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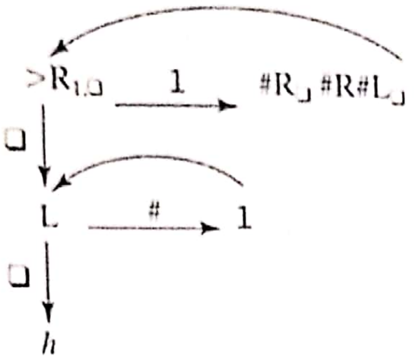
Name: Adam Stammer

CS 435 Exam #3
November 20, 2019

1. [10 points] Consider the following Turing Machine M:



What is the result of running M on the following inputs (i.e., what will the tape look like when M halts if the input is initially the only thing on the tape)?

(a) ab

(b) aab

2. [10 points] Consider the following unrestricted grammar:

1 $Sa \to aT$
2 $Sb \to bT$
3 $Ta \to S$
4 $Tb \to S$
5 $SS \to \epsilon$
6 $TS \to \epsilon$

What is computed by this grammar on the input abba (i.e.,, what is produced on input Sabba$S$)?

1→ aTbbaS
4→ aSbaS
2→ abTaS
3→ abSS
5→ ab

ab

✓

3. [16 points] Construct a Turing Machine that takes as input a string a^n and computes the string $a^n b^{2n}$.

$\square a\, a\, a \square$

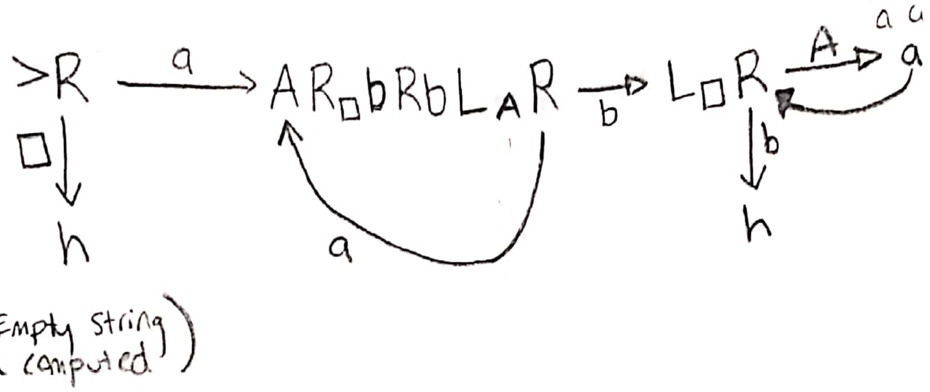
A a a b b

A A a b b b b

A A A b b b b b b

a a a b b b b b b

$a^n \rightarrow a^n b^{2n}$



✓

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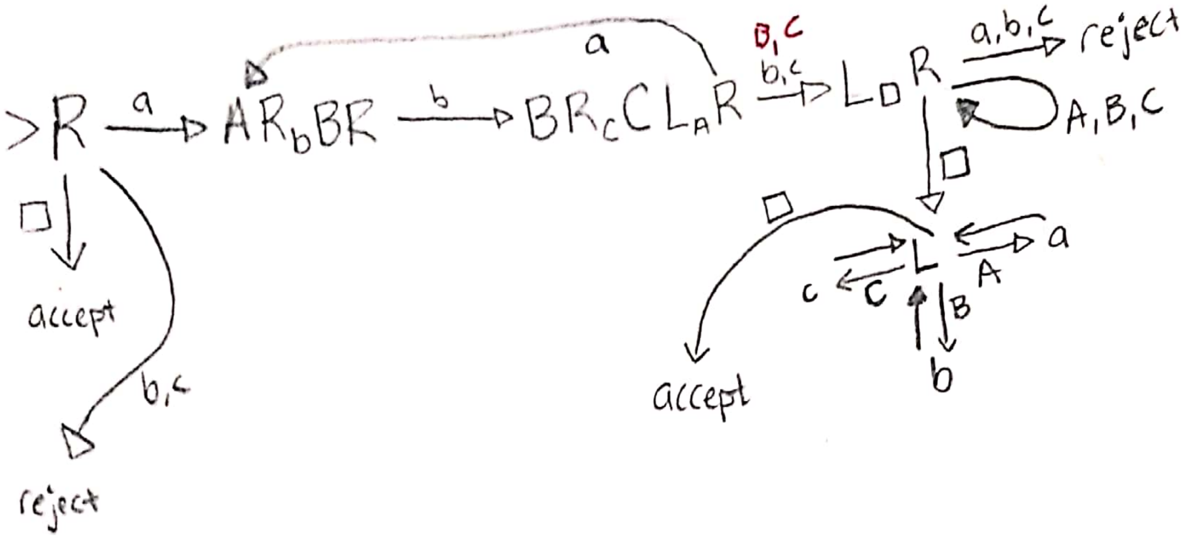
4. [16 points] Construct a Turing Machine that accepts $L = \{a^n b^{2n} c^n : n \geq 0\}$.



