

Last Name, First Name

Student No.

Check your tutorial section(**REQUIRED!**):

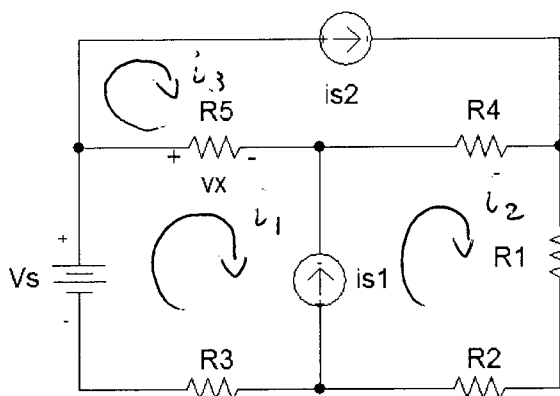
TUT0101	TUT0102	TUT0103	TUT0104	TUT0105	TUT0106	TUT0107	TUT0108
Thu. 9 am	Thu. 9 am	Thu. 9 am	Thu. 9 am	Mon.10am	Mon.10am	Mon. 3 pm	Mon. 3 pm
BA2165	BA2155	BA2145	BA2195	BA2145	BA2165	BA2145	HA410
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Department of Electrical & Computer Engineering
ECE212F – Circuit Theory
Quiz 1 – October 10, 2002, 6:30-7:30 PM

Instructions: Non-programmable calculators allowed. No other aids. Answer in the space provided on these sheets. The back sides of these sheets can be used as well. For full marks (25) you must show methods, state UNITS and compute numerical answers when requested.

1. Node-voltage or mesh current method.

- Formulate a set of node-voltage equations or mesh current equations for the circuit below. (3 marks)
- Solve the equations from part (a) when $v_s=10V$, $R_1=R_2=R_3=R_4=1\text{ k}\Omega$, $R_5=2\text{ k}\Omega$, $i_{s1}=5mA$, $i_{s2}=10mA$. (3 marks)
- Use your result from part (b) to determine v_x and i_x . (2 marks)
- Determine the total power absorbed in the circuit and the total power delivered by the sources. (2 marks)



(a)

$$v_s - (i_1 - i_3)R_5 - (i_2 - i_3)R_4 - i_2(R_1 + R_2) - i_1R_3 = 0$$

$$i_3 = i_{s2}$$

$$i_{s1} = i_2 - i_1$$

$$i_1(R_1 + R_2 + R_3 + R_4 + R_5) = v_s + i_{s2}(R_5 + R_4) - i_{s1}(R_4 + R_1 + R_2)$$

(b) $i_1 \cdot 6000\Omega = 10V + 10mA \cdot 3000\Omega - 5mA \cdot 3000\Omega = 25V$
 $\rightarrow i_1 = 4.167\text{ mA}$, $i_2 = i_1 + i_{s1} = 9.167\text{ mA}$, $i_3 = i_{s2} = 10\text{ mA}$

(c) $v_x = R_5(i_1 - i_3) = -11.67V$, $i_x = i_2 = 9.167\text{ mA}$

(d) $P_{\text{resistors}} = (R_1 + R_2)i_2^2 + R_3i_1^2 + R_5(i_1 - i_3)^2 + R_4(i_2 - i_3)^2 = 254.2\text{ mW}$

$$P_{\text{sources}} = -v_s \cdot i_1 + i_{s1}(-v_s + i_1 R_3 + (i_1 - i_3)R_5) + i_{s2} \cdot ((i_1 - i_3)R_5 + (i_2 - i_3)R_4)$$

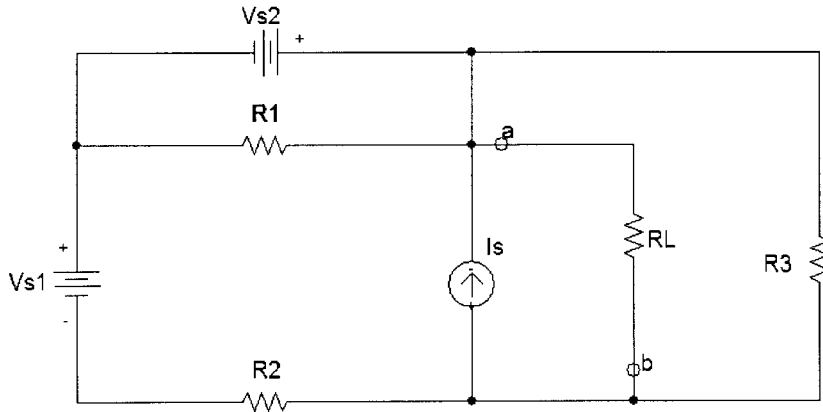
$$= (-41.67 \quad -87.5 \quad -125)\text{ mW} = -254.2\text{ mW}$$

