UACE PHYSICS PAPER 2009

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) (i) Show that the effective focal length, f, of two thin lenses in contact is given by

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$, where f_1 and f_2 are the foal lengths of the individual lenses. (04marks)

(ii) A compound lens consists of two lenses in contact having powers of +12.5D and -2.5D. Find the position and nature of the image of an object placed15.0cm from the compound lens. (03marks)

(b)(i) Define refractive index (01marks)

(ii) An equi-convex lens is placed on a horizontal plane mirror and a pin held vertically above the lens is found to coincide with its image when positioned 20.0cm above the lens. When a few drops of liquid is placed between the lens and the mirror, the pin had to be raised 10.0cm to obtain coincidence with the image. If the refractive index of the lens is 1.5, find the refractive index of the liquid. (05marks)

(c) (i) What is meant by magnifying power of optical instrument? (01mark)

(ii) Derive an expression for magnifying power of a compound microscope in normal adjustment. (05marks)

(iii) Why should the objective and eye piece of a compound microscope have short focal length? (01 marks)

2. (a) What is meant by the following terms as applied to optics

(i) refraction (01mark)

(ii) critical angle (01mark)

(b) Show that the refractive index, n, of a medium is given by, n = $\frac{real\ depth}{apparent\ depth}$ (04marks)

(c) A scratch is made at the bottom of a thick glass container which is filled with water. The scratch appears displaced by 0.5cm when viewed from above the water. If the refractive indices of water and glass are 1.33 and 1.50 respectively, find the apparent displacement when water is removed and the scratch is again observed from above. (05marks)

(d) A ray of light incident at an angle, I, on a prism of an angle, A, passes through it symmetrically.

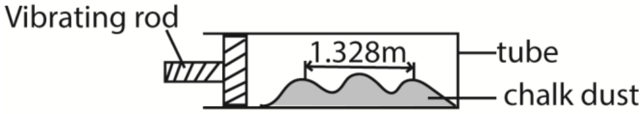
(i) Write the expression for deviation, d, of the ray in terms of i and A, (01mark)

(ii) Find the value of d if the angle of the prism is 60^0 and the refractive index of glass is 1.48. (03marks)

(e) Describe how you would determine experimentally the angle of minimum deviation produced by a prism. (05marks)

3. (a)(i) A progressive wave represented by y = asin$2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$is reflected along the same path. Show how the overlap of the two waves may give rise to a stationary wave. (03marks)

(ii) In an experiment to determine the speed of sound in air n a tube, chalk dust settled in heaps as shown below



If the frequency of the vibrating rod is 252Hz and the distance between three consecutive heaps is 1.328m, calculate the speed of sound in air. (03marks)

(b) The speed of sound in air is given by $v = \sqrt{\frac{\gamma P}{\rho}}$ where P is the pressure, l the density and γ the ratio of the principal heat capacities of air.
Use this expression to explain the effect of temperature on the speed of sound in air (03marks)

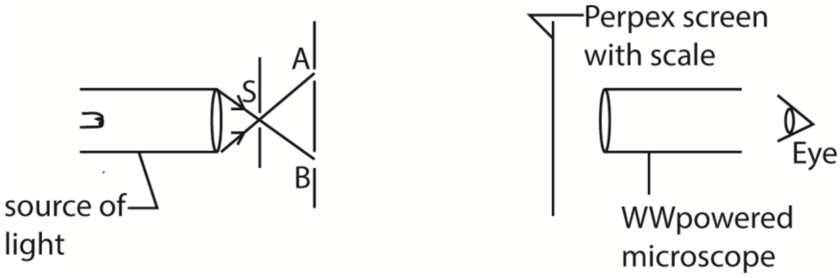
(c)(i) A train moving with uniform velocity, v_1 sounds a horn as it passes a stationary observer. Derive expression for the apparent frequency of sound detected by the observer. (03marks)

(d) Describe a simple experiment to show interference of longitudinal waves. (04marks)

4. (a) State three differences between mechanical and electromagnetic waves (03marks)

(b)(i) State the principal of superposition of waves (01mark)
(ii) Explain how interference pattern is formed (03marks)

(c)



A source of light, a single slit, S, and a double slit (A and B) are arranged as shown in figure 2.

(i) Describe what is observed on the screen through the microscope when white source of light is used. (02marks)

(ii) How would you use the set up above to compare the wavelength of red and blue light? (04marks)

(iii) Explain what is observed when slit, S, is gradually widened. (03marks)

(d) A diffraction grating of 500 lines per mm is illuminated normally by light of wavelength 5.26×10^{-7}m. Find the total number of images seen. (04marks)

SECTION B

5. (a) Define the terms magnetic flux and magnetic flux density. (02marks)

(b) A straight wire of length 20cm and resistance 0.25Ω lies at right angles to a magnetic field of flux density 0.4T. The wire moves when a p.d of 2.0V is applied across its ends. Calculate the;

(i) initial force on the wire

(ii) force on the wire when it moves at a speed of $15ms^{-1}$. (02marks)

(iii) Maximum speed attained by the wire (02marks)

(c) (i) sketch the magnetic field pattern around a vertical straight wire carrying a current in the earth's magnetic field and use it to explain a neutral point in magnetic field. (03marks)

(ii) Two long parallel wires placed 12cm apart in air carry currents of 10A and 15A respectively in the same direction. Determine the position where the magnetic flux is zero. (04marks)

(d) Describe with the aid of a diagram, an absolute method of determining resistance. (05mark).

