Section 4.2 Linearity Property

4.1 Calculate the current $i_o$ in the current of Fig. 4.69. What does this current become when the input voltage is raised to 10 V?

![Figure 4.69](image)

For Prob. 4.1.

4.2 Using Fig. 4.70, design a problem to help other students better understand linearity.

![Figure 4.70](image)

For Prob. 4.2.

4.3 (a) In the circuit of Fig. 4.71, calculate $v_o$ and $i_o$ when $v_s = 1$ V.
(b) Find $v_o$ and $i_o$ when $v_s = 10$ V.
(c) What are $v_o$ and $i_o$ when each of the 1-Ω resistors is replaced by a 10-Ω resistor and $v_s = 10$ V?

![Figure 4.71](image)

For Prob. 4.3.

4.4 Use linearity to determine $i_o$ in the circuit of Fig. 4.72.

![Figure 4.72](image)

For Prob. 4.4.

4.5 For the circuit in Fig. 4.73, assume $v_o = 1$ V, and use linearity to find the actual value of $v_o$.

![Figure 4.73](image)

For Prob. 4.5.

4.6 For the linear circuit shown in Fig. 4.74, use linearity to complete the following table.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>$V_s$</th>
<th>$V_o$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12 V</td>
<td>4 V</td>
</tr>
<tr>
<td>2</td>
<td>16 V</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1 V</td>
<td>-2 V</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Figure 4.74](image)

For Prob. 4.6.

4.7 Use linearity and the assumption that $V_o = 1$ V to find the actual value of $V_o$ in Fig. 4.75.

![Figure 4.75](image)

For Prob. 4.7.

Section 4.3 Superposition

4.8 Using superposition, find $V_o$ in the circuit of Fig. 4.76.

![Figure 4.76](image)

For Prob. 4.8.
4.9 Use superposition to find $v_o$ in the circuit of Fig. 4.77.

4.10 Using Fig. 4.78, design a problem to help other students better understand superposition. Note, the letter $k$ is a gain you can specify to make the problem easier to solve but must not be zero.

4.11 Use the superposition principle to find $i_o$ and $v_o$ in the circuit of Fig. 4.79.

4.12 Determine $v_o$ in the circuit of Fig. 4.80 using the superposition principle.

4.13 Use superposition to find $v_o$ in the circuit of Fig. 4.81.

4.14 Apply the superposition principle to find $v_o$ in the circuit of Fig. 4.82.

4.15 For the circuit in Fig. 4.83, use superposition to find $i_o$. Calculate the power delivered to the $3\Omega$ resistor.

4.16 Given the circuit in Fig. 4.84, use superposition to get $i_o$. 

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**Figure 4.77**
For Prob. 4.9.

**Figure 4.78**
For Prob. 4.10.

**Figure 4.79**
For Prob. 4.11.

**Figure 4.80**
For Probs. 4.12 and 4.35.

**Figure 4.81**
For Prob. 4.13.

**Figure 4.82**
For Prob. 4.14.

**Figure 4.83**
For Probs. 4.15 and 4.56.

**Figure 4.84**
For Prob. 4.16.
4.17 Use superposition to obtain $v_x$ in the circuit of Fig. 4.85. Check your result using PSpice.

- **Figure 4.85**
  - For Prob. 4.17.

4.18 Use superposition to find $V_o$ in the circuit of Fig. 4.86.

- **Figure 4.86**
  - For Prob. 4.18.

4.19 Use superposition to solve for $v_x$ in the circuit of Fig. 4.87.

- **Figure 4.87**
  - For Prob. 4.19.

Section 4.4 Source Transformation

4.20 Use source transformations to reduce the circuit in Fig. 4.88 to a single voltage source in series with a single resistor.

- **Figure 4.88**
  - For Prob. 4.20.

4.21 Using Fig. 4.89, design a problem to help other students better understand source transformation.

- **Figure 4.89**
  - For Prob. 4.21.

