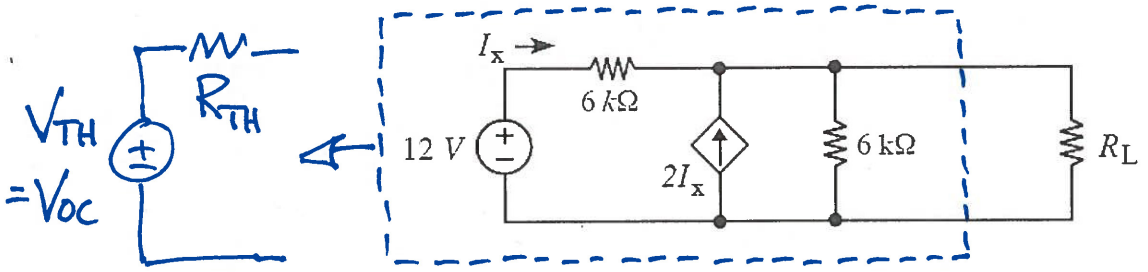
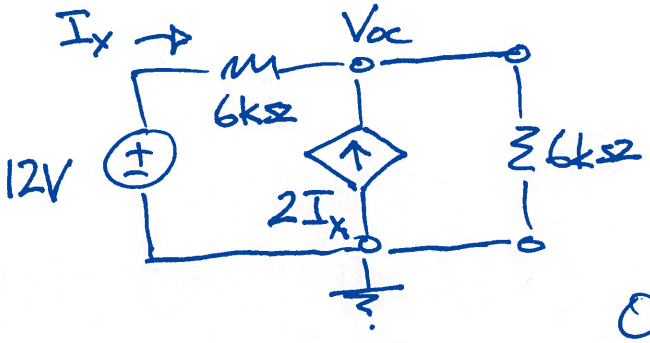
SA 4. (5 marks) Consider the following circuit and determine the value of R_L that would result in the maximum amount of power transferred to it from the rest of the circuit. You do not need to calculate the value of the power.



$V_{TH} = V_{OC}$, R_{TH}

The max. pwr. will be transferred if $\boxed{R_L = R_{TH}}$



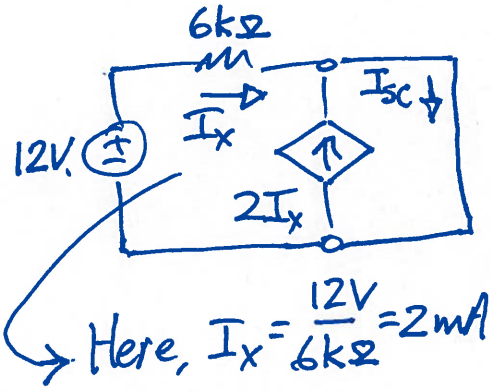
KCL: $-I_x - 2I_x + \frac{V_{OC}}{6k\Omega} = 0$

$-3I_x + \frac{V_{OC}}{6k\Omega} = 0$ — (1)

Ohm's Law: $I_x = \frac{12V - V_{OC}}{6k\Omega}$ — (2)

(2) → (1): $-3\left(2mA - \frac{V_{OC}}{6k\Omega}\right) + \frac{V_{OC}}{6k\Omega} = 0$

$\therefore \boxed{V_{OC} = 9V}$

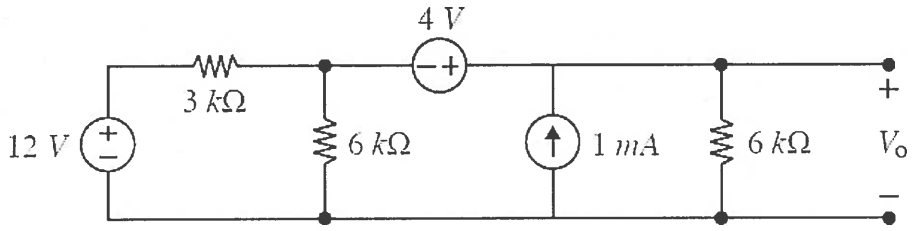


Here, $I_x = \frac{12V}{6k\Omega} = 2mA$

$\boxed{I_{SC} = I_x + 2I_x = 6\,mA}$

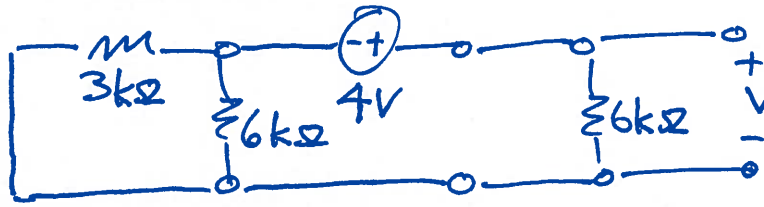
$\boxed{R_{TH} = \frac{V_{OC}}{I_{SC}} = \frac{9V}{6\,mA} = 1.5\,k\Omega}$

