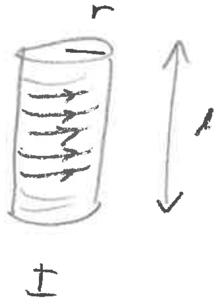
Chpt 32:

(1.)



solenoid: $N = 440$ turns, $\ell = 25$ cm

$r = 1.7$ cm

$A = \pi r^2$ $\quad n = \frac{N}{\ell}$

a) $L = \mu_0 n^2 A \ell$

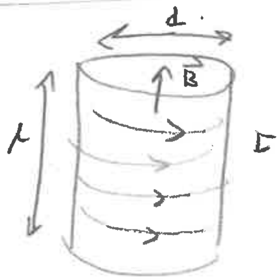
$= \mu_0 \frac{N^2 A}{\ell}$

$= \boxed{0.88\ mH}$

b) $\mathcal{E} = -L \frac{di}{dt}$ solve for $\frac{di}{dt}$ $\rightarrow$ $\frac{di}{dt} = -\frac{\mathcal{E}}{L}$

For $\mathcal{E} = 70\,mV$, $\left|\frac{di}{dt}\right| = \frac{\mathcal{E}}{L} = \boxed{5.88\ \frac{A}{s}}$

(2.)



$I = 36.5\ mA$

$N = 400$ turns

$d = 16.5\ mm$

$\ell = 11.5$ cm

~~a) $B = \mu_0 I n$ (const inside solenoid)~~

$\rightarrow n = \frac{N}{\ell}$, $A = \pi \left(\frac{d}{2}\right)^2$

a) $B = \mu_0 I n$ (constant inside solenoid, pointing upward)

$= 8.07 \times 10^{-5}\ T = \boxed{80.7\ \mu T}$

b) $\Phi_B = NBA = \boxed{6.9 \times 10^{-6}\ T \cdot m^2}$

For single turn $\Phi_B \Big|_{N=1} = BA = \boxed{1.7 \times 10^{-8}\ T \cdot m^2}$

c) Inductance:

$L = \mu_0 n^2 A \ell = 9.57 \times 10^{-5}\ H = \boxed{0.096\ mH}$

d) magnetic field and magnetic flux depend on current

(3.) $L = 70\ mH$ inductor

$i(t) = 3t^2 - 7t$ where t is in seconds

a) $\mathcal{E} = -L\frac{di}{dt} = -L(6t-7)$

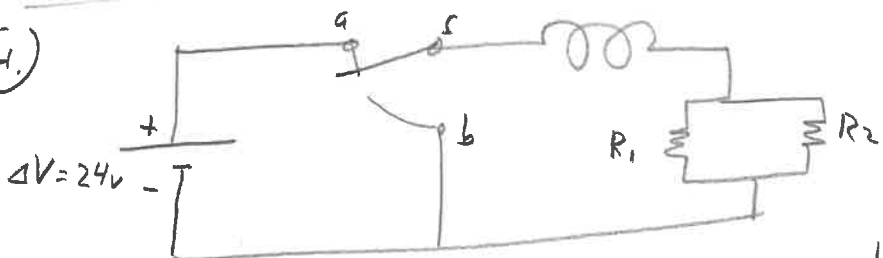
Magnitude $|\mathcal{E}(t)| = L\,|(6t-7)|$

At $t = 1\,sec$, $|\mathcal{E}(t=1sec)| = L \times \frac{1\,Amp}{s} = \boxed{70\ mV}$

b) At $t = 4\,sec$, $|\mathcal{E}(t=4sec)| = L \times 17\frac{A}{s} = \boxed{1{,}190\ mV}$

c) $\mathcal{E} = 0$ when $6t - 7 = 0 \rightarrow \boxed{t = \frac{7}{6}\ sec}$

(4.)



$L = 4.65\ mH$

$R_2 = 445\ \Omega$

$\tau_L = 14.9\ \mu s$

a) $\tau_L = \frac{L}{R_{eff}}$ where $R_{eff} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$

$\rightarrow R_{eff} = \frac{L}{\tau_L} = \boxed{312\ \Omega} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$

$\frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{R_{eff}} \rightarrow \frac{1}{R_1} = \frac{1}{R_{eff}} - \frac{1}{R_2}$

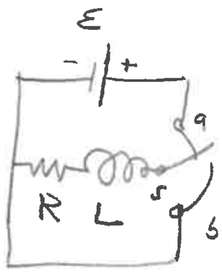
$= \frac{R_2 - R_{eff}}{R_2 R_{eff}}$

so $R_1 = \frac{R_2 \cdot R_{eff}}{R_2 - R_{eff}} = \boxed{1.044\ k\Omega}$

b) Current is maximum when switch thrown to b

$I = \frac{\Delta V}{R_{eff}} = \boxed{77\ mA}$

5.



