INSIGHT

Trial Exam Paper

2008

PHYSICS

Written examination 2

Worked Solutions

This book presents:

- worked solutions, giving you a series of points to show you how to work through the questions
- mark allocation details.

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SECTION A – Core

Area of study 1 – Electric power

The following information applies to Questions 1 and 2.

Figure 1 shows two current-carrying wires, A and B, both 2 m long. They each have the same current flowing through them.

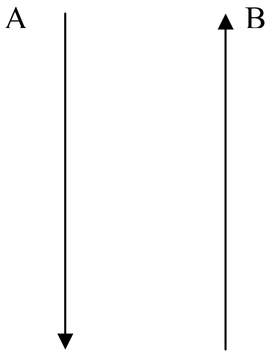


Figure 1

Question 1

The two wires would experience a force

A. both to the left

B. both to the right

C. towards each other

D. away from each other

Worked solution

In this situation, there will be either an attractive or repelling force. The use of the right-hand grip rule followed by the right-hand slap rule will quickly show the correct answer.

D

2 marks

Question 2

What is the current flowing through wire A if it is in a magnetic field of 4×10^{-2} T and is experiencing a force of 8×10^{-3} N?

Worked solution

$F = BIL$

$$B = \frac{F}{BL} = \frac{8\times10^{-3}}{4\times10^{-2}\times2} = 0.1\text{ A}$$

0.1 A

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

The following information applies to Questions 3–7.

A coil, with 50 turns, is set up between two magnets, as shown in Figure 2. The maximum flux through the coil is 8×10^{-5} Wb. The distance of *AB* is 10 cm and *BC* is 20 cm.

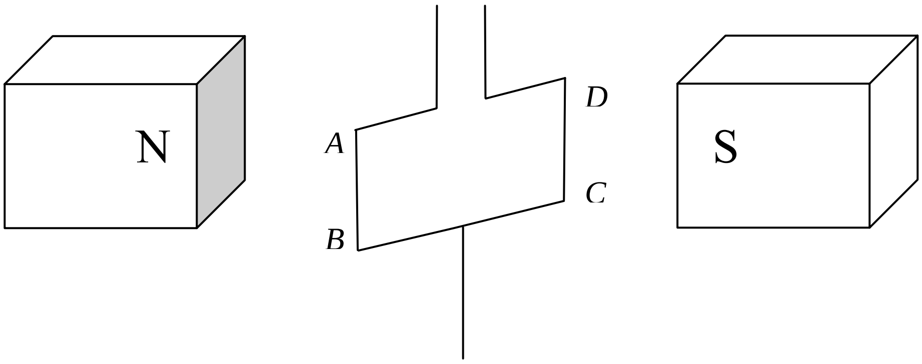


Figure 2

Question 3

What is the magnitude of the magnetic field through the coil? Include the unit in your answer.

Worked solution

$$B = \frac{\phi}{A}$$
$$= \frac{8 \times 10^{-5}}{0.1 \times 0.2}$$
$$= 0.004$$

Unit: T or Wbm^{-2}

Magnitude: 4×10^{-3}

2 marks

Unit: T or Wbm^{-2}

2 marks

Total: 2 + 2 = 4 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for calculating magnitude correctly.
- 2 marks for correct unit.

Tip

- *Marks are awarded for workings, so clearly show all workings.*

Question 4

Show that if the coil is rotated at 10 Hz, the average Emf generated is 1.6 V.

Worked solution

$$\text{Emf} = \frac{N\Delta\phi}{\Delta t}$$

$$= \frac{500 \times 8 \times 10^{-5}}{\left(\frac{0.1}{4}\right)}$$

$$= 1.6 \text{ V}$$

1.6 V

3 marks

Mark allocation

- 1 mark for noting that change in time is one-quarter of a rotation.
- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Tip

- *For a maximum change in flux, the coil will rotate only one-quarter of a rotation.*

Question 5

A battery of 3.2 V supplies a current of 0.2 A through the coil from *A* to *B*. What is the magnitude **and** direction of the force on side *AB*?

Worked solution

First, find the magnitude:

F = NBIL

= 50 × 0.004 × 0.2 × 0.1

= 0.004 N

Second, find the direction:

Choose direction from: up
down
left
right
out of page
into page

Using right-hand slap rule: current down, magnetic field left to right, gives force direction **out of the page**.

Magnitude: **0.04 N**

2 marks

Direction: out of page

2 marks
Total: 2 + 2 = 4 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for calculating magnitude correctly.
- 2 marks for correct direction.

Tip

- *All forces have to be at* ***right angles*** *to each other.*

Question 6

Explain what would happen to the coil after the battery is connected.

Worked solution and mark allocation

- The motor would rotate to 90°. (1 mark)
- It would then **stop**. (1 mark)

2 marks

Question 7

Explain the operation of a split ring commutator in a DC motor.

