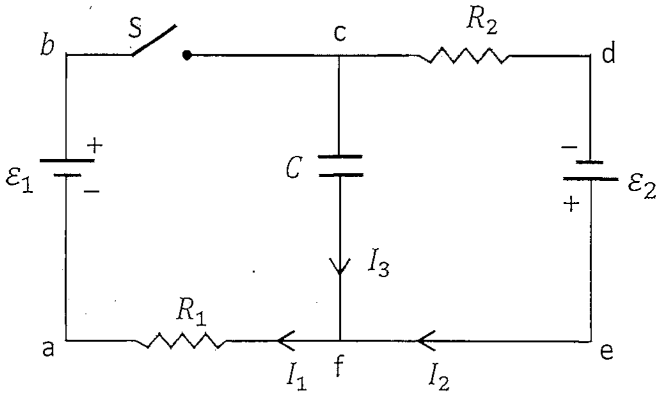
	YTU Physics Department, 2016-2017 Spring Semester		Exam Date: 20 May 2017			Exam Time: 90 min.	
	FIZ1002 Physics-2 Midterm-II		P1	P2	P3	P4	TOTAL
Name Surname							
Registration No							
Department							
Group No	Exam Hall	Signature of the Student	The 9th article of Student Disciplinary Regulations of YÖK Law No.2547 states *"Cheating or helping to cheat or attempt to cheat in exams"* de facto perpetrators takes one or two semesters suspension penalty. Calculators are not allowed. Do not ask any questions about the problems. There will be no explanations. Use the allocated areas for your answers and write legible				
Lecturer's Name Surname							

PROBLEM 1

The switch S in the circuit is initially open and the capacitor is uncharged. In here, $\varepsilon_1 = 1\,V$, $\varepsilon_2 = 3\,V$, $R_1 = 0.2\,\Omega$, $R_2 = 0.3\,\Omega$ and $C = 5\,\mu F$.



a) Find the **currents** running in the circuit and **the charge on the capacitor** after a long time while S is still open.

$I_1 = I_2 = I_3 = 0$ 3

$Q_i = C\,\Delta V_C$ 1

$Q_i = C.\mathcal{E}_2 = (5\mu F)(3V)$

$\boxed{Q_i = 15\mu C}$ 2

b) Now the switch is closed. Find the **currents** and the **charge on the capacitor** after a long time after S is closed.

1 $I_3 = 0$; $I_1 = I_2 = \dfrac{\mathcal{E}_1 + \mathcal{E}_2}{R_1 + R_2}$ 2

$I_1 = I_2 = \dfrac{4}{0.5} = \dfrac{40}{5}$

$\boxed{I_1 = I_2 = 8A}$ 2

Charge; Loop abcfa:

or Q/C

$\mathcal{E}_1 + \Delta V_C - I_1 R_1 = 0$ 3

$\Delta V_C = I_1 R_1 - \mathcal{E}_1 = 8(0.2) - 1$

$\boxed{\Delta V_C = 0.6V}$

$Q_f = C.\Delta V_C = (5\mu F)(0.6)$

$\boxed{Q_f = 3\mu C}$ 3

c) Find **powers supplied by the batteries** and **consumed across the resistors** after switch S is closed for a long time.

$P_{\mathcal{E}_1} = \mathcal{E}_1 I_1 = 1.8 = 8W$ 2

$P_{\mathcal{E}_2} = \mathcal{E}_2 I_2 = 3.8 = 24W$ 2

$P_{\mathcal{E}} = P_{\mathcal{E}_1} + P_{\mathcal{E}_2} \Rightarrow \boxed{P_{\mathcal{E}} = 32W}$

