ECE 320 - Final pt 1 - Name ___________________

Semiconductors and Diodes. October 26, 2017

1a) What is the difference between n-type and p-type semiconductors?

n-type $e^- >> $ holes

p-type holes $>> e^-$

1b) For a semiconductor, does resistance go up or down as temperature goes up? Why?

R goes down.

As T↑, the number of thermal e^- & holes goes up. More charge carriers means less resistance.

1c) Why does current flow from p to n for a diode but not n to p?

p to n uses majority carriers (low R)

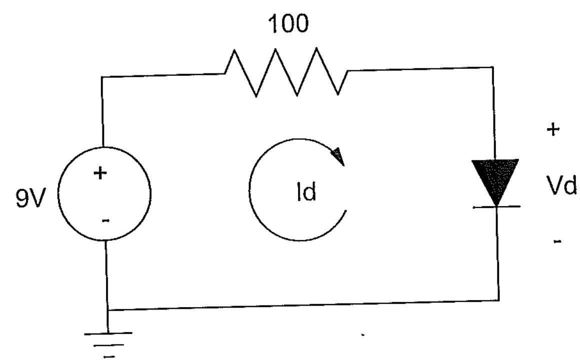
n to p uses minority carriers (high R)

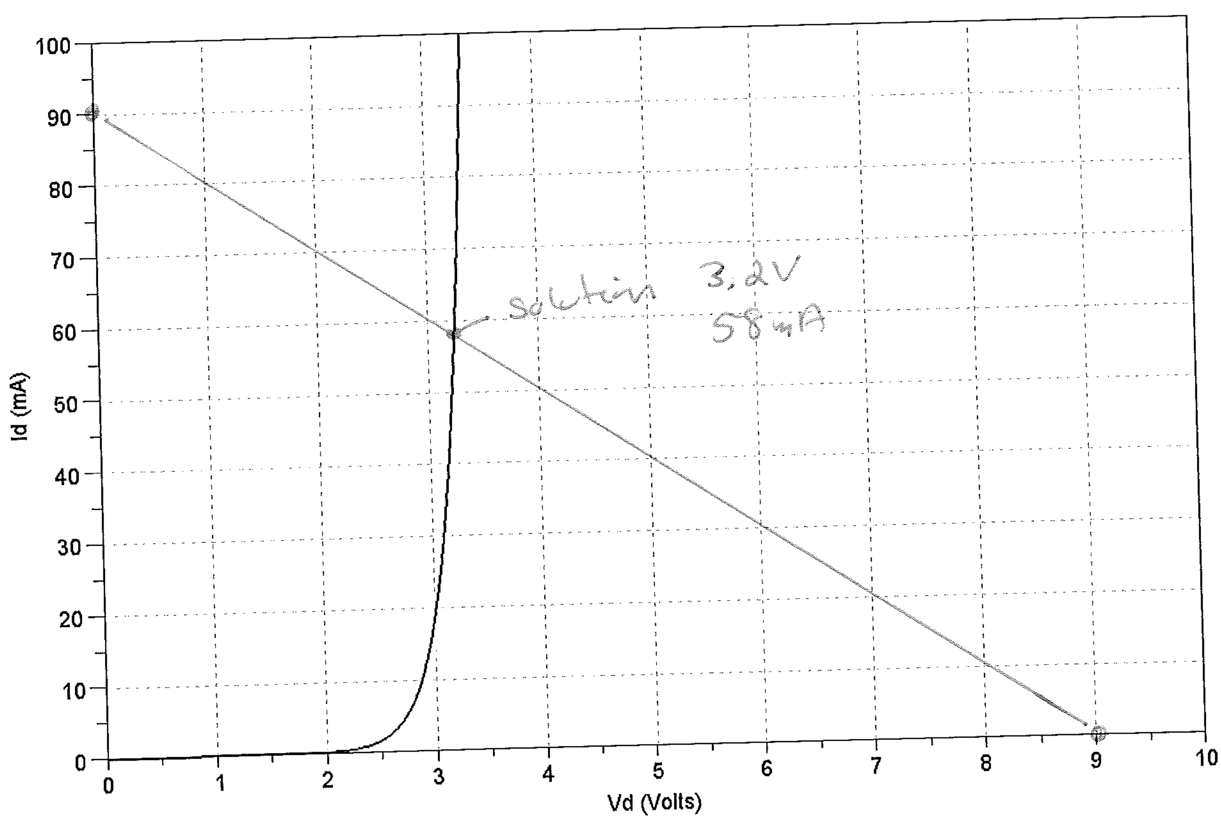
voltage p to n reduces the depletion zone to zero, allowing current flow

