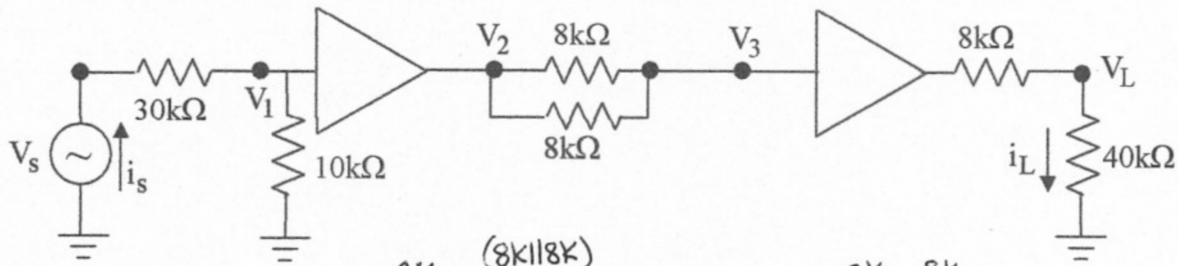
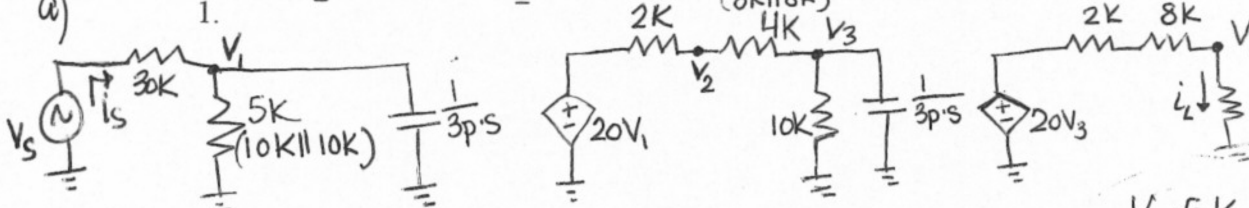
ECE2280 **Homework #3** **Spring 2007**



a)



$$V_L = \frac{20\cdot V_3\cdot 40K}{50K}$$

$$V_3 = \frac{20\cdot V_1\cdot(10K \| \frac{1}{3p\cdot s})}{(10K \| \frac{1}{3ps}) + 6K}$$

$$V_3 = \frac{\frac{20\cdot V_1\cdot 10K\cdot \frac{1}{3ps}}{(10K+\frac{1}{3ps})}}{\frac{10K\cdot\frac{1}{3ps}}{(10K+\frac{1}{3ps})} + 6K}\left[\frac{(10K+\frac{1}{3ps})}{(10K+\frac{1}{3ps})}\right]\cdot\frac{3ps}{3ps}$$

$$V_3 = \frac{20\cdot 10K\cdot V_1}{10K + 6K\cdot 10K\cdot 3p\cdot s + 6K} = \frac{200K}{16K(11.25n\cdot s+1)}$$

$$V_1 = \frac{V_s\cdot 5K}{30K(5K\cdot 3\cdot p s+1)+5K} = \frac{V_s\cdot 5K}{35K(1.29\times10^{-8}\cdot s+1)}$$

$$\frac{V_L}{V_s} = \frac{20\cdot 40K\cdot 200K\cdot 5K}{50K\cdot 16K\cdot 35K(11.25ns+1)(1.29\times10^{-8}s+1)}$$

