

Physics 2
0780

GENERAL CERTIFICATE OF EDUCATION BOARD
General Certificate of Education Examination

JUNE 2024

ADVANCED LEVEL

Subject Title	Physics
Subject Code	0780
Paper No.	Paper 2

Duration: Three Hours

Answer ALL questions

Section I is designed to be answered in 1 hour, Section II in 30 minutes and Section III in 1 hour.

You are advised to divide your time accordingly.

You are reminded of the necessity for good English and orderly presentation in your answers.

In calculations you must show all the steps in your working, giving your answer at each stage.

Calculators and formulae booklet are allowed.

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SECTION I Answer all Questions

(One hour)

1. Figure 1 shows a current-carrying solenoid wound on a steel rod.

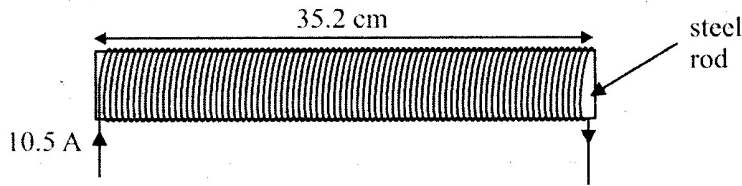


Figure 1

From Biot-Savart law, it can be shown that the size of the magnetic flux density (B) inside the solenoid is given by

$$B = \mu n I$$

Where μ is the permeability of the medium, n is the number of turns of coil per unit length and I is the current in the solenoid.

- Draw a diagram to show the magnetic flux pattern of the solenoid in figure 1.
- using only units show that the above equation is homogenous
- If steel has a relative permeability of 2000 and the above solenoid has 250 turns, determine the magnetic field strength inside the solenoid.

(6 marks)

2. Copper has about 8.49×10^{28} charge carriers per unit volume and a resistivity of $1.68 \times 10^{-8} \Omega \text{ m}$. In figure 2, a copper cable with a cross-sectional area of 0.27 mm^2 is connected in series with a battery. The connecting cables have negligible resistance.

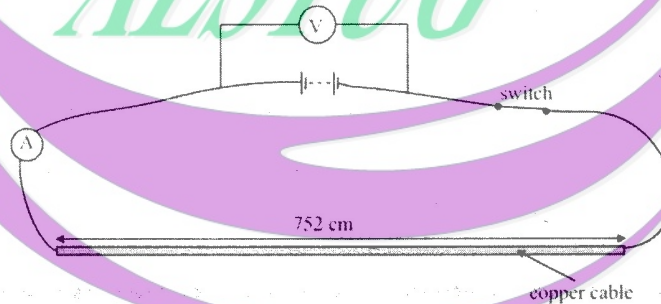


Figure 2

- If the ammeter reading is 6.04 A, determine;
 - the drift velocity of charge carriers through the copper wire
 - the reading of the voltmeter
- Explain why the reading of the voltmeter increases when the switch is opened.

(6 marks)

3. Figure 3 shows a brick wall of thickness, x and surface area, A . The heat entering the inner wall is Q_1 at temperature T_1 and that leaving the outer wall is Q_2 at temperature T_2 .

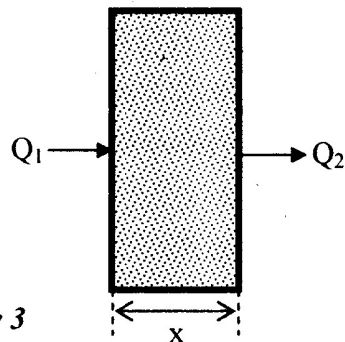


Figure 3



- (a) State two conditions for the heat conduction through the wall above to reach a steady state.
 (b) Define temperature gradient and write an expression for it for the wall above.
 (c) If the wall is 12.0 cm thick, with a heat flow surface of 0.08 m² and is made of brick of thermal conductivity 0.80 W m⁻¹ K⁻¹.
 i) Determine the thermal resistance of the wall.
 ii) Hence or otherwise, calculate the rate of heat flow through the wall if T₁ is 355 K and T₂ is 330 K.

(6 marks)

4. (a) Define simple harmonic motion.
 (b) Figure 4 shows how the energy (E) of a simple harmonic oscillator varies with displacement (x) from the equilibrium position.