n to p makes the depletion zone bigger

2) Load-Line pn-junciton. The VI characteristics for a white LED is shown below. Draw the load line for the following circuit and determine Vc and Id

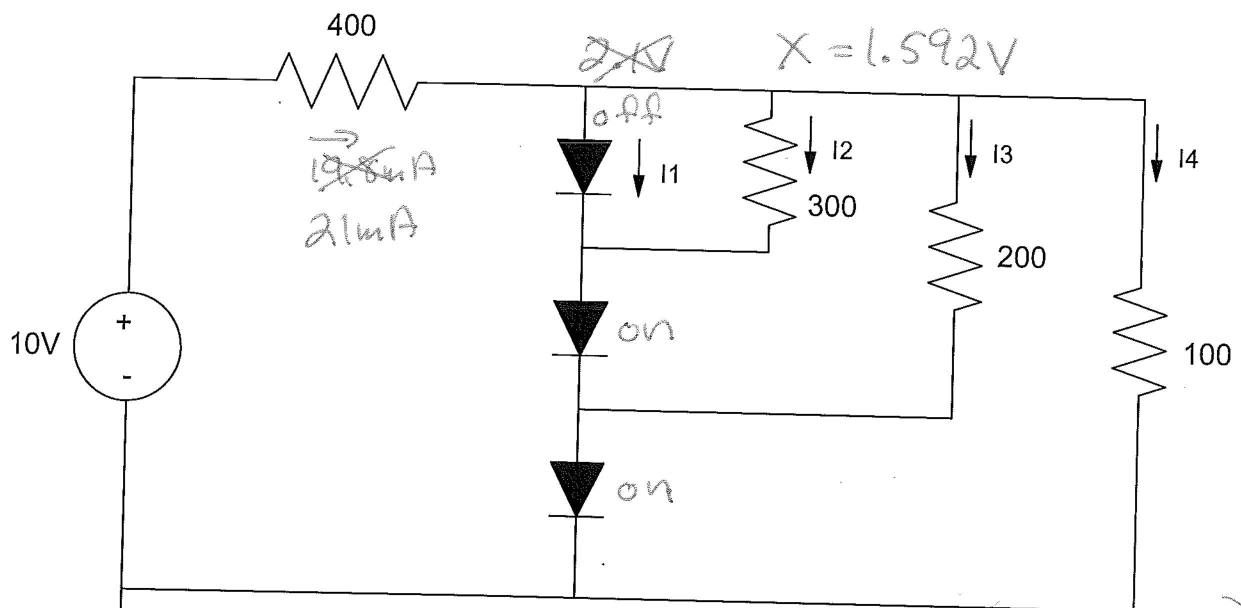
Load Line (Id vs Vd)	Vd	Id
show on graph	@ 3.2V	58mA





3) Assume ideal silicon diodes with Vf = 0.7V. Determine the currents I1 .. I4

I1	I2	I3	I4
0 mA	.6 mA	4.5 mA	15.9 mA



assume all on (doesn't work)

assume D2 is off

$$\frac{X-.7}{200} + \frac{X}{100} + \frac{X-10}{400} = 0$$

$$\left(\frac{1}{200} + \frac{1}{100} + \frac{1}{400}\right) X = \left(\frac{.7}{200} + \frac{10}{400}\right)$$

