UACE PHYSICS PAPER 2014

Instructions to the candidates:

Answer **five** questions taking at least one from each of the sections **A, B, C** and **D**, but not more than one question should be chosen from either section **A** or **B**

Any additional question (s) will not be marked.

Mathematical tables and squared paper will be provided

Non programmable calculators may be used.

Assume where necessary

Acceleration due to gravity, g	$9.81ms^{-2}$
Electron charge, e	$1.6 \times 10^{-19}C$
Electron mass	$9.11 \times 10^{-31}kg$
Plank's constant, h	$6.6 \times 10^{-34}Js$
Speed of light in the vacuum, c	$3.0 \times 108ms^{-1}$
Specific heat capacity of water	$4.200Jkg^{-1}K^{-1}$
Avogadro's number, N_A	$6.02 \times 10^{23}mol^{-1}$
The constant, $\frac{1}{4\pi\varepsilon_0}$	$9.0 \times 10^{9}F^{-1}m$
Permittivity of free space, μ_0	$4.0\pi \times 10^{-7}Hm^{-1}$
Permittivity of free space, ε_0	$8.85 \times 10^{-12}Fm^{-1}$
One electron volt	$1.6 \times 10^{-19}J$
Resistivity of Nichrome wire at 25^0C	$1.2 \times 10^{-6}\Omega m$

SECTION A

1. (a) Distinguish between a real and virtual image (02marks)

(b) Derive an expression relating the focal length, f, of a convex mirror to the object distance, u and image distance, v.

(c) A convex mirror forms an image half the size of the object. The object is then moved towards the mirror until the image is three quarter that of the object. If the image is moved by a distance of 0.6cm, calculate

(i) focal length of the mirror. (03marks)

(ii) new potion of the object (03marks)

(d) (i) What is critical angle? (01mark)

(ii) Explain how mirage is formed (04marks)

(e) State four applications of total internal reflection (02marks)

2. (a) State laws of refraction. (02marks)

(b) (i) The deviation, d, by small angle prism of refractive angle A and refractive index, n, is given by

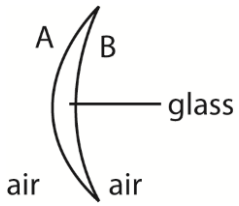
$$d = A(n-1)$$

Use this expression to show that the focal length, f, of a thin converging lens of refractive index, n, is given by

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

where r_1 and r_2 are radii of curvature of the lens surfaces (05marks)

(ii) The figure below is a glass convex lens in air with surfaces A and B having radii of curvature 10cm and 15cm respectively.



If the refractive index of the glass material is 1.50. Calculate the power of the lens. (03marks)

(c) (i) with the aid of a ray diagram, describe the structure and action of a Galilean telescope in normal adjustment. (05marks)

(ii) Derive an expression for angular magnification of the telescope in (c)(i). (03marks)

(d) Explain the disadvantage of a Galilean telescope over refracting type. (02marks)

SECTION B

3. (a) (i) Distinguish between free oscillation and damped oscillation.(02marks)

(ii) What is meant by resonance as applied to sound? (01mark)

(b) Describe an experiment to determine the velocity of sound in air using tuning forks of different frequencies and resonate tube. (05marks)

(c) A uniform tube of 80cm long is filled with water and a small loudspeaker connected to signal generator is held over the open end of the tube. With the signal generator set at 600Hz, the water level in the tube is lowered until resonance is first obtained when the length of air column is 13cm. If the third resonance is obtained when the air column is 69.8cm long; calculate the

(i) Velocity of sound

(ii) Fundamental frequency for the tube is it were open at both ends.

(d) (i) What is meant by Doppler Effect?

(ii) A motor cyclist and police car are approaching each other. The motor cyclist is moving at $10ms^{-1}$ and the police car at $20ms^{-1}$. If the police siren is sounded at 480Hz. Calculate the frequency of the note heard by the cyclist after the police car passes by. (03marks

(iii) Give two applications of the Doppler Effect.

4. (a) Explain the formation of fringes by transmission gratings. (05marks)

(b) Describe how the wavelength of monochromatic light can be measured using a diffraction grating and a spectrometer.(07marks)

(c) Explain why an oil layer on the water surface appears colored on a rainy day.(03marks)

(d) Explain

(ii) What is meant by plane polarized light (02marks)

(iii) One application of polarized light. (03marks)

SECTION C

5. (a) Define the following:

(i) Magnetic flux density (01mark)

(ii) Magnetic flux linkage (01mark)

(b) (i) A rectangular coil of N turns, length, L and breadth, b, carrying a current, I, is placed with its plane making an angle, θ, to a uniform magnetic field of flux density, B. Derive the expression for torque exerted on the coil. (05marks)

(ii) A current of 3.25A flows through a long solenoid of 400 turns and length 40.0cm.

Determine the magnitude of force exerted on a particle of charge 15.0μC moving at $1.0 \times 10^3 ms^{-1}$ through the center of the solenoid at an angle of 11.5^0 relative to the axis of the solenoid. (04marks)

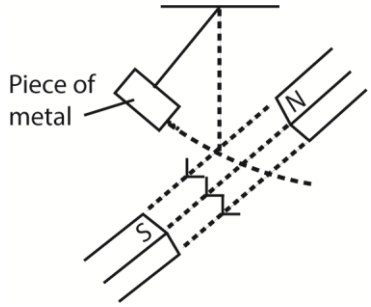
(c) Describe with the aid of a diagram, an absolute method of measuring current. (06marks)

(d) Explain why a current carrying conductor placed in a magnetic field experiences a force. (03marks)

6. (a) (i) State Lenz's law of electromagnetic induction (01mark)

(ii) Describe an experiment to demonstrate Faraday's law of electromagnetic induction. (06marks)

(b) The figure below shows a piece of metal swing in between opposite magnetic poles



Explain what will be observed after some period of time (04marks)

(c) (i) Define the term self-induction and mutual induction. (02marks)

(ii) Describe an experiment which can be used to demonstrate self-induction. (03marks)

(d) A search coil has 40 turns of wire and cross section area of $5cm^2$. The coil is connected to a ballistic galvanometer and then with its plane perpendicular to uniform magnetic field of flux density B.

