NAME: **KEY** **KP ITM:** ________________

Program: ____________

TEST 2 – Oct 3rd 2006

Answer ALL questions ON the paper provided to you. DO NOT USE ADDITIONAL PAPERS.

1. (a) State Ohm's Law and state Kirchoff's Current and Voltage Rules

Ohm's Law: The ratio of potential difference across a device to the current through it is a constant OR *The current through a resistor is directly proportional to the potential difference across it and inversely proportional to its resistance*

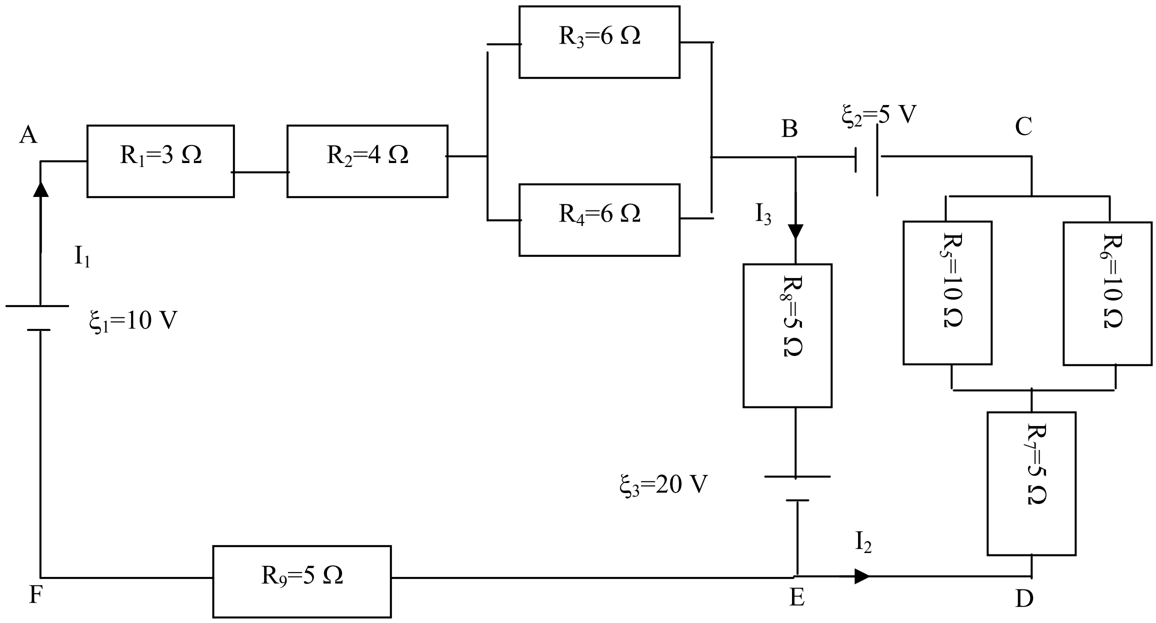
Kirchoff's Law: Rule I: The sum of currents into a circuit junction is equal to the sum of currents leaving that junction

Rule II: In a circuit loop, the sum of potential drops must equal the potential rise.

(8 marks)

(b) Given the circuit below,

i. Determine the equivalent resistance R_{1234} and the equivalent resistance R_{567}, respectively.
ii. Apply Kirchoff's current rule at junction E.
iii. Write the potential drops and potential rise for loops AFEB and BCDE respectively.
iv. Use part (ii) to simplify part (iii).



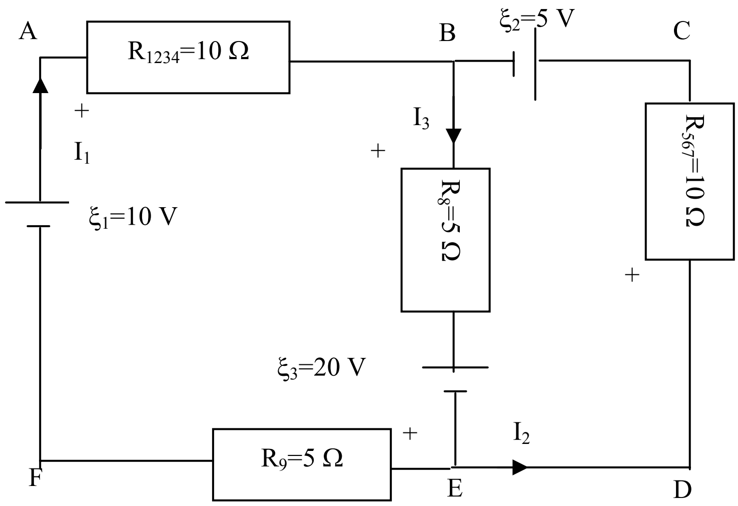
v) Determine the actual current directions and magnitude for currents I_1, I_2, and I_3. Show ALL your work.