$X \approx 1.628V > 1.4V$

assume D2 is on

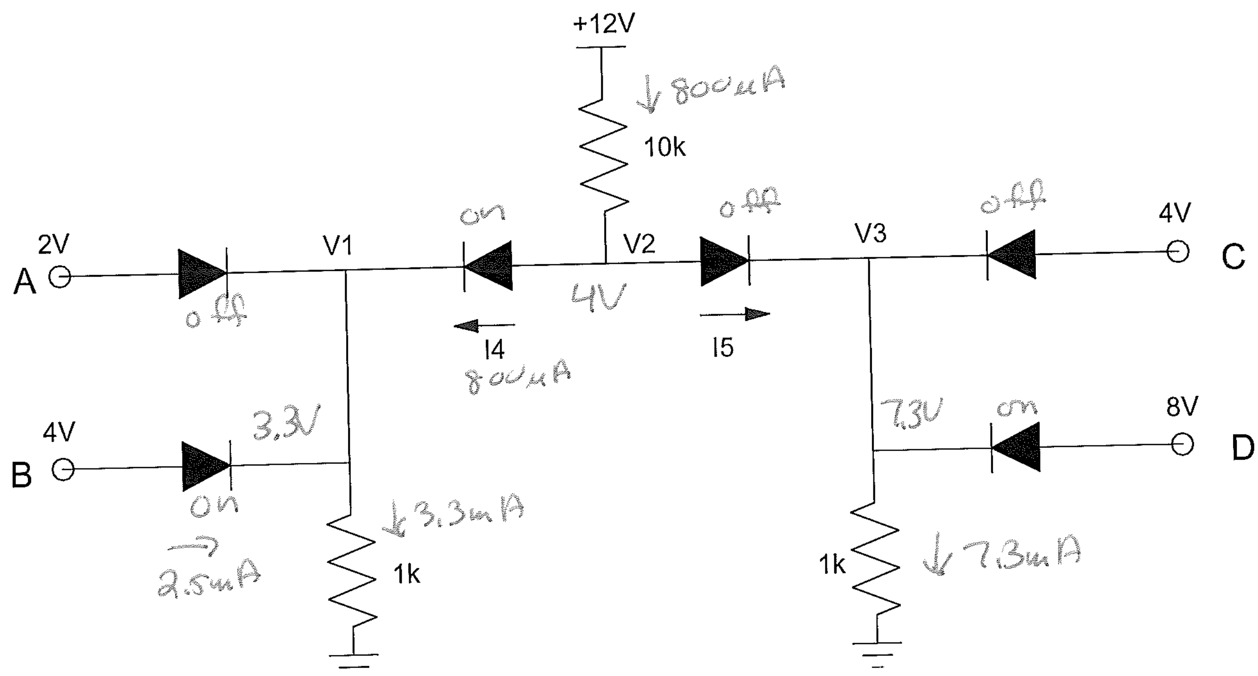
$$\frac{X}{100} + \frac{X-.7}{200} + \frac{X-1.4}{300} + \frac{X-10}{400} = 0$$

$$\left(\frac{1}{100} + \frac{1}{200} + \frac{1}{300} + \frac{1}{400}\right) X = \left(\frac{10}{400} + \frac{1.4}{300} + \frac{.7}{200}\right)$$

$X = 1.592V$

4) Assume ideal silicon diodes with Vf = 0.7V. Determine the voltages and currents for the following max / min circuit.

