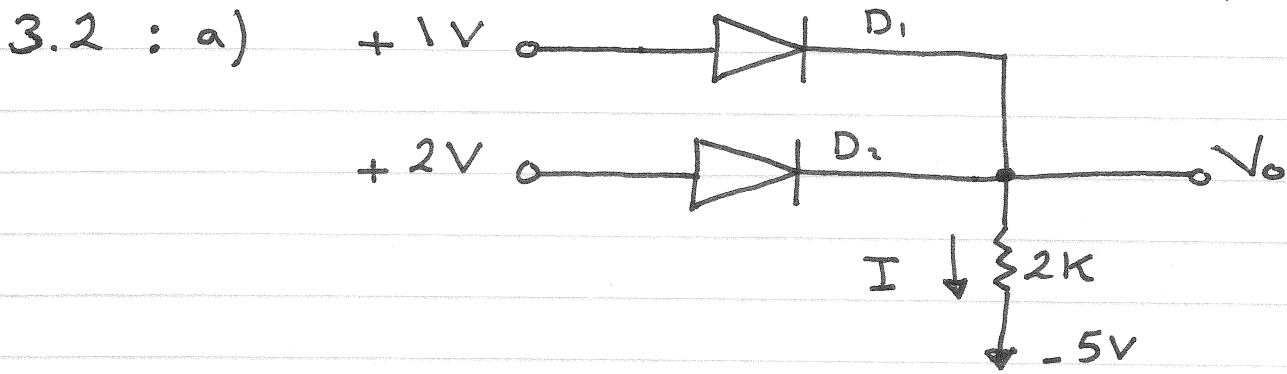
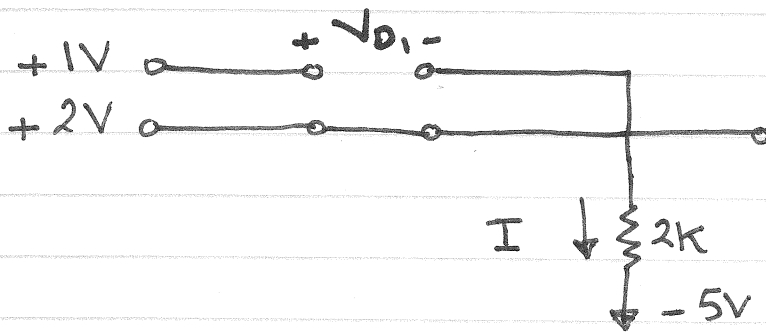