Worked solution and mark allocation

- The commutator reverses the current through the coil, which reverses the turning effect of the force. (1 mark)
- This will then allow the coil to continue to rotate. (1 mark)

2 marks

Tip

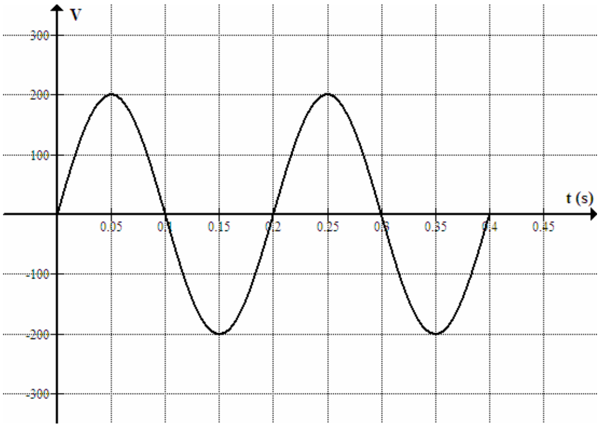
- *Questions like this one are common. You should include clear and concise explanations on your A4 sheet. In questions that require an explanation, the number of marks generally equates to the number of relevant points that should be made.*

The following information applies to Questions 8 and 9.

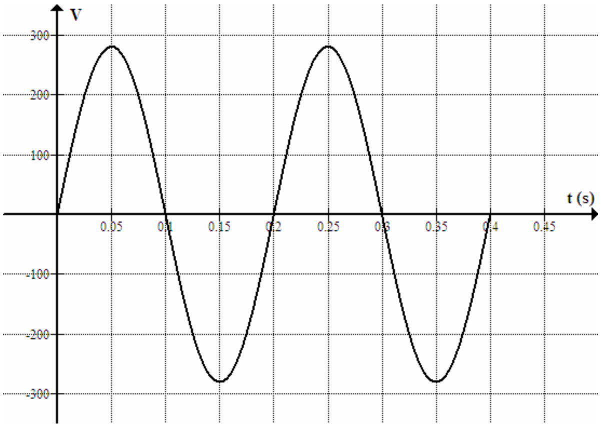
Question 8

A generator, rotating at 50 revolutions per second, has a RMS output of 200 V. Which of the following graphs represents this?

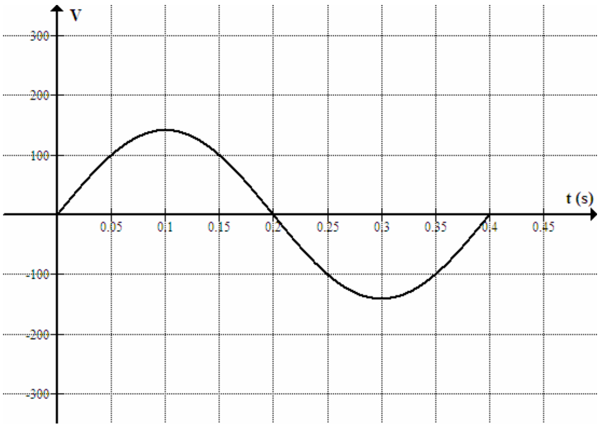
A.



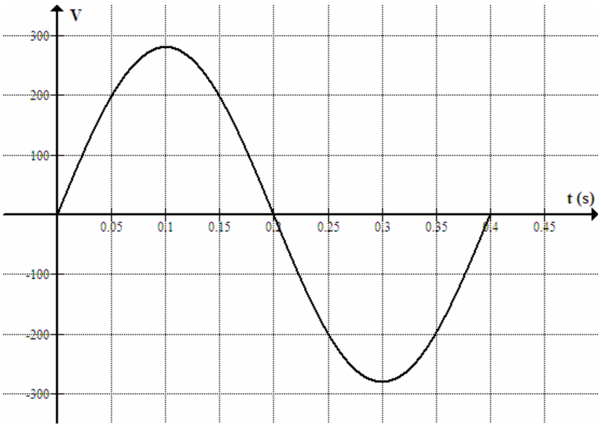
B.



C.



D.



Worked solution

B is the correct answer because it has a peak of $200 \times \sqrt{2} = 283$ V, and a time period of one cycle taking 1/50 = 0.2 s.

B

2 marks

Question 9

The generator is slowed to 25 Hz. Which graph now best represents the output?

Worked solution

Halve the frequency equals double the time period, and halves the output Emf.

C

2 marks

The following information applies to Questions 10–15.

David is trying out his new video game system. It draws 50 mA when connected to a 12 V AC power supply. Therefore, it needs a transformer so it can run from the 240 V mains electricity supply, as shown in Figure 3.

