(1) Develop the Thevenin equivalent circuit as seen looking into terminals a-b of the circuit of Figure 1. Using your Thevenin circuit, connect a 100 Ω resistor between terminals a-b and determine $V_{ab}$.

![Circuit Diagram](image1.png)

Figure 1: Circuit for problem 1.

(2) Find $I_b$ in the network of Figure 2 using Thevenin’s theorem.

![Circuit Diagram](image2.png)

Figure 2: Circuit for problem 2.
(3) You are given the circuit of Figure 3.

(a) Place a short across a-b and determine the current flowing from a to b. Call this $I_b$.

(b) Find the Thevenin resistance looking into terminals a-b.

(c) Draw the Norton equivalent circuit as seen by looking into terminals a-b.

Figure 3: Circuit for problem 3.

(4) You are given the circuit of figure 4. The circuit is in steady state. In other words, I as shown in the circuit, equal 0. Find $v_1$, $v_2$, and $v_3$. How much energy is stored in the 5 μF capacitor?

Figure 4: Circuit for problem 4.
(5) Determine the voltage gain $V_{\text{out}}/V_{\text{in}}$ for the op amp circuit shown in Figure 5. Your answer should be a function of $R_A, R_B, R_C, R_D$.

![Circuit for problem 5](image)

Figure 5: Circuit for problem 5.

(6) For the op amp circuit shown in Figure 6, find the value of $R_X$ that results in $V_{\text{out}} = 20V_{\text{in}}$.

![Circuit for problem 6](image)

Figure 6: Circuit for problem 6
(1) Find the Thévenin. Attach 100Ω, find \( V_{ab} \)

To find \( R_{TH} \): Remove (Reactivate) independent sources.

Practically by inspection

\[ R_{TH} = 25Ω \]

To find \( V_{TH} \):

\[
\begin{bmatrix}
100 & -100 \\
-100 & 150
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2
\end{bmatrix}
= 
\begin{bmatrix}
-50 \\
25
\end{bmatrix}
\]

\[ I_1 = -1.25 A \quad I_2 = 0 \]

\[ V_{TH} = I_2 \times 50 = 0 \]

\( V_{ab} = 0 \)
(2) Find \( i_o \) using Thevenin:

\[
\begin{align*}
\text{To Find } R_{\text{TH}}
\end{align*}
\]

\[
R_{\text{TH}} = 12 \, \text{K} \Omega
\]

\[
\begin{align*}
\text{To Find } V_{\text{TH}}
\end{align*}
\]

\[
V_{\text{TH}} = V_{\text{ab}}
\]

\[
-V_{\text{ab}} + 12 - (12 \, \text{K}) (4 \, \text{K}^2) = 0
\]

\[
V_{\text{ab}} = 12 - 48 = -36 \, \text{V}
\]

\[
\begin{align*}
\text{To Find } i_o
\end{align*}
\]

\[
\begin{align*}
i_o = \frac{-36}{12 \, \text{K}}
\end{align*}
\]

\[
\begin{align*}
i_o = -2 \, \text{mA}
\end{align*}
\]
(2) Alternate Solution for checking purposes

\[ 18i_1 + 6i_2 - 6k_i3 = 12 \]
\[ 6i_1 + 8i_2 - 4k_i2 = -12 \]
\[ 6i_1 + 10i_2 + i_3 = 4mA \]

\[ i_1 = 0.002 A \]
\[ i_2 = 0.0005 A \]
\[ i_3 = 0.004 A \]

\[ i_0 = i_1 - i_2 = 0.002 - 0.004 \]
\[ i_0 = -2 mA \text{ check} \]
(b) Determine I_{ss}.
(c) Find the input resistance.
(d) Draw Norton's equivalent looking into a-b.

\[ V_x = 12V \]

To determine I_{ss},

\[ V_x = 12V \]

Placing a short from a to b causes the 12\Omega resistor to be shunted, which in turn makes \( V_x = 0 \). If \( V_x = 0 \), the current source is 3\Omega, which means open-circuit. The circuit becomes as below:

\[ I_{IN} = \frac{30V}{12\Omega} = 2.5A \]
To find \( R_{th} \)

Deactivate all independent sources, since we are left with a dependent source, we must place either a voltage \( V_L \) or current source \( I_V \) at the load and solve for \( V_L \).

