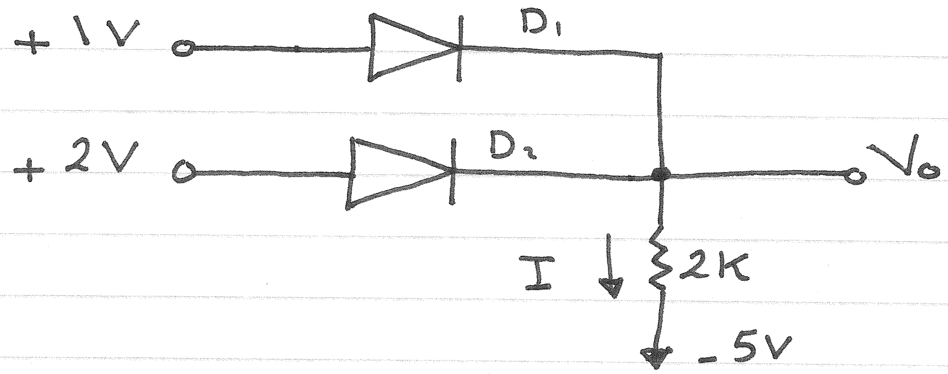
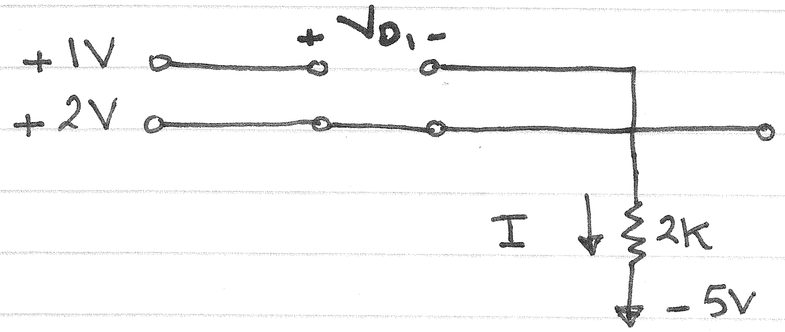
Homework Solutions Chapter 3 EE 233

3.2 : a)



Diode D_1 is OFF, Diode D_2 is on



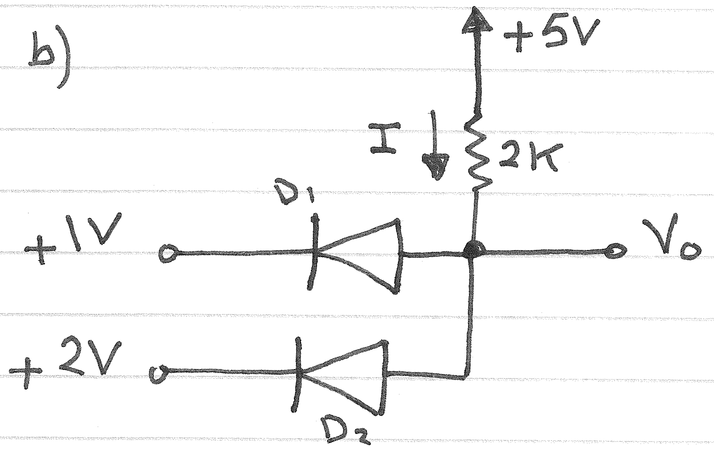
$V_o = 2V$

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

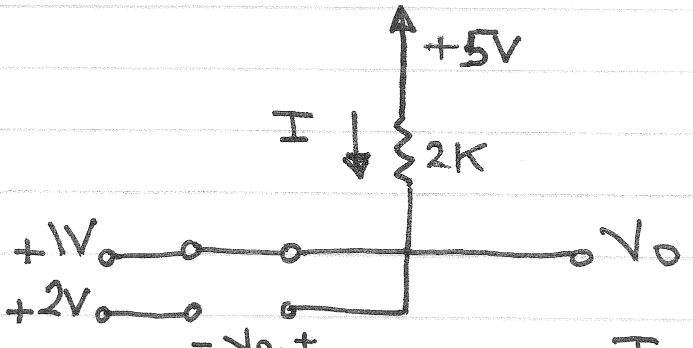
$I_{D_2} = I > 0$

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

b)



