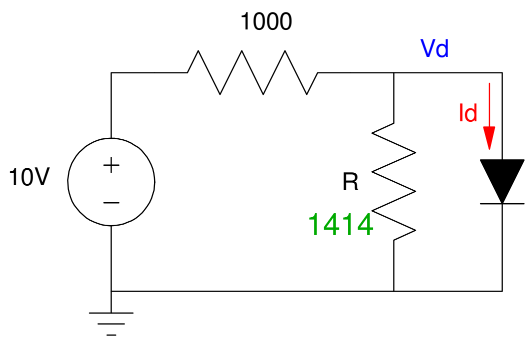
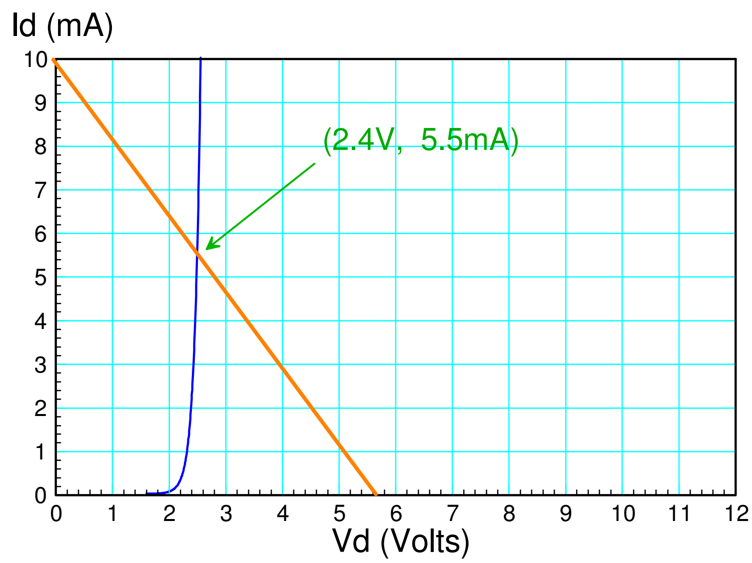
ECE 320 - Final (pt 1) - Name ____________________

Semiconductors & Diodes

1) Load Lines: Assume the VI characteristics for the diode is as shown in the graph. Draw the load line for the following circuit and determine Id and Vd. Assume R = 900 + 100*(your birth month) + (your birth date).

R 900 + 100*mo + day	Load Line x-intercept (volts)	Load Line y-intercept (mA)	Vd Volts	Id mA
1414	**5.857V**	**10.0mA**	**2.4V**	**5.5mA**





x-intercept (Id = 0)

$$V_d = \left(\frac{1414}{1414+1000}\right) 10V = 5.857V$$

y-intercept (Vd = 0)