1 → Convert a → A, b → B, and c → C only in ABBC units
(if there are too many or not enough of any letter,
there will remain lowercase letters in the string)

2 → when out of a's to convert, make sure the string has only uppercase
letters in it

3 → convert back and accept

-1

5. [16 points] Write an unrestricted grammar for the language $L = \{a^n b^{2n} c^n : n \geq 0\}$.

$S \to \cancel{aBc}$ ε

$S \to aBSc$

) build a's and c's with b placeholder

$Ba \to aB$) push B place holder to the center

$Bc \to bbc$

$Bb \to bbb$

) replace b placeholders with actual b's

OK

6. [16 points] Consider the language $L = \{1x\#x^R0 : \text{ where } x \in \{0,1\}^*\}$. Note that the strings of this language start with 1 and end with 0, and the bits between the leading 1 and the # are the reverse of the bits between the # and the trailing 0. For example, $1\#0 \in L$ and $10110101\#10101100 \in L$, but $11011\#10110 \notin L$ and $1110\#000110 \notin L$. State whether L is regular, context-free but not regular, or not context-free. Prove your answer.

Context free but not regular

$\underbrace{1}_{1}\underbrace{1^k}_{2}\underbrace{\#}_{3}\underbrace{1^k}_{4}\underbrace{0}_{5}$ where $k \geq 1$ would be an accepted string.

$|xy| \leq k$ so y is either in region 1, 2, or overlapped

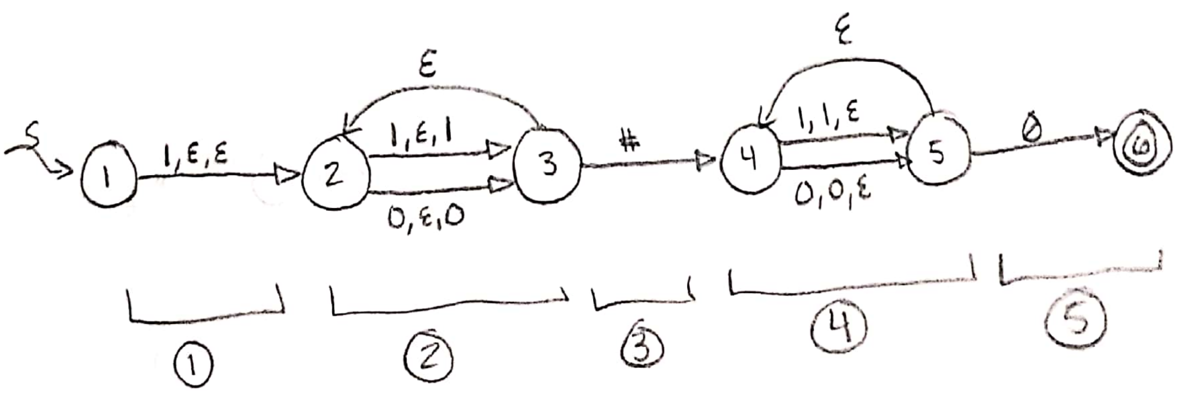
to simplify this we can rewrite the string as $\underbrace{1^{k+1}}_{1}\underbrace{\#}_{2}\underbrace{1^k}_{3}\underbrace{0}_{4}$

where y must fall within region 1

$1^{k+1+p}\#1^k0$ where $k \geq p \geq 1$

pump up once shows $1^{k+2}\#1^k0$ which is no longer an accepted string, thus L is not regular.

A PDA will prove it context free



✓

7. [16 points] Consider the language $L = \{x\#y :$ where $x \in \{0,1\}^*$ is the 1s complement of $y \in \{0,1\}^*\}$. Note that the 1s complement of a binary number is the number with all of its bits flipped. So, the 1s complement of 10110 is 01001. Thus, $10110\#01001 \in L$. State whether L is regular, context-free but not regular, or not context-free. Prove your answer.

