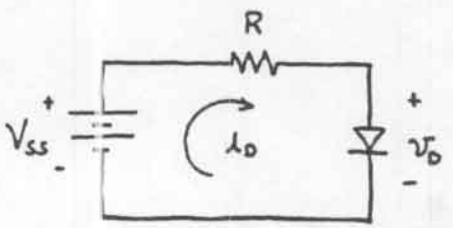
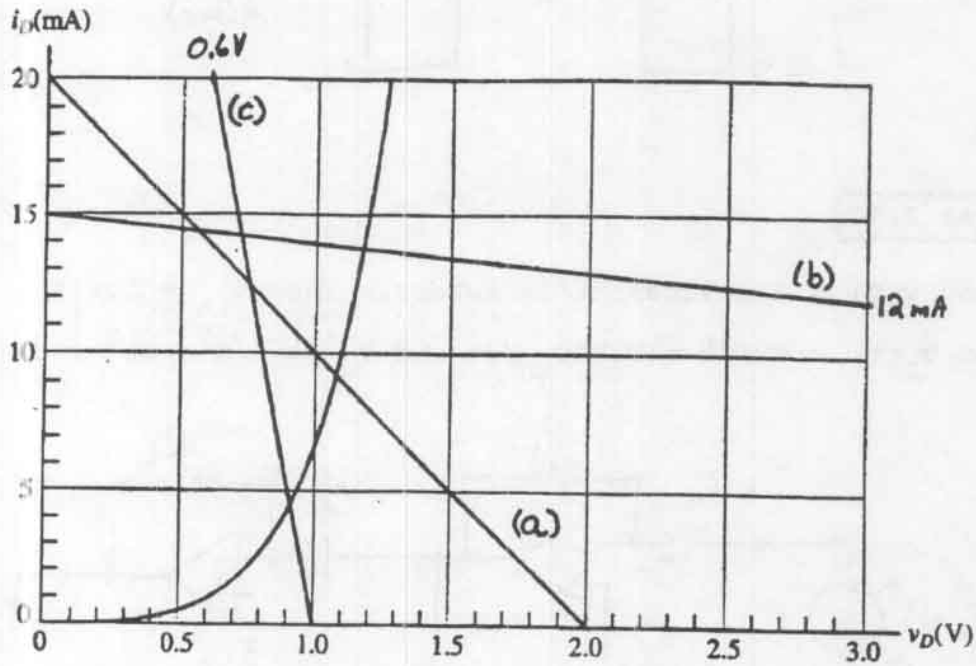
Chapter 3

Exercise 3.1



Load-line equation:

$$V_{SS} = Ri_D + v_D$$



At the intersections of the respective load lines with the diode characteristic, we have

(a) $v_D \cong 1.08$ V $\quad i_D \cong 9.2$ mA

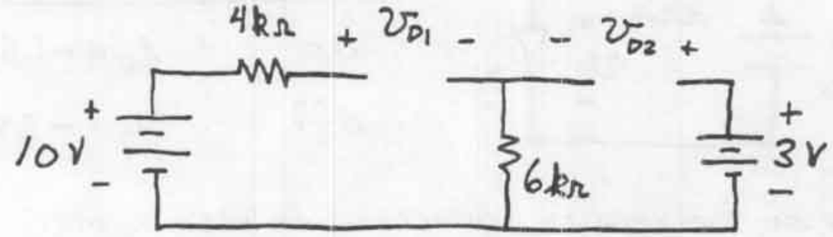
(b) $v_D \cong 1.18$ V $\quad i_D \cong 13.8$ mA

(c) $v_D \cong 0.91$ V $\quad i_D \cong 4.5$ mA

Exercise 3.2

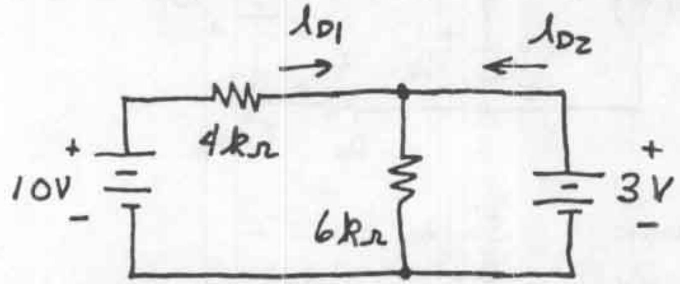
The equivalent circuit is shown on the next page. Solving for the voltages across the diodes we obtain v_{D1} = 10 V and v_{D2} =

