4190.309A: Electrical and Electronic Circuits
Exam #1
October 11th, 2018
Professor Jae W. Lee

Student ID #: ____________________

Name: ____________________

This is a closed book, closed notes exam.
75 Minutes
12 Pages

Total Score: 200 points

Notes:
- Please turn off all of your electronic devices (phones, tablets, notebooks, netbooks, and so on). A clock is available on the lecture screen.
- Please stay in the classroom until the end of the examination.

- You must not discuss the exam's contents with other students during the exam.
- You must not use any notes on papers, electronic devices, desks, or part of your body.

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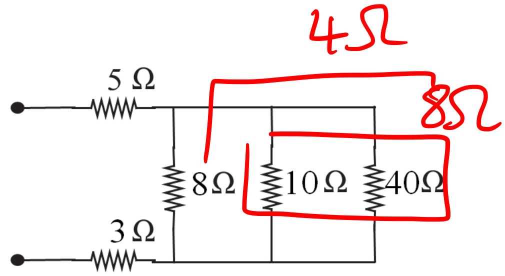
Part A: Resistive Networks (28 points)

Question 1 (28 points)

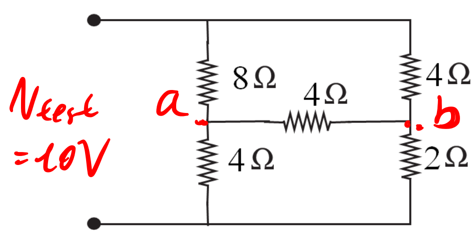
Find the equivalent resistance between the two indicated terminals.

(1)



$\therefore 5+4+3 = 12\Omega$

(2)



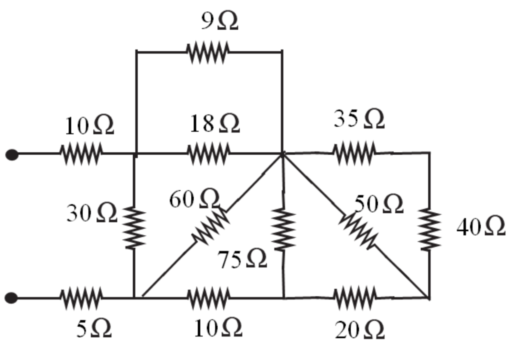
$$\begin{cases} \dfrac{10-a}{8} = \dfrac{a-b}{4} + \dfrac{a}{4} \\ \dfrac{10-b}{4} = \dfrac{b-a}{4} + \dfrac{b}{2} \end{cases} \Rightarrow \begin{cases} 5a-2b=10 \\ -a+4b=10 \end{cases}$$

