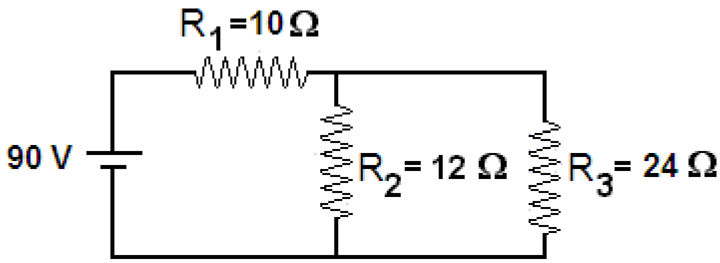
Physics II

Electric Power

$$Power = VI = \frac{V^2}{R} = I^2 R$$

Problem 1.- Find the power delivered by the voltage source:



Solution: To find the power delivered by the voltage source, notice that the three resistors are equivalent to a single resistance. To find this equivalent resistance we see that the 12Ω and the 24Ω resistors are in parallel, so they are equivalent to $R_{equivalent} = \frac{1}{\frac{1}{12\Omega} + \frac{1}{24\Omega}} = 8\Omega$, and then this equivalent resistor is in series with the 10Ω resistor, giving a total of 18Ω. So the power is:

$$Power = \frac{(90V)^2}{18\Omega} = \textbf{450W}$$

Problem 2.- Which has more resistance a 100-W light bulb or a 75-W light bulb? Explain your rationale.

Solution: Since power is given by: $Power = \frac{V^2}{R}$, the lower the power the higher the resistance, for a fixed voltage.

Answer: the **75-W light bulb**.

Problem 3.- If two identical resistors are connected in series to a battery, does the battery have to supply more power or less power than when only one of the resistors is connected?

Solution: If two identical resistors (of value R) are connected in series they have a total resistance R + R = 2R and the power they dissipate is $\frac{V^2}{2R}$, which is less than if only one is connected the battery $\left(\frac{V^2}{R}\right)$.

If two resistors are connected in parallel, their total resistance is $\frac{1}{\frac{1}{R}+\frac{1}{R}} = \frac{R}{2}$, so the power they dissipate will be $\frac{V^2}{(R/2)} = \frac{2V^2}{R}$ which is more than one resistor alone will dissipate $\left(\frac{V^2}{R}\right)$.

Problem 4.- If you are given two identical speakers with resistance of 4Ω each, and an amplifier with an output resistance of 8Ω. How should you connect the speakers to get the maximum power output?

(a) In series (b) In parallel (c) Connect just one.

Solution: To get the maximum power we need to match the resistance of the amplifier (which is 8Ω) so we better connect the speakers **in series** to get 8Ω too.

So, why is this different than the previous problem?
This problem does consider the internal resistance of the source. In the previous case we assumed we had an ideal voltage source, with no internal resistance.

Problem 4a.- If you are given two identical speakers with resistance of 8Ω each, and an amplifier with an output resistance of 8Ω. How should you connect the speakers to get the maximum power output?

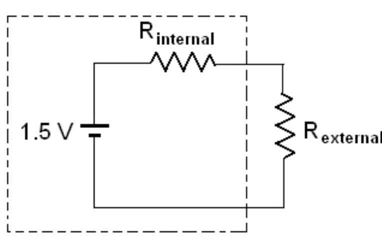
(a) In series (b) In parallel (c) Connect just one.

Solution: To get the maximum power output off an amplifier you should match the internal resistance. The answer is **just one 8-ohm** speaker.

Problem 4b.- The output of an amplifier can be modeled as a 1.5 volt source in series with an internal resistance of $R_{internal}$=5Ω.

a) What external resistance will give the maximum power transfer?

b) How much power is dissipated in the **external** resistance then?



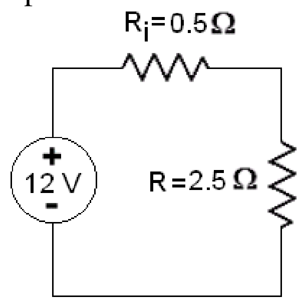
Solution:

a) The external resistance should match the internal one to get the maximum power transfer, so it should be 5Ω.

b) When the external resistance is 5Ω the total resistance is 10Ω, so the current is 0.15A and the power:

$Power = RI^2 = 5 \times 0.15^2 =$ **112.5 mW**

Problem 5.- A model of a battery is represented by an ideal 12-V voltage source in series with an internal resistance of 0.5Ω
Calculate the power delivered to a lamp whose resistance is 2.5 Ω



Solution: The current is: $I = \frac{V}{R} = \frac{12}{2.5 + 0.5} = 4A$

The power dissipated by the 2.5-ohm resistor is $P = I^2 R = 4^2 \times 2.5 =$ **40 watt**