Context free but not regular

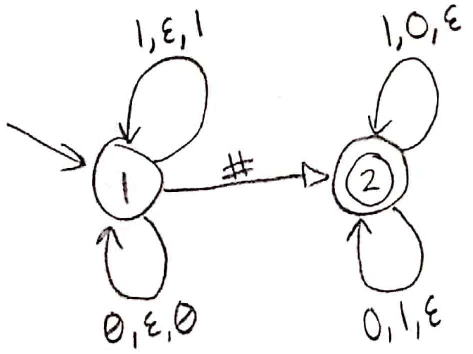
The PDA below shows context freedom

$\underset{①}{0^k}\ \underset{②}{\#}\ \underset{③}{1^k}$ $k \geq 1$ would be an accepted String (all zeros is the 1's comp. of all ones)

$|xy| \leq k$ so y must fall in region ①

$0^{k+p} \# 1^k$ $k \geq p \geq 1$

So pump up once $0^{k+1} \# 1^k$ is not accepted because region ① is no longer the 1's comp of region ②.



not context-free

−8

10/10

Theory of Comp. Adam Stammer
Ch 23 # 1d, 2a

1d) Write an unrestricted grammar for $L = \{a^n b^{2n} c^{3n} : n \geq 1\}$

$S \rightarrow aZccc$
$S \rightarrow aZSccc$] build a's and c's

$Za \rightarrow aZ$] push place holders Z's to the center

$Zc \rightarrow bbc$
$Zb \rightarrow bbb$] convert Z's to b's

✓

Could've put 2 place holder Z's here and then only converted to single b's here

2a) Show grammar to compute as follows
$f(a,b)^+ \rightarrow \{a,b\}^+$ where $f(s = a_1 a_2 a_3 \ldots a_{|s|}) = a_2 a_3 a_4 \ldots a_{|s|} a_1$

So, shift the string left with wrap around,
or push the first character all the way to the end

✓

$Sa \rightarrow A$
$Sb \rightarrow B$] make first character placeholders

$Aa \rightarrow aA$
$Ab \rightarrow bA$
$Ba \rightarrow aB$
$Bb \rightarrow bB$] push placeholder to the right

$AS \rightarrow a$
$BS \rightarrow b$] convert placeholder back and terminate string (only possible at the right end of the string)

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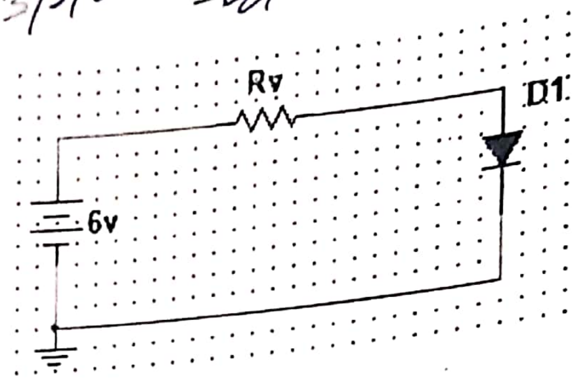
NATHAN

