Module 3: Scientific Notation and the Metric System

Introduction

Science often deals with numbers that are extremely large or extremely small.

For example:

- The number of atoms in a sample of matter may be greater than 10^{23}.
- The diameter of an atom may be approximately 10^{-10} meters.

Writing these numbers in ordinary decimal form would be inconvenient and difficult to read.

To solve this problem, scientists use scientific notation, a method for writing numbers using powers of ten.

Scientific notation makes calculations easier and allows scientists to clearly express extremely large or extremely small quantities.

Scientific Notation

Scientific notation expresses a number in the form:

$a \times 10^n$

where:

a = a number between 1 and 10
n = an integer exponent

The exponent indicates how many places the decimal point has been moved.

Example 1

Write 3000 in scientific notation.

Step 1
Move the decimal point so the number becomes between 1 and 10.

3.0

Step 2
Count how many places the decimal point moved.

3 places

Step 3
Write the exponent.

3×10^3

Example 2

Write 0.00045 in scientific notation.

Step 1
Move the decimal point.

4.5

Step 2
Count decimal movement.

4 places

Step 3
Determine exponent.

4.5×10^{-4}

The exponent is negative because the original number is less than one.

Interpreting Scientific Notation

Scientific notation can also be converted back into ordinary decimal form.

Example

Convert **6.2×10^{3}** to decimal form.

The exponent 3 means the decimal moves three places to the right.

6.2 → 6200

Answer:

6200

Example

Convert **8.1×10^{-5}** to decimal form.

Move the decimal five places to the left.

0.000081

Why Scientific Notation Is Useful

Scientific notation has several advantages.

It simplifies calculations

Multiplying powers of ten is straightforward.

Example:

$10^3 \times 10^2 = 10^5$

It improves readability

Instead of writing:

602000000000000000000000

Scientists write:

6.02×10^{23}

It allows clear comparison of magnitudes

Scientific notation makes it easy to compare very large and very small quantities.

Multiplication in Scientific Notation

When multiplying numbers in scientific notation:

1. Multiply the decimal numbers.
2. Add the exponents.

Example

$(2 \times 10^3)(3 \times 10^4)$

Step 1
Multiply decimals.

$2 \times 3 = 6$

Step 2
Add exponents.

$10^3 \times 10^4 = 10^7$

Answer:

6×10^7

Division in Scientific Notation

When dividing numbers in scientific notation:

1. Divide the decimal numbers.
2. Subtract the exponents.

Example

$(8 \times 10^6) \div (2 \times 10^3)$

Step 1
Divide decimals.

$8 \div 2 = 4$

Step 2
Subtract exponents.

$10^6 \div 10^3 = 10^3$

Answer:

4×10^3

The Metric System

Science uses the metric system, which is based on powers of ten.

Because the metric system is decimal-based, it works naturally with scientific notation.

The metric system is used worldwide in scientific research.

Fundamental Metric Units

Quantity	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K

Metric Prefixes

Metric prefixes indicate multiples or fractions of a unit.

Prefix	Symbol	Value
kilo	k	10^3
hecto	h	10^2
deca	da	10^1
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Example of Metric Conversion

Convert 3 kilometers to meters.

1 kilometer = 1000 meters

3 km × (1000 m / 1 km)

= 3000 meters

Example

Convert 500 milligrams to grams.

1 mg = 10^{-3} g

500 mg = 500 × 10^{-3} g

= 0.5 g

Relationship Between Scientific Notation and Metric Prefixes

Scientific notation and metric prefixes describe the same powers of ten.

For example:

Metric Prefix	Scientific Notation
1 kilometer	10^3 meters
1 millimeter	10^{-3} meters
1 micrometer	10^{-6} meters

Understanding both systems helps simplify scientific calculations.

Estimation in Science

Scientists often estimate quantities using powers of ten.

For example:

• thickness of a human hair ≈ 10^{-4} meters
• diameter of an atom ≈ 10^{-10} meters
• distance to the Sun ≈ 10^{11} meters

Scientific notation makes these values easier to compare.

Worked Problem

Convert 0.0000063 into scientific notation.

Step 1
Move decimal until number is between 1 and 10.

6.3

Step 2
Count decimal places.

6 places

Step 3
Write exponent.

6.3×10^{-6}

Practice Problems

1. Write 450000 in scientific notation.

2. Write 7.8×10^{-4} in decimal form.

3. Convert 0.00000081 into scientific notation.

4. Multiply:

$(3 \times 10^4)(2 \times 10^3)$

5. Divide:

$(6 \times 10^7) \div (3 \times 10^2)$

Metric Conversion Practice

1. Convert 5 km to meters.

2. Convert 200 cm to meters.

3. Convert 3 milligrams to grams.

4. Convert 0.5 meters to centimeters.