Electro Critical Skills Resource Suite

Entry Level Literacy and Numeracy Assessment for the Electrotechnology Trades

Enrichment Resource

UNIT 6: Scientific Notation

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SCIENTIFIC NOTATION

Electrical mathematics often involves using numbers in the thousands and larger, as well as numbers of less than one or down to a thousandth or less.

Scientific notation, sometimes referred to as standard form notation, is a method of reducing these cumbersome numbers to a more manageable form so that there is less chance of making mistakes. The numbers are expressed as powers of ten.

When using a scientific calculator, scientifically notated values can be entered directly into the calculator which reduces the potential for keying in errors.

For example

6,400,000 ohms in standard form is 6.4 x 106

0.0048 amps in standard form is 4.8×10^{-3}

LEARNING OUTCOME

- Can use scientific notation to accurately express numbers in a manageable form.

PERFORMANCE CRITERIA

- Identifies the need for scientific notation.
- Understands the concept of numbers expressed as powers of 10.
- Uses a scientific calculator to accurately apply scientific notation.

PRELIMINARY EXERCISES

Multiplying and Dividing by 10's:

When multiplying by multiples of ten, the decimal point is moved over the same number of places as there are zeros in the multiplier,
e.g.

3.54 x 10 = 35.4	(One zero implies one place).
3.54 x 100 = 354	(Two zeros implies two places).
3.54 x 1000 = 3540	(Three zeros implies three places).

EXERCISE 1

(Without a Calculator)

a) 0.73 x 10 =

b) 0.73 x 1000 =

c) 12.6 x 100 =

d) 0.0089 x 10 =

e) 761.2 x 100 =

f) 3.504 x 100 =

g) 0.6821 x 10000 =

When dividing by multiples of ten, the decimal point moves to the left, the same number of places as there are zeros in the divisor,
e.g.

2.67 ÷ 10 = 0.267	398.6 ÷ 10 = 39.86
2.67 ÷ 100 = 0.0267	398.6 ÷ 100 = 3.986
2.67 ÷ 1000 = 000267	398.6 ÷ 1000 = 0.3986

EXERCISE 2

(Without a Calculator)

a) 0.087 ÷ 10 =

b) 56.8 ÷ 100 =

c) 156.7 ÷ 1000 =

d) 2.4 ÷ 100 =

e) 0.003 ÷ 10 =

f) 100.67 ÷ 100 =

☑ **Use the answer sheet to check your work**

SCIENTIFIC NOTATION – POWERS OF TEN

Electrical quantities can have very large or small values. For example a resistor may have a value of eighty two million ohms or a capacitor may have a value of thirty three millionths of a Farad.

- Eighty two million ohms = 82,000,000 Ω
- Thirty three millionths of a farad = 0.000033F

Look at all the zeros that have to be written, and at all the chances for making mistakes.

A method of simplifying such numbers is to use scientific notation, i.e. expressing the number using powers of ten. This means any number can be expressed as a number between 1 and 10 that is multiplied by 10 raised to some power.

The power of 10 is the exponent: it tells us how many times 10 is multiplied by itself.

Example 1:

$10^0 = 1$
$10^1 = 10$
$10^2 = 10 \times 10 = 100$
$10^3 = 10 \times 10 \times 10 = 1,000$

Note: When a number is raised to the power 0 then it equals 1
Eg. $10^0 = 1$

A method of determining the power of ten is to count the zeros in the multiplier (number you are writing in scientific notation)

Example 2: Write the following numbers in scientific notation:

a) 100 — 100 has 2 zeros therefore $100 = 10^2$

b) 1000 — 1000 has 3 zeros therefore $1000 = 10^3$

Positive powers of ten most commonly used:

$10^0 = 1$
$10^1 = 10$
$10^2 = 100$
$10^3 = 1,000$
$10^4 = 10,000$
$10^5 = 100,000$
$10^6 = 1,000,000$
$10^7 = 10,000,000$
$10^8 = 100,000,000$
$10^9 = 1,000,000,000$

USING SCIENTIFIC NOTATION NUMBERS LARGER THAN ONE

Express 82,000,000 ohms in scientific notation.