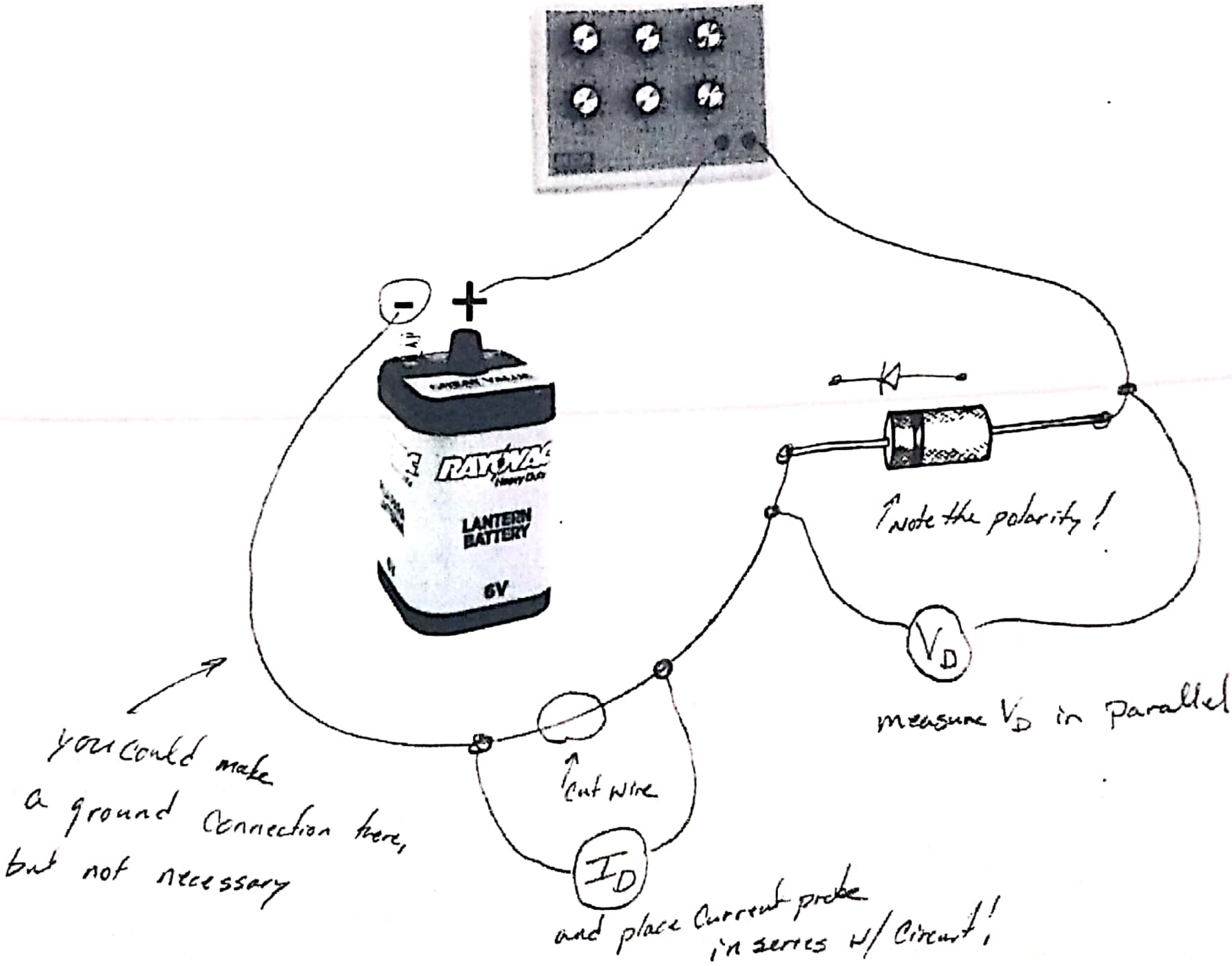
Exam 2, Electronics

possible
6/4/8 4/3/3/8

Suppose you want to create a circuit that will allow you to perform the load-line analysis of a diode with no part number. Rv is a variable resistor box like the ones we have in lab.



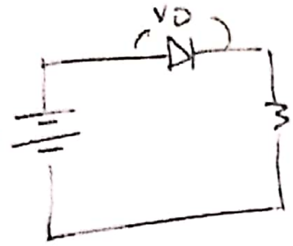
1. (2 points) Draw in wire connections for components to create the circuit at right.
2. (4 points) If you wanted to measure the voltage across the diode, V_D, and the diode current, I_D, draw in those current (I_D) and voltage (V_D) meters.



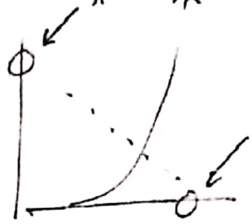
$R_L = 50\Omega$
$V_{SS} = 6V$ (from prev. page)

By varying the Load Resistance, R

3. (4 points) You go ahead with the measurement from the previous page and collect the data shown in the graph on this page. Based on the graph (shown at two levels of zoom), what is the operating point of the diode?

