

**EE 115A  
Winter 2010  
Midterm Exam  
Feb 9<sup>th</sup> 2010**

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**Instructor: Prof. M.F. Chang**

**Name:**

**UID:**

**Left student's name:**

*Solution*

**Right student's name:**

**Problem1:**

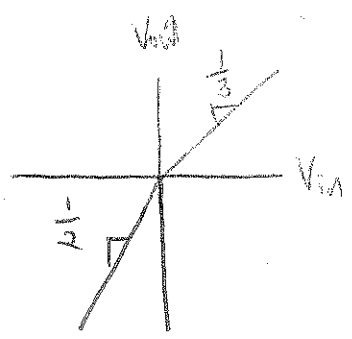
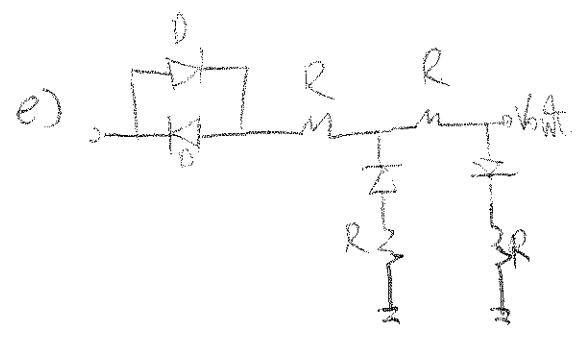
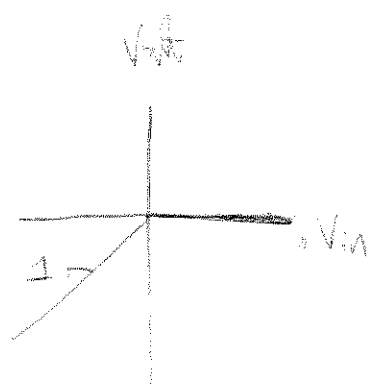
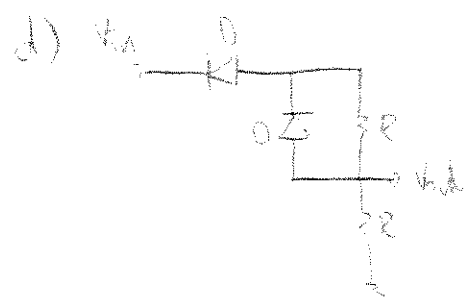
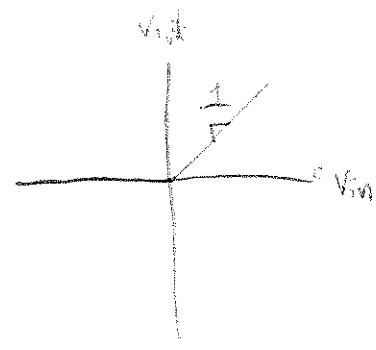
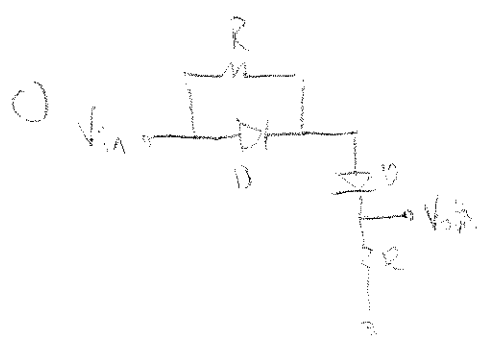
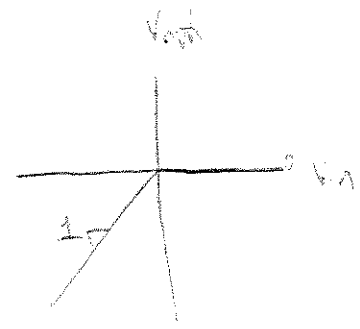
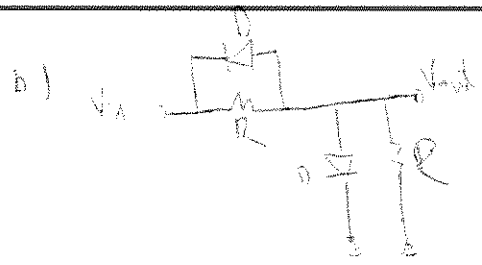
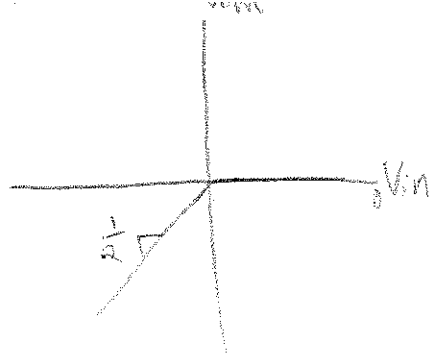
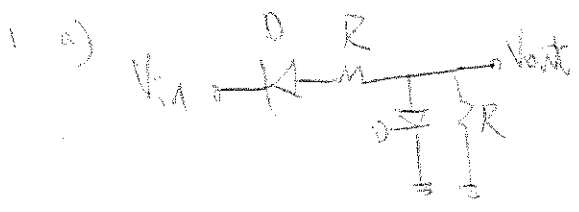
**Problem2:**

