**Ex:** The following equation describes the voltage, \( v_L \), across an inductor as a function of time. Find an expression for the current, \( i_L(t) \), through the inductor as a function of time. Assume that \( i_L(t = 0) = 0 \) A.

\[
v_L(t) = 2 + 6(1 - e^{-t/12.5\mu s}) \text{ kV}
\]

**SOL’N:** We use the defining equation for an inductor and solve for \( i \) in terms of \( v \).

\[
v_L = L \frac{di_L}{dt}
\]

First, we multiply both sides by \( dt \).

\[
v_L dt = Ldi_L
\]

Second, we integrate both sides and use limits that correspond to the variable of integration for each side and are evaluated at the same points in time for both sides.

\[
\int_0^t v_L dt = \int_{i_L(t=0)}^{i_L(t)} Ldi_L
\]

The integral on the right side simplifies nicely.

\[
\int_0^t v_L dt = Li_L|_{i_L(t=0)}^{i_L(t)} = L[i_L(t) - i_L(t = 0)]
\]

or

\[
i_L(t) = \frac{1}{L} \int_0^t v_L dt + i_L(t = 0)
\]

The above expression applies to any inductor in any circuit.

We now substitute the formula given for \( v_L(t) \) and the value given for \( i_L(t = 0) \) to find \( i_L(t) \):

\[
i_L(t) = \frac{1}{L} \left[ \int_0^t \left(2 + 6(1 - e^{-t/12.5\mu s})\right) \text{ kV} \right] dt + 0 \text{ A}
\]

or

\[
i_L(t) = \frac{1}{L} \left[ \int_0^t \left(8 - 6e^{-t/12.5\mu s}\right) \text{ kV} \right] dt + 0 \text{ A}
\]

or
\[ i_L(t) = \frac{1}{L} \left[ 8t|_0^f + 6 \cdot 12.5 \mu s \cdot e^{-t/12.5 \mu s}|_0^f \right] \text{kV} \]

or

\[ i_L(t) = \frac{1}{L} \left[ 8t + 75 \mu s \cdot \left( e^{-t/12.5 \mu s} - 1 \right) \right] \text{kV} \]

or

\[ i_L(t) = \frac{1}{L} \left[ 8 \text{kV} \cdot t + 75 \text{mV} \cdot \left( e^{-t/12.5 \mu s} - 1 \right) \right] \]

Using \( L = 10 \text{ mH} \) we find the final numerical answer.

\[ i_L(t) = \frac{1}{10 \text{ mH}} \left[ 8 \text{kV} \cdot t + 75 \text{mV} \cdot \left( e^{-t/12.5 \mu s} - 1 \right) \right] \]

or

\[ i_L(t) = 0.8 \text{MA} \cdot t + 7.5 \text{A} \cdot \left( e^{-t/12.5 \mu s} - 1 \right) \]