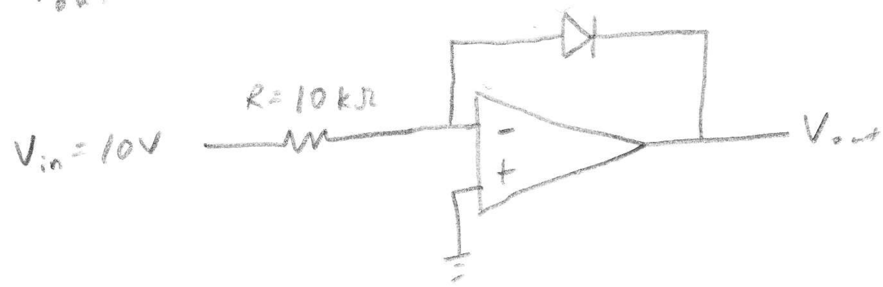
Find V_{out}



Note – This is a log amp

KCL @ V_-

$$\frac{V_{in}}{R} = I_0\left(e^{V_{out}/nU_T} - 1\right) \approx I_0 e^{-V_{out}/nU_T} \quad \text{if forward biased}$$

$$\frac{V_{in}}{R I_0} = e^{-V_{out}/nU_T}$$

$$\ln\left(\frac{V_{in}}{R I_0}\right) = \frac{-V_{out}}{nU_T}$$

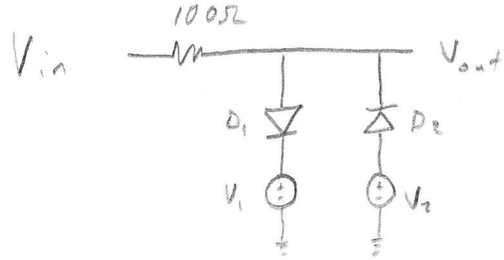
$$V_{out} = -nU_T \ln\left(\frac{V_{in}}{R I_0}\right)$$

$n = 1$

$$U_T = \frac{kT}{q} = \frac{(1.38 \times 10^{-23}\ J/K)(300K)}{(1.602 \times 10^{-19}\ C)} = 25.84\ mV$$

↖ T was given at the top of the homework assignment

$$V_{out} = -(25.84\ mV) \ln\left(\frac{10V}{(10k\Omega)(0.1pA)}\right) = \boxed{-0.5951V}$$



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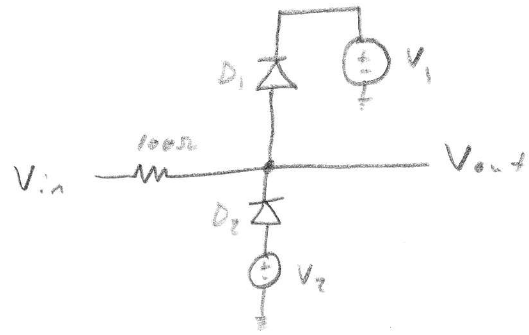


$-1V \leq V_{out} \leq 5V$

$V_{ON} = 0.7V$

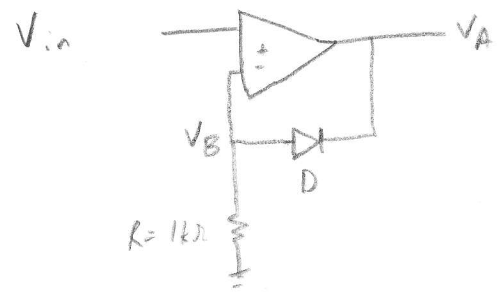
Note, the value of the resistor does not play a significant role

D_1 will forward bias if $V_{out} > V_{ON} + V_1$

$\Rightarrow V_1 = 5V - 0.7V = \underline{\underline{4.3V}}$

D_2 will forward bias if $V_{out} < -V_{ON} + V_2$

$\Rightarrow V_2 = V_{out} + V_{ON} = -1V + 0.7V = \underline{\underline{-0.3V}}$



