Calculating Energy for Juno

Understanding how much sunlight the Juno spacecraft is receiving, and by extension how much energy the solar panels can generate at any point on its journey to Jupiter is vital to mission success and as simple as understanding division and exponents. We use these math concepts to describe a relationship between Earth, the sun and the spacecraft in a law known as the inverse square law.

The inverse square law is expressed as $\frac{1}{d^2}$ where d equals distance in astronomical units (AU) to the spacecraft as compared with Earth's distance to the sun. An astronomical unit is the average distance between Earth and the sun – about 149.6 million kilometers. The inverse square law tells us how much energy is received at any point compared to a reference point. In this case, the reference point is Earth.

Juno at …	Distance (d)	$\frac{1}{d^2}$	Percent of energy received	Watts per square meter available
Earth	1.00	$\frac{1}{1^2}$	100%	1360.8 w/m^2
Mars orbit	1.52	$\frac{1}{1.52^2}$	43.3%	589 w/m^2
Ceres orbit (asteroid belt)	2.77	$\frac{1}{2.77^2}$	13.0%	177 w/m^2
record setting distance	5.30	$\frac{1}{5.3^2}$	3.6%	48 w/m^2
Jupiter (at farthest distance from sun)	5.37	$\frac{1}{5.37^2}$	3.4%	47 w/m^2

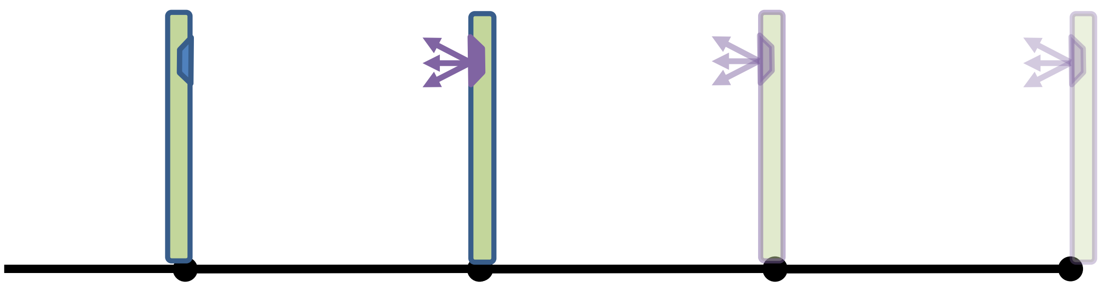
Juno's massive solar panels provide 49.7 m^2 of active solar cells. However, they do not turn 100% of the available energy into power for the spacecraft. If the solar panels were able to convert 28% of the energy that falls on the solar panels into useable power, how much power could they potentially generate at each of the locations named above?

	Earth	Mars orbit	Ceres orbit	Record setting distance	Jupiter
Power generated (watts)	18,937 watts	8,197 watts	2,463 watts	668 watts	654 watts

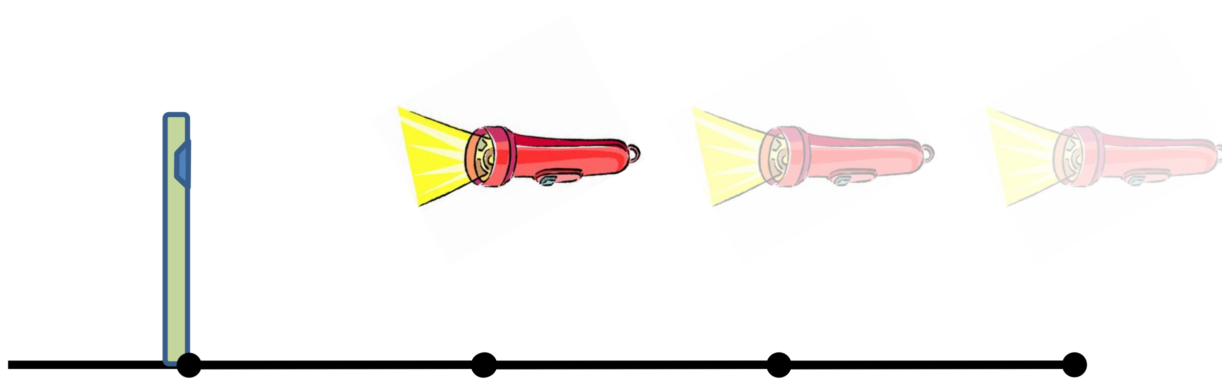
Testing the Inverse Square Law

1. In a dark room, stand a mobile device upright as close to vertical as you can with the light sensor (typically on the front) facing in the direction of your light source. You may need to brace it with books to keep it perpendicular to the surface.
2. Open the lux measurement app.
3. Place the light source one foot away and record the lux reading. If you have a second mobile device with an LED light, that can be used as a light source pointing toward the first device with the lux meter app.
   SAFETY: LEDs from mobile devices provide an even output of very low temperature light compared to flashlights with incandescent bulbs and reflectors. If you use a flashlight and have removed the reflector housing to create an even light source, the exposed bulb can become very hot. Be careful to avoid burns.
4. Based on the one-foot reading, use the inverse square law to calculate what the light reading will be at two, three, four and five feet.
5. Move the light source an additional foot away. Record the lux measurement and check to see if the measurement matches your prediction. Because there may be stray light reaching the light sensor, the measurement may not exactly match your prediction.
6. Continue recording light measurements at three, four and five feet from the sensor, comparing measurements to predictions.

Sample setups



Mobile device w/ light sensor
Mobile device with LED
1 foot
2 feet
3 feet



Mobile device w/ light sensor
Flashlight
1 foot
2 feet
3 feet

Testing the Inverse Square Law

Distance to light source (d)	$\frac{1}{d^2}$	Fraction of energy received	Percent of energy received	Lux
1 foot	$\frac{1}{1^2}$	$\frac{1}{1}$	100%	Measured: ________
2 feet	$\frac{1}{2^2}$	$\frac{1}{4}$	25%	Predicted: ________ Measured: ________
3 feet	$\frac{1}{3^2}$	$\frac{1}{9}$	11%	Predicted: ________ Measured: ________
4 feet	$\frac{1}{4^2}$	$\frac{1}{16}$	6%	Predicted: ________ Measured: ________
5 feet	$\frac{1}{5^2}$	$\frac{1}{25}$	4%	Predicted: ________ Measured: ________