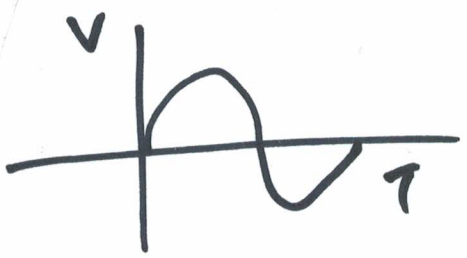
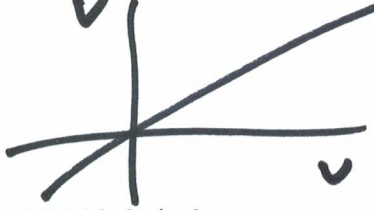
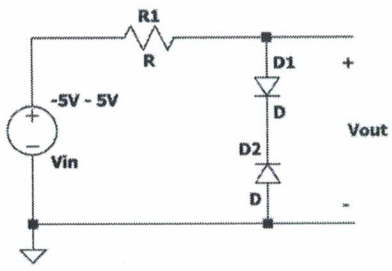




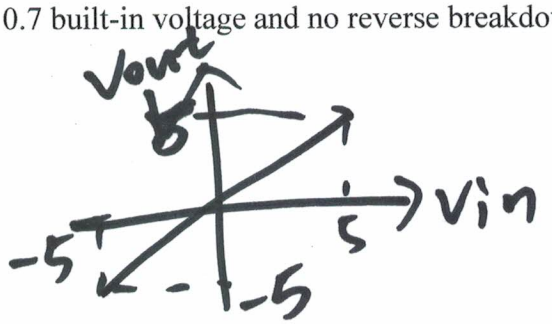
DC 等 sweep

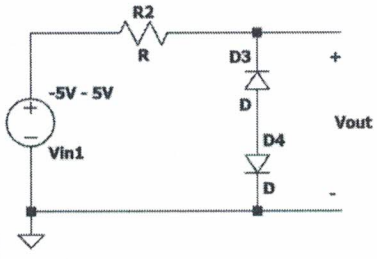
ENGR338 Quiz 3

1. Draw the Vin versus Vout curves for the following circuits when Vin is swept from -5V to 5V. (The diodes are real diodes with a 0.7 built-in voltage and no reverse breakdown). (60 points)

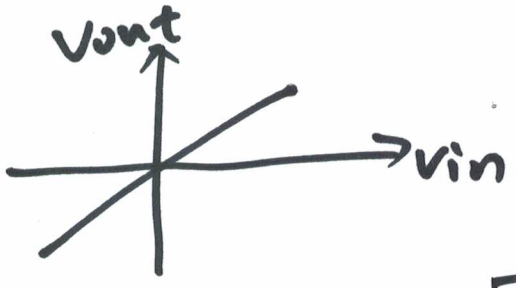


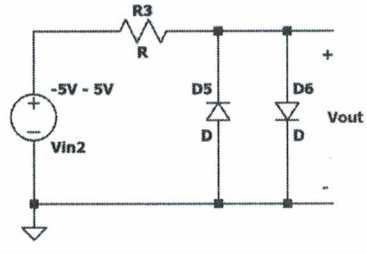
(a)



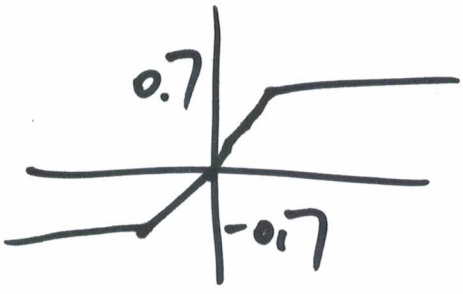


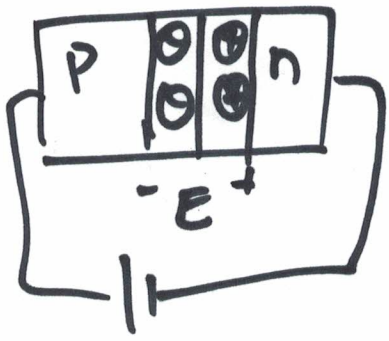
(b)



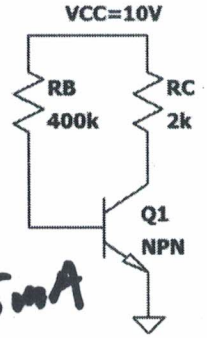


(c)





2. Determine the Q point values and draw the DC load line of the following circuit. (assume VCC=10V, R_B=400k, R_C=2k, β=100, V_{BE}=0.7V) (20 points)



