EE10

Midterm Exam

Fall 2012

Group 1

Time Limit: 1 hour and 50 minutes

Open Book, Open Notes

Calculators are allowed.

Your Name:

Emily Im

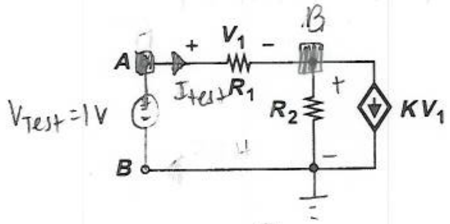
Name of Person to Your Left: Zhibing Wu

Name of Person to Your Right: Ahmed Hassan

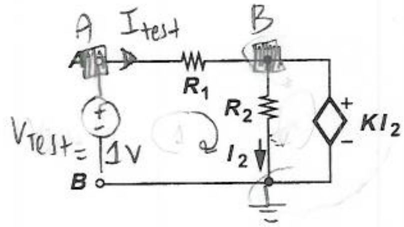
1.	9	/14
2.	10	/15
3.	10	/10
4.	6	/6
	35	

9

1. (a) Consider the circuit shown in (I) below. Determine the equivalent resistance between terminals A and B.
(b) What happens to the equivalent resistance as K approaches $1/R_1$? Can you explain intuitively why?
(c) Consider the circuit shown in (II) below. Determine the equivalent resistance between terminals A and B.



(I)



(II)

ⓐ $I_{test} = \dfrac{V_1}{R_1}$ $\quad V_1 = I_{test} R_1$

KCL @B: $I_{test} = kV_1 + \dfrac{V_B}{R_2}$

(*) $I_{Test} = k I_{Test} R_1 + \dfrac{V_B}{R_2}$

KVL: $+1 - V_B - V_1 = 0$

$V_B = 1 - V_1$

$V_B = 1 - I_{test} R_1$

(*) $I_{test} = k I_{test} R_1 + \dfrac{1}{R_2} - \dfrac{I_{test} R_1}{R_2}$

$\left(1 - kR_1 + \dfrac{R_1}{R_2}\right) I_{test} = \dfrac{1}{R_2}$

5

$I_{Test} = \dfrac{1}{R_2\left(1 - kR_1 + \dfrac{R_1}{R_2}\right)}$

$\boxed{R_{eq} = R_2 - kR_1R_2 + R_1}$

ⓑ $\boxed{\text{as } k \to \frac{1}{R_1},\ R_{eq} \to R_1}$

the current provided by this $k = \frac{1}{R_1}$ current source will be the same as the current going through the R_1 resistor so no current would go through the R_2 resistor, (current source is acting like a short in this specific case)

