Physics 142, Spring 2009

Quiz 4

1. [8 points] An inductor with an inductance of 20.0 mH and a resistance of 5.00 Ω is connected to a 9.00-volt battery. Find the current in the circuit 5.00 ms later.

\[
I_{\text{max}} = \frac{V}{R} = \frac{9.00\ \text{V}}{5.00\ \Omega} = 1.80\ \text{A}
\]

\[
T = \frac{L}{R} = \frac{20.0\ \text{mH}}{5.00\ \Omega} = 4.00\ \text{ms}
\]

\[
I_{\text{max}} - I = I_{\text{max}} e^{-t/T}
\]

\[
(1.8\ \text{A}) - I = (1.8\ \text{A}) e^{-5/4}
\]

\[
I = 1.28\ \text{A}
\]

2. [6 points] A 5.00-μF capacitor is charged by a 30.0-V power supply. The fully charged capacitor is then discharged through a 20.0-mH inductor. Find the maximum current in the resulting oscillations.

\[
Q = CV = (5.00\ \mu\text{F})(30.0\ \text{V}) = 150\ \mu\text{C}
\]

\[
\text{energy} = \frac{Q^2}{2C} = \frac{(150\ \mu\text{C})^2}{2(5.00\ \mu\text{F})} = 2.25\ \text{mJ}
\]

\[
\text{energy} = \frac{1}{2} I^2 L
\]

\[
2.25\ \text{mJ} = \frac{1}{2} I^2 (20.0\ \text{mH})
\]

\[
I = 474\ \text{mA}
\]
3. [6 points] A 400-μF capacitor with an initial charge of 150 μC is connected to a 90.0-mH inductor. Determine the charge left on the capacitor after 5.00 ms.

\[
\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(90.0 \text{ mH})(400 \mu F)}} = 166.7 \text{ rad/sec}
\]

\[Q = Q_0 \cos(\omega t)\]

\[Q = (150 \mu C) \cos[(166.7 \text{ rad/sec})(5.00 \text{ ms})]\]

\[= 101 \mu C\]