

Physics for future Presidents

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Homework 10, due in recitation on Thursday, Oct 17th

Some thoughts on power extension cords

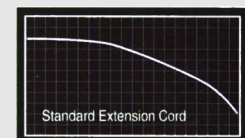
A well-known manufacturer of high-end electric and electronic equipment praises their (12 ft) power extension cords with the following words, plus the accompanying picture:

“Ordinary extension cords often fail to deliver the high current your high powered audio components need to maintain peak performance.

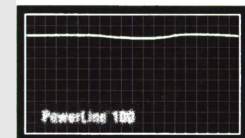
Your high-powered components (like TVs, laser printers, and receivers) may not be getting all the current they need to maximize performance. Ordinary power extension cords with smaller gauge wire often fail to deliver or maintain the consistent level of high current necessary to drive your high-powered components. As a result, you lose the impact and drama in the sound your components were originally designed to deliver.

Connecting your high-powered components to a high current extension cable can help deliver greater sound impact and drama.

Proper connection with a high current extension cable can help ensure your high-powered components get all the power they need. Advanced winding construction boosts low-end bass for greater sound depth.”



Gradual loss of power resulting from the use of a standard power extension cable.



Advanced winding construction maintains high current.

Let's put our nascent understanding of electric current and circuits to good use and analyze this sales pitch.

1. Phrase in your own words, using proper physical terminology, what the vendor is saying (or in your interpretation seems to be saying). Do the (supposedly measured) curves support these claims?
2. “High powered” technically refers to electrical devices which have a high wattage. How many watts does a typical TV, laser printer, or receiver use?
3. What might be the physical reason that a piece of electrical equipment is not getting all the current it needs?

please turn over...

Let's now get serious with some more input. In the US the diameter of electric wires is measured (since 1857) by the "American Wire Gauge", also called the "Brown & Sharpe wire gauge". The number itself is related to the number of *drawing operations* by which wires are manufactured. Hence, a *bigger* number means a *thinner* wire. The diameter d_n of a wire with gauge n is given by the formula

$$d_n = 0.005 \times 92^{(36-n)/39} \text{ inch} . \quad (1)$$

For a gauge 16 wire this means the diameter is $d_{16} = 0.005 \times 92^{20/39} \text{ inch} \approx 0.0508 \text{ inch} \approx 1.29 \text{ mm}$, giving it a cross-sectional area of $A_{16} = 1.31 \text{ mm}^2$. (Optional: try to see whether you can verify this calculation!)

Moreover, the resistance R of a wire can be calculated by the following formula, which makes what we've learned in class more quantitative:

$$R = \rho \frac{L}{A} , \quad (2)$$

where L is the length of the wire, A is its cross-sectional area, and ρ (pronounced "rho") is the *resistivity*, which depends on the material (and also on the temperature). For copper (at 20 C) we find the value $\rho = 1.68 \times 10^{-8} \Omega\text{m}$. " Ω " is the Greek capital letter "Omega" and is used as the symbol for the unit of resistance, "Ohm" (recall that $\Omega = \text{V}/\text{A}$). Also, the "m" behind it is "meter".

4. Calculate the resistance of an ordinary plain vanilla 12 ft extension cord made of gauge 16 copper wire. (Think first carefully about how long the wire is. No, this is *not* a trivial question! Also, *be careful with units!*)
5. Consider now a 400 W electrical appliance. Assume that your electrical outlet delivers 120 V, and neglect potential complications due to the fact that this is alternating current.
 - a) How much current will flow through this device if *directly* plugged into the outlet? Recall that power is current times voltage.
 - b) What, therefore, is its internal resistance? Recall that resistance is voltage divided by current.
 - c) How much *less* current will flow through the device if you instead power it through the extension cord from problem 4? Hint: The resistance of the extension cord and that of the electrical appliance will *add up* to a somewhat bigger *total resistance*, which then determines the somewhat smaller new current that will flow.
 - d) Briefly discuss the significance of your finding (in the context of the above sales-pitch). Don't neglect to contemplate the likelihood that your outlet really delivers 120 V, given that there's also wiring in your apartment going on.