Problem 1

An electric field of 1.50 kV/m and a perpendicular magnetic field of 0.400 T act on a moving electron to produce no net force. What is the electron's speed?

No net force:

$$\vec{F}_E + \vec{F}_B = 0$$

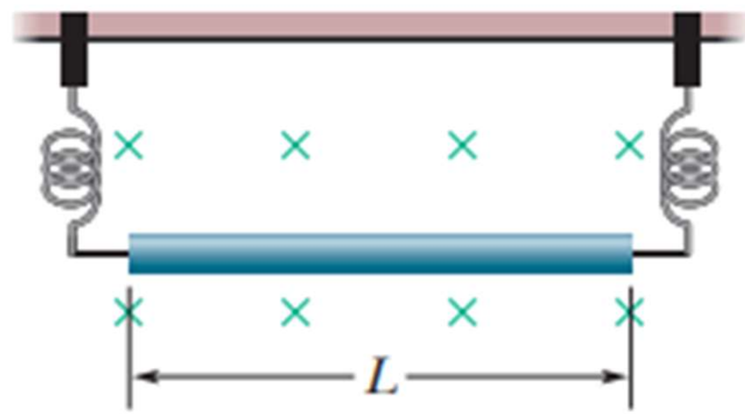
$$\rightarrow |\vec{F}_E| = |\overrightarrow{F_B}|$$

$$\rightarrow \; qE = qvB$$

$$\rightarrow v = \frac{E}{B} = 3.75 \times 10^3 \; (m/s)$$

Problem 2

A 13.0 g wire of length L = 62.0 cm is suspended by a pair of flexible leads in a uniform magnetic field of magnitude 0.440 T (Fig. 28-41). What are the magnitude and direction (left or right) of the current required to remove the tension in the supporting leads?



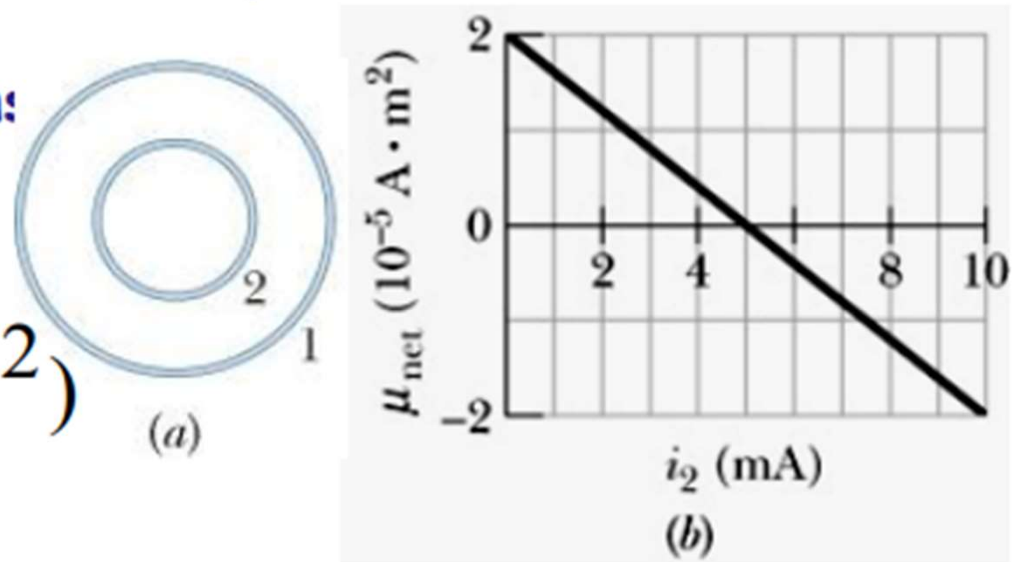
The magnetic force on the wire must be upward and have a magnitude equal to the gravitational force *mg* on the wire.
Since the field and the current are perpendicular to each other the magnitude of the magnetic force is given by FB = iLB, where L is the length of the wire.

$$iLB = mg \quad \Rightarrow \quad i = \frac{mg}{LB} = \frac{(0.0130\,\text{kg})(9.8\,\text{m/s}^2)}{(0.620\,\text{m})(0.440\,\text{T})} = 0.467\,\text{A}.$$

Applying the right-hand rule reveals that the current must be from left to right.