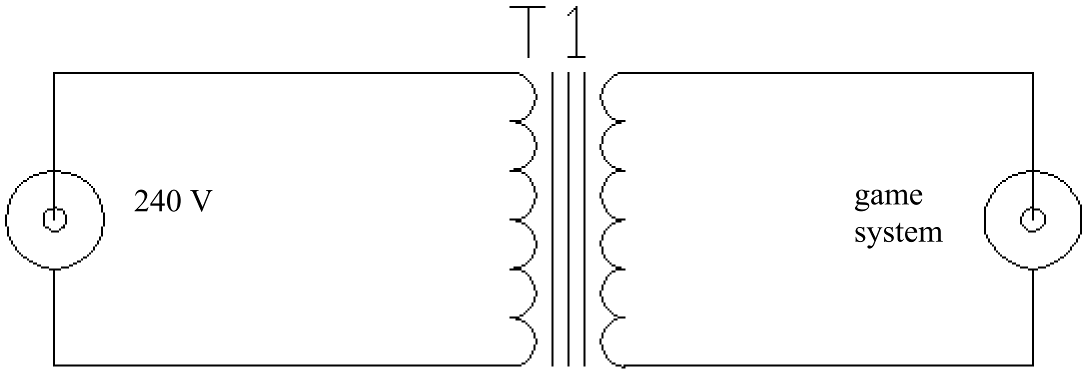


Figure 3

Question 10

What power is drawn from the primary side of the transformer?

Worked solution

Power drawn is the same on both sides of the transformer.

$P = 12 \times 0.05 = 0.6$ W

0.6 W

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 11

What current is drawn in the primary side of the transformer?

Worked solution

$P = VI$

$I = \frac{P}{V} = \frac{0.6}{240}$

$= 0.0025 = 2.5 \text{ mA}$

2.5 mA

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Tip

- *You work only with 'ideal transformers'.*

Question 12

If the number of turns in the primary is 500, calculate the number of turns, *N*, in the secondary.

Worked solution

$\frac{V_s}{V_p} = \frac{N_s}{N_p}$

$\frac{12}{240} = \frac{N_s}{500}$

$N_s = \frac{500 \times 12}{240}$

$= 25$

$\mathbf{N_s = 25}$

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 13

Calculate the resistance of the game system.

Worked solution

$V = IR$

$R = \frac{V}{I}$

$= \frac{12}{0.05}$

$= 240\ \Omega$

240 Ω

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 14

What is the power loss in the system if the game system is connected to an extension cord with a total resistance of 20 Ω?

Worked solution

$P_{\text{loss}} = I^2R - 0.05^2 \times 20 = 0.05$ W

0.05 W

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 15

At what voltage would the game system operate at now?

Worked solution

$P = VI$

$V_{\text{drop}} = \frac{P_{\text{loss}}}{I} = \frac{0.05}{0.05} = 1\text{ V}$

Game system runs at 12 – 1 = 11 V

11 V

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

The following information applies to Questions 16 and 17.

A physics teacher drops her wedding ring next to a magnet during class. It falls between the teacher and the magnet, is perpendicular to the magnetic field, and does not spin. The ring has a radius of 0.5 cm, and the ring cuts into the magnetic field of 5×10^{-3} T in only 0.01 seconds.

Question 16

What is the Emf induced in the teacher's ring?

Worked solution

$$\text{Emf} = \frac{\Delta\phi}{\Delta t} = \frac{\Delta B \times A}{\Delta t}$$

$$= \frac{5\times10^{-3}\times\left(\pi\times\left(0.5\times10^{-2}\right)^2\right)}{0.01}$$

$$= 3.9\times10^{-5}$$

3.9 × 10^{-5} V

3 marks

Mark allocation

- 1 mark for calculating correct area.
- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Tip

- *Make sure all units are SI before using them in a formula.*

Question 17

From the teacher's point of view, in which direction would the current flow in the ring?

(Circle the correct answer).

clockwise anti-clockwise

Worked solution

The correct answer is clockwise. From the teacher's point of view, the magnetic field towards the teacher would be increasing as the ring goes into the magnetic field. Lenz's law states that the ring will resist this change, therefore setting up a magnetic field towards the coil. To do this, it needs to produce a current **clockwise**.

2 marks

Tip

- *Have it very clear in your mind what the difference between Faraday's Law and Lenz's Law is.*

Area of study 2 – Interactions of light and matter

Question 1

Explain the term **incandescent** in terms of the production of light.

Worked solution and mark allocation

In terms of the production of light, incandescent refers to the thermal (1 mark) vibration of electrons that lose energy as photons (1 mark).

2 marks

Tip

- *In explanation-type questions some students write everything they can think of related to the topic, instead of answering the question asked. This often results in contradictions. When this occurs, full marks cannot be awarded.*

Question 2

Light **never** displays properties of

A. **mass**
B. momentum
C. acceleration
D. energy

Worked solution and mark allocation

A is correct: light **never** has mass (2 marks).

B is incorrect because the **de Broglie relations** show that the wavelength is inversely proportional to the momentum of a particle and that the frequency is directly proportional to the particle's kinetic energy Therefore, light has momentum.

C is incorrect because when light changes mediums, it has a change in velocity, which equals acceleration.

D is incorrect because as $E = hf$, and light has a frequency, it follows that light has energy.

A

2 marks

The following information applies to Questions 3–10.

Some Nobel Laureate prize winners set up the following experiment, as shown in Figure 1.

