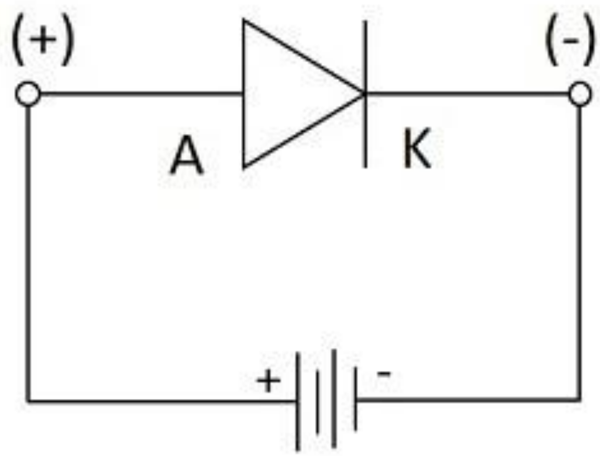
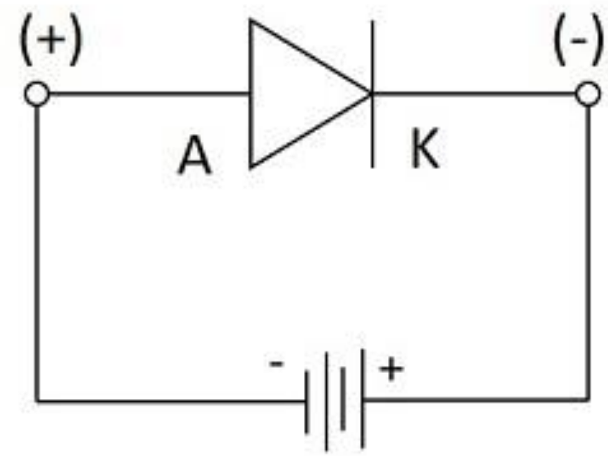
# Diode Applications