3 V. However $v_{D1} > 0$ and $v_{D2} > 0$ are not consistent with the assumption that the diodes are off.



Exercise 3.3

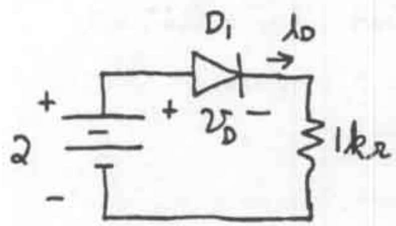
Assuming that the diodes are on, the equivalent circuit is:



Solving for the currents, we determine that $i_{D1} = (10 - 3)/4000 = 1.75$ mA and $i_{D2} = 3/6000 - i_{D1} = -1.25$ mA. However $i_{D2} < 0$ is inconsistent with the assumption that D_2 is on.

Exercise 3.4

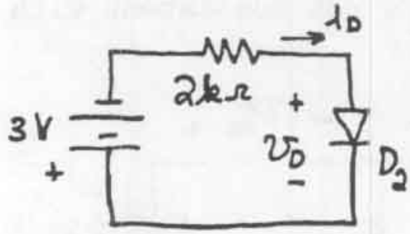
(a)



Assume D_1	Solve for v_D or i_D
on	$i_D = 2mA$
off	$v_D = +2V$

$v_D = +2$ is inconsistent with the assumption that D_1 is off. On the other hand, $i_D = 2$ mA is consistent with the assumption that D_1 is on. Thus we conclude that D_1 is on and $i_D = 2$ mA.

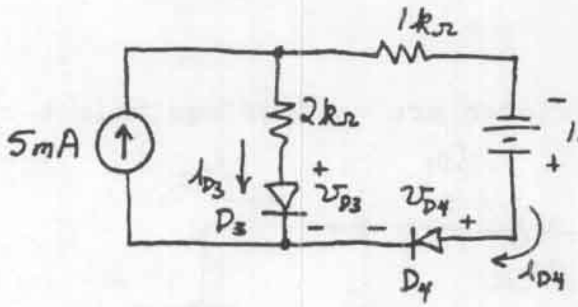
(b)



Assume D_2	Solve for v_D or i_D
on	$i_D = -1.5mA$
off	$v_D = -3V$

In this case the results are consistent with D_2 off.

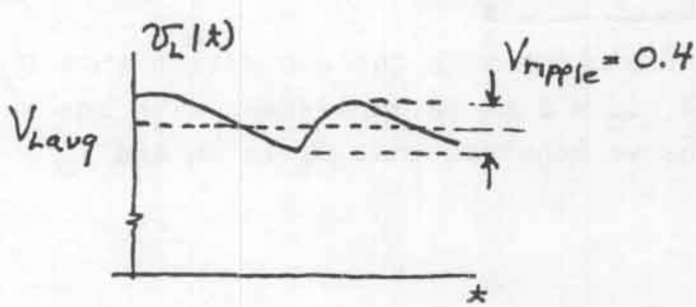
(c)



Assume D_3	D_4	Solve circuit for v_D's and i_D's
off	off	impossible — no closed path for 5mA
off	on	$i_{D4} = 5mA$ $v_{D3} = -5V$
on	off	$i_{D3} = 5mA$ $v_{D4} = 20V$
on	on	$i_{D3} = -1.67mA$ $i_{D4} = 6.67mA$

Thus we conclude that D_3 is off and D_4 is on.

