Title: **What’s the Difference between Energy and Power?**

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Abstract: This module will show the difference between energy and power. It will do this with examples from the Sun and in the deep Universe, and also with examples from everyday life.

Audience: Undergraduate general-education, introductory astronomy for non-majors, undergraduate general science, and K12 science. A pre-algebra mathematical background is assumed, involving multiplication and units. A Flesch-Kincaid readability test shows that the module is written at a grade level of 9.0.

Educational Goals: This module will show the difference between a solar prominence and a solar flare. It will then use the prominence and the flare to explain the difference between energy and power. This will illustrate a central principle in science: that physical law is *universal*, with the same laws valid everywhere in the Universe.

Module Type: This module is designed to be flexible. It can be used either as an in-class or lab activity, a worksheet, or as a homework assignment.

Module Outline: See the abstract above and the module itself, since the module is only four pages long.

Resources Needed: A basic, four-function calculator would be useful.

References: *Energy: Its Use and the Environment, 5th ed.,* by Roger A. Hinrichs and Merlin H. Kleinbach (Cengage Learning, 2012); also *Astronomy for Beginners, preliminary editon*, by Frederick A. Ringwald (Kendall-Hunt, 2013) or any other fine introductory astronomy text.

What's the Difference between Energy and Power?

<u>Objectives</u>: This module will show the difference between energy and power. It will do this with examples from the Sun and in the deep Universe, and also with examples from everyday life. This will illustrate a central principle in science: that physical law is *universal*, with the same laws valid everywhere in the Universe.

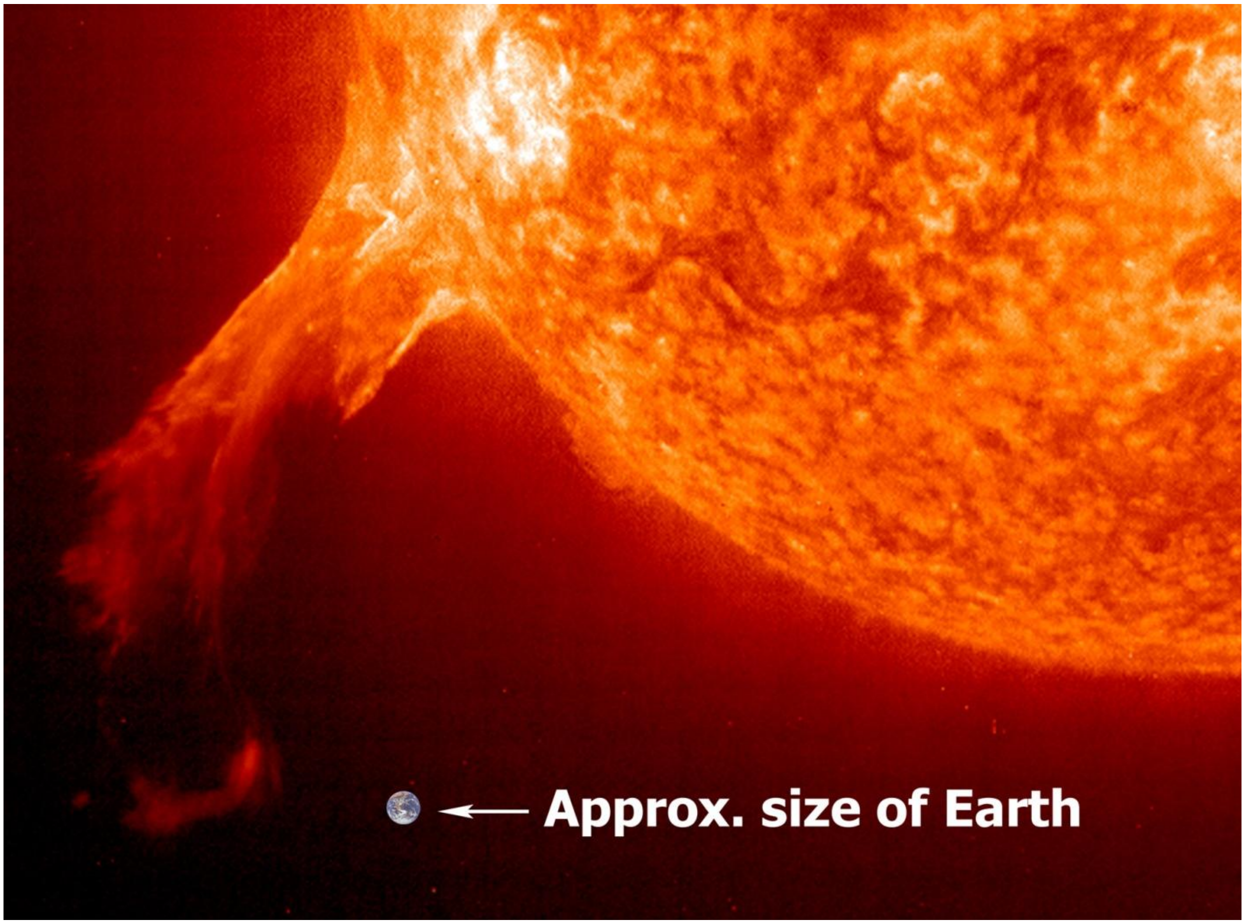

Figure 1: A solar prominence is hot gas rising from the Sun (NASA/ESA/SOHO).

