P510/2
PHYSICS
AUGUST 2004
2 ½ HOURS

ST. HENRY'S COLLEGE KITOVU
S.6 MOCK EXAMINATIONS 2004
PHYSICS
PAPER TWO
2 HOURS 30 MINUTES

INSTRUCTIONS:

Attempt **five** questions, including at least **one**, but not more than **two** from each of the sections A, B and C.

Assume where necessary:

Speed of light in a vacuum, c	=	3.0×10^{8} ms^{-1}
Election charge, e	=	1.6×10^{-19}C
Permeability of free space, μ_0	=	$4\pi \times 10^{-7}$ Hm^{-1}
Permittivity of free space, ε	=	8.85×10^{-12} Fm^{-1}
The constant $\frac{1}{4\pi\varepsilon_0}$	=	9.0×10^{9} F^{-1} m.

SHACK PHYSICS DEPARTMENT 2004

SECTION A

1. (a) Describe an experiment you can carry out to verify the laws of reflection of light.
(4 marks)

(b) A finite object is placed perpendicularly to the principal axis of a concave mirror of focal length **f,** at a distance, **u**, from the mirror. An upright image of the object is formed at a distance, **v**, from the mirror.

(i) Draw a ray diagram to show the formation of the image. (2 marks)

(ii) Use the ray diagram in (i) above to show that $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ (4 marks)

(c) Draw a ray diagram to show the essential features of a projection lantern. State the functions of each of the labelled features. (5 marks)

(d) A projection lantern has an objective lens of focal length 20 cm. It is required to project clear images on the screen for distances between the slide and the screen ranging from 8m to 14 m.

(i) Calculate the displacement of the lens that would be required to achieve proper focussing between the two extremes. (4 marks)

(ii) Determine the ratio of the magnifications at the two extremes. (1 mark)

2. (a) Explain with the aid of ray diagrams:

(i) principal focus. (1 mark)
(ii) conjugate points. (2 marks)

(b) Show that the focal length **f** of a thin convex lens in air as given by:

$$\frac{1}{\mathbf{f}} = (\mathbf{n} - 1)\left(\frac{1}{\mathbf{r_1}} + \frac{1}{\mathbf{r_2}}\right)$$

where **n** is the refractive index of the material of the lens, $\mathbf{r_1}$ and $\mathbf{r_2}$ the radii of curvature of the surfaces of the lens. (5 marks)

(c) A thin biconvex lens is placed on a plane mirror. A pin is clamped horizontally above the lens so that its apex lies on the principal axis of the lens. The position of the pin is adjusted until the pin coincides with its image at a distance of 15 cm from the mirror. When a thin layer of water of refractive index 1.33 is placed between the lens and the mirror, the pin coincides with its image at a point 22.5 cm from the mirror.

When the water is replaced by paraffin, the pin coincides with its image at a distance of 27.5 cm from the mirror.

Calculate the refractive index of paraffin. (6 marks)

(d) An equilateral prism of refractive index 1.50 is placed in water of refractive index 1.33.

(i) Calculate the angle of minimum deviation for light refracted through the prism.

(ii) The prism is now placed in air.

Find the angle of incidence of a ray in air when the angle of deviation is a maximum.

Find also the greatest angle of the prism for light to be refracted through the prism. (5 marks)

(e) State why a prism is preferred to a plane mirror when used as a reflector. (1)

3. (a) State the conditions necessary for "beats" to be heard and deduce an expression for the beat frequency. (5 marks)

(b) The velocity **v**, of propagation of transverse waves along a wire under tension **T** is given by:

$$\mathbf{v} = \sqrt{\left(\frac{\mathbf{T}}{\mathbf{m}}\right)}$$

where **m** is the mass per unit length of the wire. Verify that this expression is dimensionally correct. (3 marks)

(c) Beats are produced by a plucked stretched wire, and a resonance tube closed at one end, each sounding its fundamental note.

The air column has a length of 0.168 m, the end correction for the tube being 0.012 m.
The wire has a vibrating length of 0.270 m and under tension of 100N; the mass of this portion of the wire is 4.0×10^{-4} kg.