4.22 For the circuit in Fig. 4.90, use source transformation to find $i$.

- **Figure 4.90**
  - For Prob. 4.22.

4.23 Referring to Fig. 4.91, use source transformation to determine the current and power in the 8-Ω resistor.

- **Figure 4.91**
  - For Prob. 4.23.

4.24 Use source transformation to find the voltage $V_L$ in the circuit of Fig. 4.92.

- **Figure 4.92**
  - For Prob. 4.24.
Sections 4.5 and 4.6  Thevenin’s and Norton’s Theorems

4.33 Determine $R_{TH}$ and $V_{TH}$ at terminals 1-2 of each of the circuits in Fig. 4.101.

\[ \begin{align*}
10 \Omega & \\
20 \Omega & \\
40 \Omega & \\
10 \Omega & \\
\end{align*} \]

(a)

\[ \begin{align*}
60 \Omega & \\
2 \Omega & \\
30 \Omega & \\
\end{align*} \]

(b)

**Figure 4.101**  
For Probs. 4.33 and 4.46.

4.34 Using Fig. 4.102, design a problem that will help other students better understand Thevenin equivalent circuits.

\[ \begin{align*}
I & \\
R_1 & \\
R_2 & \\
R_3 & \\
V & \\
\end{align*} \]

**Figure 4.102**  
For Probs. 4.34 and 4.49.

4.35 Use Thevenin’s theorem to find $V_o$ in Prob. 4.12.

4.36 Solve for the current $i$ in the circuit of Fig. 4.103 using Thevenin’s theorem. (Hint: Find the Thevenin equivalent seen by the 12-Ω resistor.)

\[ \begin{align*}
10 \Omega & \\
12 \Omega & \\
40 \Omega & \\
50 \Omega & \\
\end{align*} \]

**Figure 4.103**  
For Prob. 4.36.

4.37 Find the Norton equivalent with respect to terminals $a$-$b$ in the circuit shown in Fig. 4.104.

\[ \begin{align*}
3 \text{ A} & \\
20 \Omega & \\
180 \Omega & \\
\end{align*} \]

**Figure 4.104**  
For Prob. 4.37.

4.38 Apply Thevenin’s theorem to find $V_o$ in the circuit of Fig. 4.105.

\[ \begin{align*}
4 \Omega & \\
1 \Omega & \\
3 \text{ A} & \\
16 \Omega & \\
10 \Omega & \\
5 \Omega & \\
10 \Omega & \\
8 \text{ V} & \\
\end{align*} \]

**Figure 4.105**  
For Prob. 4.38.

4.39 Obtain the Thevenin equivalent at terminals $a$-$b$ of the circuit in Fig. 4.106.

\[ \begin{align*}
1 \text{ A} & \\
10 \Omega & \\
16 \Omega & \\
10 \Omega & \\
5 \Omega & \\
8 \text{ V} & \\
\end{align*} \]

**Figure 4.106**  
For Prob. 4.39.

4.40 Find the Thevenin equivalent at terminals $a$-$b$ of the circuit in Fig. 4.107.

\[ \begin{align*}
+ V_o & \\
10 \text{ kΩ} & \\
20 \text{ kΩ} & \\
70 \text{ V} & \\
\end{align*} \]

**Figure 4.107**  
For Prob. 4.40.
4.41 Find the Thevenin and Norton equivalents at terminals $a-b$ of the circuit shown in Fig. 4.108.

![Figure 4.108](image)

For Prob. 4.41.

4.42 For the circuit in Fig. 4.109, find the Thevenin equivalent between terminals $a$ and $b$.

![Figure 4.109](image)

For Prob. 4.42.

4.43 Find the Thevenin equivalent looking into terminals $a-b$ of the circuit in Fig. 4.110 and solve for $i_x$.

![Figure 4.110](image)

For Prob. 4.43.

4.44 For the circuit in Fig. 4.111, obtain the Thevenin equivalent as seen from terminals:

(a) $a-b$

(b) $b-c$

![Figure 4.111](image)

For Prob. 4.44.

