Homework #12

Problems 6.35, 6.51, 6.58, and 6.61

Problem 6.35

For each of the circuits shown in Fig. P6.35, find the emitter base, and collector voltages and currents. Use $\beta = 50$, but assume $|V_{BE}| = 0.8$ V independent of current level.

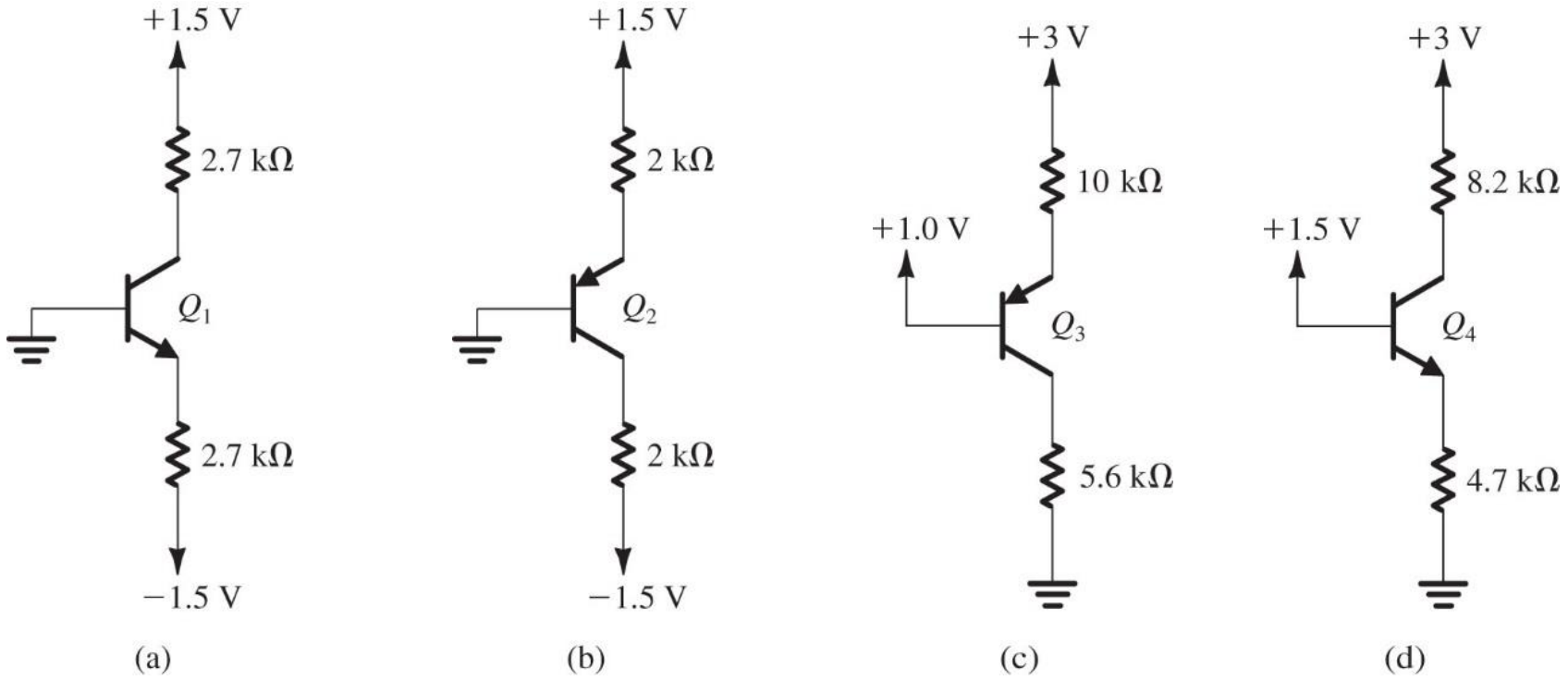
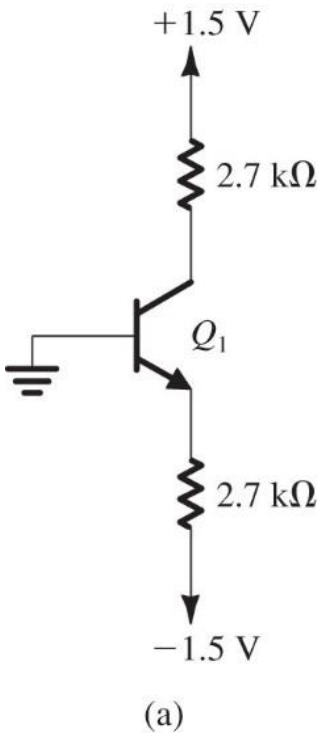


Figure P6.35

Problem 6.35a

For each of the circuits shown in Fig. P6.35, find the emitter base, and collector voltages and currents. Use $\beta = 50$, but assume $|V_{BE}| = 0.8$ V independent of current level.



