2. Relative dielectric constant for water is 78.5.

The transducer consists of two capacitors in parallel:
- One above the surface of the liquid.
- One below the surface of the liquid.

\[ C_{\text{above}} = 200 \times \frac{100 - x}{100} = 200 - 2x \]
\[ C_{\text{below}} = 200 \times \frac{x}{100} \times 78.5 = 157x \]

\[ C_{\text{total}} = C_{\text{above}} + C_{\text{below}} = 200 + 155x \text{ pF} \]

Now, suppose there are 100 cm of water.

\[ C_{\text{total}} = 200 \times 78.5 = 15700 \text{ pF} \]

However, if the top 1 cm is oil rather than water:

\[ C_{\text{water}} = 200 \times \frac{99}{100} \times 78.5 = 15543 \]
\[ C_{\text{oil}} = 200 \times \frac{1}{100} \times 10 = 20 \]

\[ C_{\text{total}} = 15543 + 20 = 15563 \text{ pF} \]

\[ \Delta C_{\text{total}} = 15700 - 15563 = 137 \text{ pF} \]
3. Find open-circuit voltage

\[ V_{oc} = \frac{10 \times 2.13}{4.7 + 2.13} = \frac{23}{7} = 3.29 \text{ V} \]

Find Thévenin Resistance

\[ R_{eq} = 6.8 + \frac{1}{\frac{1}{4.7} + \frac{1}{2.13}} = 8.34 \text{ k\Omega} \]

\[ I_{sc} = \frac{V_{oc}}{R_{eq}} = 0.39 \text{ mA} \]

Thévenin equivalent

Norton equivalent
4. Find open-circuit voltage through superposition

\[ V_{oc1} = 2.5 \text{ V} \]

\[ V_{oc2} = -5 \text{ V} \]

\[ V_{oc} = V_{oc1} + V_{oc2} = -2.5 \text{ V} \]

Find Thévenin resistance by short-circuit current by superposition

\[ I_{sc1} = 1 \text{ A} \]

\[ I_{sc2} = -2 \text{ A} \]

\[ I_{sc} = I_{sc1} + I_{sc2} = -1 \text{ A} \]

\[ R_{eq} = \frac{V_{oc}}{I_{sc}} = 2.5 \Omega \]

Find Thévenin resistance in alternative way

\[ R_{eq} = \frac{1}{\frac{1}{5} + \frac{1}{5}} = 2.5 \Omega \]

Thévenin equivalent is below
5. The battery can be considered as a circuit with the \textit{venn equivalent}

\[ V_{oc} = 6V = V_T \]

The measured current when connecting a 40\,\Omega is -0.11:

\[ R_{eq} + 40 \Rightarrow \frac{6}{1125} = 53.33 \]

\[ R_{eq} = 13.33 \, \Omega = R_T \]
Analysis: Specify a ground node and the polarity of the voltage across \( R \). Suppress the voltage source by replacing it with a short circuit. Redraw the circuit, as shown in Figure 3.30(b), and apply KCL:

\[
-I_b + \frac{V_{R-I}}{R_b} + \frac{V_{R-I}}{R_g} + \frac{V_{R-I}}{R} = 0
\]

\[
V_{R-I} = \frac{I_b}{1/R_b + 1/R_g + 1/R} = \frac{12}{1 + 1/0.3 + 1/0.23} = 1.38 \text{ V}
\]

Suppress the current source by replacing it with an open circuit, draw the resulting circuit, as shown in Figure 3.30(c), and apply KCL:

\[
\frac{V_{R-V}}{R_b} + \frac{V_{R-V} - V_G}{R_g} + \frac{V_{R-V}}{R} = 0
\]

\[
V_{R-V} = \frac{V_G/R_g}{1/R_b + 1/R_g + 1/R} = \frac{12/0.3}{1 + 1/0.3 + 1/0.23} = 4.61 \text{ V}
\]

Finally, we compute the voltage across \( R \) as the sum of its two components:

\[
V_R = V_{R-I} + V_{R-V} = 5.99 \text{ V}
\]

Comments: Superposition essentially doubles the work required to solve this problem. The voltage across \( R \) can easily be determined by using a single KCL.

\[
C_{total} = \frac{1}{\frac{1}{1015} + \frac{1}{1022 + 0.1}} = 0.1 \mu \text{F}
\]

\[
L_{total} = \frac{1}{\frac{1}{2} + \frac{1}{1+2.5}} = 1.62 \text{ mH}
\]
8. \[ I_0 = C \frac{d}{dt} V_c(t) \]

\[ dV_c = \frac{I_0}{C} \, dt \]

Integrating: \[ V_c = \frac{I_0}{C} \int dt \]

\[ = \frac{I_0 t}{C} + k \]

\( k \) represents the value of \( V_c \) at time \( t = 0 \)

\[ k = 0 \]

\[ V_c = \frac{10 \text{ mA}}{10 \text{ mF}} \cdot t = 1000 t \text{ vol} \]

9.

\[ Q = CV = 5 \times 10^{-6} \times 10^3 = 5 \text{ mC} \]

\[ W = \frac{1}{2} Cv^2 = \frac{1}{2} \times 5 \times 10^{-6} \times (10^3)^2 = 2.5 \text{ J} \]

\[ P = \frac{\Delta W}{\Delta t} = \frac{2.5}{10^{-6}} = 2.5 \text{ MW} \]
\[ i(t) = C \frac{dv}{dt} \]
\[ = 10^{-6} \frac{d}{dt} (100e^{-100t}) \]
\[ = -0.01e^{-100t} \text{ A} \]

\[ p(t) = v(t)i(t) \]
\[ = -e^{-200t} \text{ W} \]

\[ w(t) = \frac{1}{2} C[v(t)]^2 \]
\[ = 5 \times 10^{-3} \times e^{-200t} \text{ J} \]