Homework Solutions Chapter 3

EE 233



Diode D_1 is OFF, Diode D_2 is ON

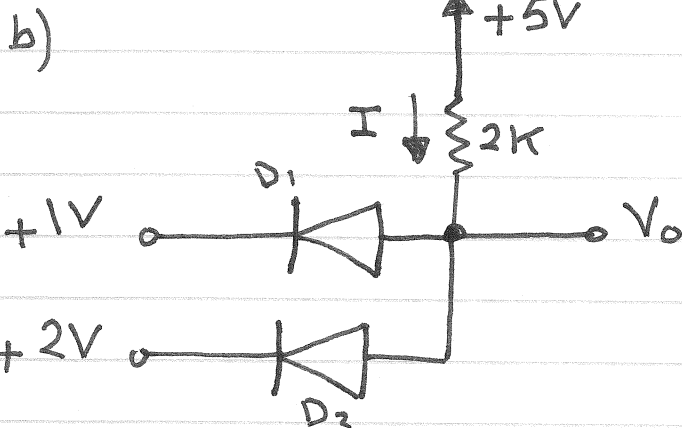


$$V_0 = 2V$$

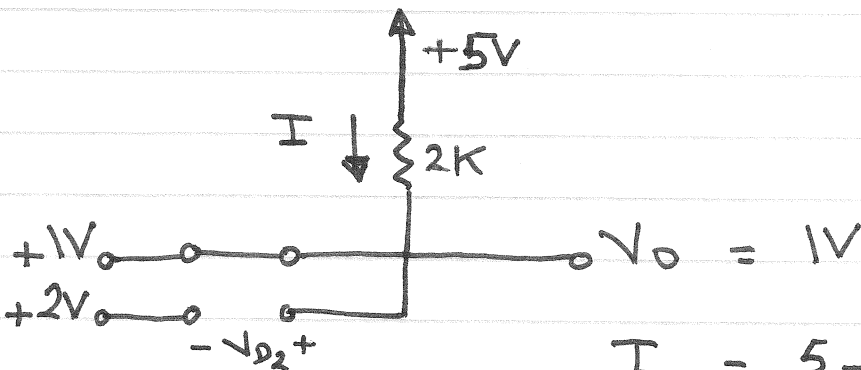
$$I = \frac{2+5}{2K} = 3.5mA$$

$$I_{D_2} = I > 0$$

$$V_{D_1} = 1-2 = -1V < 0$$



D_1 is ON, D_2 is OFF



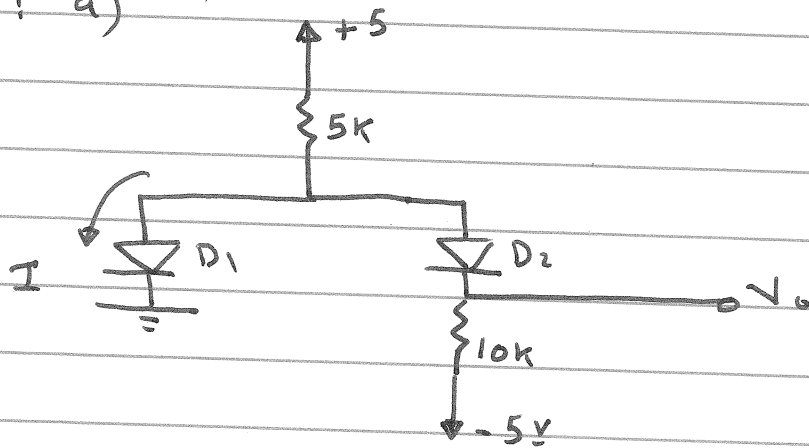
$$I = \frac{5-1}{2K} = 2mA$$

$$I_{D_1} = I > 0$$

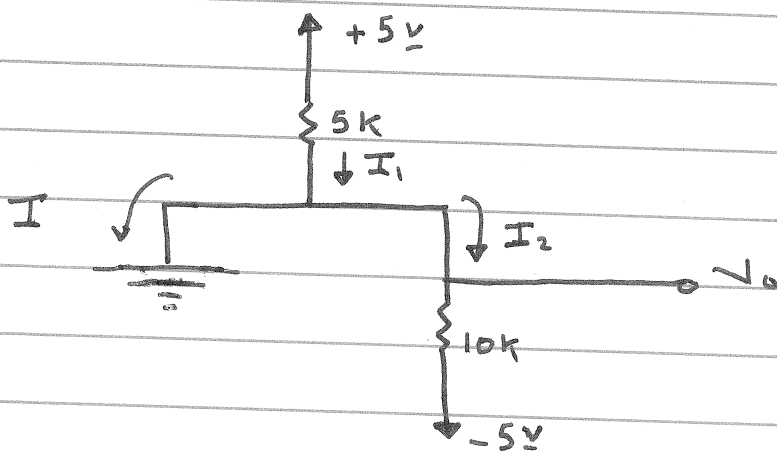
$$V_{D_2} = 1-2 = -1V < 0$$

..

3.7: a)



both diodes are on



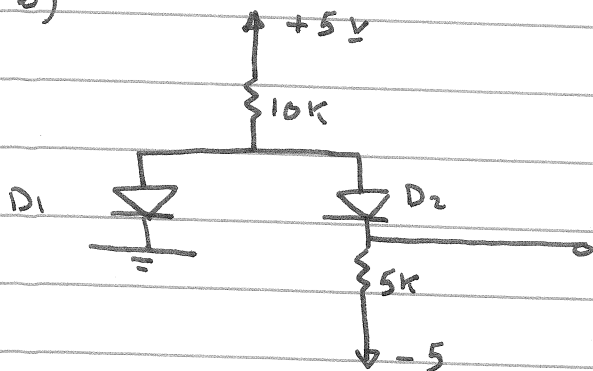
$$I_2 = \frac{0+5}{10k} = 0.5 \text{ mA} \quad ; \quad I_1 = \frac{5-0}{5k} = 1 \text{ mA}$$

$$\therefore I = I_1 - I_2 = 0.5 \text{ mA}$$

$$V_o = 0$$

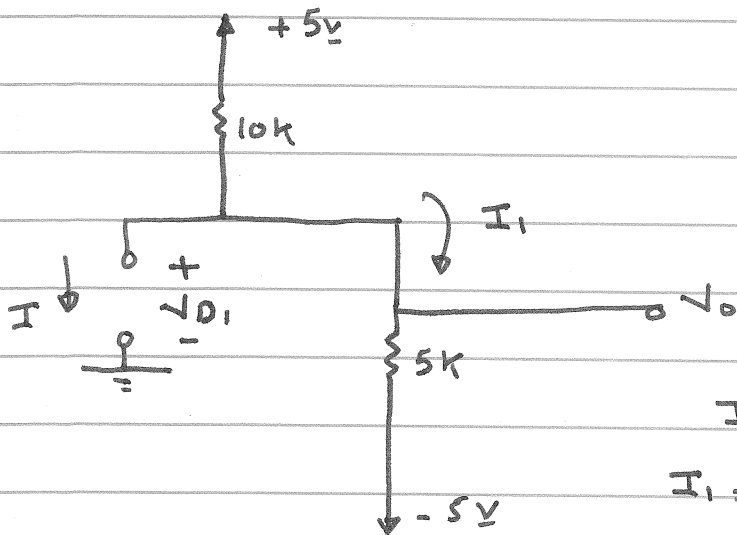
$$I_{D1} = I > 0 \quad ; \quad I_{D2} = I_2 > 0$$

b)



