EECS311 PS4 Solution

P4.1

$$f_M \le \frac{SR}{2\pi V_{FS}}$$

$$\le \frac{10\ V/\mu s}{2\pi \times 10V}$$

$$\le 159.16kHz$$

$$\boxed{f_M = 159.16kHz}$$ #

P4.2

$$SR = \frac{\Delta V}{\Delta t} = \frac{20V}{2\mu s} = \boxed{10\ V/\mu s}$$ #

P4.3
3.21

$$I_D = I_S\left(e^{\frac{V_D}{nV_T}} - 1\right)$$

pick the value from the graph

$V_{D_1} = 0.6V \Rightarrow I_{D_1} = 10^{-4}A$

$V_{D_2} = 0.2V \Rightarrow I_{D_2} = 10^{-9}A$

$$\frac{I_{D1}}{I_{D2}} = \frac{e^{\frac{V_{D1}}{nV_T}} - 1}{e^{\frac{V_{D2}}{nV_T}} - 1} \Rightarrow \frac{10^{-4}}{10^{-9}} = \frac{e^{\frac{0.6}{n(25m)}} - 1}{e^{\frac{0.2}{n(25m)}} - 1}$$

$$\Rightarrow \boxed{n = 1.39}$$ #

$$10^{-4} = I_S \times \left(e^{\frac{0.6}{1.39 \times 25m}} - 1\right)$$

$$\Rightarrow \boxed{I_S = 3.17 \times 10^{-12} A}$$

#

3.22 $I_S = 10^{-18} A,\ n = 1.05$

a) $I_D = I_S\left(e^{\frac{V_D}{nV_T}} - 1\right)$

$70\mu = 10^{-18}\left(e^{\frac{V_D}{1.05 \times 25m}} - 1\right)$

$\Rightarrow \boxed{V_D = 0.836 V}$ #

b) $5\mu = 10^{-18}\left(e^{\frac{V_D}{1.05 \times 25m}} - 1\right)$

$\Rightarrow \boxed{V_D = 0.767 V}$ #

c) $I_D = 10^{-18} \times (e^{0} - 1) = \boxed{0 A}$ #

d) $I_D = 10^{-18} \times \left(e^{\frac{-0.075}{1.05 \times 25m}} - 1\right)$

$= \boxed{-9.43 \times 10^{-19} A}$ #

e) $I_D = 10^{-18} \times \left(e^{\frac{-5}{1.05 \times 25m}} - 1\right)$

$= \boxed{-1 \times 10^{-18} A}$ #

3.24 $I_s = 10^{-17} A$, $n = 1$

a) $V_D = 0.675\ V$

$$I_D = I_s\left(e^{\frac{V_D}{nV_T}} - 1\right)$$

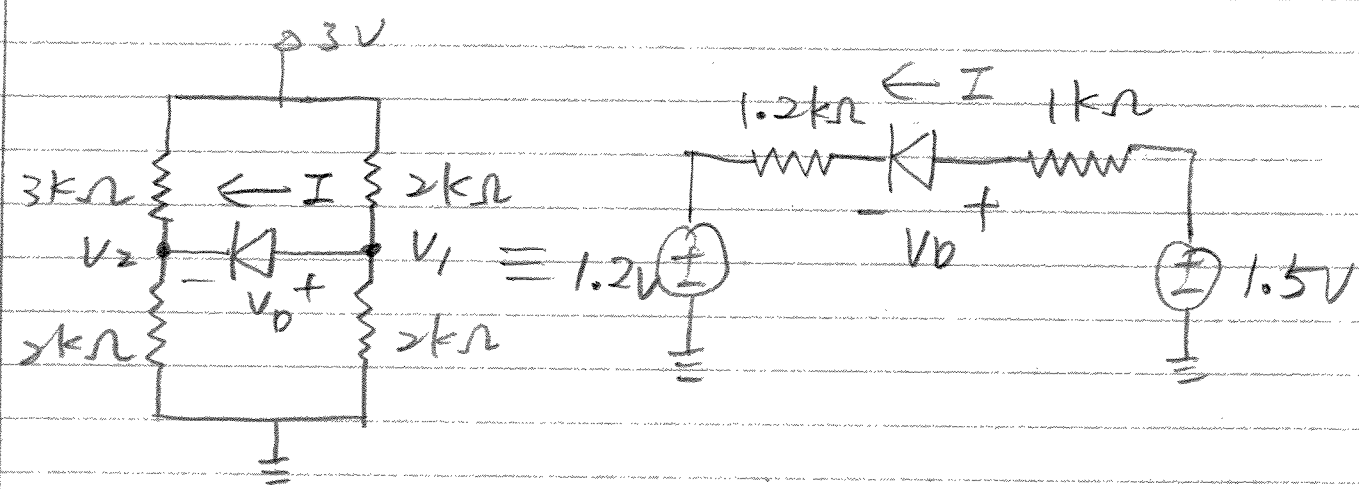
$$= 10^{-17}\left(e^{\frac{0.675}{1\times 25m}} - 1\right)$$

