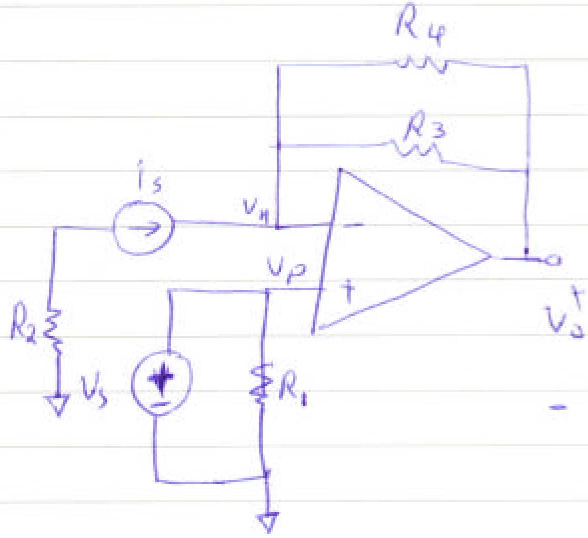
1)



Derive symbolic expression for v_o

in Linear mode $V_n = V_p$

$V_p = V_s$

since no current goes into the op-amp,

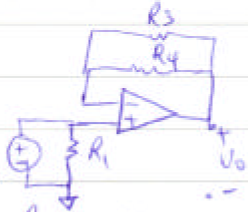
i_s passes through to $R_3 // R_4$

$v_o = V_n - i_s(R_3 // R_4)$

$\Rightarrow V_o = V_s - i_s(R_3 // R_4)$

2) a) If $i_s = 0$

$$V_n = V_p = V_s = 1$$



since no current is flowing from V_n to V_o

$V_o = V_n = 1\ V$

any value of R_1 would not change the value of V_p or V_n or V_o because the voltage across R_1 will always be equal to V_s as V_s is in parallel to R_1.

b) when $V_s = 0$, we can use the expression we derived before

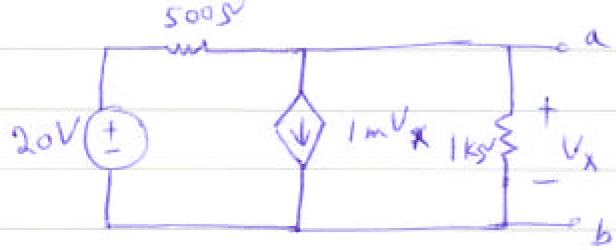
$$V_o = V_s - i_s(R_3 // R_4)$$
$$-1 = 0 - i_s(10K // 10K)$$
$$\Rightarrow -1 = 0 - 5k\, i_s$$
$$\Rightarrow i_s = \frac{1}{5k} = 0.2\ mA$$

c) $R_{in} = V_s / i_1 = R_1$

$\Rightarrow R_{in} = R_1$

whatever the value we choose for R_1 is our input resistance

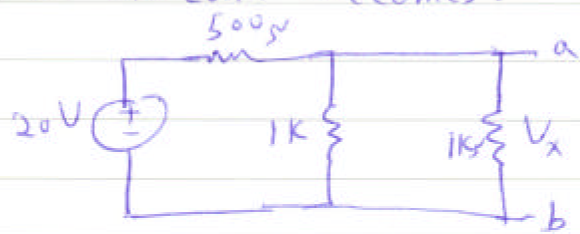
3. a)



we can replace the dependant source with an equivalent resistance

$$R = \frac{V}{I} = \frac{V_x}{1m\,V_x} = 1k\Omega$$

The circuit becomes:



$$V_{th} = V_x = 20V \times \frac{1k\Omega // 1k\Omega}{1k\Omega // 1k\Omega + 500}$$

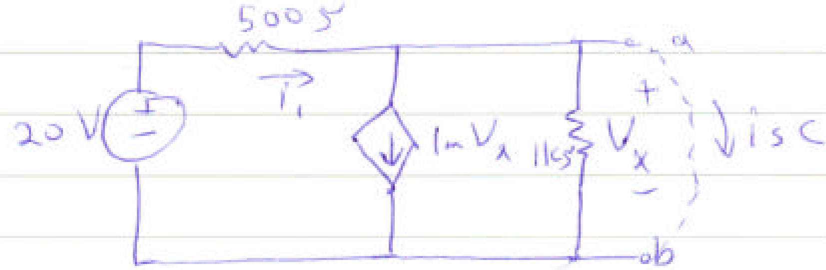
$$= 20 \times \frac{500}{500 + 500} = 10V$$

$$R_{th} = (1k\Omega // 1k\Omega) // 500\Omega$$

$$= 500\Omega // 500\Omega$$

$$= 250\Omega$$

a) other solution:



sum loop Votages

$$20V - 500 i_1 - V_x = 0 \quad \text{—— (1)}$$

node currents

$$i_1 = 1mV_x + \frac{V_x}{1k\Omega}$$

$$\Rightarrow i_1 = 1mV_x + 1mV_x = 2mV_x$$

substituting into (1)

$$20 - 500 \times 2mV_x - V_x = 0$$

$$\Rightarrow 20 - 2V_x = 0$$

$$\Rightarrow V_x = 10V$$

$$V_{th} = V_x = 10V$$

$$i_{sc} = \frac{20V}{500\Omega} = 40\,mA$$

$$R_{th} = \frac{V_{th}}{i_{sc}} = \frac{10}{40\,mA} = 250\Omega$$

b) R_L that would absorb maximum power = R_{th}
= 250 Ω

c) The maximum power $= \frac{V_L^2}{4R_L} = \frac{10^2}{4 \times 250} = \frac{100}{1000}$
$= 0.1\,W$