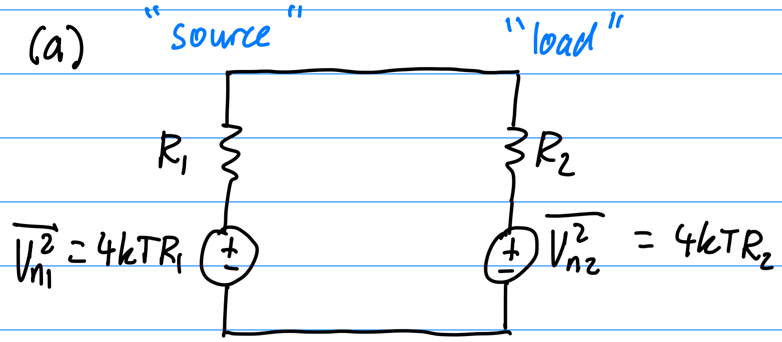
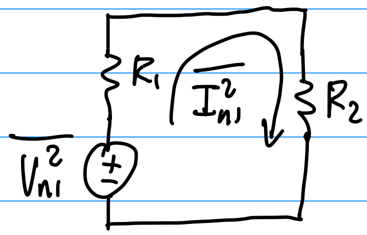
(a)



One source at a time, turn off indep. sources.

By superposition, consider power delivered by V_{n1}.



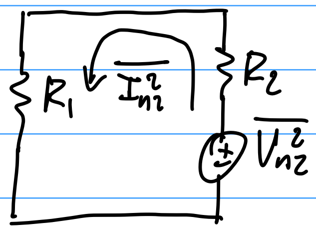
$$I_{n1} = \frac{V_{n1}}{R_1 + R_2} \qquad \therefore \overline{I_{n1}^2} = \frac{\overline{V_{n1}^2}}{(R_1+R_2)^2}$$

$$\overline{P_{R2}} = \overline{I_{n1}^2}\, R_2 = \frac{\overline{V_{n1}^2}\, R_2}{(R_1+R_2)^2} = \frac{4kT R_1 R_2}{(R_1+R_2)^2}$$

expected value of power delivered to R_2 by R_1

Next consider $\overline{V_{n2}^2}$.

$$I_{n2} = \frac{V_{n2}}{R_1 + R_2}$$



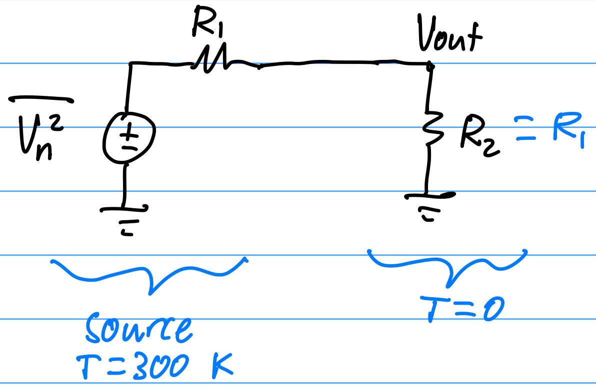
$$\therefore \overline{I_{n2}^2} = \frac{\overline{V_{n2}^2}}{(R_1+R_2)^2} = \frac{4kTR_2}{(R_1+R_2)^2}$$

expected value of power delivered to R_1 by R_2

$$\overline{P_{R1}} = \overline{I_{n2}^2}\, R_1 = \frac{4kT R_1 R_2}{(R_1+R_2)^2}$$

Since $\overline{P_{R1}} = \overline{P_{R2}}$ there is no net flow of power.
$\therefore$ We did not break physics!

(b)



Maximum power transfer requires $R_1 = R_2$.

$$V_{out} = \frac{R_2}{R_1 + R_2} V_n = \frac{R_1}{R_1 + R_1} V_n = \frac{V_n}{2}.$$

$$\therefore \overline{V_{out}^2} = \frac{\overline{V_n^2}}{2^2} = \frac{4kTR_1}{4} = kTR_1.$$

$$P = \frac{V^2}{R} \quad \therefore \overline{P} = \frac{\overline{V_{out}^2}}{R_1} = kT.$$

Think about the units. $\left[\overline{V_{out}^2}\right] = \frac{V^2}{Hz}$

$$\therefore \left[\frac{\overline{V_{out}^2}}{R}\right] = \frac{V^2}{Hz \cdot \Omega} = \frac{W}{Hz}.$$

Check: $[kT] = \frac{J}{K} \cdot K = J = \frac{J \cdot s}{s} = W \cdot s = \frac{W}{Hz}.$

(c). $BW = 1$ GHz $\therefore \overline{P} = kT \times 1 \times 10^9$

$$= 1.38 \times 10^{-23} \times 300 \times 1 \times 10^9$$
$$= 4.14 \times 10^{-12}\ W.$$

$\therefore$ 4 pW (requiring cooling to 0 K) is not practical!