D_1 is on, D_2 is OFF



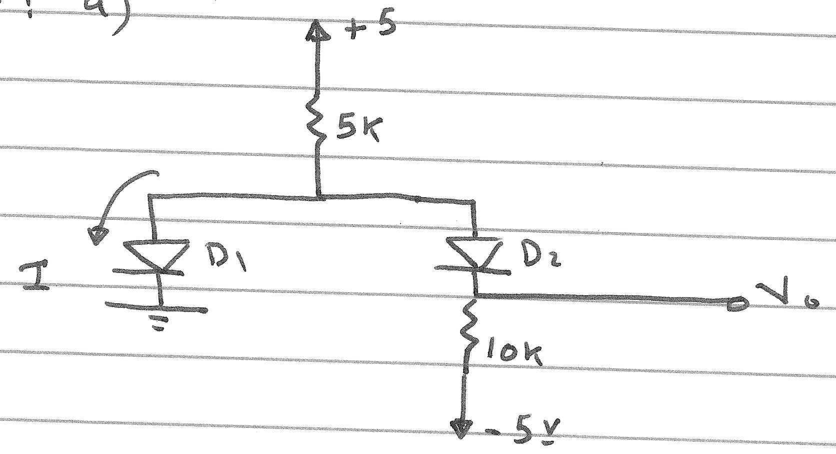
$V_o = 1V$

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

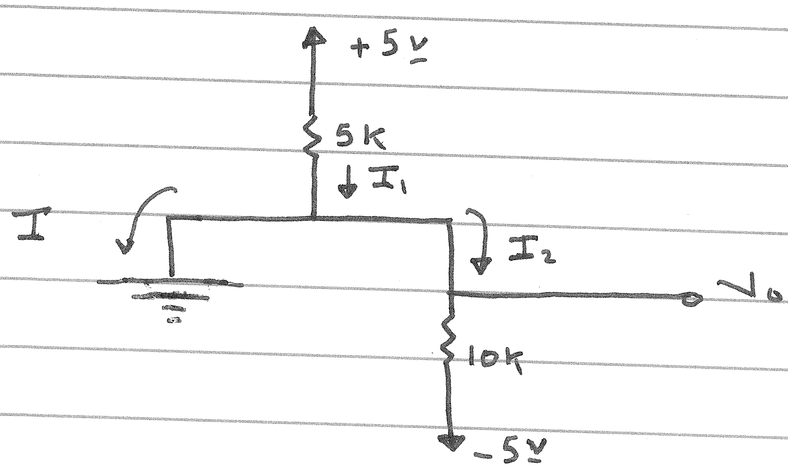
$I_{D_1} = I > 0$

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

3.7 : a)



both diodes are on



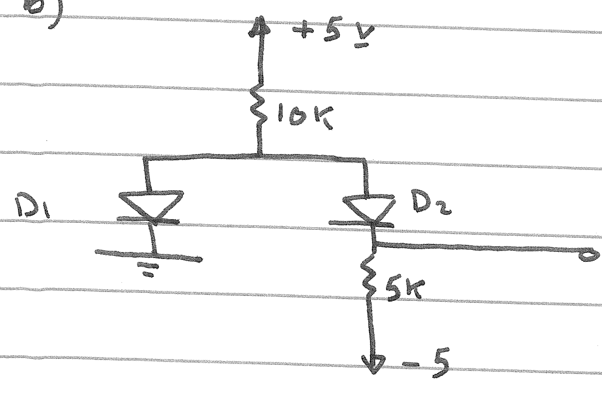
$$I_2 = \frac{0+5}{10K} = 0.5\,mA \quad ; \quad I_1 = \frac{5-0}{5K} = 1\,mA$$

$$\therefore \; I = I_1 - I_2 = 0.5\,mA$$

$$V = 0$$

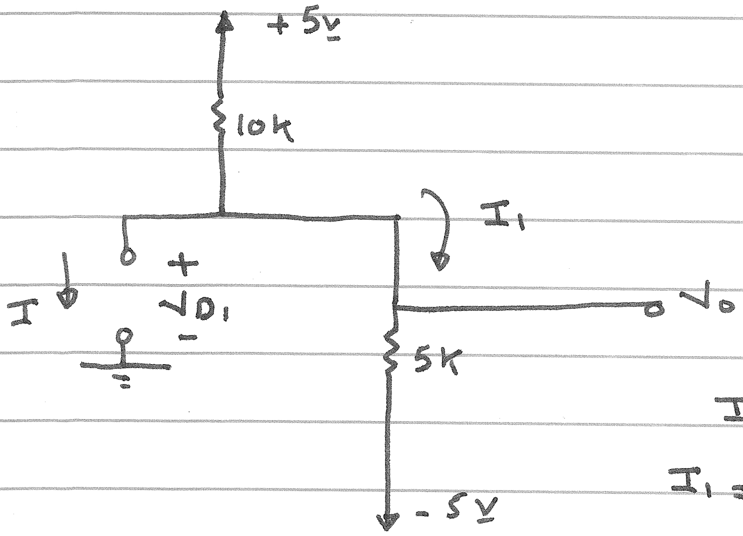
$$I_{D1} = I > 0 \quad ; \quad I_{D2} = I_2 > 0$$

b)