$$I_d = \left(\frac{10V}{1000\Omega}\right) = 10mA$$

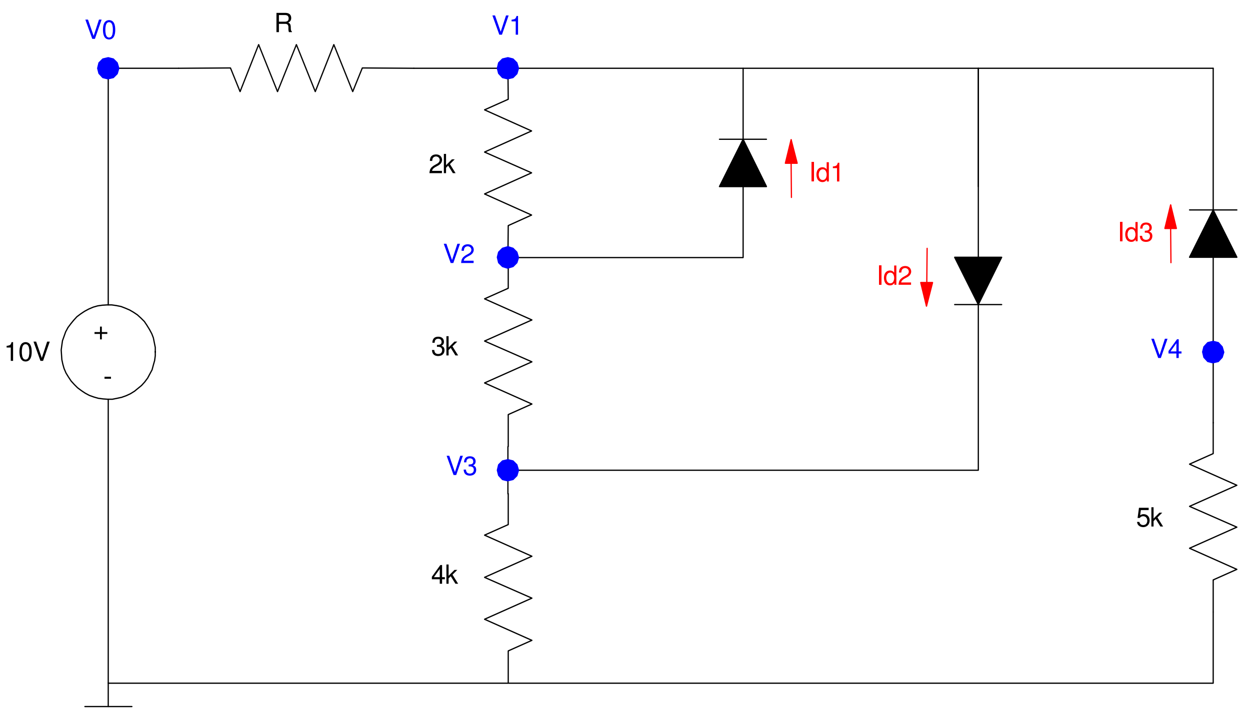
2) Nonlinear equations: Diode circuit

Assume the VI characteristics for the diodes shown below are

$$V_d = 0.038 \ln\left(10^{11} \cdot I_d + 1\right) \qquad I_d = 10^{-11} \cdot \left(\exp\left(\frac{V_d}{0.038}\right) - 1\right)$$

Write N equations to solve for N unknonws: {V1, V2, V3, V4, Id1, Id2, Id3}.

- Note: you do not need to solve.
- R = 900 + 100*(your birth month) + (birth date).



$$I_{d1} = 10^{-11} \cdot \left(\exp\left(\frac{V_2 - V_1}{0.038}\right) - 1\right)$$

$$I_{d2} = 10^{-11} \cdot \left(\exp\left(\frac{V_1 - V_3}{0.038}\right) - 1\right)$$

$$I_{d3} = 10^{-11} \cdot \left(\exp\left(\frac{V_4 - V_1}{0.038}\right) - 1\right)$$

$$\left(\frac{V_1 - V_0}{R}\right) + \left(\frac{V_1 - V_2}{2000}\right) - I_{d1} + I_{d2} - I_{d3} = 0$$

$$\left(\frac{V_2 - V_1}{2000}\right) + \left(\frac{V_2 - V_3}{3000}\right) + I_{d1} = 0$$

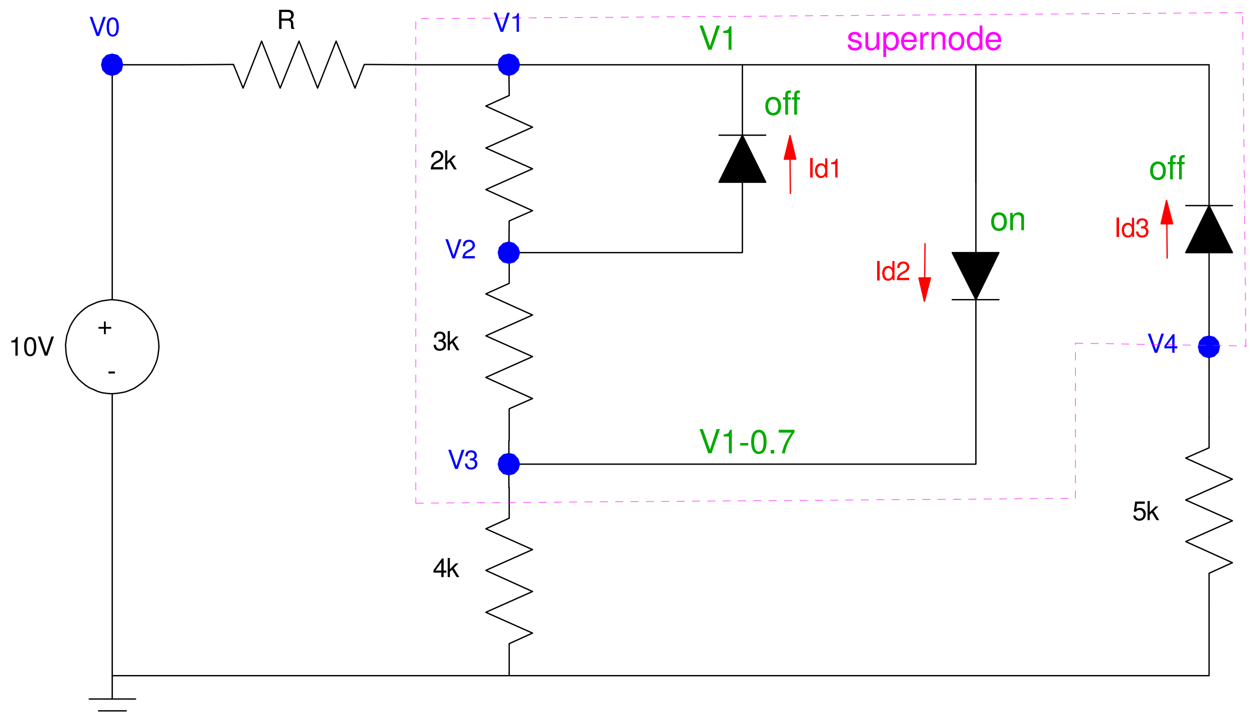
$$\left(\frac{V_3 - V_2}{3000}\right) + \left(\frac{V_3}{4000}\right) - I_{d2} = 0$$