$$= \boxed{5.32\ \mu A}$$ #

b) $$5.32\mu \times 3 = 10^{-17} \times \left(e^{\frac{V_D}{1\times 25m}} - 1\right)$$

$$\boxed{V_D = 0.7\ V}$$ #

3.66



a) Ideal diode model (no voltage drop)

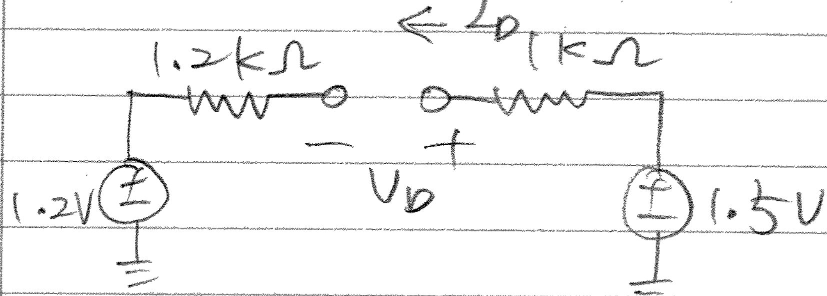
$$\boxed{\begin{array}{l} V_D = 0 \\ I_D = \dfrac{1.5 - 1.2}{(1.2+1)k} = 0.13\ mA \end{array}}$$ #

b) Constant voltage drop ($V_{on} = 0.6V$)

$V_D = 0.6\ V$

$$I_D = \frac{1.5 - 0.6 - 1.2}{(1.2+1)\,k} = -0.13\,mA$$

The current is negative which violates the convention diode model when the diode is on. ⇒ Diode is off

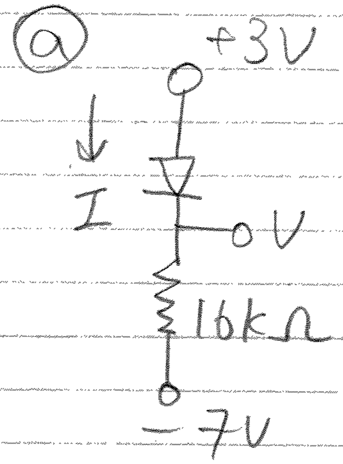


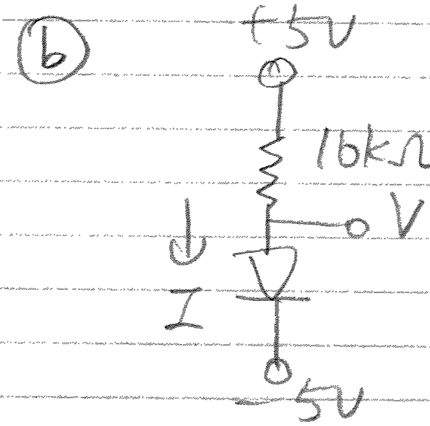
$$\therefore \boxed{I_D = 0A,\ V_D = 1.5 - 1.2 = 0.3\,V}$$ #

c) The second model is more realistic. The voltage across the diode for b) is not sufficient to turn on the diode, so the resulting current will be really small.