(a)

$\beta := 50$ $V_{BE} := 0.8\,V$

$$I_E := \frac{-V_{BE} - -1.5V}{2.7k\Omega} = 259.259\mu A$$

$$I_C := \frac{\beta}{\beta + 1} I_E = 254.176\ \mu A$$

$$I_B := I_E - I_C = 5.084\ \mu A$$

$$I_B := \frac{I_C}{\beta} = 5.084\mu A$$

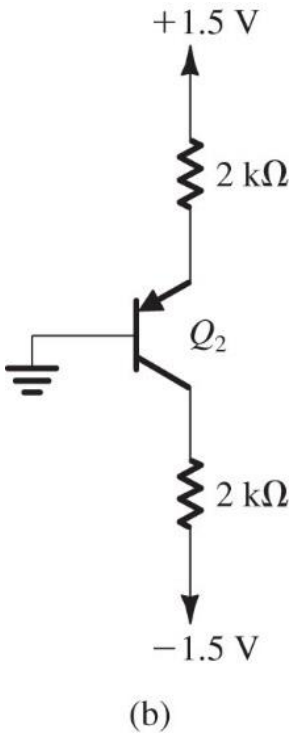
$V_B = 0$ V

$V_E = -0.8$ V

$V_C := 1.5\,V - I_C \cdot 2.7\,k\Omega = 0.814\ V$

Problem 6.35b

For each of the circuits shown in Fig. P6.35, find the emitter base, and collector voltages and currents. Use $\beta = 50$, but assume $|V_{BE}| = 0.8$ V independent of current level.



(b)

$$I_E := \frac{1.5V - V_{BE}}{2k\Omega} = 350\mu A$$

$$I_C := \frac{\beta}{\beta + 1} I_E = 343.137\ \mu A$$

$$I_B := I_E - I_C = 6.863\ \mu A$$

$$I_B := \frac{I_C}{\beta} = 6.863\mu A$$

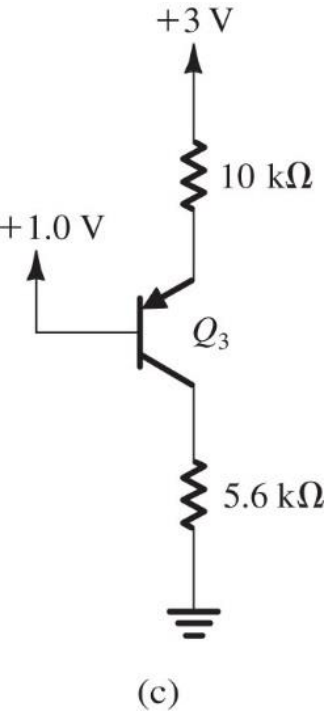
$$V_B = 0\ \text{V}$$

$$V_E = 0.8\ \text{V}$$

$$V_C := -1.5\,V + I_C \cdot 2k\Omega = -0.814\ V$$

Problem 6.35c

For each of the circuits shown in Fig. P6.35, find the emitter base, and collector voltages and currents. Use $\beta = 50$, but assume $|V_{BE}| = 0.8$ V independent of current level.



