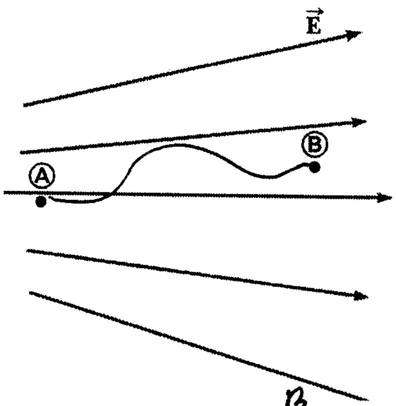
Name KEY

SP212R Exam 2

Points ____\ 100

1. Given the electric field below, the potential difference along a path from A to B is (5 pts):



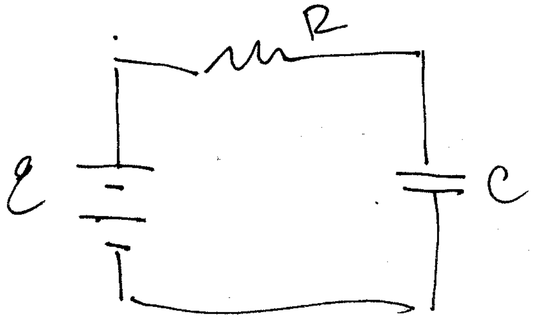
A. 0 V
(B) < 0 V
C. > 0 V
D. NOT ENOUGH INFORMATION

ANSWER B

WORK:

$\Delta V = -\int_A^B \vec{E} \cdot d\vec{s}$ (path) = since $\vec{E} \cdot d\vec{s} > 0$ $\Rightarrow \Delta V < 0$

2. An RC circuit consists of a **50.0 kΩ** resistor in series with a **20.0 μF** capacitor, both connected to a **25.0 V** emf. At what time will the current be at 75% of its maximum? (10 pts)



$I = \frac{\varepsilon}{R} e^{-t/\tau}$

$\tau = RC$

$0.75 \frac{\varepsilon}{R} = \frac{\varepsilon}{R} e^{-t/\tau}$

$e^{-t/\tau} = 3/4$

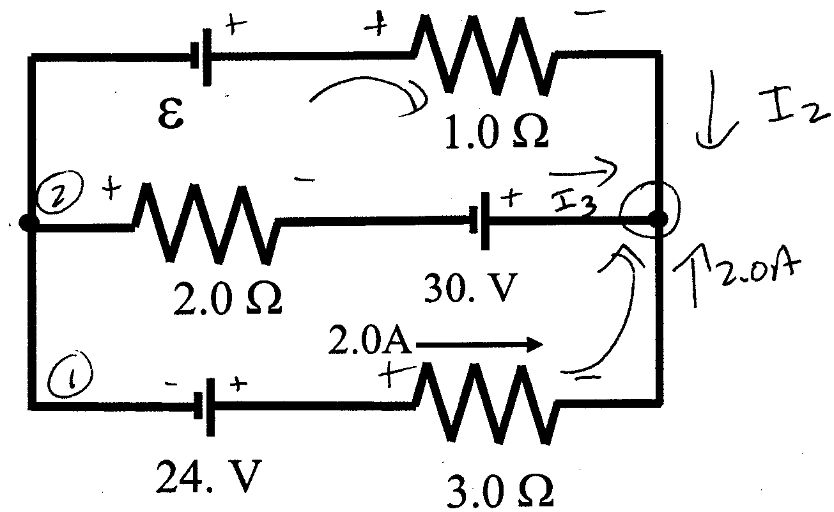
$-t/\tau = \ln(0.75)$

$t = -RC \ln(0.75) = -(50.0 \times 10^3 \Omega)(20.0 \times 10^{-6} F) \ln 0.75$

$t = 0.29 s$

Name_______________________________ SP212R Exam 2

3. Given the following DC circuit as sketched (25 points):



Label currents and then write the necessary Kirchoff Law Equations to solve this circuit here. Then answer the following questions:

1) $2.0A + I_2 + I_3 = 0$

(1) $-30.0V + I_3(2.0\Omega) + 24.0V - (2.0A)(3.0\Omega) = 0$

(2) $\mathcal{E} - I_2(1.0\Omega) - 30.0V + I_3(2.0\Omega) = 0$

a. What is the current in the 2.0 Ω resistor? (5)

Solve (1): $I_3(2.0\Omega) = (2.0A)(3.0\Omega) - 24.0V + 30.0V =$

$I_3 = 6.0\ A$ ~~[illegible]~~)

b. What is the current in the 1.0 Ω resistor? (5)