4

ⓒ KVL: $-1 + R_1 I_{test} + K I_2 = \emptyset$

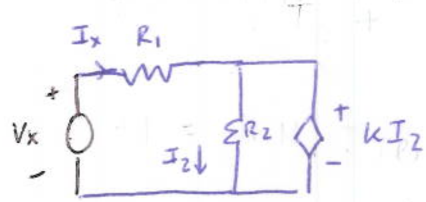
$R_1 I_{Test} = 1 - k I_2$

$I_{test} = \dfrac{1 - kI_2}{R_1}$

$I_2 R_2 = k I_2$

$k = R_2$

ⓒ ⇒ 5 pts

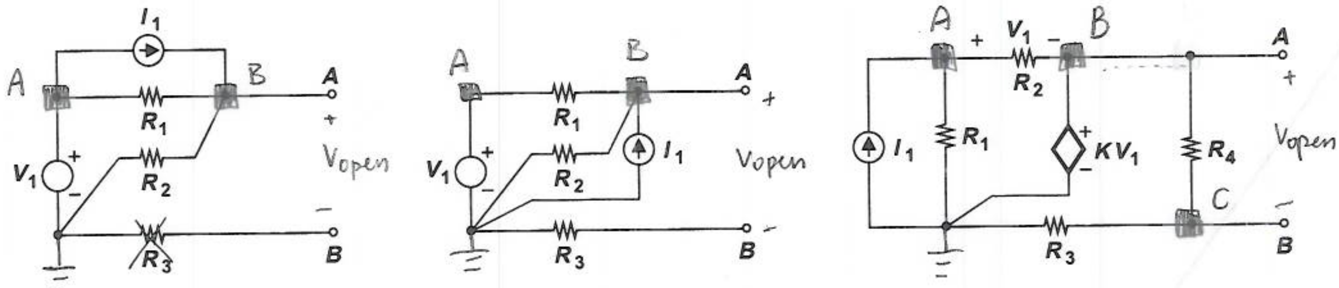


$\dfrac{kI_2}{R_2} = I_2 \Rightarrow I_2 = \emptyset$

$\Rightarrow \dfrac{V_x}{I_x} = R_1$

+10

2. Determine the Thevenin equivalent circuit of each circuit shown below.



(a) (b) (c)

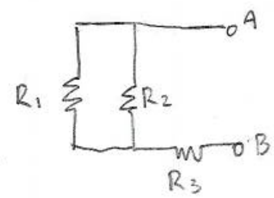
a) $V_A = V_1 \quad V_B = V_{open}$

KCL @ B: $I_1 = \frac{V_B}{R_1} - \frac{V_A}{R_1} + \frac{V_B}{R_2}$

$I_1 = V_B\left(\frac{1}{R_1} + \frac{1}{R_2}\right) - \frac{V_1}{R_1}$

$I_1 + \frac{V_1}{R_1} = V_B\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

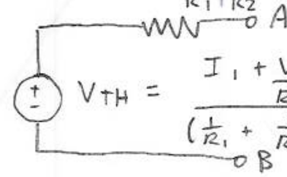
$V_B = V_{open} = V_{TH} = \dfrac{I_1 + \frac{V_1}{R_1}}{\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}$ Volts



$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} + R_3$

+J

$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} + R_3$ (ohms)

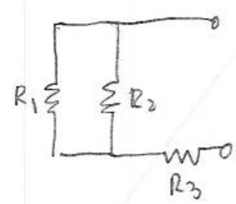


$V_{TH} = \dfrac{I_1 + \frac{V_1}{R_1}}{\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}$ (volts)

b) $V_A = V_1 \quad V_B = V_{open}$

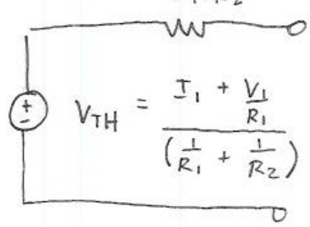
KCL @ B: $I_1 = \frac{V_B}{R_1} - \frac{V_A}{R_1} + \frac{V_B}{R_2}$

$V_{TH} = \dfrac{I_1 + \frac{V_1}{R_1}}{\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}$ Volts



$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} + R_3$ +4

$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} + R_3$ (ohms)



$V_{TH} = \dfrac{I_1 + \frac{V_1}{R_1}}{\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}$ (volts)

c) $V_B = kV_1 \qquad V_1 = V_A - V_B$

KCL @ A: $I_1 = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)V_A - \frac{1}{R_2}V_B$

KCL @ C: $0 = \left(\frac{1}{R_4} + \frac{1}{R_3}\right)V_C - \frac{1}{R_4}V_B \Rightarrow V_C = \dfrac{\frac{1}{R_4}kV_1}{\left(\frac{1}{R_4} + \frac{1}{R_3}\right)}$

$V_{open} = V_B - V_C$

$kV_1 - V_C$

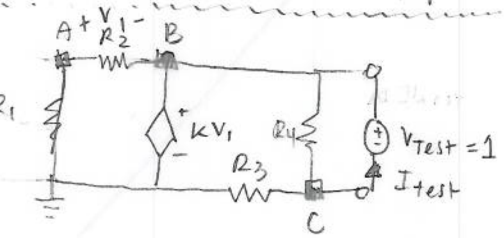
$\Rightarrow$ $V_{open} = kV_1\left(1 - \frac{1}{R_4\left(\frac{1}{R_4} - \frac{1}{R_3}\right)}\right)$

$\boxed{V_{TH} = kV_1\left(1 - \frac{1}{\left(1 - \frac{R_4}{R_3}\right)}\right) \text{ (volts)}}$

6 pts in total

X

+1



$V_B = kV_1 \quad V_1 = V_A - V_B \quad V_A = V_1 + V_B \quad V_B - V_C = 1 \quad V_C = V_B - 1$