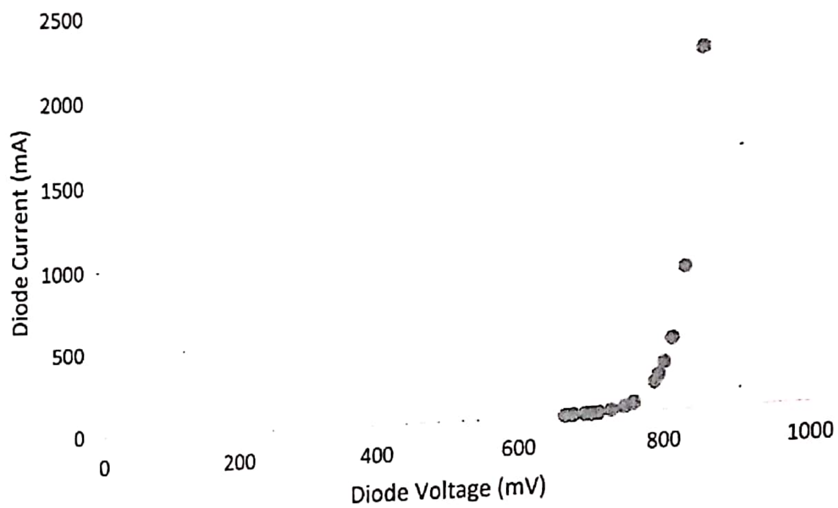


$i = V_{SS}/R$ b/c $V_D = 0$



$i = 0$ point,
$V_D = V_{SS}$

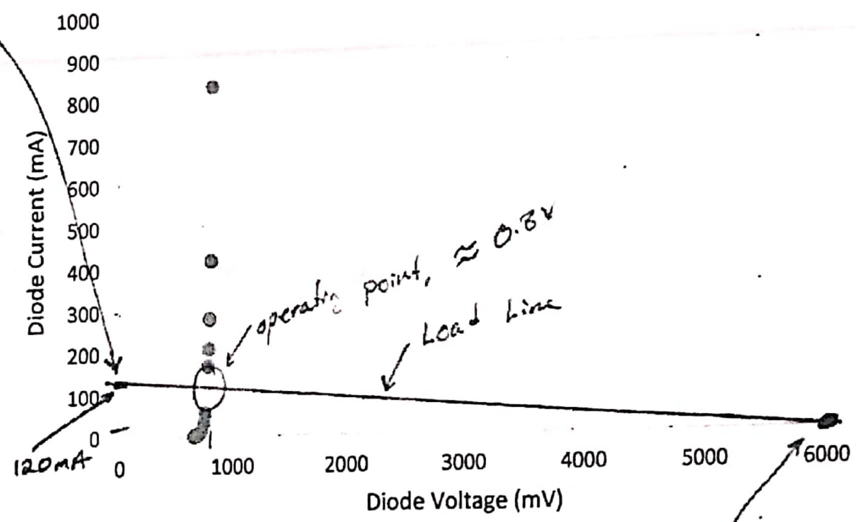
$V_{SS} = V_D + V_R$
$V_{SS} = V_D + IR$
if $I = 0$, $V_S = V_D = 6V$
if $V_D \to 0$
$V_{SS} = IR$
$I = V_{SS}/R$



$V_{SS} = 6$ volts

$I = \frac{V_{SS}}{R} = \frac{6V}{50\Omega} = 0.12A = 120mA$

via graph, assumed operating point is $V_D \approx 0.8$ volts

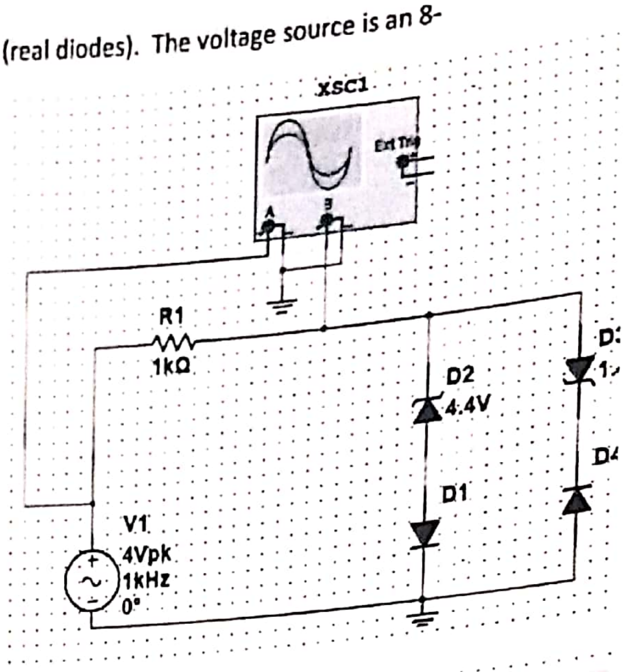


$V_D = V_{SS}$

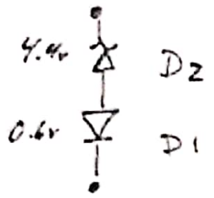
4. Imagine that you're given the following circuit in lab (real diodes). The voltage source is an 8-volt (peak to peak) sine wave a 1kHz.

   a. (4 points) Explain how the circuit modifies the signal and sketch what you would see on the oscilloscope (trace A is shown).

   b. (4 points) If we wired a current probe in series with the resistor, what current would it show over time? Explain your thinking and make another sketch.