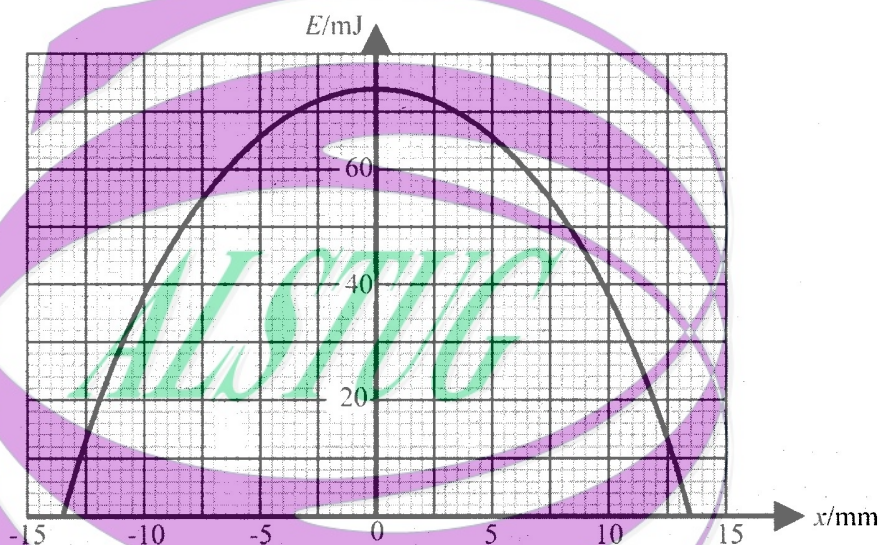


Figure 4

- i) State, with a reason, whether E represents the total mechanical energy, the kinetic energy or the potential energy of the oscillator.
 ii) If the oscillator has a mass of 30.0 g, use the graph to determine its frequency of oscillation.

(6 marks)

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5. According to kinetic theory, the pressure of an ideal gas is given by the equation:

$$P = \frac{1}{3} \rho \overline{c^2}$$

Where P is the pressure of the gas, ρ is its density and $\overline{c^2}$ is the mean-square speed of the molecules.

- (a) State TWO assumptions used to derive this equation.
 (b) Use the above equation to show that $\overline{c^2}$ is related to the absolute temperature of the gas by;

$$\overline{c^2} = \frac{3RT}{M}$$

Where R is the molar gas constant, T is the absolute temperature of the gas and M is the molar mass of the gas.

- (c) The root-mean-square (rms) speed of a certain gas is 850 m s⁻¹ at a room temperature of 30.0 °C. Determine the root-mean-square speed of the molecules if the gas is heated to a temperature of 150 °C.

(6 marks)



Turn Over

Answer EITHER 6 (a), (b) and (c) OR 6 (d), (e) and (f).

EITHER 6 (a), (b) and (c)

6. (a) Figure 5 shows a set-up used to determine the specific heat capacity of a liquid.

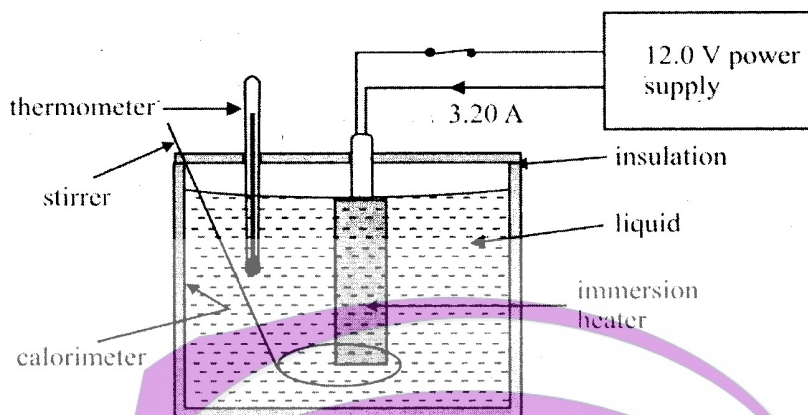


Figure 5

The calorimeter has a mass of 200 g and a specific heat capacity of $385 \text{ J kg}^{-1} \text{ K}^{-1}$.

- Explain why the liquid is stirred during the experiment and why the calorimeter is insulated.
 - After heating for 180 s, the temperature of the liquid increases from 20.5°C to 37.7°C . If the mass of the liquid in the calorimeter is 280 g, determine the specific heat capacity of the liquid.
 - The length of the liquid column in the above thermometer is 3.0 cm at 0°C and 36.0 cm at 100°C . What will be the length of the liquid column when temperature rises to 70.5°C ?
- (8 marks)
- (b) Differentiate between the following classes of waves giving one example in each class.
- Transverse and longitudinal waves.
 - Mechanical and electromagnetic waves.
- (6 marks)
- (c) Figure 6 below shows two light beams A and B of wavelength 450 nm travelling in air and incident on a composite crystal of thickness $20 \mu\text{m}$. The refractive index of X is 1.40 and that of Y is 1.45.