All sources deliver power. Therefore $P_{\text{absorbed}} = P_{\text{resistors}}$

$$P_{\text{delivered}} = P_{\text{sources}}$$

2. Thevenin or Norton equivalent circuit.

- (a) Find the Thevenin or Norton equivalent circuit between terminals a and b, seen by the load resistance R_L when $v_{s1}=30V$, $v_{s2}=60V$, $i_s=100mA$, $R_1=R_3=60\Omega$, 1000Ω , and $R_2=100\Omega$. **(5 marks)**
- (b) Find the required value for R_L such that R_3 absorbs 3.75 W. Calculate the power delivered to R_L . **(3 marks)**
- (c) Determine the maximum power available to the load. **(1 mark)**
- (d) Calculate the power delivered to the load when $R_L=30\Omega$, 60Ω , and 100Ω . **(1 mark)**



$$(a) \quad v_T = v_{oc} = v_{s1} \frac{R_3}{R_3 + R_2} + v_{s2} \frac{R_3}{R_3 + R_2} + i_s \cdot \frac{R_2}{R_3 + R_2} \cdot R_3$$

(superposition)

$$v_T = 11.25V + 22.5V + 3.75V = \underline{\underline{37.5V}}$$

$$R_T = R_2 \parallel R_3 = \underline{\underline{37.5\Omega}}$$

$$(b) \quad P_{R_3} = 3.75W = V_{ab}^2 / R_3 \rightarrow V_{ab} = 15V = v_T \cdot \frac{R_L}{R_L + R_T}$$

$$\rightarrow R_L = 25\Omega$$

$$P_L = 9W$$

$$(c) \quad P_{max} = \frac{v_T^2}{4R_T} = 9.375W \quad \text{when } R_L = R_T$$

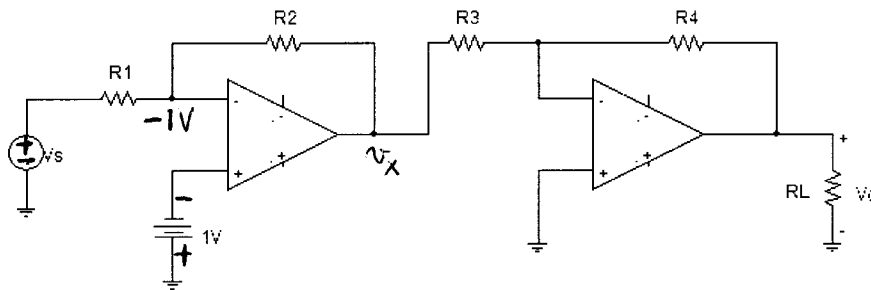
$$(d) \quad P_L(30\Omega) = 9.26W$$

$$P_L(60\Omega) = 8.88W$$

$$P_L(100\Omega) = 7.44W$$

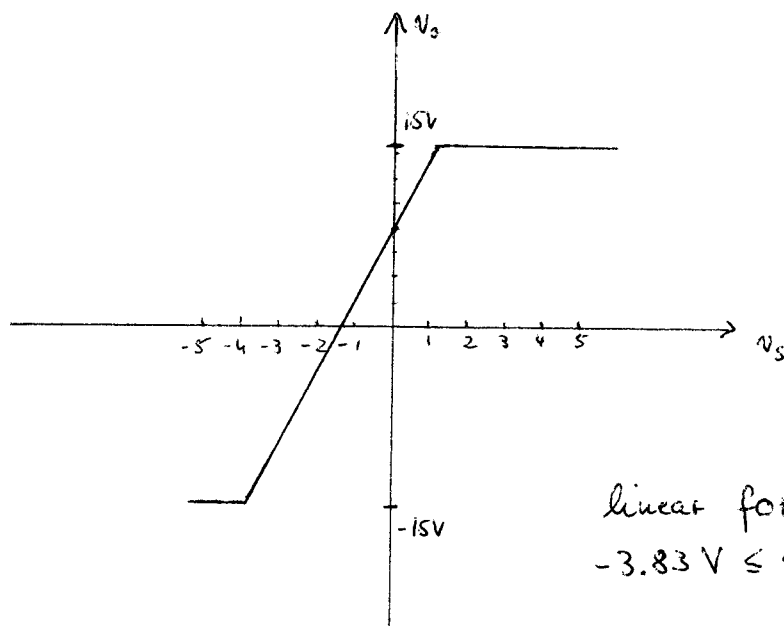
3. **OP-AMP.** In the circuit below $V_{CC} = \pm 15V$ for both OP-amps, $R_1 = 10k\Omega$, $R_2 = 30k\Omega$, $R_3 = 10k\Omega$, $R_4 = 20k\Omega$, and $R_L = 5k\Omega$.

- (a) Find the relationship between output v_o and input v_s . (3 marks)
 (b) Sketch the circuit transfer characteristic for the range $-5V < v_s < 5V$. (2 marks)



$$\begin{aligned}
 (a) \quad v_o &= -\frac{R_4}{R_3} v_x = -\frac{R_4}{R_3} \left(-1 - R_2 \cdot \frac{v_s + 1}{R_1} \right) \\
 &= -2(-1 - 3 \cdot (v_s + 1)) \\
 &= 6v_s + 8 \text{ (V)}
 \end{aligned}$$

(b)



linear for:
 $-3.83V \leq v_s \leq 1.167V$