$$\left(\frac{V_4}{5000}\right) + I_{d3} = 0$$

3) Ideal Silicon Diodes. Assume the diodes in this circuit are ideal silicon diodes:

- Vd = 0.7V   Id > 0
- Id = 0   Vd < 0.7V
- R = 900 + 100*(your birth month) + (birth date).

R 900 + 100*mo + day	Id1	Id2	Id3
1414	**0**	**1.578mA**	**0**
V1	V2	V3	V4
7.571V	**7.291V**	**6.871V**	**0V**



$$\left(\frac{V_1-10}{1414}\right)+\left(\frac{V_1-0.7}{4k}\right)+0=0$$

$$V_1=7.571V$$

$$V_3=V_1-0.7=6.871V$$

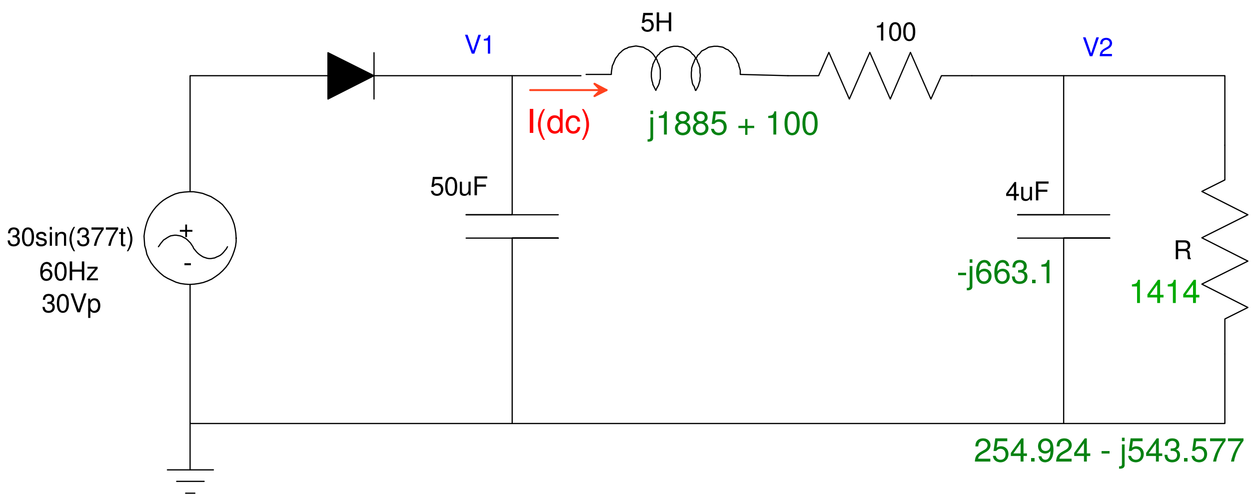
$$V_2=\left(\frac{3}{5}\right)V_1+\left(\frac{2}{5}\right)V_3=7.291V$$

$$V_4=0V$$

$$I_{d2}=\left(\frac{10V-V_1}{R}\right)-\left(\frac{V_1-V_3}{5k}\right)=1.578mA$$