D₁ is OFF

D₂ is ON



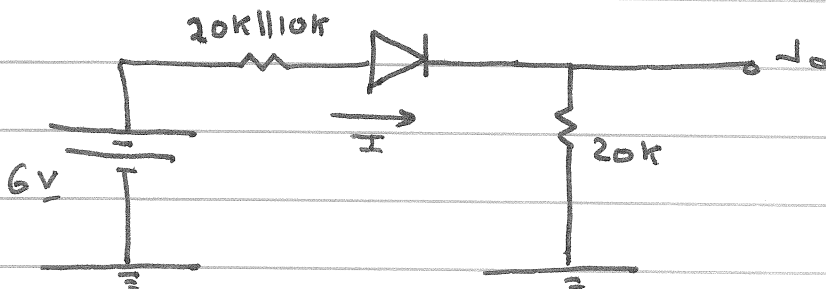
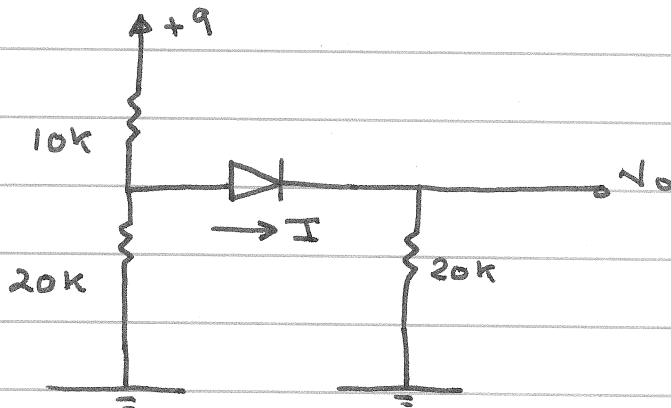
$$I = 0$$

$$I_1 = \frac{5+5}{15} = \frac{2}{3} \text{ mA}$$

$$V_o = (5k)(I_1) - 5 = -\frac{5}{3} \text{ V}$$

$$I_{D2} = I_1 = \frac{2}{3} \text{ mA} > 0 ; V_{D1} = V_o = -\frac{5}{3} \text{ V} < 0$$

3.8 a)

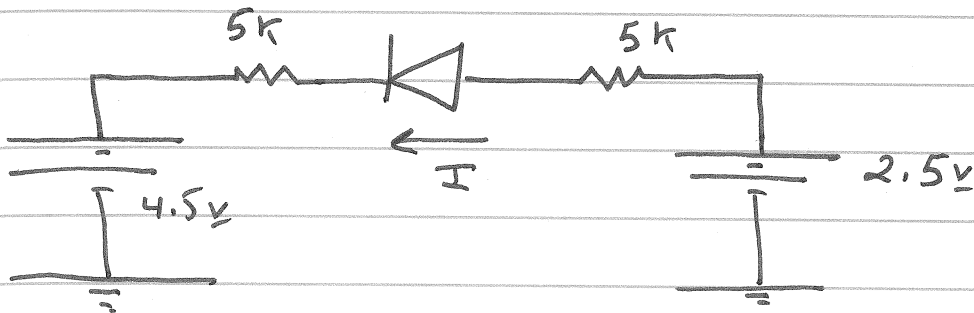
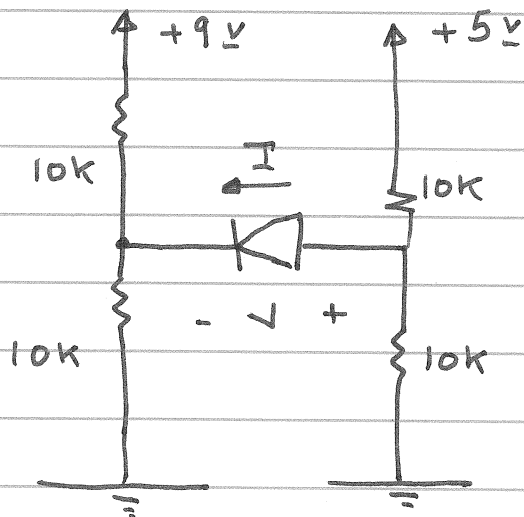