**Problem3:**

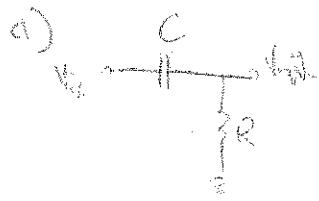
**Problem4:**

**Bonus:**

**Total:**



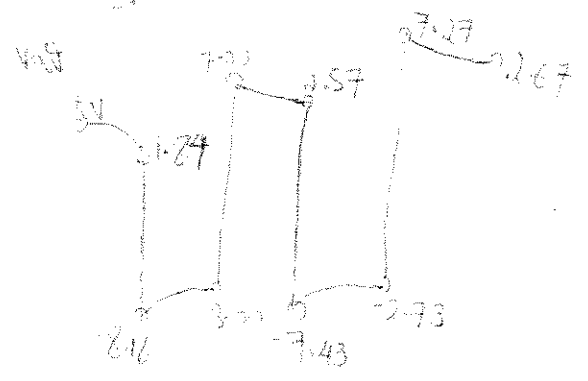
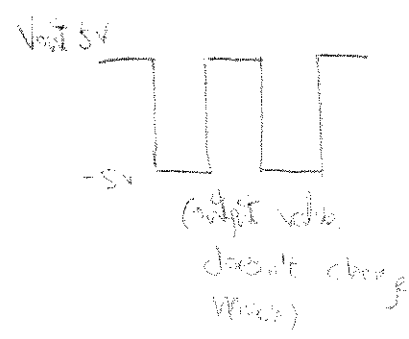
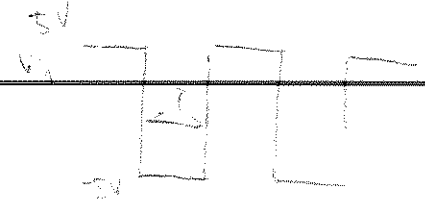
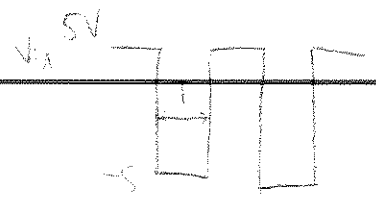
#2



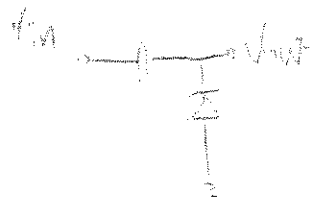
(Assume C isn't charged initially)

i)  $RC \gg T$

ii)  $RC = T$



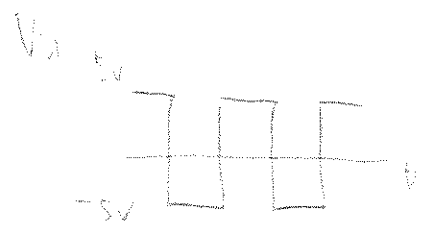
b)