Problem 3

62. In Fig. 28-47a, two concentric coils, lying in the same plane, carry currents in opposite directions. The current in the larger coil i is fixed. Current i_2 in coil 2 can be varied. Figure 28-47b gives the net magnetic moment of the two-coil system as a function of i_2. If the current in coil 2 is then reversed, what is the magnitude of the net magnetic moment of the two-coil system when i_2 = 7.0 mA?



- i_1 and i_2 are in opposite directions

$$\mu_{net} = \mu_1 - \mu_2$$

At i_2 = 0:

$$\mu_{net} = \mu_1 = 2\times10^{-5}(A.m^2)$$

At i_2 = 5 mA:

$$\mu_{net} = \mu_1 - N_2 i_2 A_2 = 2\times10^{-5} - N_2 A_2 \times 5\times10^{-3} = 0$$

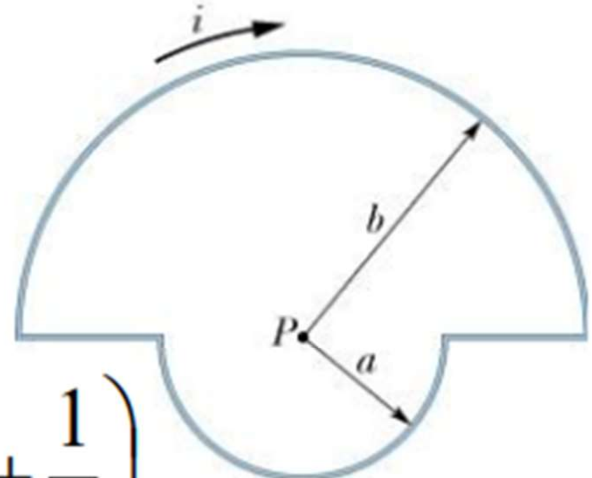
$$\Rightarrow N_2 A_2 = 4.0\times10^{-3}$$

- if i_2 is inversed:

$$\mu_{net} = \mu_1 + N_2 i_2 A_2 = 2\times10^{-5} + 4.0\times10^{-3}\times7\times10^{-3} = 4.8\times10^{-5}(A.m^2)$$

Problem 4

62. In Fig. 29-66, current i = 56.2 mA is set up in a loop having two radial lengths and two semicircles of radii a = 5.72 cm and b = 8.57 cm with a common center P. What are the (a) magnitude and (b) direction (into or out of the page) of the magnetic field at P and the (c) magnitude and (d) direction of the loop's magnetic dipole moment?



(a) The B field due to a circular arc at its center:

$$B = \frac{\mu_0 i \phi}{4\pi R}$$

For the two semicirles:

$$B = B_a + B_b = \frac{\mu_0 i \pi}{4\pi a} + \frac{\mu_0 i \pi}{4\pi b} = \frac{\mu_0 i}{4}\left(\frac{1}{a} + \frac{1}{b}\right)$$

(b) Using the right hand rule, the B direction points into the page

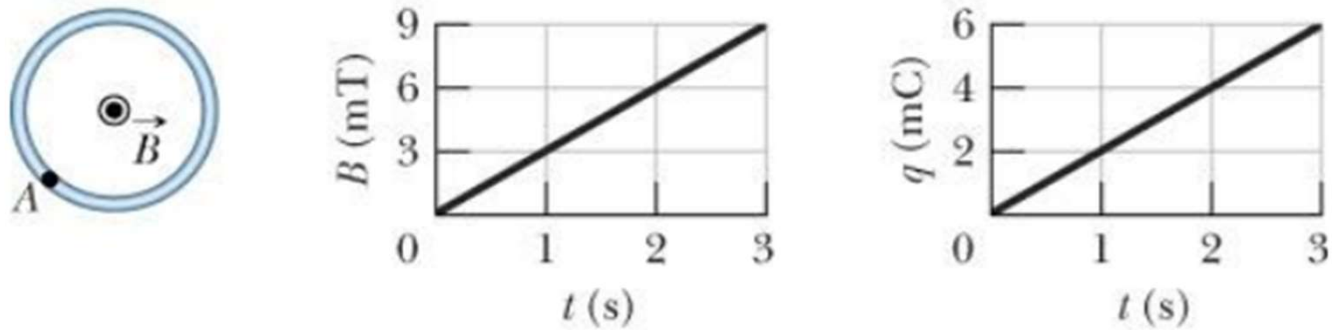
(c) The magnetic dipole moment:

$$\mu = NiA = iA = i\,\frac{\pi(a^2 + b^2)}{2}$$

(d) $\vec{\mu}$ points into the page (the same direction as $\vec{n}$)

Problem 5

10. In Fig. 30-41a, a uniform magnetic field B increases in magnitude with time t as given by Fig. 30-41b. A circular conducting loop of area 8.0×10^{-4} m^2 lies in the field, in the plane of the page. The amount of charge q passing point A on the loop is given in Fig. 30-41c as a function of t. What is the loop's resistance?