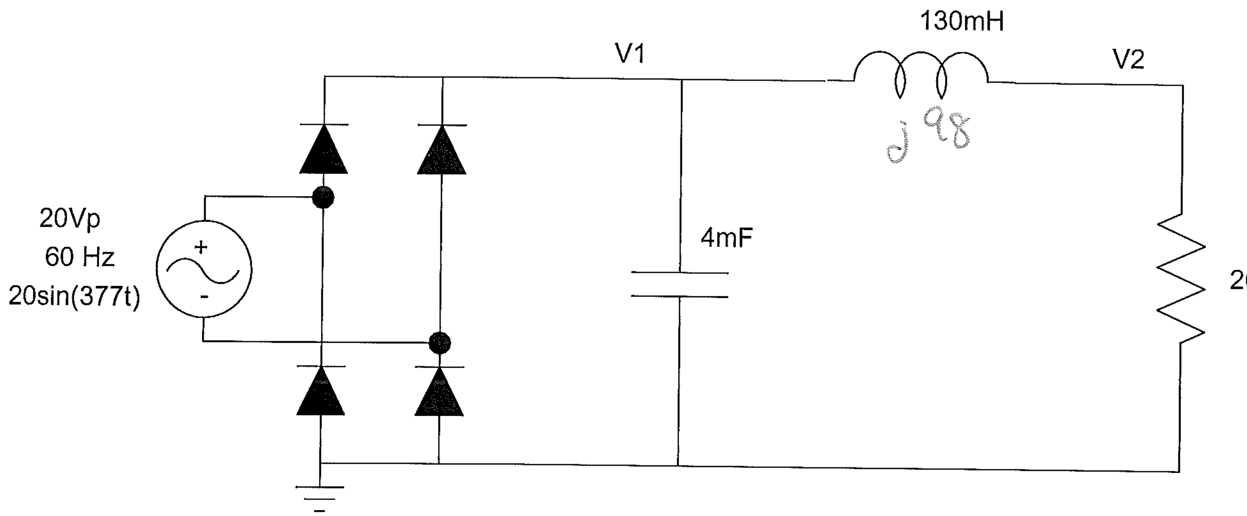
V1	V2	V3	I4	I5
3.3V	4V	7.3V	800uA	0



5. Determine the DC and AC voltages at V1 and V2 for the following AC to DC converter:

V1		V2	
max(V1)	V1pp (AC)	avg(V2) (DC)	V2pp (AC)
18.6V	1.938V_{pp}	17.6V	387mV_{pp}

← $18.6V - \frac{1}{2} V_{pp}$



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

$V_{2pp} = \left(\frac{20}{20 + j98}\right) V_{1pp}$

$I \approx \frac{18.6V}{20\Omega} = 930mA$

$= .387\angle -78^\circ$

$930mA = (4mF) \frac{dV}{1/120}$

$dV = 1.938 V_{pp}$

NREL

Bonus! The US Energy Information Administration (EIA) estimates the cost of producting electricity by source for the year 2022. Rank the sources from least expensive (1) to most expensive (5)

Clean Coal 30% Carbon Capture	Natural Gas	Nuclear	Solar	Wind
12¢–19¢	5¢–8¢	~~9¢–10¢~~	~~5¢–14¢~~	4¢–7¢
5	2	4	3	1

EIA 2022

6¢–15¢ (no co2)