$$I_E := \frac{3V - (1V + V_{BE})}{10k\Omega} = 120\mu A$$

$$I_C := \frac{\beta}{\beta + 1} I_E = 117.647\ \mu A$$

$$V_B = 1\ \text{V}$$

$$I_B := I_E - I_C = 2.353\ \mu A$$

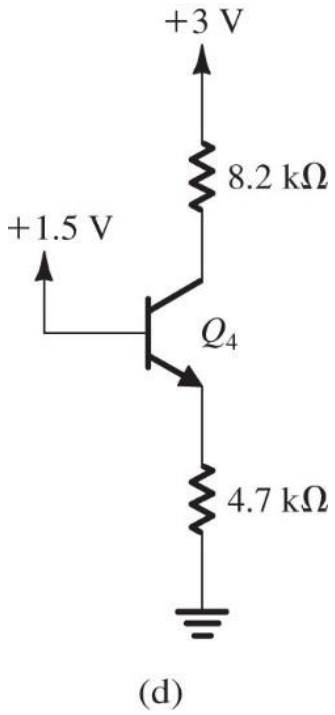
$$V_E = 1.8\ \text{V}$$

$$I_B := \frac{I_C}{\beta} = 2.353\mu A$$

$$V_C := I_C \cdot 5.6\,k\Omega = 0.659\ V$$

Problem 6.35d

For each of the circuits shown in Fig. P6.35, find the emitter base, and collector voltages and currents. Use $\beta = 50$, but assume $|V_{BE}| = 0.8$ V independent of current level.



(d)

$$I_E := \frac{1.5V - V_{BE}}{4.7k\Omega} = 148.936\mu A$$

$$I_C := \frac{\beta}{\beta + 1} I_E = 146.016\ \mu A$$

$$V_B = 1.5\ \text{V}$$

$$I_B := I_E - I_C = 2.92\ \mu A$$

$$V_E = 0.7\ \text{V}$$

$$I_B := \frac{I_C}{\beta} = 2.92\mu A$$

$$V_C := 3V - I_C \cdot 8.2\,k\Omega = 1.803\ V$$

Problem 6.51

The transistor in the circuit of Fig. P6.51 has a very high β. Find V_E and V_C for V_B (a) + 2.0 V, (b) +1.7 V, and (c) 0 V.

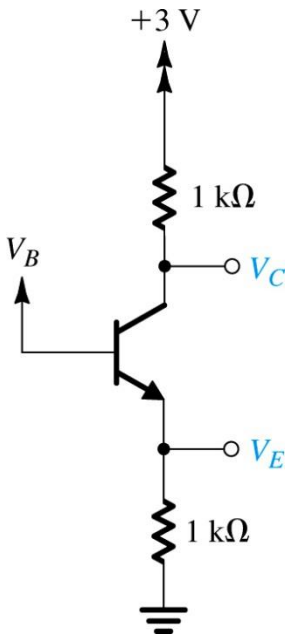


Figure P6.51

V_B (a) + 2 V

$V_B = 2\text{ V}$

$V_E = 1.3\text{ V}$

$$I_E \approx I_C = \frac{1.3\text{ V}}{1\text{ k}\Omega} = 1.3\text{ mA}$$

$$V_C = 3\text{ V} - 1\text{ k}\Omega \times 1.3\text{ mA}$$

$V_C = 1.7\text{ V}$

V_B (b) +1.7 V

$V_B = 1.7\text{ V}$

$V_E = 1.0\text{ V}$

$$I_E \approx I_C = \frac{1.0\text{ V}}{1\text{ k}\Omega} = 1\text{ mA}$$

$$V_C = 3\text{ V} - 1\text{ k}\Omega \times 1\text{ mA}$$

$V_C = 2.0\text{ V}$

V_B (c) 0 V

$V_B = 0\text{ V}$

$V_E = 0\text{ V}$

$I_E = I_C = 0\text{ mA}$

$V_C = 3\text{ V}$

Problem 6.58a

In the circuit shown in Fig. P6.58, the transistor has $\beta = 40$. Find the values of V_B, V_E and V_C. If R_B is raised to 100 kΩ, what voltages result? With $R_B = 100$ kΩ, what value of β would return the voltages to the values first calculated?

$R_B = 20$ kΩ

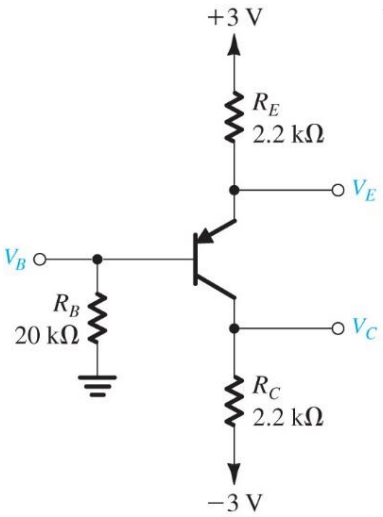


Figure P6.58

$$\beta = \frac{I_C}{I_B} = \frac{I_E - I_B}{I_B}$$

$$\beta I_B = I_E - I_B$$

$$I_B(\beta + 1) = I_E$$

$$I_B = \frac{I_E}{(\beta + 1)}$$

$$V_E = V_B + 0.7\text{V} = I_B R_B + 0.7\text{V} = \frac{I_E}{\beta + 1} R_B + 0.7\text{V}$$