KCL @ A: $\left(\frac{1}{R_1} + \frac{1}{R_2}\right)V_A - \frac{1}{R_2}kV_1 = 0 \Rightarrow \left(\frac{1}{R_1} + \frac{1}{R_2}\right)V_1 + \left(\frac{1}{R_1} + \frac{1}{R_2}\right)KV_1 - \frac{1}{R_2}kV_1 = 0 \Rightarrow$

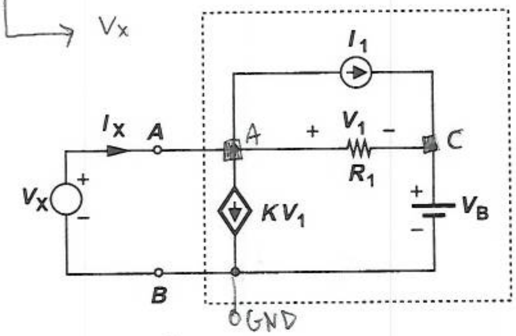
KCL @ C: $\left(\frac{1}{R_3} + \frac{1}{R_4}\right)V_C + I_{test} - \frac{1}{R_4}kV_1 = 0 \Rightarrow$

3. Consider the circuit shown in the dashed box below. We conduct two experiments.

(a) First, apply an external voltage, V_X, and measure I_X without setting any sources in the dashed box to zero. Plot I_X as a function of V_X. Assume $I_1 > V_B(K + 1/R_1)$. Clearly show the slope and the intercepts with the x and y axes.

(b) Second, determine the Thevenin resistance of the dashed box. Compare this result with the slope obtained in (a).

10

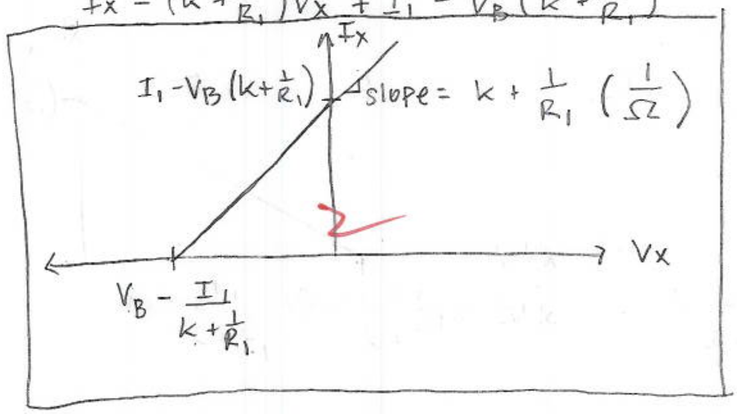


ⓐ $V_A = V_X \quad V_C = V_B \quad V_1 = V_A - V_B$

KCL @ A: $I_X = kV_1 + I_1 + \frac{V_1}{R_1}$ 2 $\quad V_1 = V_X - V_B$

$I_X = kV_X - kV_B + I_1 + \frac{V_X}{R_1} - \frac{V_B}{R_1}$

$I_X = (k + \frac{1}{R_1})V_X + I_1 - V_B(k + \frac{1}{R_1})$

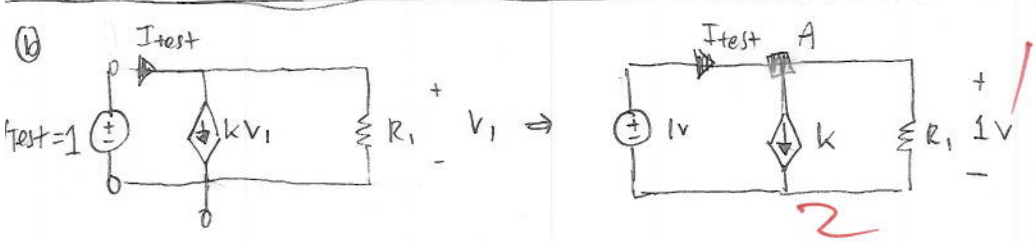


$I_X = 0 \Rightarrow (k + \frac{1}{R_1})V_X = V_B(k + \frac{1}{R_1}) - I_1$

$V_X = \frac{V_B(k + \frac{1}{R_1}) - I_1}{(k + \frac{1}{R_1})}$

$V_X = V_B - \frac{I_1}{(k + \frac{1}{R_1})}$.

