Problem 1

- Using a current divider, \( I_{RL} = I \left[ \frac{R_p}{R_p + R_L} \right] \)

The power absorbed by \( R_L \) is \( (I_{RL})^2 R_L \)

So, \( P_{RL} = \left[ \frac{I R_p}{R_p + R_L} \right]^2 R_L \)

\[
= I^2 R_p^2 \left[ \frac{R_L}{(R_p + R_L)^2} \right]
\]

To find the maximum, take \( \frac{dP_{RL}}{dR_L} \) and set to zero. Note that \( I \) and \( R_p \) are constants.
\[
\frac{d}{dR_L} (P_{RL}) = \frac{d}{dR_L} \left[ I^2 R_p^2 \left( \frac{R_L}{(R_p+R_L)^2} \right) \right] \\
= I^2 R_p^2 \left[ \frac{(R_p+R_L)^2 - 2R_L(R_p+R_L)}{(R_p+R_L)^2} \right]
\]

Set the derivative to zero:

\[
(R_p+R_L)^2 - 2R_L(R_p+R_L) = 0
\]

or

\[
R_p + R_L - 2R_L = 0
\]

or \[ R_p = R_L \]

Some of the

The

\[ \text{for max power } R_S = R_L \]

Notes: we can also show this result with PSpice
PARAMETERS:

\[
\frac{R_{val}}{R_p} = 1k \quad DC = 0.001
\]
Problem 3

The load line for $V_x + R_x$ is

\[ V_x \quad \leftarrow \quad R_x \quad \rightarrow \quad O^+ \]

\[ I_{2B} \]

\[ V_{2B} \]

\[ \frac{V_x}{R_x} \]

\[ V_x \quad \rightarrow \quad V_{2B} \]

Any load line that intersects $V_{2B} = 4$ and $I_{2B}$ equals 1mA will be a solution.

There are an infinite number of solutions.

Pick a line and solve. I will draw my line on the original graph.
Problem 3

The circuit element above is called a Zeta Bugger. It has the I-V characteristic shown below.

1) Specify \( V_x \) and \( R_x \) so that the circuit will have a numerical solution of \( V_{2B} = 4V \) and \( I_{2B} = 1mA \).
From the graph we see
\[ V_x = 5.75 \text{ - good guess} \]
\[ \frac{V_x}{\text{mA}} = 4 \implies V_x = 5.75 \]
\[ R_x = 1437 \Omega \]

**Problem 4**

\[ R_{\text{eq}} = R_1 + R_2 || R_3 \]

For max power to \( R_{\text{eq}} \), we need \( R_{\text{eq}} = R_s \)

So

\[ R_s = R_1 + R_2 || R_3 \]

or

\[ R_1 = R_s - R_2 || R_3 \]

\[ = 2k - 2k/14k \]

\[ = 2k - 1333 \]

\[ = 667 \]
6) First we will calculate the power absorbed in the equivalent circuit.

\[ I = \frac{10V}{4K} = 2.5 \text{mA} \]

\[ P_{VX} = -I \cdot V_x = (-2.5\text{mA})(10V) = -25 \text{mW} \]

\[ P_{RS} = I^2 \cdot R_S = (2.5\text{mA})^2(2000) = 12.5 \text{mW} \]

\[ P_{R\Omega} = I^2 \cdot R_{\Omega} = (2.5\text{mA})^2(2000) = 12.5 \text{mW} \]

Now look at the equivalent circuit.
We know that we have 5V across each Reg. From before, we need to find the voltage across $R_1$, $R_2$ and $R_3$

\[ V_{R_1} = 5V \left( \frac{R_1}{R_1 + R_2||R_3} \right) = 5V \left( \frac{667}{667 + 1333} \right) = 1.6675V \]

\[ V_{R_2} = V_{R_3} = 5V \left( \frac{R_2||R_3}{R_1 + R_2||R_3} \right) = 5V \left( \frac{1333}{667 + 1333} \right) = 3.3325V \]

Now we can use $P_R = \frac{V^2}{R}$

\[ P_{R_1} = \frac{V_{R_1}^2}{R_1} = \frac{(1.6675V)^2}{667\Omega} = 4.16875\text{mw} \]

\[ P_{R_2} = \frac{V_{R_2}^2}{R_2} = \frac{(3.3325V)^2}{2k} = 5.5528\text{mw} \]

\[ P_{R_3} = \frac{V_{R_3}^2}{R_3} = \frac{(3.3325V)^2}{4000} = 2.7764\text{mw} \]
c) $P_{RS} = 12.5 \text{ mw}$

$$P_{R1} + P_{R2} + P_{R3} = 4.16875 \text{ mw} + 5.5528 \text{ mw} + 2.7764 \text{ mw}$$

$$= 12.49795 \text{ mw}$$

Close to 12.5 mw

d) $P_{Vx} = -25 \text{ mw} = 25 \text{ mw of sourced power}$

$$P_{RS} + P_{R1} + P_{R2} + P_{R3} = 12.5 \text{ mw} + 4.16875 \text{ mw}$$

$$+ 5.5528 \text{ mw} + 2.7764 \text{ mw}$$

$$= 24.99795 \text{ mw}$$

Close to 25 mw