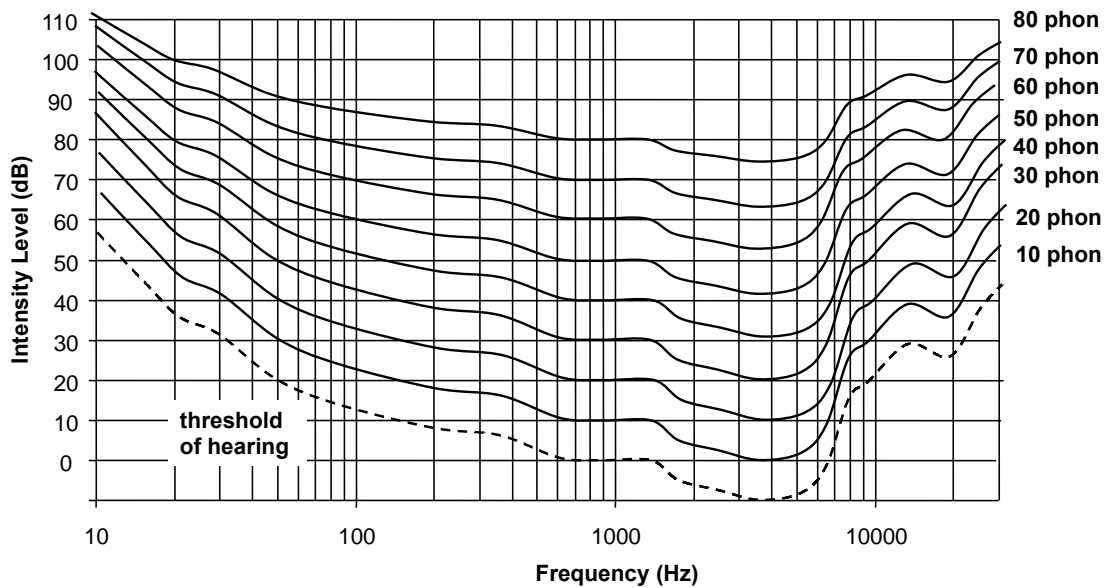


Figure 3

SECTION B – Detailed Study 3 – continued

Question 4

Which of the following sounds would appear louder than 300 Hz at 65 dB?

- A. 50 Hz at 70 dB
- B. 100 Hz at 70 dB
- C. 3000 Hz at 63 dB
- D. 20 Hz at 80 dB

A student is investigating resonance in a tube which is open at one end only. A microphone is placed at the closed end and moves towards the open end. At 0.8 m from the closed end, it detects the first quiet point. You may assume the speed of sound in the air in the tube is 340 ms^{-1} . Figure 4 details the dimensions of the setup.

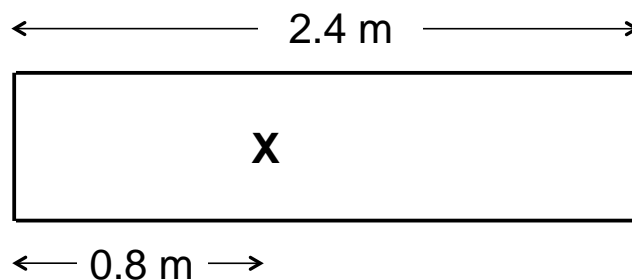


Figure 4

Question 5

Which of the following best approximates the wavelength of the resonant frequency which is being detected by the microphone?

- A. 71 Hz
- B. 106 Hz
- C. 212 Hz
- D. 425 Hz

Question 6

Which of the following is the correct terminology for the resonant frequency that is being detected by the microphone in Question 5?

- A. Fundamental, 1st Harmonic
- B. 2nd Harmonic
- C. 3rd Harmonic
- D. 5th Harmonic

SECTION B – Detailed Study 3 – continued
TURN OVER

The student is now able to replace the air inside the tube with helium. The speed of sound in helium is 1500 ms^{-1} .

Question 7

Which of the following best describes the effect on the fundamental resonant frequency detected in the tube?

- A. The frequency of the fundamental resonant frequency would increase.
- B. The wavelength of the fundamental resonant frequency would increase.
- C. The wavelength of the fundamental resonant frequency would decrease.
- D. The frequency of the fundamental resonant frequency would decrease.

Question 8

Which of the following phenomena is a baffle primarily designed to mitigate?

