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ZIMSEC
For Performance Measurement

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

PHYSICS 9188/3

PAPER 3

NOVEMBER 2007 SESSION 2 hours 30 minutes

Additional materials:
- Answer paper
- Electronic Calculator and / or Mathematical tables
- Ruler (mm)

TIME 2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer paper/answer booklet.

Answer **five** questions.

Answer **two** questions from Section A and **three** questions from Section B.

Write your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
All working for numerical answers must be shown.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You are reminded of the need for good English and clear presentation in your answers.

Candidates are advised to spend 1 hour on Section A and 1 hour 30 minutes On Section **B**.

This question paper consists of 9 printed pages and 3 blank pages.

[Turn over

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
gravitational potential,	$\phi = -\frac{Gm}{r}$
refractive index,	$n = \frac{1}{\sin C}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
energy of charged capacitor,	$W = \frac{1}{2}QV$
alternating current/voltage,	$x = x_0 \sin \omega t$
hydrostatic pressure,	$p = \rho g h$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = \frac{3H_0^2}{8\pi G}$
equation of continuity,	$Av = \text{constant}$
Bernoulli equation (simplified),	$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$
Stokes' law,	$F = Ar\eta v$
Reynolds' number,	$R_e = \frac{\rho v r}{\eta}$
drag force in turbulent flow,	$F = Br^2 \rho v^2$

[Turn over

Section A

*Answer any **two** questions from this section.*

1 (a) (i) Distinguish between *scalar* and *vector* quantities.

(ii) Give an example of each. [4]

(b) The resonance frequency, *f*, of a monometer wire is given by the equation

$$f = \frac{1}{2L}\sqrt{\left(\frac{4T}{\pi d^2 \rho}\right)} \quad \text{where}$$

T is the tension in the wire, L is the length of the wire, ρ is the density of the wire and d is the diameter of the wire.

(i) Use base units to show that the equation is homogeneous.

(ii) A wire of length (85.60 ± 0.01) cm, diameter (1.00 ± 0.01) mm and a constant density of 8800 kgm^{-3} resonates when the tension in the wire is (52.00 ± 0.05) N.

1. Calculate the resonance frequency.

2. Calculate the uncertainty in the frequency.

3. Give your value for the frequency with its uncertainty quoted. [8]

(c) (i) Distinguish between *systematic* and *random* errors.

(ii) Give **two** examples of systematic errors and explain how each can be avoided.

(iii) Discuss **two** ways in which random errors can be minimized. [8]

2 (a) Define *simple harmonic motion.* [2]

(b) Oscillation of a simple pendulum can be considered to be simple harmonic.

State and explain a condition that should be satisfied for the motion to be simple harmonic. [2]

(c) For the simple pendulum, explain the relationship between the direction of

(i) velocity and accelaration,

(ii) force and the direction of acceleration. [4]

(d) A simple pendulum of length 0.80 m has an amplitude of 5.0 cm. The mass of the bulb is 40.0 g. Given that the period, T of oscillation is given by,

$$T = 2\pi\sqrt{l/g},$$

where l is the length of the pendulum, calculate

(i) the kinetic energy of the bob,

(ii) its potential energy at a displacement of 3.2 cm. [5]

(e) Explain why the pendulum finally comes to rest. [3]

(f) Suggest why in the formation of stationary waves in strings only particular values of frequency will result in loops being formed. [4]

3 (a) State the *Laws of refraction*. [2]

(b) When light passes from glass into air, it bends away from the normal.

(i) Explain using ray diagrams how this fact leads to total internal reflection.

(ii) Describe the use of total internal reflection in fibre optics.

(iii) Give **one** advantage of fibre optics in communication. [7]

(c) (i) Distinguish between *transverse* and *longitudinal* waves and give an example of each.

(ii) Explain what is meant by the term diffraction as applied to wave motion.

(iii) Calculate the wavelength associated with a sprinter of mass 60.0 kg who runs through an open door at a velocity of 10.0 ms^{-1}.

(iv) Explain why no diffraction pattern is observed in **(c)(iii)**. [10]

(d) State **one** phenomenon which is associated with transverse waves only. [1]

Section B

*Answer any **three** questions from this section.*

4 (a) Define *potential difference* and *the volt.* [2]

(b) A voltmeter was connected to measure the potential difference across the 10.0 kΩ resistor as in **Fig. 4.1**. The potential difference was found to be 3.1 V.

