UNIVERSITY OF RUHUNA

BACHELOR OF SCIENCE (GENERAL) DEGREE LEVEL I (SEMESTER II) EXAMINATION – JANUARY 2014

SUBJECT: PHYSICS

COURSE UNIT: PHY 1214 **TIME: 2 hours & 30 minutes**

PART II

Answer FIVE (05) Questions only

Answer minimum of ONE (01) question from each of the parts A, B and C

All symbols have their usual meaning.

$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{Hm^{-1}}$ $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2N^{-1}m^{-2}}$ $g = 9.8\ \mathrm{ms^{-2}}$ $e = 1.6 \times 10^{-19}\ \mathrm{C}$

Part A

1. (a) Write down Coulomb's law in electrostatics.
What are meant by *field, field strength and potential* in connection with electrostatics?

(b) A large hollow metallic sphere A and small solid metallic sphere B are charged positively to potentials of 100 V and 50 V, respectively. Then B is placed inside the sphere A and connected to A by a wire. Explain, briefly what might happen.

(c) Two parallel conducting plates 1.5×10^{-2} m apart are held horizontally one above the other in air. The upper plate is maintained at a positive potential of 1.5 kV and the lower plate is earthed.

(i) Calculate the electric field between the two plates.
(ii) If an electron is floating between the two plates calculate the net electric force experienced by the electron.
(iii) Calculate the number of electrons which must be attached to a small particle of mass 4.9×10^{-15} kg to maintain it at rest in between the plates.
(iv) If the potential of the upper plate is suddenly changed to -1.5 kV, what would be the initial acceleration of the particle?
(v) Discuss any practical application of such a system.
(Assume the density of air and the mass of the electron is negligible.)

2. (a) Indicating reasons, describe how charges are distributed in an insulated sphere, a conducting sphere and a conducting shell.
Usually, microphone cables or antenna cables are covered externally with conducting foils. Explain why?
State the Gauss' theorem in electrostatics.

(b) An insulating sphere of radius R has a positive charge $(+Q)$ being distributed uniformly. Find the electric fields at distances r from the center,

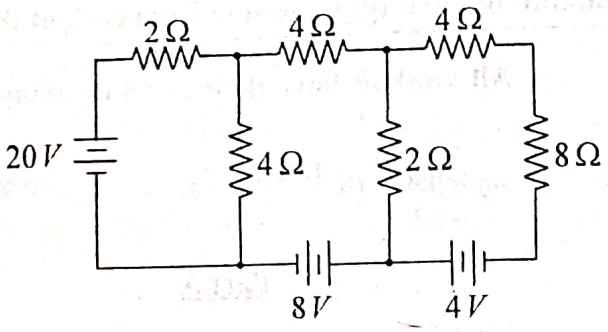
i. when $r < R$.

ii. when $r > R$.

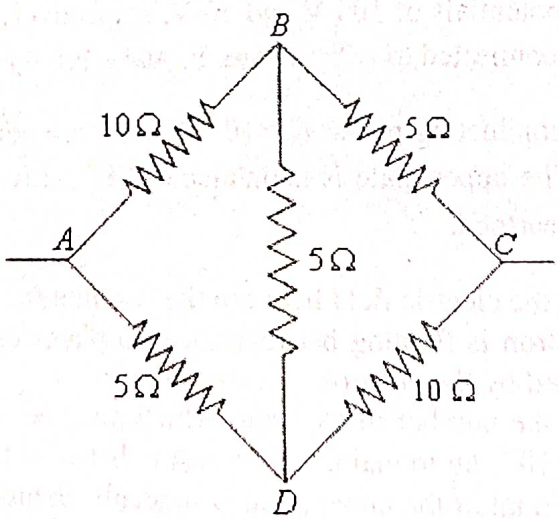
Compare the results obtained. Find the potential in each of the above cases. Sketch above variations of the electric field and the potential.