Solve 1): $2.0A + I_2 + I_3 = 0 \Rightarrow I_2 = -2.0A - I_3 = -2.0$ ~~[illegible]~~) $-6.0A$

$I_2 =$ ~~[illegible]~~ $-8.0A$ (i.e. opposite direction

c. What is the top battery electromotive force, ε? (5)

Solve (2): $\mathcal{E} = I_2(1.0\Omega) + 30.0V - I_3(2.0\Omega) = (-8.0\ A)(1\Omega) + 30.0V - (6.0A)(2.0\Omega)$

$\mathcal{E} =$ ~~[illegible]~~ ~~[illegible]~~ $10.0V$

d. What is the power dissipated in the 3 Ω resistor? (5)

$P = I^2R = (2.0A)^2(3.0\Omega) = 12\ W$

Name______________________________ SP212R Exam 2

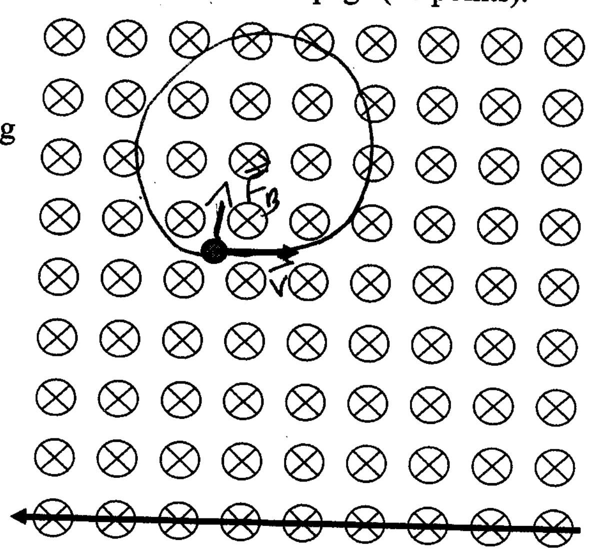
e. The 3 Ω resistor is a cylinder with length of 1 cm and a cross section of 0.0013 m^2. What is the resistivity of the material in the resistor? (5)

$R = \frac{\rho l}{A} \Rightarrow \rho = \frac{RA}{l} = \frac{(3\Omega)(0.0013 m^2)}{0.01}$

$\rho = 0.39\ \Omega m$

4. A proton is traveling at 5.0 x 10^5 m/s in a direction perpendicular to a uniform magnetic field with magnitude 0.0050 T, directed into the page (20 points).

$m_p = 1.67 \times 10^{-27}$ kg
$e = 1.6 \times 10^{-19}$ C



a. Sketch the path of the proton. The magnetic field can be made bigger if needed to complete the path(5)

b. What is the radius of the path? (5)

$F_B = qvB = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{qB} = \frac{(1.67\times10^{-27}\,kg)(5.0\times10^{5}\,m/s)}{(1.60\times10^{-19}\,C)(0.0050\,T)}$

$= \quad r = 1.04\,m$

c. What is the period of the circular motion? (Hint: The period is the time it takes to make one complete circle, i.e., travel a distance equal to the circumference) (5)

$T = \frac{2\pi r}{v} = \frac{2\pi(1.04\,m)}{(5.0\times10^{5}\,m/s)} = 1.31\times10^{-5}\,s$

d. A wire at the bottom of the field is used to supply power to the system that creates the protons (the system not shown). The wire carries a current of 5.0 A and is 20.0 cm long. What is the magnitude **and direction** of the force on the wire? (5)

$\vec{F} = I\vec{\ell}\times\vec{B} \Rightarrow$ downward

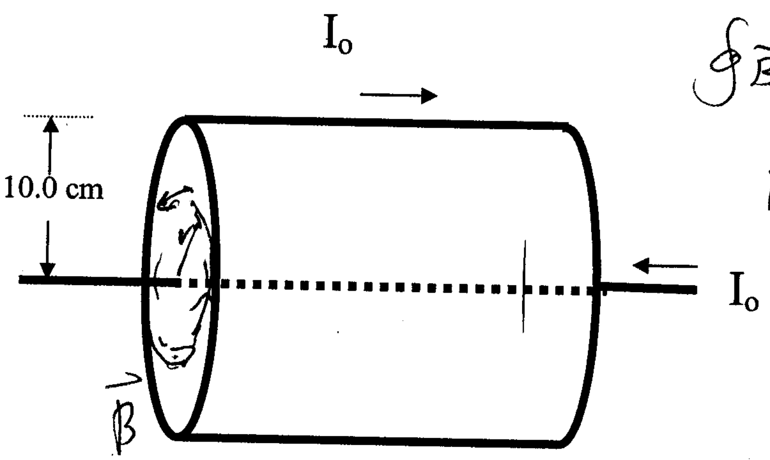
$F = I\ell B = (5.0\,A)(0.2\,m)(0.0050\,T)$

