

CHUKA



UNIVERSITY

UNIVERSITY EXAMINATIONS

FIRST YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF
SCIENCE IN PHYSICS

PHYS 241: ELECTRICITY AND MAGNETISM

STREAMS: B.Sc COMPUTER, B.Sc APPLIED COMPUTER, B.Ed SCIENCE & BSC
PHYSICS

TIME: 2 HOURS

DAY/DATE: THURSDAY 7/12/2017

2.30 P.M - 4.30 P.M.

INSTRUCTIONS:

Speed of light = 3.0×10^8 m/s

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

$K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ Nm²c⁻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

[4 Marks]

- (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 300 Ω and operated by 240V power supply terminal. Calculate the current flowing through it and explain use of the mother board. [3 Marks]

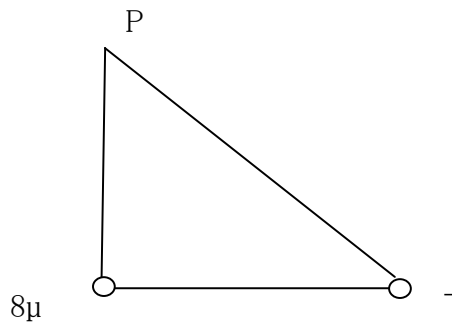
ci). State Kirchoff's laws

[2 Marks]

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

[5 Marks]

d) 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. [4 Marks]



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 the current in the wire? [4 Marks]

f. A student makes a 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 [3 Marks]

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 . [2 Marks]

g) What is the value of the unknown resistor R if the voltage drop across the 500Ω resistor is 2.5 volts? All resistances are in ohm. [3 Marks]

QUESTION TWO 20 MARKS

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

ii) Find the current after ONE time constant as elapsed $i_t=63.2\%$ [2 Marks]

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 2.80×10^{-3} 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 2 Ω . 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. [4 Marks]

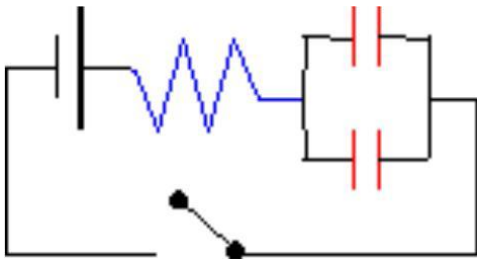
e). Two resistors R1 and R2 may be connected either in series or parallel across a battery with emf ϵ . We desire the thermal energy transfer rate for parallel combination to be five times that for the series combination. If R1=100 Ω . What is R2? [4 Marks]

f) An ideal 800W transformer has 50turns 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? [2 Marks]

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. [3 Marks]

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. [4 Marks]



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 [3 Marks]
 (ii) Magnitude of the charge on each plate [2 Marks]

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 $q_3=50^\circ$. [4 Marks]

e) A proton moves at $4.0 \times 10^6\text{ m/s}$ 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? [4 Marks]

QUESTION FOUR 20 MARKS

a) State Coulomb's TWO laws for the electrostatics [2 Marks]

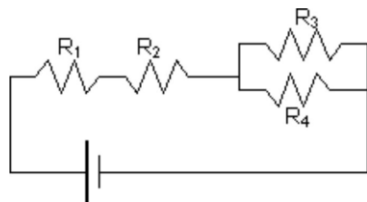
b) What is the current through the battery and power provided in the circuit drawn below? (Neglect the internal resistance and $V= 18\text{V}$). [3 Marks]

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

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 [2 Marks]
 - ii). Faraday's law of induction [2 Marks]
 - iii). Back emf [1 Mark]

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. [3 Marks]

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

c) The charge Q of a capacitor decays according to the equation $Q = Q_0 e^{-t/RC}$. 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 $e = 2.72$) [3 Marks]

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 [3 Marks]

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]

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