1. (13 pts) The current through and the voltage across an unknown component are shown below.
   a) What type of component is it? Give a good reason for your choice.
   b) What is the value of the component?

2. (27 pts) a) The switch has been closed for a long time and is opened (as shown) at time \( t = 0 \). Find the initial and final conditions and write the full expression for \( v_C(t) \), including all the constants that you find.
   b) What is \( v_C \) at 1.1ms?
   c) At time \( t = 1.1 \text{ms} \) the switch is closed again. Find the complete expression for \( v_C(t') \), where \( t' \) starts when the switch closes. Be sure to clearly show the time constant.

3. (22 pts) \( Z_{eq} \) is the total impedance between the two terminals
   a) Find an expression for \( Z_{eq} \) without any numbers, just in terms of \( j \), \( \omega \), \( L \), \( C \), & the Rs.
   b) Find \( Z_{eq} \) in numeric form (polar or rectangular). For partial credit, you must show work and/or intermediate results.
   c) If you applied a sinusoidal voltage to this impedance:
      (Circle 1)
      i) The current would lead the voltage
      ii) The voltage would lead the current
4. (21 pts) a) Find $Z_1$. For partial credit, you must show work and/or intermediate results.

\[ I_T := (20 - 6j) \text{mA} \]

\[ I_1 = 8 \text{mA} / 20^\circ \]

\[ Z_1 = ? \]

\[ Z_2 = 1k\Omega / 12^\circ \]

b) To make $Z_1$ in the simplest way, what part(s) would you need? Just circle the needed part(s), don’t find the values.

- resistor
- capacitor
- inductor
- power supply
- current source
- Thevenin resistor
- Ideal transformer
- voltmeter
- ammeter
- scope

5. (17 pts) Two voltage waveforms are shown below, $v_1(t)$ and $v_2(t)$. Find the sum of the two ($v_3(t) = v_1(t) + v_2(t)$), and express it as a cosine wave with the correct amplitude and phase angle. You do not need to determine $\omega$, just use the symbol $\omega$.

\[ v_3(t) = v_1(t) + v_2(t) \]

Answers

1.a) inductor: $v(t) := \frac{L}{dt} i(t)$ This fits the graphs, $v(t)$ corresponds to slope of $i(t)$ Besides, capacitor voltage can’t change instantly.

b) $8 \cdot \text{mH}$

2.a) $18 \cdot \text{V} - 13.5 \cdot \text{V} \cdot e^{\frac{t}{0.9 \text{ms}}}$

b) $14 \cdot \text{V}$

c) $4.5 \cdot \text{V} + 9.5 \cdot \text{V} \cdot e^{\frac{t}{0.45 \text{ms}}}$

3.a) $Z_{eq} := \frac{1}{R + j\omega L + j\omega C}$

b) $(12.5 - 11.4j) \cdot \Omega$

c) $i$

4. $1905\Omega / -43^\circ$

5.a) $10 \cdot \text{V} \cdot \cos(\omega \cdot t + 36.9\text{deg})$

b) $Z_1$ has a negative phase angle of less than $90^\circ$, so you need: resistor & capacitor