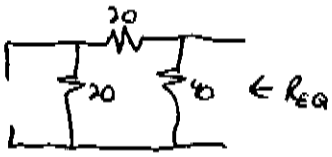
ENGR 210 Spring '05 HW 6 Solutions

(#1) a) Find R_L for max power

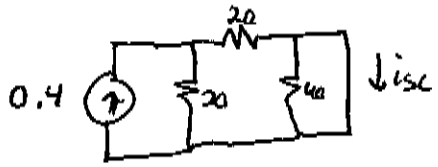
Max Power when $R_L = R_N = R_T$

Find R_N:



$R_N = 40 // (20+20)$ $\boxed{R_N = R_L = 20\Omega}$

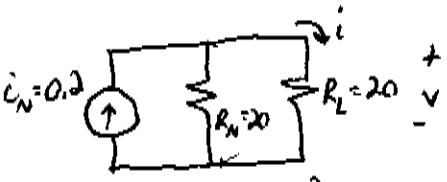
Find I_N:



$I_N = i_{sc} = \left(\frac{20}{20+20}\right)(.4)$

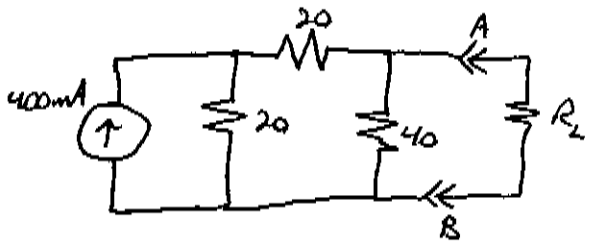
$i_N = 0.2\ A$

Find P_{max}:



$P = iv = i^2 R_L = \left[\left(\frac{20}{20+20}\right)(.2)\right]^2 (20)$

$\boxed{P_{max} = 0.2\ W}$

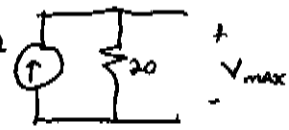


b) Find R_L for max voltage

Max Voltage when R_L = Open ckt

$\boxed{R_L = \infty}$

Find V_{max}:



$V_{max} = i_N R_N = (0.2)(20)$

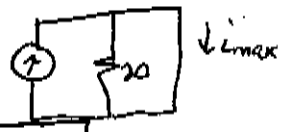
$\boxed{V_{max} = 4V}$

c) Find R_L for max current

Max Current when $R_L = 0$ short ckt

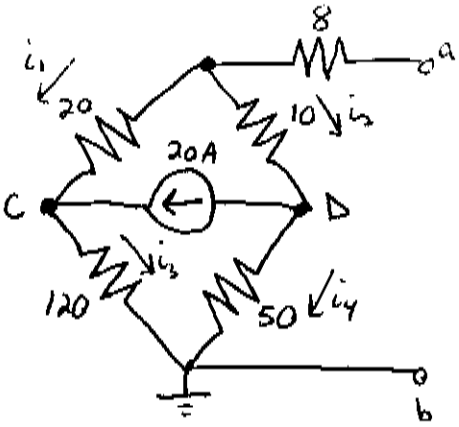
$\boxed{R_L = 0\ \Omega}$

Find i_{max}:

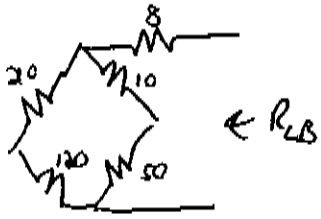


$\boxed{i_{max} = i_N = 0.2A}$

(#2) To find R_L and P_{max}, first find thevenin Eq.



$R_T = R_{LB}$



$R_T = 8 + (140 // 160)$

$\boxed{R_T = 50\,\Omega = R_L}$ for max power

$V_T = V_{oc}$ Use Node Voltage (or some other technique)