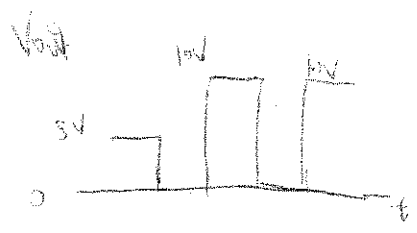
(Assume C isn't initially charged)

i)  $RC \gg T$

ii)  $RC = T$



The same as ) since there is no R.



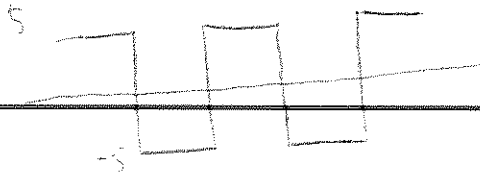
#2



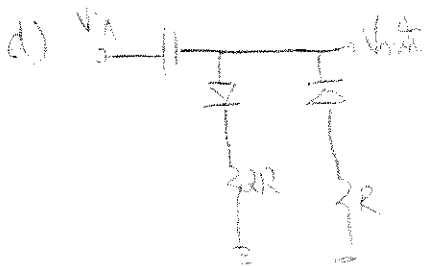
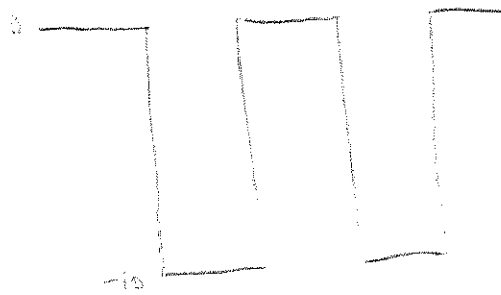
(Assume C is not charged initially and  $V_{0,0in} = 0$ )

i)  $RC \gg T$

ii)  $RC = T$



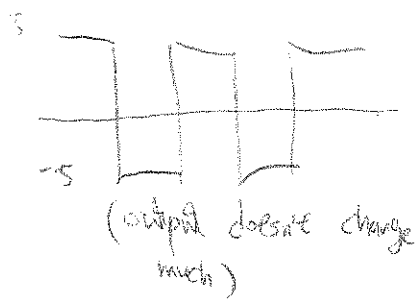
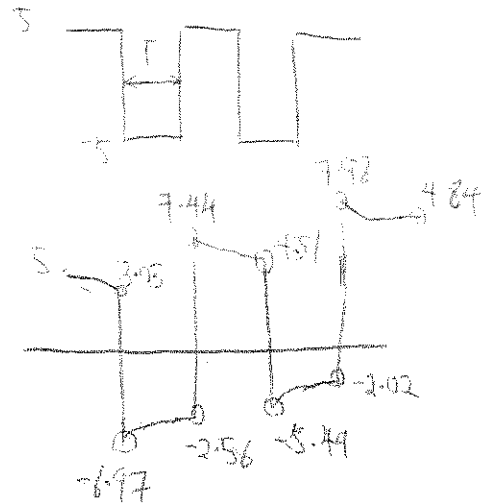
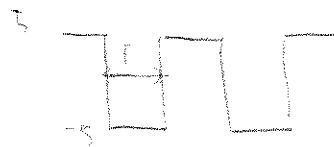
The same as the left (i) because R is not in the picture.