# Forward and reverse bias

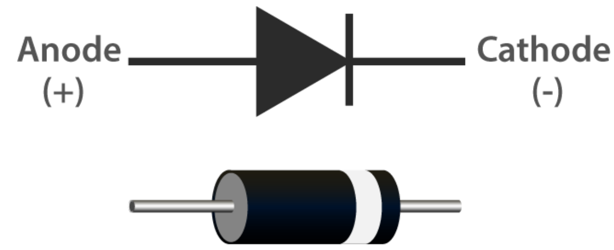



Forward biased Connection



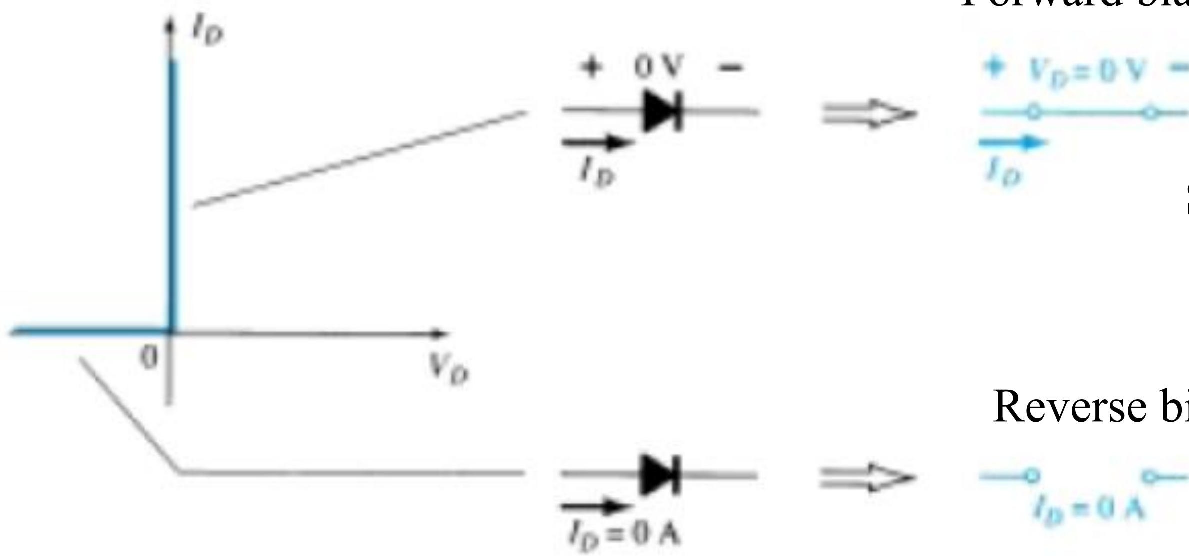

Reverse biased Connection

# Ideal diode model




Diode and diode symbol

- Short circuit when forward biased
- Open circuit when reversed biased



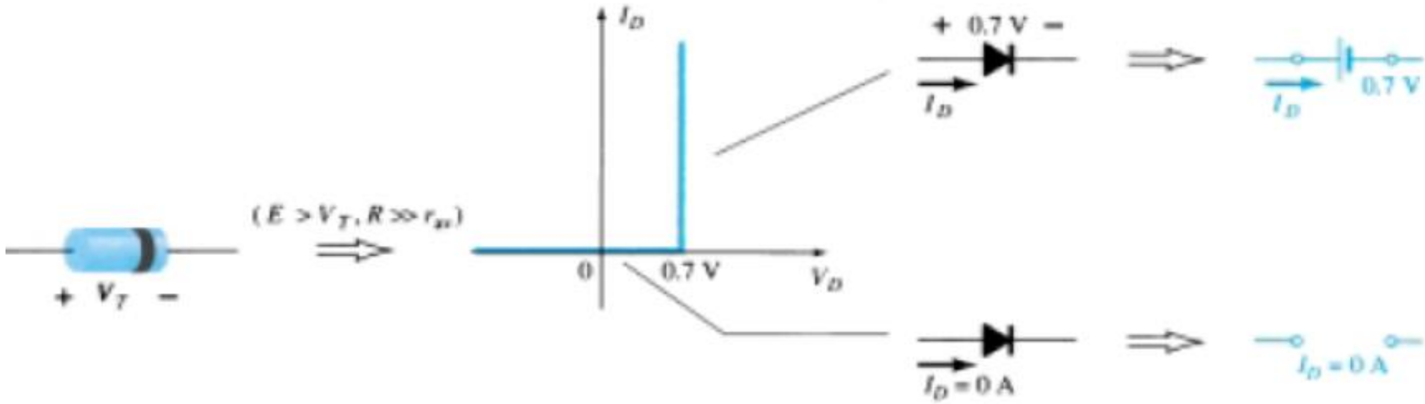

Forward bias

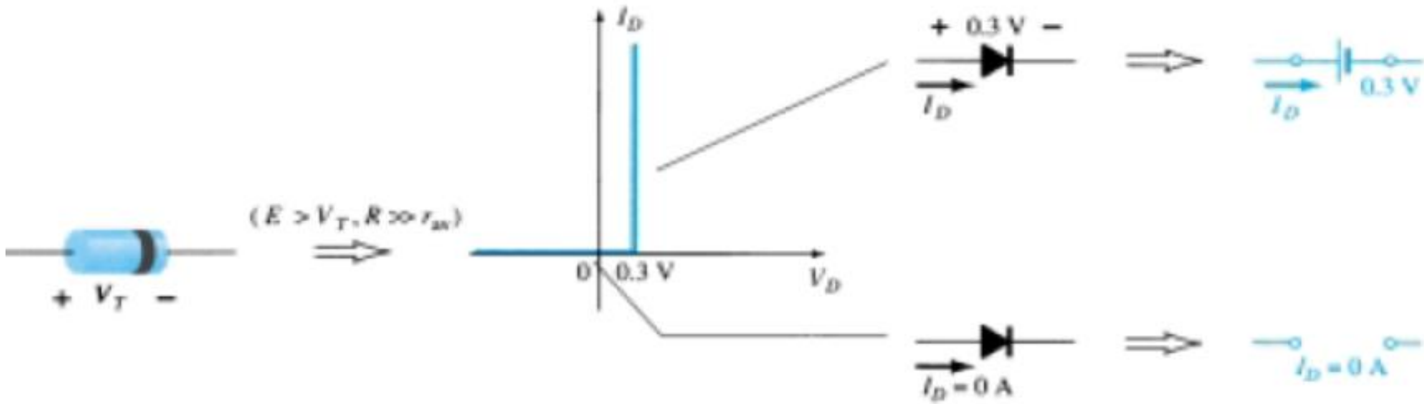
Short circuit

Reverse bias

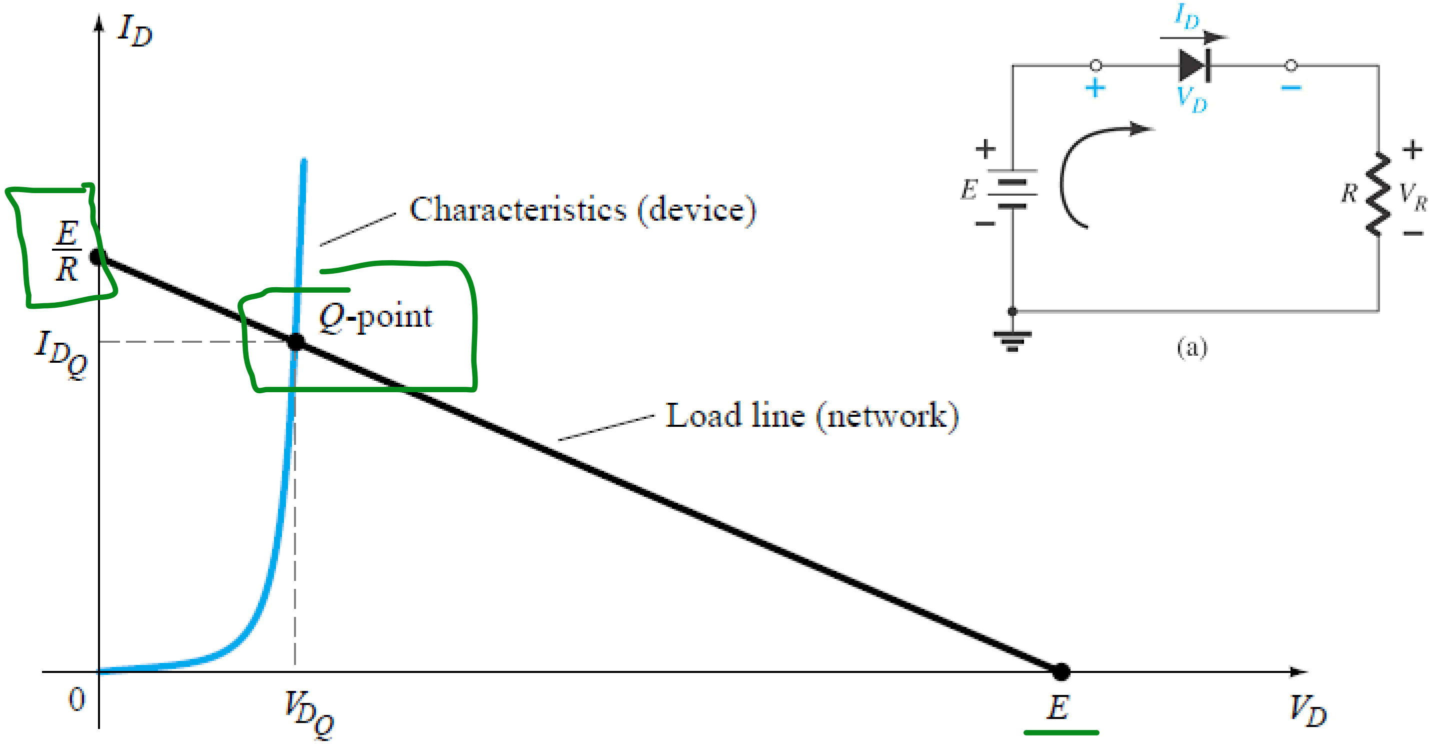
Open circuit

# Practical diode simplified model



# Load-Line Analysis




Drawing the load line and finding the point of operation.

$$I_D = \frac{E}{R}\bigg|_{V_D = 0\ \text{V}}$$

$$V_D = E\big|_{I_D = 0\ A}$$

# Series diode circuit

- Determine the state of the diode first.
- Si diodes need 0.7 V and Ge diodes need 0.3 V to turn on.
- Replace the diode with a model.
- Connect a series resistance in any diode circuit to limit the current.