4) AC to DC: Analysis: Determine V1 and V2 (both DC and AC) for the following AC to DC converter

R 900 + 100*mo + day	V1		V2	
	DC	AC	DC	AC
1414	**26.07V**	**6.451Vpp**	**24.35V**	**2.791V$_{pp}$**



DC:

$$\max(V_1) = 29.3V$$

$$I = \frac{29.3V}{1414\Omega + 100\Omega} = 19.35mA$$

$$I = C \cdot \frac{dV}{dt}$$

$$19.35mA = 50\mu F \cdot \frac{dV}{1/60s}$$

$$dV = 6.451V_{pp}$$

$$V_1(DC) = 29.3V - \frac{1}{2} \cdot 6.451V_{pp} = 26.07V$$

$$V_2(DC) = \left(\frac{1414}{1414+100}\right) 26.07V = 24.35V$$

AC:

$$V_1(AC) = 6.451V_{pp}$$

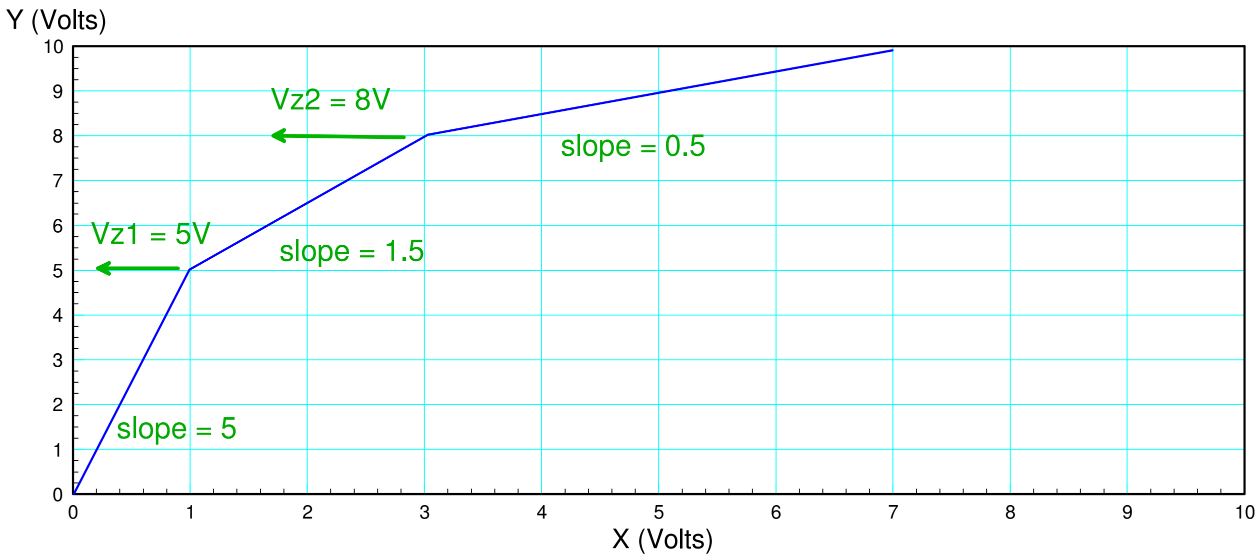
$$V_2(AC) = \left(\frac{(254.924 - j543.577)}{(254.924 - j543.577) + (100 + j1885)}\right) \cdot 6.451V_{pp}$$

