- From "chapter 3, no solutions"

1. Expressions: $V_1 + V_2 = 1.657\ V$ (1)

$$V_{DD} - I(1.67k) = 5 - 1.67k\, I = 1.657\ V \quad (2)$$

$$I = I_S\, e^{\frac{V_1}{nV_T}} \quad (3)$$

$$\frac{I}{M} = I_S\, e^{\frac{V_2}{nV_T}} \quad (4)$$

4 eqns

4 unknowns (I, V_1, V_2, M)

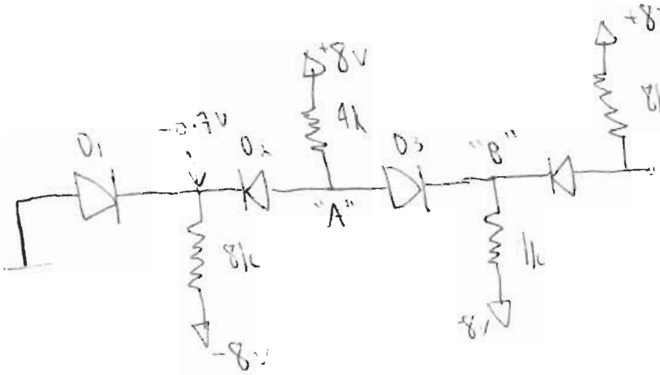
=> (2) yields $\boxed{I = 2mA}$ directly

=> multiply (3) × (4) -> $\frac{I^2}{M} = I_S^2\, e^{\frac{V_1+V_2}{nV_T}}$ -> known from (1)

=> use (1) -> $M_1 = \frac{I^2}{I_S^2\, e^{\frac{1.657}{1.25(25m)}}} = \boxed{37.56}$ (pick a real integer: 37 or 38)

can now solve (3), (4) for V_1, V_2 easily.

2.



=> We must make assumptions & test them!

=> is D_3 off? Try it!

=> get $\frac{8 - V_{out}}{8k} = \frac{(V_{out} - 0.7) + 8}{1k}$

$V_{out} = -5.6V$, so node B = $-6.3V$

=> D2 off would be obviously inconsistent!

=> D2 on puts node "A" at ground -> no good for D3 off!

∴ D3 is ON

-> so node "A" is at V_{out}

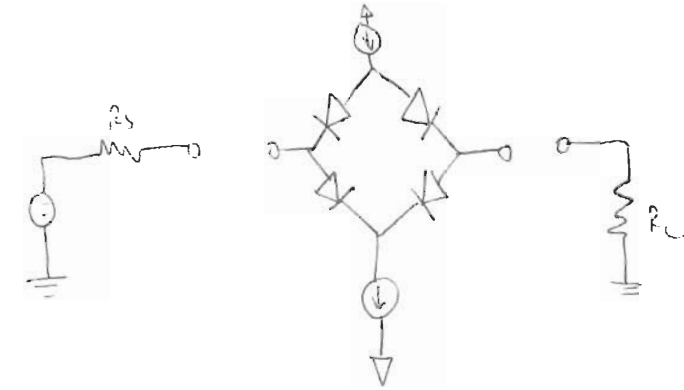
-> Try D2 off: $\frac{(V_{out} - 0.7) + 8}{1k} = \frac{8 - V_{out}}{4k} + \frac{8 - V_{out}}{8k} = 3 \times \frac{8 - V_{out}}{8k}$ $\quad V_{out} = -3.127\ V$

=> is D2 off? YES

- solution is consistent.

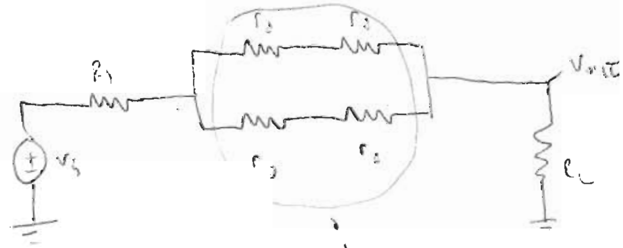
3.

a)



b) by symmetry : $I_{D_{1,2,3,4}} = \frac{I_{ref}}{2}$; $r_d = \frac{2nV_T}{I_{ref}}$

c)



$$\frac{V_{out}}{v_s} = \frac{R_L}{R_s + r_d + R_L}$$

$= 2r_d \| 2r_d$

$= r_d$!

4. D_2, D_3 off by inspection

D_1, D_4 cannot both be on

D_5 is most likely ON → $V_o = 1.3$ → is D_1 on?

yes → (get by analysis) $I_{300\Omega} = 11.3\,mA$ (no good... D4 is off by assumption!)

no → D4 must be on → $I_{300k} = \frac{2V}{300+700} = 2mA$ ok

check D7 :

off as assumed

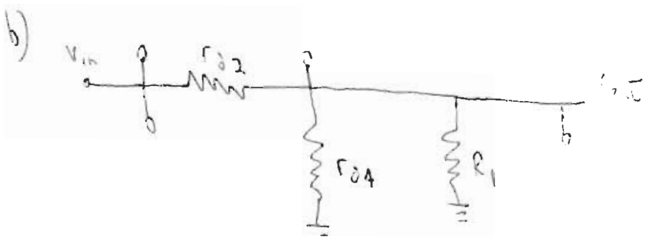
b) $I = \frac{1.3}{400} = 3.25\,mA$ (There must be 1.25 mA in D5 ... D5 is ON as expected)

c) $I_{300k} = 2mA$.