Analysis:

$$\boxed{V_D = V_T}$$

$$\boxed{V_R = E - V_T}$$

$$\boxed{I_D = I_R = \frac{V_R}{R}}$$

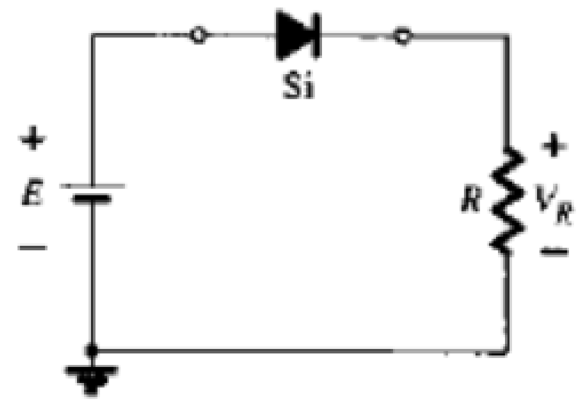



**Figure 2.10** Series diode configuration.

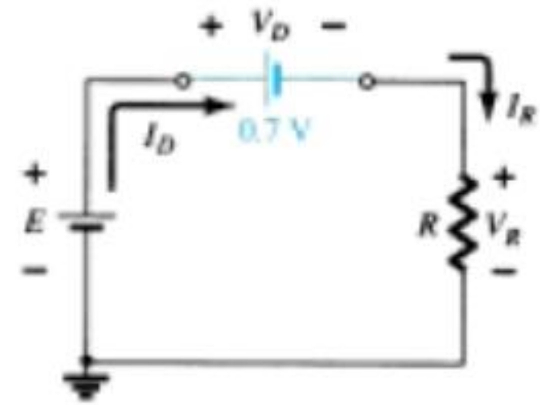



**Figure 2.12** Substituting the equivalent model for the "on" diode of Fig. 2.10.

# Reversed biased diode

- In this circuit of Fig. 2.13 the diode is reversed biased.

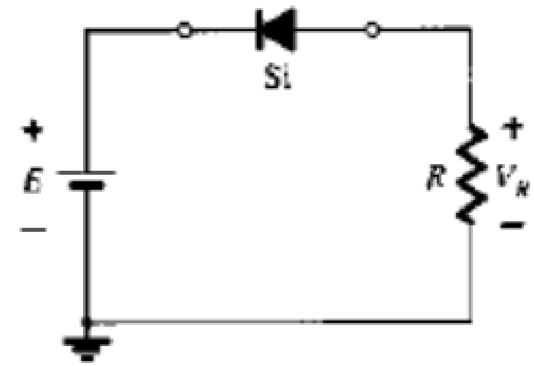



Figure 2.13 Reversing the diode of Fig. 2.10.

- So, in fig. 2.15, the diode is replaced by its reversed biased model, a open circuit.

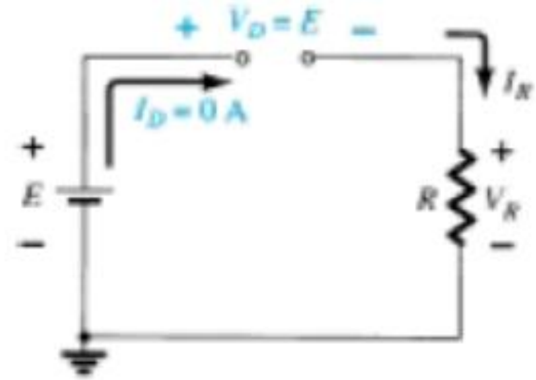



Figure 2.15 Substituting the equivalent model for the "off" diode of Figure 2.13.