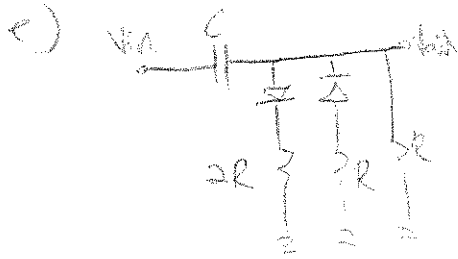
(Assume C is not charged initially and  $V_{0,0in} = 0$ )

i)  $RC \gg T$

ii)  $RC = T$



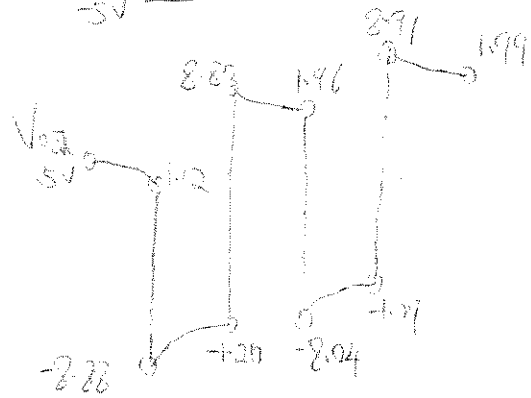
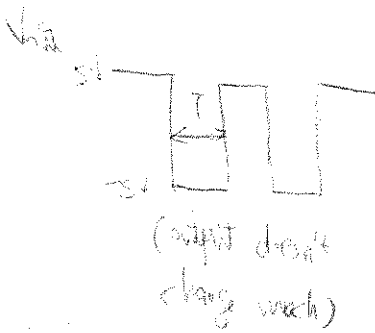
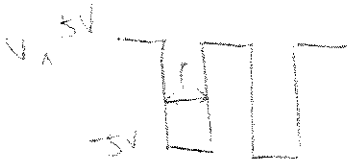
A 2



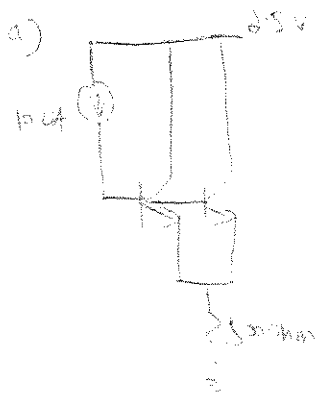
$$2R \parallel R = \frac{2R^2}{2R+R} = \frac{2}{3}R, \quad R \parallel R = \frac{1}{2}R$$

i) RC → T

ii) RC = T



#3



$$I_{B_1, B_2} = 50 \mu A$$

$$I_{C_1, B_2} = 500 \mu A$$

$$V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right) = 776 \text{ mV}$$

$$I_E = 500 \mu A, \quad V_E = (2)(500 \mu A)(500) = 0.505 \text{ V}$$

$$V_{CE} = 1.995 \text{ V, Forward Active}$$

#3

b)



$$I_E = 2 \text{ mA}$$

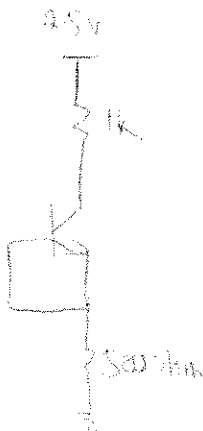
$$I_C = (2 \text{ mA}) \times (0.99) = 1.98 \text{ mA}$$

$$V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right) = 742 \text{ mV}$$

$$V_{CE} = V_{BE} = 742 \text{ mV}$$

Forward Active

c)



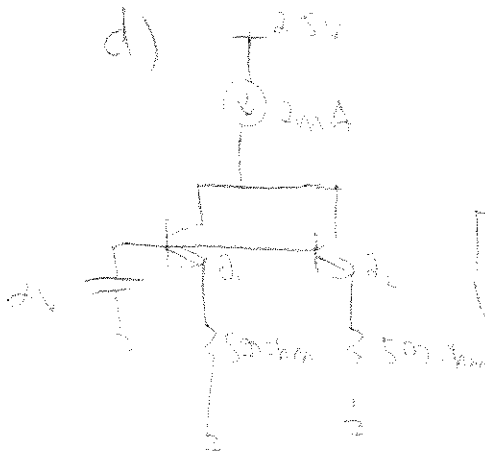
$$V_{BE} = 0$$

$$I_C = 0 \quad (\text{because } V_{BE} = 0)$$

$$V_{CE} = 2.5$$

Cutoff

d)