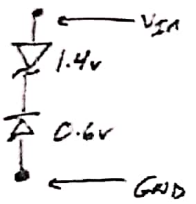
(a) When do the two diode branches turn on?



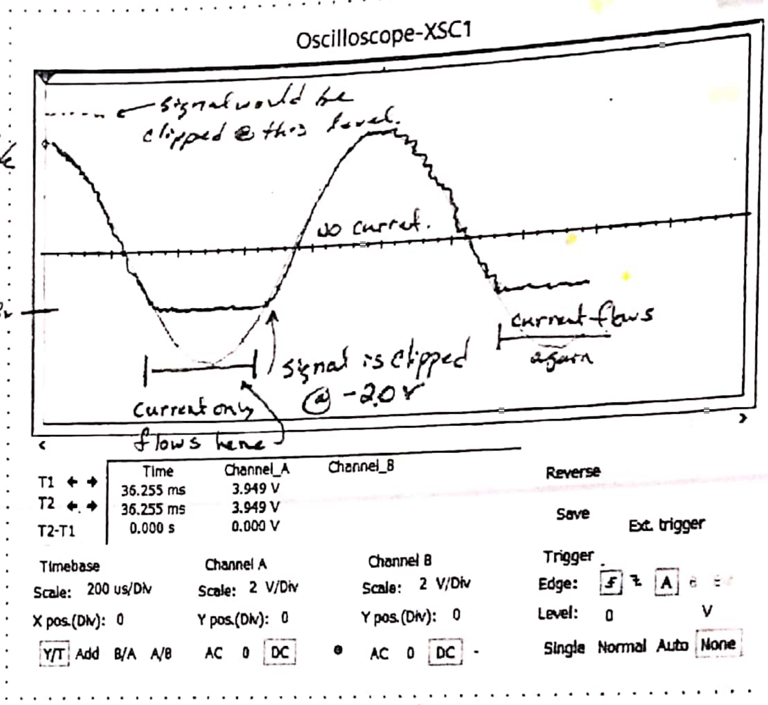
turns on when $V_{IN} \geq 5v$

THIS NEVER HAPPENS!

Branch is only active for higher amplitude inputs.



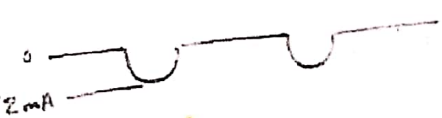
This branch is on only when $V_{IN} \leq -2.0v$



(b) Current flows only when Zener is active, this is when signal is clipped, $V_{in} \leq -2.0v$

this would be a leftword current through R

so current like



zener voltage

$V_R = -4v \cdot \sin \omega t + 2v$

~~[...]~~

$[-4, -2]v$

somewhere in this range

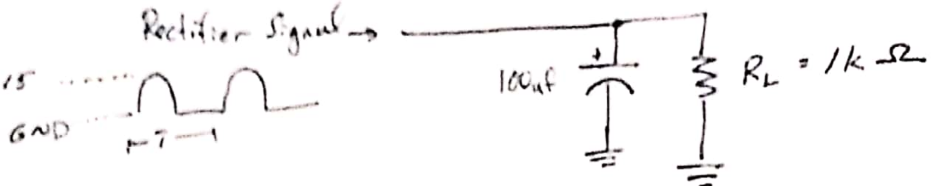
so $V_R = [-2, 0]$ volts

Then, $V = IR$ so

$I = \frac{[-2, 0] \text{ volts}}{1k\Omega} \approx [2 - 0] mA$

this current flows only when $V_{in} \leq -2v$

5. (4 points) Imagine you have a 100uf capacitor that you're planning to use to smooth out the signal from a half-wave rectifier. The load has an implicit resistance of 1K Ohm. If the output from the rectifier is the positive half of a sine wave, running at 60Hz, with an amplitude of 15v, what ripple voltage can we expect to see across the load?



What governs Ripple Voltages?

Charge that flows from Capacitor is → $\Delta V \cdot C = \Delta Q$ (1)

↑ Ripple Voltage

Current/Charge flows through load is

$I \cdot \Delta t = \Delta Q$

Don't KNOW this, but

Resistor (Load), $R = 1k\Omega$

Resistor Voltage is $V_m = 15v$

or, if you like, typical voltage is

$\left(V_m - \frac{V_R}{2}\right)$

so Charge that flows across Load is

$\Delta Q = I \cdot \Delta t = \left(\frac{V}{R}\right) \cdot \Delta t$ (2)

$= \frac{V_m}{R} \cdot \Delta t$ or $\frac{\left(V_m - \frac{V_R}{2}\right)}{R} \cdot \Delta t$ ↙ probably more correct.