3.69

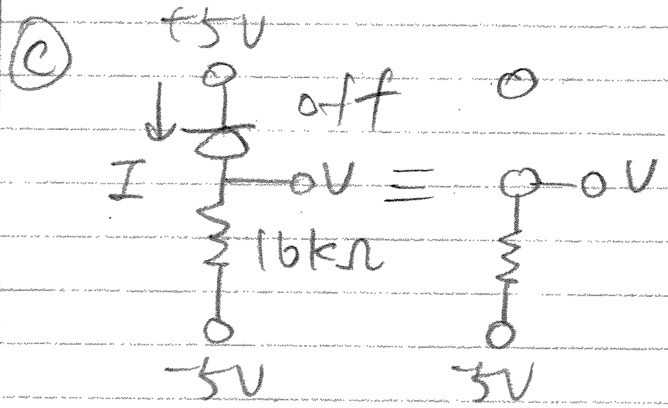
a)

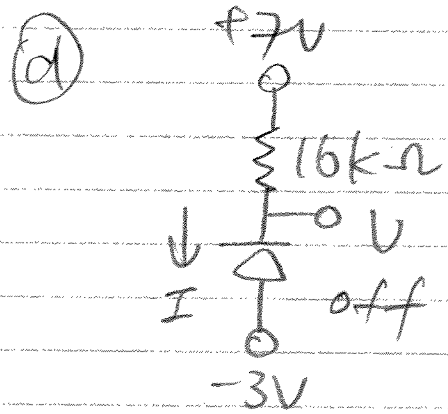




$\boxed{V = 3\text{ V} \quad I = \frac{3+7}{16k} = 0.625\text{ mA}}$ #

$\boxed{V = -5\text{V} \quad I = \frac{5+5}{16k} = 0.625\text{ mA}}$ #

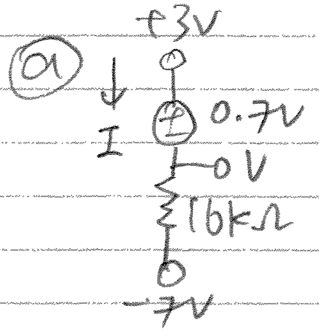




$\boxed{I = 0\text{A} \quad V = -5\text{V}}$ #

$\boxed{I = 0\text{ A} \quad V = 7\text{ V}}$ #

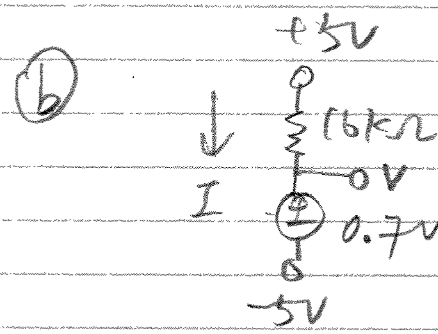
3.69
b)



