Working with Rates

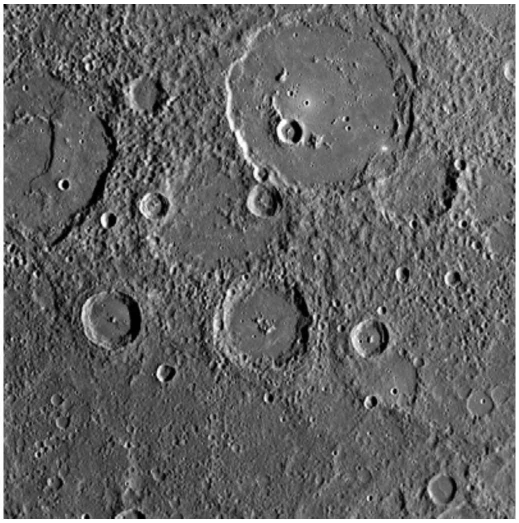

Image of craters on Mercury taken by the MESSENGER spacecraft.

Because things change in the universe, astronomers often have to work with mathematical quantities that describe complex rates.

Definition: A rate is the ratio of two quantities with different units.

In the problems below, convert the indicated quantities into a rate.

Example: 15 solar storms in 2 weeks becomes the rate:

$$R = \frac{\text{15 solar storms}}{\text{2 weeks}} = \frac{15}{2}$$

R = 7 solar storms/week.
or 7 solar storms per week.

Problem 1 - 15 meteor impacts in 3 months.
Problem 2 - 2,555 days in 7 years
Problem 3 - 1,000 atomic collisions in 10 seconds
Problem 4 - 36 galaxies in 2 two clusters
Problem 5 - 1600 novas in 800 years
Problem 6 - 416 gamma-ray bursts spotted in 52 weeks
Problem 7 - 3000 kilometers traveled in 200 hours.
Problem 8 - 320 planets orbiting 160 stars.
Problem 9 - 30 Joules of energy consumed in 2 seconds

Compound Units:

Problem 10 - 240 craters covering 8 square miles of area
Problem 11 - 16,000 watts of energy collected over 16 square meters.
Problem 12 - 380 kilograms in a volume of 20 cubic meters
Problem 13 - 6 million years for 30 magnetic reversals
Problem 14 - 1,820 Joules over 20 square meters of area
Problem 15 - A speed change of 50 kilometers/sec in 10 seconds.

Scientific Notation:

Problem 16 - 3×10^{13} kilometers traveled in 3×10^{7} seconds.
Problem 17 - 70,000 tons of gas accumulated over 20 million square kilometers
Problem 18 - 360,000 Newtons of force over an area of 1.2×10^{6} square meters
Problem 19 - 1.5×10^{8} kilometers traveled in 50 hours
Problem 20 - 4.5×10^{5} stars in a cluster with a volume of 1.5×10^{3} cubic lightyears

Answer Key

Problem 1 - 15 meteor impacts in 3 months. = **5 meteor impacts/month.**
Problem 2 - 2,555 days in 7 years = 2,555 days / 7 years = **365 days/year**
Problem 3 - 1,000 atomic collisions in 10 seconds = **100 atomic collisions/second**
Problem 4 - 36 galaxies in 2 two clusters = **18 galaxies/cluster**
Problem 5 - 1600 novas in 800 years = **2 novas/year**
Problem 6 - 416 gamma-ray bursts spotted in 52 weeks = **8 gamma-ray bursts/week**
Problem 7 - 3000 kilometers traveled in 200 hours. = **15 kilometers/hour**
Problem 8 - 320 planets orbiting 160 stars. = **2 planets/star**
Problem 9 - 30 Joules of energy consumed in 2 seconds = **15 Joules/second**

Compound Units:

Problem 10 - 240 craters covering 8 square miles of area = **30 craters/km^2**
Problem 11 - 16,000 watts of energy collected over 16 square meters. = **1000 watts/km^2**
Problem 12 - 380 kilograms in a volume of 30 cubic meters = **19 kilograms/m^3**
Problem 13 - 6 million years for 30 magnetic reversals = **200,000 years/reversal**
Problem 14 - 1,820 Joules over 20 square meters of area = **91 Joules/m^2**
Problem 15 - A speed change of 50 kilometers/sec in 10 seconds. = **5 km/sec^2**

Scientific Notation:

Problem 16 - 3×10^{13} kilometers traveled in 3×10^{7} seconds.
= **1.0×10^{6} kilometers/sec**
Problem 17 - 70,000 tons of gas accumulated over 20 million square kilometers
= 70,000 tons/20 million km^2 = **0.0035 tons/km^2**
Problem 18 - 360,000 Newtons of force over an area of 1.2×10^{6} square meters
= 392,000 Newtons/1,200,000 m^2 = **0.3 Newtons/m^2**
Problem 19 - 1.5×10^{8} kilometers traveled in 50 hours
= 1.5×10^{8} km/50 hrs = **3 million km/hr**
Problem 20 - 4.5×10^{5} stars in a cluster with a volume of 1.5×10^{3} cubic lightyears
= **300 stars/cubic lightyear**