Student name: _____

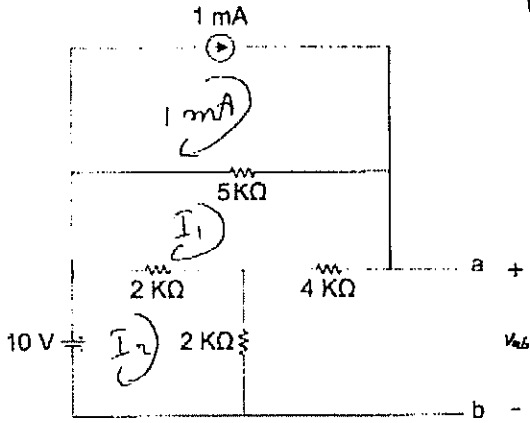
ID number: _____ Solution

University of Toronto
Department of Electrical & Computer Engineering
ECE110S – Electrical Fundamentals
Quiz 3A – March 12, 2008, 4:30-5:00 PM

($e = 1.6 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m, $g = 9.81$ N/kg)

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 you must show methods, state UNITS and compute numerical answers when requested. **Please write in PEN, not pencil.**

1. (a) For the circuit below, use LOOP ANALYSIS to calculate v_{ab}, the voltage between the points a and b. **(6 marks)**
   (b) Calculate the load resistor R_L that must be connected between the two points a and b for maximum power transfer. **(2 marks)**
   (c) Express P_L, power absorbed by the load resistor, in terms of R_L and v_{ab}, and calculate the maximum P_L. **(2 marks)**



(a) KVL 1: $5(I_1 - 1) + 4I_1 + 2(I_1 - I_2) = 0 \Leftrightarrow$

$11I_1 - 2I_2 = 5$

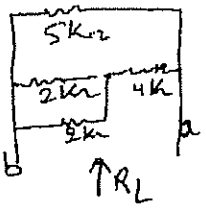
KVL 2: $-10 + 2(I_2 - I_1) + 2I_2 = 0 \Leftrightarrow$

$-2I_1 + 4I_2 = 10$

$\begin{cases} 11I_1 - 2I_2 = 5 \\ -2I_1 + 4I_2 = 10 \end{cases} \Rightarrow \begin{cases} I_1 = 1\text{ mA} \\ I_2 = 3\text{ mA} \end{cases}$

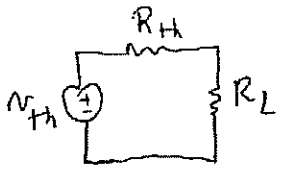
$V_{ab} = 4I_1 + 2I_2 = 10\text{V}$

(b) $R_L = R_{th} = (2//2 + 4)//5$



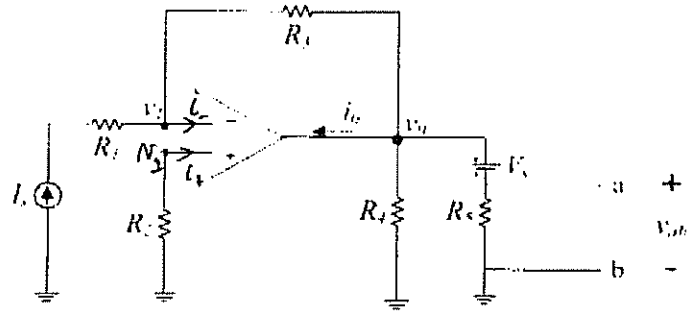
$= 2.5\text{ k}\Omega$

$\uparrow R_L$



(c) $P_L = \frac{v_{th}^2}{4R_{th}} = \frac{v_{ab}^2}{4R_L} = 10\text{ mW}$

2. Consider the circuit shown below with an ideal op-amp. I_s, V_s, R_1, R_2, R_3, R_4 and R_5 are known parameters.
   (a) Express v_1 in terms of known parameters. **(2 marks)**
   (b) Express v_{ab} in terms of known parameters. **(3 marks)**
   (c) Express i_o in terms of known parameters. **(5 marks)**



(a) $i_+ = 0$ so $v_2 = 0$ and $v_1 = v_2$ so $\boxed{v_1 = 0}$

(b) KCL: $-I_s + i_- + \frac{v_1 - v_o}{R_3} = 0 \Leftrightarrow v_o = -R_3 I_s$

KVL: $v_{ab} = v_o - V_s = -I_s R_3 - V_s$

(c) KCL: $i_o + \frac{v_o - v_1}{R_3} + \frac{v_o}{R_4} + \frac{v_o - V_s}{R_5} = 0 \Leftrightarrow$

$$i_o = -\frac{I_s R_3}{R_3} + I_s \frac{R_3}{R_4} + I_s \frac{R_3}{R_5} + \frac{V_s}{R_5}$$

$$= I_s \left(1 + \frac{R_3}{R_4} + \frac{R_3}{R_5}\right) + \frac{V_s}{R_5}$$