$V = 2.2V$

$I = \frac{2.2+7}{16k} = 0.575mA$

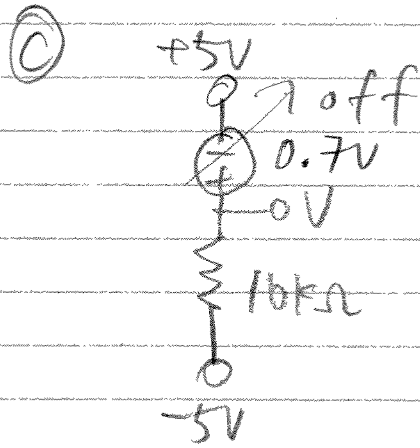
#



$V = -5+0.7 = -4.3V$

$I = \frac{5+4.3}{16k} = 0.58mA$

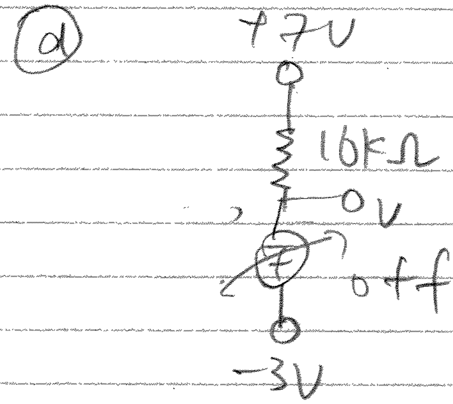
#



$V = -5V$

$I = 0A$

#



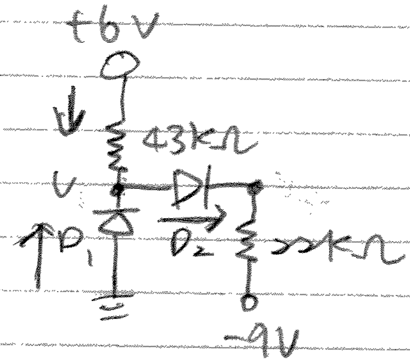
$V = 7V$

$I = 0A$

#

3.71

a) ⓐ



Assume D_1 off, D_2 on

D_2: $V_2 = 0$, $I_2 = 15/65k = 0.23m$

$\Rightarrow V_1 = -3.89$ (D_1 should be on

Assume D_1 on, D_2 on

D_2: $I_2 = \dfrac{0+9}{22k} = 0.409mA$

$V_2 = 0$

D_1: $V_1 = 0$

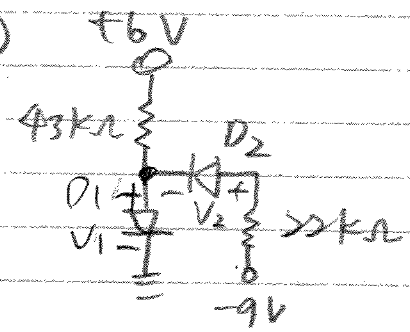
$I_1 = \dfrac{6-(-9+22\times0.409)}{43k} - 0.409$

$= -0.269mA$

$$\boxed{\begin{aligned} D_1 &: V_1 = 0 \\ & \quad I_1 = 0.269mA \\ D_2 &: V_2 = 0 \\ & \quad I_2 = 0.409mA \end{aligned}}$$

#

ⓑ



Assume D_2 off, D_1 on

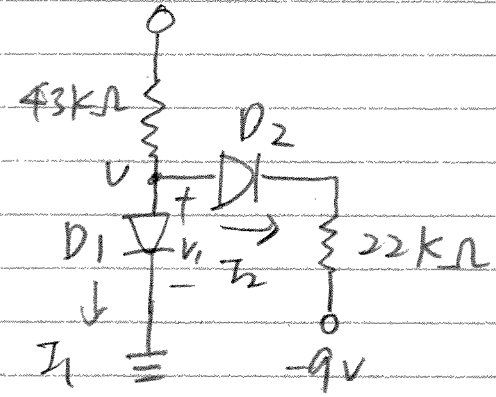
✓ D_1: $V_1 = 0$, $I_1 = 6/43k = 0.139mA$

Assume D_1 off, D_2 on (x)

$$\boxed{\begin{aligned} D_1 &: V_1 = 0 \\ & \quad I_1 = 0.139mA \\ D_2 &: V_2 = -9V \\ & \quad I_2 = 0A \end{aligned}}$$

#

(c)



Assume D_1, D_2 are on

$D2: V_2 = 0$

$$I_2 = \frac{9}{22k} = 0.409\,mA$$

$D1: V_1 = 0$

$$I_1 = \frac{6-(-9+22k\times 0.409m)}{43k} - 0.409m$$

$$= -0.269\,(mA)$$

$\Rightarrow$ D_1 is off.