D1 is OFF

D2 is on



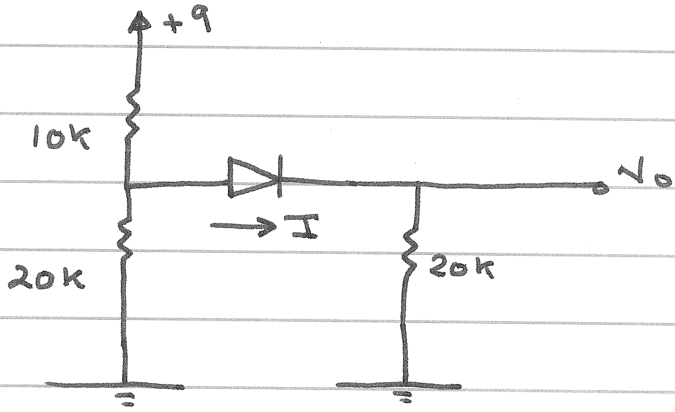
$$I = 0$$

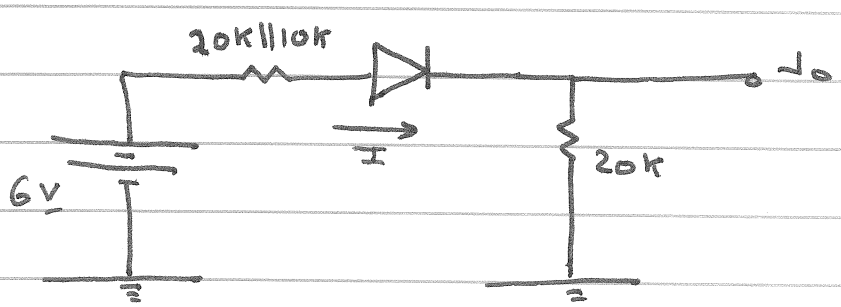
$$I_1 = \frac{5+5}{15} = \frac{2}{3}\ mA$$

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

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

3.8 a)



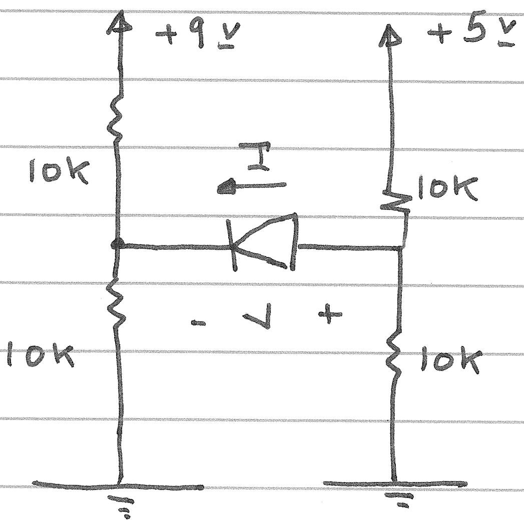


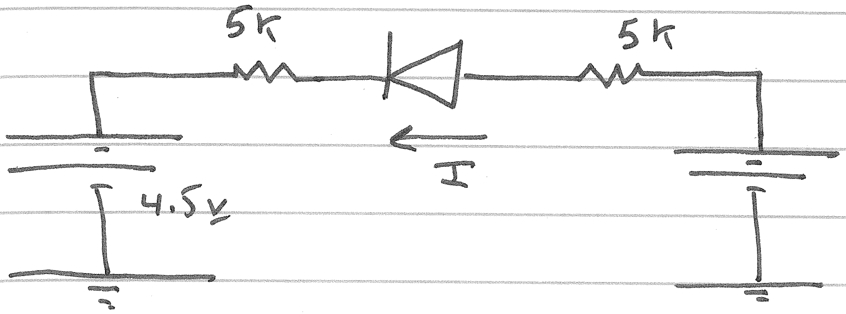
Diode is on

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

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

3.8 b)

