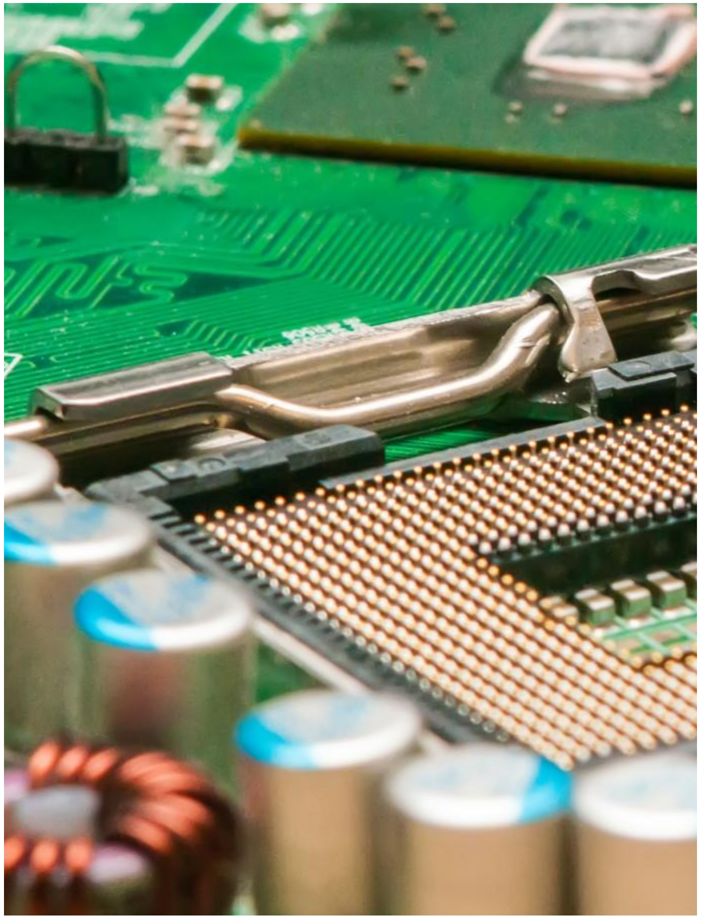
Fundamentals of Electrical & Electronic Engineering

Prof. John G. Breslin, Electrical & Electronic Engineering



Lecture 1

Quantities and Units

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Summary (1 of 27)

Scientific and Engineering Notation

Very large and very small numbers are represented with scientific and engineering notation. In **scientific notation**, a quantity is expressed as a product of a number between 1 and 10, and a power of ten.

In engineering notation, a number can have from one to three digits to the left of the decimal point and the power-of-ten exponent *must* be a multiple of three.

Example What is 47,000,000 in scientific and engineering notation?

47,000,000 =

Summary (2 of 27)

Scientific and Engineering Notation

Very large and very small numbers are represented with scientific and engineering notation. In **scientific notation**, a quantity is expressed as a product of a number between 1 and 10, and a power of ten.

In engineering notation, a number can have from one to three digits to the left of the decimal point and the power-of-ten exponent *must* be a multiple of three.

Example What is 47,000,000 in scientific and engineering notation?

$$47{,}000{,}000 = 4.7 \times 10^{7} \text{ (scientific notation)}$$

$$= 47 \times 10^{6} \text{ (engineering notation)}$$

Scientific and Engineering Notation

Example What is 0.000 027 in scientific and engineering notation?

0.000027 =

A negative exponent means to move the decimal point to the left by the number of places indicated to get the equivalent decimal number.

Example Convert 6.05×10^{-1} (scientific notation) to the equivalent decimal number and to engineering notation.

$6.05 \times 10^{-1} =$

$6.05 \times 10^{-1} =$

Scientific and Engineering Notation

Example What is 0.000 027 in scientific and engineering notation?

$$0.000027 = 2.7 \times 10^{-5} \text{ (scientific notation)}$$

$$= 27 \times 10^{-6} \text{ (engineering notation)}$$

A negative exponent means to move the decimal point to the left by the number of places indicated to get the equivalent decimal number.

Example Convert 6.05×10^{-1} (scientific notation) to the equivalent decimal number and to engineering notation.

$$6.05 \times 10^{-1} = 0.605$$

$$6.05 \times 10^{-1} = 605 \times 10^{-3}$$

Summary (5 of 27)