Analysis:

$$V_R = I_R R = I_D R = (0\ \text{A})R = 0\ \text{V}$$

# Si and Ge diodes in series

*EXAMPLE 2.9* Determine $V_o$ and $I_D$ for the series circuit of Fig. 2.21.

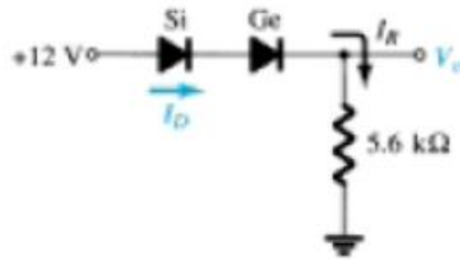



**Figure 2.21** Circuit for Example 2.9.

**Solution**

$$V_o = E - V_{T_1} - V_{T_2} = 12\text{ V} - 0.7\text{ V} - 0.3\text{ V} = \mathbf{11\ V}$$

and

$$I_D = I_R = \frac{V_R}{R} = \frac{V_o}{R} = \frac{11\text{ V}}{5.6\text{ k}\Omega} \cong \mathbf{1.96\ mA}$$

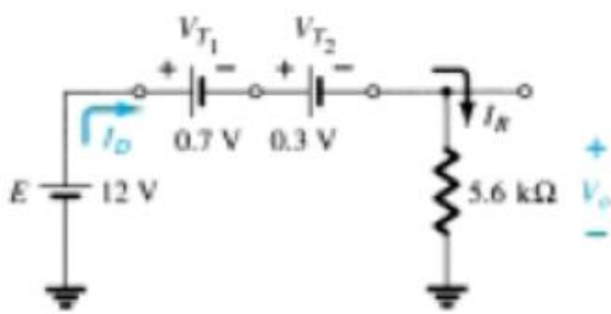



**Figure 2.22** Determining the unknown quantities for Example 2.9.

# Back to back diode connection

EXAMPLE 2.10 Determine $I_D$, $V_{D_2}$, and $V_o$ for the circuit of Fig. 2.23.

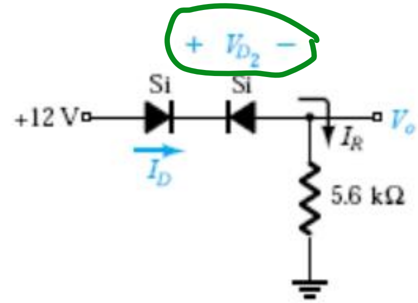



Figure 2.23 Circuit for Example 2.10.

## Solution

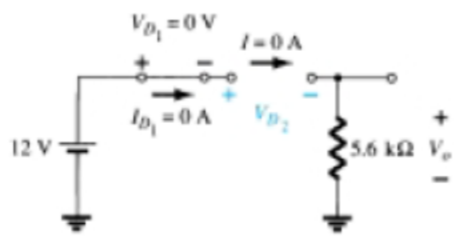



Figure 2.26 Determining the unknown quantities for the circuit of Example 2.10.

$$V_o = I_R R = I_D R = (0\text{ A})R = 0\text{ V}$$

and $$V_{D_2} = V_{\text{open circuit}} = E = \mathbf{12\ V}$$

Applying Kirchhoff's voltage law in a clockwise direction gives us

$$E - V_{D_1} - V_{D_2} - V_o = 0$$

and $$V_{D_2} = E - V_{D_1} - V_o = 12\text{ V} - 0 - 0$$
$$= \mathbf{12\ V}$$

with $$V_o = \mathbf{0\ V}$$

# Parallel diodes

EXAMPLE 2.12 Determine $V_o$, $I_1$, $I_{D_1}$, and $I_{D_2}$ for the parallel diode configuration of Fig. 2.30.

