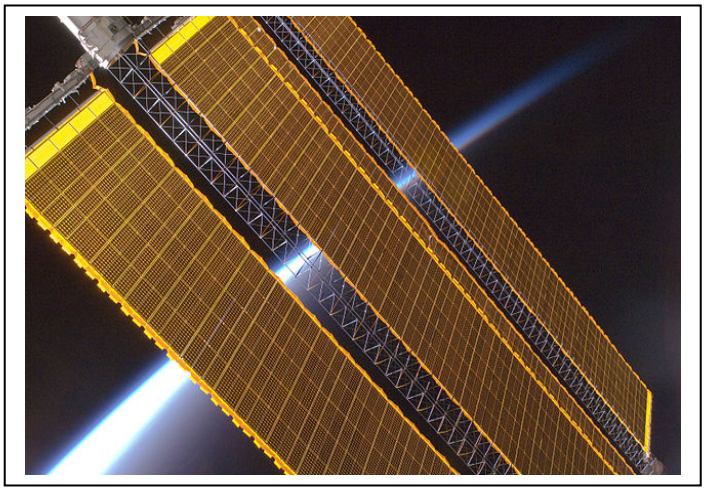
Solar Electricity in Space



Since the beginning of the Space Program, engineers have developed solar panels as the most efficient way to generate electricity in space.

Sunlight strikes a solar cell and causes electrons to flow in the compounds of which the cells are made, usually silicon and germanium. These electrons are collected and produce an electrical current that can be used to operate spacecraft equipment.

The bigger the area of a solar cell, the more electricity they can generate from sunlight. Because the mass of a solar panel increases as its area gets bigger, engineers try to keep the mass of the solar panel as small as possible. Solar panels are rated by the number of watts they generate per square-meter of area. One rating, call it X, is similar to the ordinary solar cells that you can buy at a hobby or crafts store. A second rating, call it Y, is a bit more expensive but generates more electricity per kilogram than Type X. Solve the problems below to determine X and Y.

Problem 1 – The combined mass of the Juno and Dawn spacecraft is 4375 kilograms. As it turns out, the difference between two times the Juno mass and five times the Dawn mass equals 3500 kg. What is the mass of each spacecraft?

Problem 2 - Solar cell efficiency the ratio of the power in watts produced to the area of the panel in square meters. For example, a solar panel that produces 1000 watts and has an area of 50 meter^2 has an efficiency of 1000/50 = 20 watts/m^2. The Chandra spacecraft uses 26 square meters of solar panels with an efficiency of X to generate its electricity, while the Juno spacecraft uses a solar panel with 45 square meters with an efficiency Y to generate its electricity. The total amount of power produced for both spacecraft is 11,340 watts. If Y added to 3 times X gives a total efficiency of 470 watts/m^2, what are X and Y?

Problem 3 - The Aura spacecraft orbits Earth and measures atmospheric ozone. The instruments require 10,300 watts of power and use Efficiency Y solar cells. How many square meters of solar panels does the spacecraft use to generate the electricity?

Answer Key

Problem 1 – The combined mass of the Juno and Dawn spacecraft is 4375 kilograms. As it turns out, the difference between two times the Juno mass and five times the Dawn mass equals 3500 kg. What is the mass of each spacecraft?

Answer: $J + D = 4375$
$2J - 5D = 3500$

By substitution: $D = 4375 - J$,
Then $2J - 5(4375-J) = 3500$
So $7J = 25375$
And so, $J = 3625$ kg and $D = 4375-3625 = 750$ kg

Dawn =750 kg, and Juno = 3625 kg.

Problem 2 – Solar cell efficiency is a measure of the ratio of the power in watts produced to the area of the panel in square meters. The Chandra spacecraft uses 26 square meters of solar panels with an efficiency of X to generate its electricity, while the Juno spacecraft uses a solar panel with 45 square meters with an efficiency Y to generate its electricity. The total amount of power produced for both spacecraft is 11,340 watts. If Y added to 3 times X gives a total efficiency of 470 watts/m^2, what are X and Y?

Sum of wattage for two spacecraft: $11340 = 26 X + 45 Y$
Sum of efficiencies: $470 = 3 X + Y$

By substitution: $Y = 470 - 3X$ then
$11340 = 26 X + 45 (470- 3X)$
$11340 = 21150 - 109 X$
$-9810 = -109 X$
So **$X = 90$**
Then $470 = 3 (90) + Y$
So **$Y = 200$**

Note: The units for X and Y are watts/$meter^2$
so **$X = 90$ watts/m^2 and $Y = 200$ watts/m^2**

Problem 3 - The Aura spacecraft orbits Earth and measures atmospheric ozone. The instruments require 10,300 watts of power and use Efficiency Y solar cells. How many square meters of solar panels does the spacecraft use to generate the electricity?

Answer: Type Y is 200 watts/m^2, so Area = 10300/200 = **51 $meters^2$**.