a) 82,000,000 ohms = 82 x 1,000,000 ohms
= 82 x 10^6 ohms

Note: There are 6 zeros in the multiplier so it becomes 10^6

OR

b) 82,000,000 ohms = 8.2 x 10,000,000 ohms
= 8.2 x 10^7

Note: There are 7 zeros in the multiplier so it becomes 10^7

Consider the following:

Express 450,000 in scientific notation:

450,000	= 45,000 x 10	= 45,000 x 10^1
450,000	= 4,500 x 100	= 4,500 x 10^2
450,000	= 450 x 1,000	=450 x 10^3
450,000	= 45 x 10,000	= 45 x 10^4
450,000	= 4.5 x 100,000	= 4.5 x 10^5
450,000	= 0.45 x 1,000,000	= 0.45 x 10^6

All of the above answers are equal.

COEFFICIENTS AND EXPONENTS

When a number is expressed in scientific notation it has two parts:

- coefficient
- exponent (power of ten)

eg. 3.6 x 10^3
coefficient exponent

When working with electrical quantities the exponents are generally a multiple of 3 ie. 10^3, 10^6, 10^9, 10^{12}

Therefore: 4,500 volts is expressed as:
4.50 x 10^3
or
0.0045 x 10^6

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RULE 1:

For a number larger than 1, move the decimal point to the left until a number between 1 and 10 results. Then count the number of places the decimal was moved, and use that number as a positive power of 10.

eg. $3,720,000 = 3.72 \times 10^6$

(Decimal point moved 6 places to the left)

EXERCISE 3

Express the following in scientific notation:

a) 2,850 = 2.85 x 1,000 = 2.85 x ....………......................

b) 10,300 = 1.03 x 10,000 = ……………………….x………...............................

c) 3,000,000 = 3 x …………………=……………………...x………….........

d) 2,200 volts =……………...x…………..volts =………..….x…………..volts

e) 2,560,000ohm = ……………………………………………………….ohms

f) 12,000,000,000 watts = ……..watts

☑ **Use the answer sheet to check your work.**

NUMBERS SMALLER THAN ONE

Scientific notation can also be used to simplify very small values. A negative exponent or power indicates the inverse of a positive value.

$10^{1} = 10$

$10^{-1} = \frac{1}{10} = 0.1$

Example 3:

$10^{2} = 10 \times 10 = 100$

$10^{-2} = \frac{1}{10} \times \frac{1}{10} = \frac{1}{100} = 0.01$

$10^{3} = 10 \times 10 \times 10 = 1{,}000$

$10^{-3} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = \frac{1}{1{,}000} = 0.001$

Negative powers of ten commonly used:

$10^{-1} = 0.1$
$10^{-2} = 0.01$
$10^{-3} = 0.001$
$10^{-4} = 0.0001$
$10^{-5} = 0.00001$
$10^{-6} = 0.000001$

Example 4

$6 \times 10^{-2} = 6 \times \frac{1}{100} = 6 \times 0.01 = 0.06$

$6 \times 10^{-3} = 6 \times \frac{1}{1{,}000} = 6 \times 0.0001 = 0.006$

$6 \times 10^{-4} = 6 \times \frac{1}{10{,}000} = 6 \times 0.0001 = 0.0006$

In the above examples, the decimal point is moved to the left the number of places indicated by the power of 10.

Example 5

Express 0.0254 in scientific notation.

$0.0254 = 0.254 \times \frac{1}{10} = 0.254 \times 10^{-1}$

$0.0254 = 2.54 \times \frac{1}{100} = 2.54 \times 10^{-2}$

$0.0254 = 25.4 \times \frac{1}{1{,}000} = 25.4 \times 10^{-3}$

$0.0254 = 254 \times \frac{1}{10{,}000} = 254 \times 10^{-4}$

RULE 2:

For a number smaller than 1, move the decimal point to the right until a number between 1 and 10 results. Then count the number of places the decimal was moved, and use that number as a negative power of 10.

eg. $0.00372 = 3.72 \times 10^{-3}$

(Decimal point moved 3 places to the right)

Consider the following:

$628 = 6.28 \times 10^{2}$
$2{,}000 = 2 \times 10^{3}$
$0.05 = 5 \times 10^{-2}$
$0.0064 = 6.4 \times 10^{-3}$

In Summary

How to write a number in a standard form

Rewrite the number with the decimal point after the first non-zero digit.

