ACTIVITY 1-1 **Scientific Notation and The Speed of Light**

Radio waves, like all electromagnetic waves, travel at the speed of light – 300 000 000 meters per second (3 hundred million meters per second). The speed of light is obviously a large number. In working with this number, and other large numbers, it is convenient to express it in **scientific notation**. In scientific notation, powers of ten are used to represent the zeroes in large numbers. The following table shows how this is done.

Number	Name	Power of ten
1	one	10^0
10	ten	10^1
100	hundred	10^2
1000	thousand	10^3
10000	ten thousand	10^4
100000	hundred thousand	10^5
1000000	million	10^6
10000000	ten million	10^7
100000000	hundred million	10^8
1000000000	billion	10^9

If you examine the first and last columns, you can see that the power of ten is the same as the number of zeroes in the number. So the speed of light, which is 3 followed by 8 zeroes, becomes 3×10^8 meters per second. The standard symbol for the speed of light is **c**, so we can write:

$$c = 3 \times 10^8 \text{ m/s}$$

Since radio waves travel at a constant speed, the distance traveled is given by:

distance = speed times time

or $d = c\,t$

where d = distance in meters
t = time in seconds
c = 3×10^8 meters per second

Example Problem: How far does a radio wave travel in 5 minutes?

$t = 5 \text{ min} = 5(60) = 300 \text{ s} = 3 \times 10^2 \text{ s}$
$c = 3 \times 10^8$ m/s
d = ? m

$d = c\,t$
$d = (3 \times 10^8)(3 \times 10^2)$
$d = (3 \times 3) \times 10^{8+2}$
$d = 9 \times 10^{10}$ m

RULE: to multiply,

MULTIPLY the numbers,
ADD the powers of ten

Problems:

1. How far does light travel in 20 seconds?
2. How far does light travel in 30 minutes?
3. How far does light travel in 4 hours?
4. How far does light travel in 2 days?

If you know the distance and the speed (c), you can find the time it takes for radio waves to travel that distance using:

$$d = c\,t$$

$$t = \frac{d}{c}$$

where d = distance in meters (m)
c = speed of light (3×10^8 m/s)
t = time in seconds (s)

Example Problem: How long does it take radio waves to travel from Earth to the moon, a distance of 400 000 kilometers?

$d = 400\,000$ km $= 400\,000\,000$ m $= 4 \times 10^8$ m
$c = 3 \times 10^8$ m/s
$t = ?$

$$t = \frac{d}{c}$$

$$t = \frac{4 \times 10^8}{3 \times 10^8}$$

$$t = \frac{4}{3} \times 10^{8-8}$$

$$t = 1.33 \times 10^0 \qquad (\text{NOTE: } 10^0 = 1)$$

$$t = 1.33 \text{ s}$$

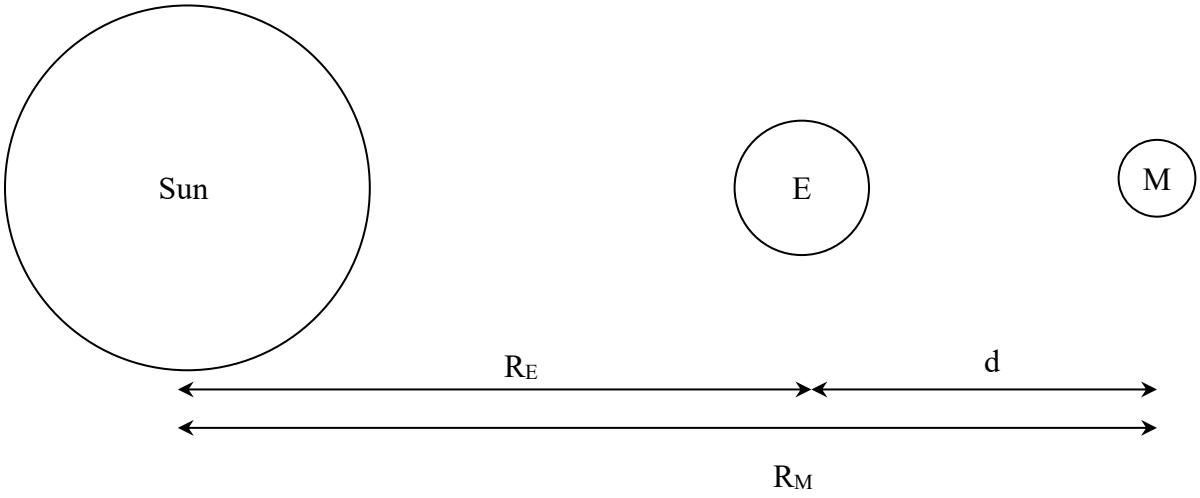
RULE: to divide,

DIVIDE the numbers and SUBTRACT the powers of ten. (Subtract the bottom power from the top)

Example Problem: How long does it take radio waves to travel Mars to Earth when Earth and Mars are on the same side of the sun?

For this problem, we will be working with large numbers that have several non-zero digits. In this case, the power of ten indicates how many places to move the decimal to the right rather than the number of zeroes to add. We will also round off the values so that there are only three nonzero digits with one digit to the left of the decimal. This is called **standard form**.

radius of Mars' orbit $R_M = 227,940,000 \text{ km} = 2.28 \times 10^8 \text{ km} = 2.28 \times 10^{11} \text{ m}$
radius of Earth's orbit $R_E = 149,600,000 \text{ km} = 1.50 \times 10^8 \text{ km} = 1.50 \times 10^{11} \text{ m}$



$d = R_M - R_E$

$d = 2.28 \times 10^{11} - 1.50 \times 10^{11}$

$d = 2.28 - 1.50 \times 10^{11}$

$d = .78 \times 10^{11}$

$d = 7.8 \times 10^{10} \text{ m}$ (NOTE: standard form)

RULE: to subtract,

IF the powers of ten are the same, SUBTRACT the numbers and the power of ten remains the SAME.

$$t = \frac{d}{c}$$

$$t = \frac{7.8 \times 10^{10}}{3 \times 10^8}$$

$t = 2.6 \times 10^{10-8} = 2.6 \times 10^2$

$t = 260 \text{ s}$ (4 minutes 20 seconds)

Use the following table for Problems 5-8.

Planet	Radius of orbit
Mercury	57,910,000 km
Venus	108,200,000 km
Earth	149,600,000 km
Mars	227,940,000 km
Jupiter	778,330,000 km
Saturn	1,429,400,000 km

In the following problems, assume that the planets are on the same side of the sun (as close to one another as possible).

Problems:

5. How long would it take radio waves to travel from Jupiter to Mars?
6. How long would it take radio waves to travel from Jupiter to Venus?

On these last two problems, be careful when you subtract the distances that they have the same power of ten. (HINT: one distance will not be in standard form.)

7. How long would it take radio waves to travel from Jupiter to Saturn?
8. How long would it take radio waves to travel from Mercury to Mars?

Answer key for Activity 1.

1. 6×10^9 m
2. 5.4×10^{11} m
3. 4.32×10^{12} m
4. 5.18×10^{13} m
5. 1.83×10^3 s (30.6 minutes)
6. 2.23×10^3 s (37 minutes)
7. 2.17×10^3 s (36 minutes)
8. 5.6×10^2 s (9.4 minutes)