Figure 1 shows a solar *prominence*. A prominence is a streamer of hot gas rising from the Sun. They can look like loops, or like flames. Prominences can extend a million miles into space: notice how Figure 1 shows the size of Earth, to show just how big a prominence can be. Of course, Earth is never this close to the Sun: this is just a size comparison. A prominence can last for about 8 hours. It's fun to use a safe solar telescope to watch prominences come and go, over an afternoon.

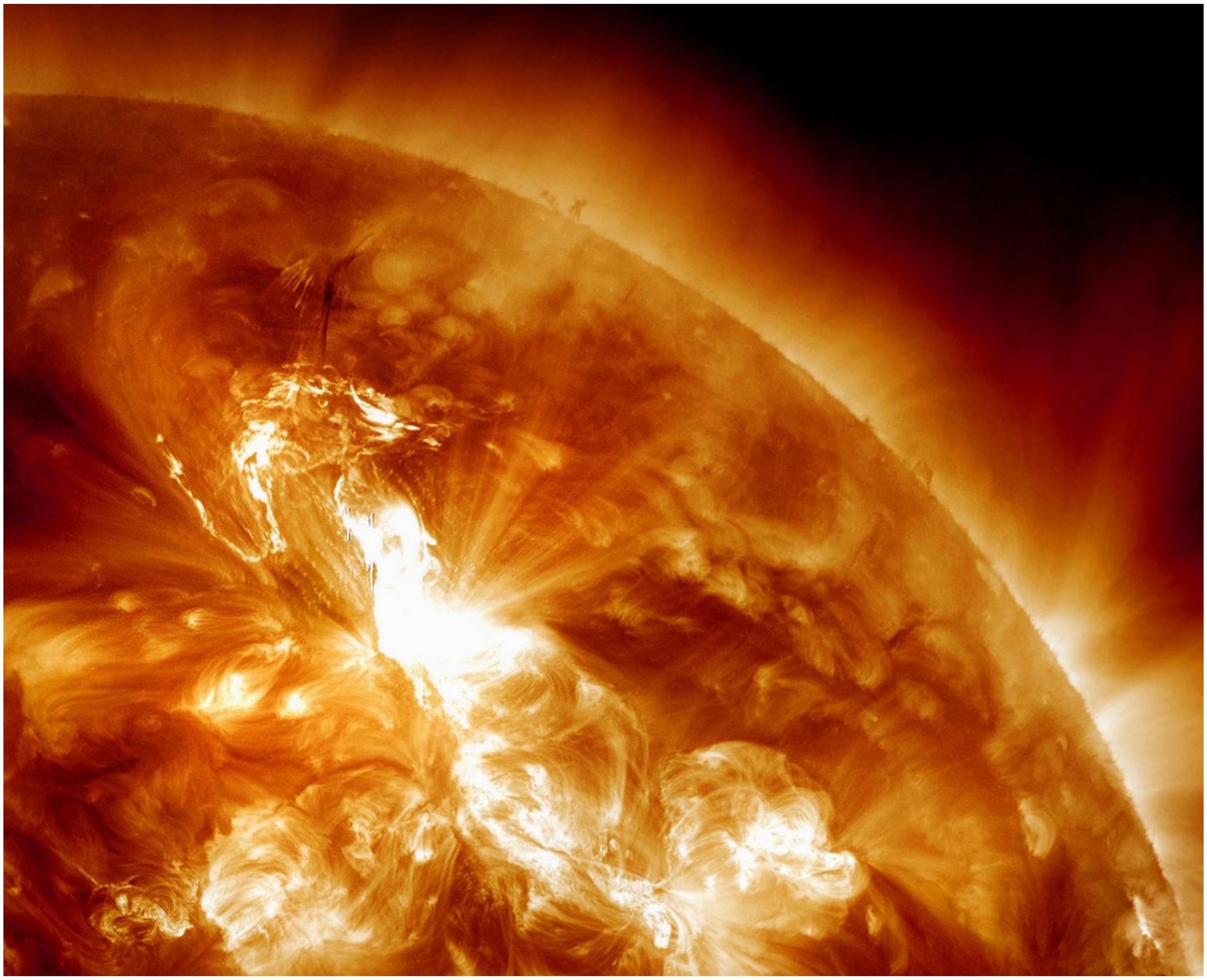

Figure 2: A solar flare is a violent explosion on the Sun (NASA/SDO).