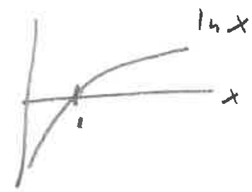
$L = 140\ mH$
$R = 5.2\ \Omega$
$\mathcal{E} = 6.0$ volts

a) After switch is thrown to a

$$i(t) = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau_L}\right), \qquad \tau_L = \frac{L}{R} = \boxed{27\ ms}$$

Find t such that $i(t) = 220\ mA$:

$$\frac{R\,i(t)}{\mathcal{E}} = 1 - e^{-t/\tau_L}$$



$$\rightarrow \quad e^{-t/\tau_L} = 1 - \frac{R\,i(t)}{\mathcal{E}}.$$

$$-t/\tau_L = \ln\left(\frac{\mathcal{E} - R\,i(t)}{\mathcal{E}}\right)$$

$$\boxed{t = -\tau_L \ln\left(\frac{\mathcal{E} - R\,i(t)}{\mathcal{E}}\right) = \tau_L \ln\left(\frac{\mathcal{E}}{\mathcal{E} - R\,i(t)}\right)} = \boxed{5.7\ ms}$$

b) $$i(t = 10\,s) = \frac{\mathcal{E}}{R}\left(1 - e^{-10s/\tau_L}\right) = \boxed{1.15\ A}$$

c) Switch thrown from a to b:

$$i(t) = \frac{\mathcal{E}}{R} e^{-t/\tau_L}$$

Want $i(t) = 160\ mA$

solve for t:

$$e^{-t/\tau_L} = \frac{R\,i(t)}{\mathcal{E}}$$

$$-t/\tau_L = \ln\left(\frac{R\,i(t)}{\mathcal{E}}\right)$$

$$\rightarrow \boxed{t = \tau_L \ln\left(\frac{\mathcal{E}}{R\,i(t)}\right)} = \boxed{53\ ms}$$

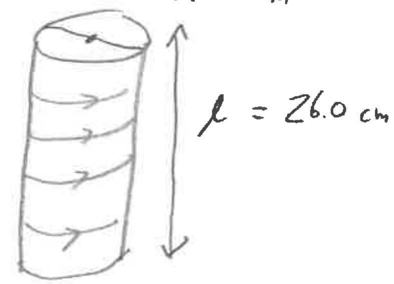
(6.) $E = 147 \frac{V}{m}$, $B = 4.5 \times 10^{-5}$ T

a) $u_E = \frac{1}{2}\epsilon_0 E^2 = \boxed{95.6 \text{ nJ/m}^3}$

b) $u_B = \frac{1}{2\mu_0} B^2 = \boxed{806 \mu\text{J/m}^3}$

(7.) $B = 4.9$ T = const

$d = 6.20$ cm



a) $u_B = \frac{1}{2\mu_0} B^2 = \boxed{9.55 \times 10^6 \frac{J}{m^3}}$

b) $U_B = u_E \cdot$ volume

$= u_E \; \pi \left(\frac{d}{2}\right)^2 \cdot \ell$

$= \boxed{7{,}500 J} = \boxed{7.5 \text{ kJ}}$

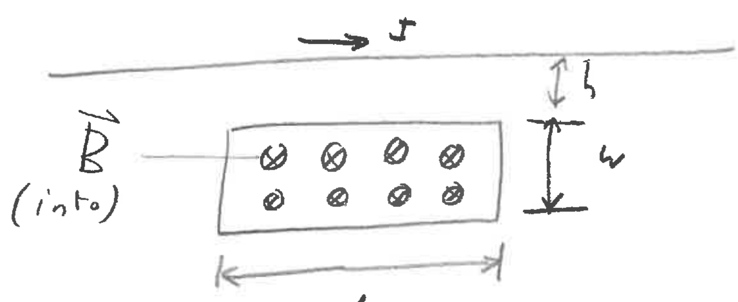
(8.) $M = 130 \mu H$ $\qquad i_0 = 15A \qquad \omega = 1.25 \times 10^3 \frac{rad}{s}$

$i(t) = 15 \sin(1.25 \times 10^3 t) = i_0 \sin(\omega t)$

$\mathcal{E} = -M \frac{di}{dt} = -M i_0 \omega \cos(\omega t)$

$\mathcal{E}_{peak} = M i_0 \omega = \boxed{2.44 V}$

(9.)