(11+2+12+4+11 = 40 marks)

Solution: i) $\frac{1}{R_{34}} = \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{6\Omega} + \frac{1}{6\Omega} = \frac{2}{6\Omega}$ $R_{34} = 3\Omega$; So, $R_{1234} = R_1 + R_2 + R_{34} = 10\Omega$

$\frac{1}{R_{56}} = \frac{1}{R_5} + \frac{1}{R_6} = \frac{1}{10\Omega} + \frac{1}{10\Omega} = \frac{2}{10\Omega}$. $R_{57} = 5\Omega$; So, $R_{567} = R_{56} + R_7 = 10\Omega$.

(ii) At E: Current rule: $\sum I_{in} = \sum I_{out}$: so, $I_3 = I_1 + I_2$ - *eqn 1*

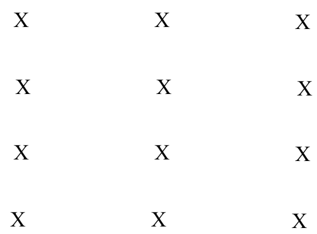


iii) Voltage rule: $\sum V_{drop} = \sum V_{rise}$. Follow the direction of the loop. Potential Drop is when we move from high potential (the positive end) to low potential (negative end). Potential rise is when we move from low potential (negative end) to high potential (positive end).
Potential drops AFEBF: $V_{drop} = \xi_1 = 10V; V_{rise} = 5I_1 + 20V + 5I_3 + 10I_1$
Potential drops BCDEB: $V_{drop} = 0; V_{rise} = 5V + 10I_2 + 20V + 5I_3$

iv) Using the voltage rule & substituting eqn 1:
$10V = 5\Omega I_1 + 20V + 5\Omega I_3 + 10\Omega I_1; 15\Omega I_1 + 5\Omega(I_1 + I_2) = -10V$;
Then, $20\Omega I_1 + 5\Omega I_2 = -10V$ - eqn 2
$0 = 5V + 10\Omega I_2 + 20V + 5\Omega I_3; 10\Omega I_2 + 5\Omega(I_1 + I_2) = -25V$.
Then, $15\Omega I_2 + 5\Omega I_1 = -25V$ - eqn 3

v) Eliminate I_1: Multiply eqn 3 by -4 and add to eqn 2
$20\Omega I_1 + 5\Omega I_2 = -10V$ - eqn 2
$-20\Omega I_1 - 60\Omega I_2 = -100V$ - eqn 3-1
$-55\Omega I_2 = -110V$. So $I_2 = 110V/55\Omega = 2A$. Now substitute I_2 into eqn. 3
$15\Omega \times 2A + 5I_1 = -25V$. So, $15\Omega I_1 = -25V - 30V$. Then $I_1 = -55V/15\Omega = -3.67A$.
Substitute I_1 & I_2 into eqn 1: $I_3 = -3.67A + 2A = -1.67A$

2. (a) For the cases below, either charges are moving at a constant speed *v*, or current–carrying wires are in a magnetic field B as shown in the picture. State the directions of the magnetic force and write the magnitude of the that force



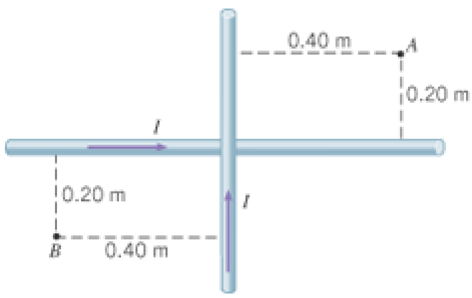
i) Positive charge moving from left to right.
ii) Positive charge moving upwards.
iii) Positive charge moving into the page.
iv) Conductor carrying current I, I to the right

v) Conductor carrying current I, I downwards.

Soln:
i) Upwards; F=qvB. ii) left; F=qvB iii) No force since v & B same direction.
iv) Upwards; F= ILB. v) right; F=ILB.

(10 marks)

(b) The drawing shows two perpendicular, long, straight wires, both of which lie in the plane of the paper. Each wire carries the same current *I*.