$V_a = V_{oc}$

① $\frac{V_a - V_c}{20} + \frac{V_a - V_b}{10} = 0$

$3V_a - V_c - 2V_b = 0$

② $\frac{V_a - V_c}{20} + 20 = \frac{V_c}{120}$

$6V_a - 7V_c = -20(120)$

③ $\frac{V_a - V_b}{10} = 20 + \frac{V_b}{50}$

$5V_a - 6V_b = 20(50)$

Put into calculator to solve

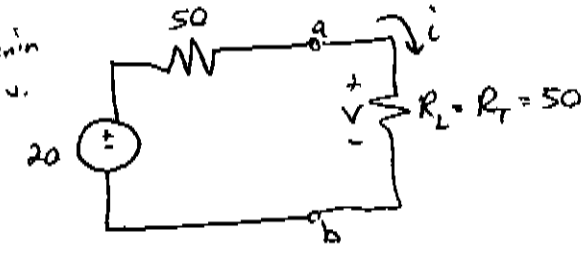
$V_a = 20$

$V_c = 360$

$V_b = -150$

$V_{oc} = V_T = 20V$

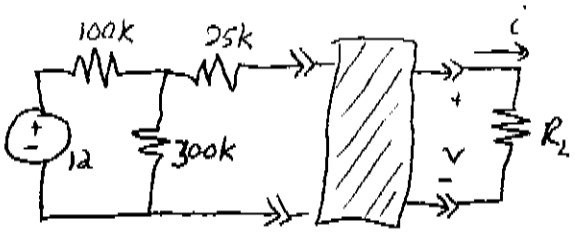
Thevenin Equiv.



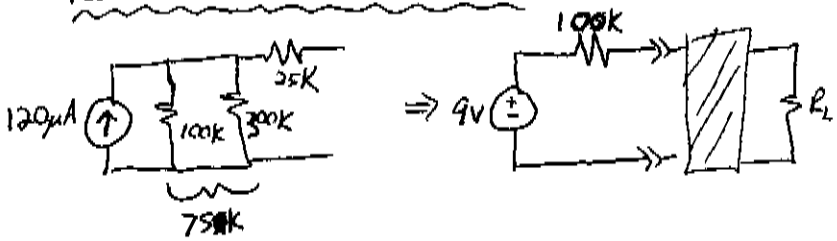
$P_{max} = iV = \frac{V^2}{R} = \frac{\left[\left(\frac{50}{50+50}\right)(20)\right]^2}{50}$

$\boxed{P_{max} = 2W}$

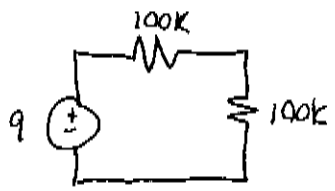
(#3) $P_{max} = 1\,mW$



Reduce Ckt on left of interface



What is P_{max} from Source?



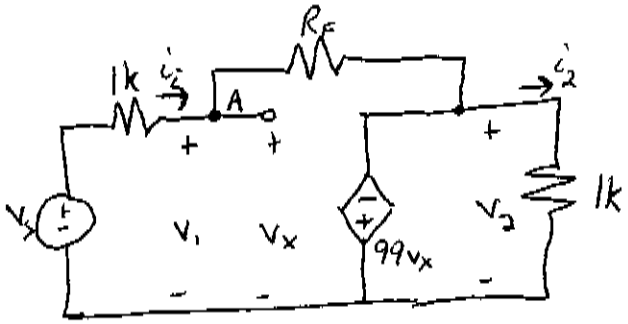
$$P_{max} = \frac{\left(\frac{9}{2}\right)^2}{100K} = \underline{0.2025\,mW}$$

Max Power is already less than 1mW

No interface ckt is necessary

Inserting an interface ckt and calculating values would show the same result

(#4) a) $v_2 = ?$ $\frac{i_2}{i_1} = ?$ $V_s = 10mV$ $R_F = 10k\Omega$



KCL @ A $\quad \frac{V_s - V_x}{1k} = \frac{V_x - V_2}{R_F}$

$V_2 = -99V_x$

$\frac{V_s - V_x}{1k} = \frac{V_x - -99V_x}{R_F}$

$10V_s - 10V_x = 100V_x$

$V_x = \frac{10}{110} V_s = \frac{10}{110}(10mV) = 909\mu V$

$\boxed{V_2 = -99V_x = -90mV}$

$\frac{i_2}{i_1} = \frac{\frac{V_2}{1k}}{\frac{V_s - V_x}{1k}} = \frac{V_2}{V_s - V_x} = \frac{-90mV}{10mV - 909\mu V}$

$\boxed{\frac{i_2}{i_1} = -9.9}$

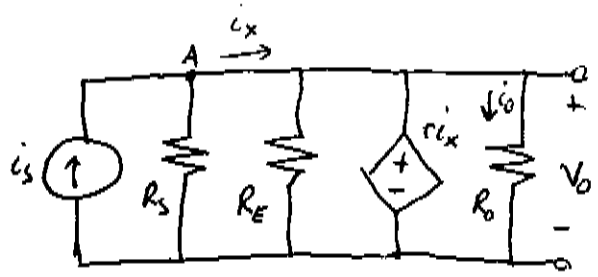
b) $R_{IN} = ? = V_1 / i_1$

$\frac{V_1}{i_1} = \frac{V_1}{\frac{V_s - V_1}{1k}} = \frac{V_x\,(1k)}{V_s - V_x}$

