

CHUKA UNIVERSITY

PHYS 241 : ELECTRICITY AND MAGNETISM

STREAMS: BSC COMPUTER, BSC APPLIED COMPUTER, Bed SCIENCE & BSC PHYSICS **TIME: 2 HRS**

INSTRUCTIONS:

Speed of light = 3.0×10^8 m/s

$\epsilon_0 = 8.85 \times 10^{-12}$ C²/N.m

$$K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2 \text{ C}^{-2}$$

$e = 1.6 \times 10^{-19}$ C

Answer question ONE which is compulsory and any other TWO questions

QUESTION ONE 30 MARKS

a. Define the following terms

[4marks]

- (i). Capacitor
- (ii). Electric field
- (iii). Electron Volt
- (iv). Equipotential

b. A computer data acquisition card, inserted into the expansion slot in its motherboard has a resistance of 300Ω and operated by 240V power supply terminal. Calculate the current flowing through it and explain use of the mother board. (3marks)

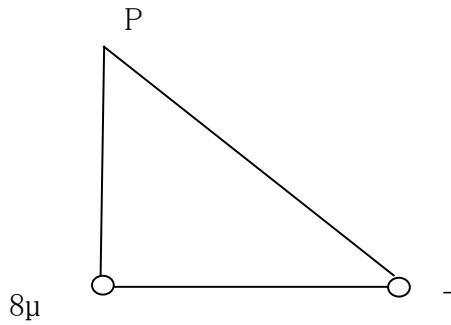
ci). State Kirchoff's laws

(2marks)

ii). Find the values of I_1, I_2 and I_3 in the circuit below.

(5marks)

e. A $8 \mu\text{C}$ point charge is at the origin, and a point charge of $-3 \mu\text{C}$ is on the x axis at (6, 0) m as the figure below. If the electric potential is taken to be zero at infinity, find the total electric potential due to these charges at point p, with coordinates (0, 8) m. (4marks)



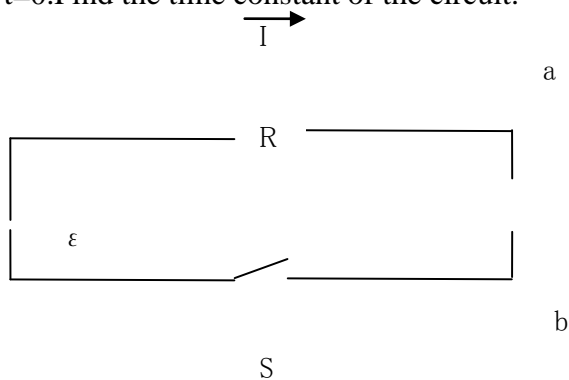
e. Calculate the resistance per unit length of a 22-gauge nichrome wire of radius 0.28mm. Resistivity of the wire is $1.5 \times 10^{-6} \Omega \cdot \text{m}$. ii. If a potential of 16.0V is maintained across a 1.0m length of nichrome wire. What is what is current in the wire? (4marks)

f. A student makes circular coil of 800 loops of thin copper wire with a resistance of 0.25Ω . The coil diameter is 14.0cm and the coil is connected to a 12.0V battery. Determine:

- i). The magnetic moment of the coil (3marks)
- ii). The maximum torque on the coil if it were placed between the poles of a magnet where the magnetic field strength was 1.8T. (2marks)
- g) What is the value of the unknown resistor R in if the voltage drop across the 500Ω resistor is 2.5 volts? All resistances are in ohm. (3marks)

QUESTION TWO 20 MARKS

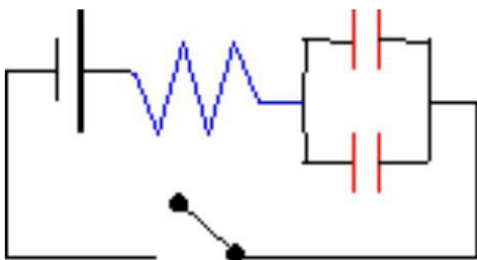
a). The circuit shown below consists of a 32mH inductor, a 4.0Ω resistor, and a 12 V battery. The switch is closed at $t=0$. Find the time constant of the circuit. (2marks)



- ii) Find the current after ONE time constant as elapsed $i = 63.2\%$ (2marks)
- b) . Calculate the inductance of a solenoid containing 800 turns if the solenoid is 20cm and its cross sectional area is 2cm^2 . (3marks)
- c. An airplane with a wing span of 80m flies parallel to the earth's surface at a location in which the downward component of the Earth's magnetic field is $2.80 \times 10^{-3} \text{ T}$. Find the difference in potential between the wing tips when the speed of the plane is 700m/s. (3marks)
- d. A coil of 200 turns of wire is wrapped on a square frame 16cm on side. The total resistance of the coil is 2Ω . A uniform magnetic field is applied perpendicularly to the plane of the frame and the field changes uniformly from 0 to 0.6T in 0.2s. Find the magnitude of the induced emf in the coil while the field is changed. (4marks)
- e). Two resistors R_1 and R_2 may be connected either in series or parallel across a battery with emf ϵ . We desire the thermal energy transfer rate for parallel combination to be five times that for the series combination. If $R_1 = 100 \Omega$. What is R_2 ? (4marks)
- f) An ideal 800W transformer has 50 turns on its primary coil and 100 turns on its secondary coil. If the primary coil is connected to a 120.0V source. What is the output voltage of the secondary coil? (2marks)