3. (a) Write down Kirchhoff's laws in current electricity.

(b) State Nortan's theorem clearly. Use the Nortan's theorem to find the current through the 8 Ω resister in the following circuit.



(c) If the 8 Ω resister of the above circuit is replaced with A and C terminals of the following network, find the current through the new network.



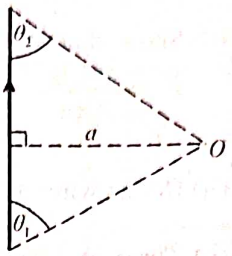
Part B

4. Write down Biot-Savart law.

a) Figure shows a straight wire carrying a current I. Show that the magnitude of the magnetic field at the point O is given by

$B = \frac{\mu_0 I}{4\pi a}(cos\theta_1 + cos\theta_2)$.

What is the direction of $\vec{B}$ at O?

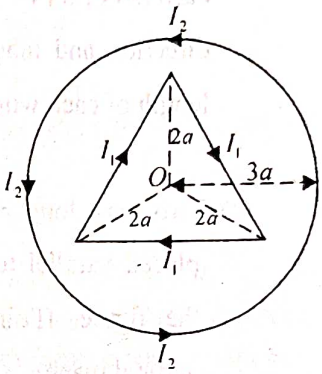


b) Figure shows an equi-lateral triangular current loop, carrying a current I_1 and a circular current loop of radius $3a$ and carrying a current I_2. Find the magnetic field (B) at the center O due to both loops.

c) If the point O is a neutral point, show that

$\frac{I_1}{I_2} = \frac{2\pi}{9\sqrt{3}}$.

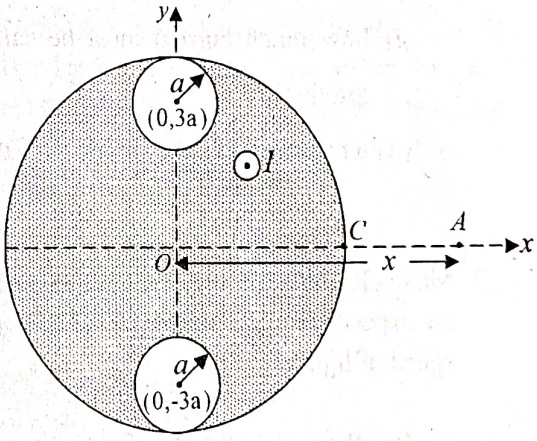
$(cos\ 30° = \frac{\sqrt{3}}{2}, sin\ 30° = \frac{1}{2})$



5. a) State Amphere's circuital law.

b) An infinitely long solid cylindrical conductor of radius $4a$ has two infinitely long identical cylindrical holes of radii a such that the two axes of hollow cylinders are parallel to the axis of the cylindrical conductor as shown in the figure .

Assume the current I passing through the conductor along the z direction is uniformly distributed over the cross section of the conductor.



(i) Obtain an expression for the current density (J).

(ii) Using a suitable strategy, show that the magnitude of the magnetic field at the point A is given by $B_A = \frac{\mu_0 I}{7\pi}\left(\frac{4}{x} - \frac{x}{2(x^2+9a^2)}\right)$.

Indicate the direction of $\vec{B}_A$.

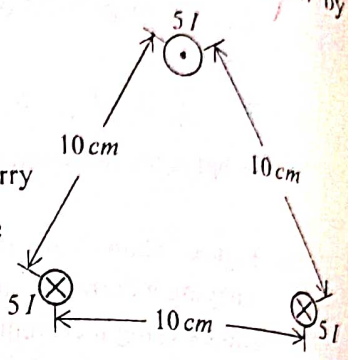
(iii) Using the result in part (ii), find the field ($\vec{B}$) at point C.