$5\,mN$

Name________________________________ SP212R Exam 2

5. A long straight walled cylindrical shell (hollow and very thin) with a radius of 10.0 cm carries a current $I_o = 5.0$ A to the right. Along the longitudinal axis of the cylinder is a thin wire with a current of I_o to the left. (10 points)

a. Use Ampere's law to find an expression for the magnetic field at a distance of 5.0 cm from the inner wire. **Sketch the direction of this field.** (5)



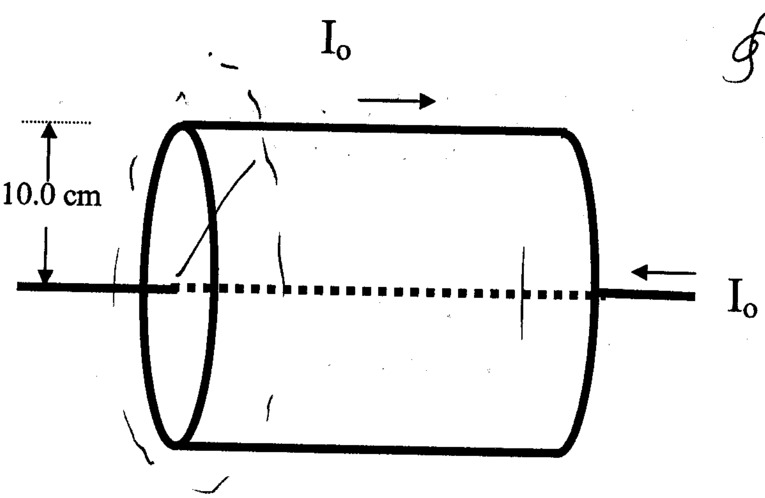
$$\oint \vec{B} \cdot d\vec{s} = \mu_o I_{encl}$$

$$B = \frac{\mu_o I_o}{2\pi r}$$

$$= \frac{(4\pi \times 10^{-7})(5.0\,A)}{2\pi(0.05m)}$$

$$= 2.0 \times 10^{-5}\,T$$

b. Use Ampere's law to find an expression for the magnetic field at a distance of 15.0 cm from the inner wire. **Sketch the direction of this field.** (5)



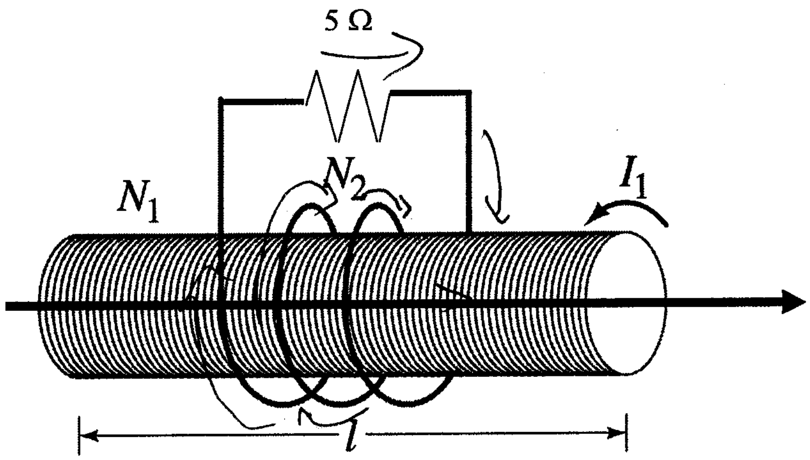
$$\oint \vec{B} \cdot d\vec{s} = \mu_o I_{encl}$$

$$I_{encl} = 0$$

$$\Rightarrow B = 0$$

For any partial credit, be sure you start with Ampere's Law and clearly show the path around which you are integrating.