$I_{CmAX} = \frac{V_{CC}}{R_C} = 5mA$

Self-biased

$I_B = I_{BQ} = \frac{V_{CC} - 0.7}{R_B} = \frac{10 - 0.7}{400k}$

$= 23.25\mu A$

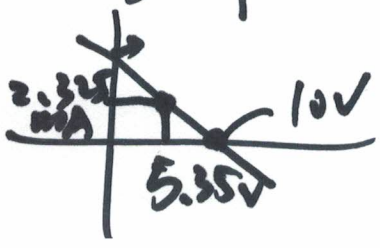
$I_{CQ} = \beta \cdot I_{BQ}$

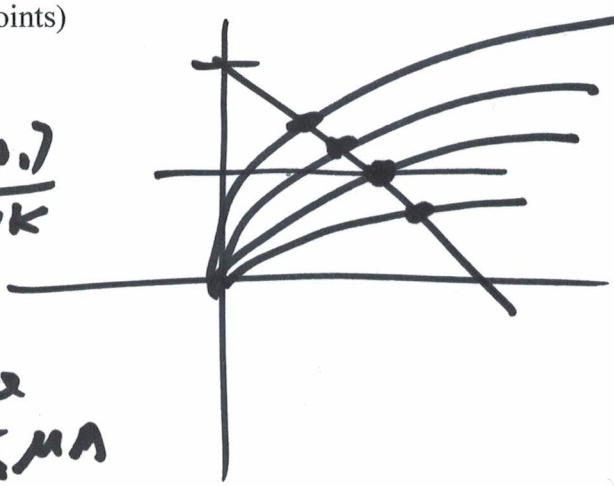
$= 100 \cdot 23.25\mu A$

$= 2.325mA$

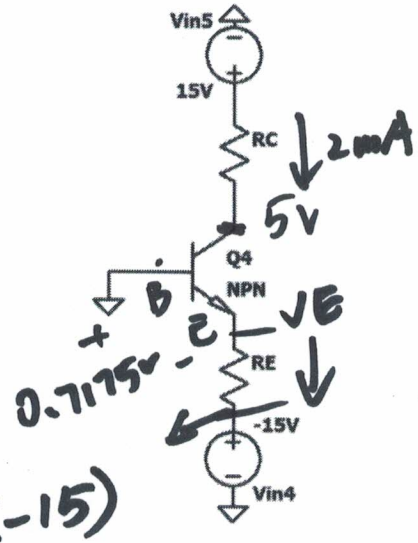
$V_{CEQ} = V_{CC} - I_{CQ} \cdot R_C = 10 - 2K \cdot 2.325mA$

$= 5.35V$





3. $\beta=100$, $V_{BE}=0.7V$ at $I_C=1$ mA. Design the circuit (find appropriate R_C and R_E) so that when $I_C=2mA$, $V_C=5V$ ($V_T=25mV$ at room temperature). (20 points)



$$R_C = \frac{15-5}{2mA} = 5K\Omega$$

$$I_C = I_S \cdot e^{V_{BE}/V_T}$$

$$\begin{cases} 1mA = I_S \cdot e^{0.7/V_T} \\ 2mA = I_S\, e^{V_{BE}/V_T} \end{cases}$$