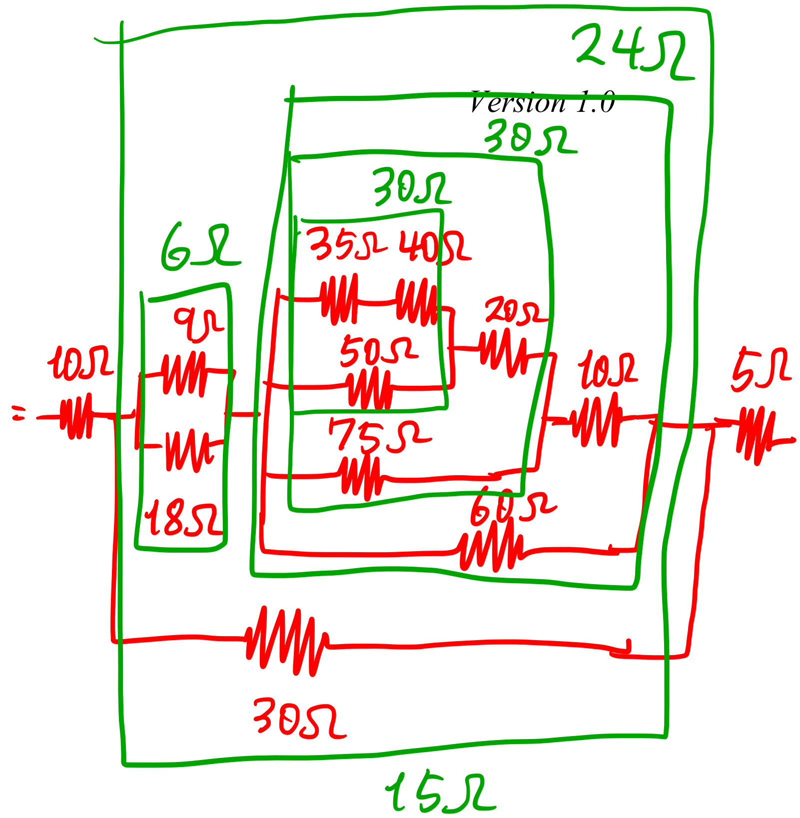
$\therefore a=b=\frac{10}{3}$

$\Rightarrow$ a-b 사이 4Ω X.

$\therefore 12\Omega // 6\Omega = 4\Omega$

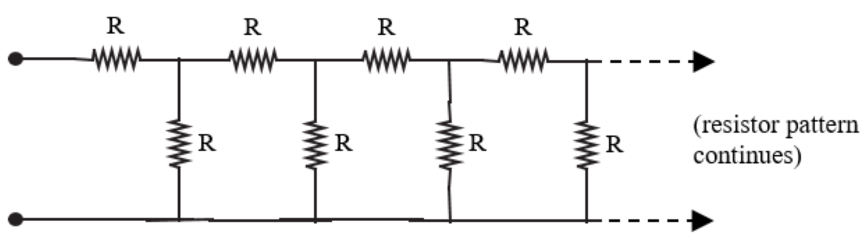
(3)





$\therefore 10+15+5=30\Omega$

(4)



$R_{eq} = R + R /\!/ R_{eq}$

$\Rightarrow R_{eq} = R + \dfrac{R \cdot R_{eq}}{R + R_{eq}}$

$\Rightarrow R_{eq}^2 - R \cdot R_{eq} - R^2$

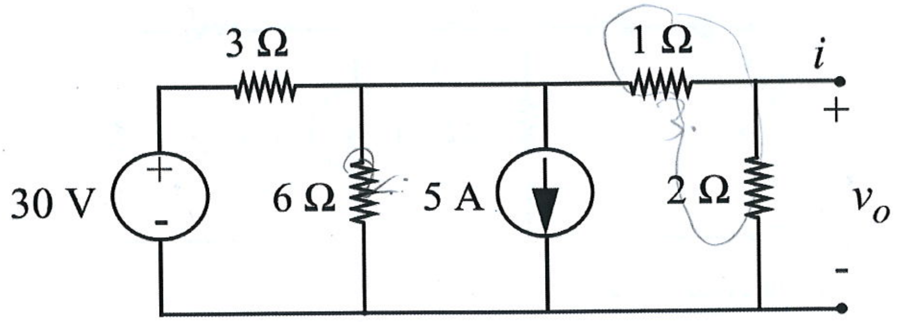
$\therefore R_{eq} = \dfrac{1+\sqrt{5}}{2} R$

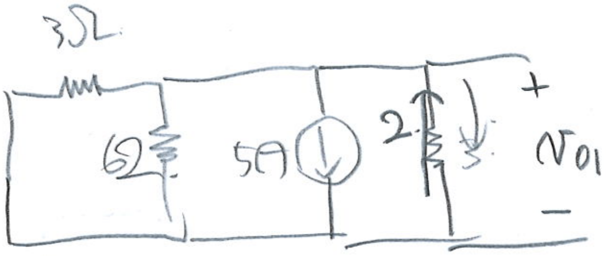
Part B: Network Theorems (70 points)

Question 2 (20 points)