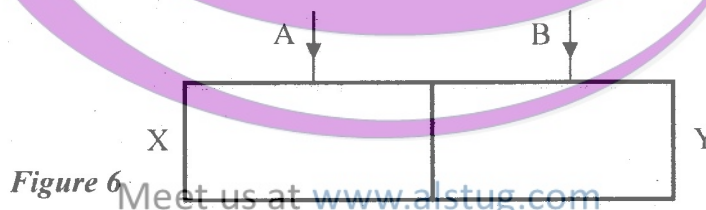


Figure 6

- Determine which beam will first emerge from the crystal.
 - If A and B are in phase as they enter the crystal, calculate their phase difference as they leave the crystal.
- (6 marks)
- (Total = 20 marks)

OR 6 (d), (e) and (f).

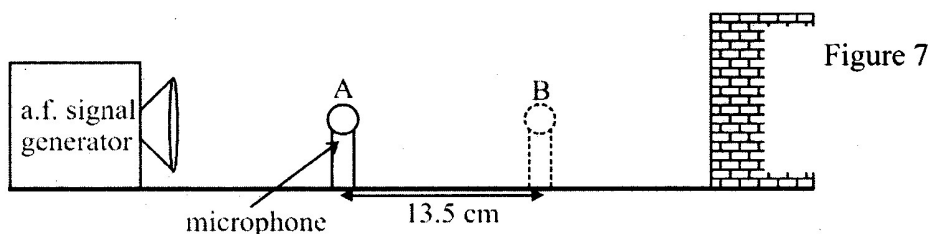
6. (d) Figure 7 shows a set-up used by an upper sixth student to measure the speed of sound in air. The audio frequency generator is placed some distance away from the wall and the microphone is placed between them.

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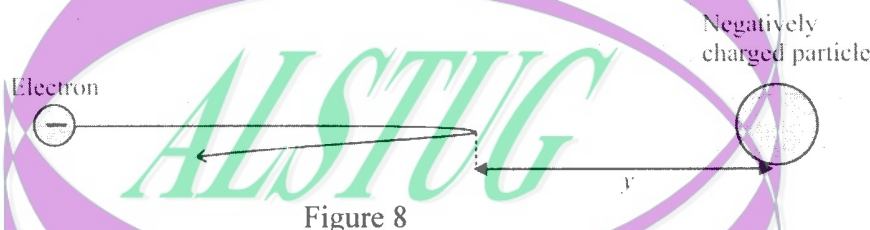
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- Explain why alternate loud and soft sounds are heard when the microphone is moved between the a.f. signal generator and the wall.
- At position A, the sound is loudest. The microphone is then moved away from A until the softest sound is heard at B. If the sound from the generator has a frequency of 610 Hz, determine the speed of sound in air.
- A motorist riding towards the a.f. signal generator observes that the frequency of sound from the generator is 640 Hz. Use your answer in d)(ii) above to estimate the speed of the motorist.

(7 marks)

- The light from a filter has a wavelength of 560 nm
 - What is the energy, in joules, of each photon of the above light?
 - Determine the maximum kinetic energy of the electrons that will be emitted if this light falls on a metal surface with a work function of 1.32 eV.
 - Figure 8 shows what happens to one of the electrons with the maximum kinetic energy as it approaches a negatively charged particle with a charge of 3.0×10^{-16} C.



Determine the distance of closest approach, y .

(8 marks)

- Figure 9(a) shows a simple a.c. circuit containing a resistor and an inductor while figure 9(b) shows how the a.c. voltage in the circuit varies with time.

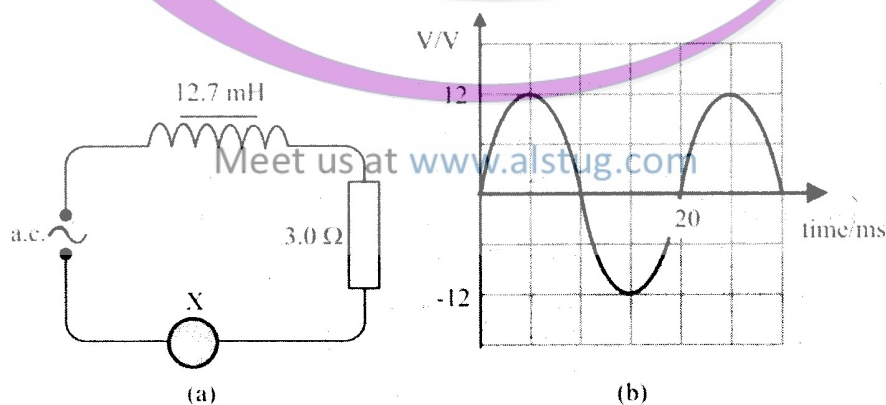


Figure 9

X in the circuit is an appliance that gets destroyed when the peak current through it is above 4.2 A.