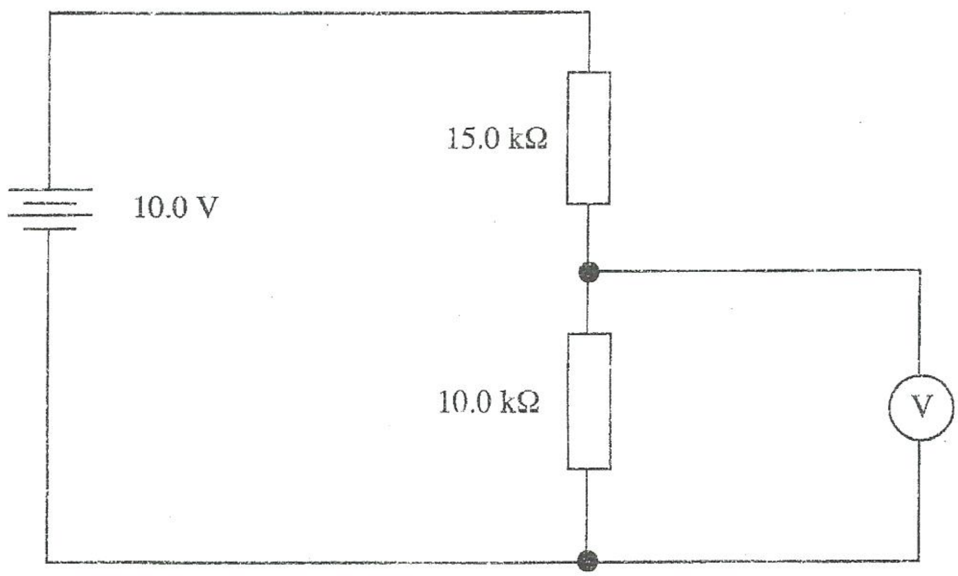

Fig. 4.1

(i) Calculate the potential difference across the 10.0 kΩ resistor before the voltmeter is connected.

(ii) Compare and comment on the two values of the potential difference.

(iii) Calculate the resistance of the voltmeter. [7]

(c) An operational amplifier is added to the circuit in **(b)** as shown in **Fig. 4.2**.

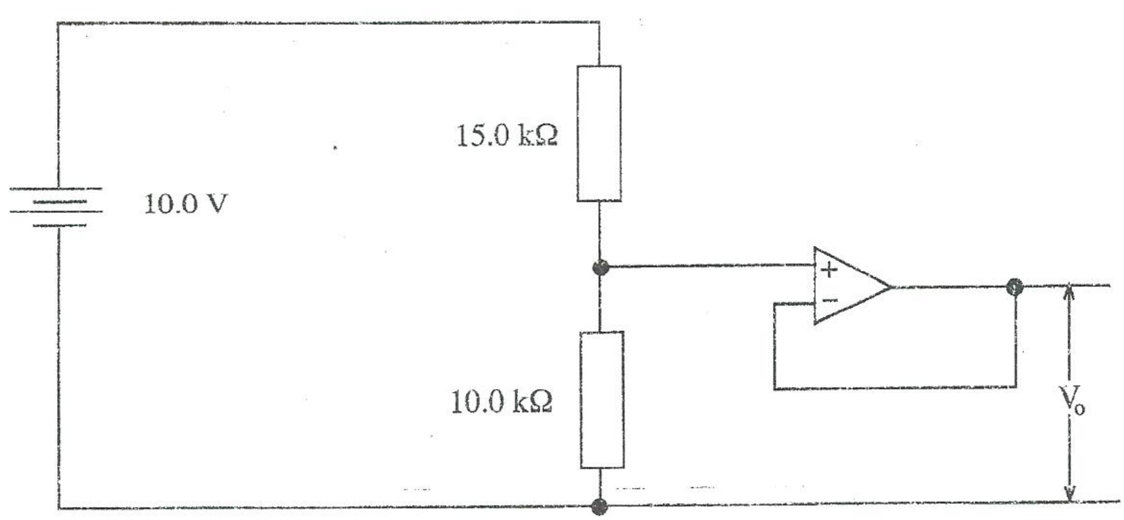

Fig. 4.2

(i) Predict the output voltage.

(ii) Suggest an explanation for your prediction. [5]

(d) The circuit of **Fig. 4.2** is modified so that it can act as a burglar alarm operated by a light. The light switches on when either a window or door is opened. The output of the circuit is a buzzer.

(i) Draw circuit diagrams that will be used for the burglar alarm.

(ii) Explain how the circuit diagram works. [6]

5 **(a)** Define *magnetic flux* and the *weber*. [2]

(b) **Fig. 5.1** shows a square coil of sides 50.0 cm moving at a steady speed of 0.25 ms^{-1} through a **uniform** vertical magnetic field of flux density 0.050 T.