Diode is on

$$V_o = \frac{20k}{20k + 10k \parallel 20k} \cdot 6 = 4.5 \text{ V}$$

$$I = \frac{V_o}{20k} = 0.225 \text{ mA} > 0$$

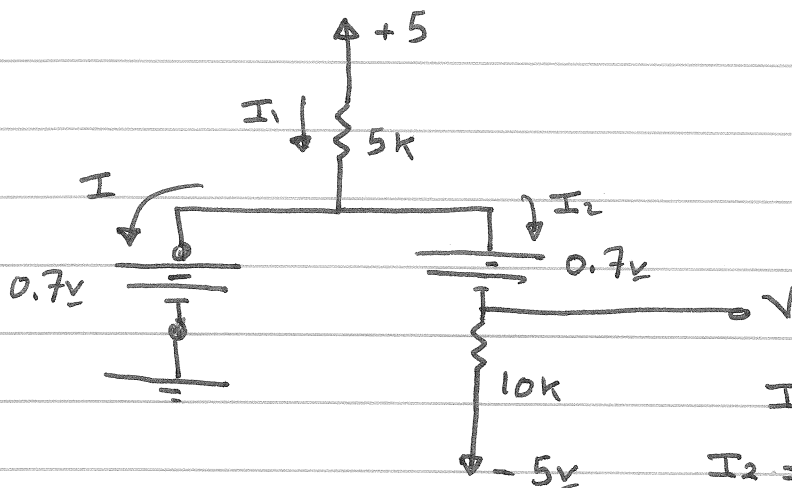
3.8 b)



Diode is OFF $\therefore I = 0$

$$V = 2.5 - 4.5 = -2V < 0$$

3.33 : a) D_1 is on, D_2 is on



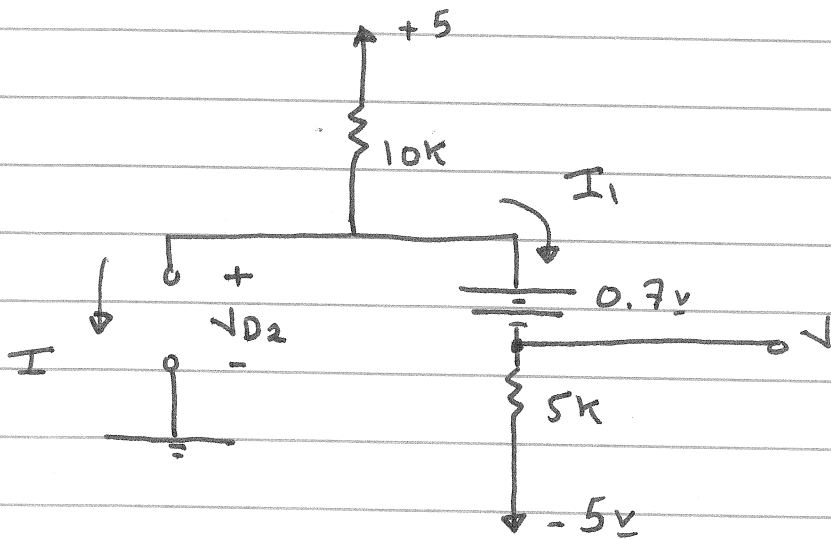
$$I_1 = \frac{5 - 0.7}{5k} = 0.86 \text{ mA}$$

$$I_2 = \frac{5}{10k} = 0.5 \text{ mA}$$

$$I_{D1} = I > 0; I_{D2} = I_2 > 0 \therefore I = 0.86 \text{ mA} - 0.5 \text{ mA} = 0.36 \text{ mA}$$

$$V = 0V$$

b) D_1 is OFF, D_2 is ON



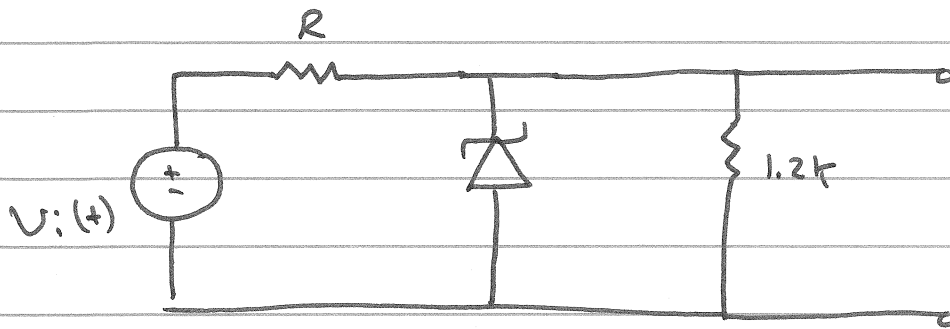
$$I = 0, \quad I_1 = \frac{5 + 5 - 0.7}{15k} = 0.62 \text{ mA}$$