~~15¢/kwh~~ | 9¢–13¢ | 6¢–25¢ | ~~4¢–8¢~~

~~10¢~~ | ~~6¢–14¢~~ | ~~3¢–6¢~~

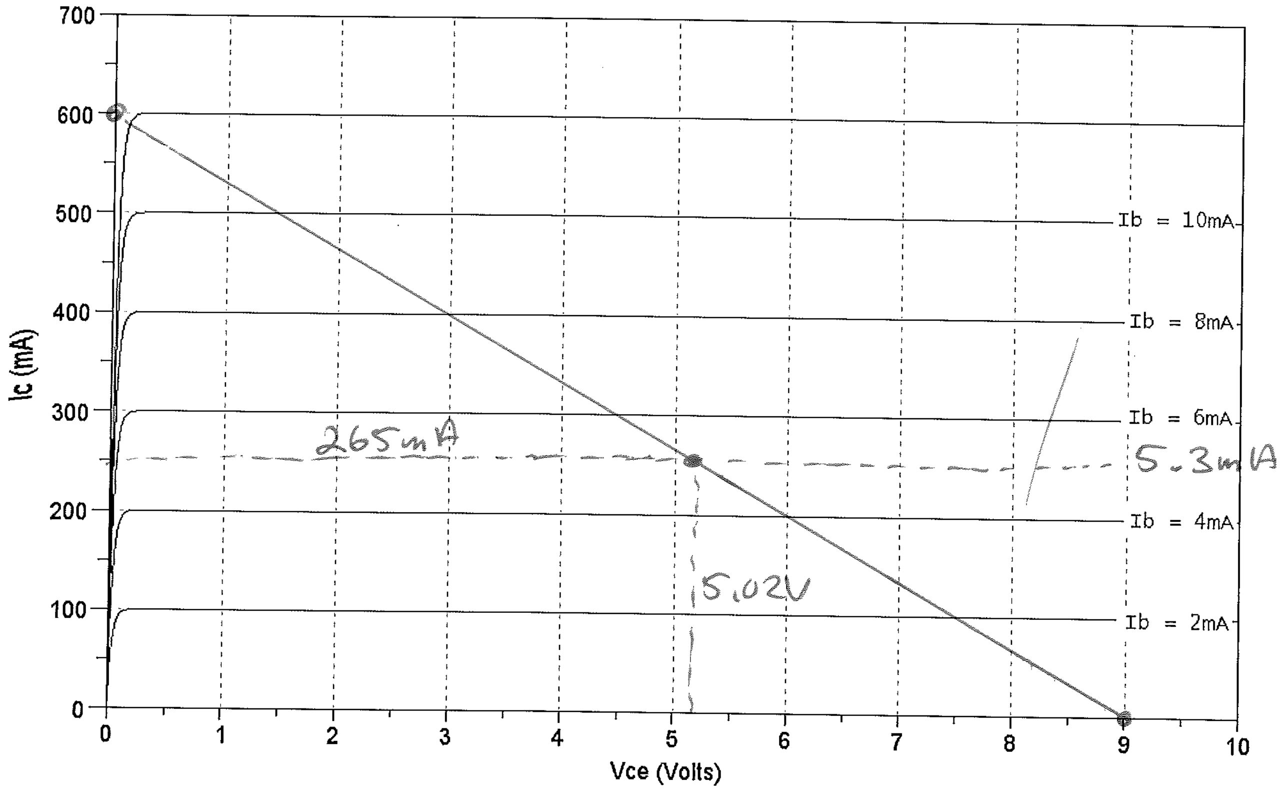
NREL Mar 2015: 14¢–19¢ | 5¢–8¢ | 4¢–8¢ NREL

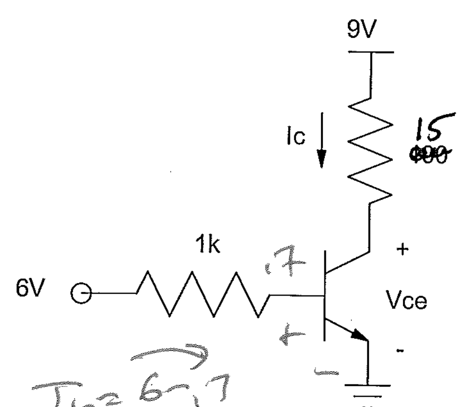
ECE 320 - Final pt 2 - Name ____________________

Transistors and Op-Amp Circuits. October 27, 2017

1) Transistor Load Line

Load Line	Current Gain Beta	~~Vd~~ Vce	~~Id~~ Ic
Show on Graph	50	5.02V	265mA





$I_b = \frac{6 - .7}{1k} = 5.3mA$

2) A transistor allows a 0V / 5V digital input to turn on and off a white LED at 100mA.

Input:

- 0V / 5V binary signal capable of 10mA

Output:

- 3W White LED. Vf = 3V @ 1A.

Relationship:

- When the input is 0V, 0mA flows through the LED
- When the input is 5V, 100mA flows through the LED.