- Write down the peak voltage and the frequency of the above a.c.
- Show that the total impedance in the circuit is 5.0 Ω.
- Determine, by calculation, whether X will be destroyed.

(5 marks)

(Total = 20 marks)



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SECTION II (30 minutes)

DATA ANALYSIS

7. When electromagnetic radiation of sufficiently high frequency falls on a clean metal surface, electrons are emitted from it. Even the most energetic electron is prevented from leaving the metal surface when a stopping potential, V is applied to the metal. The frequency of the incident radiation and the stopping potential of the metal are related by the equation

$$hf - hf_0 - eV = 0$$

where e is electronic charge, h and f_0 are constants.

In one such experiment to verify the relationship between the frequency of incident radiation and the stopping potential of a clean zinc plate, the following data was obtained.

V/V	$f \times 10^{14}$ Hz
1.30	6.0
2.95	10.0
4.17	14.0
6.25	19.0
8.33	24.0
10.40	30.0
12.45	35.0
14.53	41.0

- (a) Plot a suitable graph from which h and f_0 can be calculated.
 (b) Hence calculate h and f_0 .
 (c) i) What is the physical significance of f_0
 ii) Calculate the work function of zinc

(9 marks)

(8 marks)

(3 marks)

(Total = 20 marks)

SECTION III (1 hour)

OPTIONS

Answer any two questions from the four options

OPTION 1: ENERGY RESOURCES AND ENVIRONMENTAL PHYSICS

8. (a) Figure 10 shows a photovoltaic plate with a power output of 30 mW cm^{-2} and an efficiency of 40%.

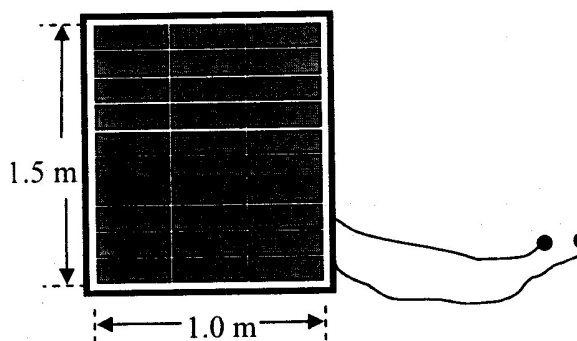


Figure 10



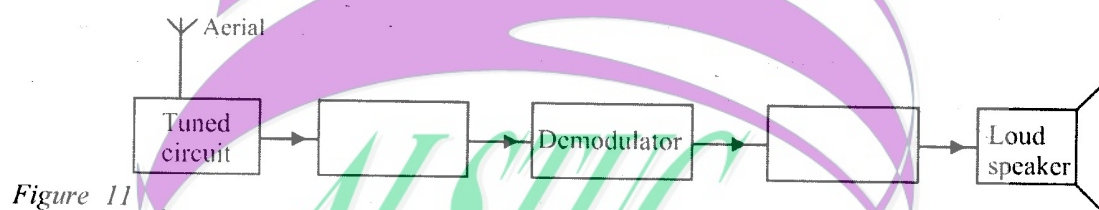
Determine;

- i) the amount of solar energy falling on it per unit time.
- ii) how many such plates can supply energy directly to a 3 horse power electric pump switched on for 20 minutes if the intensity of solar radiation is assumed constant within this time and $1\text{hp} = 800\text{ W}$. (6 marks)
- (b) Explain why solar energy is referred to as being
 - i) environmentally friendly
 - ii) functional
 - iii) renewable (3 marks)
- (c) i) What is climate change?
- ii) Name two climate change-related disasters
- iii) State two human activities that lead to climate change. (6 marks)

(Total = 15 marks)

OPTION 2: COMMUNICATION.

9. (a) Figure 11 shows the block diagram of an amplitude modulation (AM) radio receiver.