Supplied power

— o —

$P_{R_1} = I_1^2 R_1 = 8^2(0.2) = 12.8W$ 2

$P_{R_2} = I_2^2 R_2 = 8^2.(0.3) = 19.2W$ 2

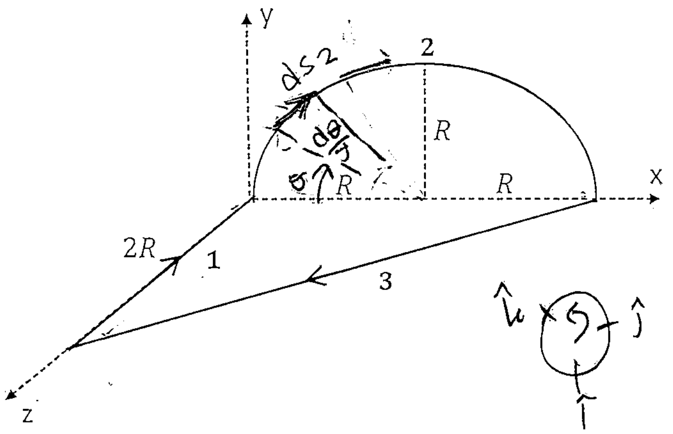
$P_R = P_{R_1} + P_{R_2} = 12.8 + 19.2$

$\boxed{P_R = 32W}$

Consumed power

PROBLEM 2

A closed loop carrying a constant current I is in a uniform magnetic field given by $\vec{B} = B_0(\hat{\imath}+\hat{\jmath})$ (T) as shown in figure ($\pi = 3$).



a) Find the **magnetic forces acting on each wire.**

Wire 1: $\vec{F}_1 = I\vec{l}_1 \times \vec{B}$; $\vec{l}_1 = 2R(-\hat{k})$ (1)

$\vec{F}_1 = 2IRB_0 (-\hat{k}) \times (\hat{\imath}+\hat{\jmath})$

$\boxed{\vec{F}_1 = 2IRB_0 (\hat{\imath}-\hat{\jmath})}$ (3)

Wire 2: $\vec{F}_2 = I\vec{l}_2 \times \vec{B}$; $\vec{l}_2 = 2R\hat{\imath}$ (2)

$\vec{F}_2 = 2IRB_0\, \hat{\imath} \times (\hat{\imath}+\hat{\jmath})$

$\boxed{\vec{F}_2 = 2IRB_0\, \hat{k}}$ (3)

Wire 3: $\vec{F}_3 = I\vec{l}_3 \times \vec{B}$, $\vec{l}_3 = 2R(-\hat{\imath}+\hat{k})$ (2)

$\vec{F}_3 = 2IRB_0 (-\hat{\imath}+\hat{k}) \times (\hat{\imath}+\hat{\jmath})$

$\vec{F}_3 = 2IRB_0 (-\hat{k}+\hat{\jmath}-\hat{\imath})$ (3)

$\vec{F}_3 = 2IRB_0 (-\hat{\imath}+\hat{\jmath}-\hat{k})$

$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$ //

Alternative method for wire 2:

$\vec{F}_2 = I\int d\vec{s}_2 \times \vec{B}$; $d\vec{s}_2 = R\,d\theta\,(\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath})$

$\vec{F}_2 = IRB_0 \int_0^{\pi} \left((\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath}) \times (\hat{\imath}+\hat{\jmath}) \right) d\theta$

$\vec{F}_2 = IRB_0 \int_0^{\pi} (\sin\theta - \cos\theta)\, d\theta\ \hat{k}$

$\vec{F}_2 = IRB_0 \left(-\cos\theta - \sin\theta\right)\Big|_0^{\pi} (\hat{k})$

$\boxed{\vec{F}_2 = 2IRB_0 (\hat{k})}$

b) Find the **magnetic dipole moment** $\vec{\mu}$ of the loop.

$\vec{\mu} = \vec{\mu}_1 + \vec{\mu}_2$ (1)

$\vec{\mu}_1 = I\vec{A}_1 \Rightarrow \vec{\mu}_1 = I\frac{\pi R^2}{2}(-\hat{k})$ (2)

$\vec{\mu}_2 = I\vec{A}_2 \Rightarrow \vec{\mu}_2 = I\frac{4R^2}{2}(-\hat{\jmath})$ (2)

$\vec{\mu} = \frac{3IR^2}{2}(-\hat{k}) + 2IR^2(-\hat{\jmath})$

$\boxed{\vec{\mu} = IR^2\left(-2\hat{\jmath} - \frac{3}{2}\hat{k}\right)}$ (2)

c) Find the **magnetic potential energy** U of the loop.