$$V = (5k)(0.62 \text{ mA}) - 5$$
$$V = -1.9 \text{ V}$$

$$I_{D2} = I_1 > 0$$

$$V_{D2} = -10k I_1 + 5 = -1.2 \text{ V} < 0.7 \text{ V}$$

3.52 :



$$V_Z = 7.5\text{V} \quad @ \quad I_Z = 12\text{mA}$$

$$V_Z = 30\Omega \quad I_{ZK} = I_Z(\text{min}) = 0.5\text{mA}$$

$$V_Z = V_{Z0} + V_Z I_Z$$

$$7.5 = V_{Z0} + (30\Omega)(12\text{mA})$$

$$\therefore V_{Z0} = 7.14\text{V}$$

$$\text{let } I_Z = 12\text{mA} \rightarrow V_Z = 7.5\text{V}$$

$$I_S = \frac{V_i - V_Z}{R} = I_Z + I_L$$

$$I_L = \frac{V_Z}{R_L} = \frac{7.5}{1.2\text{k}} = 6.25\text{mA}$$

$$\therefore I_S = I_Z + I_L = 18.25\text{mA}$$

$$I_S = \frac{V_i - V_Z}{R}$$

$$V_i = 10\text{V}, \quad V_Z = 7.5\text{V}, \quad I_S = 18.25\text{mA}$$

$$\therefore R = 137\Omega$$

A second method

$$R_s < \frac{V_i(\text{min}) - V_z}{I_z(\text{min}) + I_L(\text{max})}$$

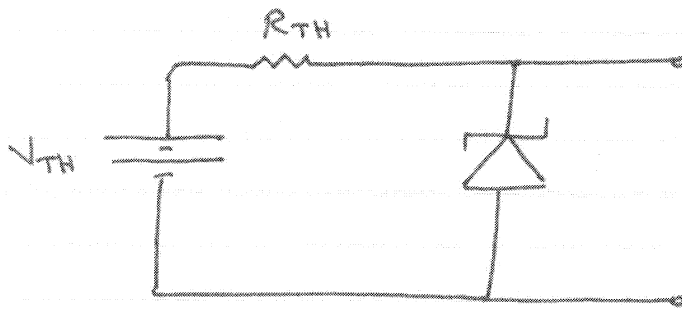
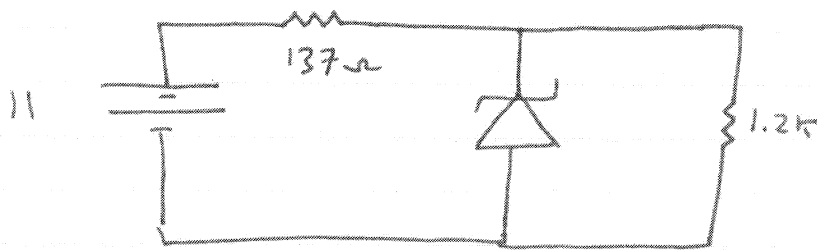
$$\begin{aligned} V_z &= V_{z0} + V_z I_z \\ &= 7.14 + (30)(0.5\text{mA}) \end{aligned}$$

$$V_z = 7.155 \text{ V}$$

$$R_s < \frac{10 - 7.155}{0.5\text{mA} + \frac{7.155}{1.2\text{k}}}$$

$$R_s < 440.23 \Omega$$

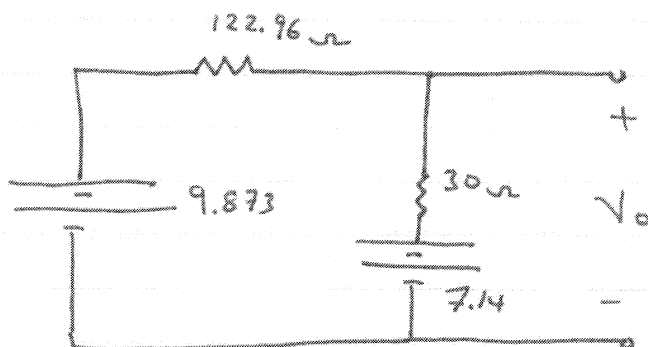
b) when $V_i = 11 \text{ V}$



$$R_{TH} = 137\Omega \parallel 1.2k\Omega = 122.96\Omega$$

$$V_{TH} = \frac{1.2k\Omega}{1.2k\Omega + 137\Omega} \cdot 11 = 9.873 \text{ V}$$

