ENEE 236

Solutions to problems ON Diodes & Applications

Q5.a

$I = 0mA$ since diode is reverse biased

b. $V_{20\Omega} = 20 - 0.7 = 19.3\,V$ since diode is forward biased

$I = 19.3/20 = 0.965\,A$

c. $I = \frac{10\,V}{10\,\Omega} = 1A$ since center branch is open

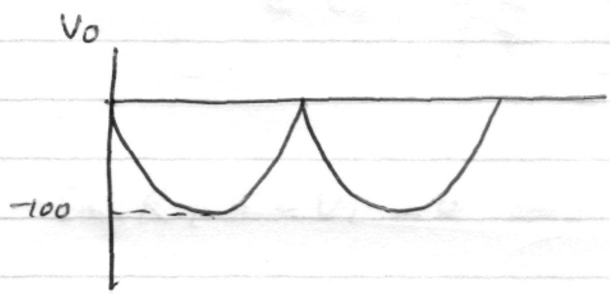
Q7. (a) $V_o = \frac{2K}{2K+2K}(20-0.7-0.3) = 9.5\,V$ (since both diodes are ON)

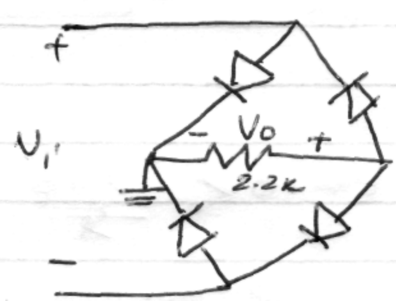
(b) $I = \frac{10+2-0.7}{1.2K+4.7K}$, since diode is ON and by writting KVL for the loop

$= \frac{11.3\,V}{5.9K\Omega} = 1.915\,mA$

$V_o = I \cdot R - 2V = 1.915mA \cdot 4.7K - 2V = 7V$

Q29.





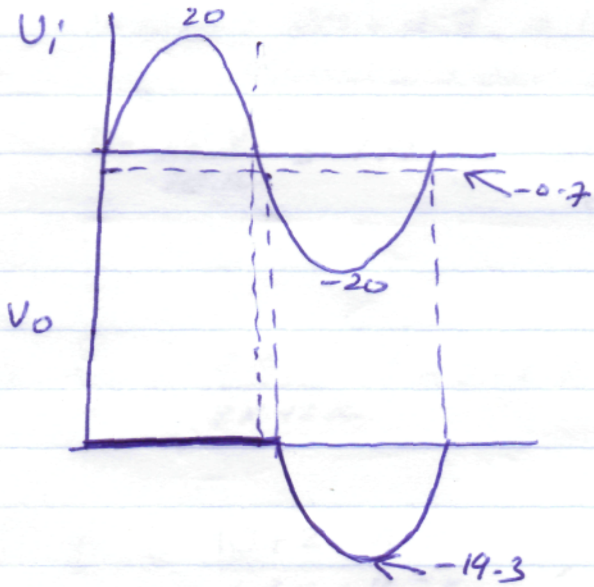
PIV ≥ 100 V

Q32 a. 1) Diode open for $V_i < 0 \Rightarrow V_o = 0$

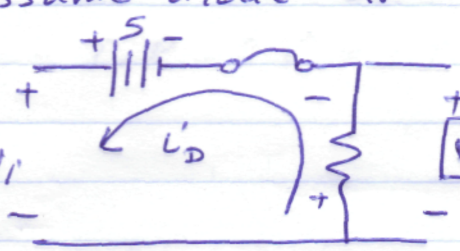
2) For ~~V~~ $-20 < V_i \leq -0.7\ V$ diode ON $\Rightarrow V_o = V_i + 0.7$