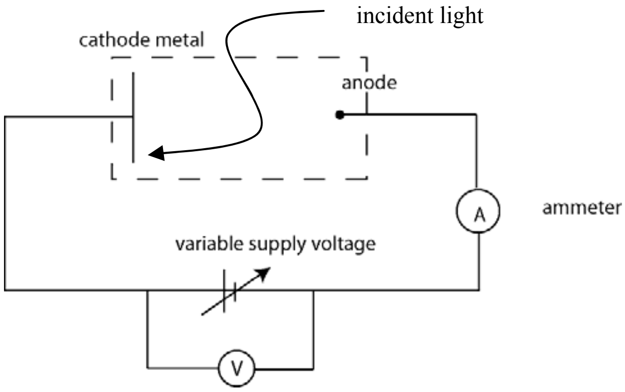


Figure 1

They find that the ammeter shows zero when the incident light frequency falls below 5×10^{14} Hz *no matter what the supply voltage*. They shine some red light of $f = 7.3 \times 10^{14}$ Hz onto the cathode metal.

Question 3

Calculate the wavelength, λ, of the incident light.

Worked solution

$$\lambda = \frac{v}{f}$$

$$= \frac{3 \times 10^{8}}{7.3 \times 10^{14}}$$

$$= 4.1 \times 10^{-7} \text{ m}$$

4.1 × 10^{-7} m

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 4

Find the energy of the incident photon in electron Volts.

Worked solution

$E = hf$

$= 4.14 \times 10^{-15} \times 7.3 \times 10^{14}$

$= 3.02$ eV

3.02 eV

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 5

The ammeter is reading 2 mA. The decision is made to change the incident frequency to 9×10^{14} Hz. The reading on the ammeter would

A. remain the same

B. increase

C. decrease

D. increase, then decrease

A

1 mark

Question 6

Explain your answer to Question 5.

Worked solution

Option A is the correct answer because an increase of frequency of the incident light will give any photoelectrons more kinetic energy, yet will have no effect on the number of electrons released, which is what the ammeter is reading.

2 marks

Question 7

If the intensity of the incident light is increased, the reading on the ammeter would

A. remain the same

B. increase

C. decrease slightly

D. decrease to zero

B

2 marks

Question 8

Explain your answer to Question 7.

Worked solution

Option B is the correct answer because more intensity means more photons of light, which means more photoelectrons – which is the same as the current.

2 marks

Question 9

What is the work function of the metal in eV?

Worked solution

$W = hf_0$

$= 4.14 \times 10^{-15} \times 5 \times 10^{14}$

$= 2.07$ eV

2.07 eV

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

The intensity and frequency are changed back to their original levels.

Question 10

What voltage would be needed to stop the current flowing through the ammeter?

Worked solution

Voltage needed to stop would be the same as the KE_{max}.

$KE_{\text{max}} = hf - W$

$= 4.14 \times 10^{-15} \times 7.3 \times 10^{14} - 2.07$

$= 0.95$

0.95 V

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Tip

- *Questions 5–10 are examples of light behaving as a particle.*

Question 11

A laser hits a double slit, as shown in Figure 2. The pattern shows clearly on the screen. Explain why point *P*, which is equidistant from both slits, is a very bright band.

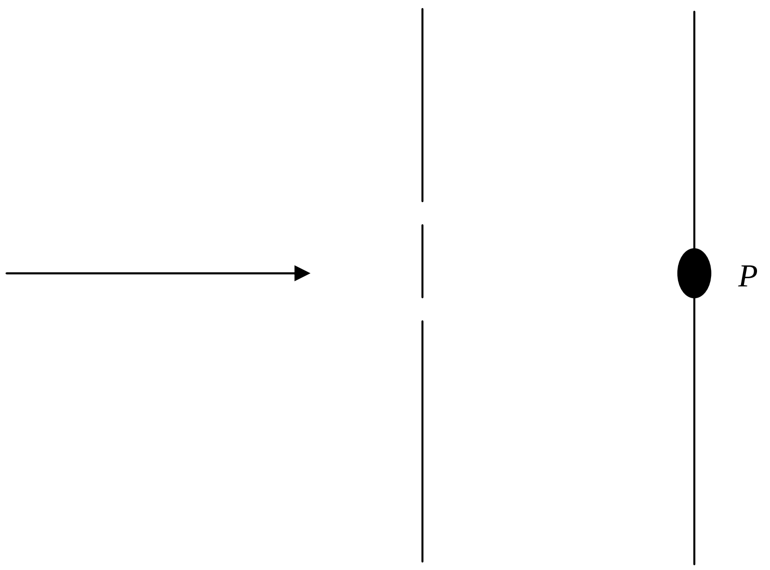


Figure 2

Worked solution and mark allocation

As the path length from each slit is equal, there is no path difference. (1 mark)

This gives constructive interference (1 mark) and thus a bright band.

2 marks

Question 12

An electron gun shoots electrons (mass = 9.1×10^{-31} kg) with a velocity of 3×10^{7} ms^{-1}, as shown in Figure 3.