(a) (b) (c)

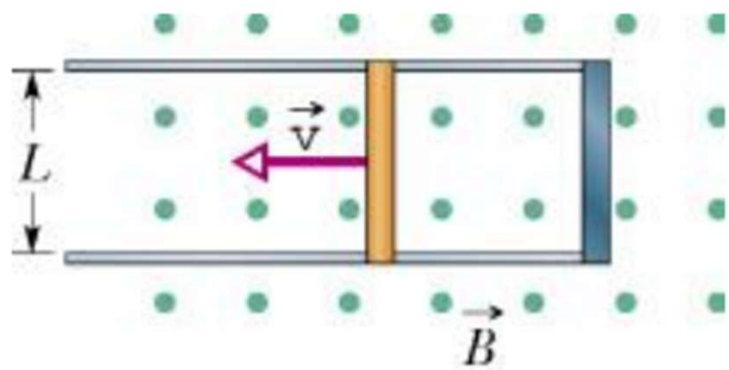
$$\varepsilon = -\frac{d\Phi_B}{dt} = -A\frac{dB}{dt} = -0.003A \quad (V)$$

$$i = \frac{dq}{dt} = 0.002 \quad (A)$$

$$\Rightarrow R = \frac{|\varepsilon|}{i} = \frac{0.003 \times 8 \times 10^{-4}}{0.002} = 0.0012(\Omega)$$

Problem 6

29. In Fig. 30-52, a metal rod is forced to move with constant velocity v along two parallel metal rails, connected with a strip of metal at one end. A magnetic field of magnitude B = 0.350 T points out of the page. (a) If the rails are separated by L = 25.0 cm and the speed of the rod is 55.0 cm/s, what emf is generated? (b) If the rod has a resistance of 18.0 Ω and the rails and connector have negligible resistance, what is the current in the rod? (c) At what rate is energy being transferred to thermal energy?



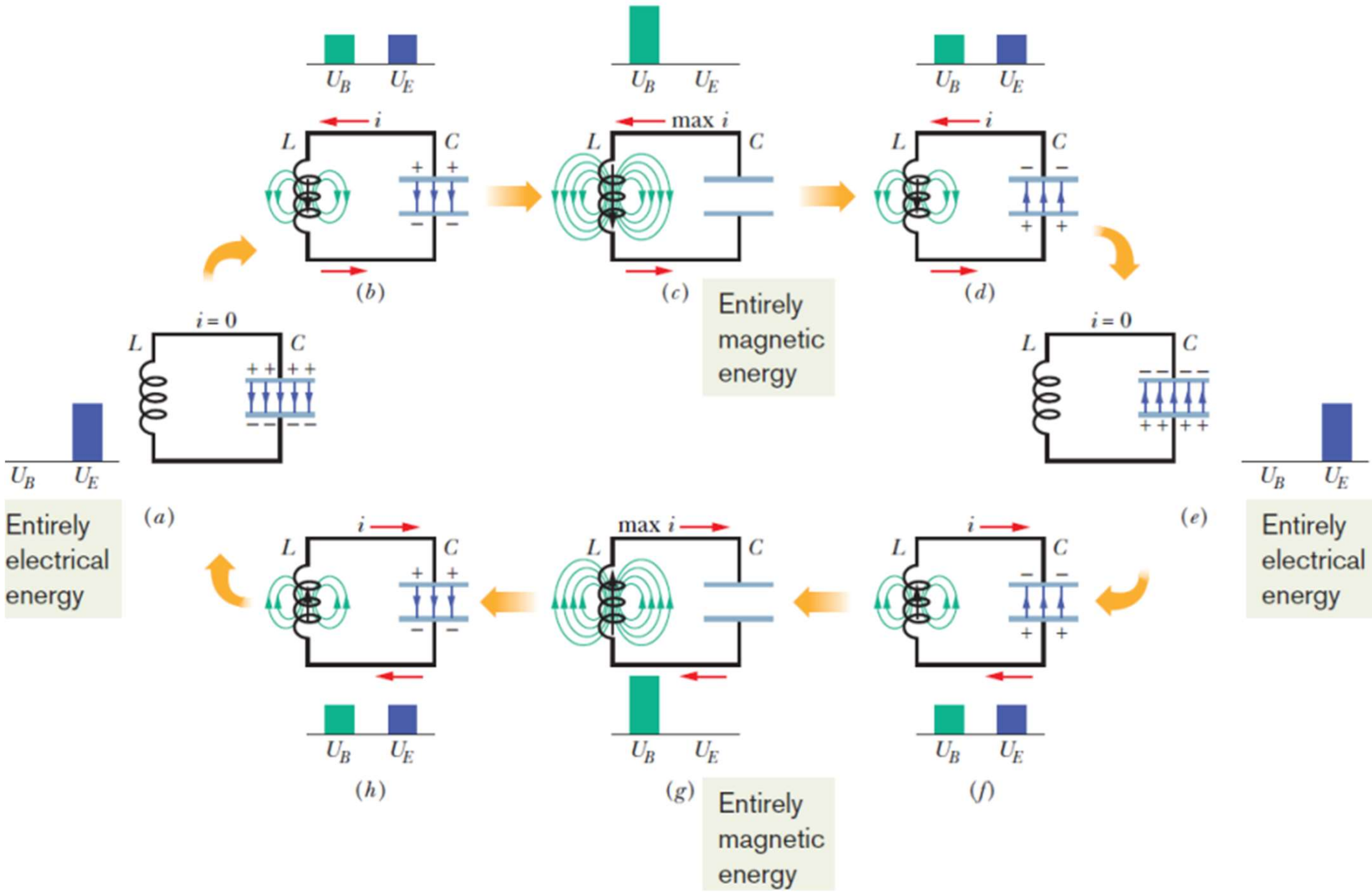
(a) $$\varepsilon = \left| -\frac{d\Phi_B}{dt} \right| = \frac{d(BLvt)}{dt} = BvL$$