for example for $V_i = -20 \Rightarrow V_o = -20 + 0.7 = -19.3$

for $V_i = -0.7 \Rightarrow V_o = -0.7 + 0.7 = 0V$



b) 1) Assume diode ON



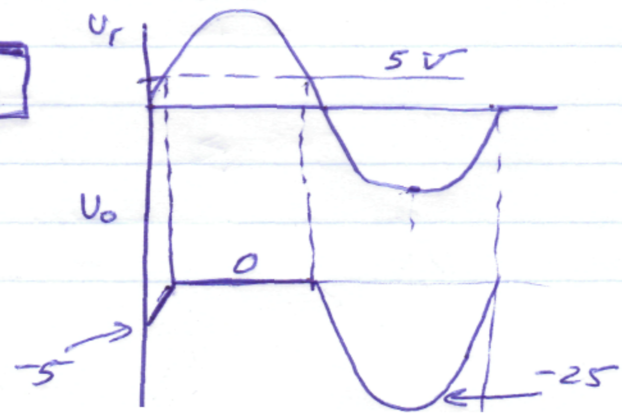
$V_o = V_i - 5$ ← when diode ON

$-i_D \cdot R + 5 - V_i = 0 \Rightarrow i_D = \frac{5 - V_i}{R} > 0 \Rightarrow$

$5 - V_i > 0 \Rightarrow$ $V_i < 5$ results in diode being ON

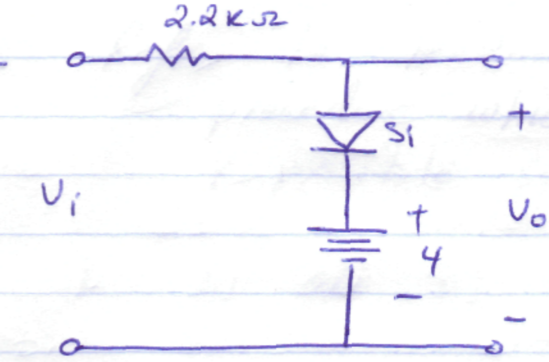
2) otherwise, when $V_i > 5$ diode is off & $\Rightarrow$

$V_o = 0$

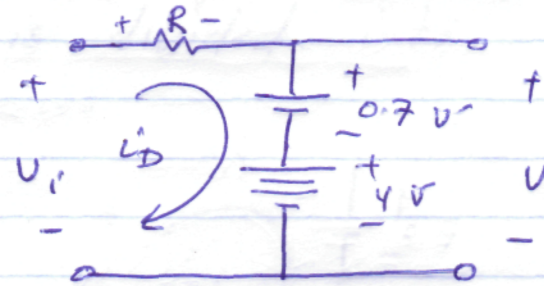


Q35.

a)



1) Assume diode is ON

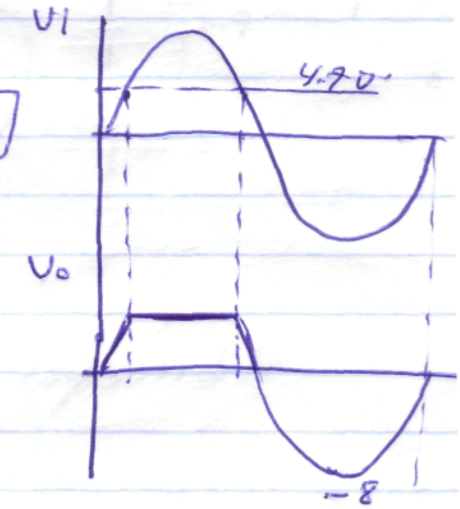


$V_i - i_D R - 0.7 - 4 = 0 \Rightarrow i_D = \frac{V_i - 4.7}{R} > 0$

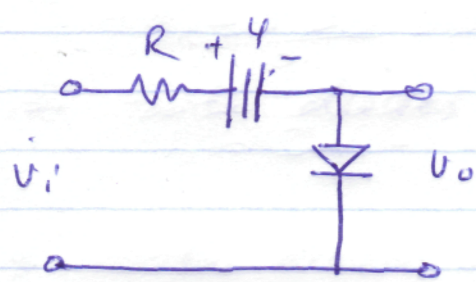
$V_i - 4.7 > 0 \Rightarrow$ $\boxed{V_i > 4.7}$ diode is ON