Assume D_1 is off, D_2 is on

D_2: $I_2 = \dfrac{6+9}{65k} = 0.23\,mA$

D_1:

$V_1 = 6 - 43k\times 0.23m = -3.89\,V$

$I_1 = 0\,A$

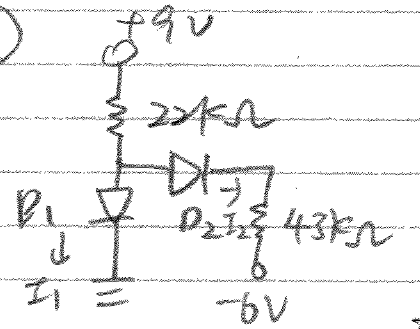
D_2:

$V_2 = 0\,V$

$I_2 = 0.23\,mA$

#

(d)



Assume all on

$D_2: V_2 = 0$

$$I_2 = \frac{0+6}{43k} = 0.139\,mA$$

$D_1: V_1 = 0$

$$I_1 = \frac{9-(-6+43\times 0.139)}{22k} - 0.139\,mA = 0.27\,m$$

D_1: $V_1 = 0$

$I_1 = 0.41\,mA$

D_2: $V_2 = 0$

$I_2 = 0.27\,mA$

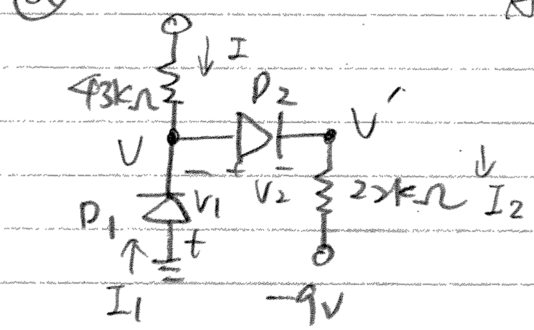
#

3.71

b)

$V_{on} = 0.75V$

(a)



Assume D_1 on, D_2 on

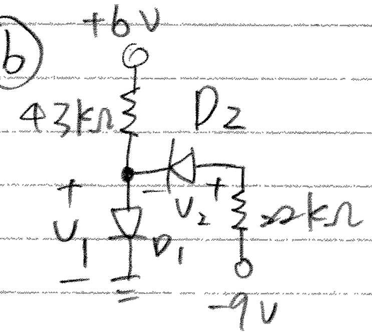
$V = -0.75V$, $I = \frac{6+0.75}{43k} = 0.157mA$

$V' = -1.4V$, $I_2 = 0.345mA$

$$\boxed{\begin{aligned} D_1:\ & V_1 = 0.75V \\ & I_1 = 0.345 - 0.157 = 0.188m \\ D_2:\ & V_2 = 0.75V \\ & I_2 = 0.345mA \end{aligned}}$$

#

(b)

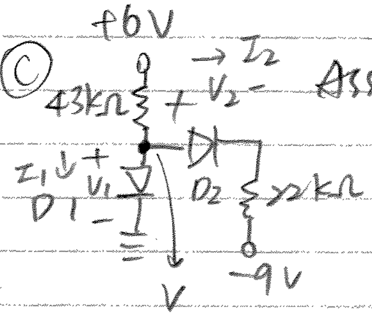


Assume D_1 on, D_2 off

$V_1 = 0.75V$, $I_1 = 0.122mA$

$$\boxed{\begin{aligned} D_1:\ & V_1 = 0.75V \\ & I_1 = 0.122mA \\ D_2:\ & V_2 = -9.75V \\ & I_2 = 0A \end{aligned}}$$

(c)



Assume D_1 is off, D_2 is on

$$I_2 = \frac{(6 - 0.75 + 9)}{65k} = 0.219 mA$$

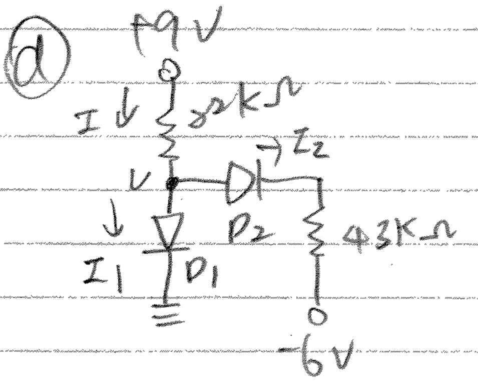
$$V = 6 - 43k \times (0.219)m = -3.417V$$