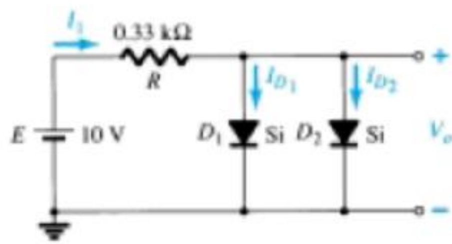



**Figure 2.30** Network for Example 2.12.

## Solution

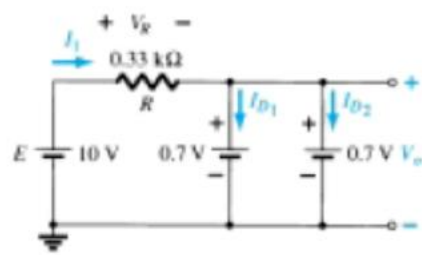



**Figure 2.31** Determining the unknown quantities for the network of Example 2.12.

The current

$$I_1 = \frac{V_R}{R} = \frac{E - V_D}{R} = \frac{10\text{ V} - 0.7\text{ V}}{0.33\text{ k}\Omega} = \mathbf{28.18\text{ mA}}$$

Assuming diodes of similar characteristics, we have

$$I_{D_1} = I_{D_2} = \frac{I_1}{2} = \frac{28.18\text{ mA}}{2} = \mathbf{14.09\text{ mA}}$$

# Parallel reverse diodes

Determine the current $I$ for the network of Fig. 2.32.

EXAMPLE 2.13

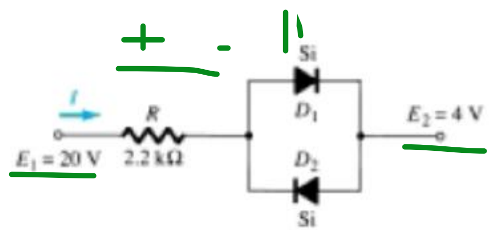
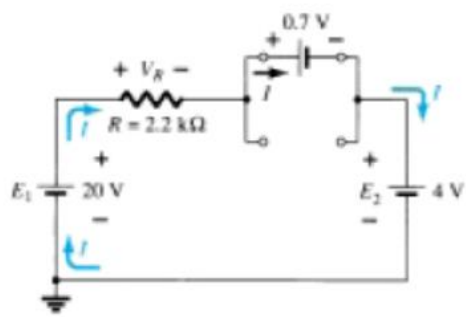



**Figure 2.32** Network for Example 2.13.

## Solution

Redrawing the network as shown in Fig. 2.33 reveals that the resulting current direction is such as to turn on diode $D_1$ and turn off diode $D_2$. The resulting current $I$ is then

$$I = \frac{E_1 - E_2 - V_D}{R} = \frac{20\text{ V} - 4\text{ V} - 0.7\text{ V}}{2.2\text{ k}\Omega} \cong \mathbf{6.95\ mA}$$




2.2k x + 0.7 = 20 - 4

**Figure 2.33** Determining the unknown quantities for the network of Example 2.13.

# Si and Ge diodes in parallel

EXAMPLE 2.14

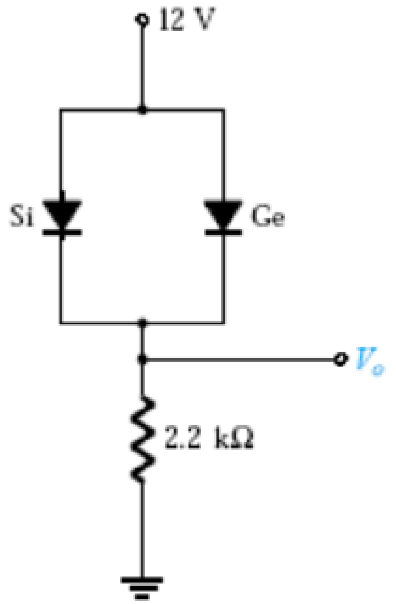



Figure 2.34 Network for Example 2.14.