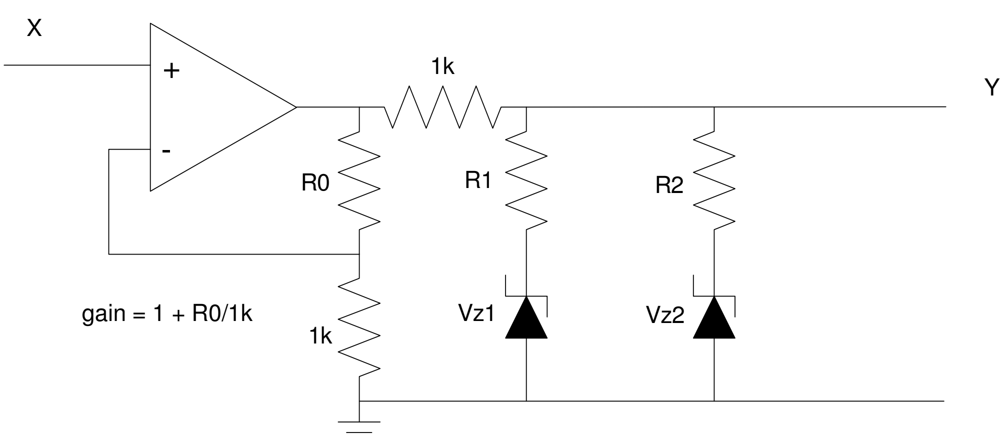
$$|V_2(AC)| = 2.791V_{pp}$$

5) Clipper Circuit: Determine the resistors and zener votlages to implement the following function: Y = f(X). Assume

- Ideal silicon diodes (Vf = 0.7V)
- R = 900 + 100*(your birth month) + (birth date)

R 900 + 100*mo day	R0	R1	Vz1	R2	Vz2
1414	**4k**	**428.5**	**5V**	**150.0**	**8V**





$$1 + \frac{R_0}{1k} = 5 \quad \Rightarrow R_0 = 4k\Omega$$

$$\left(\frac{R_1}{R_1+1000}\right)5 = 1.5 \quad \Rightarrow R_1 = 428.5\Omega$$

$$\left(\frac{R_{12}}{R_{12}+1000}\right)5 = 0.5 \quad \Rightarrow R_{12} = 111.1\Omega$$

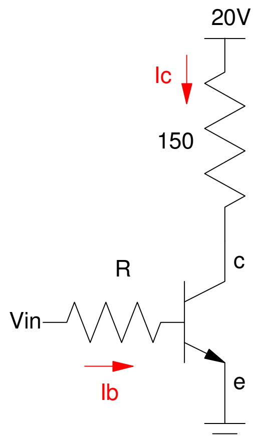
$$R_{12} = R_1 || R_2 \quad \Rightarrow R_2 = 150.0\Omega$$

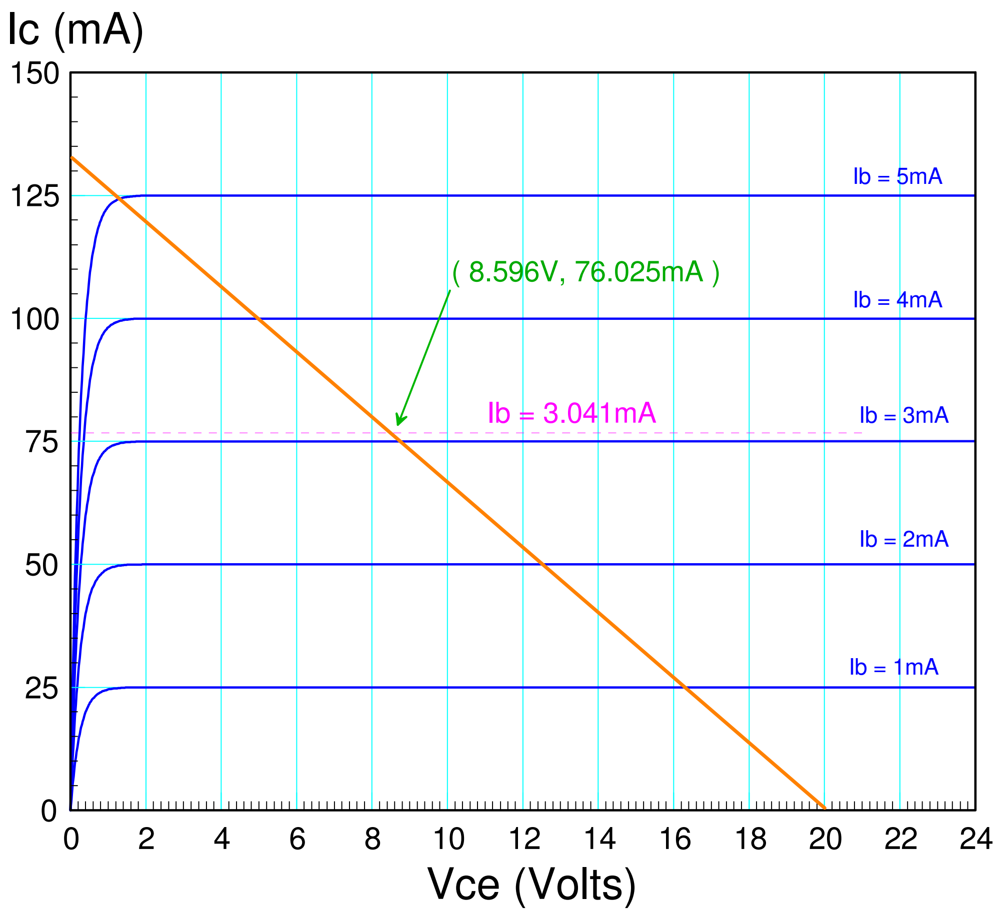
ECE 320 - Final (pt 2) - Name ____________________