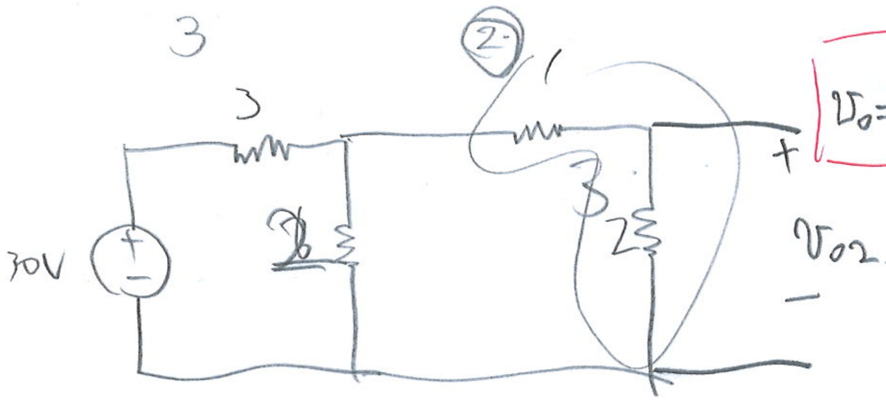
In the figure below, find v_o using your favorite method.

4V





$v_{01} = -4V$



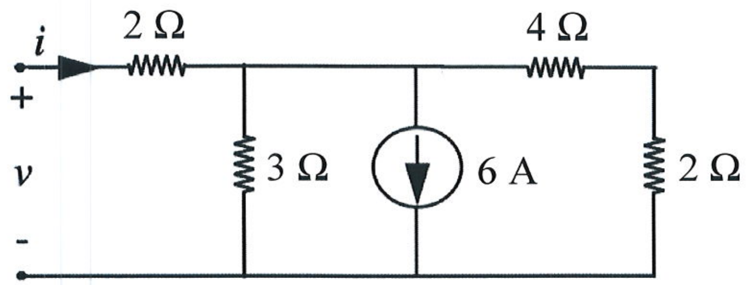
$\boxed{v_o = v_{01} + v_{02} = 8V - 4V = 4V}$

$$v_{02} = 30 \times \frac{2}{5} \times \frac{2}{3} = 8V$$

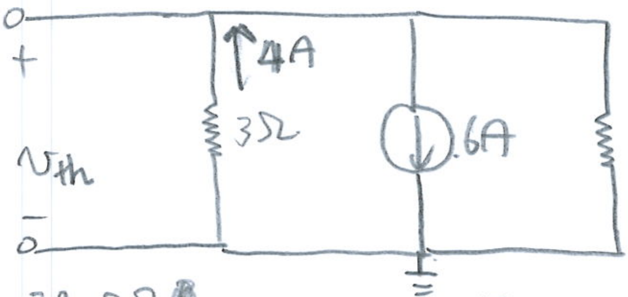
Part C: Thévenin's and Norton's Theorem (XX points)

Question 3 (XX points)

Draw the Thévenin (1) and Norton (2) equivalent circuit of the circuit below.

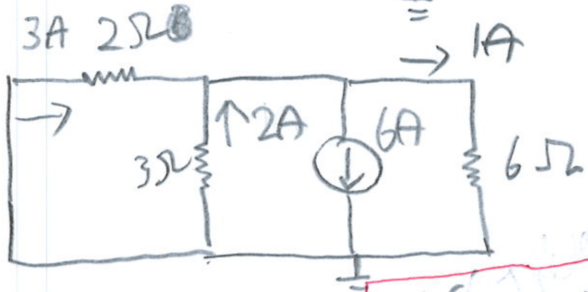


(1) (open)



$V_{th} = 12V$.

(short)

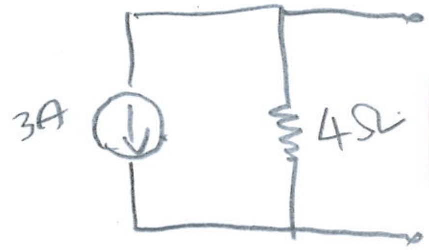


$\therefore R_{th} = \frac{12}{3} = 4$

(2)