Assumption was correct.

$$\boxed{\begin{aligned} D_1:\ & V_1 = -3.42V \\ & I_1 = 0A \\ D_2:\ & V_2 = 0.75V \\ & I_2 = 0.219mA \end{aligned}}$$

#

(d)



Assume D_1, D_2 are on

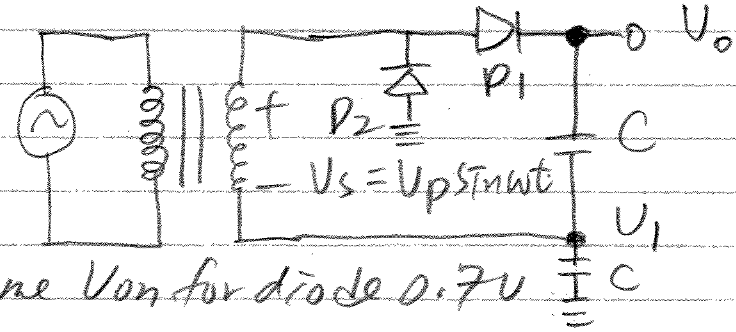
$V = 0.75V$, $I = \frac{9-0.75}{22K} = 0.375mA$

$I_2 = \frac{6}{43K} = 0.14mA$

$$\boxed{\begin{array}{l} D_1: V_1 = 0.75V \\ \quad I_1 = 0.235mA \\ D_2: V_2 = 0.75V \\ \quad I_2 = 0.14mA \end{array}}$$