6. (a) Derive an expression for the charge, Q, induced in a coil of N turns when the magnetic flux through it changes. (04marks)

(b) (i) Describe how a ballistic galvanometer of an unknown charge sensitivity can be used to measure magnetic flux density in a region between the poles of a magnet. (05marks)

(ii) State the possible sources of error in above experiment. (02mark)

(c) A flat circular coil with 2000turns, each of radius 50cm, is rotated at a uniform rate of 600 revolutions per minute about its diameter at right angle to a uniform magnetic flux density 5×10^{-4}T. Calculate the amplitude of the induced e.m.f. (03marks)

(d) Describe with the aid of a labelled diagram, the structure and action of a hot wire ammeter. (06marks)

7. (a) (i) what is meant by peak value of a sinusoidal current? (01mark)

(ii) A source of sinusoidal voltage of amplitude V_0 and frequency f is connected across a capacitor of capacitance, C. Derive an expression for instantaneous current which flows (03marks)

(iii) With reference to the circuit in (a)(ii), sketch using the same axes, graphs to show the variation of voltage and current with time. (02marks)

(b)(i) Explain why an alternating current apparently flow through a capacitor whereas a direct current does not. (03marks)

(ii) Explain the advantages of a.c over d.c in power transmissions. (02marks)

(c) With the aid of a diagram, describe how a half wave rectifier type of meter works. (04marks)

(d) A sinusoidal voltage $V = 339\sin 100\pi t$ is connected across 40Ω resistor. Find the;

(i) amplitude of the current through the resistor. (02marks)

(ii) average power developed in the resistor. (03marks)

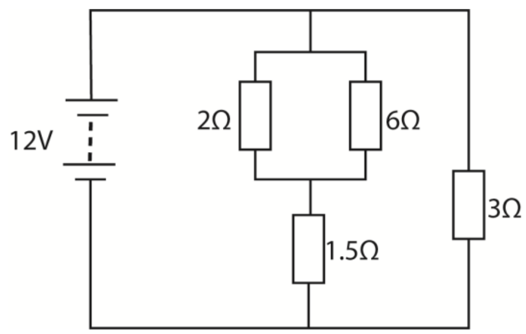
SECTION C

8. (a) (i) State Ohm's law. (01mark)

(ii) Give two examples of non-Ohmic conductors and sketch their current-voltage characteristic. (03marks)

(b) (i) Derive an expression for electrical energy dissipated in a resistor of resistance, R ohms carrying current I ampere for t seconds. (03marks)

(ii) A network of resistors of 2Ω, 6Ω, 1.5Ω and 3Ω are connected to a 12V d.c. supply of negligible internal resistance as shown below



Calculate the power dissipated in the 6Ω resistor. (04marks)

(c) (i) Define temperature coefficient of resistance (01mark)

(ii) Explain why semiconductors have negative temperature coefficient of resistance. (02marks)

(d) An electric heater consists of 5.0m of nichrome wire of diameter 0.58mm. When connected to a 240V supply, the heater dissipated 2.5kW and the temperature of the heater is found to be 1020^0C. If the resistivity of nichrome at 10^0C is $10.2 \times 10^{-7}\Omega$m, calculate

(i) The resistance of nichrome at 10^0C (03marks)
(ii) The mean temperature coefficient of resistance of nichrome between 10^0C and 100^0C. (03marks)

9. (a) Define electric potential difference (01mark)

(b) Explain briefly what happens to the potential energy as two point charges of the same sign are brought closer. (02marks)

(c) Three point charges of +5µC, -3µC and +2µC are placed respectively at three corners of a square of side 6.3cm in a vacuum.

(i) Sketch the electric field lines due to the charges. (02marks)
(ii) Calculate the electric filed potential at the fourth corner of the square (04marks)
(iii) Find the electric potential energy, if a charge of -4µC is placed at the fourth corner. (02marks)

(d) Describe, with the aid of a diagram, how a high voltage can be generated using a Van de Graff generator. (06marks)

(e) Explain how two insulating bodies rubbed together acquire charge.

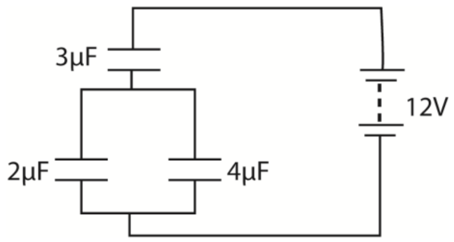
10. (a) (i) Define capacitance of a capacitor. (01mark)

(ii) Drive an expression for energy stored in a capacitor of capacitance C charged to a p.d, V. (04marks)

(b)(i) Explain the effect of placing an insulator between the plates of a charged capacitor. (05marks)

(ii) State two physical properties desirable in a material to be used as a dielectric in a capacitor. (02marks)

(c)



A battery of e.m.f12V is connected across a system of capacitors as shown in the figure above. Find the

(i) Charge on the 3μF capacitor (03marks)

(ii) Energy stored in the 4μFcapacitor (03marks)

(d) Describe a simple experiment to show that capacitance of a capacitor increases with surface area of the plates. (02marks)

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