$R_{IN} = \frac{(909\mu V)(1k)}{10mV - 909\mu V}$

$\boxed{R_{IN} = 100\,\Omega}$

(#5) $i_o/i_s = ?$



KCL @ A: $i_s = \frac{V_o}{R_s} + i_x = \frac{i_o R_o}{R_s} + i_x$

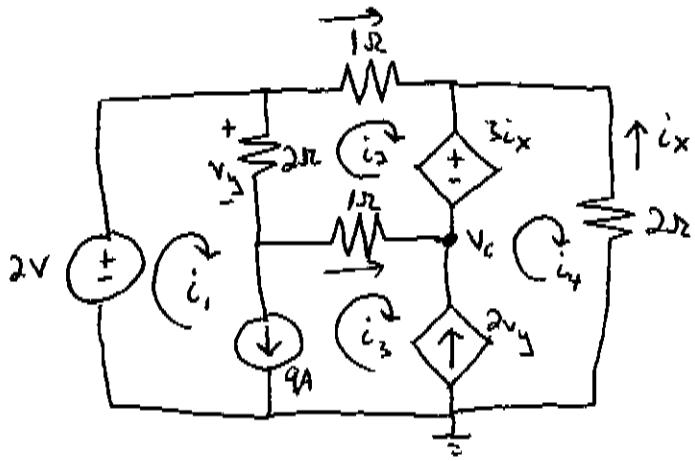
$ri_x = V_o = i_o R_o$

$i_x = \frac{i_o R_o}{r}$

$i_s = \frac{i_o R_o}{R_s} + \frac{i_o R_o}{r}$

$$\boxed{\frac{i_o}{i_s} = \frac{r R_s}{R_o(r+R_s)}}$$

(#6) a) Use Mesh Currents, find V_c and i_x



$i_1 - i_3 = 9A$

$2v_y = i_4 - i_3 = 4i_1 - 4i_2$

$i_4 = -i_x$

$V_y = 2(i_1 - i_2)$

$(i_2 - i_3)(1) + (2)(i_2 - i_1) + i_2(1) + 3i_x = 0$ KVL around top middle loop

$-2 + (1)i_2 + 2i_4 = 0$ KVL around outside loop

① $i_1 - i_3 = 9$

② $4i_1 - 4i_2 + i_3 - i_4 = 0$

③ $-2i_1 + 4i_2 - i_3 - 3i_4 = 0$

④ $i_2 + 2i_4 = 2$

} put into calculator to solve

$i_1 = 2A$

$i_2 = 0$

$i_3 = -7$

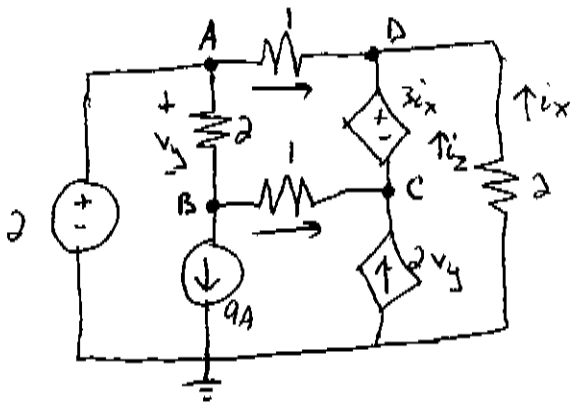
$i_4 = 1$

$$\boxed{i_x = -i_4 = -1A}$$

$V_c = -3i_x - 2i_x$ (KVL around right loop)

$$\boxed{V_c = 5V}$$

#6 b) Use Node Voltage, to find V_C and i_x



$V_A = 2V$ $\quad V_y = V_A - V_B$

$i_x = \frac{-V_D}{2}$

KCL @ B: $\frac{V_A - V_B}{2} = 9 + \frac{V_B - V_C}{1} + \frac{2 - V_B}{2}$

KCL @ C: $\frac{V_B - V_C}{1} + 2(V_A - V_B) = i_2$

KCL @ D: $i_2 + \frac{V_A - V_D}{1} + i_x = 0$

$i_2 = 3\frac{V_D}{2} - V_A = \frac{3V_D}{2} - 2$

KVL around right loop: $V_C + 3i_x = V_D = V_C - \frac{3V_D}{2}$

$V_C = 5\frac{V_D}{2}$

① $-\frac{3}{2}V_B + V_C = 8$

② $-V_B - V_C - \frac{3}{2}V_D = -6$

③ $V_C - \frac{5}{2}V_D = 0$

} put into calc to solve

$V_B = -2V$

$\boxed{V_C = 5V}$

$V_D = 2V$

$\boxed{i_x = \frac{-V_D}{2} = -1A}$