$$\begin{cases} I_E = (1+\beta) I_B \\ I_B = \frac{I_C}{\beta} \end{cases}$$

$$\frac{1}{2} = e^{(0.7-V_{BE})/V_T}$$

$$I_E = \frac{2mA}{100} \cdot (1+\beta)$$

$$= \frac{2mA}{100} \cdot 101$$

$$= 2.02mA$$

$$\ln 0.5 = (0.7-V_{BE})/V_T$$

$$-0.7 = (0.7-V_{BE})/25m$$

$$-17.5m = 0.7 - V_{BE}$$

$$V_{BE} = 0.7 + 17.5\times10^{-3}$$

$$= 0.7 + 0.0175$$

$$= 0.7175V$$

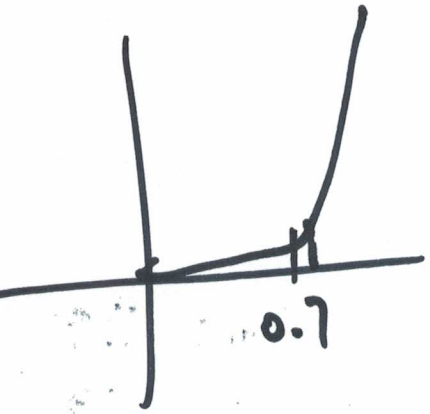
$V_E - (-15)$

$= V_{RE}$

$$\frac{V_{RE}}{I_E} = R_E$$

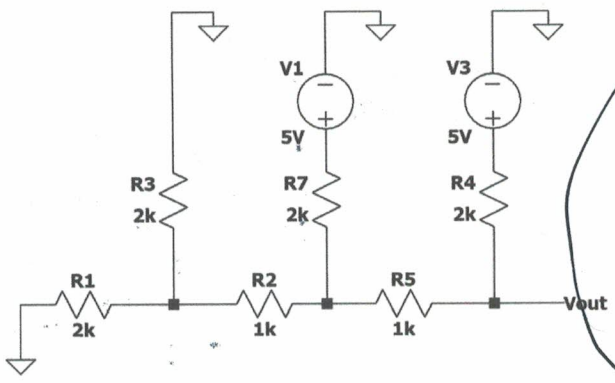
$$= \frac{-0.7175-(-15)}{2.02mA}$$

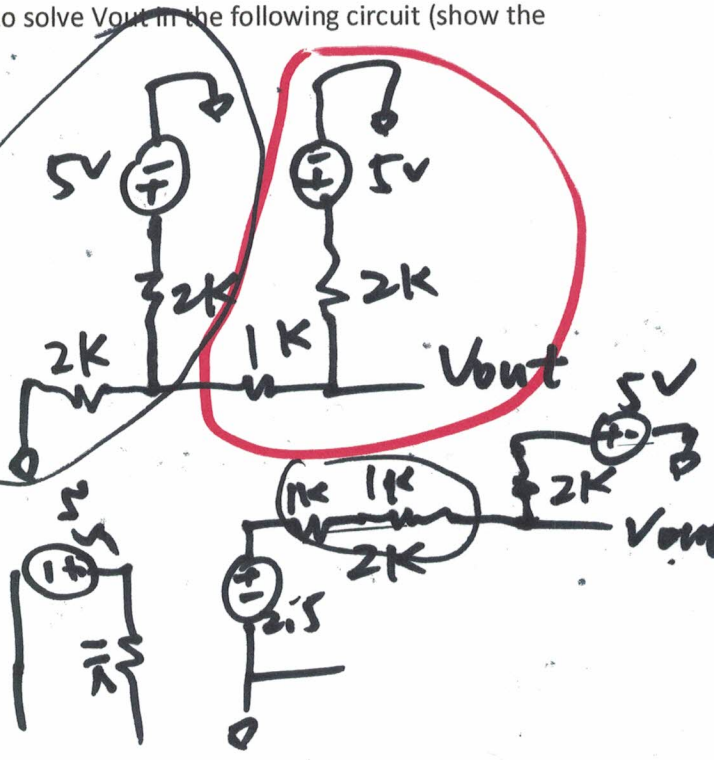
$$= 7.07K\Omega$$



ENGR338 Digital Electronics (55 minutes, close-book, close-notes)

1. Use Thevenin's equivalent theory and superposition to solve Vout in the following circuit (show the calculation process for credits). (10 points)

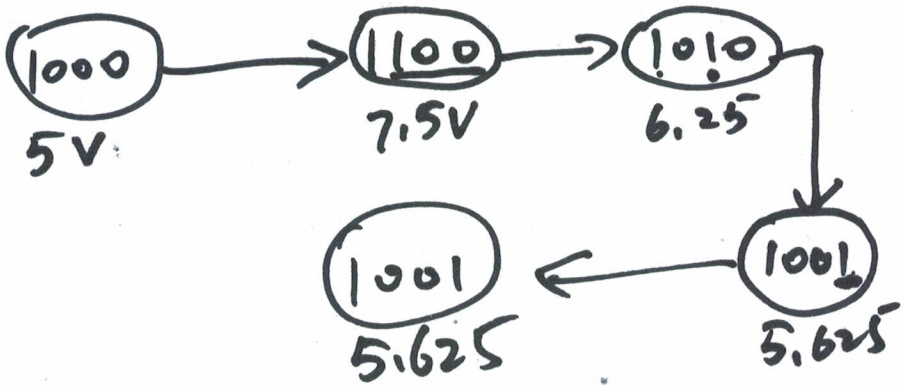


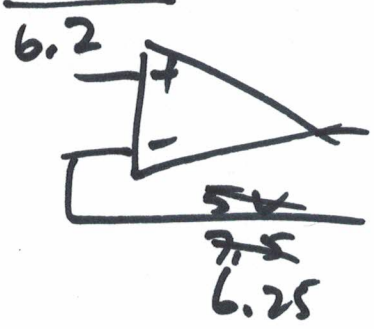


$V_{out} = 2.5 + 1.25 = 3.75\,V.$

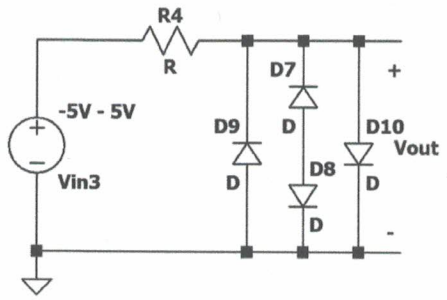
2. For a 4-bit SAR ADC, V_{REF} for the DAC is 10 V, Vin at a moment is 6.2V. Show all the states of the ADC's output in a state diagram. Show both the analog voltage and the digital voltage for each state. (20 points)

