30-9. Note: Eq. 30.7, Eq. 30.8, and Fig. 30.6. If we define ΔV in the same way as we do for a resistor (i.e., so that $\Delta V = +IR$ rather than $\Delta V = -IR$) we have:

$$-\mathcal{E} = \Delta V = L\,\frac{di}{dt}$$

Additionally note that that the ab orientation of the inductor in this problem (Fig. 30.18) is the opposite as in Fig. 30.6.

(a) The word "emf" in the problem suggests $\mathcal{E}$ (rather than ΔV) is requested.

$$\mathcal{E} = -L\,\frac{di}{dt} = -0.260(-.018) = +4.68 \times 10^{-3}\ \mathrm{V}$$

(b) Here $\mathcal{E} > 0$ (or $\Delta V < 0$) so a has the higher potential.

30-15. (a)

$$B = \mu_0 \frac{N}{L} I = 4\pi \times 10^{-7}\,\frac{400}{.25}\,80 = 0.161\ \mathrm{T}$$

(b)

$$u = \frac{B^2}{2\mu_0} = 1.03 \times 10^4\ \mathrm{J/m^3}$$

(c) We make the approximation that the field is uniform inside the solenoid and zero outside the solenoid. (To some extent these approximations result in canceling errors: the magnetic field extends beyond the solenoid (i.e., larger volume), but it is everywhere less than 0.161 T calculated above—in fact about half that value at the solenoid ends.)

$$U = u \cdot \text{Volume} = uAL = 1.03 \times 10^4 \cdot 0.5 \times 10^{-4} \cdot 0.25 = 0.129\ \mathrm{J}$$

(d) Rearrange: $U = \frac{1}{2}LI^2$: $L = 2U/I^2$:

$$L = 2U/I^2 = \frac{2 \cdot 0.129}{80^2} = 4.02 \times 10^{-5}\ \mathrm{H}$$

30-48. (a) For $a < r < b$:

$$B = \frac{\mu_0 i}{2\pi\, r}$$

(b)

$$d\Phi_B = B\ell\,dr = \frac{\mu_0 i \ell}{2\pi}\,\frac{dr}{r}$$

(c)

$$\Phi_B = \int B\,dA = \int B\ell\,dr = \frac{\mu_0 i\ell}{2\pi}\int_a^b \frac{dr}{r} = \frac{\mu_0 i\ell}{2\pi}\,\ln\left(\frac{b}{a}\right)$$

(d)

$$L = \frac{\Phi_B}{i} = \frac{\mu_0 \ell}{2\pi} \ln\left(\frac{b}{a}\right)$$

(e)

$$U = \frac{1}{2} L I^2 = \frac{\mu_0 \ell I^2}{4\pi} \ln\left(\frac{b}{a}\right)$$

30-73. compare to: **old exam #13**

(a) For $a < r < b$:

$$B = \frac{\mu_0 N i}{2\pi\, r}$$

$$d\Phi_B = Bh\, dr = \frac{\mu_0 N i h}{2\pi} \frac{dr}{r}$$

$$\Phi_B = \int B\, dA = \int Bh\, dr = \frac{\mu_0 N i h}{2\pi} \int_a^b \frac{dr}{r} = \frac{\mu_0 N i h}{2\pi} \ln\left(\frac{b}{a}\right)$$

(b) The flux for all N turns is $N\Phi_B$, so

$$L = \frac{N\Phi_B}{i} = \frac{\mu_0 N^2 h}{2\pi} \ln\left(\frac{b}{a}\right)$$

(c) Remark: the book's series is incorrect. . . it should alternate as in:

$$\ln(1+z) = z - \frac{1}{2}z^2 + \frac{1}{3}z^3 - \dots$$

Since we only use the first term in this series, this error should not affect your answer. We use:

$$\ln\left(\frac{b}{a}\right) \approx \frac{b-a}{a}$$

$$L = \frac{\mu_0 N^2 h}{2\pi} \ln\left(\frac{b}{a}\right) \approx \frac{\mu_0 N^2 h}{2\pi} \frac{b-a}{a}$$