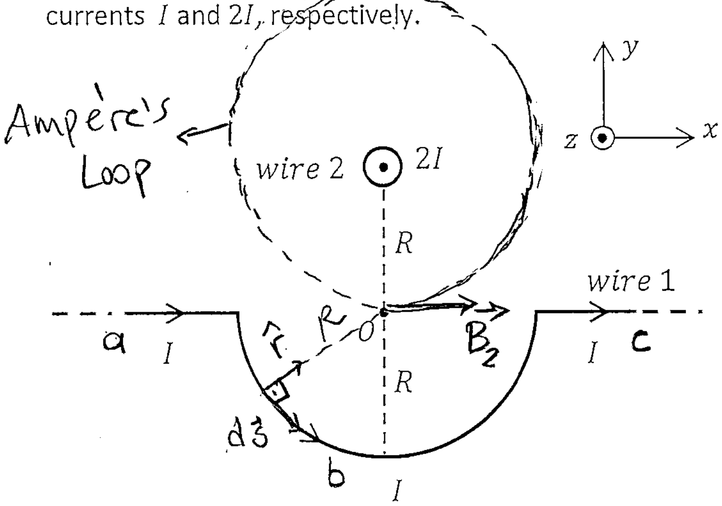
$U = -\vec{\mu}\cdot\vec{B}$ (2)

$U = +IR^2\left(2\hat{\jmath} + \frac{3}{2}\hat{k}\right)\cdot B_0(\hat{\imath}+\hat{\jmath})$ 1

$\boxed{U = 2IB_0R^2}$ (2)

PROBLEM 3

An infinitely long current wire (wire 1) is bent into a semicircle of radius R and two semi-infinitely long straight wires. Wire 1 is placed on xy-plane as shown in figure. Another infinitely long straight wire (wire 2) is placed parallel to z-axis at $y = R$. Wire 1 and wire 2 are carrying currents I and $2I$, respectively.



a) Find the **total magnetic field vector at point O** due to the wire 1 and wire 2.

Wire 1: Since $|d\vec s \times \hat r| = 0$ there is no contribution from segments a and c; $\boxed{B_a = B_c = 0}$ (2)

Segment b: Biot-Savart Law (1) or $B = \frac{\mu_0 I}{4\pi}\int \frac{ds \sin\theta}{r^2}$

$$B_b = \frac{\mu_0 I}{4\pi}\int \frac{|d\vec s \times \hat r|}{r^2} \quad ; \quad \boxed{r = R} \ (1)$$

$|d\vec s \times \vec r| = ds$ direction $\rightarrow \odot\ \hat k$

$$B_b = \frac{\mu_0 I}{4\pi}\int \frac{ds}{R^2} \ (2) = \frac{\mu_0 I}{4\pi R^2}\underbrace{\int ds}_{\pi R}$$

$$B = \frac{\mu_0 I}{4R} \ (2)$$

$$\boxed{\vec B_b = \frac{\mu_0 I}{4R}\hat k} \ (1)$$

$$\vec B_1 = \vec B_a + \vec B_b + \vec B_c$$

$$\boxed{\vec B_1 = \frac{\mu_0 I}{4R}\hat k} \ (2)$$

Wire 2; Ampère's Law

$$\oint \vec B_2 \cdot d\vec s = \mu_0 I_{in} \ (2)$$

$$B_2\, 2\pi R = \mu_0 \cdot 2I \ (2)$$

$$\boxed{\vec B_2 = \frac{\mu_0 I}{\pi R}\hat i} \ (2)$$

$$\vec B_O = \vec B_1 + \vec B_2$$

$$\boxed{\vec B_O = \frac{\mu_0 I}{R}\left(\frac{1}{\pi}\hat i + \frac{1}{4}\hat k\right)} \ (3)$$

b) A charge $+q$ is passing through point O with a velocity of $\vec v = v_0\hat j$. Find **the magnetic force acting on the charge.**

$$\vec F_B = q\,\vec v \times \vec B_o \ (2)$$

$$\vec F_B = \frac{q v_0 \mu_0 I}{R}\,\hat j \times \left(\overbrace{\frac{1}{\pi}\hat i}^{-\hat k} + \underbrace{\frac{1}{4}\hat k}_{\hat i}\right)$$

$$\boxed{\vec F_B = \frac{q v_0 \mu_0 I}{R}\left(\frac{1}{4}\hat i - \frac{1}{\pi}\hat k\right)} \ (3)$$