- A. Interference: the baffle reduces the interaction between regions of high and low pressure
- B. Diffraction: the baffle increases the effective width of the speaker to maximise diffraction
- C. Resonance: the baffle reduces resonance by increasing the effective mass of the speaker.
- D. Reflection: the baffle reduces reflections from the back of the speaker.

A student with a sound level meter records an elevated point source at 95 dB at a distance of 5 m. The student attempts to reduce the intensity level to a more peaceful 75 dB by moving further away from the source.

Question 9

Which of the following best approximates the final distance that the student would need to be positioned from the speaker to record an intensity level of 75 dB?

- A. 10 m
- B. 20 m
- C. 25 m
- D. 50 m

Question 10

Which of the following best approximates the acoustic power of the source?

- A. $1 \times 10^{-5} \text{ W}$
- B. 1 W
- C. $3.16 \times 10^{-3} \text{ W}$
- D. $1.58 \times 10^{-2} \text{ W}$

A member of an audience in a hall is attempting to listen to a recording delivered by a single speaker positioned centrally on a stage at the front of the venue, as shown in Figure 5. A gap in the heavy stage curtain is the only opening through which the speaker broadcasts sound. Positioned at **X**, she is disappointed by the lack of intensity she detects when a particular sustained frequency is delivered.

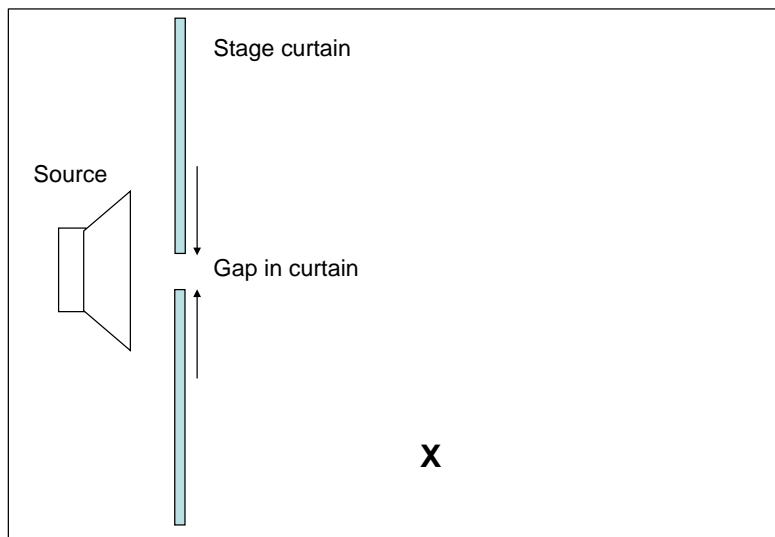


Figure 5

Question 11

Which of the following changes would lead to an increase in intensity for the audience member positioned at **X**?

- A. Reduce the width of the gap in the curtain by half.
- B. Increase the width of the gap in the curtain by half.
- C. Increase the frequency of the note being broadcast.
- D. Reduce the volume of the speaker to improve the fidelity.

Question 12

Which of the following pairs of microphone types both use electromagnetic induction as part of the process of converting a sound signal to an electrical signal?

- A. Crystal and dynamic microphone
- B. Velocity and dynamic microphone
- C. Electret condenser and crystal microphone
- D. Electret and velocity microphone

END OF QUESTION AND ANSWER BOOK

Data Sheet

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

1	photoelectric effect	$E_{k \max} = hf - W$
2	photon energy	$E = hf$
3	photon momentum	$p = \frac{h}{\lambda}$
4	de Broglie wavelength	$\lambda = \frac{h}{p}$
5	resistors in series	$R_T = R_1 + R_2$
6	resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
7	magnetic force	$F = I l B$
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	$m_e = 9.1 \times 10^{-31} \text{ kg}$
14	charge on the electron	$e = 1.6 \times 10^{-19} \text{ C}$
15	Planck's constant	$h = 6.63 \times 10^{-34} \text{ J s}$ $h = 4.14 \times 10^{-15} \text{ eV s}$
16	speed of light	$c = 3.0 \times 10^8 \text{ m s}^{-1}$

Detailed study 3.1 - Synchrotron and its applications

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

Detailed study 3.2 - Photonics

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

Detailed study 3.3 - Sound

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

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	<input type="checkbox"/>
2. Photonics	<input type="checkbox"/>
3. Sound	<input type="checkbox"/>

Answers – Circle ONE of A-D for each of the twelve 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