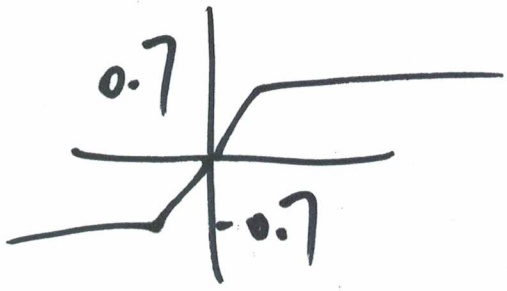
states = N + 1 = 5

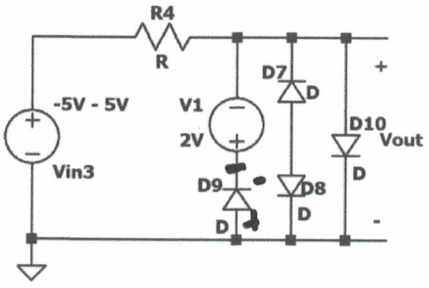


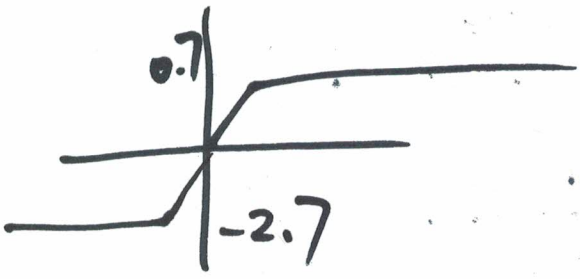


3. Draw the Vin – Vout curves for the following circuits when Vin is swept from -5V to 5V. (The diodes are real diodes with a 0.7 built-in voltage and no reverse breakdown). (20 points)

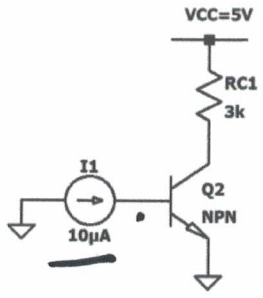








4. For the following NPN BJT, Is=10^{-15}A, β=100. (1) Find VBE and VCE. (2) Replace the 10 uA current source with a resistor and a 5V voltage source, what resistance is required to result in the same operation? (20 points)



① $I_B = 10\mu A \Rightarrow I_C = 100 \cdot I_B = 1mA$

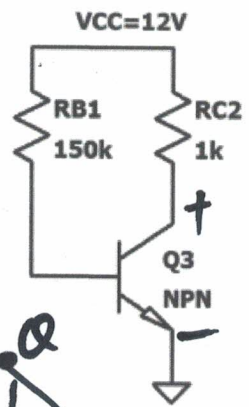
$V_{CE} = V_{CC} - V_{RC} = 5V - 1mA \cdot 3K = 2V$

$I_C = I_S e^{V_{BE}/V_T} \Rightarrow V_{BE} = V_T \cdot \ln \frac{I_C}{I_S} =$ VBE

② 5V — 0.7V — 10mA

$R_B = \frac{5V - 0.7}{10mA} = 430K\Omega$

5. Is the following NPN BJT operated in linear, saturation, or cutoff region? Determine the Q point and draw the load line. (20 points) $\beta = 100$



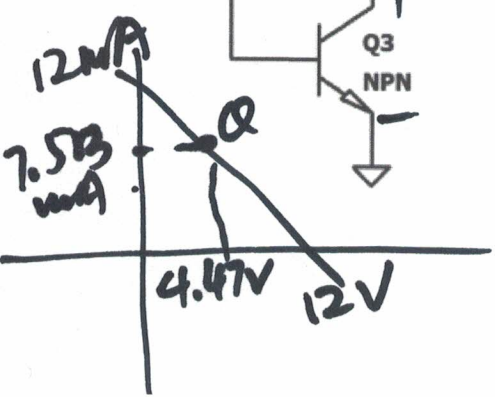
Assume it is operated in the linear region

$I_B = \frac{12 - 0.7}{150K} = 75.3\mu A$

$I_C = \beta \cdot I_B = 1.53mA$

$V_{CE} = V_{CC} - V_{RC} = 12V - 7.53V = 4.47V$

So it is in linear region. $> V_{BE}$



6. Explain the following concepts. Draw diagrams to help with interpreting the concepts if necessary. (10 points)

a. NMOS Channel Length Modulation (CLM)

b. CMOS Latch-Up

c. NMOS Body Effect

d. Formation of the depletion region of a pn junction

e. I_S and I_D for a forward biased pn junction. Which current is larger? Why?

f. Why the N-Well sheet resistance is a constant?

g. What are n_i, n_n, n_p, p_n, p_p, N_A, *and* N_D?