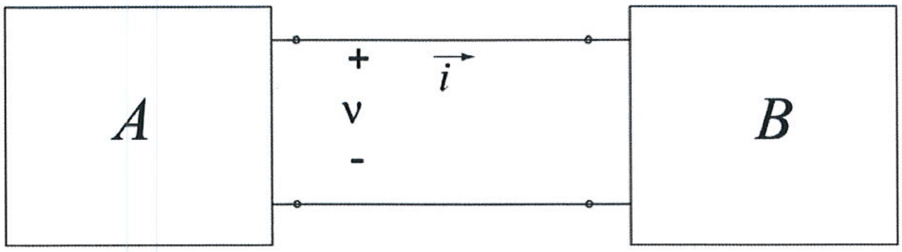
<Thévenin>

<Norton>

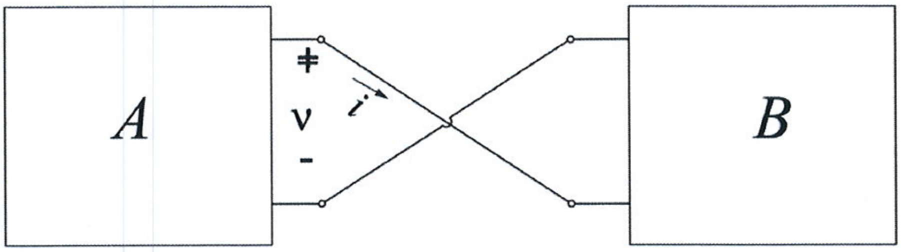


Question 4 (XX points)

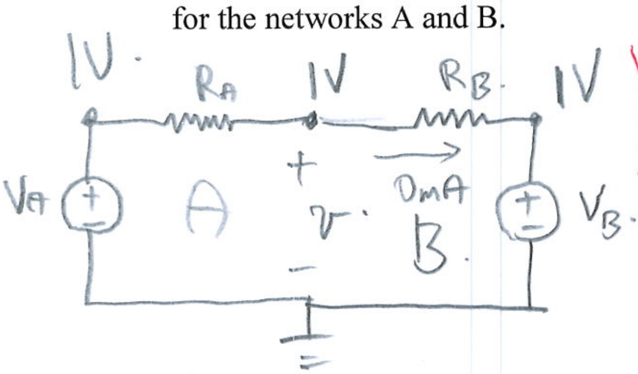
Two networks A and B composed only of resistors and sources are connected together as shown below,



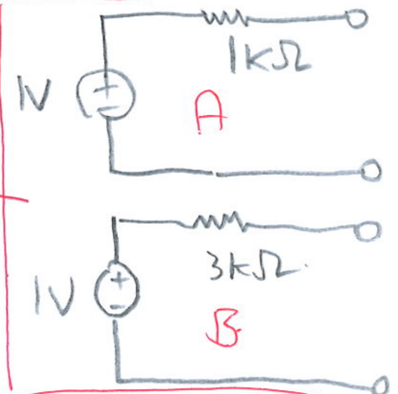
And the voltage and current indicated are found to be $v = 1\ V$, $i = 0\ mA$. When the connection is reversed, as shown below,

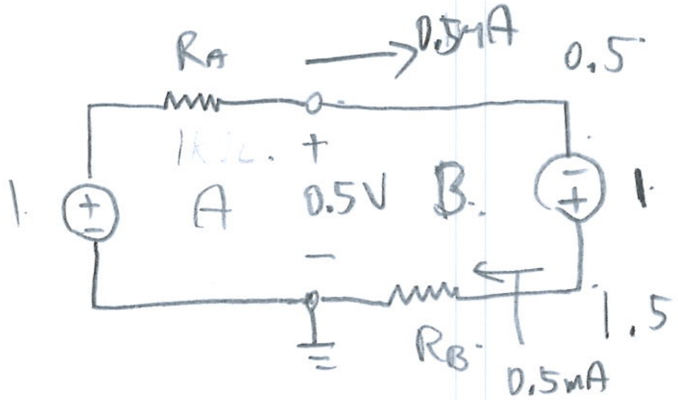


the voltage and current become $v = 0.5\ V$, $i = 0.5\ mA$. Determine the Thévenin equivalent networks for the networks A and B.