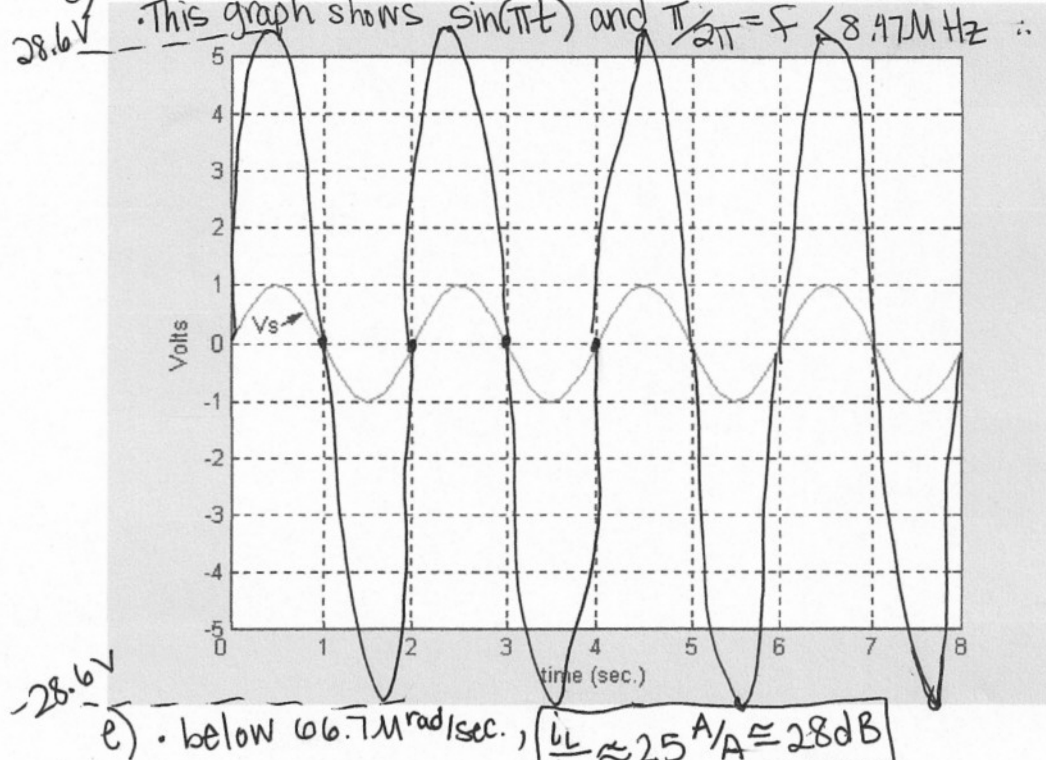
$$\boxed{\frac{V_L}{V_s} \cong \frac{+28.57}{(\frac{s}{89M}+1)(\frac{s}{77.6M}+1)}}$$

b. overall gain → $\boxed{28.57\ V/V}$

c. f_{3dB}: $10^{\left(\frac{20\log(28.57)-3dB}{20}\right)} = \dfrac{28.57}{\sqrt{(\frac{f_{3dB}}{89M})^2+1^2}\cdot\sqrt{(\frac{f_{3dB}}{77.6M})^2+1^2}}$

solving ⇒ $\boxed{f_{3dB} = 53.2\ M\,rad/sec. = 8.47\ MHz}$

d) · This graph shows $\sin(\pi t)$ and $\pi/2\pi = f < 8.47MHz$ ∴ gain ≈ +28.6V (not inverting) (Note ⇒ too high for amplifier power supplies) → clipping will occur



e) $i_L = V_L/40K$, $i_s = \dfrac{V_s - V_1}{30K}$

$$i_s = \frac{V_s 35K\cdot 1.29\times10^{-8}s + 35K V_s - V_s 5K}{30K\cdot 35K(1.29\times10^{-8}s+1)}$$

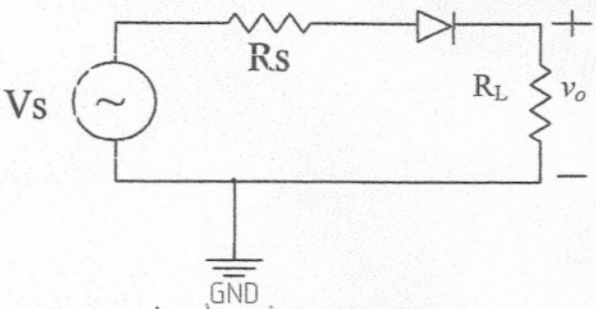
$$i_s = V_s\frac{(30K(1.505\times10^{-8}s+1))}{30K\ 35K(\frac{s}{77.6M}+1)}$$