Since $V_{TH} > V_{Z0}$; Zener diode is in the
breakdown region



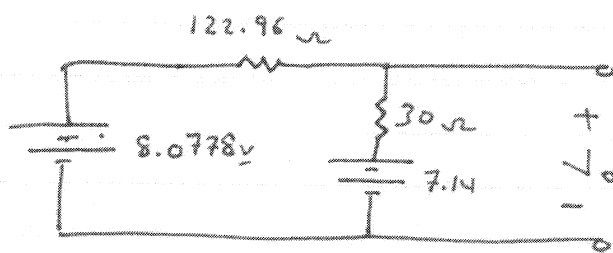
$$V_o = 7.14 + \frac{9.873 - 7.14}{152.96} \cdot 30 = 7.676 \text{ V}$$

When $V_i = 9 \text{ V}$

$$R_{TH} = 122.96 \Omega$$

$$V_{TH} = 8.0778 \text{ V}$$

Since $V_{TH} > V_{z0}$; Zener diode is in the
breakdown region

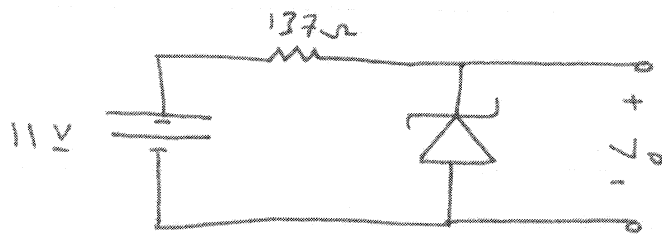


$$V_o = 7.14 + \frac{8.0778 - 7.14}{152.96} \cdot 30 = 7.324 \text{ V}$$

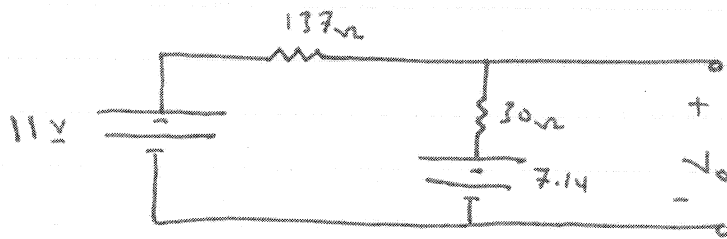
$$\therefore \text{or } 11 \text{ V} \geq V_i \geq 9 \text{ V}$$

$$7.676 \text{ V} \geq V_o \geq 7.324 \text{ V}$$

c) when $V_i = 11 \text{ V}$ and $R_L = \infty$



Since $V_i > V_{z0}$, Zener diode is in breakdown



$$V_o = 7.14 + \frac{11 - 7.14}{167} \cdot 30 = 7.833 \text{ V}$$

d) For $I_z = I_{zK} = I_z(\text{min})$

$$V_z = V_{z0} + r_z I_z(\text{min}) = 7.155 \text{ V}$$

$$I_z = I_s - I_L \geq I_z(\text{min})$$

$$\frac{V_i(\text{min}) - V_z}{137} - \frac{V_z}{R_{L,\text{min}}} \geq I_z(\text{min})$$

$$\therefore R_{L,\text{min}} \geq 551.7 \Omega$$

3.58

$$V_p = 12\sqrt{2} - (2)(0.7) = 15.57V$$

The diodes start conducting at θ where

$$12\sqrt{2} \sin \theta = 2 \times 0.7$$

$$\therefore \theta = \sin^{-1} \frac{2 \times 0.7}{12\sqrt{2}} = 0.0826 \text{ rad} \\ (4.737^\circ)$$

each diode conducts $\left(\frac{\pi - 2\theta}{2\pi} \times 100\% \right)$ of the cycle
each diode conducts (47.37%) of the cycle

$$V_{o,av} = \frac{1}{\pi} \int_{\theta}^{\pi - \theta} (12\sqrt{2} \sin \phi - 2 \times 0.7) d\phi$$

