A. 1. a. No. The current drops off as in this graph. (The graph in your notes is charge as a function of time, but it follows from $V = q/C$ and $I = V/R$ that voltage and current drop off the same way.) The curve has an asymptote; it never actually reaches zero.

b. Yes. In this kind of circuit, the current goes back and forth, passing through zero lots of times.

2. $q = Q_{\text{max}} \cos(\omega t + \phi)$

   \[
   \phi = 0 \text{ because the switch was closed at } t = 0.
   \]

   \[
   Q_{\text{max}} = 17 \mu\text{C} \text{ because that was the charge at } t = 0.
   \]

\[
A) \quad t = 100 \mu\text{s} \implies 6.16 \mu\text{C} = (17\mu\text{C}) \cos \left( \omega \cdot 0.0001 \text{s} \right)
\]

\[
\frac{6.16}{17} = \cos \left[ \omega \left( 0.0001 \right) \right]
\]

\[
1.20 \text{ rad} = \omega \left( 0.0001 \text{ sec} \right)
\]

\[
\omega = \frac{12,000 \text{ rad}}{5}
\]

\[
B) \quad \omega = \frac{1}{\sqrt{LC}} \implies \omega^2 = \frac{1}{LC} \implies L = \frac{1}{\omega^2 C}
\]

\[
L = \frac{1}{(12,000)^2 (2.5 \times 10^{-6} \text{ F})} = 2.78 \times 10^{-4} \text{ H}
\]
B. a) \( \tau = RC = (2.00 \times 10^6 \Omega)(6.00 \times 10^{-6} F) = 12.0 \text{ s} \)

For a capacitor charging up: 
\[
q = CV(1-e^{-t/\tau}) = (6.00 \times 10^{-6})(20)(1-e^{-7/12})
\]
\[
= (1.20 \times 10^{-4})(1-.558) = 5.30 \times 10^{-5} \text{ C}
\]

(b) \( C = \frac{Q}{V} \Rightarrow V = \frac{Q}{C} = \frac{5.3 \times 10^{-5} C}{6 \times 10^{-6} F} = 8.83 V \)

(c) Loop rule:
\[
\begin{align*}
&20 V \\
&I \quad \quad \frac{1}{8.83 V} \\
&+20 - 8.83 - V_R = 0
\end{align*}
\]
\( 11.2 V = V_R \)

(d) Ohm's Law: \( V = IR \)
\[
11.2 = I(2 \times 10^{-6} A)
\]
\[
I = \frac{11.2}{2 \times 10^{-6}} = 5.60 \times 10^{-6} A
\]

C. 1. Decreases. More voltage means more charge in the capacitor. \( (Q = CV) \)
More charge in it means more repulsion against additional charge trying to flow in. So, as the capacitor approaches full charge, the current flowing into it approaches zero.

2. a. For a discharging capacitor: 
\[
q = Q_0e^{-t/(RC)} = (40.0 \mu F)e^{-0.0000000075} = (40.0 \mu F)e^{-1.333} = (40.0 \mu F)(.2636) = 10.5 \mu F
\]
b. From \( C = q/V, \quad V = q/C = (10.5 \times 10^{-6} C)/(2.5 \times 10^{-6} F) = 4.22 V \)
c. Applying the loop rule to the circuit shown shows that the voltage across the capacitor is the same as the voltage across the resistor. So, put 4.22 V into Ohm’s law:

\[
I = \frac{V}{R} = \frac{4.22 \text{ V}}{3000 \Omega} = 0.00141 \text{ A}
\]

D.1. 8.00 mH. Inductance is a fixed property of the coil, depending on size, number of windings, and so forth. (The usual mistake here is to confuse inductance with induced emf. The final emf is zero, but that’s not what the question asks.)

2.

\[
a) \quad \tau = \frac{L}{R} = \frac{0.008 \text{ H}}{4 \Omega} = 0.002 \text{ s} \\
b) \quad I = \frac{\frac{6V}{4\Omega}}{\left(1 - e^{-\frac{t}{\tau}}\right)} = \frac{1.5}{1 - e^{-\frac{250 \mu s}{0.002 s}}} = \left(1.5 \times 1175\right) = 1760 \text{ A} \\
c) \quad I = \left(1.5 \times 1 - e^{-\frac{t}{\tau}}\right) = \left(1.5 \times 1 - e^{-\frac{250 \mu s}{0.002 s}}\right) = 1.50 \text{ A}
\]

Final steady-state current is reached when \(t\) becomes very large.
E. 1. The time constant means how long it takes to get 1-1/e (about 63%) of the way from where you started to where you’ll end up.

a. 63% of the way from 15 V down to 0 V would mean you are now at 37% of the original voltage:

\[(1/e)(15 \text{ V}) = (.36788)(15 \text{ V}) = 5.52 \text{ V}\]

b. 63% of the way from 0 V up to 15 V would mean you are now at 63% of the final voltage:

\[(1-1/e)(15 \text{ V}) = (.63212)(15 \text{ V}) = 9.48 \text{ V}\]

2. a. \(q = Q_{\text{max}} \cos(\omega t + \phi)\) where \(\omega = \frac{1}{\sqrt{LC}}\)

\(\phi = 0\) because the process starts at \(t = 0\).

\[\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(0.003H)(2.5 \times 10^{-6} F)}} = 11547 \frac{rad}{s}\]

\(q = (40 \mu C)\cos[(11547)(.0013s)] = 40 \cos(15.01 \text{ rad}) = (40)(-0.7669) = -30.7 \mu C\)

b. \(C = \frac{q}{V} \Rightarrow V = \frac{q}{C} = \frac{-30.7 \times 10^{-6}}{2.5 \times 10^{-6}} = -12.3 \text{ V}\)