In this case, \( V_L = V_x \), by inspection.

Writing a nodal equation at \( V_L \) gives

\[
\frac{V_L}{12} + \frac{V_L}{126} + 2V_L = I_L
\]

\[
126V_L + 12V_L + 3054V_L = 1512I_L
\]

\[
\frac{V_L}{I_L} = \frac{1512}{3142} = 0.478 \, \Omega
\]

\[
R_{th} = 0.478 \, \Omega
\]

Norton Circuit
(4) Doing capacitance reductions:

12 \mu F \text{ in series with } 6 \mu F

\frac{12 \times 6 \mu F}{18} = 4 \mu F

3 \mu F \text{ in parallel with } 7 \mu F = 12 \mu F

We have

\begin{align*}
30V & \quad 4 \mu F \\
& \quad 12 \mu F \\
& \quad 5 \mu F \\
& \quad 16 \mu F
\end{align*}

or

\begin{align*}
30V & \quad 20 \mu F = C_1 \\
& \quad V_1 \\
& \quad 5 \mu F = C_2 \\
& \quad V_2 \\
& \quad 12 \mu F = C_3 \\
& \quad V_3
\end{align*}

\frac{1}{C_{eq}} = \frac{1}{20} + \frac{1}{5} + \frac{1}{12}

\frac{1}{C_{eq}} = 3 + 12 + 5 = 20

C_{eq} = 3 \mu F

Q = C_{eq}V = (3 \mu F)(30V) = 90 \times 10^{-6} C
\( V_1 = \frac{Q}{C_1} = \frac{90 \times 10^{-6}}{20 \times 10^{-6}} = 4.5 \text{ V} \)

\( V_2 = \frac{Q}{C_2} = \frac{40 \times 10^{-6}}{5 \times 10^{-6}} = 8 \text{ V} \)

\( V_3 = \frac{Q}{C_3} = \frac{90 \times 10^{-6}}{12 \times 10^{-6}} = 7.5 \text{ V} \)

\[ V_1 + V_2 + V_3 = 4.5 + 8 + 7.5 = 20 \text{ V} \]

Energy stored in the 5 \( \mu \text{F} \) capacitor

\[ W_5 = \frac{1}{2} C_5 V_5^2 \]

\[ W_5 = \frac{1}{2} \times 5 \times 10^{-6} \times (18)^2 = \]

\[ W_5 = 0.81 \text{ mJ} \]
(8) Determine $V_{out}/Vin$ for the following op-amp circuit.

\[ V_1 = \frac{Vin \cdot RB}{RA + RB} \]

\[ V_2 = \frac{Vo \cdot Re}{Re + RD} \]

Now $V_1 = V_2$

\[ \frac{Vo \cdot Re}{Re + RD} = \frac{Vin \cdot RB}{RA + RB} \]

\[ \frac{Vo}{Vin} = \frac{RB (Re + RD)}{Re (RA + RB)} \]
(c) Find \( R_x \) that results in \( V_{out} = 20V_{in} \)

\[
V_z = \frac{V_{in} \times R_x}{R_x + 19K}
\]

\[ V_z = V_{in} \]

but \( V_z = V_v \)

\[ \frac{V_0 \times R_x}{R_x + 19K} = V_{in} \]

\[ V_0 = \left( \frac{R_x + 19K}{R_x} \right) V_{in} \]

\[ V_0 = \frac{R_x + 19K}{R_x} \times V_{in} \]

\[ \therefore \frac{R_x + 19K}{R_x} = 20 \]

\[ R_x + 19K = 20R_x \]

\[ 19R_x = 19K \]

\[ R_x = 1K \]