5. a) D_1, D_5 off by inspection

$I_{D2} = I_1$, $I_{D3} = I_2$, $I_{D4} = I_1 + I_2$ → These 3 diodes are ON

b)



c) $\frac{v_{out}}{v_{in}} = \frac{R_1 \| r_{d4}}{R_1 \| r_{d4} + r_{d2}} = 0.196$ V/V

$r_{d2} = \frac{nV_T}{I_1}$, $r_{d4} = \frac{nV_T}{I_1 + I_2}$

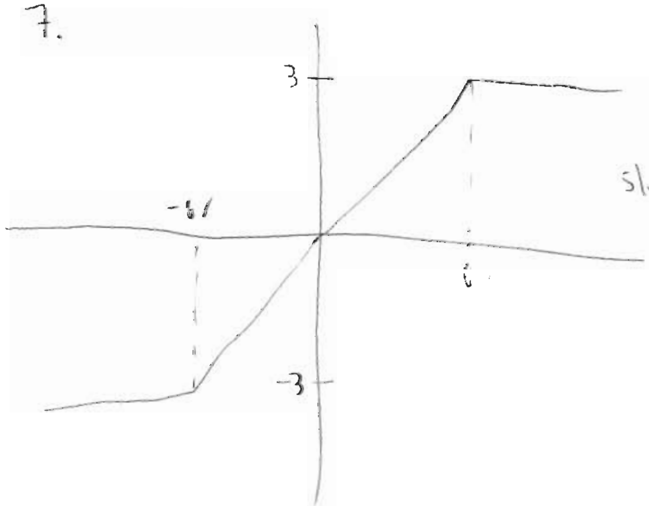
6. $I_{D_3} = I$; if D7 is on then D8 is off (has 0.2 V reverse bias) (D8 on is impossible ... turns off D7 ... no current flow in D8!)

⟹ D7 on requires D4, D5, D6 on too → $I_{D_{4,5,6,7}} = \frac{I}{2}$

D1, D2 are off (because v_{in} is not DC input)

$\frac{v_{out}}{v_{in}} = 0.294$ V/V by analysis

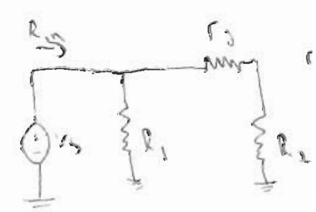
7.



slope - $\frac{1}{2}$ by voltage divider

8-9 (skip)

10. DC analysis - $I_{R_1} = \frac{5V}{R_1}$; $I_{R_2} = \frac{4.3V}{R_2}$

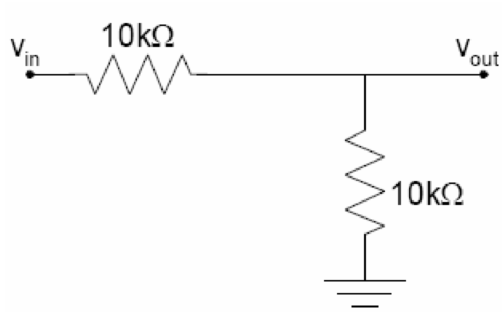


$r_d = \frac{nV_T \cdot R_2}{4.3}$

$R_{in} = R_1 \| \left(R_2 * \left(1 + \frac{nV_T}{4.3}\right)\right)$

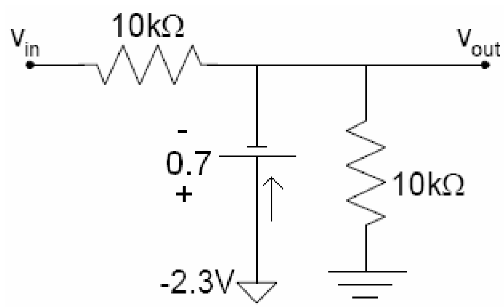
7. (contd…)

1- When both diodes are off:



$$V_{out} = \frac{10k\Omega}{10k\Omega + 10k\Omega} V_{in} = V_{in}/2$$

2-The required input voltage to create the “ON” voltage at the cathode of D_2 (let's call it V_A):



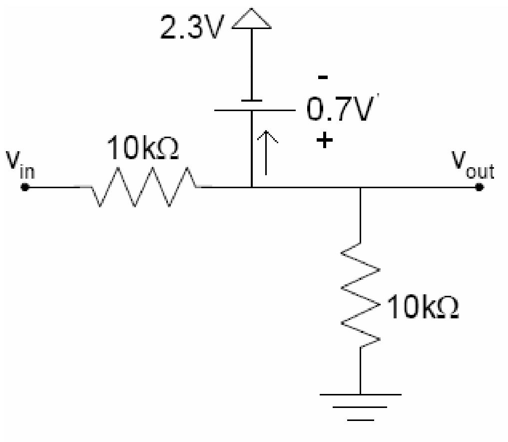
When diode hasn't switched yet,

$$I_{D2} = 0A \quad \Rightarrow \quad V_A = \frac{10k\Omega}{10k\Omega + 10k\Omega} V_{in} = V_{in}/2$$

We know V_A should be V_A<-2.3-0.7=-3 (note not -1.6) to switch D_2 “ON”

Therefore v_{in}<-6 for switching D_2 “ON” and v_{out}=-3

3- Now, the required input voltage to create the “ON” voltage at the Anode of D_1 (let's call it V_A again, it is the same node):



When the diodes are still off,

$$I_{D2} = 0A \quad \Rightarrow \quad V_A = \frac{10k\Omega}{10k\Omega + 10k\Omega} V_{in} = V_{in}/2$$

We know V_A should be V_A>2.3+0.7=3 to switch D_1 “ON”

Therefore v_{in}>6 for switching D_1 “ON” and v_{out}=3