$$I_C = I_E = 1 \text{ mA}$$

$$V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right) = 724 \text{ mV}$$

$$\frac{I_E}{I_C} = \frac{I_C}{0.99} = 1.01 \text{ mA}$$

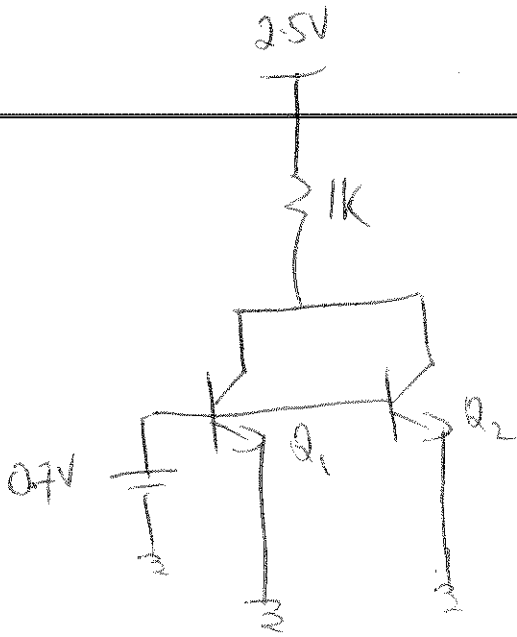
$$V_E = 0.505 \text{ V}$$

$$V_{CE} = 2.5 - 0.505 = 1.99 \text{ V}$$

Forward Active

#3

e)



$$I_{Q1} = I_{Q2} = I_S \exp\left(\frac{0.7}{26\text{mV}}\right) = 0.39\text{mA}$$

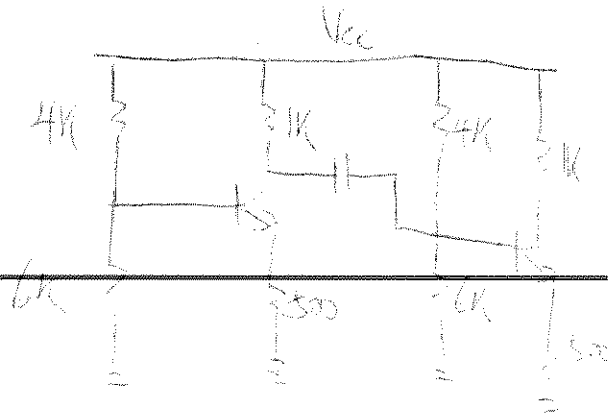
$$V_{BE} = 0.7\text{V}$$

$$V_{CE} = 2.5 - (2)(0.39)(1\text{K}) = 1.72\text{V}$$

Forward Active

# 4

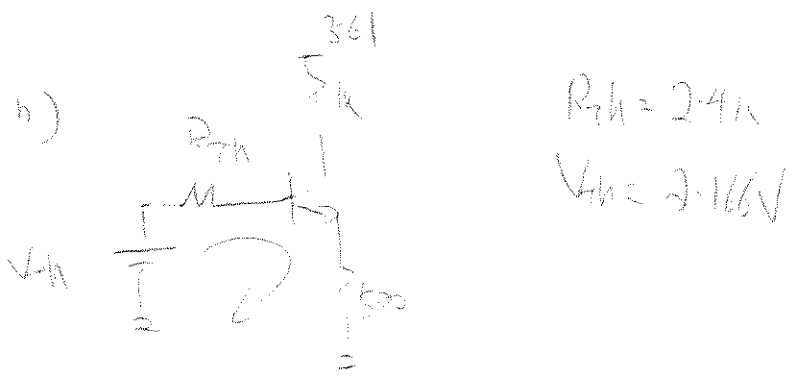
a)



$$\frac{V_{cc}}{10k} + \frac{V_{cc} - 0.7}{1.5k} + \frac{V_{cc}}{1.2k} + \frac{V_{cc} - 0.7}{1.5k} = 5$$