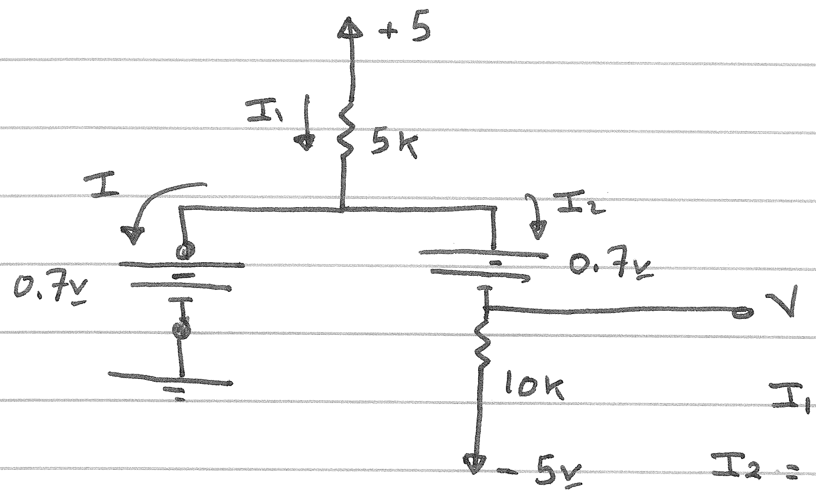




Diode is OFF $\therefore I = 0$

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

3.33 : a) D_1 is on , D_2 is on



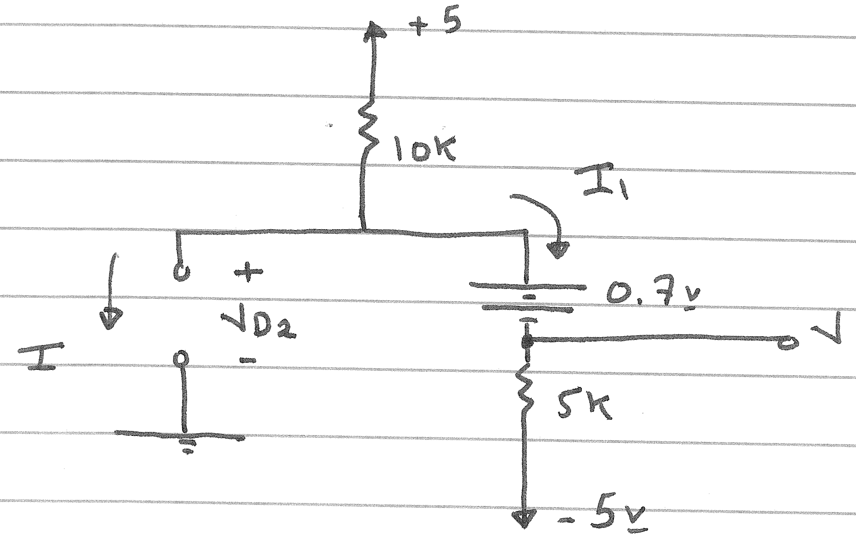
$I_1 = \frac{5-0.7}{5k} = 0.86mA$

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

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

$V = 0v$

b) D_1 is OFF, D_2 is on



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

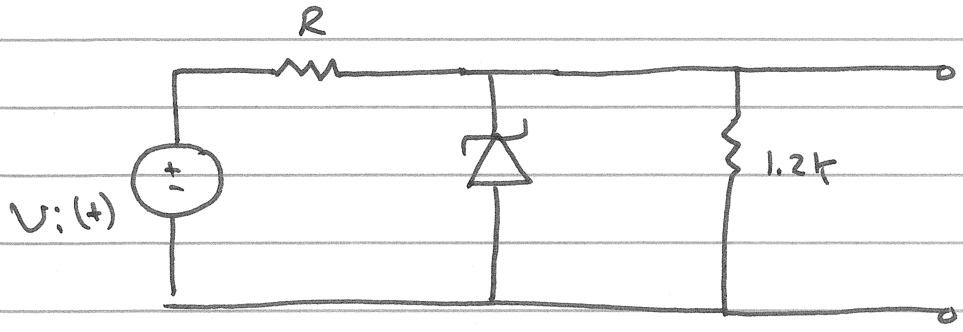
$V = (5K)(0.62mA) - 5$

$V = -1.9V$.

$I_{D2} = I_1 > 0$

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

3.52 :