QUESTION THREE 20 MARKS

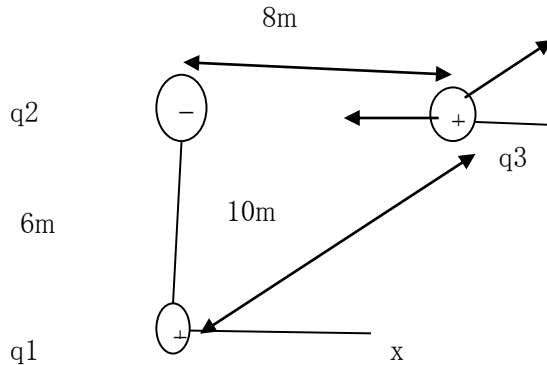
- a). Show that the magnetic field inside and outside a long straight wire carrying a current, I , is directly proportional and inversely proportional to r respectively, where r is the distance from the center of the wire. [3marks]
- b) How long does it take for 50% of the maximum charge to be deposited on the circuit below when the switch is closed? The resistor is 4 million ohms and each capacitor is 20nF. (4marks)



- c). A parallel plate capacitor has plates with dimensions $2\text{cm} \times 4\text{cm}$ separated by 2mm. The plates are connected across a 24 V battery. Determine the:

- (i) Capacitance of the capacitor (3marks)
(ii) Magnitude of the charge on each plate (2marks)

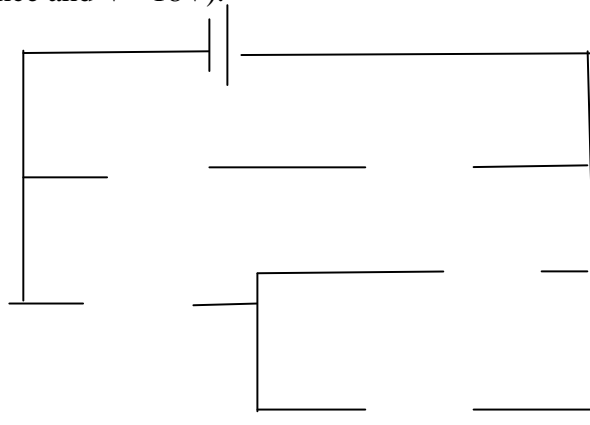
d). Consider three point charges at the corners of triangle $q_1=8\times 10^{-9}$, $q_3=5\times 10^{-9}$, $q_2=-2\times 10^{-9}$. Calculate resultant force at q_3 . (4marks)



e) A proton moves at 4.0×10^6 m/s along the x axis. It enters a region where there is a magnetic field of magnitude 7.5 T directed at an angle of 30° from the positive y -axis and lying in the xy -plane. What is the initial force the proton feels and what is its acceleration? (4marks)

QUESTION FOUR 20 MARKS

- a) State Coulomb's TWO laws for the electrostatics (2marks)
b) What is the current through the battery and power provided in the circuit drawn below? (Neglect the internal resistance and $V= 18V$). (3marks)

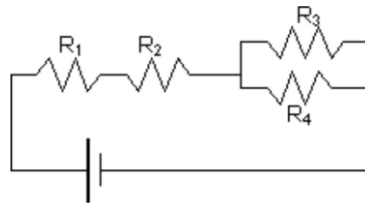


c) An electron and a proton are separated by a distance of 8.2×10^{-11} m. Find the electrostatic force between them. (3marks)

d) Show that the equivalent capacitance of capacitors C_1 and C_2 connected in series is

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} \quad (3 \text{ marks})$$

e) What is the equivalent resistance of this circuit? $R_1= 4\Omega$, $R_2= 8\Omega$, $R_3= 10\Omega$, $R_4= 20\Omega$



(4 marks)

f) Calculate the expression for the electric potential difference at a point (P) a distance (Z) along the axis of a uniform ring of radius (R) and total charge (Q). Discuss the limit $z \gg R$. (5 marks)

QUESTION FIVE 20 MARKS

(a). State:

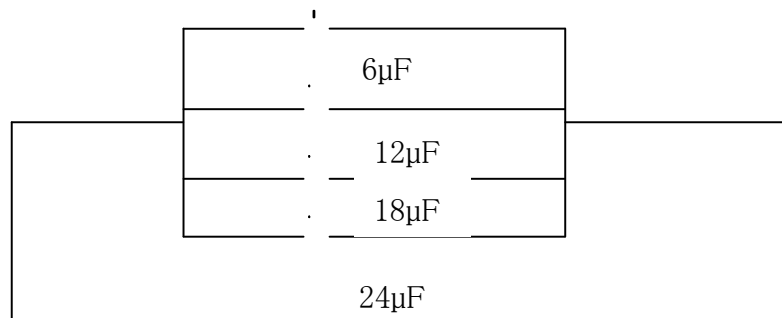
- i).Lenz’s law (2marks)
- ii).Faraday’s law of induction (2marks)
- iii).Back emf (1mark)

b.i An electric heater is operated by applying a potential difference of 240V to a nichrome wire of total resistance 12Ω .Find the current carried by the wire and the Power rating of the heater. [3marks]

ii).If the heater is operated daily for 8hours how much will cost to pay electricity bill at the end 30 days. One kWh costs 12.40. [2marks]

c)The charge Q of a capacitor decays according to the equation $Q=Q_0e^{-t/RC}$. If a fully charged capacitor carries a charge of 9.2×10^{-3} C, what will be the amount of charge on the plates of the capacitor after a period of time equal to the time constant.(use $e=2.72$) (3marks)

d) Determine the capacitance of a single capacitor that is equivalent to the parallel combination of capacitors shown below .Find voltage on the $12\mu\text{F}$ capacitor [3marks]



e) Suppose one wants to make a 0.25Ω resistor out of 2g of copper. If the resistor is a uniform cylinder, what is the diameter and length required? Take the density of copper to be $8.95 \times 10^3 \text{ Kg m}^{-3}$. and resistivity to be $1.7 \times 10^{-8} \Omega \cdot m$
(4 marks)