if $V_{in} > 0V \Rightarrow D = OFF$

$\Rightarrow V_A = V_{sat}$

$\Rightarrow V_B = 0V$

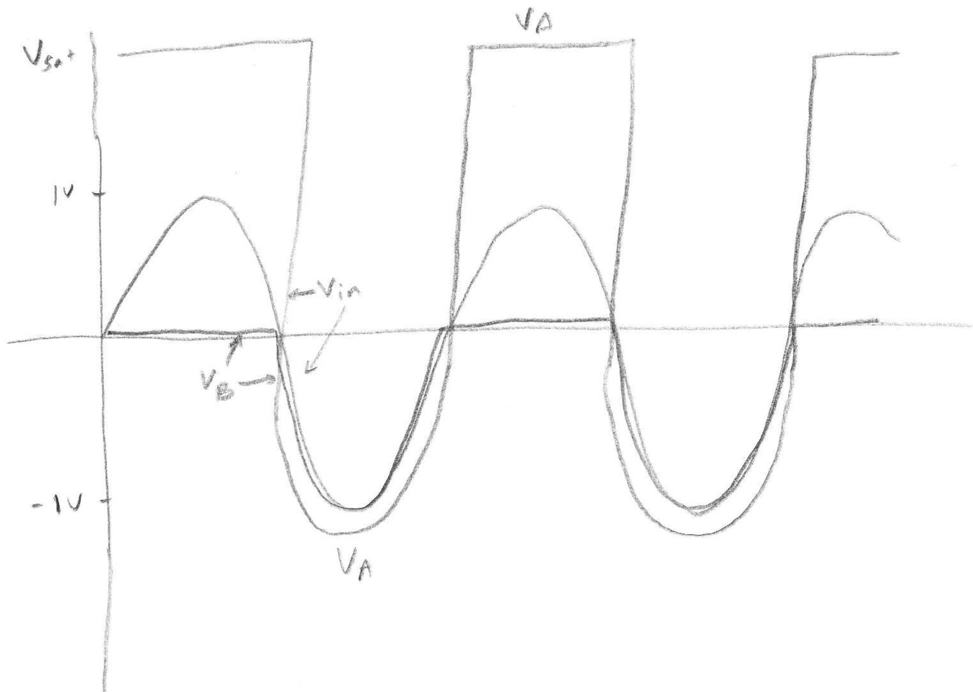
if $V_{in} < 0V \Rightarrow D = ON$

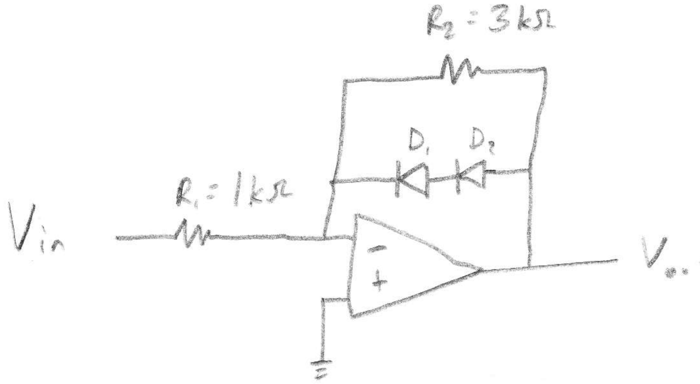
Negative Feedback is engaged

$V_B = V_{in}$

$V_A = v_B - V_{ON}$

$V_A = V_{in} - V_{ON}$





If $V_{in} > 0 \Rightarrow D_1$ and D_2 are off

$\Rightarrow$ Looks like an inverting amp with gain = -3

If $V_{in} < 0 \Rightarrow$ Two Cases

Case 1

If $0 < V_{out} < 2V_{ON}$ ⟵ since there are two diodes in series

D_1 & D_2 are off

Looks like an inverting amp with gain = -3

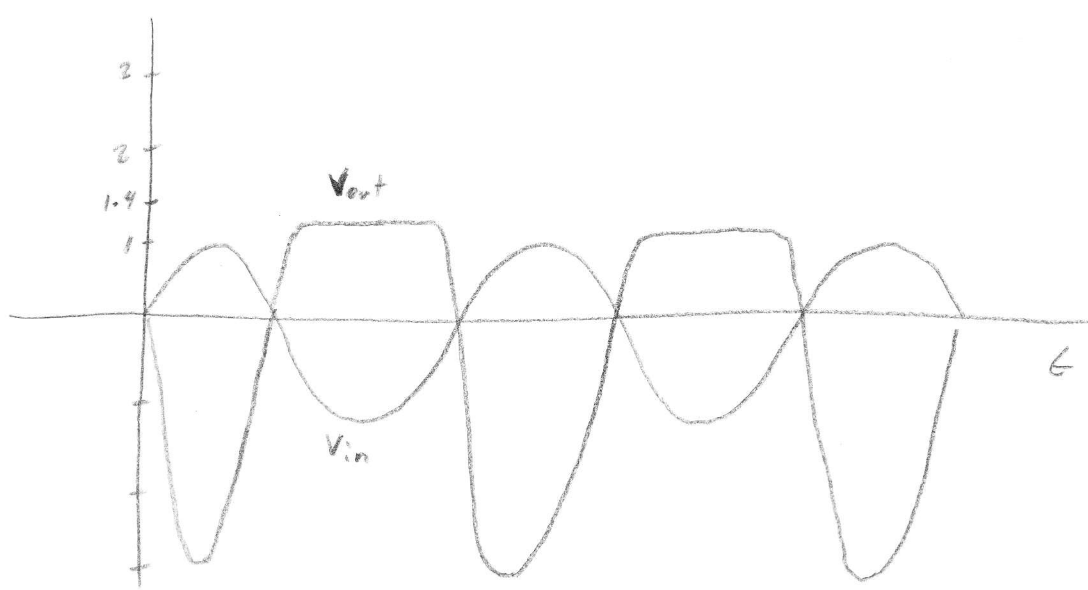
$\therefore$ This applies $0V > V_{in} > -0.4667V$