$\Delta Q = \Delta Q$ so 1+2 give

$V_R \cdot C = \left(\frac{V_m - V_R/2}{R}\right) \cdot \Delta t$

$V_R = \frac{V_m \cdot \Delta T}{RC}$ (ignoring)

and then

$V_R = \frac{15v \cdot 1/60 \text{ sec}}{1k\Omega \cdot 100\mu F}$

$= \underline{2.5 \text{ volts}}$?

More precise answer

$\frac{V_R \cdot C}{\Delta t} = \frac{V_m}{R} - \frac{V_R}{2R}$

$V_R \cdot \frac{RC}{\Delta t} = V_m - V_R/2$

$V_m = V_R\left(\frac{RC}{\Delta t} + \frac{1}{2}\right)$

$V_R = V_m \Big/ \left(\frac{RC}{\Delta t} + \frac{1}{2}\right)$

$V_R = 15v \Big/ \left(\frac{1k \cdot 100u}{1/60} + \frac{1}{2}\right)$

$= 15v \Big/ \left(60 \cdot (.1) + \frac{1}{2}\right)$

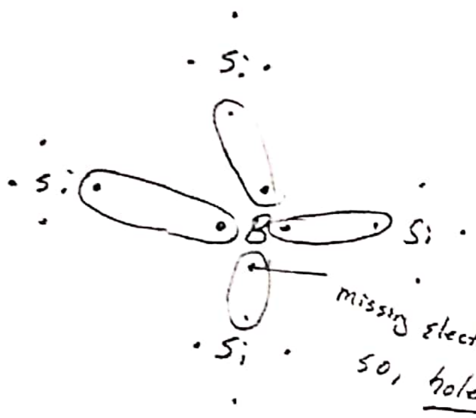
$= 15v \Big/ (6.5)$

$= 2.3v$

↑ probably closer to actual Ripple.

7. (3 points) If a spec sheet says that a device is made with silicon, doped with boron, is the material n-type or p-type? Draw a picture to illustrate your answer.

	5 B	6 C	7 N	8 O
	13 Al	14 Si	15 P	16 S
30 Zn	31 Ga	32 Ge	33 As	34 Se
48 Cd	49 In	50 Sn	51 Sb	52 Te
80 Hg	81 Tl	82 Pb	83 Bi	84 Po
112 Cn	113 Uut	114 Fl	115 Uup	116 Lv



missing electron!