$$\varepsilon = 0.35 \times 0.55 \times 0.25 = 0.048(V)$$

(b) $$i = \frac{\varepsilon}{R} = \frac{0.048}{18} = 2.7 \times 10^{-3}(A)$$

using Lenz's law: the current direction is clockwise

(c) $$P = i^2 R = 0.13(mW)$$



U_B U_E
i
L C
(b)
max i
(c)
Entirely magnetic energy
(d)
$i = 0$
(a)
Entirely electrical energy
(e)
Entirely electrical energy
(h)
(g)
Entirely magnetic energy
(f)

Problem 7

9. In an oscillating LC circuit with L = 50 mH and C = 4.0 μF, the current is initially a maximum. How long will it take before the capacitor is fully charged for the first time?

$$i = -I\sin(\omega t + \phi)$$

At t = 0, i is max:

$$\phi = \pm\pi/2$$

$$i = -I\sin(\omega t \pm \pi/2)$$

when the capacitor is fully charged, i = 0:

$$\omega t = \pi/2 \Rightarrow 2\pi\frac{t}{T} = \frac{\pi}{2} \Rightarrow t = \frac{T}{4}$$

$$t = \frac{T}{4} = \frac{2\pi\sqrt{LC}}{4} = \frac{2\pi\sqrt{50\times10^{-3}\times4\times10^{-6}}}{4} = 7\times10^{-4}(s)$$

Problem 8

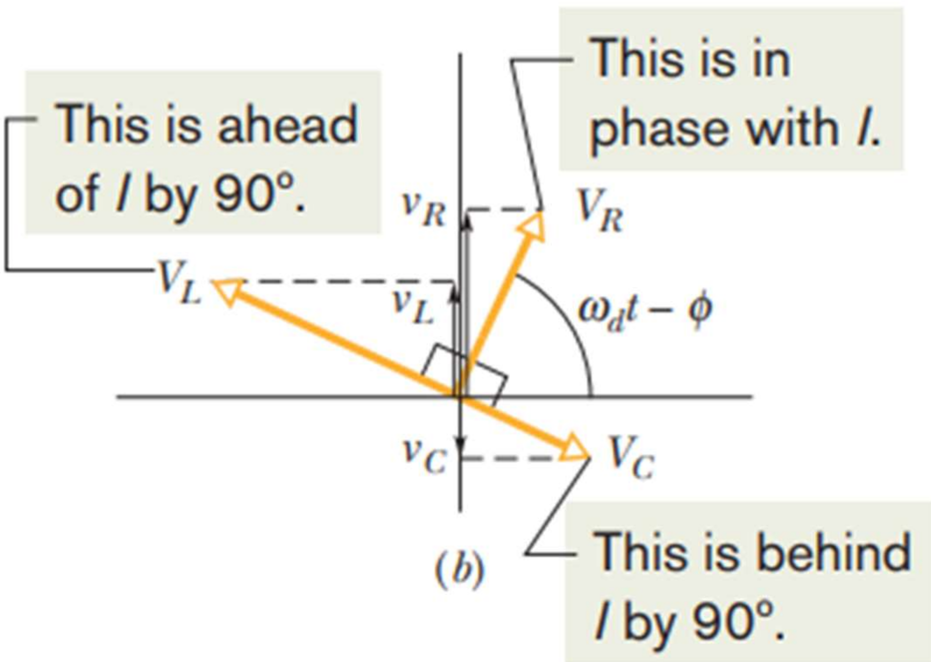
A solenoid has an inductance of 53 mH and a resistance of 0.37Ω. If the solenoid is connected to a battery, how long will the current take to reach **half its final equilibrium value**?