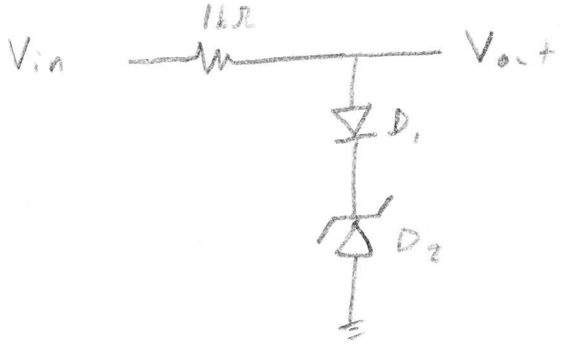
If $V_{out} > 2V_{ON}$

D_1 & D_2 are ON

$V_{out} = 1.4V$ $(2V_{ON})$

$\therefore$ This applies for $V_{in} < -0.4667V$





D_1 is a "regular" diode

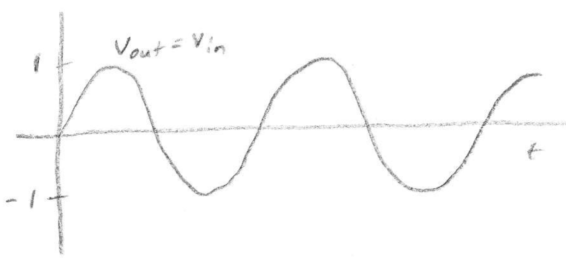
D_2 is a Zener diode

V_{out} will be restricted to be between

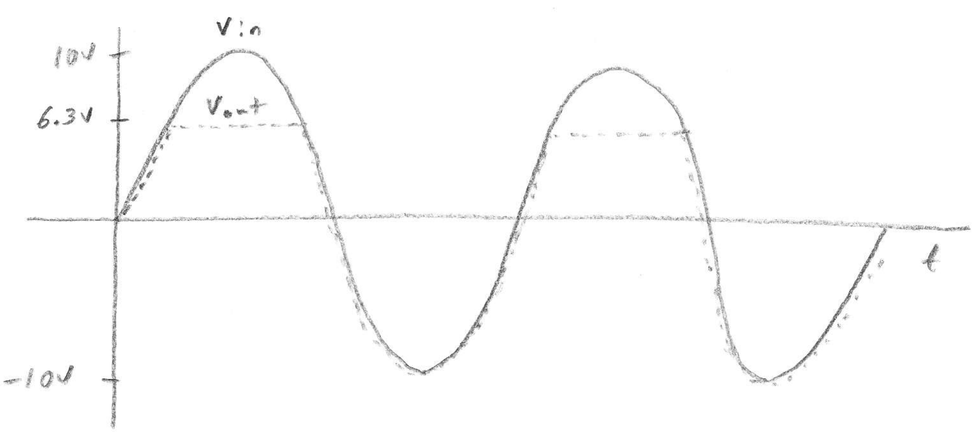
D_1 will be OFF ← $V_{low} = -\infty\Omega$

D_1 will be ON
D_2 will be in breakdown ← $V_{high} = V_{ON,1} + V_{Z,2} = 6.3V$

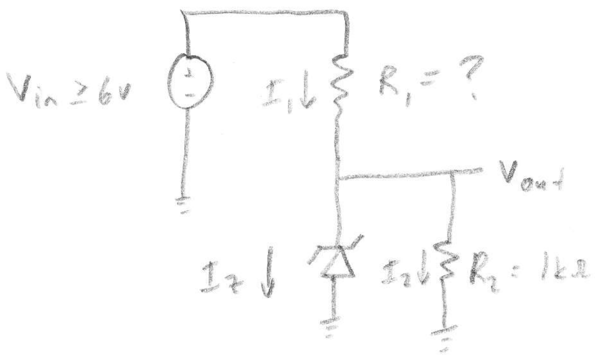
For a $2V_{p\text{-}p}$ signal, $V_{out} = V_{in}$



For a $20V_{p\text{-}p}$ signal



Determine the range of allowable values of R_1 for $V_{out} \approx 5.6V$



$V_{out} = V_Z = 5.6V$

$I_Z > 0$

$I_Z = I_1 - I_2 > 0$

$$I_Z = \frac{V_{in} - V_Z}{R_1} - \frac{V_Z}{R_2} > 0$$

$$\frac{V_{in} - V_Z}{R_1} > \frac{V_Z}{R_2}$$

$$R_1 < R_2 \left(\frac{V_{in} - V_Z}{V_Z} \right)$$

Choose the minimum possible value of V_{in} to determine the constraint on R_1

$$R_1 < (1k\Omega) \left(\frac{6V - 5.6V}{5.6V} \right)$$

$$\boxed{R_1 < 71.43\,\Omega}$$