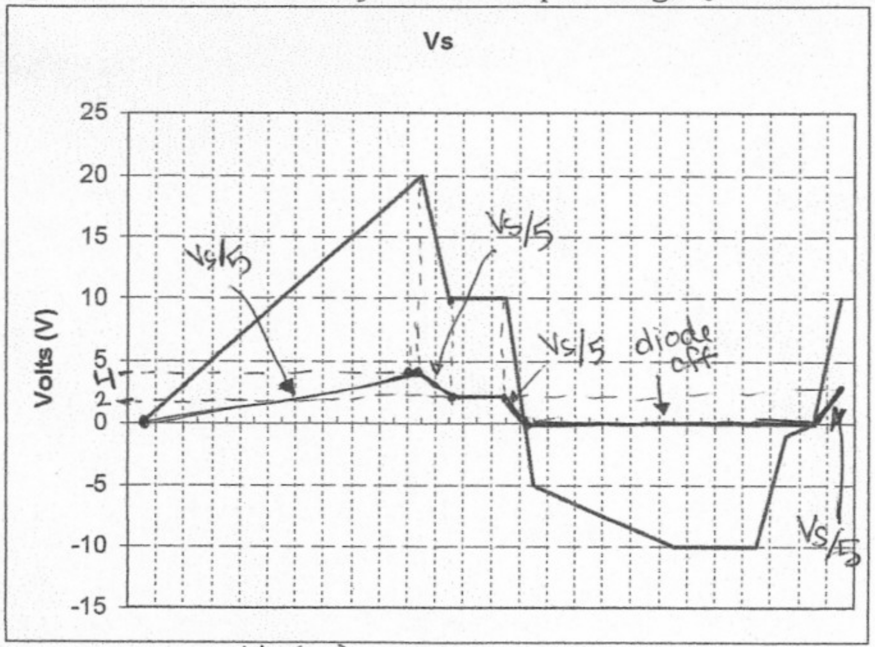
$$\frac{i_L}{i_s} \cong \frac{V_L}{V_s}\cdot\frac{35K(\frac{s}{77.6M}+1)}{40K(\frac{s}{66.7M}+1)}$$

$$\therefore \boxed{\frac{i_L}{i_s} \approx \frac{25(\frac{s}{77.6M}+1)}{(\frac{s}{66.7M}+1)(\frac{s}{89M}+1)(\frac{s}{77.6M}+1)}}$$

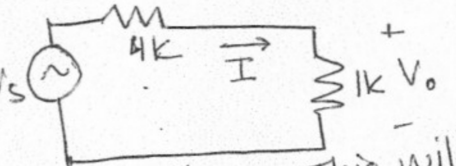
e) · below 66.7M rad/sec., $\boxed{\frac{i_L}{i_s} \approx 25\ A/A \cong 28dB}$

2. Assume the diode is ideal. Let Rs = 4kΩ, R_L=1kΩ. Sketch and clearly label the output voltage v_o. Vs is shown in the graph below.



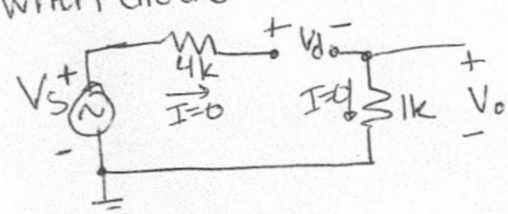


when diode is on →



$I = \frac{V_s}{5K}$ ← This will be positive for $V_s > 0 \Rightarrow V_o = I(1k) = \frac{V_s(1k)}{5k} = \frac{V_s}{5}$