Prob 2. (25 marks) Consider the following circuit that is to be analyzed using three different approaches:



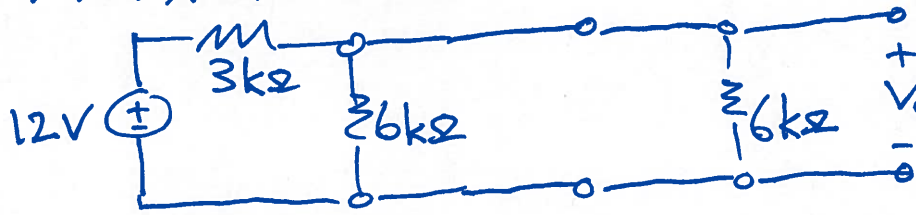
(a) (7 marks) Use the Superposition Principle to determine the voltage V_o.

(1) 4 V source alone:



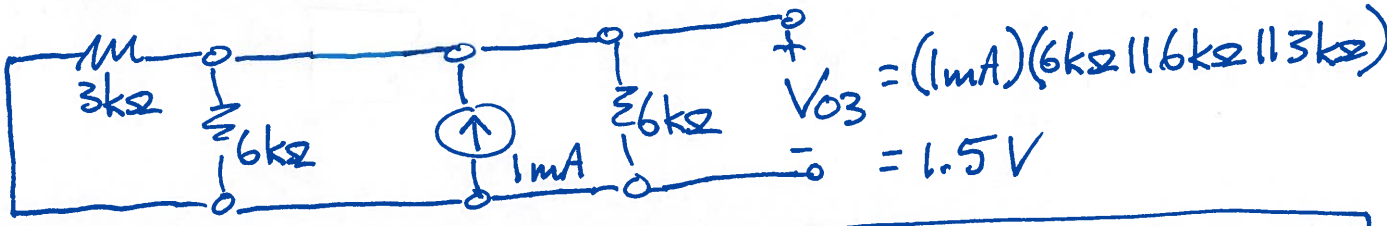
$$V_{o1} = \frac{(4V)(6k\Omega)}{(6k\Omega)+(3k\Omega \| 6k\Omega)} = 3V$$

(2) 12V source alone:



$$V_{o2} = \frac{(12V)(6k\Omega \| 6k\Omega)}{(6k\Omega \| 6k\Omega)+(3k\Omega)} = 6V$$

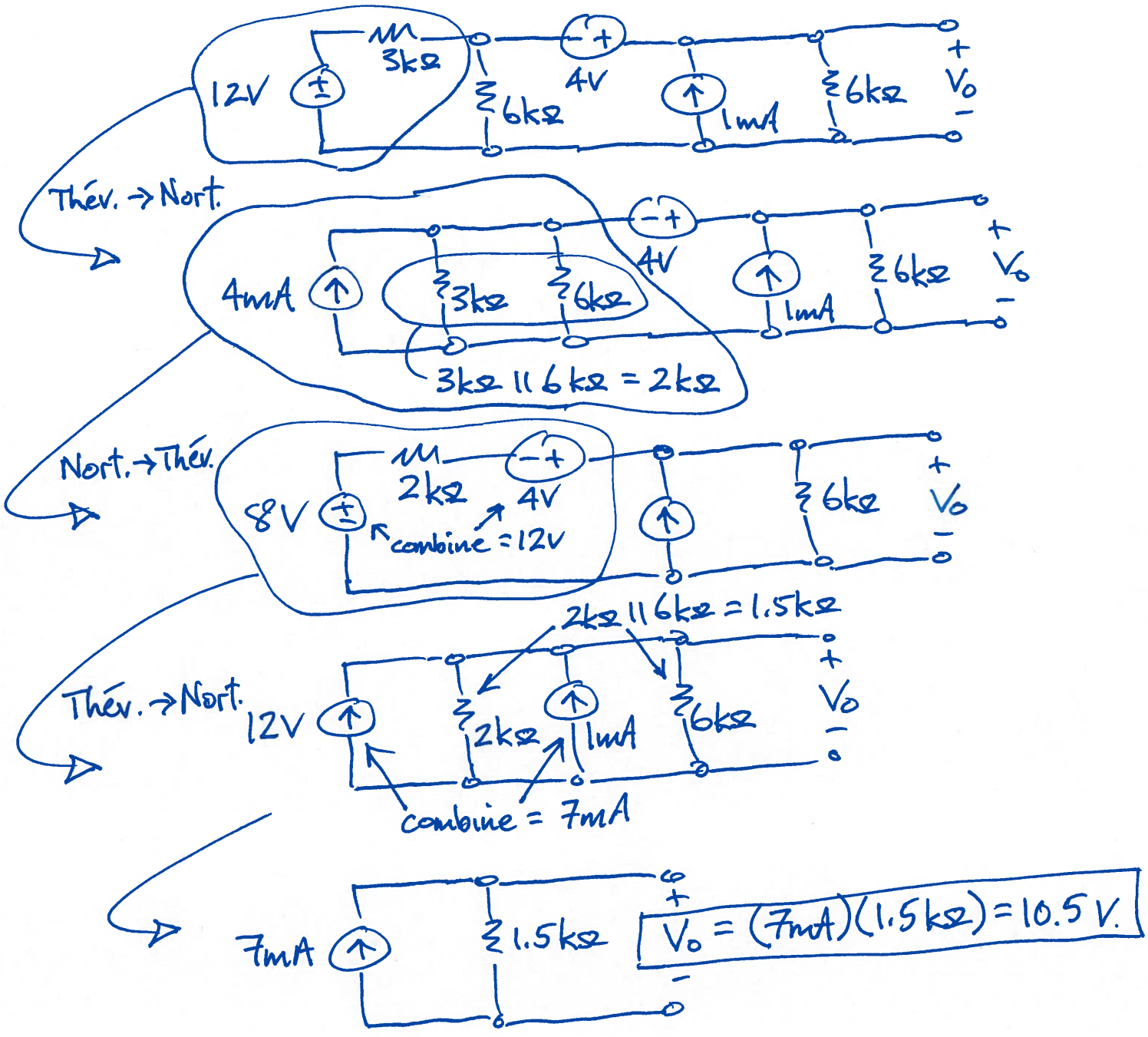
(3) 1mA source alone:



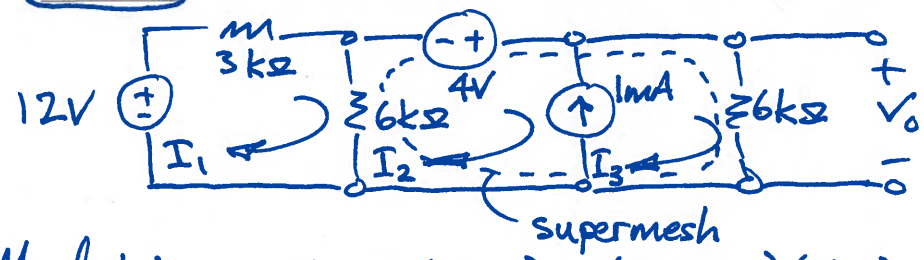
$$V_{o3} = (1mA)(6k\Omega \| 6k\Omega \| 3k\Omega) = 1.5V$$

Superposition: $V_o = V_{o1} + V_{o2} + V_{o3} = 3V + 6V + 1.5V = 10.5V.$

(b) (8 marks) Again determine the voltage V_o, but this time use Thévenin's Theorem, Norton's Theorem, or both (*i.e.*, together with one or more source transformations).



(c) (10 marks) Use a loop/mesh analysis to again determine the voltage V_o, as well as the current that flows through the 12-V source.



KVL Mesh 1: $-12V + I_1(3k\Omega) + (I_1 - I_2)(6k\Omega) = 0$ —— (1)

KVL Supermesh: $-4V + I_3(6k\Omega) + (I_2 - I_1)(6k\Omega) = 0$ —— (2)

Constraint: $I_3 - I_2 = 1mA$ —— (3)

(1) + (3) → (2): $-4V + (1mA + I_2)(6k\Omega) - 12V + I_1(3k\Omega) = 0$

$\hookrightarrow I_2(6k\Omega) + I_1(3k\Omega) = 10V.$ —— (4)

(4) → (1): $-12V + \left[\frac{10V}{3k\Omega} - \frac{I_2(6k\Omega)}{3k\Omega}\right](3k\Omega) + \left[\frac{10V}{3k\Omega} - \frac{I_2(6k\Omega)}{3k\Omega}\right](6k\Omega) - I_2(6k\Omega) = 0$

$\hookrightarrow 18V - I_2(6k\Omega + 12k\Omega + 6k\Omega) = 0$

$I_2 = \frac{18V}{24k\Omega} = 0.75\,mA$ —— (5)

(5) → (3): $I_3 = 1mA + 0.75\,mA = 1.75mA$

$\therefore \boxed{V_o = (6k\Omega)(1.75mA) = 10.5V.}$

(5) → (4): $I_1 = \frac{10V - (0.75mA)(6k\Omega)}{3k\Omega}$ $= 1.833\,mA$ = current through 12-V source