$$V_{o,av} = 9.44V$$

$$I_{av} = \frac{V_{o,av}}{R_L} = 9.44 \text{ mA}$$

3.60

a) when $V_S > 0.7\text{V}$

D_1 and D_2 are on
 D_3 and D_4 are off

$$V_0^+ = V_A - 0.7$$

$$V_0^- = V_B + 0.7$$

b) when $-0.7\text{V} < V_S < 0.7\text{V}$

all the diodes are off

$$V_0^+ = 0\text{V}$$

$$V_0^- = 0\text{V}$$

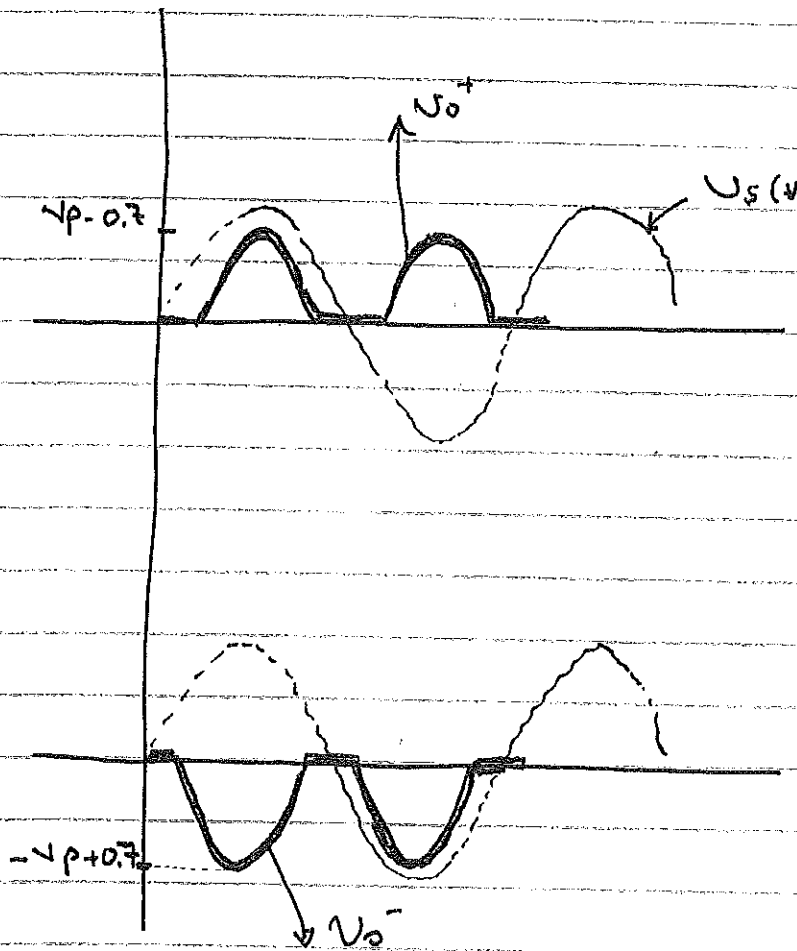
c) When $V_S < -0.7V$

D_1, D_2 are OFF

D_3, D_4 are ON

$$V_{o^+} = V_B - 0.7$$

$$V_{o^-} = V_A + 0.7$$



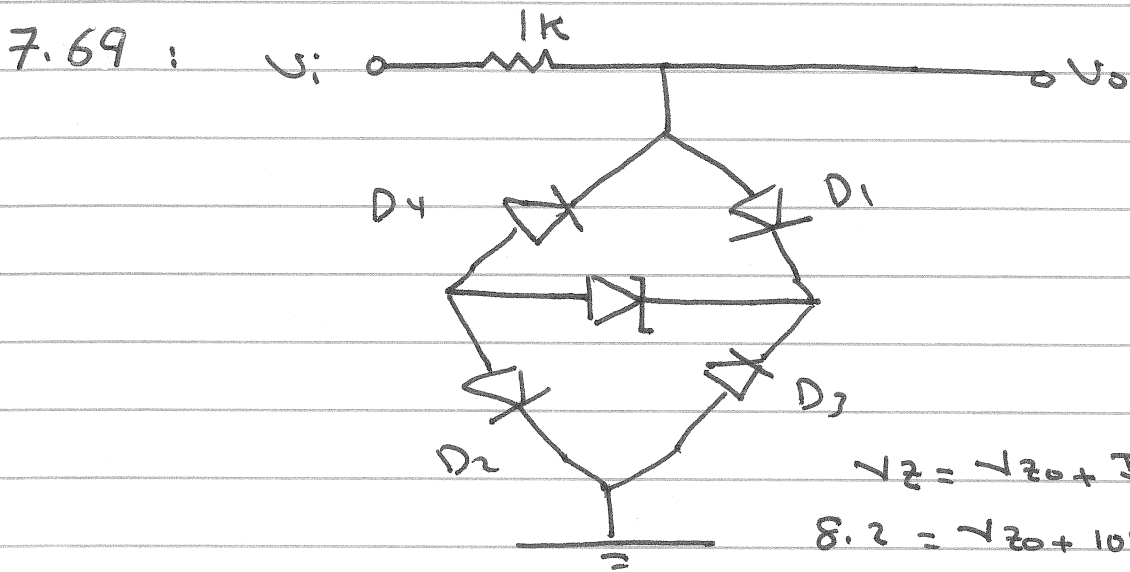
for $V_p \gg 0.7$

$$V_{o^+} \approx \frac{2V_p}{\pi} - 0.7 = 15$$

$$\therefore V_p = 24.66V$$

$2V_p = 49.32V$ * This is the required amplitude across the entire secondary winding.