when diode is off →



$V_o = 0$

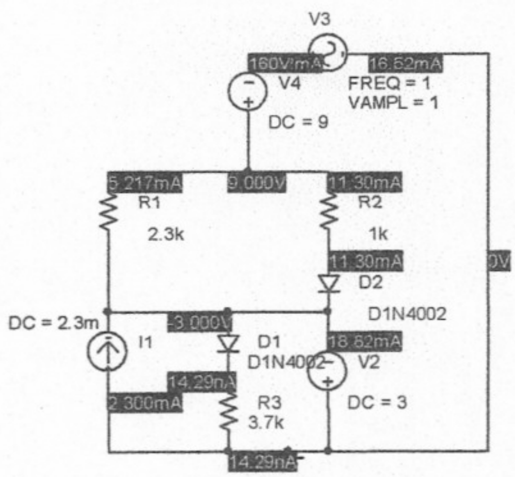
The diode will be off when $V_d < 0$

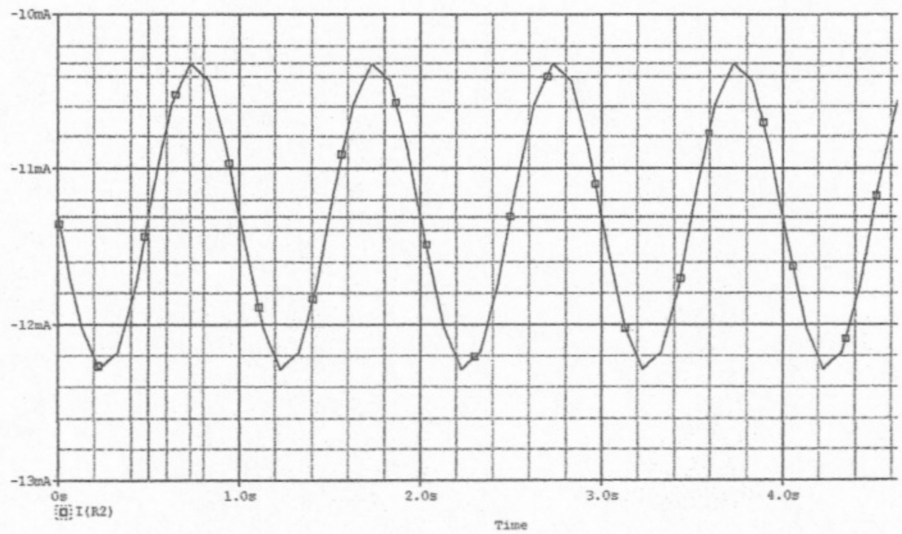
$+V_s - V_d = 0$

$V_d = V_s$ ∴ $V_d < 0$ when $V_s < 0$

3&4 on next pages

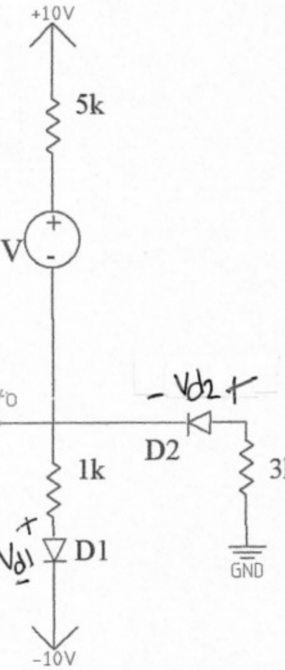
5.



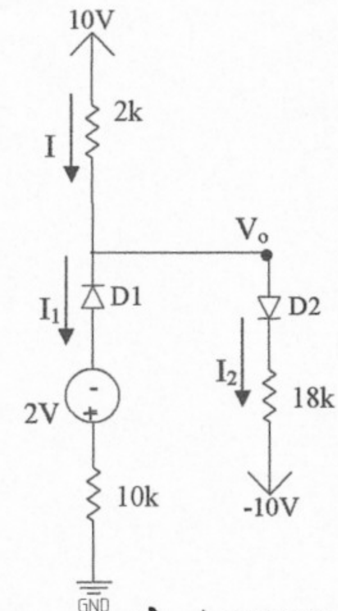


I_{D1}=11.3mA (same), **I_{D2}=14.29nA** (theoretical was 0 => This is because the diode has a small leakage current even when it is off. In this case, it is 14.29nA which flows from + to -), **Vo=-3** (same). The noise was "modeled" by using a sinusoid with amplitude 1. The transient analysis for the current, id, is shown above on the right. Using the cursors, it was measured to be around **0.999mA** peak from -11.3mA(DC value) which compares to the theoretical value of **0.998mA**.

3. Use the constant voltage drop diode model with V_{D0}=0.7 to solve the circuits below for all currents in all branches of the circuit and Vo. Verify your answers.