#

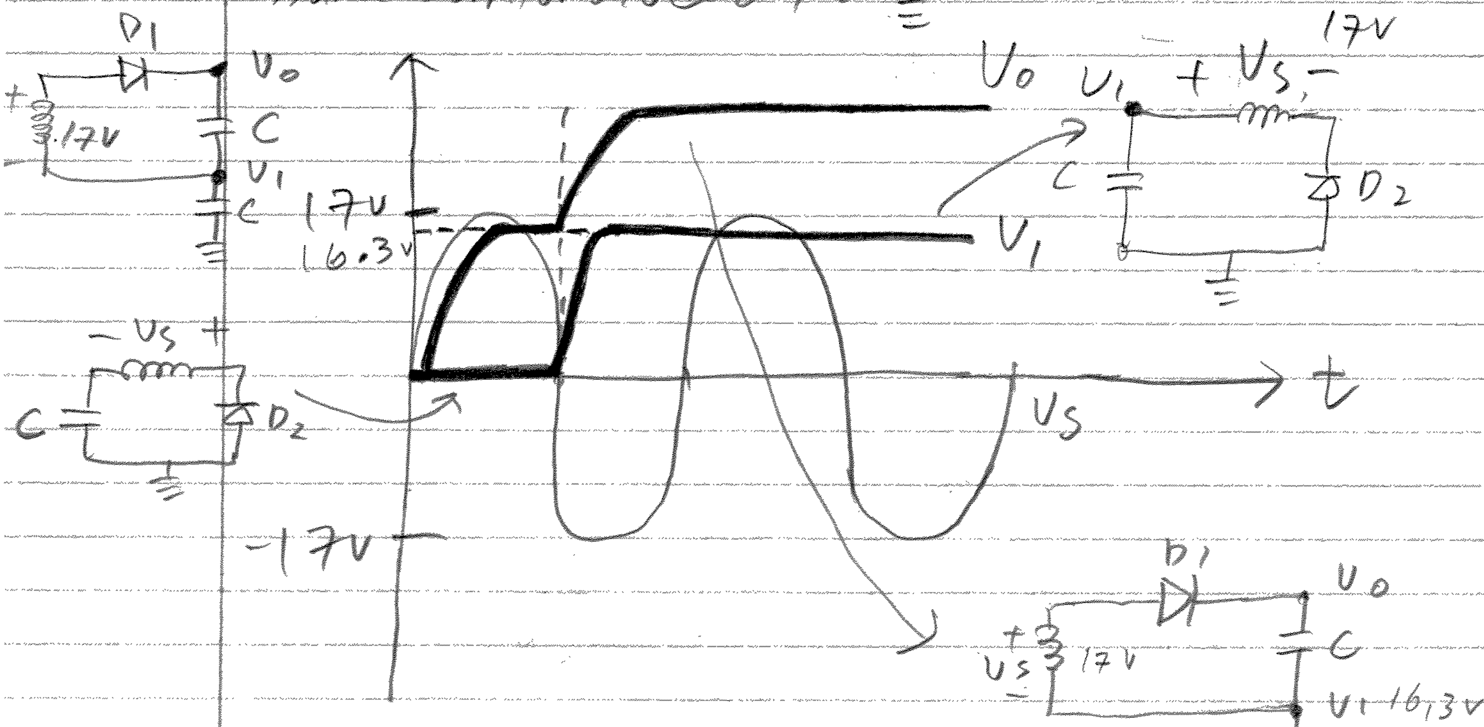
3.98



$V_p = 17$

$V_c = 17 \sin\omega t$

Assume Von for diode 0.7V



$V_{DC} = 16.3 + 16.3$
$= \boxed{32.6\ V}$ #

3.119 $I_c = 1 - 10^{-15}[\exp(40V_c) - 1]$ A

$P = V_c I_c$

$= V_c \{1 - 10^{-15}[\exp(40V_c) - 1]\}$

P_{max} occurs when $\frac{dP}{dV_c} = 0$

$\frac{dP}{dV_c} = \{1 - 10^{-15}[\exp(40V_c) - 1]\}$

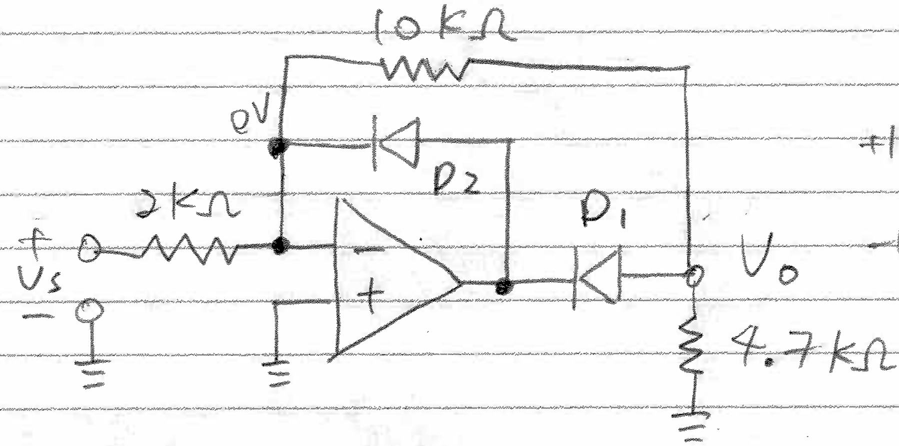
$+ V_c \times \{-10^{-15}[\exp(40V_c) - 1]\} \times 40 = 0$