Transcristors and Mosfets

6) Determine the current gain, β. Also draw the load line and determine the operating point when Vin = 5V

R 900 + 100*Mo + Day	Current Gain hfe = beta	Load Line x-intercept (Volts)	Load Line y-intercept (mA)	Vce Vin = 5V	Ic Vin = 5V
1414	**25**	**20V**	**133.3mA**	**8.596V**	**76.025mA**



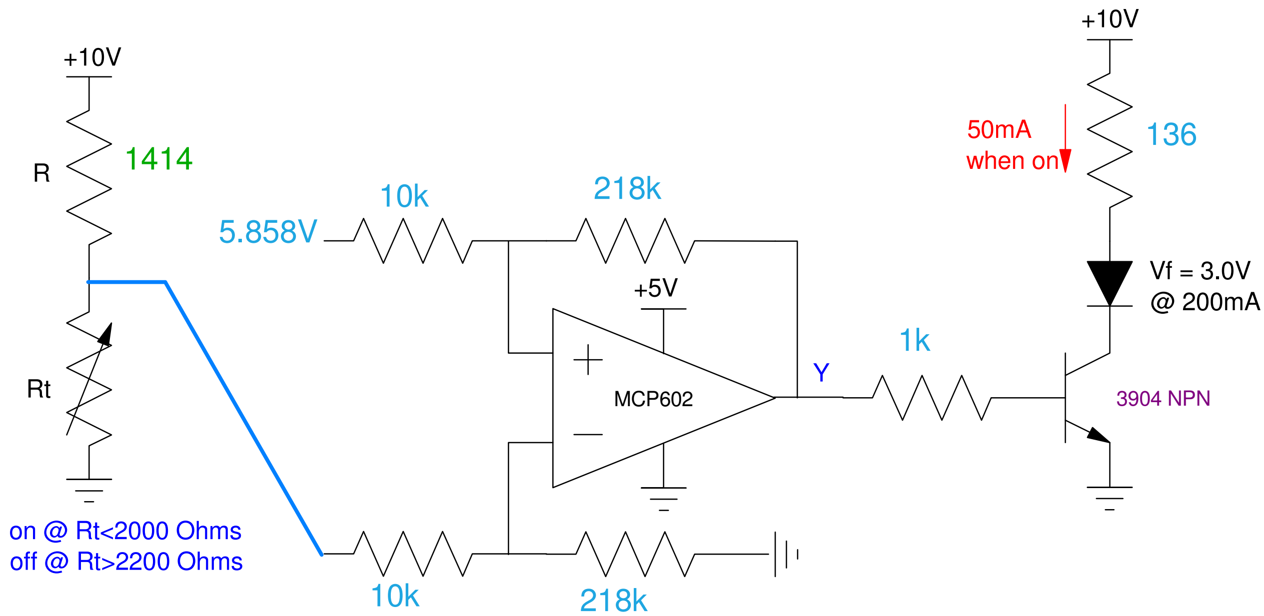


7) Design a Schmitt Trigger & transistor switch so that

- Turns on the LED at 50mA when Rt < 2000 Ohms
- Turns off the LED when Rt > 2200 Ohms

Assume

- R = 900 + 100*(your birth month) + (your birth date)
- Vce(sat) = 0.2V
- Current gain (β) = 100



Rt = 2000:

- X = 5.858V
- Y = 5V

Rt = 2200

- X = 6.087V
- Y = 0V

Connect to the minus input (V(on) < V(off))

Make the offset 5.858V (where Y goes high)