& $\underline{V_o = 4.7\ V}$

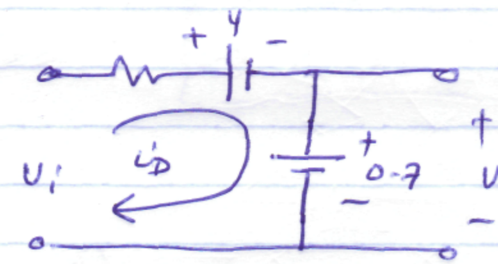
2) otherwise diode is off & $\boxed{V_o = V_i}$



b)



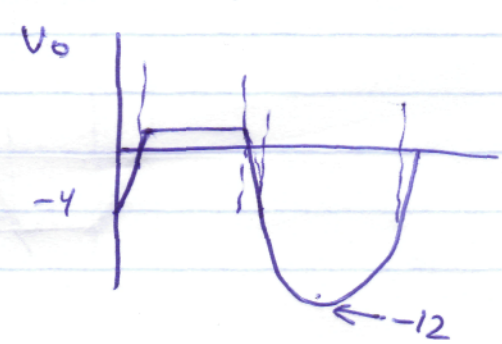
1) assume diode is ON $\Rightarrow$



$V_i - i_D R - 4 - 0.7 = 0$

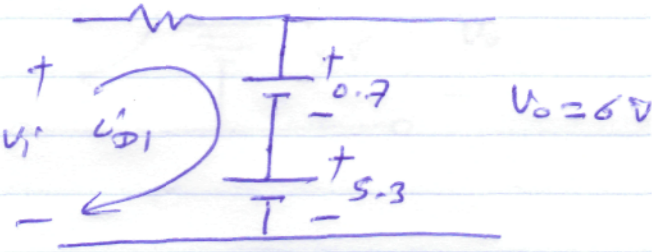
$i_D = \frac{V_i - 4.7}{R} \Rightarrow V_i > 4.7$ diode will be ON & $\underline{V_o = 0.7}$

2) otherwise when $V_i < 4.7$ diode is off & $V_o = V_i - 4$



Q36. Refer to lecture notes for solution procedure which is divided into 4-possible scenarios