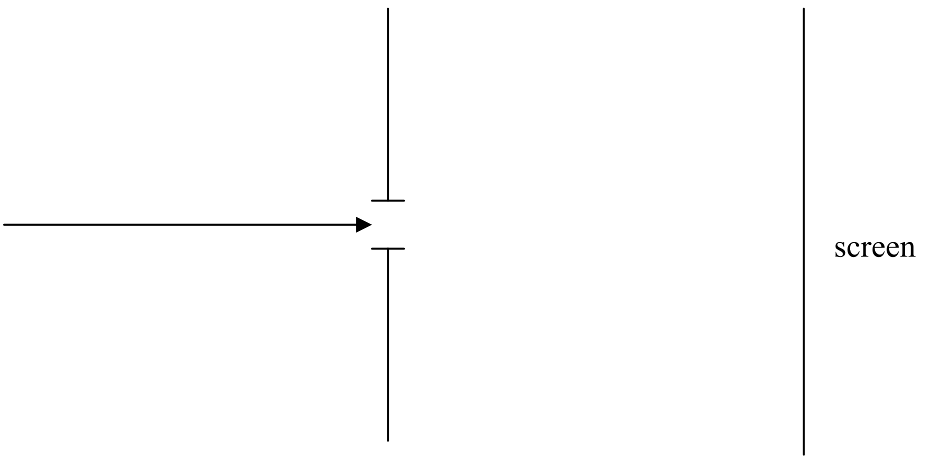


Figure 3

Determine the gap size needed in order to get a significant diffraction pattern on the screen.

Worked solution

For significant diffraction, size of gap needs to be approximately the same as the wavelength.

$$\lambda = \frac{h}{mv}$$
$$= \frac{6.63\times10^{-34}}{9.1\times10^{-31}\times3\times10^{7}}$$
$$= 2.43\times10^{-11} \text{ m}$$

2.43×10^{-11} m

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Tip

- *Questions 11 and 12 are examples of light behaving as a wave.*

The following information applies to Question 13.

The energy level diagram for hydrogen is shown in Figure 4.

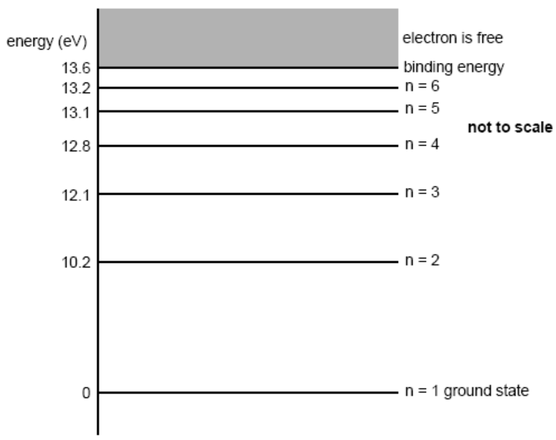


Figure 4

Question 13

If an electron falls from the 13.1 eV level (i.e. n = 5) to the 10.2 eV level (i.e. n = 2), calculate the frequency of the emitted light.

Worked solution

First, calculate energy emitted.

$E = 13.1 - 10.2 = 2.9$ eV

E = hf

$$f = \frac{E}{h}$$

$$= \frac{2.9}{4.14 \times 10^{-15}}$$

$$= 7.01 \times 10^{14} \text{ Hz}$$

7.01×10^{14} Hz

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

END OF SECTION A

SECTION B – Detailed studies

Detailed study 1 – Synchrotron and its applications

Question 1

Describe the purpose of the booster ring in the synchrotron.

Worked solution and mark allocation

The booster ring increases the energies of the electrons (1 mark) and keeps the electron beam focused. (1 mark)

2 marks

The following information applies to Questions 2 and 3.

In the storage ring, electrons are found to have a momentum of 1.5×10^{-18} kg ms^{-1} and are being bent through an arc of radius 8.1 m, as shown in Figure 1.

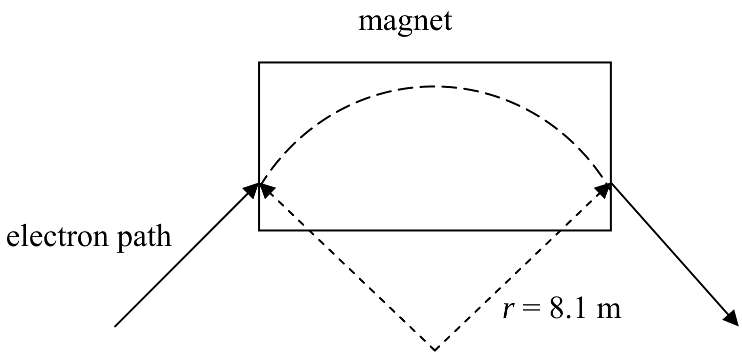


Figure 1

Question 2

Calculate the magnetic field required to keep the electrons on this arc. Include the unit in your answer.

Worked solution

$$r = \frac{p}{qB}$$

$$B = \frac{p}{qr}$$

$$= \frac{1.5 \times 10^{-18}}{1.6 \times 10^{-19} \times 8.1}$$

$$= 1.157 \text{ T}$$

Magnitude: 1.16

Unit: T

Total: 2 + 2 = 4 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.
- 2 marks for correct unit.