(i) Calculate the frequency of the beats heard if the velocity of sound in the air column is 350 ms^{-1}. (5 marks)

(ii) Calculate the change in tension of the wire that would make the frequencies of the two notes the same. (2 marks)

(iii) Explain qualitatively the observable changes in the results of (c) (i) if the temperature is slightly increased. (5 marks)

4. (a) (i) With the aid of a labelled diagram, explain the formation of interference fringes in a Young's double-slit experiment. (5 marks)

(ii) In a Young's double-slit experiment, the distance between the slits is 1.5×10^{-3} m. The screen is placed a distance 2.5m from the slits. When the slits are illuminated by monochromatic light, the distance between the central and the fifth bright fringes formed on the screen is 6.0×10^{-3} m. Calculate the wavelength of the monochromatic light. (4 marks)

(b) State the effect of:

(i) closing one of the slits;
(ii) reducing the slit separation;
(iii) reducing the distance between the source and the slits

on a Young's double-slit interference pattern. (3 marks)

(c) Monochromatic light falls normally on a diffraction grating with 500 lines per millimetre. The angle between the directions of the first and second order maxima is 12^0.

(i) Calculate the angle at which the first order maximum is observed and hence determine the wavelength of the monochromatic light. (6 marks)

(ii) Determine the maximum number of diffraction order that can be observed using this grating. (2 marks)

SECTION B

5. (a) (i) Describe the main features of a ballistic galvanometer. (4 marks)

(ii) State the factors which affect the sensitivity of a ballistic galvanometer.(2)

(b) The coil of a galvanometer has a resistance of 15Ω at 25^0C. If the temperature coefficient of resistance of the coil is 5.2×10^{-3} K^{-1} and the temperature of the coil rises to 50^0C, calculate

(i) the voltage across the coil for a full scale deflection of 150μA at 25^0C (2 marks)

(ii) the percentage error in the reading of the current. (6 marks)

(c) Explain the following observations:

(i) When a d.c. motor is switched on, the initial current decreases to a steady value when the motor is running at a constant speed.(2 marks)

(ii) If the motion of a d.c. is slowed down, the current rises and the falls again when the motor is allowed to run freely. (2 marks)

(iii) A car battery delivers less current to a starter motor on a cold day than on a hot day. (2 marks)

6. (a) (i) State Lenz's law of electromagnetic induction. (1 mark)

(ii) Show that the law can be deduced from the principle of conservation of energy. (3 marks)

(b) With the aid of a labelled diagram, describe a high voltage d.c. may be obtained from a low voltage d.c. (6 marks)

(c) (i) A vertical circular copper disc of radius 12.0 cm is rotated at a steady speed of 300 revolution per minute about a horizontal axis through its centre. If the disc is situated between a horizontal magnetic field of $0.2Wbm^{-2}$ perpendicular to its plane, calculate the induced e.m.f. between the axis and the rim of the disc. (4 marks)

(ii) Draw a diagram showing the direction of the induced e.m.f. in (c) (i) above. (1 mark)

(d) (i) Explain how eddy currents are produced. (2 marks)

(ii) Explain briefly one application of eddy currents. (3 marks)

7. (a) Describe briefly the action of a transformer. (4 marks)

(b) An ideal transformer with a variable resistor in the primary circuit and a bulb in the secondary circuit, is connected to a sinusoidal a.c. supply. The primary has 200 turns and the secondary 5 turns. A current of peak value 14.1mA flows in the primary circuit.

(i) Explain one method by which the brightness of the bulb can be reduced. (1 mark)

(ii) Calculate current in the secondary circuit. (3 marks)

(iii) When a 1-kΩ resistor is connected across the bulb, the voltage across the parallel combination is found to be 10V.

Find the resistance of the bulb. (2 marks)

(c) Why is a.c. easier and more economical to transmit over long distance than d.c.? (2 marks)

(d) A sinusoidally alternating voltage of peak value 20V and frequency 50Hz is applied across a coil of a wire of inductance 0.2H and negligible resistance.