Figure 2 shows a solar *flare*. Flares are violent, often having 10 times more energy than solar prominences. Solar flares also last only about 5 minutes. This means that solar flares are explosive, releasing their energy in 10 times less time than solar prominences do.

Solar flares are therefore 100 times more ***powerful*** than solar prominences. This is because solar flares have 10 times more energy, and release it in 10 times less time. In other words:

$$\text{Power} = \text{energy}/\text{time}.$$

In other words, power is how fast you use energy.

Why should anyone care about this? One reason is that it's practically useful. Remember that physical law is *universal*: the Universe follows orderly laws that we observe to work the same, throughout the Universe.

Name: ______________________________

Day: ________________________________

Time: ______________________________

Lab Instructor: _______________________

Worksheet: What's the Difference between Energy and Power?

Using what was written on the previous two pages, you can count up all the electrical energy that you use in a day. To do this, you need to know how much power your electrical devices use, and how much time you use them in a typical day.

Think about your dorm room, apartment, home, or whatever residence you live in, and fill in your estimates of how many hours per day, on average, you use the following electrical devices:

	Power	×	Average time in use per day	=	Energy used per day (Watt-hours)
Refrigerator	75 Watts	×	_______ hours	=	___________
Electric alarm clock	10 Watts	×	_______ hours	=	___________
Hair dryer	500 Watts	×	_______ hours	=	___________
Reading lamp	60 Watts	×	_______ hours	=	___________
Ceiling light	100 Watts	×	_______ hours	=	___________
Desktop computer	100 Watts	×	_______ hours	=	___________
Printer	50 Watts	×	_______ hours	=	___________
Air conditioner	200 Watts	×	_______ hours	=	___________
Space heater	600 Watts	×	_______ hours	=	___________
Toaster	100 Watts	×	_______ hours	=	___________
Microwave oven	100 Watts	×	_______ hours	=	___________
Charger for a cell phone (or mobile phone)	5 Watts	×	_______ hours	=	___________
Charger for a digital music player (such as an iPod)	7 Watts	×	_______ hours	=	___________
Charger for a tablet computer (such as an iPad)	10 Watts	×	_______ hours	=	___________
Television	100 Watts	×	_______ hours	=	___________
Video game controller	2 Watts	×	_______ hours	=	___________
Charger for a laptop computer	65 Watts	×	_______ hours	=	___________
Stereo or other loud music player	100 Watts	×	_______ hours	=	___________
Washing machine	100 Watts	×	_______ hours	=	___________

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Clothes dryer	300 Watts ×	_______ hours =	___________
Other 1 ______________________	___ Watts ×	_______ hours =	___________
Other 2 ______________________	___ Watts ×	_______ hours =	___________

SUM of electrical energy used per day, in Watt-hours = ___________

This is useful and practical, since the electric company calculates your electric bill in kilo-Watt-hours, abbreviated kWh, where 1000 Watt-hours = 1 kWh.

(For a more extensive list, see *Energy: Its Use and the Environment, 5th ed.*, by Roger A. Hinrichs and Merlin H. Kleinbach, 2012.)

Hint 1: Most refrigerators are on for 24 hours per day. Many desktop computers are left on for 24 hours per day. Hair dryers are used for only about 10 minutes per day, so while they use lots of power (in other words, they use energy very fast), they don't use as much energy as other appliances use, since they're not used all day.

Hint 2: Remember that: 5 minutes = 1/12 hour = 0.083 hours,
10 minutes = 1/6 hour = 0.167 hours,
15 minutes = 1/4 hour = 0.25 hours.

Hint 3: An average American household uses about 20 kWh per day.

QUESTION: Which of the electrical devices listed above uses the most power? ____________________

QUESTION: Which electrical device listed above uses the most energy, in a day? __________________

QUESTION: Which of the electrical devices listed above uses the *least* power? ____________________

QUESTION: Which electrical device listed above uses the *least* energy, in a day? __________________

Another example of the difference between energy and power is the Saturn V moon rocket. The first stage of the Saturn V was the most powerful machine ever built, 85 times more powerful than Hoover Dam, near Las Vegas. The Saturn V's first stage only fired for 12 minutes, though, in order to fly into orbit. Hoover Dam may be 85 times less powerful, but it has been in the Colorado River near Lake Mead since 1936. Hoover Dam has generated much more energy, since although it's less powerful, it has operated for a much longer time.

One more example of the difference between energy and power are quasars and gamma-ray bursts. Quasars are the most energetic things known in the Universe: they shine with the power of 10,000 galaxies for millions of years. Gamma-ray bursts are the most powerful explosions known: one gamma-ray burst was more powerful than the whole rest of the Universe, but for less than two seconds. This gamma-ray burst didn't have as much energy as a quasar, even though it was much more powerful—but only for two seconds.