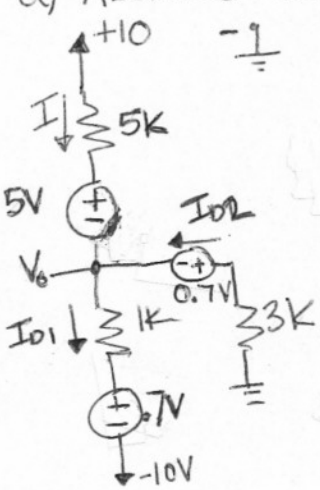


(a)



(b)

a) Assume both "on"



I_{D1} & I_{D2} need to be >0

$+10 - I(5K) - 5 - V_o = 0$

$I = \frac{5 - V_o}{5K}$

$+V_o - I_{D1}(1k) - .7 + 10 = 0$

$I_{D1} = \frac{V_o + 9.3}{1k}$

$+V_o + 0.7 + I_{D2}(3K) = 0$

$I_{D2} = \frac{-V_o - 0.7}{3K}$

$I + I_{D2} - I_{D1} = 0$

$$\frac{(5 - V_o)}{5k} + \frac{-V_o - 0.7}{3k} + \frac{-V_o - 9.3}{1k} = 0$$

$$V_o\left(\frac{1}{5k} + \frac{1}{3k} + \frac{1}{1k}\right) = \left(\frac{5}{5k} - \frac{0.7}{3k} - \frac{9.3}{1k}\right)$$

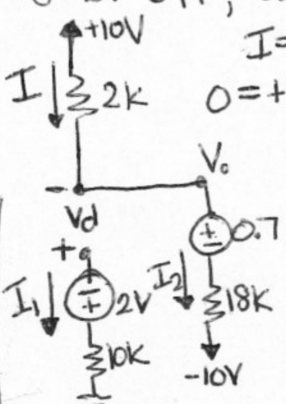
$$V_o = \frac{-8.5\times10^{-3}}{1.5\times10^{-3}} = \boxed{-5.7V}$$

$$\Rightarrow I_{D1} = \frac{-5.7 + 9.3}{1k} = \boxed{+3.6mA} > 0 \therefore \text{on}$$

$$I_{D2} = \frac{+5.7 - 0.7}{3k} = \boxed{+1.7mA} > 0 \therefore \text{on}$$

$$I = \frac{5 + 5.7}{5k} = \boxed{+2.14mA}$$

b) Assume D1 "off", D2 "on"



$I = I_2$

$0 = +10 - I_2(2k) - 0.7 - I_2(18k) + 10$

$I_2 = \frac{20 - 0.7}{20K} = \boxed{0.965mA}$

$\boxed{I = 0.965mA \quad I_1 = 0}$

$+10 - I(2K) - V_o = 0$

$V_o = \boxed{+8.07V}$

$\Rightarrow$ D2 on since $I_2 > 0$

$\Rightarrow$ D1 off:

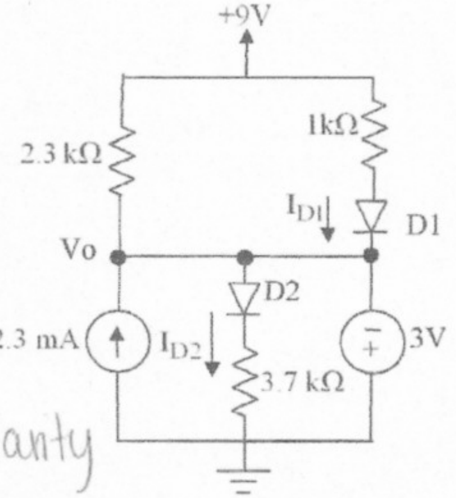
$-2V - V_d - V_o = 0$

$V_d = -2V - 8.07 = -10.07V$

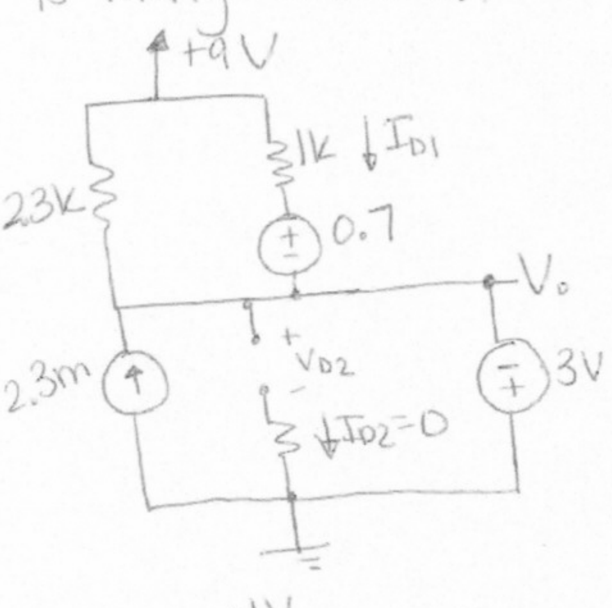
$V_d < 0$

4. Assume all diodes are identical and have V_{DO}=0.7V, n=1, and V_T=25mV. Use the constant voltage drop method. Verify that your assumption for the diode operation(i.e. on or off) are correct. Find the following making sure you find the correct operation of the diodes.

a) State your assumptions (diode is on/off).
b) The current I_{D1}
c) The current I_{D2}
d) The voltage Vo
e) Your verification to prove your assumptions for the diodes are correct.
f) If there is noise on the +9V supply of ± 1V, what is the value for i_d (the AC current through diode, D1). *{Hint: remember to use the AC model for the diode}*



a) D1 on, D2 off (D2 will have -3V across it from observation- voltage polarity is wrong direction)



$+9 - I_{D1}(1k) - 0.7 + 3 = 0$

b) $I_{D1} = \frac{11.3}{1k} = \boxed{11.3mA} > 0$

So assumption for D1 ON correct. ✓

c) $\boxed{I_{D2} = 0}$

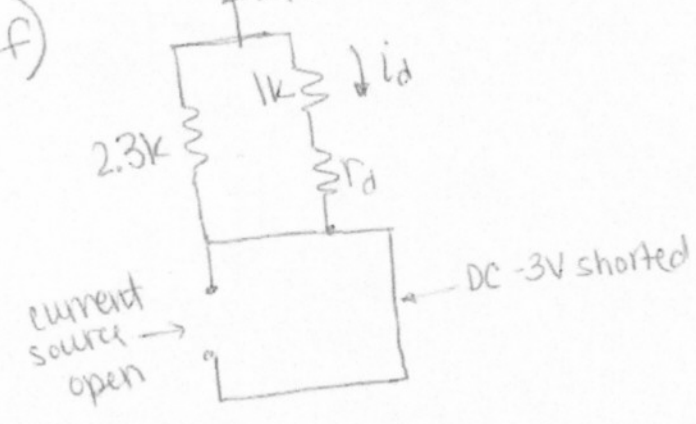
d) $\boxed{V_o = -3V}$

e) $-3V - V_{D2} = 0 \Rightarrow \boxed{V_{D2} = -3V} < 0$

∴ Assumption D2 on correct

$I_{D1} > 0$, D1 ON

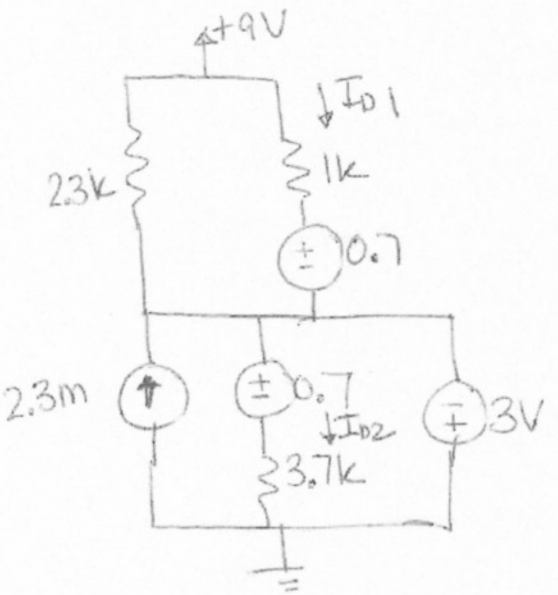
f)