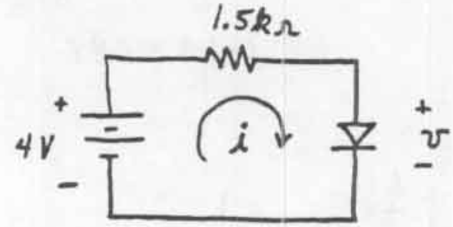
Exercise 3.5



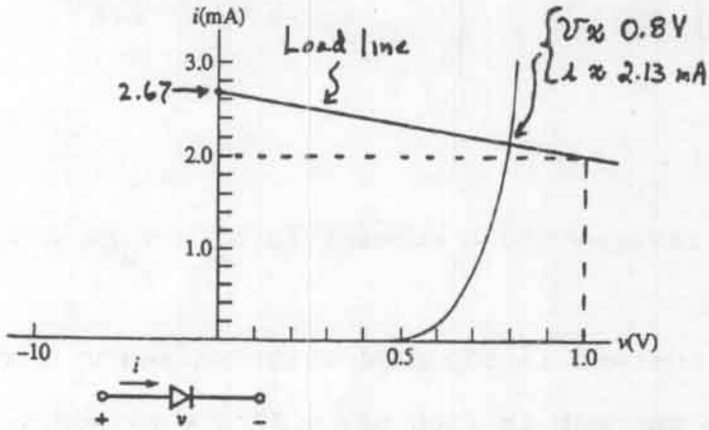
The voltage drops by approximately (2 mV/°C) × 5 diodes = 10 mV/°C. For a 10° increase in temperature the reference voltage decreases by 100 mV for a percentage change of 0.1/3 = 3.33%.

Problem 3.9

(a)

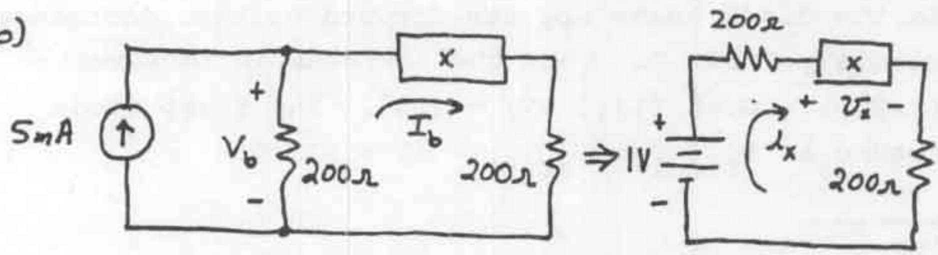


$$4 = 1.5i + v \quad (i \text{ in milliamperes})$$

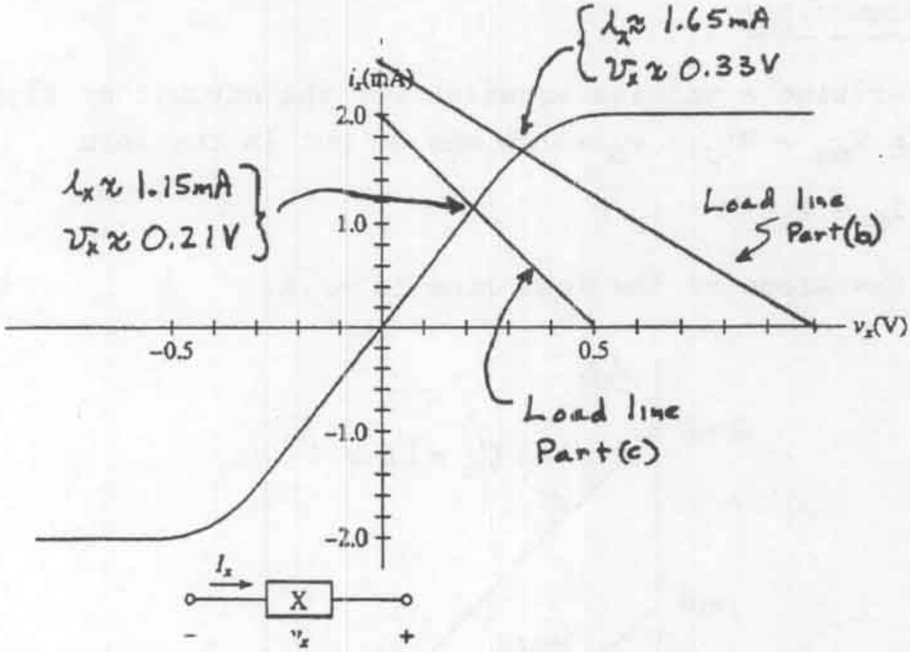


$$V_a = v \approx 0.8V \qquad I_a = i \approx 2.13\,mA$$

(b)