$V_Z = 7.5V$ @ $I_Z = 12mA$

$r_Z = 30\Omega$ $I_{ZK} = I_Z(min) = 0.5mA$

$V_Z = V_{Z0} + r_Z I_Z$

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

$\therefore V_{Z0} = 7.14V$

let $I_Z = 12mA \longrightarrow V_Z = 7.5V$

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

$I_L = \dfrac{V_Z}{R_L} = \dfrac{7.5}{1.2K} = 6.25\,mA$

$\therefore I_S = I_Z + I_L = 18.25mA$

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

$V_i = 10V$, $V_Z = 7.5V$, $I_S = 18.25mA$

$\therefore R = 137\Omega$

A second method

$$R_S < \frac{V_i(min) - V_Z}{I_Z(min) + I_L(max)}$$

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

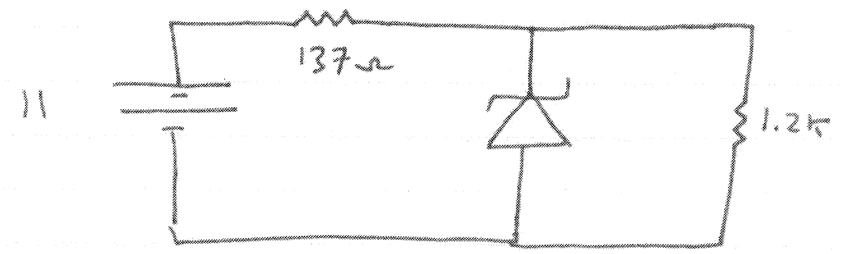
$$= 7.14 + (30)(0.5mA)$$

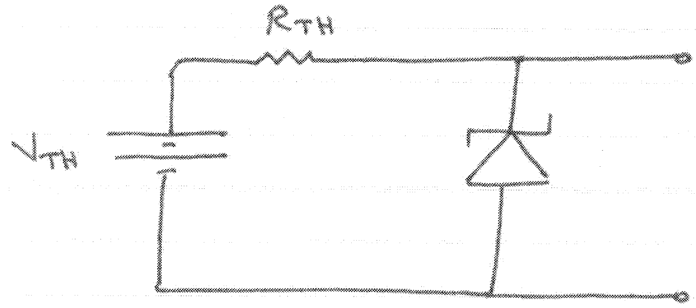
$$V_Z = 7.155\ V$$

$$R_S < \frac{10 - 7.155}{0.5mA + \frac{7.155}{1.2K}}$$

$$R_S < 440.23\ \Omega$$

b) when $V_i = 11\ V$

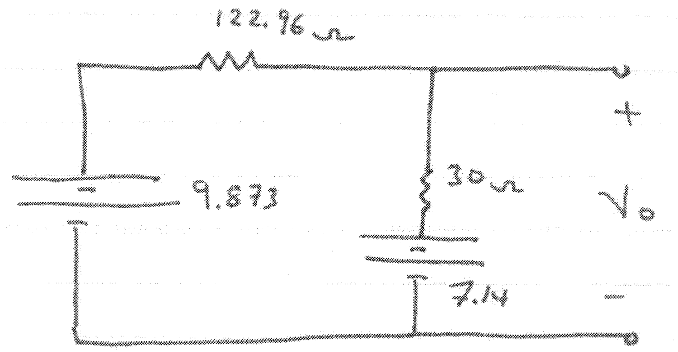




$$R_{TH} = 137\Omega \parallel 1.2K = 122.96\ \Omega$$

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

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



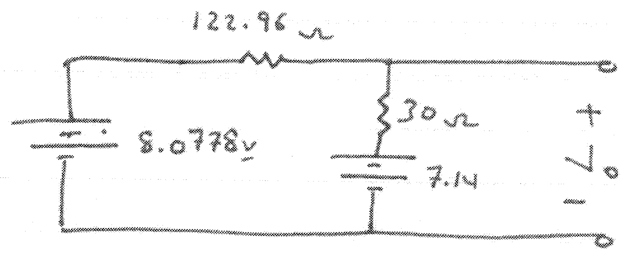
$$V_o = 7.14 + \frac{9.873 - 7.14}{152.96} \cdot 30 = 7.676\ V$$

when $V_i = 9\,V$

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

$V_{TH} = 8.0778\,V$

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

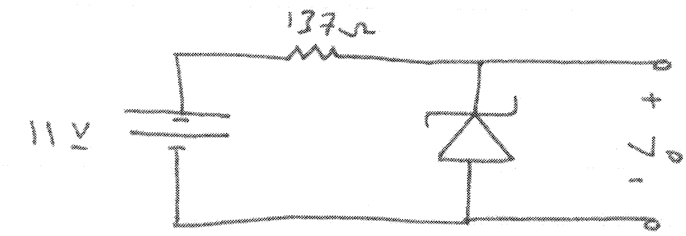


$$V_o = 7.14 + \frac{8.0778 - 7.14}{152.96} \cdot 30 = 7.324\,V$$

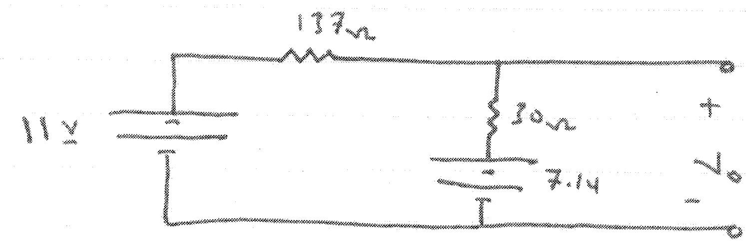
∴ as $11\,V \geq V_i \geq 9\,V$

$$7.676\,V \geq V_o \geq 7.324\,V$$

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



Since $V_i > V_{Z0}$, Zener diode is in breakdown



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

d) for $I_Z = I_{ZK} = I_{Z(min)}$

$$V_Z = V_{Z0} + r_Z I_{Z(min)} = 7.155\ V$$

$$I_Z = I_S - I_L \geqslant I_{Z(min)}$$

$$\frac{V_{i(min)} - V_Z}{137} - \frac{V_Z}{R_{L,min}} \geqslant I_{Z(min)}$$

$$\therefore R_{L,min} \geqslant 551.7\ \Omega$$

3.58

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

The diodes start Conducting at θ where

$$12\sqrt{2}\ \sin\theta = 2\times0.7$$

$$\therefore\ \theta = \sin^{-1}\frac{2\times0.7}{12\sqrt{2}} = 0.0826\ \text{rad}$$

(4.737°)

each diode Conducts $\left(\frac{\pi - 2\theta}{2\pi}\times100\%\right)$ of the cycle

