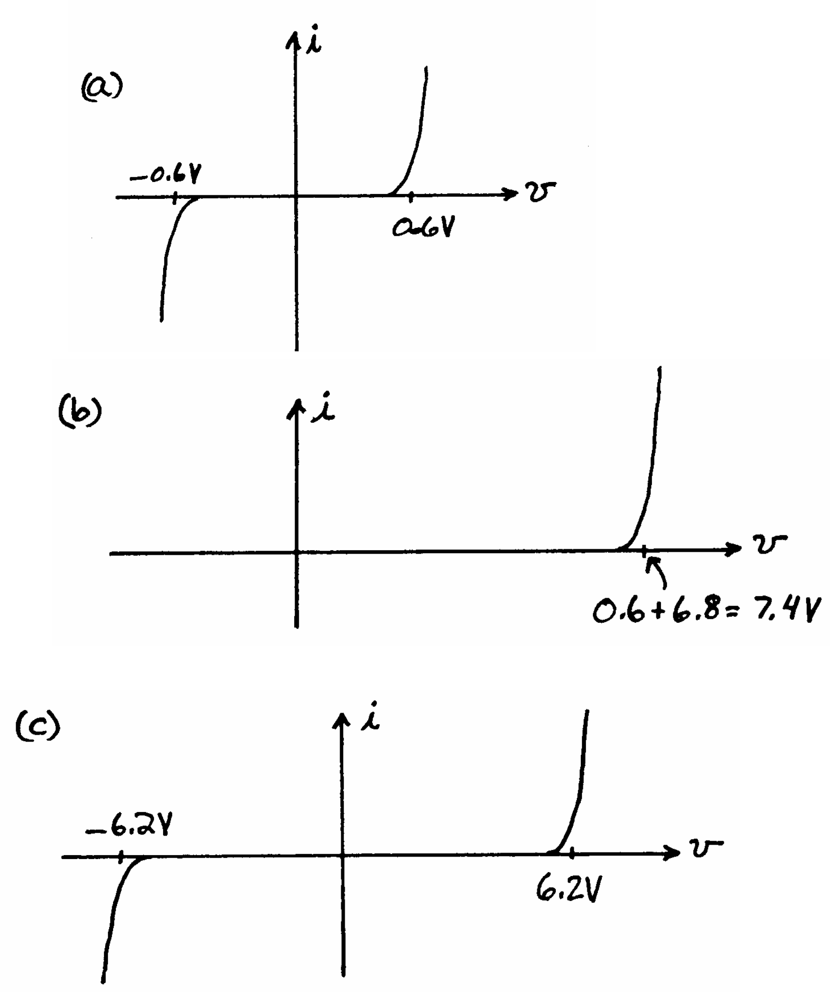
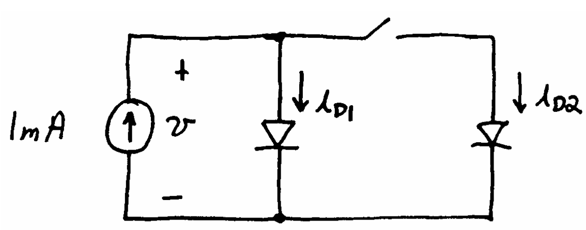
Homework # 7

P10.6*



P10.13*



With the switch open, we have:

$$i_{D1} = 10^{-3} = I_s\left[\exp(v/nV_T) - 1\right]$$

$$\cong I_s \exp(v/nV_T)$$

Thus, we determine that:

$$I_s \cong \frac{10^{-3}}{\exp(v/V_T)} = \frac{10^{-3}}{\exp(0.6/0.026)} = 9.5 \times 10^{-14} \text{ A}$$

With the switch closed, we have:

$$i_{D1} = i_{D2} = 0.5 \text{ mA}$$

$$0.5 \times 10^{-3} = I_s \exp(v/V_T)$$

$$v = nV_T \ln \frac{0.5 \times 10^{-3}}{I_s} = 582 \text{ mV}$$

Repeating the calculations with $n = 2$, we obtain:

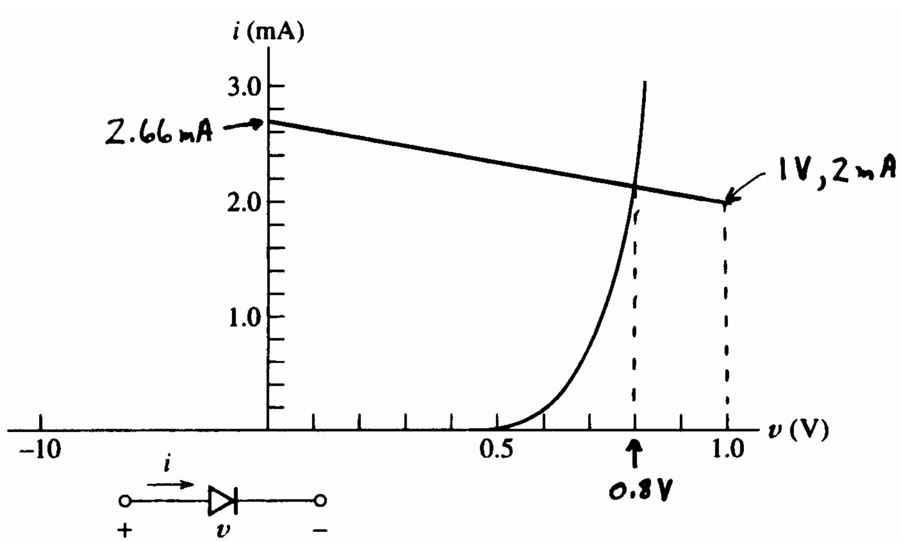
$$I_s = 9.75 \times 10^{-9} \text{ A}$$

$$v = 564 \text{ mV}$$

P10.20* (a) Writing KVL for the circuit, we have:

$$4 = 1500i + v$$

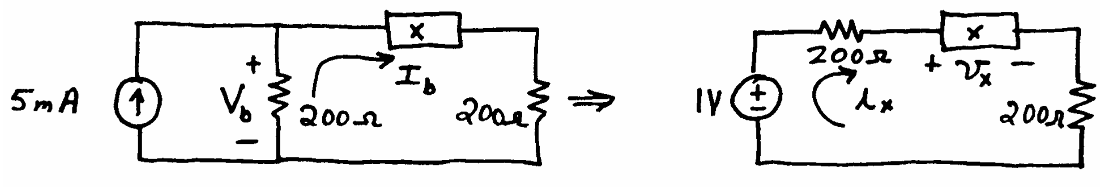
Plotting this on the characteristic for the diode, we have



Thus, the answers are:

$$v \cong 0.8 \text{ V and } i \cong 2.13 \text{ mA}$$

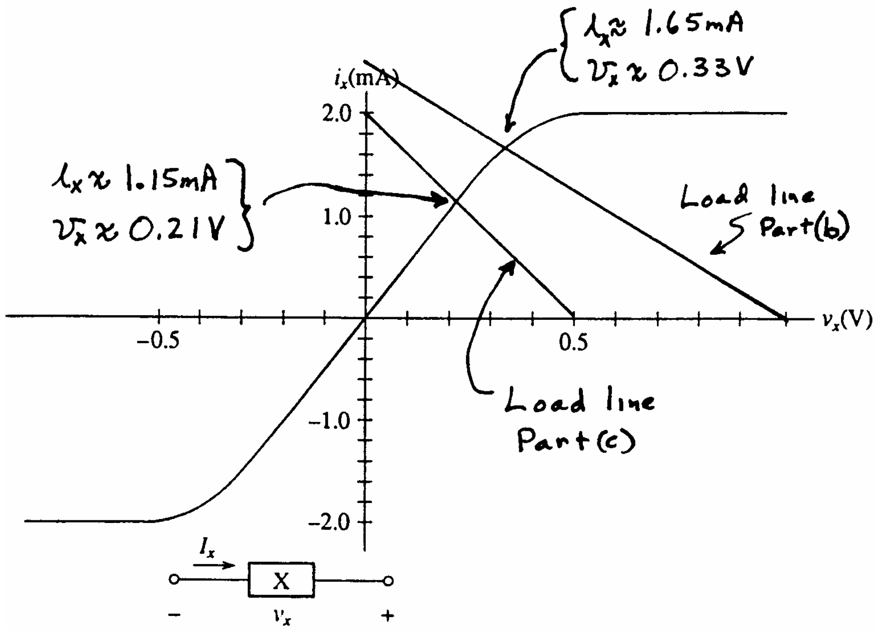
(b) Replacing the 5-mA current source and 200-Ω resistance by its Thévenin equivalent, we have:



The KVL equation for the equivalent circuit is

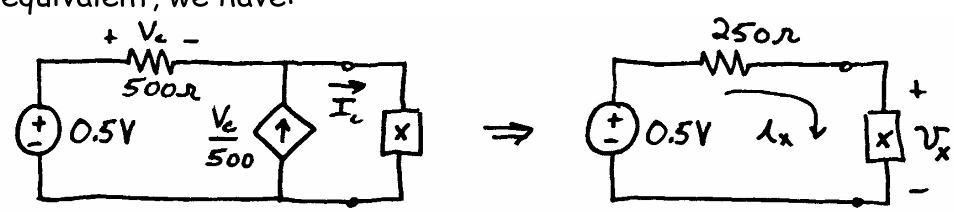
$$1 = 400 i_x + v_x$$

Drawing the load line on the device characteristic, we have:



Thus, we have $I_b = i_x \cong 1.65$ mA and $V_b = v_x + 200 i_x \cong 0.66$ V.

(c) Replacing the circuit seen by the nonlinear device by its Thévenin equivalent, we have:



Writing KVL for the equivalent circuit, we have

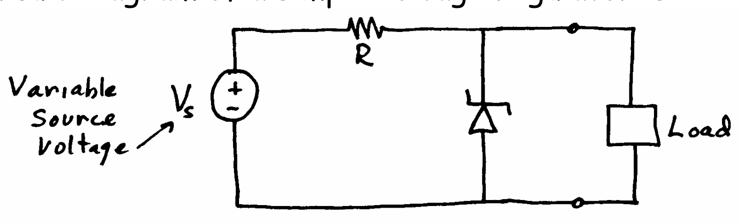
$$0.5 = 250 i_x + v_x$$

The load line is drawn in part (b) of this solution. From the load line, we have $i_x \cong 1.15$ mA and $v_x \cong 0.21$ V.

$I_c = i_x \cong 1.15$ mA

$V_c = 0.5 - v_x = 0.29$ V

P10.23* The circuit diagram of a simple voltage regulator is:

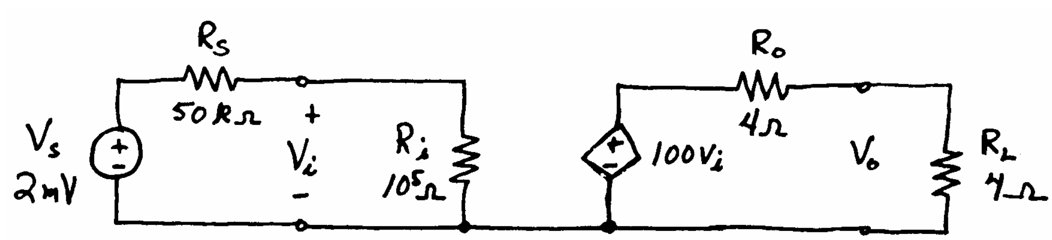


P10.33* (a) D_1 is on and D_2 is off. $V = 10$ volts and $I = 0$.

(b) D_1 is on and D_2 is off. $V = 6$ volts and $I = 6$ mA.

(c) Both D_1 and D_2 are on. $V = 30$ volts and $I = 33.6$ mA.