$\boxed{\therefore\ V_A = V_B = 1V}$





$\frac{0.5}{R_A} = 0.5mA \quad R_A = 1k\Omega$

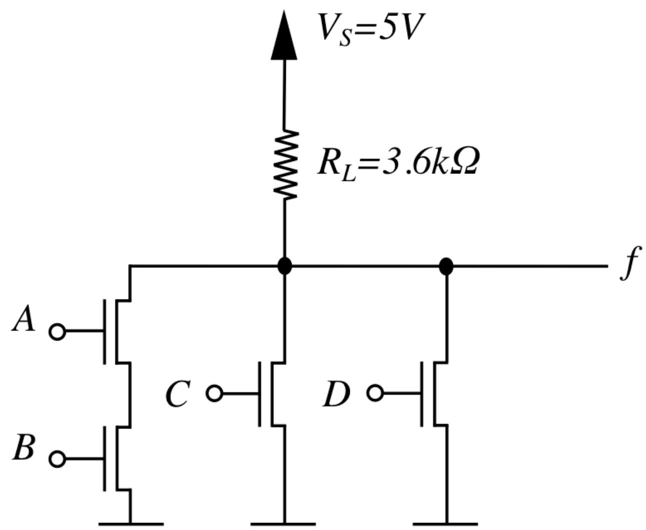
$\frac{1.5}{R_B} = 0.5mA \quad R_B = 3k\Omega$

Part C: Digital Abstraction (47 points)

Question 5 (27 points)

Ben Bitdiddle has designed the following logic gate. Answer the following questions.

Note: This question was adapted from an entrance exam question for the graduate school last year.



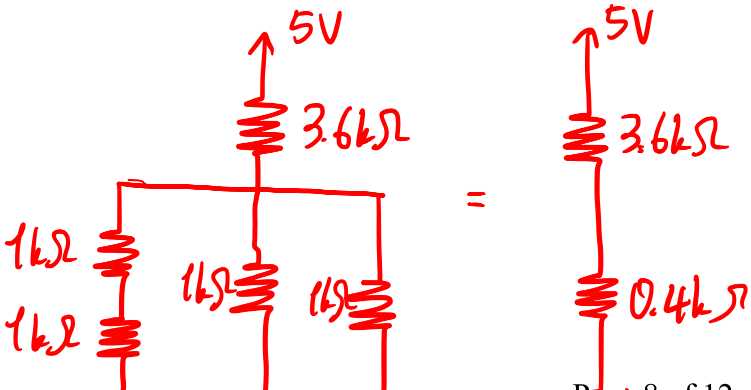
(1) Write a Boolean expression for the output *f* as a function of A, B, C and D.

$f = \overline{((A \cdot B) + C + D)}$

(2) Determine the input pattern that draws the maximum (static) power.

$(A, B, C, D) = (1, 1, 1, 1)$

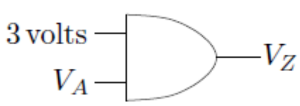
(3) Assuming R_{on} of the MOSFETs is 1kΩ, calculate the maximum power consumption.