- i) Explain the meaning of the underlined phrase.
- ii) Copy and complete the above block diagram.
- iii) State the functions of the tuned circuit and the demodulator. (6 marks)
- (b) i) Why is the mobile phone referred to as a transceiver?
- ii) Bring out two differences between mobile telephone handset and a commercial radio transmitter like that of CRTV with respect to telecommunication.
- iii) State one environmental problem which is related to the use of mobile phones. (4 marks)
- (c) Signals transmitted through optical fibres suffer less attenuation than those transmitted through copper cables. Signal attenuation, measured in decibels (dB), is given by:

$$\text{Attenuation} = 10 \log \left(\frac{P_{\text{in}}}{P_{\text{out}}} \right)$$

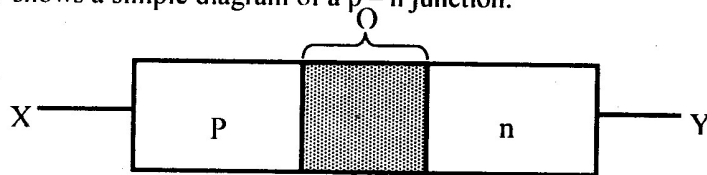
- i) State two other advantages optical fibres have over copper cables in telecommunication.
- ii) A typical multimode optical fibre has an attenuation per unit length of 0.90 dB/km. What will be the power of a 4.0 mW signal over a distance of 12 km?

(5 marks)

(Total = 15 marks)

OPTION 3: ELECTRONICS

10. (a) Figure 12 below shows a simple diagram of a p-n junction.



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- i) Name the section labelled Q and explain why it is called that way.
- ii) How can the terminals of battery be connected in figure 12 to produce a forward bias? (5 marks)

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- (b) The family of curves in *figure 13* shows the output characteristics of a transistor.

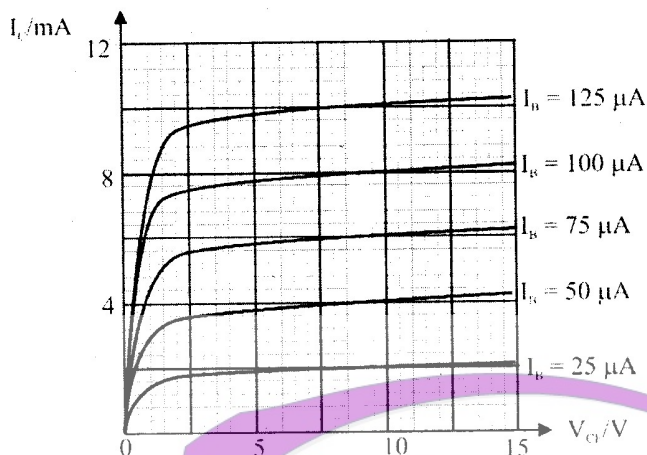


Figure 13

- Comment on the dependence of I_C on V_{CE} .
 - Construct a table of values that can be used to determine the transfer characteristics of the above transistor at a constant V_{CE} of 7.5 V.
 - Use the table in b)(ii) above to draw a graph and from it, determine the d.c. transfer ratio of the transistor
- (7 marks)
- What is a p-n junction?
 - Explain how a depletion layer is formed in the p-n junction.
- (3 marks)

(Total = 15 marks)

OPTION 4: MEDICAL PHYSICS

11. (a)

Figure 14 shows how light is focused into a defective eye.

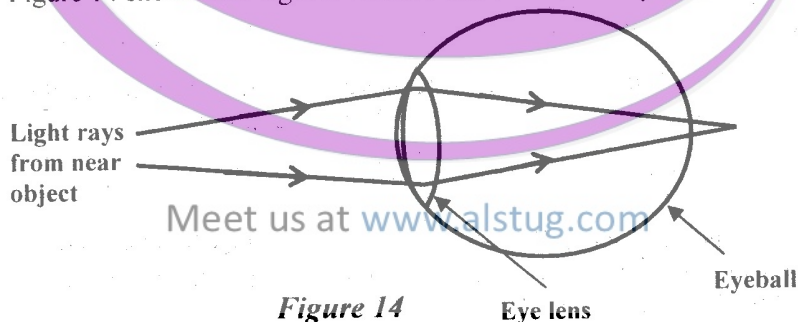


Figure 14

- Name the eye defect experienced by the person.
 - State its possible causes and using a diagram, show how it can be remedied.
 - If the near point of the eye is 2.0 m, determine the power of the lens that will enable it focus clearly a wall chart placed 1.5 m from the eye.
- (9 marks)
- (b) X-rays and ultrasound imaging are two imaging techniques used in internal organ diagnosis. State and explain which of the above techniques is usually used to;
- detect a broken bone
 - examine the growth of a foetus.
- (4 marks)
- (c) What is the full meaning of ECG?
- (2 marks)

(Total = 15 marks)



STOP

GO BACK AND CHECK YOUR WORK

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