When the coil is withdrawn from the field, the galvanometer gives a deflection of 240 divisions. When a capacitor of 4μF is charged to 20V and then discharged through the circuit, the galvanometer deflection is 180 divisions. Find the value of B, if the total resistance of the circuit is 20Ω. (04marks).

7. (a) What is meant by the terms reactance and impedance as applied to alternating currents. (02marks)

(b)(i) A source of sinusoidal current of amplitude I_0 and frequency, f, is connected across a pure inductor of inductance, I, Derive an expression for the peak voltage across the inductor. (04marks)

(ii) Sketch using the same time axis, graphs to show variations of the voltage across the inductor and current through it. (02marks)

(c) An alternating current I = 5sin 200πt, flows through a pure inductor of inductance 2.0H. Calculate the

(i) reactance of the inductor. (03marks)

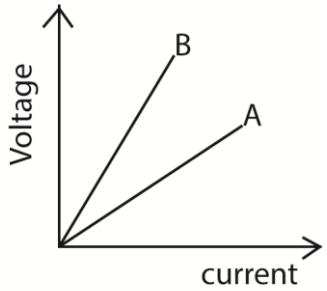
(ii) root mean square value of the voltage across the inductor. (03marks)

(d)(i) Explain how an alternating current can be measured using a rectifier meter (04marks)

(ii) Explain why a moving coil ammeter is unsuitable for measuring alternating current. (02marks)

SECTION D

8. (a)The voltage versus current graphs for two wires A and B of the same material, same radii and at the same temperature are shown in the figure below



Account for the difference between the graphs. (02marks)

(b) Three identical cells are connected in series with resistors of 3Ω and 5Ω. A current of 1.2A flows in the circuit. When the two resistors are connected in parallel across the three cells in series, the current in the circuit is 2.2A. Calculate the

(i) internal resistance of each cell(03marks)

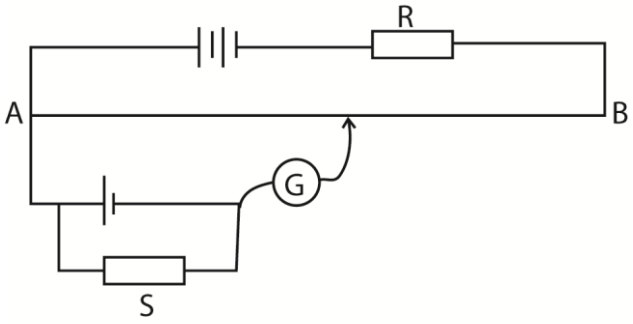
(ii) e.m.f of each cell (1mark)

(iii) power dissipated in the 3Ω resistor for parallel connection (04marks)

(c) Two students X and Y performed separate experiments using a potentiometer arranged as shown below and both obtained a balance point.

X increased the value of R

Y decreased the value of S



Explain what happened to the position of balance point when

(i) X increases the value of R (02marks)

(ii) Y decreases slightly the value of S from an initially large value (02marks)

(d) Describe an experiment to determine the e.m.f of a thermocouple (06marks)

9. (a) Define the following

(i) Capacitance (01mark)

(ii) Dielectric (01mark)

(b) Describe an experiment that can be used to show how capacitance of a capacitor depends on permittivity of dielectric. (04marks)

(c) A capacitor of capacitance C, is fully charged from a 200V battery. It is then discharged through a small coil of wire embedded in thermally insulated block of heat capacity $250KJ^{-1}$. If the temperature rose by 0.4K, Calculate C. (04marks)

(d)(i) State three properties of an equipotential surface. (03marks)

(ii) What is meant by charge quantization? (0marks)

(e) With the aid of a labelled diagram, describe the structure and action of a Van de Graf generator. (06marks)

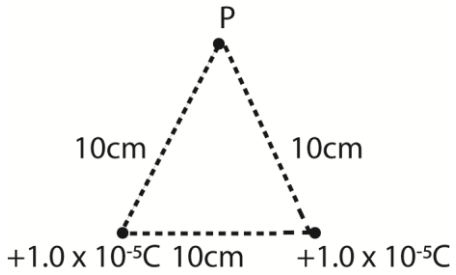
10. (a) (i) State Coulomb's law of electrostatics (01marks)

(ii) Sketch the electric field pattern for positively charged metallic sphere and for negative point charge. (02marks)

(b) (i) Define electric field intensity and electric potential at a point. (02marks)

(ii) What is the relationship between them? (01mark)

(c) Two charges of $1.0 \times 10^{-5}C$ are placed 10cm apart as shown in the figure below



Calculate the

(i) Electric field intensity at P (06marks)

(ii) Electric potential at P (03marks)

(d) Two conducting spheres A and B supported on insulating stand are placed in contact. A negatively charged rod is then held near sphere A. the spheres are then separated after which the rod is removed. With the aid of suitable diagrams, explain the processes which occur. (05marks)

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