UACE PHYSICS PAPER 2001

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) State the laws of refraction of light (02marks)

   (b) (i) Derive an expression for the refractive index of a prism in terms of refracting angle A and the angle of minimum deviation, D. (05marks)

   (ii) Monochromatic light is incident on one refracting face of a prism of refracting angle 60^0, made of glass of refractive index 1.50.

   Calculate the least angle of incidence for the ray to emerge through the second refracting face. (05marks)

   (c) (i) State three differences between compound microscopes and telescopes. (03marks)

   (ii) Describe, with the aid of a ray diagram, how a compound microscope forms a final image at near point.(05marks)

2. (a) Define the terms radius of curvature and focal length of a converging mirror. (02marks)

   (b) (i) Draw a ray diagram to show the formation of a real image of a real object in a converging mirror (02marks)

   (ii) Use the ray diagram in (b)(i) to derive the expression, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$; where u. v and f are the object distance, image distance and focal length respectively. (05marks)

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

   (ii) State two advantages of reflecting telescope over an astronomical telescope. (02marks)

   (d) An astronomical telescope has objective of focal length 100cm and eyepiece of focal length 10cm. Calculate the separation of the objective if the lenses are arranged in such a way that the final image is formed at 25cm from the eye. (04marks)

3. (a) (i) Distinguish between free and damped oscillation (02marks)
   (ii) Describe how the amplitude of a forced oscillation builds up to a constant value.
   (b) The displacement in meters of a plane progressive wave is given by the equation $y = 0.2\sin\pi(200t - \frac{20x}{17})$. Find
   (i) Wavelength and (02marks)
   (ii) Speed of the wave (02marks)

   (c)(i) Explain the occurrence of beats in sound (03marks)

   (ii) Two tuning forks X and Y are sounded together to produce beats of frequency 8HZ. Fork X has a known frequency of 512Hz.

   When Y is loaded with a small plasticine, beats at frequency of 2Hz are heard when the two tuning forks are sounded together.

Calculate the frequency of Y when unloaded. (03marks)

(d)(i) What is Doppler's Effect? (01mark)

(ii) A car sounds its horn as it travels at a steady speed of $15ms^{-1}$ along a straight load between two stationary observers A and B. The observer A hears a frequency of 538Hz while B hears a lower frequency.

Calculate the frequency heard by B, assuming the speed of sound in air is $340ms^{-1}$.

4. (a) (i) What is meant by interference and diffraction of light waves? (02marks)
(ii) State the conditions of necessary for observing diffraction (01marks)

(b) (i) Derive the expression for fringe separation in Young's interference pattern in terms of the silt-separation, d, the distance, D, of the screen from the double slits and the wavelength, λ, of the light. (05marks)

(c) Two slits of 0.5mm apart are placed at a distance of 1.0m from the screen. The slits are illuminated with light of wavelength 550nm. Calculate the distance between the fourth and second bright fringes of the interference pattern. (05marks)

(d) A transmission diffraction grating of spacing, d, is illuminated normally with light of wavelength, λ.

(i) Derive the condition for occurrence of diffraction maxima. (03marks)

(ii) Describe briefly the intensity distribution on a screen placed beyond the grating (02marks)

(iii) What is the effect on the diffraction pattern of using a grating with a larger number of lines? (02marks)

SECTION B

5. (a)(i) Define the ampere (2marks)

(ii) Write down the expression for the force on a conductor carrying current which is inclined at an angle θ to a uniform magnetic field (02mark)

(b)

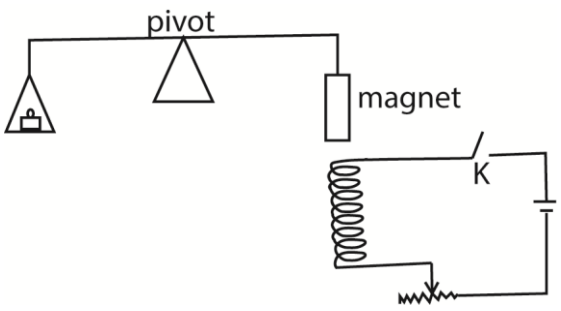


Figure above represents a current balance. When switch, K, is open the force required to balance the magnet is 0.2N. When switch, K, is closed and a current of 0.5A flows, a force of 0.22N is required for balance.

(i) Determine the polarity at the end of the magnet closest to the coil (03marks)
(ii) Calculate the weight required for balance when a current of 2A flows through the coil (03marks)

(c) A rectangular coil of N turns each of dimensions L x b is inclined at an angle θ to uniform magnetic field of flux density, B. derive an expression for torque on the coil if a current I is passed through it.

(d) A ballistic galvanometer of sensitivity 2 divisions per μC is connected across a coil of 10 turns wound tightly round the middle of a solenoid of 10^3 turns per meter and diameter 5.0cm. When the current in the solenoid is reversed, the ballistic galvanometer deflects through 8 divisions. If the total resistance of the coil and galvanometer is 20Ω, find the current in the coil.