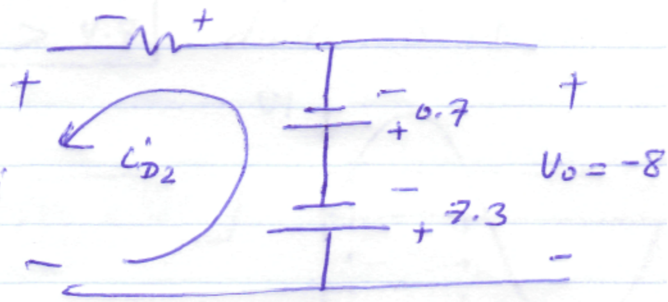
1. D1 ON, D2 off



$v_i - i_{D1} R + 6 = 0$

$i_{D1} = \frac{v_i + 6}{R} > 0 \Rightarrow \boxed{v_i > 6}$

2. D1 off, D2 ON



$v_i + i_{D2} \cdot R + 8 = 0$

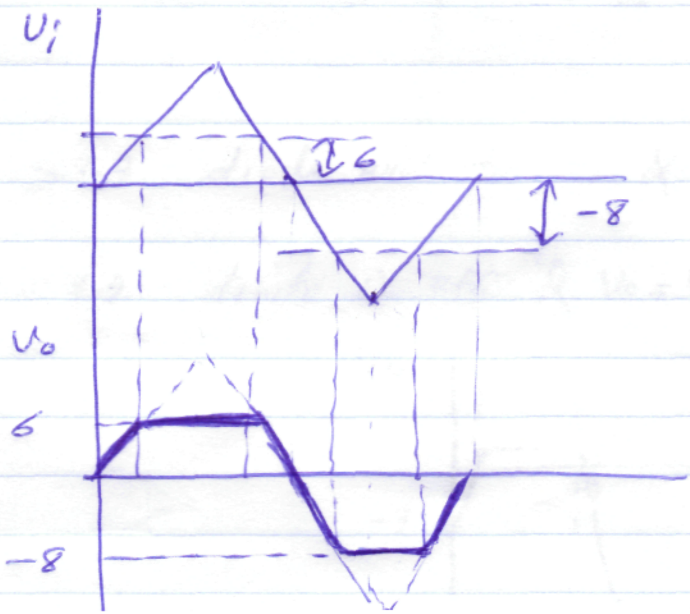
$i_{D2} = \frac{-v_i - 8}{R} > 0$

$-v_i - 8 > 0 \Rightarrow \boxed{v_i < -8}$

3. both diodes ON which is impossible

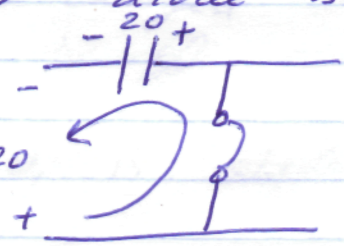
4. both diodes off when $\boxed{-8 < v_i < 6V}$

& $V_o = v_i$

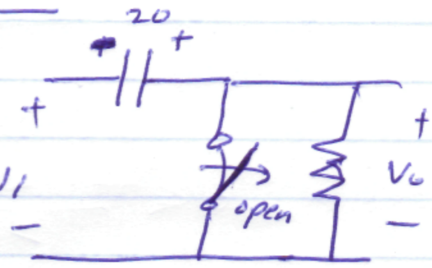


Q37. Both are clamper circuits

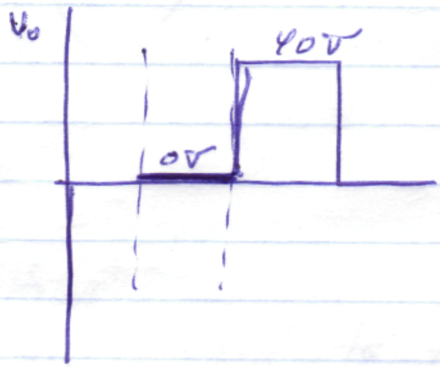
(a) starting with $v_i = -20\,V$ diode is ON & C charges to $- 20 +$



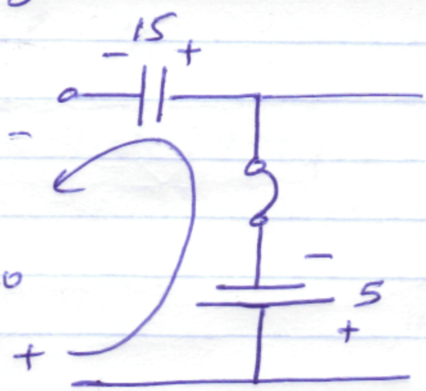
then diode will be off and and



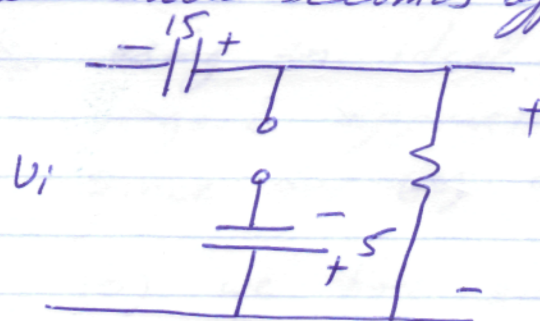
$$v_o = v_i + 20$$



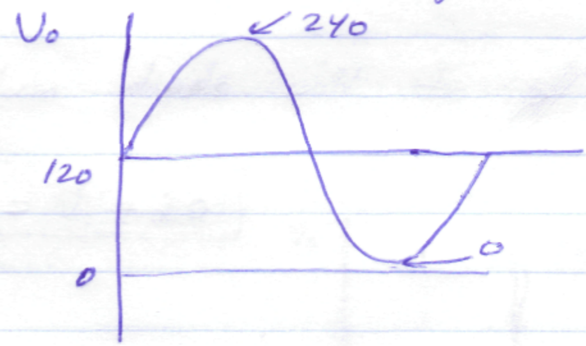
b) starting with $v_i = -20$, diode will be ON and cap charges to $- 15 +$ and $v_o = -5\,V$