$$V_E = V_{CC} - I_E R_E$$

$$\Rightarrow V_E = \frac{I_E}{\beta + 1} R_B + 0.7\text{V} = V_{CC} - I_E R_E$$

$$I_E \frac{R_B}{\beta + 1} + I_E R_E = V_{CC} - 0.7\text{V}$$

$$I_E = \frac{V_{CC} - 0.7\text{V}}{\left(R_E + \frac{R_B}{\beta + 1}\right)}$$

Problem 6.58b

In the circuit shown in Fig. P6.58, the transistor has $\beta = 50$. Find the values of V_B, V_E and V_C. If R_B is raised to 100 kΩ, what voltages result? With R_B = 100 kΩ, what value of β would return the voltages to the values first calculated?

$R_B = 20\ \text{k}\Omega$

$$I_E = \frac{V_{CC} - 0.7\text{V}}{\left(R_E + \frac{R_B}{\beta + 1}\right)}$$

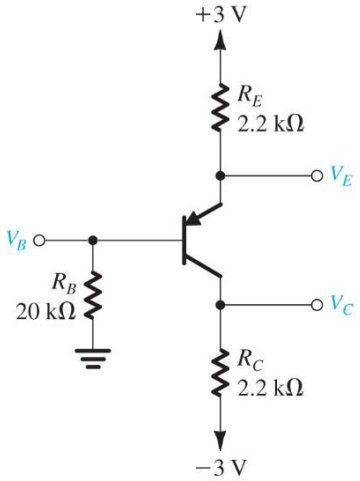


Figure P6.58

$$I_E := \frac{V_{CC} - 0.7V}{R_E + \frac{R_B}{\beta + 1}} = 855.717\mu A$$

$$I_C := \frac{\beta}{\beta + 1} I_E = 834.846\ \mu A$$

$$I_B := I_E - I_C = 20.871\ \mu A$$

$$I_B := \frac{I_C}{\beta} = 20.871\mu A$$

$$V_B := I_B \cdot R_B = 0.417\ V$$

$$V_E := 3V - I_E \cdot 2.2\,k\Omega = 1.117\ V$$

$$V_E := V_B + 0.7\,V = 1.117\ V$$

$$V_C := -3V + I_C \cdot R_C = -1.163\ V$$

$R_B = 100\ \text{k}\Omega$

$$I_E := \frac{V_{CC} - 0.7V}{R_E + \frac{R_B}{\beta + 1}} = 495.794\mu A$$

$$I_C := \frac{\beta}{\beta + 1} I_E = 483.701\ \mu A$$

$$I_B := I_E - I_C = 12.093\ \mu A$$

$$I_B := \frac{I_C}{\beta} = 12.093\mu A$$

$$V_B := I_B \cdot R_B = 1.209\ V$$

$$V_E := 3V - I_E \cdot 2.2\,k\Omega = 1.909\ V$$

$$V_E := V_B + 0.7\,V = 1.909\ V$$

$$V_C := -3V + I_C \cdot R_C = -1.936\ V$$

Problem 6.58b

In the circuit shown in Fig. P6.58, the transistor has $\beta = 50$. Find the values of V_B, V_E and V_C. If R_B is raised to 100 kΩ, what voltages result? With R_B = 100 kΩ, what value of β would return the voltages to the values first calculated?

