1. (10 points) Points) Shown below is a current divider circuit.

(a) (5 points) What is the equivalent resistance seen by the current source $I_s$?

\[ R \parallel 1.5R = \frac{R(1.5R)}{R + 1.5R} = \frac{1.5R^2}{2.5R} = 0.6R \]

(b) (5 points) How much current flows through $R$, or what is $I_x$?

\[ I_x = 10 - \frac{1.5R}{R + 1.5R} = 10 \times 0.6 = 6 \text{ A} \]
2. (20 points) Find the voltage $V_x$ across the 1KΩ resistor.

(Hint: superposition method may be helpful.)

Step 1: $V_x = 15\text{ Volts}$

Step 2: $V_x = 2\text{ mA only case}$

Step 3: $V_x = \frac{15}{(6+1.5)K} = 2\text{ mA}$$V_x = 1K\cdot 2\text{ mA} \cdot \frac{3K}{3K+3K} = 1.0\text{ V}$

Step 4: $V_x = 2\text{ mA} \times 0.8K = 1.6\text{ V}$

Step 5: $V_x = V_x = V_x|_{15\text{ Volts}} + V_x|_{2\text{ mA only}} = 1 + 1.6 = 2.6\text{ V}$
3. (20 Points) The following circuit shows that the load resistor $R_L$ is connected to a current source through some resistors.

(a) (10 points) Find the value of $R_L$ such that the power delivered to the load is maximized.

Find $R_S$ first: $20k || 30k + 8k = 20k$

For max. power transfer $R_L = R_S = \boxed{20k}$

(b) (10 points) What is the maximum power delivered to the load $R_L$?

\[ I_{RL} = \frac{8k}{(8 + 32)k} = \frac{4.0}{40} \text{ mA} = 9 \text{ mA} \]

\[ P_{RL} = I_{RL}^2 \times R = (0.09)^2 \times 20 \times 10^3 \text{ W} \]

\[ = 20 \text{ mW} \]
4. (25 point) Find the output voltage $V_o$ in the circuit below. Assume that $V_{be}=0.7V$ and $\beta=100$.

(Hint: Find $I_b$ first and then $I_c$ using the relationship $I_c=\beta I_b$.)

\[ I_b = \frac{3-0.7}{46k} - \frac{0.7}{70k} = 0.05\text{ mA} - 0.01\text{ mA} = 0.04\text{ mA} \]

\[ I_C = 100 I_b = 4\text{ mA} \]

\[ V_o = 10V - 1k(4\text{ mA}) = 6V \]
5. (25 points) Shown below is an Op Amp circuit powered by two input sources. The Op Amp is non-ideal with a finite input resistance of $R_i=1 \text{ k}\Omega$ and a rather small voltage gain of $A=100$, with its output resistance $R_o=100 \text{ }\Omega$. What is the output voltage $V_o$?

\[ KCL \text{ at ①: } 1 \text{ mA} + \frac{V_2}{1 \text{ k}\Omega} + \frac{V_0 - [-V_2 + 2V]}{1 \text{ k}\Omega} = 0 \]  
\[ KCL \text{ at ②: } \frac{V_0 - 100V_2}{100} + \frac{V_0 - [-V_2 + 2V]}{1 \text{ k}\Omega} = 0 \]

Multiplying all equations by $1 \text{ k}\Omega$,
\[ 1 + V_2 + V_0 + V_2 - 2 = 0 \]  
\[ 10V_0 - 1000V_2 + V_0 + V_2 - 2 = 0 \]

or
\[ V_0 + 2V_2 = 1 \]  
\[ 10V_0 - 999V_2 = 2 \]

\[(1)^* 	imes 999 + (2)^* \times 2 \Rightarrow 999V_0 + 22V_0 = 999 + 2(2) = 1003 \]

\[ V_0 = \frac{1003}{1021} = 0.98 \text{ V} \]