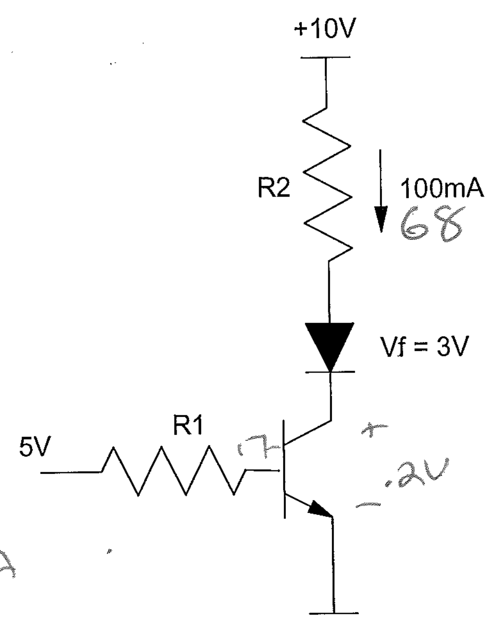
Find the allowable range of R1 and the required value for R2.

min value of R1	max value of R1	R2
4.3kΩ	430	68

⟵ swap

Assume a transistor with the following characteristics (3904)

- Vbe = 0.7V
- Vce(sat) = 0.2V
- β = 100



$I_b > 1mA$

$\frac{5 - .7}{1mA} = 4.3K$

maxR

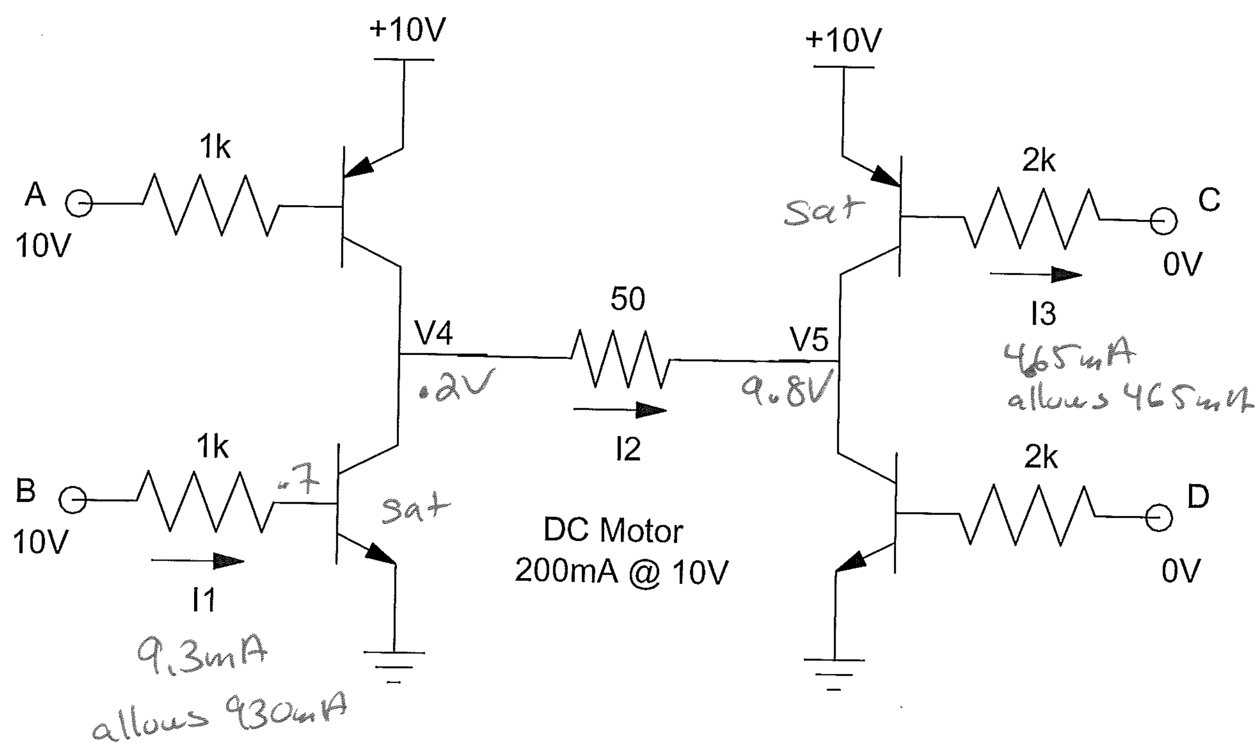
minR = 10mA