Make the gain

$$gain = \left(\frac{5V - 0V}{6.087V - 5858V}\right) = 21.81$$

For Ic = 50mA

$$R_c = \frac{10V - 3V - 0.2V}{50mA} = 136\Omega$$

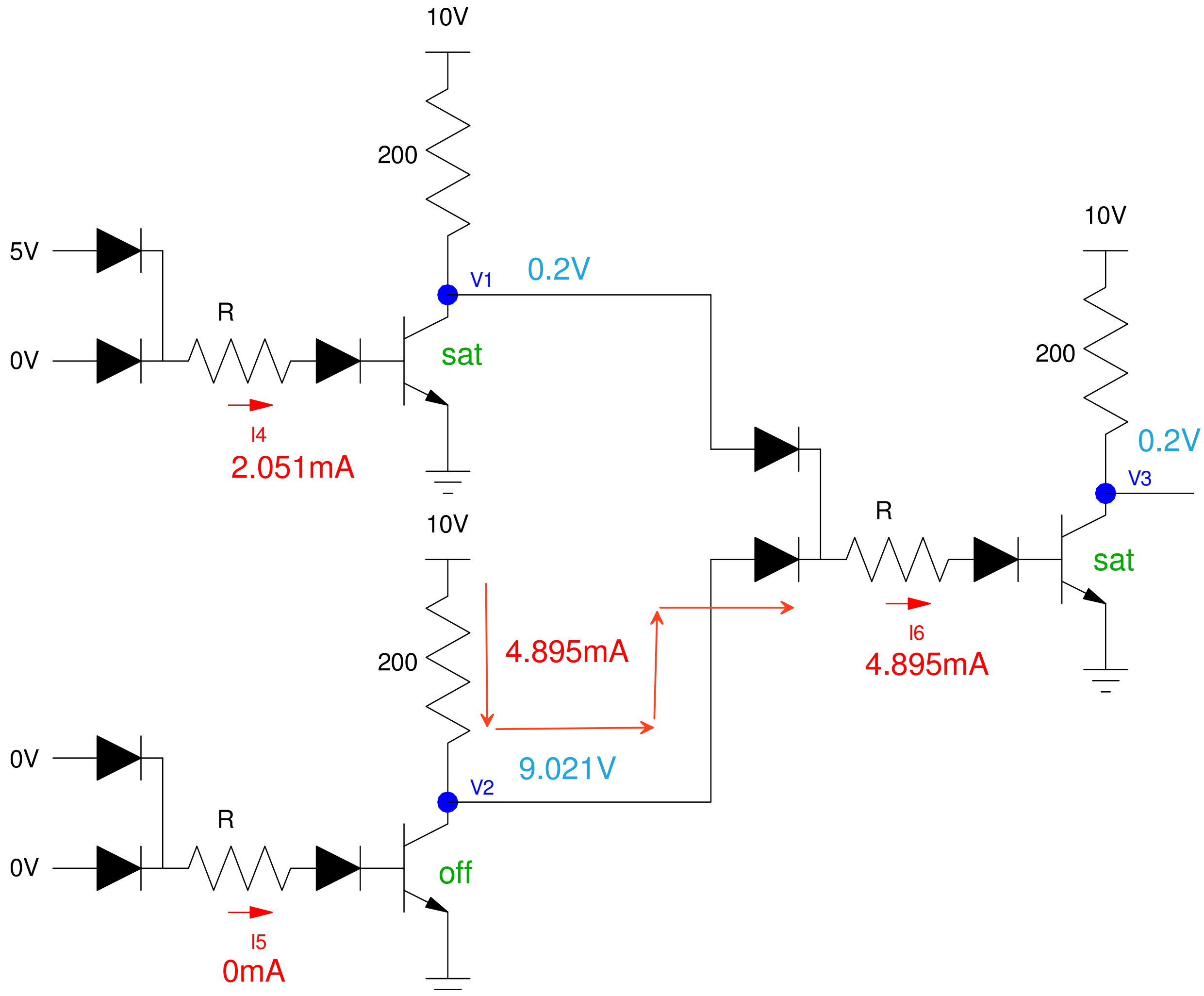
To saturate the transistor, Ib > 0.5mA. Let Ib = 4.3mA

Rb = 1000

8) DTL Logic: Determine the voltages and currents for the following DTL logic gage. Assume

- R = 900 + 100*(your birth month) + (birth day)
- Ideal silicon diodes (Vf = 0.7V), and
- Ideal 3904 transistors (Vbe = 0.7V, Vce(sat) = 0.2V, β=100)