$r_d = \frac{nV_T}{I_{D1}} = \frac{(1)(25m)}{11.3m} \cong 2.2\ \Omega$

$i_d = \frac{\pm 1V}{1k + 2.2} \approx \boxed{\pm 998\mu A\ ac}$

D1 and D2 ON ⇒



$$+9-0.7+3-I_{D1}(1k)=0$$

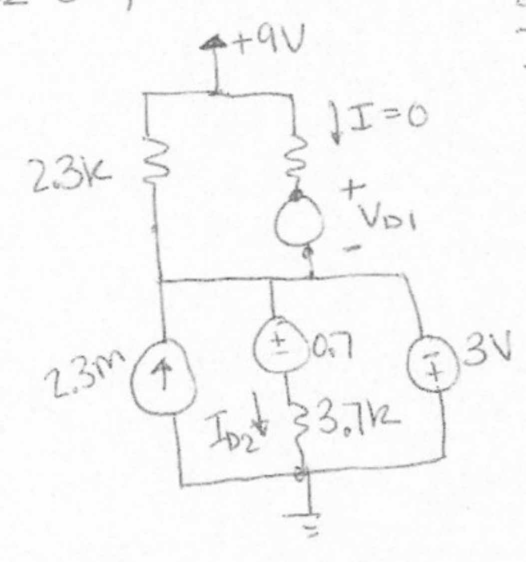
$$I_{D1}=\frac{11.3}{1k}=11.3mA$$

$$-3V-0.7-I_{D2}(3.7k)=0$$

$$I_{D2}=\frac{-3.7}{3.7k}=-1mA<0 \times$$

∴ Wrong Assumption

D2 ON, D1 off ⇒



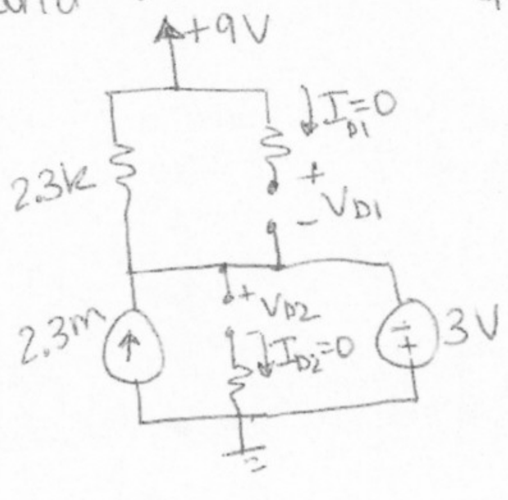
$$-3-0.7-I_{D2}(3.7k)=0$$

$$I_{D2}=\frac{-3.7}{3.7k}=-1mA<0$$ × WRONG Assumption

$$+9V-V_{D1}+3V=0$$

$V_{D1}=+12V$ which is NOT negative ⇒ WRONG ASSUMPTION

D1 and D2 off ⇒



$$+9-V_{D1}+3V=0$$

$V_{D1}=12V$ (NOT NEGATIVE)

→ wrong assumption

$$-3V-V_{D2}=0$$

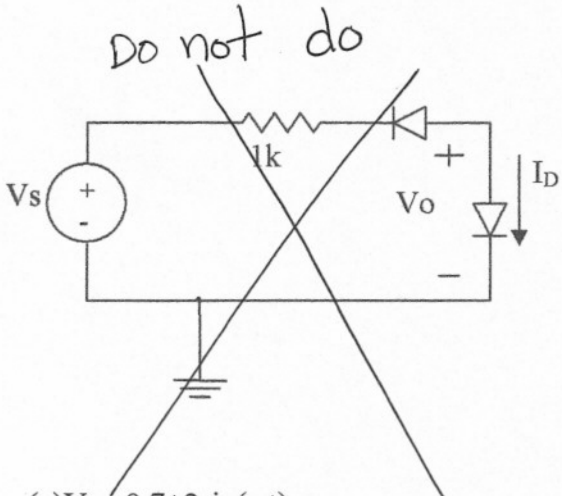
$V_{D2}=-3V<0$ (correct)

6. For the circuit in (a), assume $V_{DO}=0.7V$, $n=2$, and $V_T=25mV$.
For the circuit in (b), assume $V_{DO}=0.6V$, $n=1$, and $V_T=25mV$.