Question 3

From the following, what is the magnetic field direction in the ring?

into page

out of page

up

down

left

right

into page

2 marks

Tip

- *Electron flow is opposite to conventional current flow.*

Question 4

Electrons are fired from an electron gun and accelerated to a speed of 6×10^7 ms^{-1}. Calculate the kinetic energy of an electron in KeV.

Worked solution

$$\begin{aligned}KE &= 0.5mv^2 \\ &= 0.5(9.1\times10^{-31})(6\times10^7)^2 \\ &= 1.638\times10^{-15}\text{ J} \\ &= 1.638\times10^{-15} \div 1.6\times10^{-19}\text{ eV} \\ &= 10237.5\text{ eV} \\ &= 10.2\text{ KeV}\end{aligned}$$

10.2 KeV

3 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for calculating 10237.5 eV
- 1 mark for correct conversion to KeV.

Tip

- *Remember: answers in eV give far larger than answers in Joules. Don't convert the wrong way.*

The following information applies to Question 5.

Susie is experimenting with a pair of charged parallel plates, which has some high voltage between them. The voltage difference between the plates is 10 000 V, and static electrons are introduced. It is found that the electrons have a kinetic energy of 1.5×10^{-15} joules. She then calculates the experimental value for the charge on the electrons.

Question 5

What is Susie's value for the charge on the electrons?

Worked solution

$$\text{Work} = qV$$

$$q = \frac{W}{V}$$

$$= \frac{1.5 \times 10^{-15}}{10\,000}$$

$$= 1.5 \times 10^{-19} \text{ C}$$

1.5×10^{-19} C

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Tip

- *Do not simply write in the accepted value for the charge without showing full working. The examiners will be on the lookout for this.*

Question 6

How can Bragg diffraction be differentiated from other types of diffraction?

Worked solution

The reflected angle is equal to the incident angle.

2 marks

Question 7

Give **three** advantages that the synchrotron has over more traditional forms of radiation producers.

Advantage 1:____

Advantage 2:____

Advantage 3:____

Worked solution and mark allocation

- Synchrotron has brighter, that is, more intense radiation (1 mark) or
- Has less divergence, that is, a narrower beam (1 mark) or
- Can be pulsed (1 mark) or
- Can be polarised (1 mark)
- Any three correct answers earns 3 marks.

3 marks

Tip

- *Be very clear and concise with written answers.*

Question 8

Circle True or False for each of the following.

(a)	The electrons are produced with an electron gun.	T	F
(b)	Electrons travel through the beam lines to the experimental stations.	T	F
(c)	Thomson scattering takes a small amount of energy from electrons.	T	F

Worked solution

(a) Answer is T because this is how electrons are produced.

(b) Answer is F because radiation travels through the beam lines to the experimental stations, not electrons.

(c) Answer is F because Thomson scattering takes **no** energy from electrons.

3 marks

Mark allocation

- 1 mark per correct answer.

Question 9

Bragg diffraction is used to select desirable wavelengths from the synchrotron. Explain how this is done.

Worked solution and mark allocation

- Maxima occur that are dependant on the light's wavelength. (1 mark)
- Different wavelengths will be at different maxima. (1 mark)
- By rotating a crystal block (1 mark), light of the desired wavelength can be directed through a very narrow opening. (1 mark)

4 marks

END OF DETAILED STUDY 1
SECTION B – continued

Detailed study 2 – Photonics

The following information applies to Questions 1 and 2.

A LED is connected correctly to a variable DC voltage supply. Current flows through the circuit, producing a bright steady light.

Question 1

The band gap of the LED is 2.4 eV. Calculate the wavelength (in nm) of the light produced.

Worked solution

$$E = hf = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E}$$

$$= \frac{4.14\times10^{-15}\times3\times10^{8}}{2.4}$$

$$= 5.18\times10^{-7}\text{ m}$$

$$= 518\text{ nm}$$

518 nm

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 2

What is the colour of this light?

A. ultraviolet

B. infra-red

C. blue

D. red

E. green

Worked solution

Green light is approximately 510–520 nm.

E

2 marks

Question 3

Gertrude and Brenda are arguing about the benefits of laser light over LED light in an electro-photonic system. Gertrude has listed six reasons why she thinks that lasers are better than LEDs. From these, Brenda picks out the three correct responses easily. Can you? Circle the **three** most correct answers.

(a) brighter
(b) coherent
(c) cheaper
(d) more readily available
(e) less expensive to run
(f) monochromatic

Worked solution

Lasers are brighter (a); coherent (b); and monochromatic (f).

3 marks

Mark allocation

- 1 mark for each correct answer.

The following information applies to Questions 4–7.

Figure 1 shows a typical fibre optic cable.