$$\frac{2V_{cc}}{10k} + \frac{2V_{cc}}{1.5k} = 5 + \frac{2(0.7)}{1.5k}$$

$$V_{cc} = 3.61V$$



$$2.166 = I_D \cdot 24k + V_{BE} + I_D \cdot 500$$

$$2.166 = \frac{I_C}{\beta} \cdot 24k + V_{BE} + \frac{I_C}{\alpha} \cdot 500, \quad V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right)$$

use iteration:  $V_{BE} = 0.757$ ,  $I_{C12} = 2.66mA$



# 4

c)

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$$V_x = V_{BE} + I_E 500$$

$$= 0.757 + 1.34$$

$$= 2.1V$$

$$V_x = V_y = 2.1V$$

# 4

$$d) \text{ Total Current} = \left( \frac{3.61 - 2.1}{4k} \right) 2 + (2)(3.66)$$

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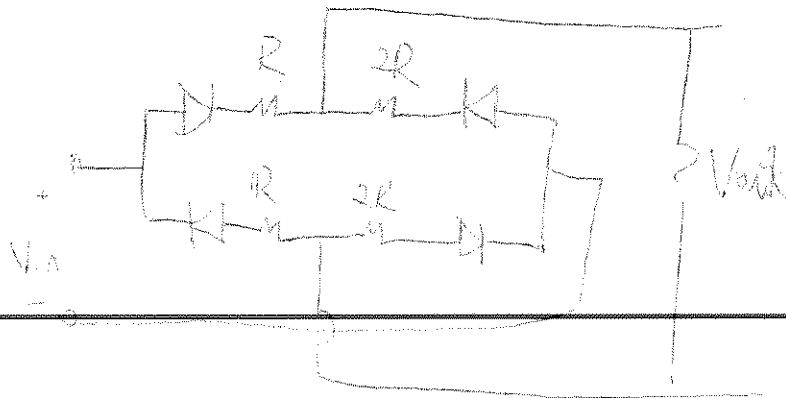
$$= 6.075 \text{ mA}$$

$$\text{Total DC power} = (6.075)(3.61) = \boxed{22 \text{ mW}}$$

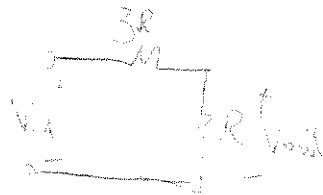
$$e) V_{CE1} = V_C - V_E = 3.61 - 2.46 - (2.1 - 0.757) \\ = -0.393 \text{ V}$$

$$V_{CE1} = V_{CE2} = -0.393 \text{ V} \quad \text{Saturation Region}$$

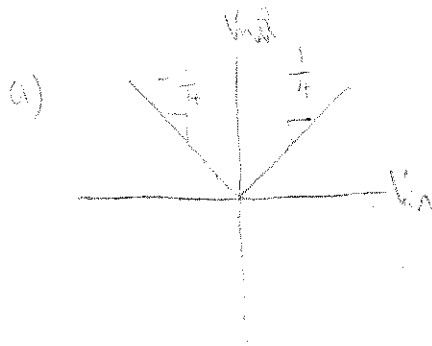
# Bonus



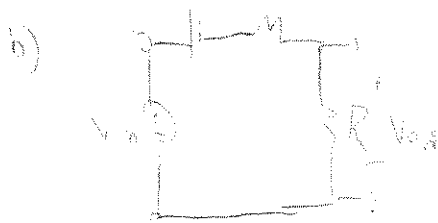
positive cycle



negative cycle



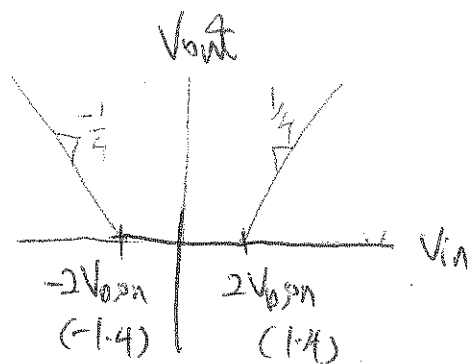
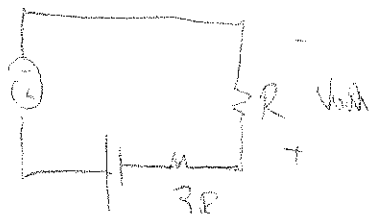
\$2V\_{D,on}\$ positive cycle