$$V_o = 12\text{ V} - 0.3\text{ V} = \mathbf{11.7\text{ V}}$$

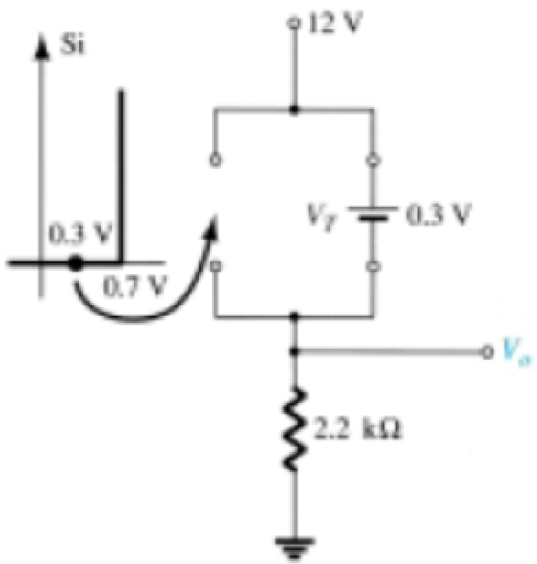



Figure 2.35 Determining $V_o$ for the network of Fig. 2.34.

# Series-parallel diodes

EXAMPLE 2.15 Determine the currents $I_1$, $I_2$, and $I_{D_2}$ for the network of Fig. 2.36.

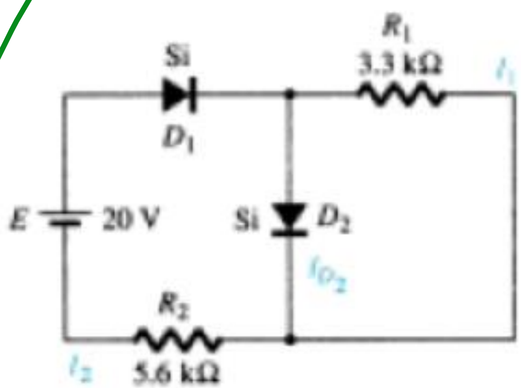



Figure 2.36 Network for Example 2.15.

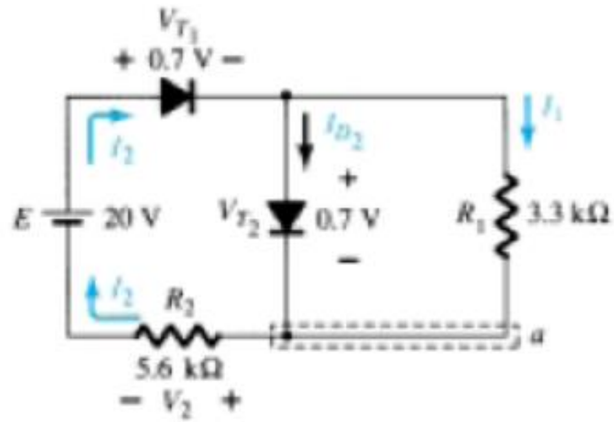



Figure 2.37 Determining the unknown quantities for Example 2.15.

$$I_1 = \frac{V_{T_2}}{R_1} = \frac{0.7\text{ V}}{3.3\text{ k}\Omega} = \mathbf{0.212\text{ mA}}$$

Applying Kirchhoff's voltage law around the indicated loop in the clockwise d tion yields

$$-V_2 + E - V_{T_1} - V_{T_2} = 0$$

and $$V_2 = E - V_{T_1} - V_{T_2} = 20\text{ V} - 0.7\text{ V} - 0.7\text{ V} = 18.6\text{ V}$$

with $$I_2 = \frac{V_2}{R_2} = \frac{18.6\text{ V}}{5.6\text{ k}\Omega} = \mathbf{3.32\text{ mA}}$$

At the bottom node (a),

$$I_{D_2} + I_1 = I_2$$

and $$I_{D_2} = I_2 - I_1 = 3.32\text{ mA} - 0.212\text{ mA} = \mathbf{3.108\text{ mA}}$$

# Application of dc diode circuits

- To drive LEDs in power indicators circuits
- LED Lighting
- Logic circuits, etc

# Points to keep in mind

- Before using a diode in a circuit, you must know at least the following:

Its forward current $I_F$,

Zener potential $V_Z$,

Maximum power dissipation ($P_{D,max}$),

and operating temperature range.

# Home work

- Solve problems at the end of Chapter 2
- Problem no. 6 to 11 and 13.

THANKS