PHYS 122 2021-2022 Spring Semester
Second Midterm
90 Minutes

1	2	3	4	5	Total

Name: ………………………………………… **Student No:**…...................**Department/Lecturer**…………….......

You can use calculator during the exam, but exchanging is not allowed.
Take ϵ_0=8,854x10^{-12} F/m, μ_0 = 4π x 10^{-7} T.m/A, q_e = 1.6 x 10^{-19} C, g = 9.80 m/s^2 if necessary. **Good luck.**

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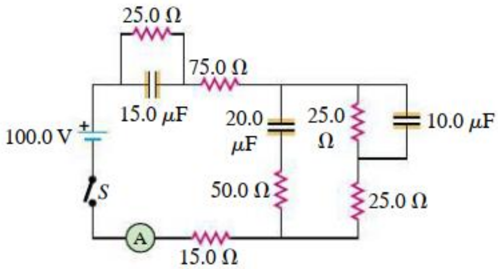
1)- In the circuit shown, the capacitors are initially uncharged, the battery has no internal resistance and the ammeter is idealized. Find the ammeter reading:

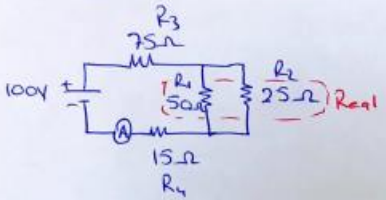
a) just after the swithch S is closed, and

b) after S has been closed for a very long time.



A1

V across uncharged capacitor is zero it behaves like short circuit. (2)

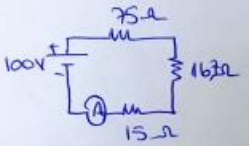


$$\frac{1}{R_{eq1}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{eq1}} = \frac{1}{25} + \frac{1}{50} \quad (2)$$

$$\frac{1}{R_{eq1}} = \frac{3}{50} \qquad R_{eq1} = \frac{50}{3}$$

(2) $\boxed{R_{eq1} = 16,7\,\Omega}$

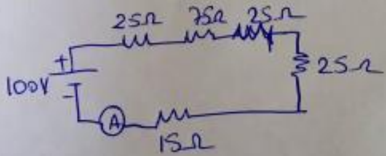


$$R_{Tot} = R_3 + R_4 + R_{eq1} = 75 + 15 + 16,7 = 106,7\,\Omega$$

(3) $\boxed{R_{Tot} = 106,7\,\Omega}$

$(I = \frac{V}{R})$, $I = \frac{100}{106,7} = 0,937\,A$ $\boxed{I = 0,937\,A}$ (3)

b) After capacitors charged-up no current flow through capacitors. (3)



$R_{eq} = 25 + 75 + 25 + 25 + 15$

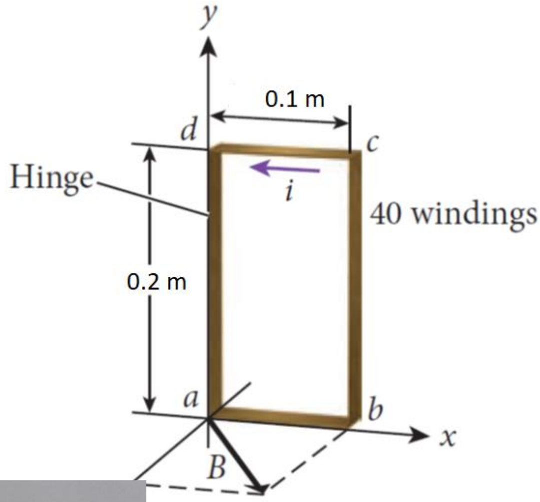
$\boxed{R_{eq} = 165\,\Omega}$ (3)

$$I = \frac{100}{165} = 0,606\,A$$

(4) $\boxed{I = 0,606\,A}$

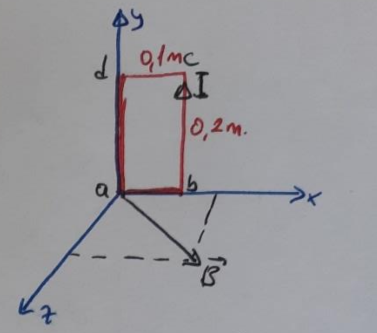
2)- A coil of wire consisting of 40 rectangular loops, with width 0.1 m and height 0.2 m, is placed in a constant magnetic field given by vector $\vec{B} = 2\hat{\imath} + 2\hat{k}$ T. The coil is hinged to a fixed thin rod along the *y*-axis (along segment *da* in the figure) and is originally located in the *xy*-plane. A current of 1.0 A runs through the wire.

a) Find the force acting on ab (F_{ab}) in unit vector notation
b) Find the force acting on bc (F_{bc}) in unit vector notation
c) What is the magnetic moment of the loop?
d) What are the magnitude of the torque?