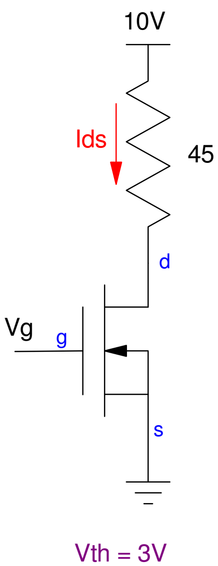
R 900 + 100*mo + da	V1	V2	V3	I4	I5	I6
1414	**0.2V** saturated	**9.021V** off	**0.2V** saturated	**2.051mA**	**0** off	**4.895mA**

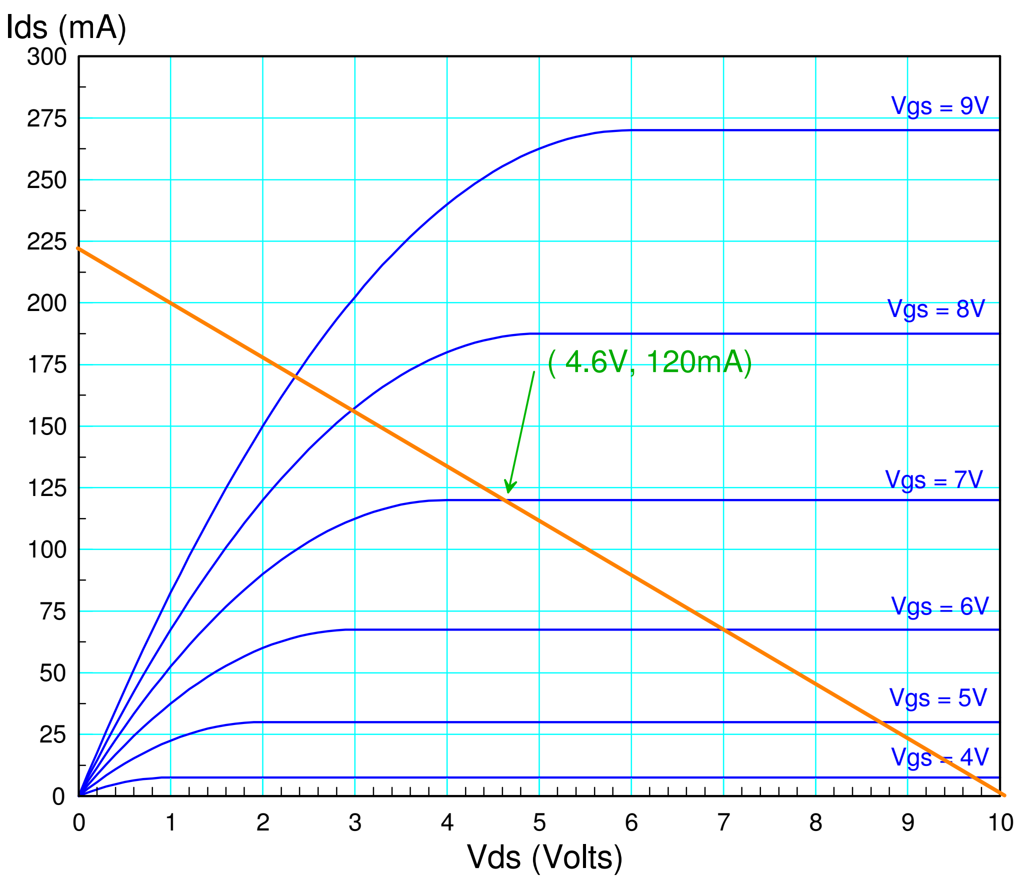


9) MOSFET Load Line: For the following MOSFET circuit

- Determine the transconductance gain, kn,
- Draw the load line (x and y intercept), and
- Determine {Vds, Ids} when Vg = 7V

kn transconductance gain	Load Line x=intercept	Load Line y intercept	Vds Vg = 7V	Ids Vg = 7V	Operating Region off / active / ohmic
0.015 A/V2	**10V**	**222.2 mA**	**4.6V**	**120mA**	**saturated**





$$270mA = \frac{k_n}{2}(9V - 3V)^2$$

$$k_n = 0.015\frac{A}{V^2}$$

10) CMOS Logic

a) Design a CMOS logic gate to implement Y=f(A,B,C,D)

AB \ CD	00	01	11	10
00	0	0	1	1
01	x	0	x	0
11	0	x	x	0
10	1	1	0	0

$$\overline{Y} = B + \overline{A}\,\overline{C} + AC$$