P11.4* The equivalent circuit is:



$$A_v = \frac{V_o}{V_i} = A_{voc}\frac{R_L}{R_o + R_L} = 100\frac{4}{4+4} = 50$$

$$A_{vs} = \frac{V_o}{V_s} = A_{voc}\frac{R_i}{R_i + R_s}\frac{R_L}{R_o + R_L}$$

$$= 100\frac{100\times 10^3}{100\times 10^3 + 50\times 10^3}\frac{4}{4+4}$$

$$= 33.33$$

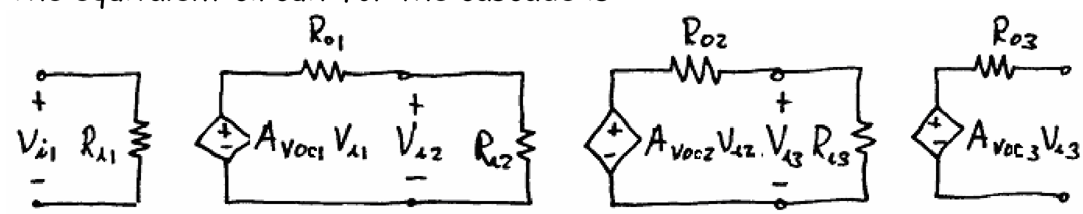
$$A_i = A_v\frac{R_i}{R_L} = 50\frac{10^5}{4} = 1.25\times 10^6$$

$$G = A_v A_i = 62.5\times 10^6$$

P11.5* $A_i = \frac{G}{A_v} = \frac{5000}{50} = 100$

$$R_i = \frac{A_i}{A_v} R_L = \frac{100}{50} \times 100 = 200\ \Omega$$

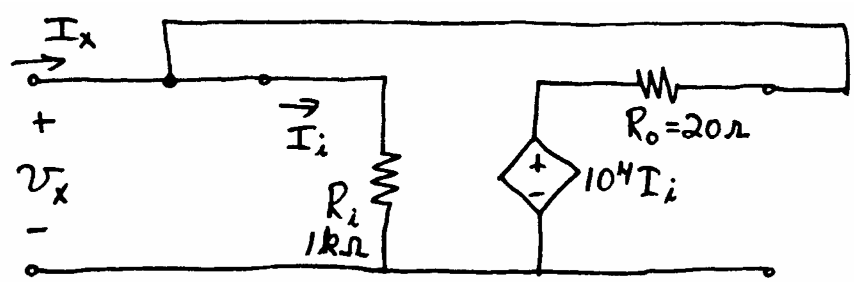
P11.17* The equivalent circuit for the cascade is:



We have:

$$R_i = R_{i1} = 2\ \text{k}\Omega$$
$$R_o = R_{o3} = 3\ \text{k}\Omega$$
$$A_{voc} = A_{voc1} A_{voc2} A_{voc3} \frac{R_{i2}}{R_{i2} + R_{o1}} \frac{R_{i3}}{R_{i3} + R_{o2}}$$
$$= 100(200)(300) \frac{4000}{4000 + 1000} \frac{6000}{6000 + 2000}$$
$$= 3.6 \times 10^6$$

P11.41* The equivalent circuit is:



We can write:

$$I_i = \frac{V_x}{R_i} \qquad (1)$$

$$I_x = I_i + \frac{V_x - R_{moc} I_i}{R_o} \qquad (2)$$

Using Equation (1) to substitute for I_i in Equation (2) and solving, we have:

$$R_x = \frac{V_x}{I_x} = \frac{1}{1/R_i + 1/R_o - R_{moc}/(R_i R_o)} = -2.23\ \Omega$$

P11.55* We are given

$$v_{\text{in}}(t) = 0.1\cos(2000\pi t) + 0.2\cos(4000\pi t + 30^\circ)$$

and

$$v_o(t) = 10\cos(2000\pi t - 20^\circ) + 15\cos(4000\pi t + 20^\circ)$$

The phasors for the 1000-Hz components are $\mathbf{V}_{\text{in}} = 0.1\angle 0^\circ$ and $\mathbf{V}_o = 10\angle -20^\circ$. Thus the complex gain for the 1000-Hz component is

$$A_v = \frac{\mathbf{V}_o}{\mathbf{V}_{\text{in}}} = \frac{10\angle -20^\circ}{0.1\angle 0^\circ} = 100\angle -20^\circ$$

Similarly, the complex gain for the 2000-Hz component is

$$A_v = \frac{\mathbf{V}_o}{\mathbf{V}_{\text{in}}} = \frac{15\angle 20^\circ}{0.2\angle 30^\circ} = 75\angle -10^\circ$$