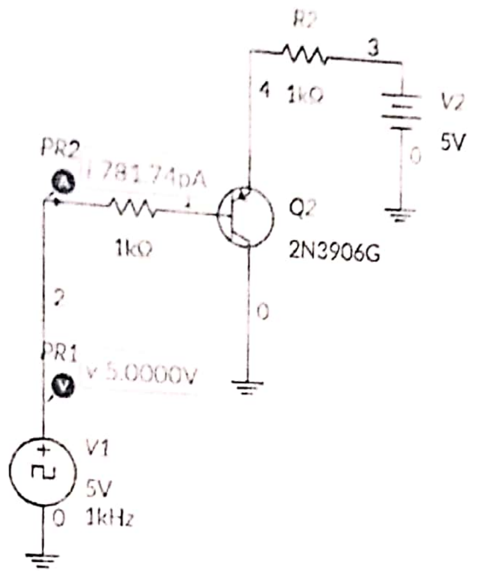
so, hole

this then is p-type

b/c it has extra positive charge

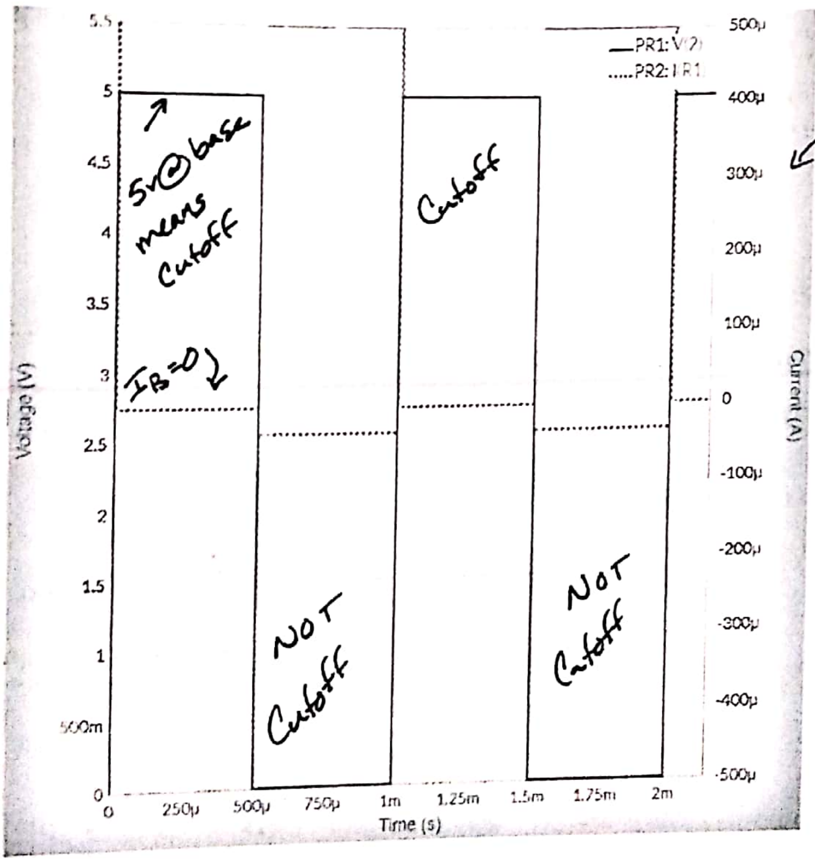
8. Here is a $\boxed{\text{PNP}}$ transistor circuit, using a 2N3906 transistor. A 0-5v square wave pulse drives the transistors' base. Let's assume that $\beta \approx 125$ for this transistor. Note that the scope shows both the base current (blue line) and the voltage from the square-wave source (green line).

(3 points) Based on the Oscilloscope trace, when (in terms of both voltage and time) is the transistor in the cutoff state? Explain your thinking.



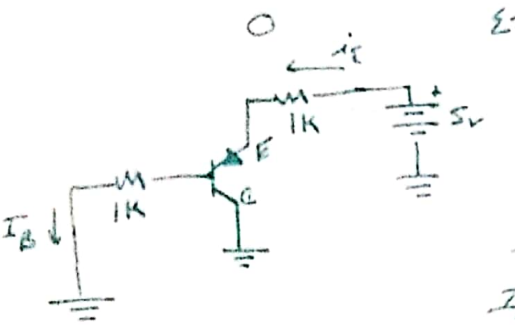
PNP transistor is in cutoff when ground is available to the base. this happens from ~~[illegible]~~ in 0-500μs trace.

Note this is also when the base current is zero!



9. (4 points) When the transistor on the previous page is on (ie, when it allows emitter to collector current flow), is it in the saturation or active state? Explain your thinking – this will probably involve a voltage loop or two.

Base: on when grounded so, circ diagram below.



E-C Loop: $5v - i_E \cdot 1K - V_{EC} = 0$

E-B Loop: $5v - i_E \cdot 1k - \underset{0.7v}{V_{EB}} - I_B \cdot 1k = 0$

$\cancel{I_C = I_B + I_E}$

$I_B + I_C = I_E$

$I_B + \beta I_B = I_E$

$I_B(1+\beta) = I_E$

$4.3v = 1K(I_E + I_B)$

$= 1k(I_B(1+\beta) + I_B)$

$4.3v = 1k \cdot I_B(\beta+2)$

and

$I_E = \frac{5v - V_{EC}}{1K}$

10. (4 points) When the transistor is on, what collector current do you expect to see, and what voltage drop do you expect to appear across resistor R2?

or $I_B = \frac{5v - V_{EC}}{1k(1+\beta)}$

so then

$4.3v = 1k(\beta+2) \cdot \frac{(5v - V_{EC})}{1K(1+\beta)}$

So

$5v - V_{EC} \simeq \cancel{5v - V_{EC}}$ $4.3v$

so $V_{EC} \simeq 0.7v$?

then

$I_E = \frac{5v - 0.7v}{1K}$

$I_E \simeq 4.3mA$

and

then

$I_B = \frac{I_E}{1+\beta}$ 125

$I_B \simeq 34\mu A$

This is Reasonable for Active state.

and $I_C \simeq I_E - I_B$

$\boxed{I_C \simeq 4.27mA}$

and

$V_{R2} = I_E \cdot 1k$

$= 4.3mA \cdot 1k$

$V_{R2} \simeq 4.3v$

again consistent w/ being in Active Region.