$\frac{5 - .7}{10mA} = 430$

3) The following H-bridge is to drive a DC motor which draws 200mA @ 10V (modeled as a 50 Ohm resistor). Determine the voltages and currents assuming ideal silicon transistors with:

- $|V_{ce(sat)}| = 0.2V$
- $|V_{be}| = 0.7V$
- $\beta = 100$

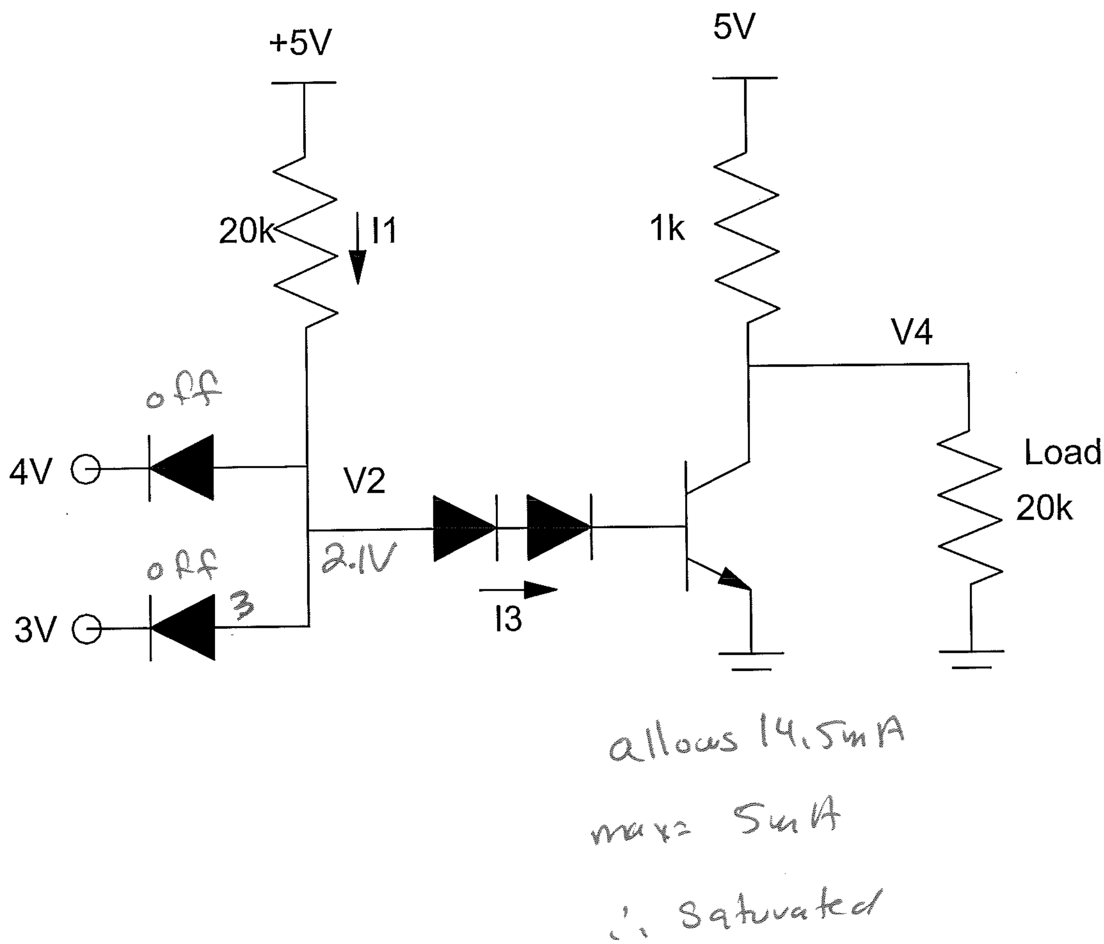
I1	I2	I3	V4	V5
9.3mA	-192mA	4.65mA	.2V	9.8V