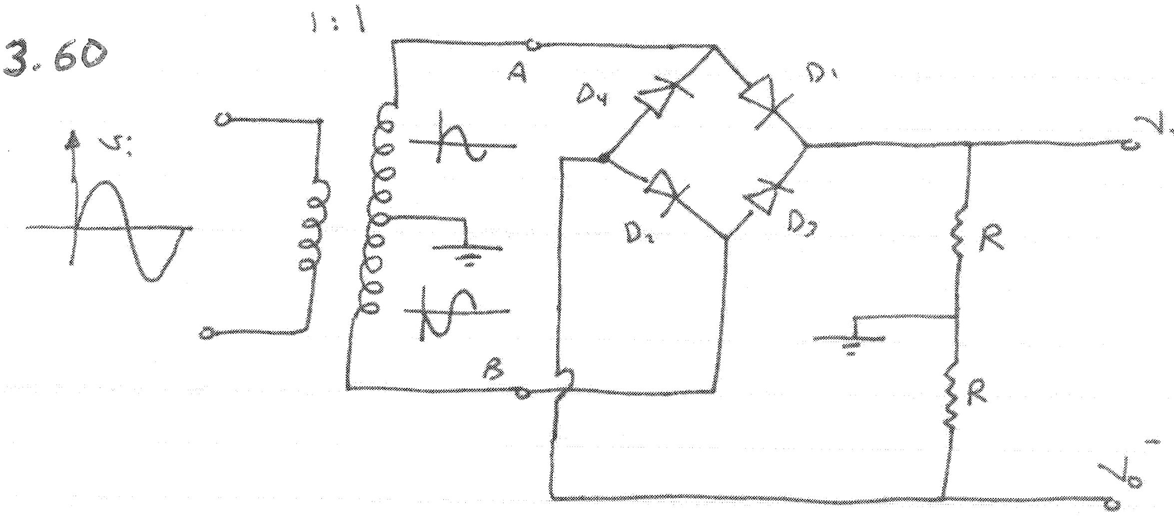
each diode Conducts (47.37%) of the cycle

$$V_{o,av} = \frac{1}{\pi}\int_{\theta}^{\pi-\theta}(12\sqrt{2}\ \sin\phi - 2\times0.7)\,d\phi$$