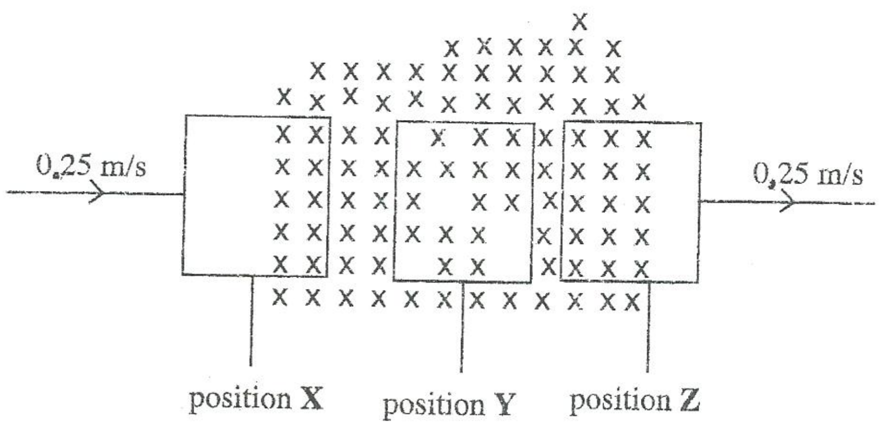

Fig. 5.1

(i) Calculate the magnetic flux linking the coil when the coil is at position **Y**.

(ii) Sketch graphs to show

1 how the magnetic flux through the coil varies with time,

2 how the induced e.m.f. in the coil varies with time as the coil moves from **X** to **Z**.

(iii) Calculate the induced current when the coil has moved into the field for 1.0 s given that the coil has a resistance of 5 Ω. [10]

(c) Describe how a Hall probe can be used to measure flux density. [6]

(d) A resistor of 6.0 Ω is connected to a secondary coil of a transformer with 1 200 turns. The primary coil of 2 400 turns is connected to a 240 V ac supply. Calculate the current through the 6.0 Ω resistor. [2]

[Turn over

6 (a) (i) State any **three** assumptions made in the kinetic theory of gases.

(ii) Suggest why oxygen enclosed in a gas cylinder at room temperature is assumed to behave ideally. [5]

(b) (i) The ideal gas equation can be expressed in the form

$$PV = \frac{1}{3} Nm < c^2 >.$$

State the meaning of each symbol in the equation.

(ii) A 0.15 m^3 container has 3.1 moles of oxygen. The root mean square speed of the molecules is 455 m/s. Calculate the pressure exerted on the walls by the gas. Mass of an oxygen molecule is 32u. [6]

(c) (i) Define *specific latent heat of vaporisation.*

(ii) Explain why one feels cold when methylated spirit evaporates from the back of the hand.

(iii) In an experiment to find the specific latent heat of vaporisation, l_v, of ethanol by an electrical method, a pupil collected 2.40 g of condensed ethanol in 30.0 s when the current flowing through the electric heater is 6.0 A and the potential difference across it is 12.0 V.

1. Calculate the value of l_v of ethanol from these results.

2. The pupil feels that the value obtained is too high and decides to obtain a more accurate value by repeating the experiment using new current and potential difference values of 5.0 A and 10.0 V. He then collects 1.62 g of condensed ethanol in 30.0 s. Use both sets of results to obtain a new value of l_v.

3. Explain why this value is more accurate. [9]

7 A beam of electrons enters a uniform electric field horizontally at 1.5 cm from the lower plate as in **Fig. 7.1**. The separation of the plates is 7.8 cm. The upper plate is maintained at a potential of 3 400 V with respect to the lower plate. The length of each plate is 20.0 cm. The speed of a particular electron in the beam is 6.7×10^7 m/s.

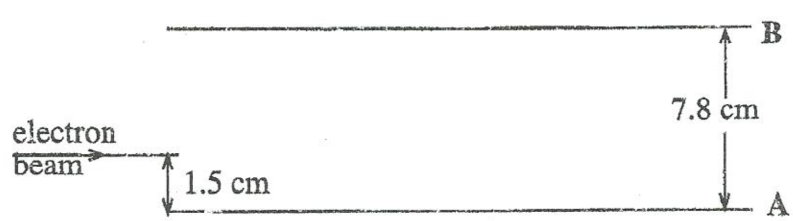

Fig. 7.1

(a) Describe and explain the path taken by the beam in the electric field. [2]

(ii) **(b)** Calculate

(i) the electric field strength between the plates,

(ii) the time in which the electron remains in the field,

(iii) the vertical displacement at which the electron emerges from the field,

(iv) the velocity of the beam on emerging from the field,

(v) the direction of the electron on emerging from the field. [10]

(c) The electrons in the beam are travelling at different velocities.

(i) Describe the changes that should be done to **Fig. 7.1** which will enable electrons travelling at 6.7×10^7 m/s to be selected.

(ii) Suggest how the charge to mass ratio of an electron can be determined. [6]

(d) The beam of electrons is in a gravitational field.

Explain why force due to gravity is not considered in the calculations above. [2]