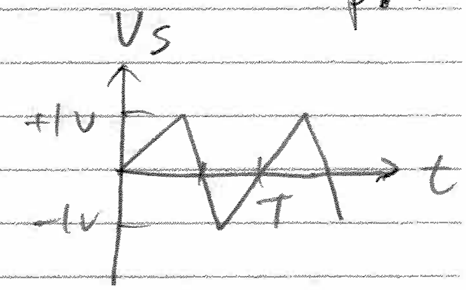
Solving V_c

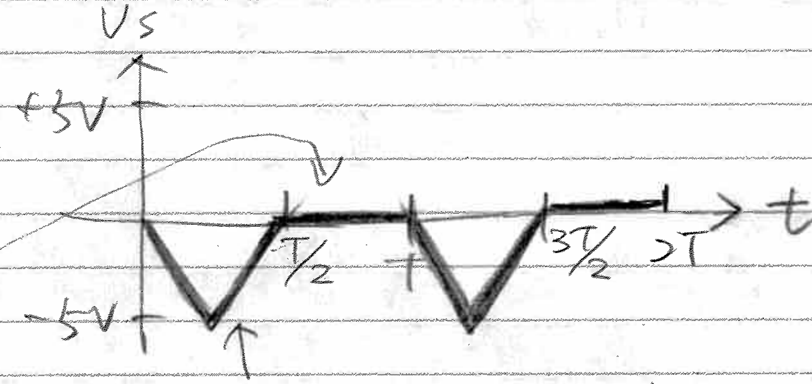
$\Rightarrow$ $\boxed{\begin{aligned} V_{oc} &= 0.78\ V \\ I_{sc} &= 0.96\ A \\ P_{max} &= 0.75\ W \end{aligned}}$

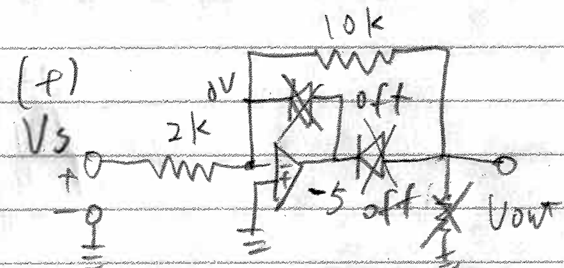
#

11.91



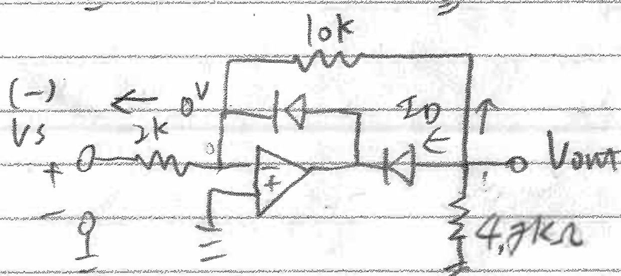






$$\frac{V_s}{2k} = \frac{-V_{out}}{10k}$$

$$\Rightarrow V_{out} = -5V_s$$



assume diodes are on ($V_{out}=-1$)

$$I_D + \frac{1}{10k} + \frac{1}{4.7k} \neq 0$$

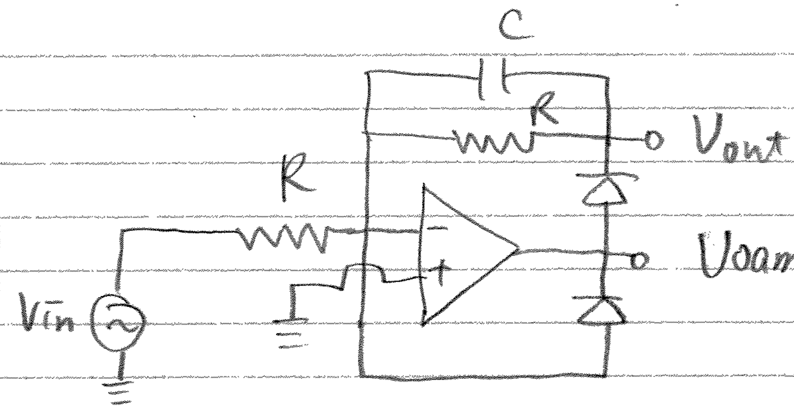
∴ diodes are off

assume diodes are off

$$\frac{V_{out}}{4.7k} + \frac{V_{out}}{10k} = 0$$

$$V_{out} = 0$$

P4.4



$V_{in} = 0.5 \cos \omega t$

$V_{on} = 0.6\,V$