$$PIV = (2V_p - 0.7) = 48.623V$$



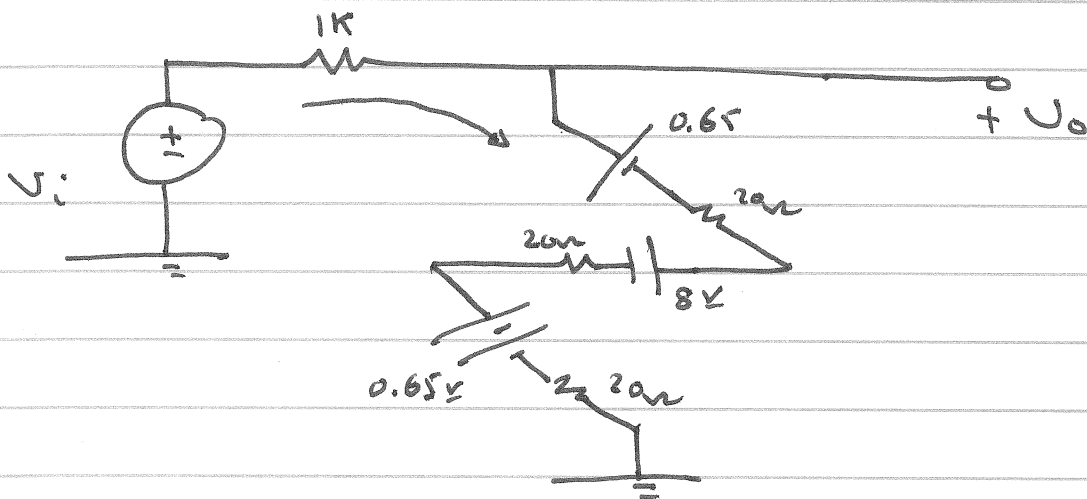
$$V_z = V_{z0} + I_z V_z$$

$$8.2 = V_{z0} + 10 \times 10^3 \times V_z$$

$$\therefore V_{z0} = 8V$$

1) when $V_i > 8 + 0.65 + 0.65 = 9.3V$

$D_1, Zener, D_2$ are conducting



$$V_o = V_i - 1k \left(\frac{V_i - 9.3}{1k + 60\Omega} \right)$$

$$V_o = \frac{60}{1060} V_i + 8.774$$

2) when

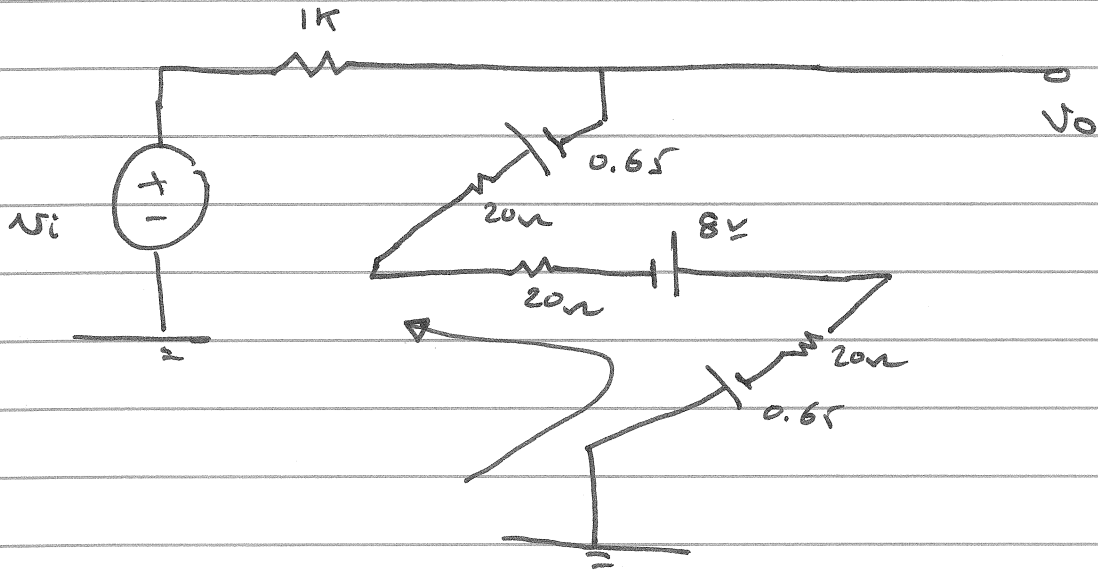
$$-9.3V < V_i < 9.3V$$

all diodes are off

and $V_o = V_i$

3) When $V_i < -9.3 \text{ V}$

$D_4, D_3, Zener$ are conduction



$$V_o = \frac{60}{1060} V_i - 8.774$$