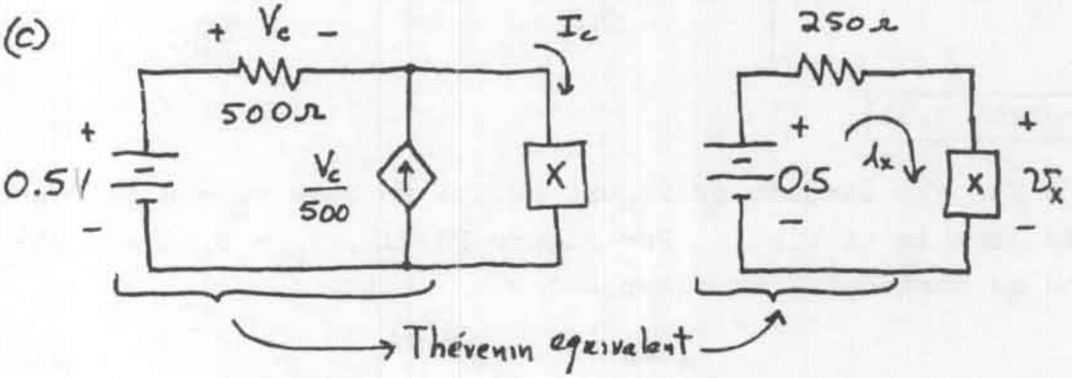


$$1V = 400 i_x + v_x \quad (i_x \text{ in amperes})$$



$I_b = i_x \approx 1.65\,mA \qquad V_b = v_x + 200 i_x \approx 0.66\,V$

(c)



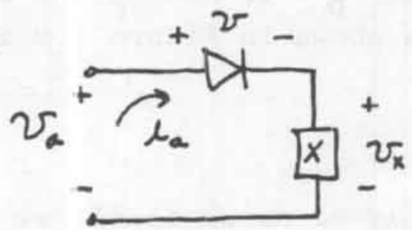
$0.5 = 250 i_x + v_x$ See Load line above.

$I_c = i_x \approx 1.15\,mA$

$V_c = 0.5 - v_x \approx 0.29$

Problem 3.12

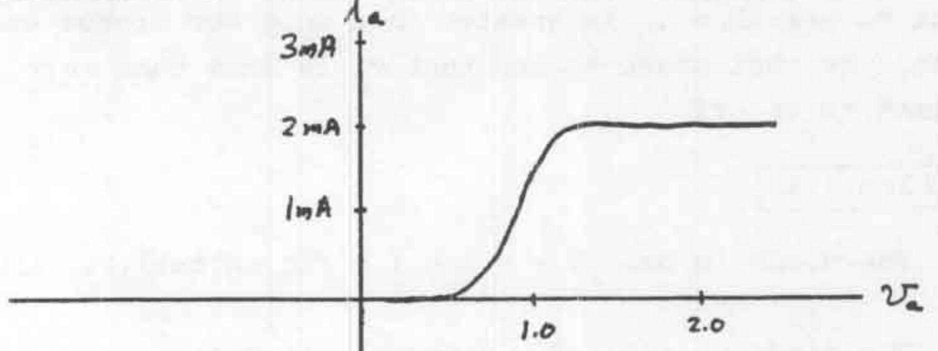
(a)



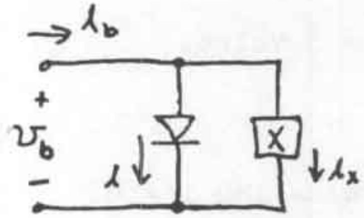
$$i_a = i = i_x$$

$$v_a = v + v_x$$

For each value of i_a add voltages.



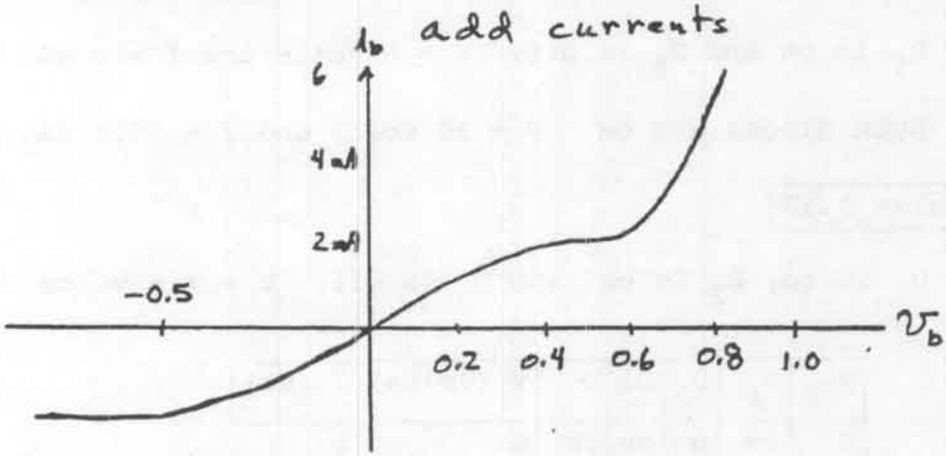
(b)



$$v_b = v = v_x$$

$$i_b = i + i_x$$

For each value of v_b add currents



Problem 3.13

The ideal diode model has $v_D = 0$ if $i_D \geq 0$, and $i_D = 0$ if $v_D \leq 0$. The volt-ampere characteristic is shown in Figure 3.8 in the book.

