1.

Physics 9C Winter 2016

Homework 7

$\boxed{1}$ a) $\Phi_B = N_2 A_2 B_1 = N_2 A \frac{N_1 \mu_0}{\ell} I_1$

through loop 2 $\quad A_1 = A_2 \quad$ due to loop 1 $\quad B_1 = n_1 \mu_0 I_1 = \frac{N_1 \mu_0 I_1}{\ell}$

$M = N_1 N_2 \mu_0 A / \ell \qquad \mu_0 \to \mu$ if iron core present

$= (300)(100)\, 4\pi \cdot 10^{-7} \frac{(\pi)(.02)^2}{2.44} \cdot 2000$

$= .0388$ Henries

b) $\mathcal{E} = M\, dI/dt = (.0388)\left(\frac{12}{.098}\right) = 4.75$ volts

$\boxed{2}$ Solenoid $\Phi_B = LI = NA\mu_0 n I = \underbrace{\frac{N^2 A \mu_0}{\ell}}_{L} I$

$L = (20000)^2\, \pi (.037/2)^2\, 4\pi \cdot 10^{-7} / .45$

$= 1.2$ Henries

$\boxed{3}$ $\mathcal{E} = L\, dI/dt$

$8.5 = L \; 45 \cdot 10^{-3} / 21 \cdot 10^{-3} \Rightarrow L = 3.97$ Henries

2.

$\boxed{4}$ Energy $= \frac{1}{2} L I^2 = \frac{1}{2}(.4)(9)^2 = 16.2\ J$

$\boxed{5}$ $\tau = L/R$

$1/2 = e^{-t/\tau}$

$\ln 1/2 = -t/\tau$

$\ln 2 = t/\tau \qquad \tau = t/\ln 2 = 2.56 \cdot 10^{-3}/\ln 2$

$= .00369 \text{ sec} = L/R$

$R = 310/.00369 = 84\ k\Omega$

$\boxed{6}$ Inductor tries to maintain current at previous

a) value. since $I_3 = 0$ before switch closed, $I_3 = 0$ just after closed. Then $I_1 = I_2$ and

$I_1 = I_2 = \mathcal{E}/(R_1 + R_2)$ by kirchoff loop law

b) after a long time, can treat inductor as resistanceless wire. $I_1 = I_2 + I_3$

$R_3 \quad \mathcal{E} - I_1 R_1 - I_2 R_2 = 0$

$\mathcal{E} - I_1 R_1 - (I_1 - I_2) R_3 = 0$

$R_2 \quad \mathcal{E} - I_1(R_1 + R_3) + I_2 R_3 = 0$

$(R_3 + R_2)\mathcal{E} - I_1(R_1 R_3 + R_1 R_2 + R_2 R_3) = 0$

3.

$$I_1 = (R_2 + R_3)\mathcal{E} / (R_1R_2 + R_1R_3 + R_2R_3)$$

Could also do by equivalent resistance method

R_2, R_3 in parallel $\Rightarrow$ $1/R_{eq} = 1/R_2 + 1/R_3$

$$R_{eq} = R_2R_3/(R_2+R_3)$$

in series with R_1

$$I = \mathcal{E}/[R_1 + R_2R_3/(R_2+R_3)]$$

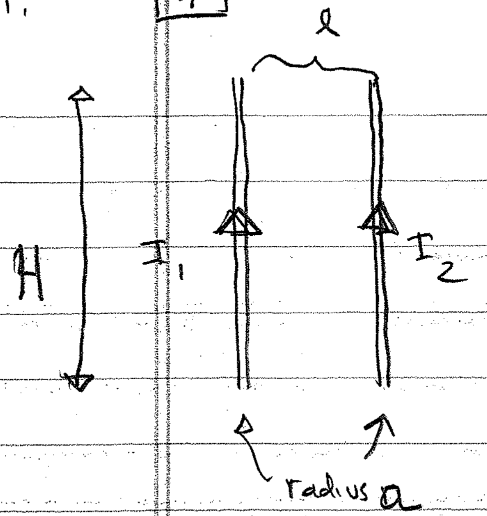
$$= \mathcal{E}(R_2+R_3)/(R_1R_2 + R_1R_3 + R_2R_3)$$

to get I_2, I_3 use

$$I_2 = 1/R_2 (\mathcal{E} - I_1R_1)$$

and $I_3 = I_1 - I_2$

4. $\boxed{7}$



$2\pi r B_1 = \mu_0 I_1$ in region between wires

$$\Phi_{B_1} = H \int_a^{l-a} \frac{\mu_0 I_1}{2\pi r}\, dr$$

H: length of wires

call radius "a" instead of r since like to use r for distance from wire

$$\frac{\Phi_{B_1}}{H} = \int_a^{l-a} \frac{\mu_0 I_1}{2\pi r}\, dr$$

$\frac{\Phi_{B_1}}{H}$: flux per length

$$= \frac{\mu_0}{2\pi} I_1 \ln r \Big|_a^{l-a}$$

$$= \underbrace{\frac{\mu_0}{2\pi} \ln\left(\frac{l-a}{a}\right)}_{\text{inductance per length}} I_1$$

Same calculation for field due to I_2 so final answer is

$$\frac{\mu_0}{\pi} \ln\left(\frac{l-a}{a}\right)$$

5.

$\boxed{8.}$ $F = ma$ ← MASS ON spring

$$-kx - \gamma \frac{dx}{dt} = m \frac{d^2x}{dt^2}$$

$$m \frac{d^2x}{dt^2} + \gamma \frac{dx}{dt} + kx = 0$$

LRC circuit

$$Q/C + L\,dI/dt + IR = 0 \qquad I = dQ/dt$$

$$L \frac{d^2Q}{dt^2} + R\frac{dQ}{dt} + \frac{1}{C} Q = 0$$

$$m \frac{d^2x}{dt^2} + \gamma \frac{dx}{dt} + kx = 0$$

$Q \leftrightarrow x$

$L \leftrightarrow m$

$R \leftrightarrow \gamma$

$1/C \leftrightarrow k$