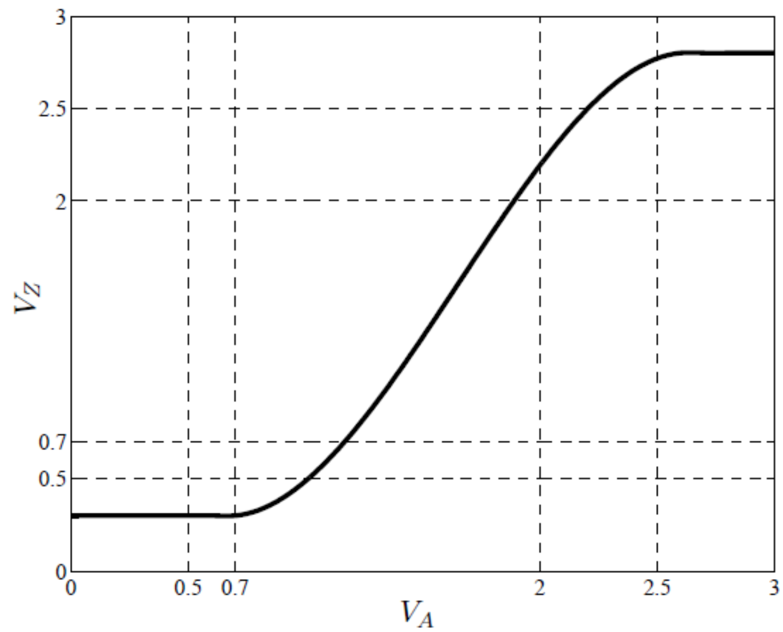


$\therefore \frac{5^2}{4k} = 6.25mW$

Question 6 (20 points)

The voltage at the output Z of the 2-input AND gate is a function of the voltage at input A, as graphed below. Assume *Vs* (supply voltage) is 3V. Does this AND gate satisfy the static discipline? Explain your answer briefly.





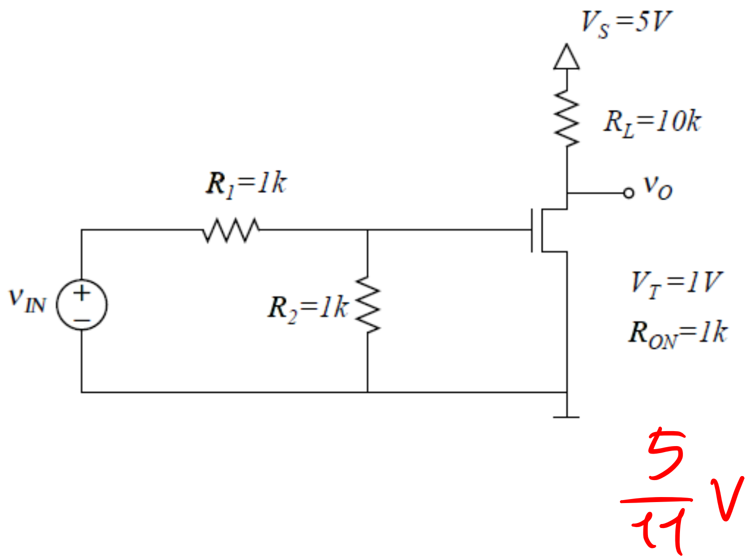
$V_{OL} = 0.5\,V$ $\quad V_{OH} = 2.5\,V$
$V_{IL} = 0.7\,V$ $\quad V_{IH} = 2.0\,V$

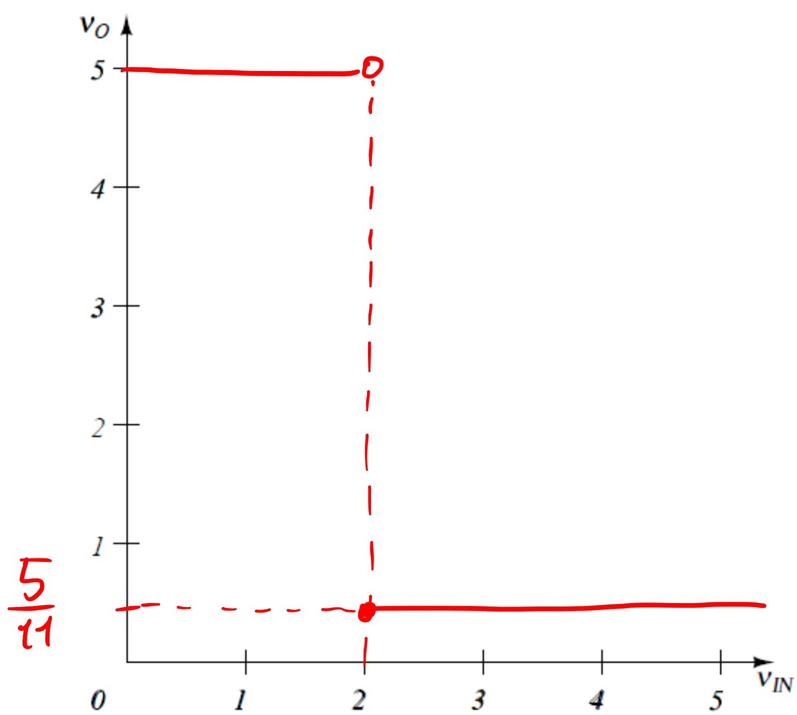
Does not satisfy. V_{OH} is violated when $V_A = V_{IL}$