6. a) Two parallel identical very long wires carry currents I_1 and I_2 in the same direction. The distance between the axes of two wires is d. (consider d is small)

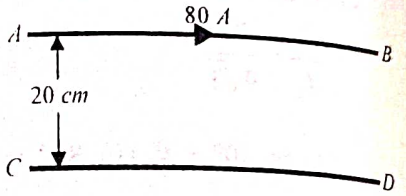
(i) Show that the magnitude of the force acting on unit length of a wire is given by $F = \frac{\mu_0 I_1 I_2}{2\pi d}$.

(ii) Do the wires attract or repel each other?

(b) Three identical very long wires parallel to each other carry currents of 5 I as shown in the following figure. Find the direction and magnitude of the force acting on a unit length of each wire.



(c) Two very long parallel wires, 20 cm apart, are placed parallel to the earth surface as shown in the figure. (Points A, B, C and D lie on a vertical plane).



The wires have linear mass density of 0.12 gm^{-1}. If the wire AB carries a current of 80 A,

(i) how much current must be carried by the wire CD so that it does not fall due to gravity?

(ii) what should be the direction of the current through the wire CD?

Part C

7. Maxwell predicted that light waves are form of electromagnetic radiation. Hertz performed an experiment that verified Maxwell's prediction. Briefly describe how he measured the speed of light.

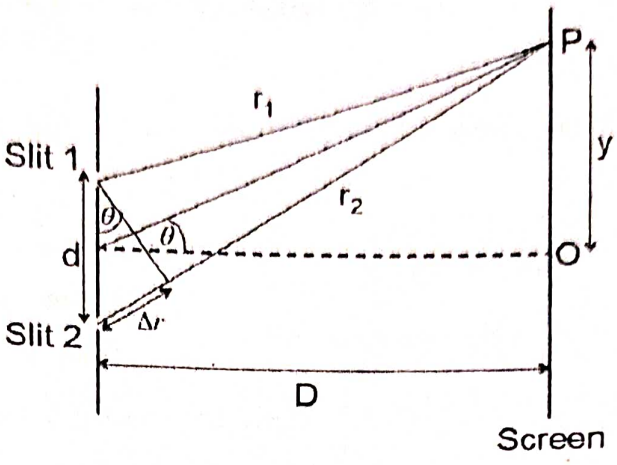
(a) Briefly explain the Huygens's principle.

(b) Consider two sinusoidal waves of same frequency but with different amplitudes and phase constants as given below.

$$x_1 = A_1 \sin(\omega t + \phi_1)$$
$$x_2 = A_2 \sin(\omega t + \phi_2)$$

Using the principle of superposition, show that the resultant wave has the same frequency but different amplitude and phase constant.

8. (a) An interference pattern is obtained on a screen as shown in the following figure using a monochromatic light beam falling on to a double slit of slit separation d as in Young's double slit experiment.



Consider the point P on the screen.

i) Write down an expression for the path difference between the two rays, r_1 and r_2.

ii) What is the condition for constructive interference at point P?

iii) What is the condition for destructive interference at point P?

iv) If D=2 m, d=0.05 mm and if the third order bright fringe is 5 cm away from the central bright fringe, find the wavelength of incident light.

v) Calculate the distance between two adjacent bright fringes.

(b) When a thin transparent plate of thickness t and refractive index μ is introduced into the upper ray r_1 the point P on the screen is found to shift to a new location Q (OQ = y! !) above it. Write down an expression for the new path difference between the two rays.

9. (a) A parallel beam of light is incident normally on a narrow slit of width 0.9 mm. The diffraction pattern is observed on a screen placed at the focal plane of a convex lens with focal length 150 mm. The convex lens is placed very close to the slit and the wavelength of the light is 640 nm. Calculate the distance between the first and third order minima on the screen.

(b) Consider a grating with 15000 lines per 2.54 cm. Show that if white light source is used, the second and third order spectra of the diffraction pattern overlap. (Assume λ_{violet} =400 nm and λ_{red} =700 nm)

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