ⓑ



KCL@A: $I_{test} = k + \frac{1}{R_1}$

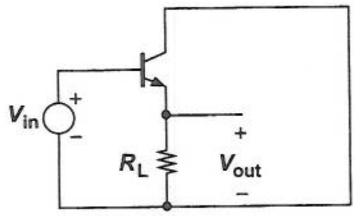
$V = IR \quad R = \frac{V_{Test}}{I_{test}} = \boxed{R_{TH} = \frac{1}{k + \frac{1}{R_1}} \ (\Omega)}$

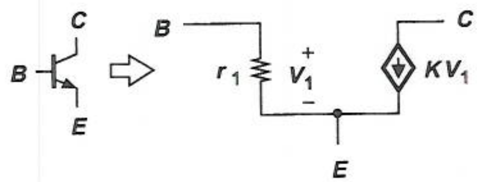
This is the inverse of the slope in part (a).

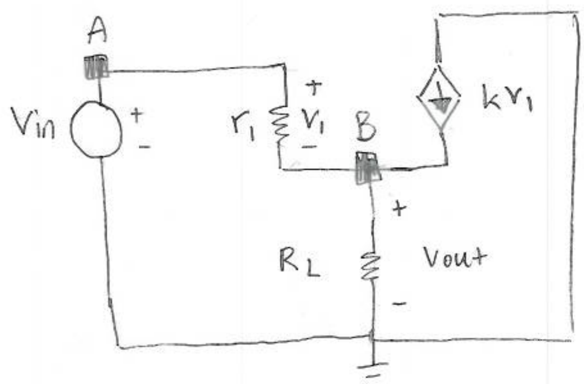
6.

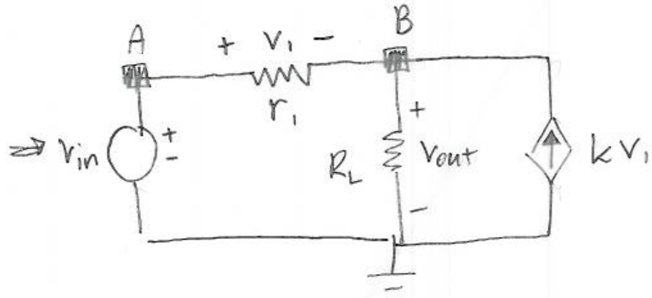
4. (a) Shown below is an amplifier incorporating a transistor. Using the circuit model shown for the transistor, determine V_{out} in terms of V_{in}.

(b) What happens as $R_L \to \infty$?









(a) $V_A = V_{in}$ $\quad V_B = V_{out}$ $\quad V_1 = V_A - V_B \Rightarrow V_1 = V_{in} - V_{out}$

KCL @ B: $kV_1 = \frac{V_{out}}{R_L} - \frac{V_1}{r_1} \Rightarrow k V_{in} - k V_{out} = \frac{V_{out}}{R_L} - \frac{V_{in}}{r_1} + \frac{V_{out}}{r_1}$

$$k V_{in} + \frac{1}{r_1} V_{in} = \frac{V_{out}}{R_L} + \frac{V_{out}}{r_1} + k V_{out}$$

$$\left(k + \frac{1}{r_1}\right) V_{in} = \left(\frac{1}{R_L} + \frac{1}{r_1} + k\right) V_{out}$$

$$\boxed{V_{out} = \frac{\left(k + \frac{1}{r_1}\right)}{\left(\frac{1}{R_L} + \frac{1}{r_1} + k\right)} V_{in}}$$

5

(b) as $R_L \to \infty$ $\quad \frac{1}{R_L} \to 0$

$$V_{out} = \frac{\cancel{\left(k + \frac{1}{r_1}\right)}}{\cancel{\left(0 + \frac{1}{r_1} + k\right)}} V_{in} \qquad V_{out} = V_{in}$$

$\boxed{\text{as } R_L \to \infty, \text{ value of } V_{out} \text{ will approach the value of } V_{in}}$

1