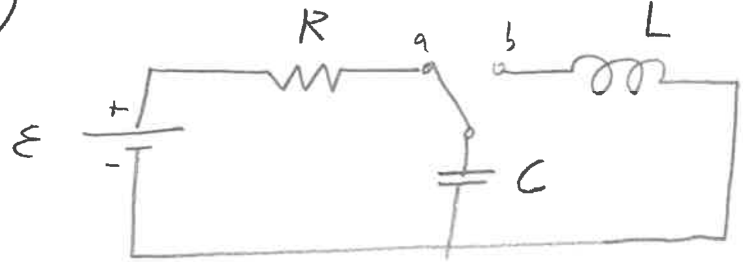
$h = 0.4$ mm
$w = 1.1$ mm
$\ell = 2.7$ mm

$M = \frac{\Phi_B}{I}$, $\Phi_B = \int_S \vec{B} \cdot \hat{n} \, da = \int_{r=h}^{h+w} dr \, \ell \frac{\mu_0 I}{2\pi r} dr$

$= \frac{\mu_0 I \ell}{2\pi} \ln\left(\frac{h+w}{h}\right)$

$\rightarrow \boxed{M = \frac{\mu_0}{2\pi} \ell \ln\left(\frac{h+w}{h}\right)} = \boxed{714 \text{ pH}}$ where $pH = 10^{-12} H$

10.



$R = 10\,\Omega$
$L = 0.1\,H$
$C = 1.1\,\mu F$
$\mathcal{E} = 12\,V$

a) $\omega = \frac{1}{\sqrt{LC}}$, $F = \frac{\omega}{2\pi} = \frac{1}{2\pi\sqrt{LC}} = \boxed{480\ Hz}$

b) max charge on capacitor

$\Delta V = \mathcal{E}$, $Q_{max} = C\,\Delta V = C\,\mathcal{E} = \boxed{13.2\,\mu C}$

c) Energy transferred back and forth between capacitor and inductor

$$E = \frac{1}{2}\frac{Q^2}{C} + \frac{1}{2}L I^2$$

where $E = \frac{1}{2}\frac{Q_{max}^2}{C} = \frac{1}{2}C\mathcal{E}^2 = $ const

Get maximum current when $Q = 0$

$$\rightarrow \quad \cancel{\frac{1}{2}}\frac{Q_{max}^2}{C} = \cancel{\frac{1}{2}}L I_{max}^2$$

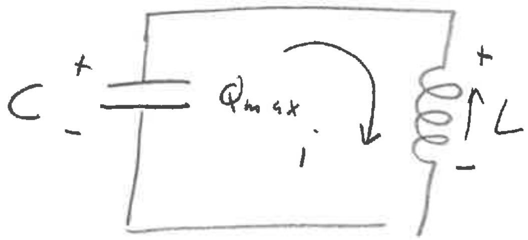
$$I_{max} = \frac{Q_{max}}{\sqrt{LC}} = \boxed{\omega Q_{max}} = \boxed{40\,mA}$$

d) Total energy = const (so has same value at all times)

$$E = \frac{1}{2}C\mathcal{E}^2 = \boxed{79.2\,\mu J}$$

11. $L = 3.3\ H$
$C = 838\ pF$
$Q_{max} = 128\ \mu C$
$t = 4.00\ ms$

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



$$i = -\frac{dQ}{dt}$$

$$\mathcal{E}_L = -L\frac{di}{dt}$$

$$Q = Q_{max} \cos(\omega t), \quad \omega = \frac{1}{\sqrt{LC}}$$

$$i = -\frac{dQ}{dt} = Q_{max}\,\omega \sin(\omega t) = i_{max} \sin(\omega t)$$

where $i_{max} = Q_{max}\,\omega$

a) $$U_C = \frac{1}{2} C \Delta V^2 = \frac{1}{2}\frac{Q^2}{C}$$

$$U_C(t) = \frac{1}{2}\frac{Q_{max}^2}{C}\cos^2(\omega t) = \boxed{8.55\ J}$$

b) $$E = \frac{1}{2}\frac{Q^2}{C} + \frac{1}{2} L I^2 = \text{const}$$

$$E = \frac{1}{2}\frac{Q_{max}^2}{C} = \boxed{9.78\ J}$$

c) $$U_L(t) = \frac{1}{2} L I^2(t) = E - \frac{1}{2}\frac{Q^2(t)}{C}$$

$$= E - U_C(t)$$

$$= \boxed{1.22\ J}$$ (using answers from (a) and (b))