$\vec{F} = I\,\vec{l} \times \vec{B}$ $N = 40$

$\vec{B} = 2\hat{\imath} + 2\hat{k}$ $I = 1$ Amper



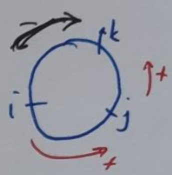
(a) 5 $\vec{F}_{ab} = N\, I\, \vec{L}_{ab} \times \vec{B}$

$\vec{L}_{ab} = (0{,}1\,m)\cdot\hat{\imath}$

$\vec{F}_{ab} = (40)\cdot(1A)\cdot(0{,}1\,m)\left[\hat{\imath} \times (2\hat{\imath} \times 2\hat{k})\right]$

$= 4 \cdot 2\left[\underbrace{\hat{\imath}\times\hat{\imath}}_{0} + \underbrace{\hat{\imath}\times\hat{k}}_{-\hat{\jmath}}\right]$

$= 8(-\hat{\jmath})\,N$



$\boxed{\vec{F}_{ab} = -8\hat{\jmath}\ N}$ $|\vec{F}_{ab}| = 8N$

(b) 5 $\vec{F}_{bc} = N\, I\, \vec{L}_{bc} \times [\vec{B}] = 40\cdot(0{,}2)(2)\left[\hat{\jmath} \times (\hat{\imath} + \hat{k})\right]$

$\vec{L}_{bc} = (0{,}2\,m)\,\hat{\jmath}$ $\vec{F}_{bc} = 16\left[\underbrace{\hat{\jmath}\times\hat{\imath}}_{-\hat{k}} + \underbrace{\hat{\jmath}\times\hat{k}}_{+\hat{\imath}}\right]$

$\boxed{\vec{F}_{bc} = 16(\hat{\imath} - \hat{k})\,N}$

(c) 5 $\vec{\mu} = N \cdot I \cdot \vec{A}$ $\mu = (40)(1A)\cdot(0{,}1\cdot 0{,}2) = 0{,}8$ Amper·meter.

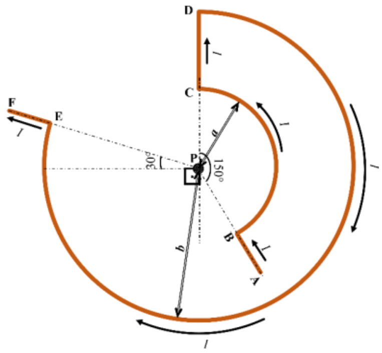
$\vec{\mu} = 0{,}8\,\hat{k}$ Amp.m.

(d) 5 $\vec{\tau} = \vec{\mu} \times \vec{B} = 0{,}8\,\hat{k} \times (2\hat{\imath} + 2\hat{k}) = 1{,}6\,(\underbrace{\hat{k}\times\hat{\imath}}_{+\hat{\jmath}})$

$\vec{\tau} = 1{,}6\,\hat{\jmath}$ N·m. $|\vec{\tau}| = 1{,}6$ N.m.

3)- The figure shows a current (I) carrying wire that consist of interconnected straight (AB, CD, EF) and circular segments (BC, DE). Point P is located at the center of the circular segments. The radius of segment BC is ***a*** and segment DE is ***b***. The lengths of segments EF and AB are half of the length of segment CD. Find the magnitudes of the magnetic fields generated by each segment of the current carrying wire at point P. What should be the ratio of **a** to **b** for the magnetic field at Point P to be zero? (Show your work)

5 points (max) for writing the basic equations:



2 points for writing following equations or similar:

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2} \text{ or } B = \frac{\mu_0}{4\pi}\frac{q}{r^2} v \sin\phi$$

3 points for writing following equations or similar:

$$d\vec{\boldsymbol{B}} = \frac{\mu_0}{4\pi}\frac{Id\vec{\boldsymbol{l}}\times\hat{\boldsymbol{r}}}{r^2} \text{or } dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\phi}{r^2}$$

5 points for writing/finding following equations or similar:

$$B = \frac{\mu_0 I}{2R}$$

6 points (max) for accurately manupilating the basic equation ($B = \frac{\mu_0 I}{2R}$) for segments BC and DE:

3 points for segment BC equation: $B = \frac{\mu_0 I}{2a} \times \frac{150}{360} = \frac{15\mu_0 I}{72a}$

3 points for segment DE equation: $B = \frac{\mu_0 I}{2b} \times \frac{300}{360} = \frac{30\mu_0 I}{72b}$

3 points (max) for implying that B fields are zero for the straight segments

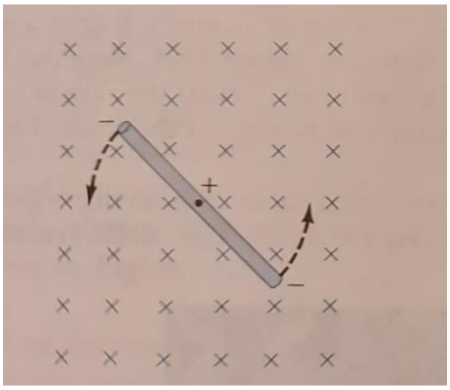
6 points (max) for forming the correct equation to find the answer and/or to accurately calculate/present the answer:

$$\frac{15\mu_0 I}{72a} = \frac{30\mu_0 I}{72b}$$

$$\frac{a}{b} = \frac{1}{2}$$

Note: Cut -1 points for each calculation mistake.

4)- A straight metallic rod is rotating about its midpoint on an axis parallel to a uniform magnetic field (see Figure). The length of the rod is $2L$, and the angular velocity of rotation is ω. What is the induced emf between the midpoint of the rod and each end?



One-half of the rod, from the midpoint to one end, takes a time $2\pi/\omega$ to sweep out the circular area πL^2. (5 point)

The rate at which this piece sweeps out area is $\frac{\pi L^2 \omega}{2\pi} = L^2\omega/2$ (5 point)

and the rate at which it sweeps across magnetic flux is $BL^2\omega/2$ (5 point)

The induced emf $\mathcal{E} = BL^2\omega/2$ (5 point)

5)- A 300 V DC power supply is used to charge a 25 μF capacitor. After the capacitor is fully charged, it is disconnected from the power supply and connected across a 10-mH inductor. The resistance in the circuit is negligible.

(a) Find the frequency and period of oscillation of the circuit.

(b) Find the capacitor charge and the circuit current 1.2 ms after the inductor and capacitor are connected.

2.5 $\omega = \sqrt{\frac{1}{LC}} = \sqrt{\frac{1}{(10 \times 10^{-3}\,\text{H})(25 \times 10^{-6}\,\text{F})}}$

$= 2.0 \times 10^3\,\text{rad/s}$ 3

The frequency f and period T are then

2 $f = \frac{\omega}{2\pi} = \frac{2.0 \times 10^3\,\text{rad/s}}{2\pi\,\text{rad/cycle}} = 320\,\text{Hz}$

2 $T = \frac{1}{f} = \frac{1}{320\,\text{Hz}}$

$= 3.1 \times 10^{-3}\,\text{s} = 3.1\,\text{ms}$

(b) Since the period of the oscillation is $T = 3.1$ ms, $t = 1.2$ ms equals $0.38T$; this corresponds to a situation intermediate between Fig. 30.14b ($t = T/4$) and Fig. 30.14c ($t = T/2$). Comparing those figures with Fig. 30.15, we expect the capacitor charge q to be negative (that is, there will be negative charge on the left-hand plate of the capacitor) and the current i to be negative as well (that is, current will flow counterclockwise).

To find q, we use Eq. (30.21), $q = Q\cos(\omega t + \phi)$. The charge is maximum at $t = 0$, so $\phi = 0$ and $Q = C\mathcal{E} = (25 \times 10^{-6}\,\text{F}) \times (300\,\text{V}) = 7.5 \times 10^{-3}$ C. Hence Eq. (30.21) becomes

$$q = (7.5 \times 10^{-3}\,\text{C})\cos\omega t$$ 2,5

At time $t = 1.2 \times 10^{-3}$ s,

$\omega t = (2.0 \times 10^3\,\text{rad/s})(1.2 \times 10^{-3}\,\text{s}) = 2.4\,\text{rad}$ 2

$q = (7.5 \times 10^{-3}\,\text{C})\cos(2.4\,\text{rad}) = -5.5 \times 10^{-3}\,\text{C}$ 2 → 2,5

the current i at any time is $i = -\omega Q\sin\omega t$. At $t = 1.2 \times 10^{-3}$ s,

$i = -(2.0 \times 10^3\,\text{rad/s})(7.5 \times 10^{-3}\,\text{C})\sin(2.4\,\text{rad}) = -10\,\text{A}$ 2