Part D: The MOSFET Switch (25 points)

Question 7 (25 points)

Using the SR MOSFET model with the circuit parameters shown in the figure, plot v_O versus v_{IN} for $0 \le v_{IN} \le 5V$. Clearly mark the values of v_{IN} and v_O at each point in the graph where there is a change of slope.



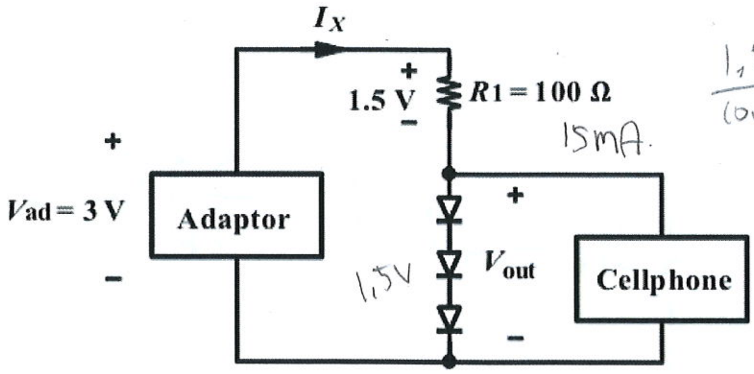


Part E: Nonlinear Circuits (30 points)

Question 8 (30 points)

Having lost her 1.5-V cellphone charger, Alice Hacker tries several stores but does not find adaptors with outputs less than 3V. She then decides to put her knowledge of electronics to work and constructs the circuit shown in the figure below, where three *identical* diodes produce a total voltage of $V_{out} = 3V_D \approx 1.5V$ and resistor $R1$ sustains the remaining 1.5V. Neglect the current drawn by the cellphone ($\approx$ 0mA). Assuming the voltage/current (i_D and v_D) characteristic equation for a diode below, please answer the following questions.

$$i_D = \begin{cases} K{v_D}^2, & v_D > 0 \\ 0, & v_D \leq 0 \end{cases}$$



$\frac{1.5}{100} = \frac{15}{1000}$

(1) Determine the K that makes $Vout$ = 1.5V.

15mA

0.5 V

$15mA = k\,(0.25)\,V$

$k = 60\,[mA/V]$

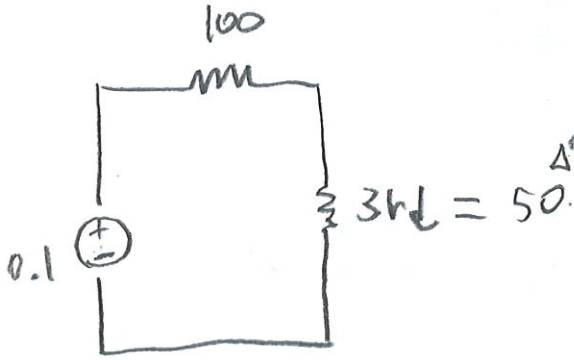
(2) By using small signal analysis, compute *Vout* if the adaptor voltage is in fact 3.1V.

$V_D = 0.5$

$$\frac{1}{r_d} = \left.\frac{dI_D}{dV_D}\right|_{V_D=0.5} = 2kV_D$$

$$= 2k\,0.5 = k = 60\ mA/V.$$

$$r_d = \frac{100\cancel{0}}{6\cancel{0}} = \frac{50}{3}$$



$$\Delta V_{out} = \frac{5\cancel{0}}{15\cancel{0}} \times 0.1 = 0.033$$

$$\therefore V_{out} = 1.5 + \Delta V_{out}$$

$$= 1.533\ V$$