6. An ideal solenoid show in the center has a cross-sectional area of 0.0050 m^2. Initially, the magnetic field caused by the current shown in the solenoid is 0.10 T. (20 points)



$B_{initial} = 0.10$ T

a. If the number of turns in the solenoid, $N_1 = 100$ and the length of the solenoid, $l = 5.0$ cm, what current, I_1, is necessary to cause the initial magnetic field of 0.10 T. (5)

$B_{sol} = \mu_0 n I \Rightarrow I = \dfrac{B}{\mu_0 (\frac{N}{l})} = \dfrac{0.10\,T}{(4\pi\times10^{-7})(\frac{100}{0.05\,m})}$

$I = 40.0\,A$

b. In a period of 0.020 seconds the current, I_1, increases and the field becomes 0.50 T. What is the change in magnetic flux in the solenoid during these 0.020 seconds? (5)

$\Phi_B = \oint \vec{B}\cdot d\vec{A} = BA$

$\Delta\Phi_B = (B_f - B_0)A = (0.50 - 0.10\,T)(0.0050\,m^2)$
$= 2.0\times10^{-3}\,T$

c. What average electromotive force (voltage) is induced in a larger **two-turn ($N_2 = 2$)** coil with cross section 0.015 m^2 surrounding the smaller solenoid as shown during this 0.020 seconds? (5)

$|\mathcal{E}| = \left|\dfrac{-N\Delta\Phi_B}{\Delta t}\right| = \left|-(2)\left(\dfrac{2.0\times10^{-3}\,T}{0.020\,s}\right)\right| = 0.2\,V$

d. The larger coil is connected to a 5.0 Ω resistor as shown (ignore the resistance of the coil wire). What is the magnitude **and direction** of the current in the resistor while the magnetic field is changing? (5)

$I = \dfrac{\mathcal{E}}{R} = \dfrac{0.2\,V}{5\,\Omega} = 0.04\,A$ to Right

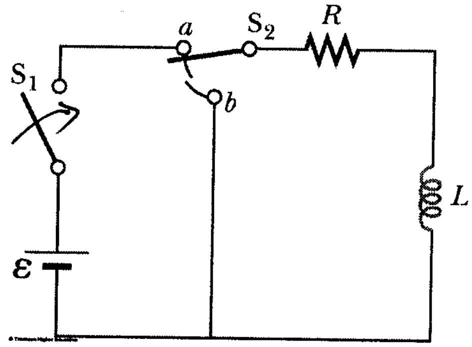
Name________________________ SP212R Exam 2

7. RL circuits and LC circuits (10 pts):

a) What is the inductance of a series *RL* circuit in which $R = 1.0\ \text{K}\Omega$ if the current increases to one-third of its final value in 30 μs (5 pts)?

- **a.** 74 mH
- **b.** 99 mH
- **c.** 49 mH
- **d.** 62 mH
- **e.** none of the above

Answer: A



$I = \frac{\mathcal{E}}{R}(1 - e^{-t/\tau})$; $\tau = L/R$

$0.33 \frac{\mathcal{E}}{R} = \frac{\mathcal{E}}{R}(1 - e^{-t/\tau}) \Rightarrow 0.33 = (1 - e^{-t/\tau})$

$-e^{-t/\tau} = -0.666 = -2/3$

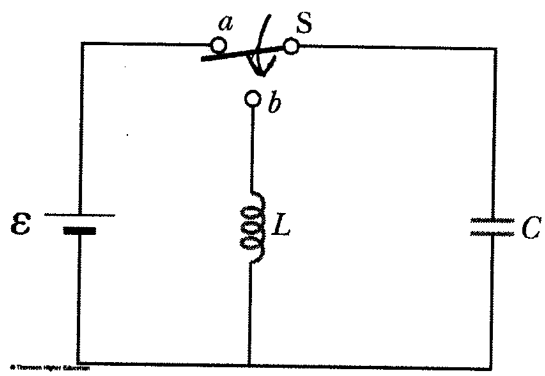
$-t/\tau = \ln(2/3)$

$\Rightarrow \tau = \frac{L}{R} = \frac{-t}{\ln(2/3)}$; $L = (1.0\times10^3\ \Omega)(30\times10^{-6}\ s)/\ln(2/3) = 74.0\ mH$

b) A series *LC* circuit contains a 100 mH inductor, a 36.0 mF capacitor that was charged with a 12 V battery. The frequency of the electromagnetic oscillations in the circuit is (5 pts)

- **a.** 5.73×10^{-4} Hz.
- **b.** 9.55×10^{-3} Hz.
- **c.** 0.442 Hz.
- **d.** 2.66 Hz.
- **e.** 44.0 Hz.

Answer: D



$\omega = \sqrt{\frac{1}{LC}}$

$= \sqrt{\frac{1}{(36.0\times10^{-3}\ F)(100\times10^{-3}\ H)}} = 16.7\ rad/s$

$f = \frac{\omega}{2\pi} = \frac{(16.7\ rad/s)}{2\pi} = 2.65\ Hz$