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

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

3.60



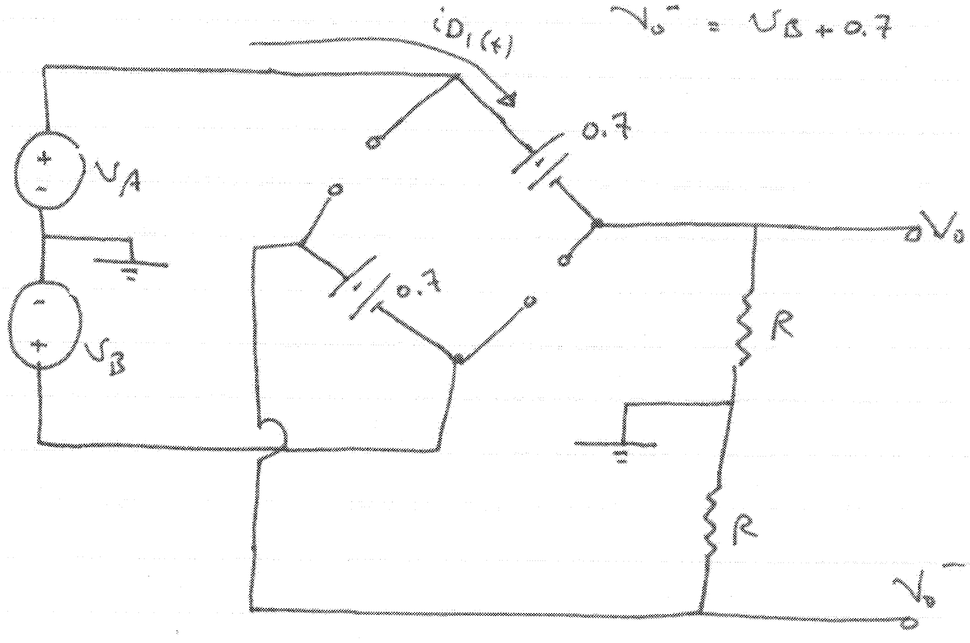
$v_A = \frac{1}{2} v_i$

$v_B = -\frac{1}{2} v_i$

1) For D_1 and D_2 on
D_3 and D_4 off

$V_o^+ = v_A - 0.7$

$V_o^- = v_B + 0.7$



$$i_{D_1}(t) = \frac{v_A - 0.7}{R} > 0$$

$v_A > 0.7\,V$; $\frac{1}{2} v_i > 0.7\,V$; $v_i > 1.4\,V$

3.60

a) when $v_i > 1.4V$

D1 and D2 are on
D3 and D4 are OFF

$$v_o^+ = v_A - 0.7$$

$$v_o^- = v_B + 0.7$$

b) when $-1.4V < v_i < 1.4V$

all the diodes are OFF

$$v_o^+ = 0V$$

$$v_o^- = 0V$$

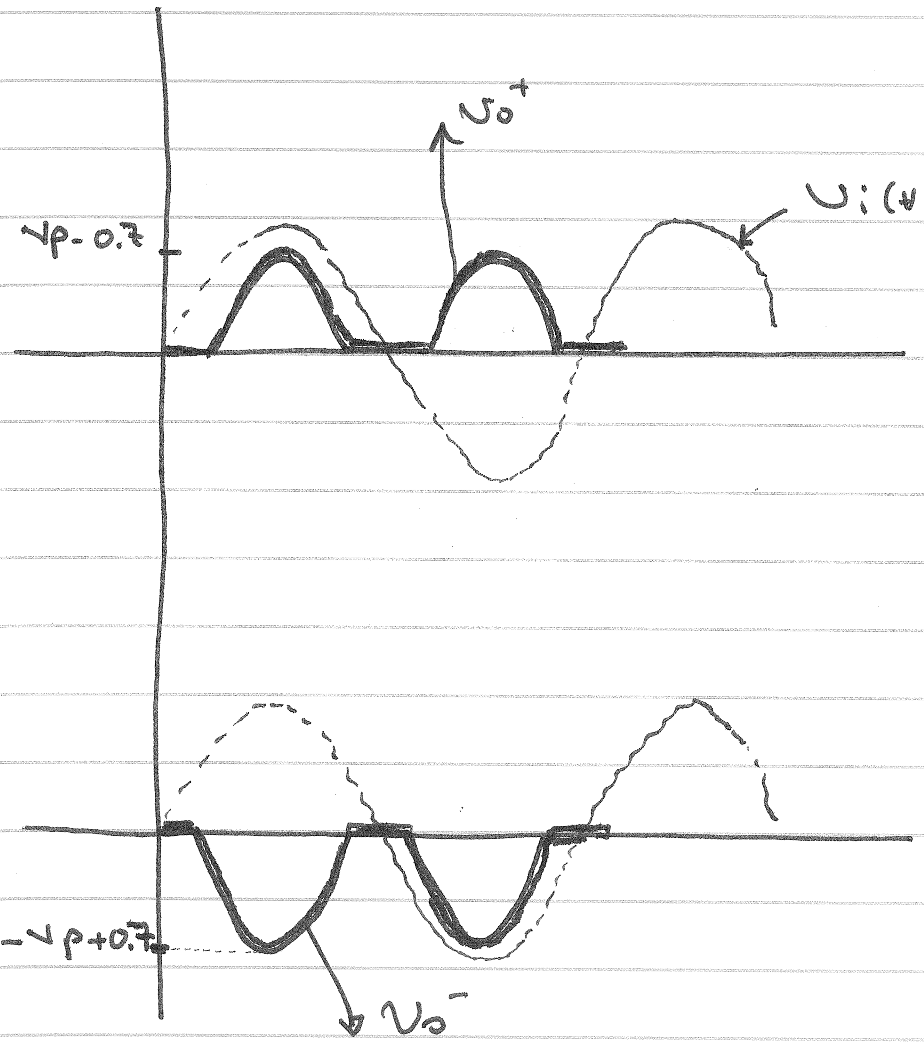
c) when $v_i < -1.4\ v$

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 $V_p >> 0.7$

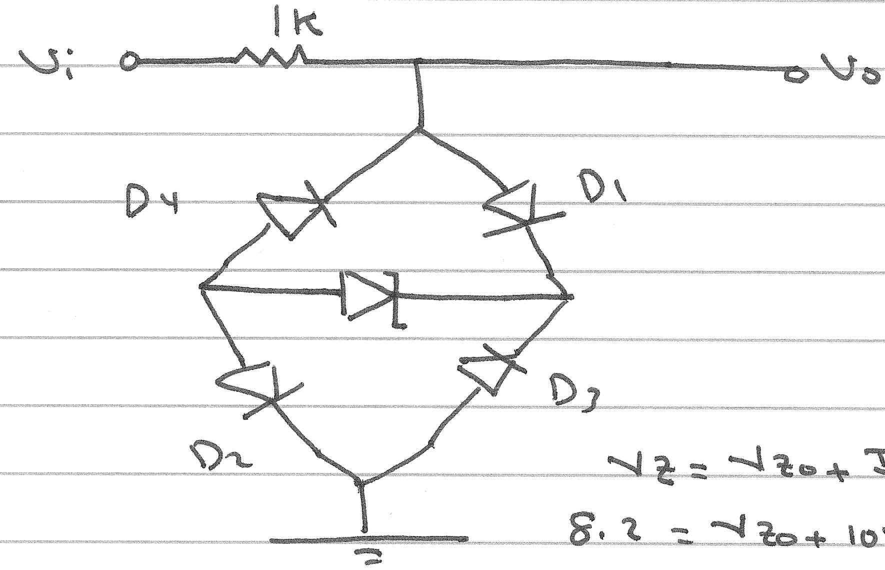
$$V_{o_{av}} \simeq \frac{2V_p}{\pi} - 0.7 = 15$$

