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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2019 /2020 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE & COMPUTER SCIENCE

COURSE CODE: **PHY 210**

COURSE TITLE: **ELECTRICITY AND MAGNETISM**

DATE: 11 DECEMBER 2019 **TIME:9:00AM-12:00PM**

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

THIS PAPER CONSISTS OF 6 PRINTED PAGES **PLEASE TURN OVER**

PHY 210: ELECTRICITY AND MAGNETISM 1

STREAM: BED (Science) & BSc (Comp. Scie.) **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

i. *Answer **TWO** questions in section **A** and any other **THREE** questions in section **B**.*

ii. *You may need to use the following constants*

- *Permittivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m (k = 8.99 x 10^9 Nm^2C^{-2})*
- *Mass of an electron, $Me = 9.11 \times 10^{-31}$ Kg*
- *Mass of a proton, $Mp = 1.67 \times 10^{-27}$ Kg*
- *Electronic charge, $e = 1.6 \times 10^{-19}$ C*
- *Permeability of free space, $\mu_o = 4\pi \times 10^{-7}$ Tm/A*
- *$1eV = 1.6 \times 10^{-19}$ J*

SECTION A (28 MARKS)

Question One (14 Marks)

(a) (i) State Coulombs law (1 Mark)

(ii) What are the two different units of electrical potential? Are they equivalent? (Hint; use dimensional analysis) (3 Marks)

(b) Find the electric field due to a single charge q_i. (2 Marks)

(c) (i) What are dielectrics? List any two of such materials. (1 Mark)

(ii)A parallel-plate capacitor with air between the plates has an area $A = 2 \times 10^{-4}$ m^2 and a plate separation $d = 1.0$ mm. Find its capacitance. (3 Marks)

(d) List any four properties of electric field lines. (4 Marks)

Question Two (14 Marks)

(a) State the Gauss's law (1 Mark)

(b) Highlight any two distinctions between the electric force and magnetic force (2marks)

(c) An insulating sphere of radius R = 0.16 m has uniform charge density $\rho = 7.2 \times 10^{-9}$ C/m^3. A small object which can be treated as a point charge is released from rest just outside the surface of the sphere. The small object has positive charge q = 3.4 x 10^{-6} C. How much work does the electric field of the sphere do on the object as the object moves to infinity point? (5 Marks)

(d) What is Resistivity (1 Mark)

(e) List factors on which resistance R of a conductor depends on. (3 Marks)

(f) A toroid wound with 60.0 turns/m of wire carries a current of 5.00 A. The torus is iron, which has a magnetic permeability of $\mu_w = 5\ 000\mu_o$ under the given conditions. Find H and B inside the iron. (2 Marks)

SECTION B (42 MARKS)

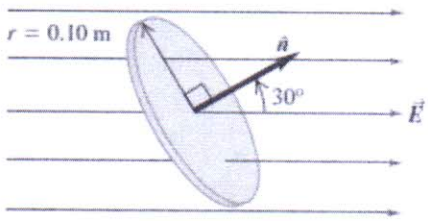
Question Three (14 Marks)

(a) A disk of radius 0.10 m is oriented with its normal unit vector $\hat{n}$ at 30° to a uniform electric field of magnitude 2 x 10^3 N/C as shown in the figure below.

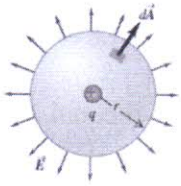
(i) What is the electric flux through the disk? (4 Marks)

(ii) What is the flux through the disk if it is turned so that is perpendicular to $\vec{E}$ (2 Marks)

(iii) What is the flux through the disk if is parallel to $\vec{E}$? (3 Marks)



(b) A point charge q = +3 μC is surrounded by an imaginary sphere of radius r = 0.2 m centred on the charge as shown in figure below.



