

## Hassle-Free Energy Consumption Measurements of Electrical Devices

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An inexpensive, new electricity usage monitor,<sup>1</sup> which plugs directly into any ordinary 120-V ac socket, greatly simplifies the process of safely measuring energy consumption of any electrical device plugged into it. Multiple push-button options display numeric values for voltage, current, power, elapsed time, and energy consumed for any load (lamp, drill, computer, refrigerator, etc.) up to 15 amperes. This device operates without any peripheral meters or extension cords, and the load can be left on and remain monitored for as long as desired.

Lynch recently reported<sup>2</sup> in the *The Physics Teacher* that monitoring electrical parameters of various ac appliances might serve as an effective strategy for capitalizing on students' preexisting knowledge when introducing basic topics about electricity and electric energy consumption (a subject<sup>3</sup> of increasing interest to the physics community and general public). He used a multimeter with a modified extension cord to monitor the current drawn by various ac appliances in order to calculate energy consumption; this setup, while useful in a supervised classroom context, calls for a certain vigilance about safety (as the editor noted) and would not be suitable for use by unsupervised students outside the classroom.

A safe, convenient, and inexpensive<sup>4</sup> new instrument for monitoring electrical parameters, the Kill-A-Watt<sup>TM</sup> monitor,<sup>1</sup> consists of circuitry in a compact 13-x-6-x-4-cm plastic case with a built-in 3-prong male plug on its back side (which simply plugs into any 120-V ac household electrical socket), a standard female three-conductor socket (for the power cord from any device to be monitored) on its front side along with a 2-x-5-cm LCD screen with five push-

buttons. According to the button pushed, the screen displays real-time RMS values for amps and volts, energy consumption rate in both watts and volt-amps, power factor (PF), line frequency (Hz), elapsed time, and accumulated energy use in kWh.

I first used these monitors last spring in my introductory physics class. Students took Kill-A-Watt<sup>TM</sup> monitors home and measured a 24-hour cycle of energy use for an appliance of their choice (lamp, clock, refrigerator, computer, etc.), estimated annual operating expense using a rough cost of \$0.10/kWh, and reported their findings briefly in class. They enjoyed these "kitchen physics" projects; some students spontaneously extended their energy consumption surveys by comparing the active-versus-sleep cycles of computers and measuring the effects of TV screen size on annual cost. From an environmental science perspective, these monitors should prove useful for introducing energy concepts in a personal and timely way by having students investigate quantitatively the relationships between kWh of electricity consumed, coal burned to produce that electricity, and consequent CO<sub>2</sub> produced by the process; suitable approximate conversion factors<sup>5</sup> are 0.5 kg coal consumed and 1 kg CO<sub>2</sub> produced per kWh of electricity derived from burning coal.

Furthermore, students studying ac theory learn that  $\Phi$  is the phase angle between the RMS voltage  $V$  and the RMS current  $I$  and that the power factor (PF) is defined as

$$PF = \cos \Phi. \quad (1)$$

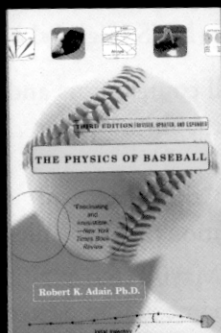
Since the monitor has separate modes show-

ing both the actual rate of energy consumption (watts =  $VA \cos \Phi = VA \cdot PF$ ) and the simple product ( $VA$ ), it can be used to dramatically display the difference between a purely resistive load, such as an incandescent light bulb (for which  $\Phi = 0$  so that watts =  $VA$  and  $PF = 1$ ), and a complex reactive load, such as a motor (with nonzero  $\Phi$  so that watts <  $VA$  and  $PF < 1$ ).

## References

1. <http://p3international.com/products/special/P4400/P4400-CE.html>.
2. John J. Lynch, "Wattage: Household appliances," *Phys. Teach.* 45, 249 (April 2007).
3. William. P. O'Brien Jr., "Mining power and hydrocarbon consciousness from the monthly electric bill : A classroom project," *Phys. Educ.* 42(1), 81-87 (Jan. 2007).
4. Available from various vendors on the Internet for about \$35.
5. Ref. 3 above and references therein.

## Einstein knew relativity, but could he bunt or punt?

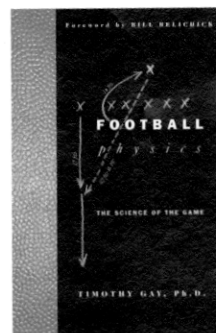


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