PROBLEM 4

A circular conductive loop of radius r is placed in a uniform magnetic field $\vec{B} = B_0\hat{j}$ (figure 1). Loop rotates about z-axis with a constant angular speed ω (figure 2). $(\theta = \omega t)$

Figure 1

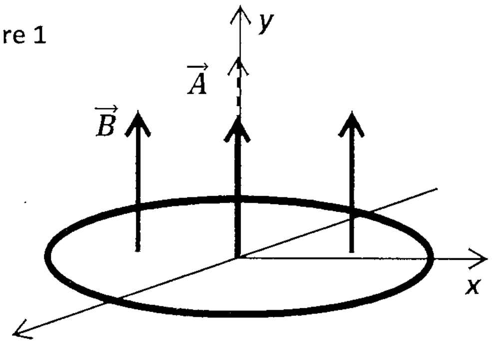
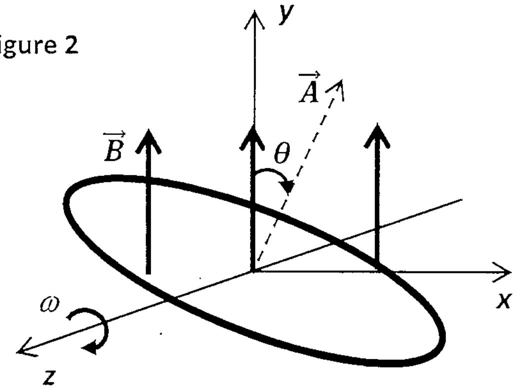


Figure 2



a) Find the **electromotive force induced in the loop** during the rotation.

$$\mathcal{E} = -\frac{d\Phi_B}{dt} \quad 2$$

$$\Phi_B = B_0 A \cos\theta \quad 4 \quad , \quad \theta = \omega t$$

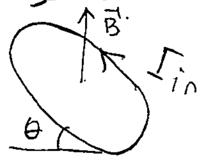
$$\Phi_B = B_0 A \cos\omega t$$

$$\mathcal{E} = -\frac{d}{dt}(B_0 A \cos\omega t) \quad 2$$

$$\boxed{\mathcal{E} = +B_0 A \omega \sin\omega t} \quad 4$$

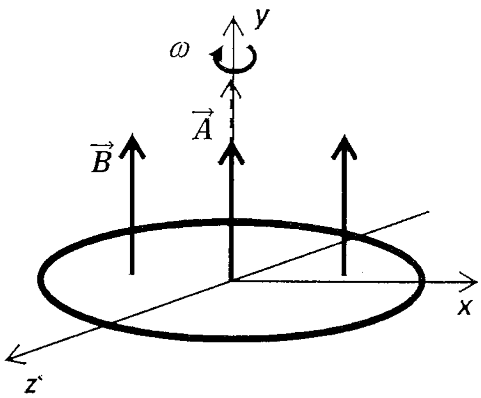
b) If the resistance of the loop is R, find the magnitude of the induced current. **Explain the direction of the induced current** when $0 < \theta < 90$ according to the Lenz Law.

Since magnetic flux decreases when $0<\theta<90$; induced current I_i must be counter clockwise in order to create magnetic field in the same direction. 2



$$I_i = \frac{|\mathcal{E}|}{R} \quad 1 \quad \Rightarrow \quad \boxed{I_i = \frac{B_0 A \omega \sin\omega t}{R}} \quad 3$$

c) Find **the electromotive force induced in the loop** if it rotates about y-axis with a constant angular speed ω.



2

In this case; $\Phi_B = B_0 A \cos 0^\circ$ and constant all the time. Therefore;

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = 0 \quad 5$$