Problem 9.1:
A) I:
\[
\bar{A}(s) = \frac{R}{R + Ls} = \frac{1}{1 + \frac{L}{R}s}; \quad Z_i(s) = R + Ls; \quad Z_o(s) = R
\]

II:
\[
\bar{A}(s) = \frac{Ls}{R + Ls} = \frac{\frac{L}{R}s}{1 + \frac{L}{R}s}; \quad Z_i(s) = R + Ls; \quad Z_o(s) = Ls
\]

B)
Problem 9.2:
A) 
\[
\tilde{A}(s) = \frac{R}{s^2 + \frac{2R}{L_1} + \frac{R}{L_2} + \frac{R^2}{L_1L_2} + \frac{R}{L_1}} = \frac{RL_1s}{s^2 + 2RL_1s + RL_1L_2s + R + L_1s} 
\]

B) Using \(R=1\) k\(\Omega\), \(L_1=1\) mH, \(L_2=0.1\) H
\[
\tilde{A}(s) = \frac{10^6s}{s^2 + (2\times10^6 + 2\times10^4)s + (10^6 \times 10^4)} \frac{10^6s}{s + 2.005\times10^6(s + 0.005\times10^6)} 
\]
\(s_1 = -2.005\times10^6, s_2 = -0.005\times10^6\)

\(0\) dB

\(0\) degrees

\(0\) to \(10^5\) rad/sec

Magnitude (dB)

Phase (deg)
D) From the above graph, the magnitude is almost flat for roughly $10^4 \text{ rad/s} < \omega < 10^6 \text{ rad/s}$
or $1.6 \text{ kHz} < f < 160 \text{ kHz}$

E) For $\omega = 10^5 \text{ rad/s}$,

$$|Z_{L_1}| = |\omega L_1| = 100 \omega \ll R$$

$$|Z_{L_2}| = |\omega L_2| = 10k \omega \gg R$$

$$\bar{A}(j10^5) = \frac{10^6(j10^5)}{(j10^5 + 2.005 \times 10^6)(j10^5 + 0.005 \times 10^6)}$$

$$\omega \frac{10^6(j10^5)}{(2.005 \times 10^6)(j10^5)} = 0.5$$

From the above we can see that $A(j\omega)$ is a constant at this frequency.
To check with the Bode plot, we convert $0.5$ to dB via:

$$dB = 20 \log|A(j\omega)|$$
to obtain $-6 \text{ dB}$.

F) Reading the magnitude and phase from the Bode plot, we have

$$|A(j10^5)| \approx 0.5, \quad < A(j10^5) \approx 0$$

$$v_o(t) = 10 \times 0.5 \cos(\omega t) = 5 \cos \omega t$$
Problem 9.3:
A) The diode is **nonconducting** because the voltage source wants current to flow in the wrong direction for the diode.

\[ v_L(t) = L \frac{di_L(t)}{dt} \]

B) \[ i_L(t) = \int \frac{v_L(t)}{L} dt = \frac{12V}{0.1H} t \] (the constant of integration is zero due to the initial condition)

C) \[ i_L(T = 1sec) = \frac{12V}{0.1H} (1sec) = 120A \]

D) \[ E_L = \frac{1}{2} LI_L^2 = \frac{1}{2} (0.1H)(120A)^2 = 3600 Joules \]

E) After the switch opens, the inductor will force current through the diode so that there isn’t an instantaneous change in the inductor current.

F) After the switch opens, the inductor forces current through diode and we have an LC circuit. The solutions we know are sinusoidal. Therefore, we can write:

\[ v(t) = V_C \sin\left(\frac{t}{\sqrt{LC}}\right) \]

The minus sign comes from the direction of the current that charges the capacitor. To find \( V_C \), we can use conservation of energy:

\[ \frac{1}{2} LI_L^2 = \frac{1}{2} CV_C^2 \]

\[ V_C = I_L \sqrt{\frac{L}{C}} \]

\[ v(t) = \sqrt{\frac{L}{C}} \sin\left(\frac{t}{\sqrt{LC}}\right) \quad t > T \]

G) The diode will stop conducting when the \( v(t) \) reaches a maximum (the inductor current goes to zero). This occurs when \[ \frac{t}{\sqrt{LC}} = \frac{\pi}{2} \]. Plugging in numbers we find that the diode stops conducting at 1.0005s.

H) We know that the capacitor voltage will be at a peak, so we only need to compute the amplitude of the expression derived in part F).

\[ v(1.0005) = \sqrt{\frac{L}{C}} = 37.9V \].