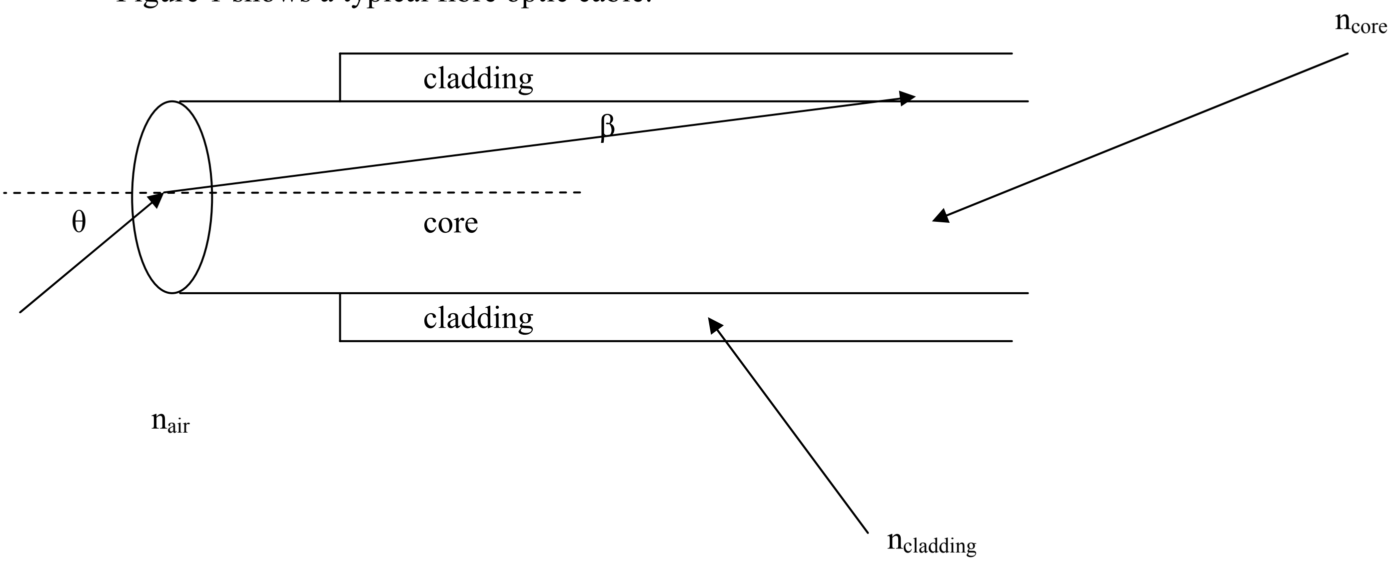


Figure 1

Question 4

Circle the correct answers within the following statement.

For the fibre optic to work correctly, n_{core}/$n_{cladding}$/n_{air} needs to be the greatest, whereas n_{core}/$n_{cladding}$/n_{air} needs to be the least.

Worked solution

n_{core}; $n_{cladding}$

2 marks

Question 5

If the n_{core} for the fibre optic cable is 1.5, what is the maximum angle θ that will allow light to enter the core?

Worked solution

There is no maximum critical angle when light passes from a lower refractive index medium to a higher one. The highest angle will be 90°.

90°

1 mark

Question 6

What is the value of $n_{cladding}$ if the critical angle of the boundary is found to be 83.4°?

Worked solution

$$\sin\theta_c = \frac{n_{cladding}}{n_{core}}$$

$n_{cladding} = 1.5 \times \sin(83.4)$

$n_{cladding} = 1.49$

1.49

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer

Question 7

What is the angle θ, as shown on the diagram?

Worked solution

$n_1 \times \sin\theta_1 = n_2 \times \sin\theta_2$

$\sin\theta = 1.5 \times \sin(6.6)$

$\theta = 9.93°$

9.93°

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

The following information applies to Questions 8 – 12.

Question 8

Chelsea and Manu are having a healthy debate about modal dispersion, which they have encountered in their new fibre optic network. Chelsea states that a larger diameter fibre is needed, as this will allow more light in, giving more signal out, thus producing a better result for all. Manu suggests the exact opposite and wants a thinner fibre.

Whose advice should they follow and why?

Worked solution and mark allocation

- Manu is correct. (1 mark)
- Modal dispersion is caused by different rays following different paths down the fibre, travelling different distances, thus getting to the other end at different times. (1 mark)
- A thinner diameter fibre means all rays will travel fewer different distances. (1 mark)

3 marks

Question 9

What is material dispersion, and what is the best way to overcome it?

Worked solution and mark allocation

- Different wavelengths of light travel at different speeds down the fibre. (1 mark)
- Using only one wavelength, such as from a laser, will overcome the problem. (1 mark)

2 marks

Question 10

The phenomenon of refraction of light is due to the fact that

A. the speed of light is constant in all media

B. light exhibits both wave and particle behaviour

C. the speed of light is not constant in all media

D. photons have momentum

Worked solution

Bending of light is due to the change in speed of the light as it passes from one medium to another.

C

2 marks

Question 11

When transmitting signals through an optical fibre, those rays entering the fibre at angles of incidence outside the cone of acceptance will be transmitted

A. through the fibre with reduced amplitude

B. through the fibre with reduced frequency

C. through the fibre with reduced intensity

D. into the cladding and lost

Worked solution

Option D is correct because the angle of incidence is less than the critical angle and, therefore, total internal reflection cannot occur.