(i) Calculate the r.m.s. value of the current which passes through the coil. (3 marks)

(ii) Using the same axes, sketch graphs to show the variation with time of the applied voltage; the current which flows and the power delivered to the inductor. (3 marks)

(iii) Explain why on the average, the power delivered to the inductor is zero. (2 marks)

SECTION C

8. (a) Distinguish between e.m.f. and terminal p.d. of a battery. (2 marks)

(b) (i) Prove that a cell generates maximum power in an external resistance when the value of the external resistance is equal to its internal resistance. (4marks)

(ii) The terminals p.d. of a battery joined to a 5-Ω resistor is 2.0V. The terminal p.d. of the same battery increases to 2.8V when a 9-Ω resistor is joined in series with a 5-Ω resistor. Calculate the maximum power which the battery is capable of generating in an external resistor. (6 marks)

(c) (i) Write down the expression for the thermal power dissipated when a steady current of I amperes is maintained in a resistor of resistance RΩ. (1 mark)

(ii) A fuse wire has length l and radius r. The wire melts when the current through it exceeds 5.0A. The wire is replaced by another of the same material and length but of radius $2r$. Find the current beyond which the second wire will melt. Assume the rate of heat loss to the surrounding is proportional to the surface area. (4 marks)

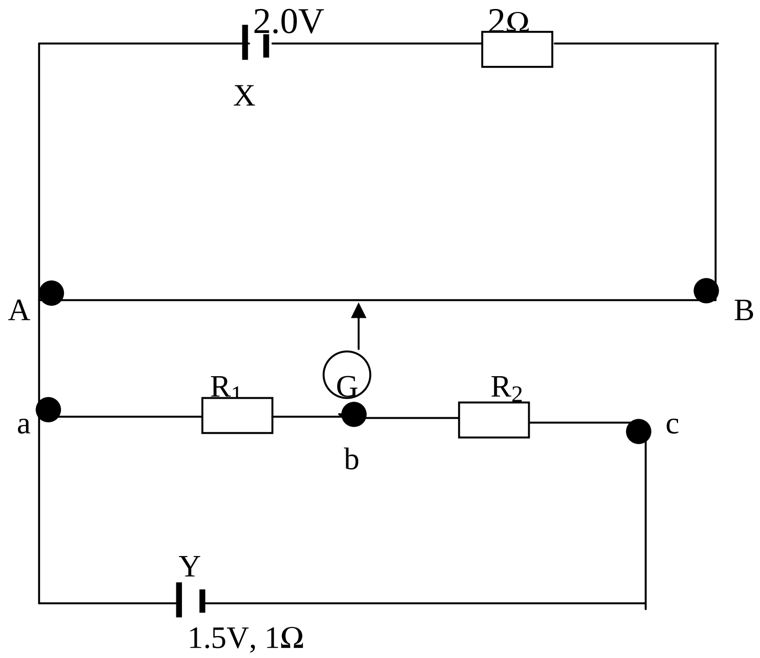
(d) Explain why a wire becomes hot when current flows through it. (3 marks)

9. (a) Explain the principle of the slide wire potentiometer. (4 marks)

(b) Using labelled circuit diagrams, describe how an ammeter is calibrated using a slide wire potentiometer. (8 marks)

(c) In the figure below, X is an accumulator of e.m.f. 2.0V and of negligible internal resistance, connected in series with 2.0Ω resistor and a wire AB of length 1.0m and resistance 8.0Ω.

A dry cell Y, of e.m.f. 1.5V and internal resistance 1.0Ω is connected in series with two resistors R_1 and R_2



The galvanometer G shows no deflection when connected respectively from points b and c to points on AB 50.0 cm and 75.0 cm from end A of the wire.

Find:

(i) the current flowing through R_1. (4 marks)

(ii) the resistances of R_1. and R_2. (4 marks)

10. (a) What is meant by dielectric constant? (1 mark)

(b) A parallel plate capacitor is charged to 100V and then isolated. When a sheet of a dielectric is inserted between its plates, the p.d. decreases top 30V.

(i) Explain why there is a decrease in p.d. across the plates. (4 marks)

(ii) Calculate the dielectric constant of the dielectric. (3 marks)

(c) A 60μF capacitor is charged to 100V supply. It is then connected across the terminals of 15μF uncharged capacitor.

Calculate:

(i) the final p.d. across the combination. (3 marks)

(ii) the difference in the initial and final energies stored in the capacitors. (3 marks)

(iii) Comment on the difference in energies in (c) (ii) above. (1 marks)

(d) Explain the action of a lightning conductor. (5 marks)

E N D