6. (a) State the laws of electromagnetic induction. (02marks)

(b) A circular coil of 100turns and cross sectional area $0.2m^2$ is placed with its plane perpendicular to horizontal magnetic field of flux density $1.0 \times 10^{-2}T$.
The coil is rotated about a vertical axis so that it turns through 60^0 in 2s.
Calculate:

(i) The initial flux linkage through the coil (02mark)

(ii) The e.m.f induced in the coil (03marks)

(c)(i) Explain the origin of the back e.m.f in an electric motor (02mark)

(ii) A motor whose armature resistance is 2Ω is operated on 240V mains supply. If the back e.m.f in the motor is 220V, calculate the armature current. (03marks)

(d) (i) Describe with the aid of a diagram the mode of action of a simple d.c. generator. (06marks)

(ii) Sketch the output of a d.c. generator. (01mark)

(iii) What is the major difference between a d.c. motor and a.c. generator? (01mark)

7. (a) Define root mean square value (r.m.s) of an alternating current. (01mark)
(b) A sinusoidal alternating voltage V = 170sin120πt, voltage, is applied across a resistor of resistance 100Ω
Determine
(i) The r.m.s value of current which flows. (03marks)
(ii) The frequency of the current through the resistor. (02marks)

(c) With the aid of a labelled diagram describe the structure and action of hot wire ammeter. (06mark)

(d) Explain the term self-induction and mutual induction. (03 marks)

(e) A coil of self-inductance, L and negligible resistance is connected across a source of alternating voltage, $V = V_0 \cos\omega t$.

(i) Find the expression for the current which flows in the coil. (03marks)

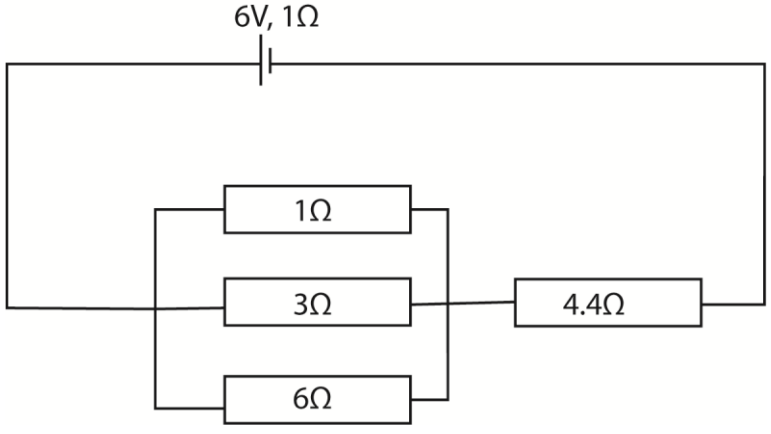
(ii) Sketch, using the same axes, the time variation of the applied voltage and the current which flows in the coil (02marks)

SECTION C

8. (a) Derive the condition for a Wheatstone bridge to be balanced. (04marks)
   (b) (i) Define temperature coefficient of resistance. (01mark)
   (ii) When a coil X connected across the left hand gap of a meter bridge is heated to a temperature of 30^0C, the balance point is found to be 51.5cm from the left-hand end of the slide wire. When the temperature is raised to 100^0C, the balance point is 54.6cm from the left end. Find the temperature coefficient of resistance of X. (06marks)

   (c) (i) A battery of e.m.f E and internal resistance, r, is connected to a resistor of variable resistance, R. Obtain the expression for maximum power dissipated in a resistor.

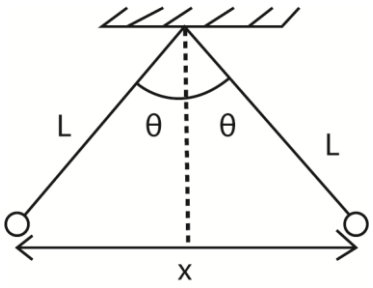
   (i) A battery of e.m.f 6V and internal resistance 1Ω is connected across a network of resistor as shown in the diagram below



   Find the current supplied by the battery. (04marks)
9. (a) State coulomb's law of electrostatics (01marks)

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

   (ii) Two identical conducting balls of mass, m, are each suspended in air from a silk thread of length L. when the two balls are each given identical charge, q, they move apart as shown in the figure below



If at equilibrium each thread makes a small angle θ with the vertical, show that the separation, x, is given by

$x = \left[\frac{q^2 L}{2\pi\varepsilon mg}\right]^{\frac{1}{3}}$; where ε is permittivity of air. (06marks)

(c) (i) Define the term capacitance of a capacitor. (01mark)

(ii) State the factors that affect capacitance of a capacitor (03marks)

(iii) Show that the energy stored n a capacitor of capacitance, C charged to a p.d V is equal to $\frac{1}{2}CV^2$. (03marks)

(d) The plates of parallel plate capacitor each of area 2.0cm^{2}are 5mm apart. The plates are in vacuum and potential difference of 10,000V is applied across the capacitor.

Find the magnitude of the charge on the capacitor (04marks)

10. (a)Define temperature efficiency of resistance and electrical resistivity. (02marks)

(b) A nichrome wire of length 1.0m and diameter 0.72mm at 25^{0}C, is made into a coil. The coil is immersed in 200cm^3 of water at the same temperature and current of 5.0A is passed through the coil for 8minutes until when the water starts to boil at 100^{0}C.

Find

(i) The resistance of the coil at 25^{0}C. (02marks)

(ii) The electrical energy expended assuming all of it goes into heating the water (02marks)

(iii) The mean temperature coefficient of resistance of nichrome wire between 0^{0}C and 100^{0}C. (06marks)

(c) Describe, with the aid of circuit diagram how a slide wire potentiometer can be used to measure e.m.f of a cell. (04marks)

(d) An accumulator of e.m.f 2.0V is connected across a uniform wire of length 1.0m and resistance 8.0Ω. A cell of e.m.f 1.50V is connected in series with a galvanometer and connected across a length L of slide wire. The galvanometer shows no deflection when L is 90.0cm. Find the internal resistance of an accumulator. (04marks)

Resistance of AC = $\frac{8\,x90}{100} = 7.2\Omega$

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