4) Determine the voltages and currents for the following DTL NAND gate. Assume ideal silicon transistors with $\beta = 100$

I1	V2	I3	V4
145 µA	2.1V	145 µA	0.2V

Saturated

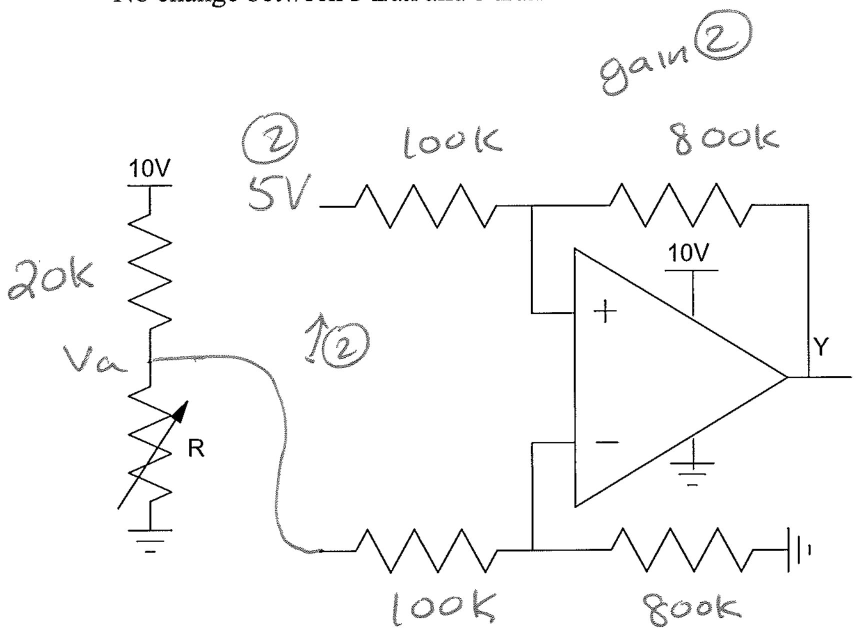


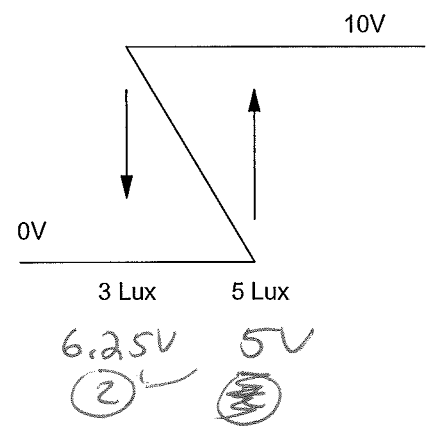
5) Schmitt Trigger: A light sensor has the following light - resistance relationship

$$R = \frac{100{,}000}{Lux}$$

Design a circuit which outputs

- 10V when the light level is more than 5 Lux
- 0V when the light level is less than 3 Lux
- No change between 3 Lux and 5 Lux





5 Lux = 20kΩ (2) 3Lux = 33.3kΩ

Va = 5V Va = 6.25V

$$gain = \frac{10V}{6.25-5} = 8$$

Bonus! Energy Return is how much energy you get from an inventment of one unit of energy. For example, coal has an energy return of 80: you get 80 kWh of energy for every 1kWh of energy you put into mining and burning coal. (Source: Wikipedia)

Match the energy source with its energy return: (1.3, 3.0, 5.0 18.0)

Coal	Corn Ethanol	Tar Sands	Shale Oil	Wind Energy
80	1.3	3.0	5.0	18.0