Calculations: According to that solution, current i increases exponentially from zero to its final equilibrium value of $\mathscr{E}/R$. Let t_0 be the time that current i takes to reach half its equilibrium value. Then Eq. 30-41 gives us

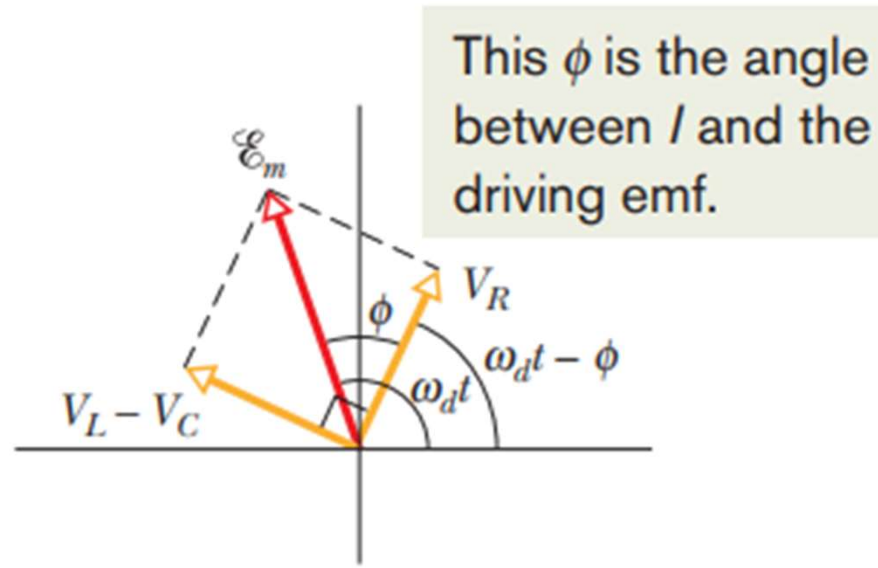
$$\frac{1}{2}\frac{\mathscr{E}}{R} = \frac{\mathscr{E}}{R}(1 - e^{-t_0/\tau_L}).$$

We solve for t_0 by canceling $\mathscr{E}/R$, isolating the exponential, and taking the natural logarithm of each side. We find

$$t_0 = \tau_L \ln 2 = \frac{L}{R}\ln 2 = \frac{53 \times 10^{-3}\ \mathrm{H}}{0.37\ \Omega}\ln 2$$
$$= 0.10\ \mathrm{s}. \qquad \text{(Answer)}$$


This is ahead of I by 90°.
This is in phase with I.
v_R
V_R
V_L
v_L
$\omega_d t - \phi$
v_C
V_C
This is behind I by 90°.

(b)


This ϕ is the angle between I and the driving emf.
$\mathscr{E}_m$
V_R
ϕ
$\omega_d t - \phi$
$\omega_d t$
$V_L - V_C$

(d)

Problem 9

A generator of frequency 3000 Hz drives a series RLC circuit with an emf amplitude of 120 V. The resistance is 40.0 Ω, the capacitance is 1.60 mF, and the inductance is 850 mH. What are (a) the phase constant in radians and (b) the current amplitude? (c) Is the circuit capacitive, inductive, or in resonance?

