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**END-OF-YEAR EXAMINATIONS**

**November 2013**

**S5 PHYSICS**

**Paper 2**

*2 hours 30 minutes*

**INSTRUCTIONS TO CANDIDATES**

*Attempt* ***FIVE*** *questions only*

*Assume where necessary:*

*Acceleration due to gravity, g = 9.81 ms-2*

*Speed of light in vacuum, c = 3.0 x 108 ms-1*

*Electron charge, e = 1.6 x 10-19 C*

*Electron mass, me = 9.11 x 10-31 kg*

*Permeability of free space, µ0 = 4.0 π x 10-7 Hm-1*

*Permittivity of free space, ε0 = 8.85 x 10-12 Fm-1*

Fill the table below to indicate the questions you have attempted, in the order you answered them.

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| --- | --- | --- | --- | --- | --- | --- |
| Question |  |  |  |  |  | Total |
| Marks scored |  |  |  |  |  |  |

1. (a) What is meant by

(i) ***principal focus*** of a concave lens. (1)

(ii) ***conjugate points*** with respect to a lens. (1)

(b) Two thin lenses of respective focal lengths f1 and f2 are arranged coaxially in contact. Derive an expression for the focal length of the combination. (5)

(c) Describe an experiment to determine the focal length of a concave lens using a convex lens. (6)

(d) (i) Write down an expression relating the focal length of a lens to the refractive index of its material and the radii of curvature of its surfaces. (1)

(ii) In an experiment to determine the refractive index of a liquid L, a little of liquid L was poured on a horizontal plane mirror facing up and a lens was placed on top. A pin viewed from above coincided with its own image at a height of 27.5 cm above the mirror.

When the procedure was repeated after replacing L with water of refractive index 1.34 the pin’s coincided with its image occurred at a height of 24.6 cm. Finally, when only the lens was on the mirror, coincidence occurred at a height of 17.0 cm.

Find the refractive index of liquid L. (6)

2. (a) (i) What is meant by ***refractive index*** of a medium? (1)

(ii) Show that when the bottom of a pond is observed from above, the refractive index, n, of the liquid in the pond is given by (5)

(iii) Describe an experiment that employs the principle in (ii) to determine the refractive index of the material of a glass block. (4)

(b) (i) Sketch a ray diagram to illustrate the deviation of a ray by a prism. (1)

(ii) Sketch a graph to show how the deviation varies with the angle of incidence.

(1)

(iii) If a graph in (ii) is obtained for a prism of refracting angle θ, describe how it can be used to determine the refractive index of the material of the prism. (2)

(c) In the figure below a ray of light from air enters prism A, of refracting angle 60o, at an angle of incidence of 30o. The ray emerges into an adjoining prism, B, of refracting angle 50o. It finally emerges out of B at an angle θ, as shown.

A

B

60o

50o

30o

θ

Given that the refractive index of the material of A is 1.51 and that of B is 1.62, determine the emergent angle θ. (6)

3. (a) (i) State the principle employed in the optical lever mirror galvanometer so as to achieve the purpose. (1)

(ii) With the aid of a diagram describe how the instrument in (i) above works (5)

(b) Sketch a ray diagram to show how a concave mirror forms a real

(i) diminished image of a real object (1)

(ii) magnified image of a real object (1)

(c) By referring to a convex spherical mirror, derive the mirror formula. (5)

(d) A concave mirror forms, on a screen, a real image half the linear dimensions of the object. The object and the screen are then shifted until the image is three times the size of the object. If the shift of the object is 25 cm, determine

(i) the focal length of the mirror (5)

(ii) the shift of the screen (2)

4. (a) What is meant by the terms

(i) ***current sensitivity*** of a galvanometer (1)

(ii) ***magnetic moment*** of a coil? (1)

(b) Account for the force on a current-carrying conductor perpendicular to a magnetic field. (3)

(c) (i) Show that the torque on a coil carrying a current, I in a uniform magnetic field of flux density, B, is independent of the shape but dependent on its area, A, number of turns, N and angle α between the normal to the plane of the coil and B. (4)

(ii) Sketch a graph showing the variation of the torque with the angle α. (1)

(d) With the aid of a labelled diagram, describe an experiment to investigate the type of majority charge carriers in a semi-conductor using the Hall effect. (4)

(e) A current of 8.0A is passed along the length of a 2mm x 2mm square cross-sectional wire placed perpendicular to a uniform magnetic field of flux density 1.6 x 10-2 T. Calculate:

(i) the force on each electron. (3)

(ii) the hall voltage between opposite faces (3)

(Take the number of electrons per unit volume of the wire = 1.0 x 1022 m-3)

5. (a) Explain the following

(i) The terminal potential difference in a circuit decreases when the current increases. (3)

(ii) The heating effect of a current is independent of the direction of current. (2)

(b) (i) Derive an expression for the balance conditions of a Wheatstone bridge. (4)

(ii) Describe an experiment to determine the resistivity of the material of a wire.

(6)

(c) In the circuit shown below, the p.d between points A and B is 2.8 V

R A 2 Ω

4 Ω

1 Ω B 4 Ω

4V

2V

3V

Determine the value of the resistance R. (5)

6. (a) (i) What is meant by the ***dielectric strength*** of a substance? (1)

(ii) Using the same axes sketch graphs to show how p.d across a capacitor and charging current vary with time. (2)

(iii) An insulated metal slice is inserted in the space between the plates of an isolated charged capacitor. Explain what happens to the potential difference between the plates.

(2)

(b) Describe an experiment, using a vibrating-reed switch arrangement, to compare capacitances of two capacitors. (5)

(c) Derive an expression for the energy stored in a capacitor of capacitance C charged to potential difference V. (5)

(d) In the figure below calculate the energy stored in the 30μF capacitor. (5)

36V

40 µF

20µF 20µF

10 µF

30 µF

7. (a) (i) What is meant by ***electrostatic induction***? (1)

(ii) State two advantages of charging by induction over charging by contact. (2)

(b) Explain why the leaf divergence of a charged gold-lead electroscope gradually decreases as a neutral conductor approaches the cap of the electroscope. (4)

(c) (i) State Coulomb’s law of electrostatics (1)

(ii) Derive an expression for the electric potential at a point, z metres from a point charge, Q, in a medium of permittivity ε. (5)

(d) In the figure below, Q1, Q2 and Q3 are point charges lying on a straight line AB, where **Q1 = ⁺4.0 μC** and **Q2 = ⁻3.0 μC** and **Q3 = ⁺3.0 μC**.

P

Q1Q3

Q2

10cm

10cm

Find: (i) the electric force acting on Q1 (4)

(ii) the work done in moving a charge of 2μC from infinity to the centre of square.

(3)

***E N D***