$$I_E = \frac{V_{CC} - 0.7\text{V}}{\left(R_E + \frac{R_B}{\beta + 1}\right)}$$

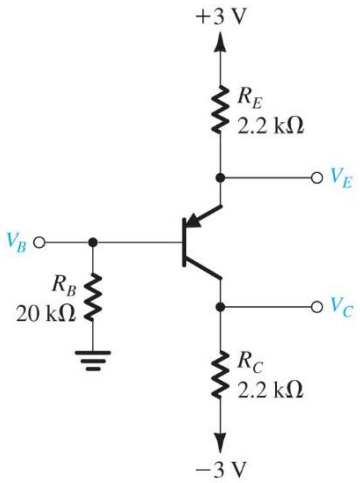


Figure P6.58

$R_B = 20\ \text{k}\Omega$

$$I_E := \frac{V_{CC} - 0.7V}{R_E + \frac{R_B}{\beta + 1}} = 855.717\mu A$$

@ R_B = 100 kΩ we want the same I_E

$$\beta_{new} := \frac{100\,k\Omega \cdot I_E}{(V_{CC} - 0.7\,V) - I_E \cdot R_E} - 1 = 204$$

$$I_E := \frac{V_{CC} - 0.7V}{R_E + \frac{100k\Omega}{\beta_{new} + 1}} = 855.717\mu A$$

Problem 6.61

For the circuits in Fig. P6.61, find values for the labeled node voltages and branch currents, Assume β to be very high.

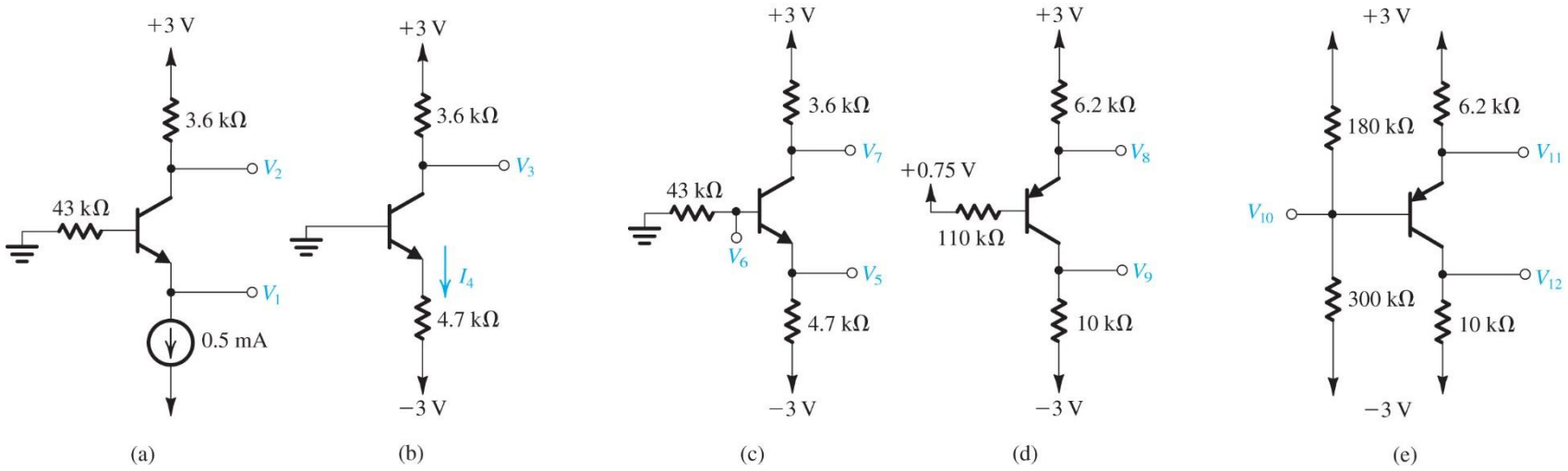
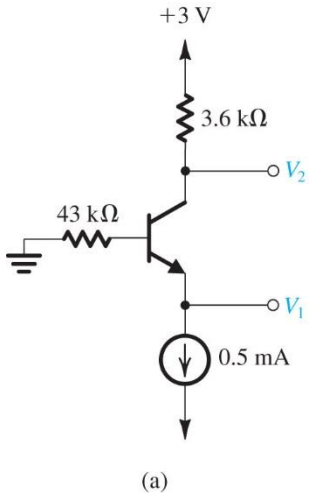


Figure P6.61

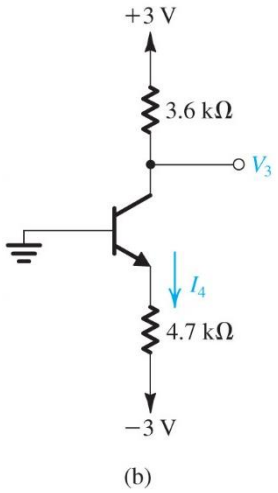
Problem 6.61 a,b

For the circuits in Fig. P6.61, find values for the labeled node voltages and branch currents, Assume β to be very high.