(a) Using $\omega = 2\pi f$, $X_L = \omega L$, $X_C = 1/\omega C$ and $\tan(\phi) = (X_L - X_C)/R$, we find

$$\phi = \tan^{-1}[(16.022 - 33.157)/40.0] = -0.40473 \approx -0.405 \text{ rad.}$$

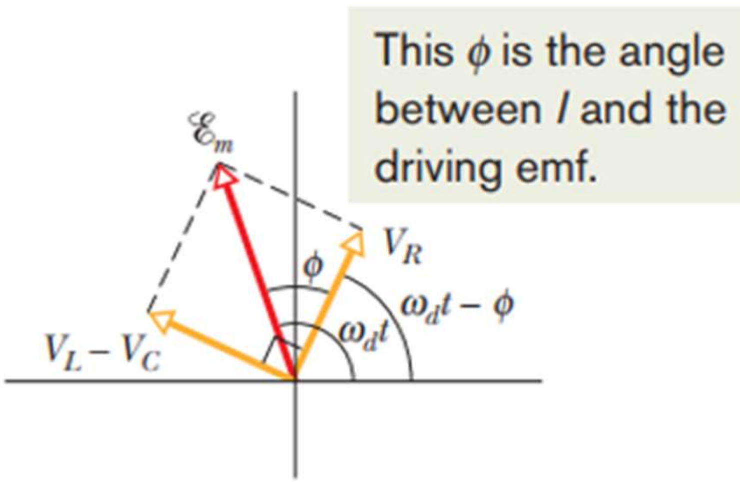
(b) $$I = \frac{\varepsilon_m}{\sqrt{R^2 + (X_L - X_C)^2}} \approx 2.76 \text{ A.}$$

(c) $X_C > X_L \Rightarrow$ capacitive.

Be careful with the numbers!

Problem 10

An alternating source drives a series RLC circuit with an emf amplitude of 6.00 V, at a phase angle of +30.0°.When the potential difference across the capacitor reaches its maximum positive value of 5.00 V, what is the potential difference across the inductor (sign included)?



(*d*)

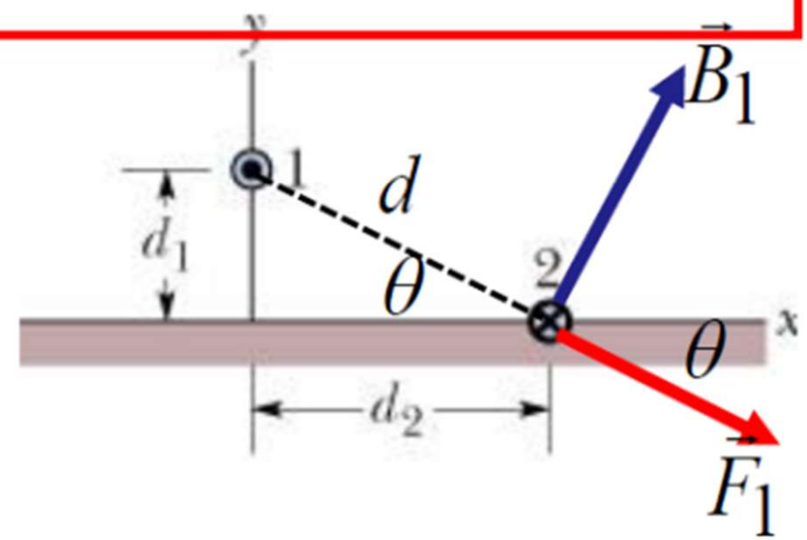
$$V_L - V_C = (6.00\text{ V})\sin(30^\circ) = 3.00\text{ V}.$$

With the magnitude of the capacitor voltage at 5.00 V, this gives a inductor voltage magnitude equal to 8.00 V. Since the capacitor and inductor voltage phasors are 180° out of phase, the potential difference across the inductor is -8.00 V .

Problem 11

35. Figure 29-55 shows wire 1 in cross section; the wire is long and straight, carries a current of 4.00 mA out of the page, and is at distance d_1 = 2.40 cm from a surface. Wire 2, which is parallel to wire 1 and also long, is at horizontal distance d_2 = 5.00 cm from wire 1 and carries a current of 6.80 mA into the page. What is the x component of the magnetic force per unit length on wire 2 due to wire 1?

$$F_1 = \frac{\mu_0 L i_1 i_2}{2\pi d}$$



$$F_{1,x} = F_1 \cos\theta = \frac{\mu_0 L i_1 i_2}{2\pi d}\cos\theta$$

$$F_{1,x} = \frac{\mu_0 L i_1 i_2 d_2}{2\pi d^2} \Rightarrow \frac{F_{1,x}}{L} = \frac{\mu_0 i_1 i_2 d_2}{2\pi\left(d_1^2 + d_2^2\right)}$$