(i) State the directions and write the magnitudes of the magnetic fields at point *A* and at point *B* respectively.
(ii) Is the magnitude of the net field at point *A* greater than, less than, or equal to the magnitude of the net field at point *B*? Explain. Obtain the fields at A and at B respectively in terms of the current I.
(iii) If the current in each of the wires is *I* = 5.6 A, calculate the magnitudes of the net fields at points *A* and *B*. (use $\mu_0 = 4\pi \times 10^{-7}\ Tm/A$).

Soln:

i) B_H *due to horizontal wire at A points* *out of page* *with strength* $B= \mu_0 I / 2\pi (0.20m)$.
B_V *due to vertical wire at A points* *into page* *with strength* $B= \mu_0 I / 2\pi (0.40m)$
B_H *due to horizontal wire at B points* *into page* *with strength* $B= \mu_0 I / 2\pi (0.20m)$.
B_V *due to vertical wire at A points* *out of page* *with strength* $B= \mu_0 I / 2\pi (0.40m)$

ii) *At A,* B_H *is stronger, at B* B_H *is stronger. Both has same strength but at A it points out of page and at B into the page. At A:*

$$B = B_{in} + B_{out} = \frac{\mu_0 I}{2\pi}\left(\frac{1}{0.40} - \frac{1}{0.20}\right) = \frac{\mu_0 I}{2\pi}\left(\frac{1}{0.40} - \frac{2}{0.40}\right) = -\frac{\mu_0 I}{2\pi(0.40)}$$ *; out of page.*

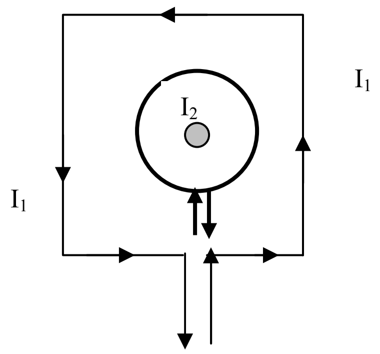
At B: $$B = B_{in} + B_{out} = \frac{\mu_0 I}{2\pi}\left(\frac{1}{0.20} - \frac{1}{0.40}\right) = \frac{\mu_0 I}{2\pi}\left(\frac{2}{0.40} - \frac{1}{0.40}\right) = \frac{\mu_0 I}{2\pi(0.40)}$$ *; into page.*

iii) At A: $$B = -\frac{\mu_0 I}{2\pi(0.40)} = -\frac{4\pi \times 10^{-7}\, Tm/A \times 5.6\, A}{2\pi(0.40m)} = -2.8 \times 10^{-6}\, T.$$

At B, $$B = \frac{\mu_0 I}{2\pi(0.40)} = 2.8 \times 10^{-6}\, T$$

(4+10+2= 16 marks)

(c) The diagram shows a circular loop carrying current I_2 = 3 A, being placed inside a square loop carrying current I_1.= 4A The radius of the circular loop is R = 20 cm and the length for each side of the square loop is L = 40 cm. The distance from the center of the circular loop to the center for each side of the square loop is 2R.



(i) Write down the magnitude and direction of the magnetic field produced by each side of the rectangular coil, at the center of the circular coil.

(ii) Write down the magnitude and direction of the magnetic field produced by the circular coil at its center.

(iii) Determine the magnitude and direction of the TOTAL magnetic field at the center of the circular coil.

Solution:

i) The B field produced by each side of the square loop, at the center of the circular coil is <u>out of the page</u> with magnitude $B = \frac{\mu_0 I_2}{2\pi a} = \frac{\mu_0 4A}{2\pi(0.40\,cm)}$. Since there are 4 sides, then B out of page has a magnitude of $B = 4\frac{\mu_0 I_2}{2\pi a} = \frac{\mu_0 16A}{2\pi(0.40cm)}$

ii) Using the 2nd rite hand rule, the magnetic field produced by the circular coil at the center of the coil is <u>into the page</u> with magnitude $B = \frac{\mu_0 I_2}{2R} = \frac{\mu_0 3A}{2(0.20cm)}$

iii) Using the convention positive for into the page and negative for out of page, then

$$B_T = B_{loop} + B_{square} = \frac{\mu_0 3A}{2(0.20cm)} - \frac{\mu_0 16A}{2\pi(0.40cm)} = \frac{\mu_0}{2(0.40cm)}(6\pi - 16) = -2.52T .$$

Negative means B out of page

(8+2+4= 14 marks)

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