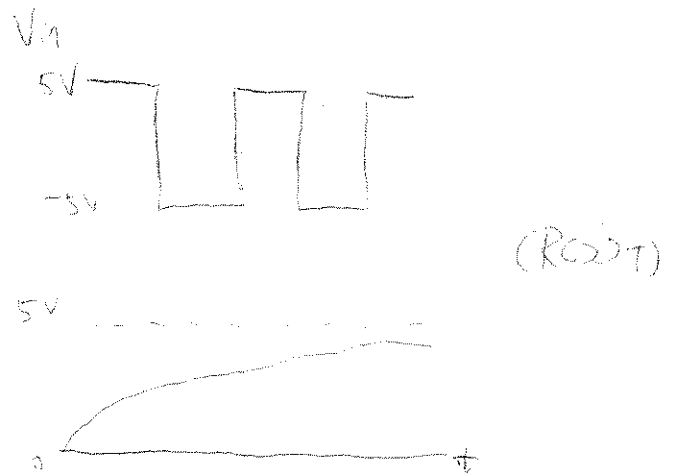
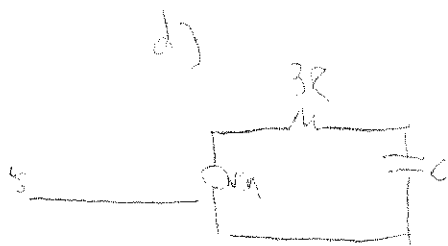
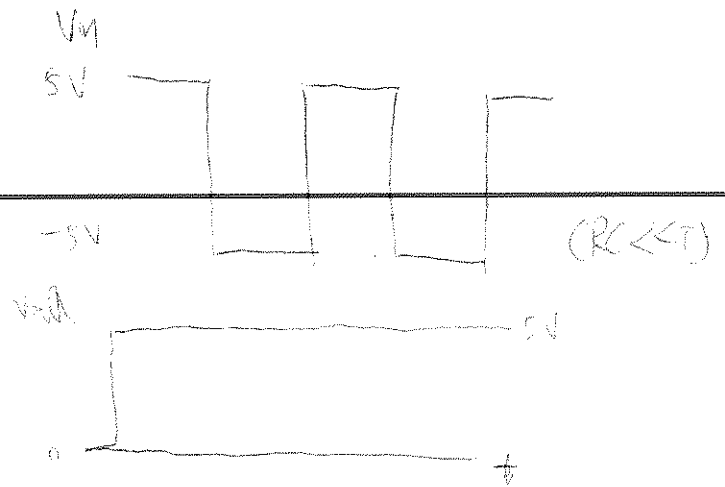
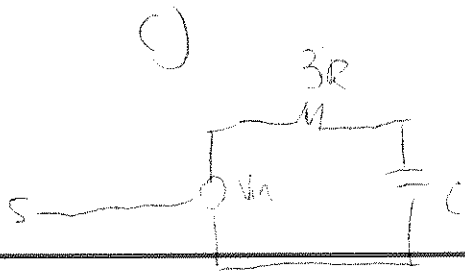
$$V_{out} = \left( \frac{V_{in} - 2V_{D,on}}{4R} \right) R$$

$$= \frac{V_{in}}{4} - \frac{V_{D,on}}{2}$$

negative cycle



# Bonus



e) cutoff freq.  $2\pi f = \frac{1}{3RC} = \frac{1}{(3 \times 10^3 \times 2 \times 10^{-12})}$

$f = 26.53 \text{ MHz}$