then diode becomes off with $v_i = +20$ and afterwards

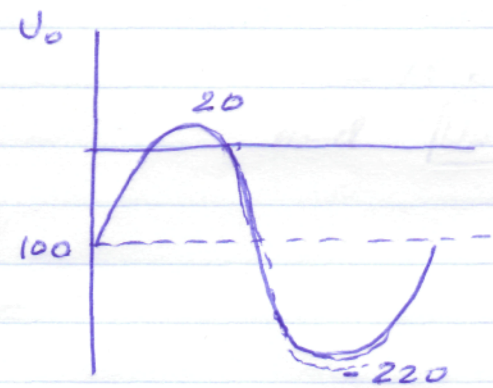


Q38 a) starting with $V_i < 0$, diode will be ON and C will be charged to $-120+$
then diode will be off and
$V_o = V_i + 120$
so the waveform V_i is shifted by $+120$



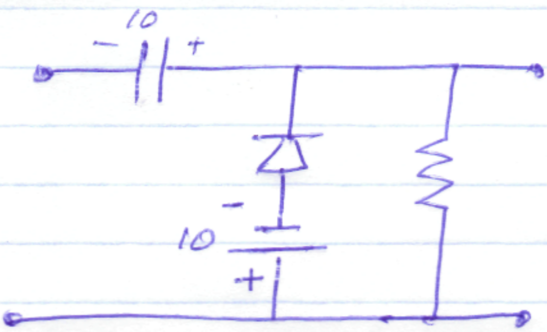
b) starting with positive $V_i \Longrightarrow$ diode is ON and C is charged to $+100-$, then diode will be off after that independant of V_i

$V_o = V_i - 100$



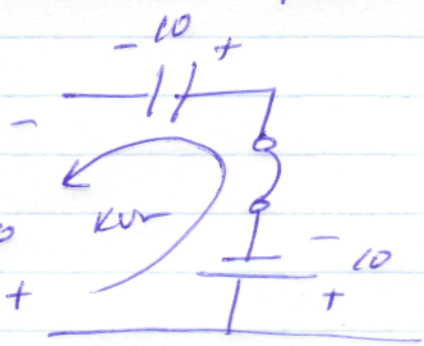
<u>Note</u> using an ideal diode model is a good approximation in both cases since for (a) we have 240 instead of 239.7 V & for (b) we have 20 instead of 20.7

Q40. By closely examining both input and output waveforms, it is noted that the V_i is shifted by $+10\,V$ to get V_o and this is a function that can be implemented using a clamper of the following form



& By analysis of the proposed clamper

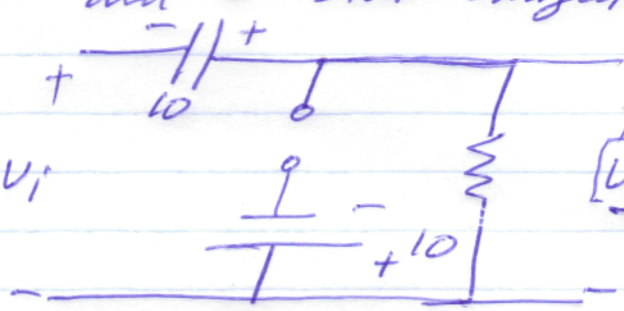
1. when $V_i < 0 \Rightarrow V_i = -20\,V$ diode is ON & C is charged to $-10+$ which is obtained from the following circuit