$$V_1 = 0\text{V} - V_{BE} = -0.7\text{V}$$

$$V_2 = 3\text{V} - I_C R_C$$
$$= 3\text{V} - 0.5\text{mA} \times 3.6\text{k}\Omega$$
$$= 1.2\text{V}$$



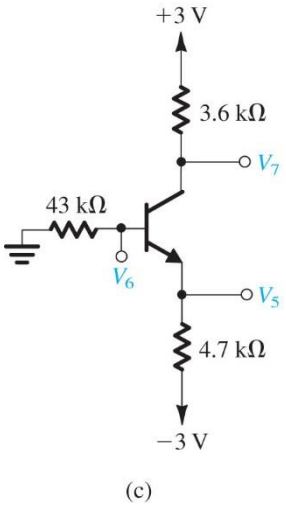
$$I_4 = \frac{-0.7\text{V} - -3V}{4.7\text{k}\Omega}$$
$$= 0.489\text{mA}$$

$$V_3 = 3\text{V} - I_C R_C$$
$$= 3\text{V} - 0.489\text{mA} \times 3.6\text{k}\Omega$$
$$= 1.24\text{V}$$

Figure P6.61

Problem 6.61 c,d

For the circuits in Fig. P6.61, find values for the labeled node voltages and branch currents, Assume β to be very high.



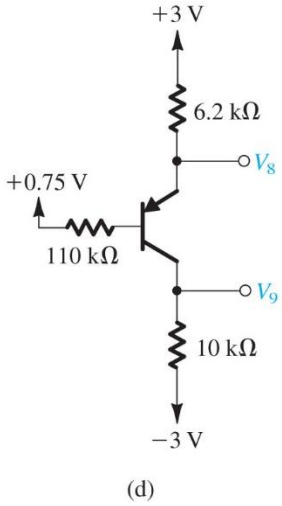


Figure P6.61

$$V_6 = 0\text{V}$$

$$V_5 = 0\text{V} - V_{BE} = -0.7\text{V}$$

$$I_C = I_E = \frac{-0.7\text{V} - -3V}{4.7\text{k}\Omega} = 0.489\text{mA}$$

$$V_7 = 3\text{V} - I_C R_C = 3\text{V} - 0.489\text{mA} \times 3.6\text{k}\Omega = 1.24\text{V}$$

$$V_8 = 0.75\text{V} + V_{BE} = 1.45\text{V}$$

$$I_C = I_E = \frac{3\text{V} - 1.45V}{6.2\text{k}\Omega} = 0.25\text{mA}$$

$$V_9 = -3\text{V} + I_C R_C = -3\text{V} + 0.25\text{mA} \times 10\text{k}\Omega = -0.5\text{V}$$

Problem 6.61 e

For the circuits in Fig. P6.61, find values for the labeled node voltages and branch currents, Assume β to be very high.

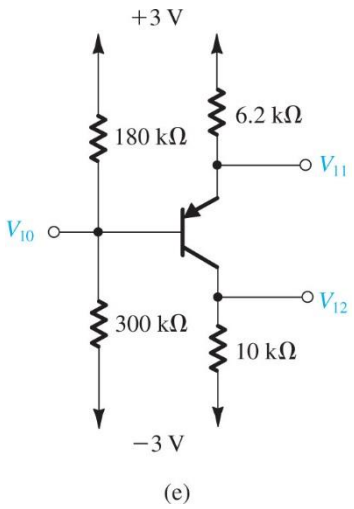


Figure P6.61

$$V_{10} = -3\text{V} + 6\text{V}\left(\frac{300\text{k}\Omega}{300\text{k}\Omega + 180\text{k}\Omega}\right)$$
$$= -3\text{V} + 6\text{V}(0.625)$$
$$= 0.75\text{V}$$

$$V_{11} = 0.75\text{V} + V_{BE} = 1.45\text{V}$$

$$I_C = I_E = \frac{-0.7\text{V} - -3V}{4.7\text{k}\Omega}$$
$$= 0.489\text{mA}$$

$$V_{12} = -3\text{V} - I_C R_C$$
$$= -3\text{V} + 0.25\text{mA} \times 10\text{k}\Omega$$
$$= -0.5\text{V}$$