Series Resistance

Circuits containing only resistors which obey Ohm's law can easily be dealt with, but if they include consumer loads with a nonlinear current vs. voltage characteristic (e.g. light bulbs), the problem generally cannot be solved algebraically.

Goals

- You can read values from a given characteristic and draw a characteristic from calculated values.
- You are familiar with the difference between a measured and a calculated characteristic.
- You know how to adjust the voltage across a lamp using a series resistance.

Time: You can work on the problem for 20 minutes.

Problem

A light bulb labelled "110 V/100 W" has the current vs. voltage characteristic displayed in the figure below. It is connected in series to a variable resistor and to a power supply with emf 125 V. Its brightness can be varied by adjusting the series resistance.

What is the light bulb's power consumption when the resistance is set to 200 Ω?

Instructions

1. Draw a schematic circuit diagram.
2. When the voltage across the light bulb has the value V_L, the voltage across the resistor must be $V_R = V_o - V_L$ (why?), where V_o is the total voltage provided by the power supply. Express the current flowing through the resistor as a function of the voltage V_L across the light bulb.
3. Calculate the current I_R through the resistor for V_L = 10 V, 30 V and 50 V. Graph I_R as a function of V_L in the diagram below.
4. There are now two graphs in the diagram: one for the current through the light bulb, the other for the current through the resistor, both as a function of the voltage across the light bulb. What is the only possible value for the real current in the circuit? Read this value from the diagram.

   Hint: Is it possible that for a given voltage across the light bulb the current through the resistor is different from the current through the light bulb?
5. Calculate the light bulb's power consumption at this setting.
6. What is the appropriate setting for the series resistance to have a current of 600 mA?

Additional problem

7. Determine the resistance such that the light bulb's power consumption is 30 W.