D

2 marks

Question 12

Besides bandwidth, list **two** advantages that optical fibres have over copper wires.

Worked solution and mark allocation

- They do not rust (deteriorate). (1 mark)
- They are not affected by electrical interference. (1 mark)

2 marks

Detailed study 3 – Sound

Take the speed of sound to be 340 ms^{-1} throughout this section.

The following information applies to Questions 1–4.

Corporal Agarn is blowing a trumpet with a fundamental frequency of 500 Hz.

Question 1

What is the wavelength of the produced sound?

Worked solution

$$v = f\lambda$$

$$\lambda = \frac{v}{f} = \frac{340}{500} = 0.68 \text{ m}$$

0.68 m

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 2

Sergeant O'Rourke is standing 3 m in front of Agarn, and records the sound level at 65 dB.

What is 65 dB in sound intensity?

Worked solution

$$dB = 10 \log_{10} \frac{I_0}{10^{-12}}$$

$$65 = 10 \log_{10} \frac{I_0}{10^{-12}}$$

$$6.5 = \log_{10} \frac{I_0}{10^{-12}}$$

$$10^{6.5} = \frac{I_0}{10^{-12}}$$

$$10^{6.5-12} = I_0$$

$$I_0 = 10^{-5.5}$$

$$I_0 = 3.16 \times 10^{-6} \text{ Wm}^{-2}$$

3.16×10^{-6} Wm^{-2}

3 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 2 marks for correct answer.

Question 3

Sergeant O'Rourke now moves so that she is 6 m from the trumpet. How will this affect the sound intensity, and what will be its new value?

Worked solution and mark allocation

Double the distance so the sound intensity decreases by a factor of $2^2 = 4$ (1 mark)

Hence, sound intensity is now $3.16\times10^{-6} \div 4 = 7.9\times10^{-7}$ Wm^{-2} (1 mark)

2 marks

Tip

- *If you answered 59 dB, you have intensity and level mixed up. Well done for realising that doubling the distance means a drop of 6 dB, but no marks – as that is not the question! Read the question more carefully!*

Question 4

The trumpet can be modelled as a pipe with one closed end. Which other frequency will it produce?

A. 250 Hz
B. 750 Hz
C. 1000 Hz
D. 1500 Hz

Worked solution

For a pipe closed at one end, the frequency of the harmonics produced is the multiple of an odd number of the fundamental frequency.

D

2 marks

Tip

- *Make sure you have a clear understanding of the differences between resonance in closed and open pipes.*

Question 5

How long is the trumpet?

Worked solution

$$L = 4\lambda = 4\frac{f}{\lambda} = 4\times\frac{340}{500} = 0.17 \text{ m}$$

0.17 m

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 6

Agarn tells O'Rourke that the trumpet is resonating. Briefly explain resonance in terms of the behaviour of the sound waves.

Worked solution and mark allocation

- Resonance is the matching of frequency between the natural frequency of the tube and the frequency within the source of the excitation, which is the blowing into the trumpet. (1 mark)
- At an open end there is a pressure node (1 mark) and this determines the natural frequency of the tube. (1 mark)

3 marks

The following information applies to Questions 7 – 9.

Shalderman is setting up his home theatre. Instructions state that all small speakers should be pointing directly at where the listener is sitting, with nothing in between. But the subwoofer, with its very low frequency output, is able to sit anywhere in the room, and does not have to be pointed directly at the listener.

Question 7

Why does the subwoofer get such special treatment?

Worked solution and mark allocation

Subwoofers produce low frequencies (1 mark) that will diffract around most things in their path. (1 mark)

2 marks

Question 8

The subwoofer is surrounded by a 'box'. What is the name of this box and what is its purpose?

Worked solution and mark allocation

- The box is called a baffle. (1 mark)
- It stops out-of-phase waves from behind the speaker (1 mark) interfering destructively with waves at the front of the speaker. (1 mark)

3 marks

Question 9

What is a drawback of this 'box' surrounding the speaker?

Worked solution and mark allocation

- It will reverberate at its natural frequency (1 mark), giving an unwanted increase in volume at this frequency. (1 mark)

2 marks

Question 10

Explain the operation of an Electret-Condenser microphone.

Worked solution and mark allocation

- The sound pressure changes the spacing between a thin metallic membrane and the stationary back plate. (1 mark)
- This causes a change in capacitance, which produces a current. (1 mark)

2 marks

Tip

- ***Include*** *a table with an explanation of different microphone types on your A4 sheet.*

The following information applies to Question 11.

Grant Spatchcock, of Spatchcock Pizzas, is complaining about the phone ringing. He says it is very loud and is of a very annoying pitch. Gerard says that pitch and frequency are the same thing, and nothing can be done.

Question 11

With reference to pitch and frequency, explain why Grant is irritated with the pitch of the phone, but no one else is.

Worked solution and mark allocation

- Pitch is a subjective attribute, and is different for everybody. (1 mark)
- Frequency is an objective measure, which is the same for everybody. (1 mark)

2 marks

END OF SOLUTIONS