Count the number of places you have had to shift the decimal point and write this as a power of 10.

If the number you started with was less than 1 (ie started after the decimal point) make the power negative.

EXERCISE 4

Express the following in scientific notation:

a) 0.0354 = 3.54 x $\frac{1}{\quad\quad}$ = ...…….…... x 10^{-2}

b) 0.0006 = ... x $\frac{1}{10,000}$ = ... x...........

c) 0.000047 = 4.7 x $\frac{\quad\quad}{100,000}$.= …..........x..........

d) 0.0000019 watts.=…….............x……………..watts

e) 0.00735 volts = ……………….x……………..volts

f) 0.0046 amps =………………...x ……………amps

MIXED PROBLEMS

EXERCISE 5

Express each of the following as a number:

a) 1.234 x 10^{-3} amps = ... **A**

b) 15 X 10^{3} volts = ..……............... **V**

c) 130 X 10^{-6} amps = ...…........... **A**

d) 12 X 10^{3} ohms = ...……........**Ω**

e) 3.3 x 10^{-9} watts = ...……...**W**

EXERCISE 6

Circle the equivalent expression for each of the following:

a) 0.000002 **A**

i) 20×10^{-5} **A** ii) 2.0×10^{-6} **A** iii) 0.02×10^{-3} **A**

b) 5,803 V

i) 0.5803×10^{2} **V** ii) 0.05803×10^{6} **V** iii) 5.803×10^{3} **V**

c) $96.348 \times 10^{6}\Omega$

i) 96,348,0000Ω ii) 963,480Ω iii) 6,348,000,0000Ω

ENTERING SCIENTIFIC NOTATION ON THE CALCULATOR

Using the calculator

Note: Steps used on some calculators may differ. Refer to your calculator guide.

Example 1

Enter 4×10^{3} on the calculator

4	EXP	3	=	4,000

Answer: 4,000

Example 2

Enter 6×10^{-3} on the calculator

6	EXP	3	+/-	=	0.006

Answer: 0.006

EXERCISE 7

Use the calculator to check your answers to Exercise 3.

☑ **Use the answer sheet to check your work.**

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ANSWERS

EXERCISE 1

a) 0.73 x 10 = 7.3

b) 0.73 x 1000 = 730

c) 12.60 x 100 = 1260

d) 0.0089 x 10 = 0.089

e) 761.2 x 100 = 76120

f) 3.504 x 100 = 350.4

g) 0.6821 x 10000 = 6821

EXERCISE 2

a) 0.087 ÷ 10 = 0.0087

b) 56.8 ÷ 100 = 0.568

c) 156.7 ÷ 1000 = 0.1567

d) 2.4 ÷ 100 = 0.024

e) 0.003 ÷ 10 = 0.0003

f) 100.67 ÷ 100 = 1.0067

EXERCISE 3

a) 2850 = 2.85 x 10^3

b) 10,300 = 1.03 X 10^4

c) 3,000,000 = 3 x 1,000,000 = 3 x 10^6

d) 220 volts = 2.2 x 100 = 2.2 x 10^2 volts

e) 2,560,000 = 2.56 x 1,000,000 = 2.56 x 10^6 ohms

f) 12,000,000,000 watts = 1.2 x 10^{10} watts

EXERCISE 4

a) 0.0354 = 3.54 x $\frac{1}{100}$ = 3.54 x 10^{-2}

b) 0.0006 = 6.0 x $\frac{1}{10000}$ = 6.0 X 10^{-4}

c) 0.000047 = 4.7 x $\frac{1}{100000}$ = 4.7 X 10^{-5}

d) 0.0000019 watts = 1.9 x 10^{-6} watts

e) 0.00735 volts = 7.35 x 10^{-3} volts

f) 0.0046 amps = 4.6 x 10^{-3} amps

EXERCISE 5

a) 1.234 x 10^{-3} amps = 0.001234**A**

b) 15 x 10^{3} volts = 15000**V**

c) 130 x 10^{-6} amps = 0.00013**A**

d) 12 x 10^{3} ohms = 12,000**Ω**

e) 3.3 x 10^{-9} watts = 0.0000000033**W**

EXERCISE 6

a)	0.000002**A**	(ii)
b)	5803**V**	(iii)
c)	96.348 x 10^{6}**Ω**	(i)