Find the resulting electric flux through the sphere. (5 Marks)

Question Four (14 Marks)

(a) (i) What is capacitance? (1 Mark)

(ii) Two parallel metallic plates of equal area A are separated by a distance d, such that one plate carries a charge $+Q$, and the other carries a charge $-Q$. Show that the capacitance is given by $\frac{A\varepsilon_o}{d}$ (5 Marks)

(b)

i) State Ampere's law (1 Mark)

ii) An electron in a television picture tube moves toward the front of the tube with a speed of 8.0 x10^6 m/s along the x axis. Surrounding the neck of the tube are coils of wire that create a magnetic field of magnitude 0.025 T, directed at an angle of 60° to the x axis and lying in the xy plane. Calculate the magnetic force on the electron (2 Marks)

(c) Show that for a positively charged particle moving in a uniform magnetic field with the initial velocity vector of the particle perpendicular to the field, its period of revolution is given by (5 Marks)

$$T = \frac{2\pi m}{qB}$$

Question Five (14 Marks)

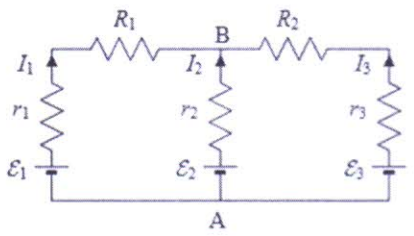
(a) State the Ohm's law (1 Mark)

(b) Given three resistors of resistances; R_1 , R_2 and R_3, derive an expression for R that:

i) Maximize the equivalent resistance (2 Marks)

ii) Minimize the equivalent resistance? (3 Marks)

c) The circuit below consists of 3 different imperfect batteries connected to two equal resistors. Find the currentsI_1, I_2 and I_3 leaving the batteries, and the potential difference from A to B, V_{AB}. (8 Marks)



Take $\mathcal{E}_1 = 6$ V, $r_1 = 1\Omega$, $\mathcal{E}_2 = 10$ V, $r_2 = 2\Omega$, $\mathcal{E}_3 = 12$ V, $r_3 = 3\Omega$ and $R_1 = R_2 = 20\Omega$.

Question Six (14 Marks)

(a)

i) Write a mathematical statement for Biot-Savert law (1 Mark)

ii) Give the equations for electric force and magnetic force (2 Mark)

b) What's the force on a 0.1 C charge moving at velocity $v = 10\hat{j} - 20\hat{k})$ m/s in a magnetic field $\hat{B} = (-3\hat{\imath} + 4\hat{k})x\ 10^{-4}T$ (5 Marks)

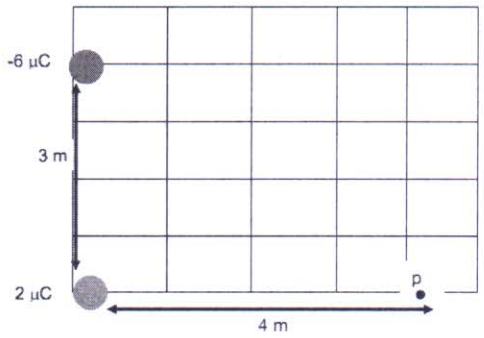
c) A rectangular coil of dimensions 5.40 cm x 8.50 cm consists of 25 turns of wire and carries a current of 15.0 mA. A 0.350-T magnetic field is applied parallel to the plane of the loop.

i) Calculate the magnitude of its magnetic dipole moment. (4 Marks)

ii) What is the magnitude of the torque acting on the loop? (2 Marks)

Question Seven (14 Marks)

(a) A charge $q_1 = 2.00\ \mu C$ is located at the origin, and a charge $q_2 = -6.00\ \mu C$ is located at (0, 3.00) m, as shown in Figure below.

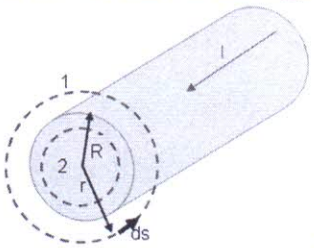


i) Find the total electric potential due to these charges at the point P, whose coordinates are (4.00, 0) m. (3 Marks)

ii) Find the change in potential energy of the system of two charges plus a charge $q_3 = 3.00\ \mu C$ as the latter charge moves from infinity to point P (3 Marks)

iii) Find the change in potential energy when *all three* charges start out infinitely far apart and are then brought to the positions. (3 Marks)

(b) A long, straight wire of radius R carries a steady current I that is uniformly distributed through the cross section of the wire as shown in figure below. Calculate the magnetic field a distance r from the centre of the wire in the regions $r \geq R$ and $r < R$. (5 Marks)



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