Problem 3.14

After solving a circuit using the ideal diode model, we must check to see that i_D is greater than zero for diodes assumed to be on. We must check to see that v_D is less than zero for diodes assumed to be off.

Problem 3.15

(a) The diode is on. $V = 0$ and $I = (10 \text{ volts})/(2.7 \text{ k}\Omega) = 3.70$ mA.

(b) The diode is off. $I = 0$ and $V = 10$ volts.

(c) The diode is on. $V = 0$ and $I = 0$.

(d) The diode is on. $I = 5$ mA and $V = 5$ volts.

Problem 3.16

(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 diodes are on. $V = 30$ volts and $I = 33.6$ mA.

Problem 3.17

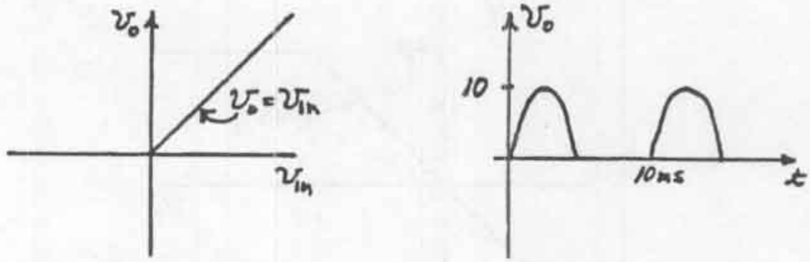
(a) D_1 is on, D_2 is on, and D_3 is off. $V = 7.5$ volts and $I = 0$.

(b)

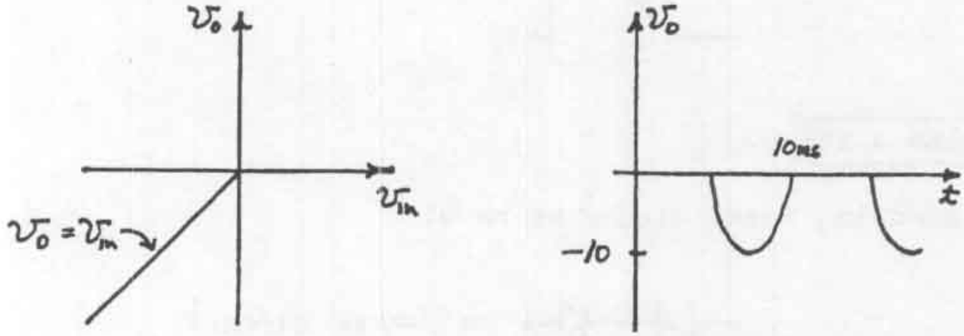
V_{in}	D_1	D_2	D_3	D_4	V (volts)	I (mA)
0	on	on	on	on	0	0
2	on	on	on	on	2	2
6	off	on	on	off	5	5
10	off	on	on	off	5	5

Problem 3.20

(a)



(b)



Problem 3.21

(a) For a half-wave rectified sine wave, we have:

$$V_{avg} = \frac{1}{T}\int_0^T v(t)\ dt = \frac{1}{T}\int_0^{T/2} V_m \sin(\omega t)\ dt = \frac{V_m}{\omega T}\Big[-\cos(\omega t)\Big]_0^{T/2} = \frac{2V_m}{2\pi} = \frac{V_m}{\pi}$$

(We have used the fact that $\omega T = 2\pi$.)

(b) For a full-wave rectified sine wave, we have:

$$V_{avg} = \frac{1}{T}\int_0^T v(t)\ dt = \frac{1}{T}\left[\int_0^{T/2} V_m \sin(\omega t)\ dt + \int_{T/2}^{T} -V_m \sin(\omega t)\ dt\right]$$

Integrating evaluating and using the fact that $\omega T = 2\pi$, we obtain

$$V_{avg} = \frac{2V_m}{\pi}$$