* An asterisk indicates a challenging problem.

4.45 Find the Norton equivalent of the circuit in Fig. 4.112.

![Figure 4.112](image)

For Prob. 4.45.

4.46 Using Fig. 4.113, design a problem to help other students better understand Norton equivalent circuits.

![Figure 4.113](image)

For Prob. 4.46.

7.47 Obtain the Thevenin and Norton equivalent circuits of the circuit in Fig. 4.114 with respect to terminals $a$ and $b$.

![Figure 4.114](image)

For Prob. 4.47.

4.48 Determine the Norton equivalent at terminals $a-b$ for the circuit in Fig. 4.115.

![Figure 4.115](image)

For Prob. 4.48.

4.49 Find the Norton equivalent looking into terminals $a-b$ of the circuit in Fig. 4.102. Let $V = 40 \text{ V}$, $I = 3 \text{ A}$, $R_1 = 10 \Omega$, $R_2 = 40 \Omega$, and $R_3 = 20 \Omega$. 

![Image](image)
4.50 Obtain the Norton equivalent of the circuit in Fig. 4.116 to the left of terminals \( a-b \). Use the result to find current \( i \).

![Figure 4.116](image)

For Prob. 4.50.

4.51 Given the circuit in Fig. 4.117, obtain the Norton equivalent as viewed from terminals:

(a) \( a-b \)

(b) \( c-d \)

![Figure 4.117](image)

For Prob. 4.51.

4.52 For the transistor model in Fig. 4.118, obtain the Thevenin equivalent at terminals \( a-b \).

![Figure 4.118](image)

For Prob. 4.52.

4.53 Find the Norton equivalent at terminals \( a-b \) of the circuit in Fig. 4.119.

![Figure 4.119](image)

For Prob. 4.53.

4.54 Find the Thevenin equivalent between terminals \( a-b \) of the circuit in Fig. 4.120.

![Figure 4.120](image)

For Prob. 4.54.

4.55 Obtain the Norton equivalent at terminals \( a-b \) of the circuit in Fig. 4.121.

![Figure 4.121](image)

For Prob. 4.55.

4.56 Use Norton's theorem to find \( V_o \) in the circuit of Fig. 4.122.

![Figure 4.122](image)

For Prob. 4.56.

4.57 Obtain the Thevenin and Norton equivalent circuits at terminals \( a-b \) for the circuit in Fig. 4.123.

![Figure 4.123](image)

For Probs. 4.57 and 4.79.
Section 4.8 Maximum Power Transfer

4.66 Find the maximum power that can be delivered to the resistor $R$ in the circuit of Fig. 4.132.

**Figure 4.132**
For Prob. 4.66.

4.67 The variable resistor $R$ in Fig. 4.133 is adjusted until it absorbs the maximum power from the circuit.
(a) Calculate the value of $R$ for maximum power.
(b) Determine the maximum power absorbed by $R$.

**Figure 4.133**
For Prob. 4.67.

*4.68 Compute the value of $R$ that results in maximum power transfer to the 10-$\Omega$ resistor in Fig. 4.134. Find the maximum power.

**Figure 4.134**
For Prob. 4.68.

4.69 Find the maximum power transferred to resistor $R$ in the circuit of Fig. 4.135.

**Figure 4.135**
For Prob. 4.69.

4.70 Determine the maximum power delivered to the variable resistor $R$ shown in the circuit of Fig. 4.136.

**Figure 4.136**
For Prob. 4.70.

4.71 For the circuit in Fig. 4.137, what resistor connected across terminals $a-b$ will absorb maximum power from the circuit? What is that power?

**Figure 4.137**
For Prob. 4.71.

4.72 (a) For the circuit in Fig. 4.138, obtain the Thevenin equivalent at terminals $a-b$.
(b) Calculate the current in $R_L = 8 \Omega$.
(c) Find $R_L$ for maximum power deliverable to $R_L$.
(d) Determine that maximum power.

**Figure 4.138**
For Prob. 4.72.