$\therefore V_p = 24.66\ v$

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

$PIV = 2V_p - 0.7 = 48.623\ v$

7.69 :



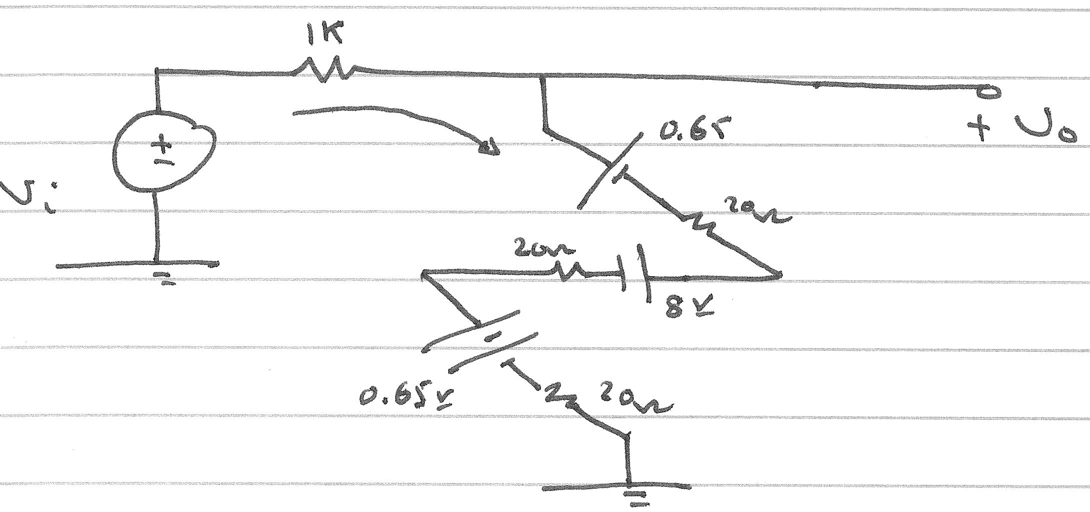
$V_Z = V_{Z0} + I_Z r_Z$

$8.2 = V_{Z0} + 10 \times 10^{-3} \times 20$

$\therefore V_{Z0} = 8V$

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

D1, Zener, D2 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

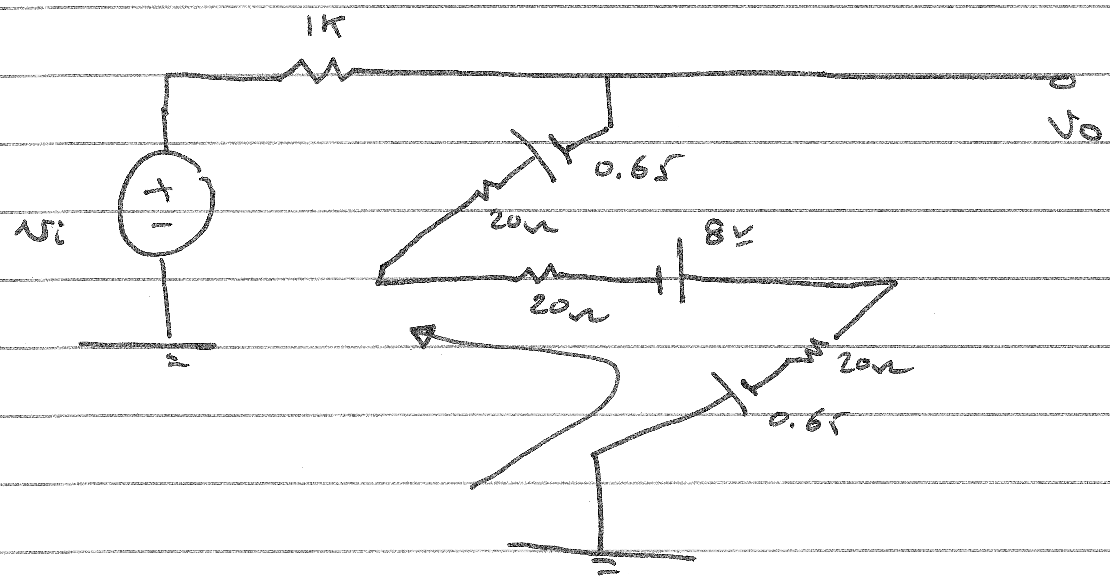
$-9.3V < V_i < 9.3V$

all diodes are OFF

and $v_o = v_i$

3) when $v_i < -9.3\,v$

D_4, D_3, Zener are conduction



$$v_o = \frac{60}{1060} v_i - 8.774$$