$20 - 10 - V_c(t) = 0 \Rightarrow$

$V_c = 10\,V$ as shown

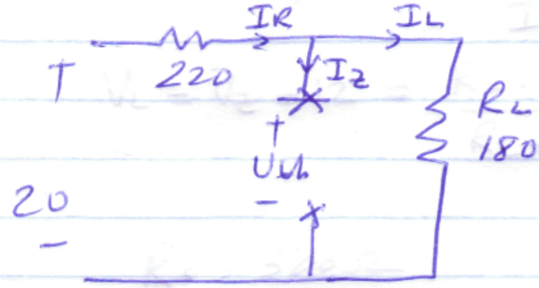
2. afterwards diode will be permanently off and C still charged to $-10+$



$V_o = V_i + 10$

$\therefore$ proposed design has been verified to do the function required

Q42. a) Remove zener diode and find V_{th}



$$V_{th} = \frac{180}{180+220} \cdot 20 = 9V$$

$V_{th} < V_Z \Rightarrow$ diode is not conducting

$I_Z = 0$

$$I_L = I_R = \frac{20}{180+220} = 50\,mA$$

b) with $R_L = 470\,\Omega$

$$V_{th} = \frac{470}{470+220} \cdot 20 = 13.62 > V_Z$$

Zener is ON & $V_L = 10V$

$$I_L = \frac{V_L}{R_L} = \frac{10}{470} = 21.28\,mA$$

$$I_R = \frac{20-10}{220} = 45.45\,mA$$

$$I_Z = I_R - I_L = 24.17\,mA$$

c) $P_{Z(max)} = 400\,mW = V_Z \cdot I_Z = 10V \cdot I_Z \Rightarrow$

$I_Z = 40\,mA$

$$I_{L(min)} = I_R - I_{Z(max)} = 45.45\,mA - 40\,mA$$
$$= 5.45\,mA$$

$$R_L = \frac{V_L}{I_{L(min)}} = \frac{10}{5.45mA} = 1.834\,k\Omega$$

d) Value of R_L is chosen such that to ensure $V_{KA} = V_L \geq V_Z = 10V$

$$V_L = \frac{R_L}{R_L + R_S} \cdot 20 = 10 \Rightarrow$$

$$10 R_L + 2200 = 20 R_L$$

$$10 R_L = 2200 \Rightarrow \boxed{R_L = 220\,\Omega}$$

Q43. a) $V_z = 12\,V$, $R_L = \frac{V_L}{I_L} = \frac{12}{200mA} = 60\Omega$

$$V_L = V_z = 12 = \frac{R_L \cdot V_i}{R_L + R_s} = \frac{60\Omega \cdot 16}{60 + R_s} \Rightarrow \text{yields}$$

$R_s = 500\Omega$

b) $P_{z(max)} = V_z \cdot I_{z(max)} = 12\,V \cdot 200\,mA = 2.4\,W$

Q44. since $I_L = \frac{V_L}{R_L} = \frac{V_z}{R_L}$ is fixed in magnitude $\Rightarrow$

$$I_{R(max)} = I_{z(max)} + I_L$$

$$I_{z(max)} = \frac{P_{z(max)}}{V_z} = \frac{400mW}{8} = 50mA$$

$$I_L = \frac{V_z}{R_L} = \frac{8}{220} = 36.36\,mA$$

$$I_{R_1 max} = 50mA + 36.36\,mA = 86.36\,mA$$

$$I_R = \frac{V_i - V_z}{R_s} \Rightarrow V_i = I_R \cdot R_s + V_z$$
$$= 7.86 + 8 = 15.86\,V$$

Also V_i value must ensure that $V_L \geq V_z$ to have zener in regulation mode

$$V_L = \frac{R_L}{R_L + R_s} \cdot V_i \geq 10 \Rightarrow$$

$$V_i \geq \frac{10(R_L + R_s)}{R_L} \geq \frac{10(220 + 41)}{220} \geq 14.136\,V$$

$$14.136\,V \leq V_i \leq ~~14.136~~\ 15.86\,V$$