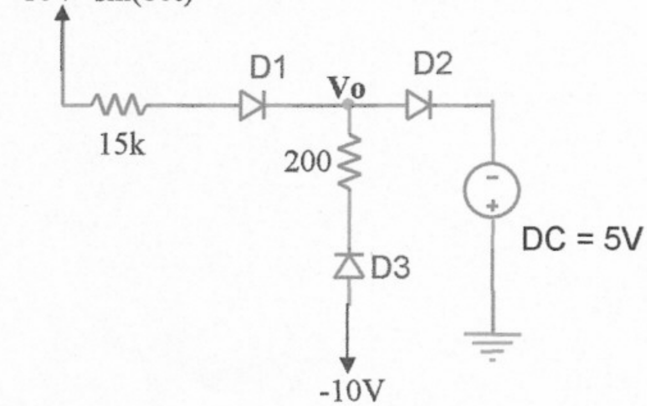
Assume identical diodes and use the constant voltage drop method when appropriate. For each circuit below,

a) Determine the **DC** component of the diode currents through all diodes, I_D.
b) Determine the **DC** component at the output, V_o.
c) Determine the **AC** component of the diode currents through all diodes, i_d.
d) Determine the **AC** component at the output, V_o.
e) What is the **total** output for V_o (Dc and AC).

Do not do

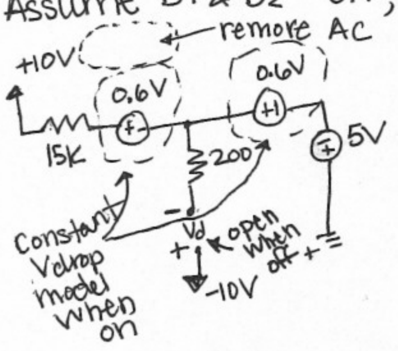


(a)Vs= 0.7+2sin(ωt)

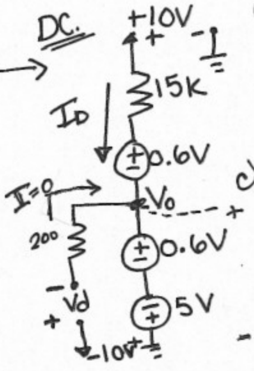


(b)

Assume D1 & D2 "on", D3 "off" →



OR



$+10 - I_D(15K) - 0.6 - 0.6 + 5 = 0$

$I_D = \frac{13.8}{15K} = \boxed{920\mu A = I_{D1} = I_{D2}}$ current through D1 & D2

check: $\therefore I_D > 0 \rightarrow$ D1, D2 on

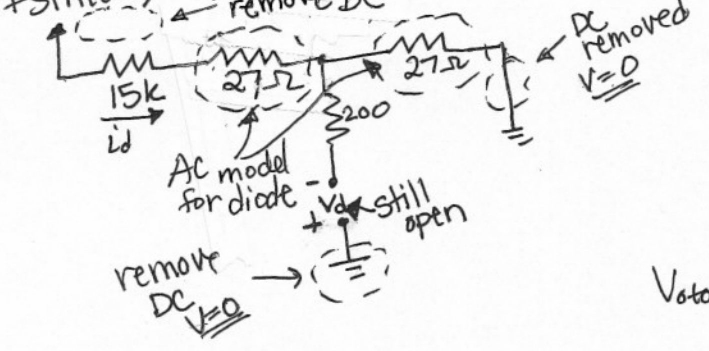
$+V_o - V_d = 0 \Rightarrow V_d = V_o$

$+V_o - 0.6 + 5 = 0 \Rightarrow \boxed{V_{o_{DC}} = -4.4V}$

$\therefore V_d = -4.4V < 0.6 \therefore$ D3 off

$\boxed{I_{D3} = 0}$

AC: $r_{d_1} = \frac{nV_T}{I_{D1}} = r_{d2} = \frac{(1)(25m)}{920\mu} \approx 27\Omega$



$+\sin(60t) - i_d(15k + 27 + 27) = 0$

$\boxed{i_d = \frac{\sin(60t)}{15{,}054}}$

$V_{O_{AC}} = i_d \cdot 27 \cong 1.8m \sin(60t)$

$V_{o\,total} = V_{o_{DC}} + V_{o_{AC}} = \boxed{[-4.4 + 1.8m \sin(60t)]V.}$