Scientific and Engineering Notation

Examples

1. Convert 5.25×10^5 to Engineering notation.

2. Convert -2.88×10^{-4} to Engineering Notation.

3. Write 3.25×10^6 as a regular decimal number.

4. Write -2.75×10^{-5} as a regular decimal number.

Summary

Scientific and Engineering Notation

Examples

1. Convert 5.25×10^{5} to Engineering notation.

   525×10^{3}

2. Convert -2.88×10^{-4} to Engineering Notation.

   $-288. \times 10^{-6}$

3. Write 3.25×10^{6} as a regular decimal number.

   3,250,000

4. Write -2.75×10^{-5} as a regular decimal number.

   -0.0000275

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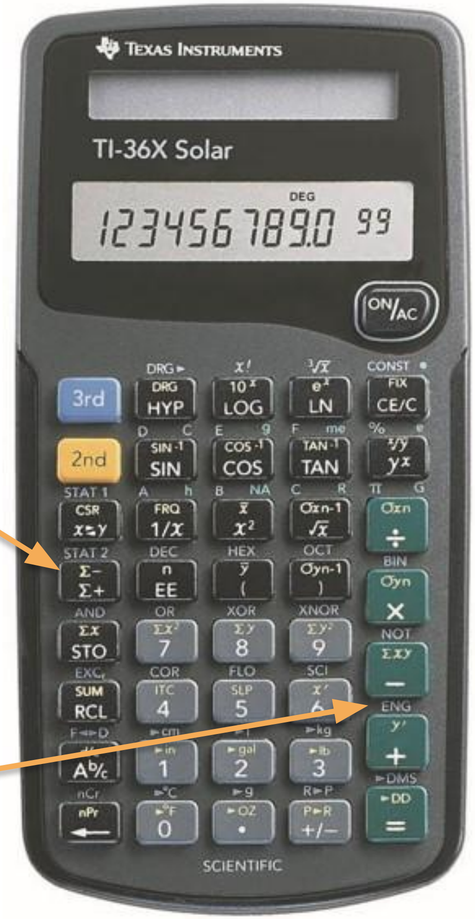
Metric Conversions

Numbers in scientific notation can be entered in a scientific calculator using the E E key.

Most scientific calculators can be placed in a mode that will automatically convert any decimal number entered into scientific notation or engineering notation.



S I Base Units

All S I units are defined from a set of seven **base** units. The base units are all defined (as of 2019) from physical constants of nature that can be realized independently at any place or time. All other units are said to be **derived** units, which can be constructed from the base units.

Quantity	Unit	Symbol
Length	meter	m
Mass	kilogram	k g
Time	second	s
Electric current	**ampere**	**a**
Temperature	kelvin	k
Luminous intensity	candela	c d
Amount of substance	mole	mol

Summary (9 of 27)

Some Important Electrical Units

Except for current, all electrical and magnetic units are derived from the base units. Current is the base unit. A few of the most common electrical units are given in the table.

Quantity	Unit	Symbol
current	**ampere**	**A**
charge	coulomb	C
voltage	volt	V
resistance	ohm	Ω
power	watt	W
frequency	hertz	Hz

These derived units can be expressed in terms of the meter-kilogram-second system, hence are called **m k s** units.

Summary

Engineering Metric Prefixes

Large

Can you name the prefixes and their meaning?

P
T
G
M
k

Summary (11 of 27)

Engineering Metric Prefixes

Large

Can you name the prefixes and their meaning?

P	**peta**	10^{15}
T	**tera**	10^{12}
G	**giga**	10^{9}
M	**mega**	10^{6}
k	**kilo**	10^{3}

Summary (12 of 27)

Engineering Metric Prefixes

Small

Can you name the prefixes and their meaning?

m
μ
n
p
f

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Engineering Metric Prefixes

Small

Can you name the prefixes and their meaning?

m	**milli**	10^{-3}
μ	**micro**	10^{-6}
n	**nano**	10^{-9}
p	**pico**	10^{-12}
f	**femto**	10^{-15}

Aside: prefixes and units gone wrong


17:47

Text Save Share

Eirgrid will buy temporary electricity generators to do the job, although it's currently unclear if these will be fired by oil and gas or a renewable (File pic)

Govt to purchase extra 450mw of electricity next year

IRELAND • 42M
By *Paul Cunningham* | Political Correspondent

The Cabinet has approved a plan from Minister Eamon Ryan to spend €350m on purchasing an additional 450 megawatts of electricity next year.

Eirgrid will buy temporary electricity generators to do the job, although it's currently unclear if these will be fired by oil and gas or a renewable.

The 350m bill will be recouped from customers over a 3-year period, but the Minister says the cost will be more than offset by a reduction in the Public Service Obligation levy.

The PSO was a~~lready reduced to~~zero, under

Metric Conversions

When converting from a larger unit to a smaller unit, move the decimal point to the right. Remember, a smaller unit means the number must be larger.

Example 1

Smaller unit

$$0.47\,\text{M}\Omega = 470\,\text{k}\Omega$$

Larger number

Summary (15 of 27)

Metric Conversions

When converting from a smaller unit to a larger unit, move the decimal point to the left. Remember, a larger unit means the number must be smaller.

Example 2

Larger unit

$$10{,}000\,\text{pF} = 0.01\,\mu\text{F}$$

Smaller number

Summary

Metric Arithmetic

When adding or subtracting numbers with a metric prefix, convert them to the same prefix first.

Example 1 $10{,}000\ \Omega + 22\ \mathrm{k}\Omega =$

$$10{,}000\ \Omega + 22{,}000\ \Omega = 32{,}000\ \Omega$$

Alternatively,

$$10\ \mathrm{k}\Omega + 22\ \mathrm{k}\Omega = 32\ \mathrm{k}\Omega$$

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Summary (17 of 27)

Metric Arithmetic

When adding or subtracting numbers with a metric prefix, convert them to the same prefix first.

Example 2 200 μA + 1.0 mA =

200 μA + 1,000 μA = 1,200 μA

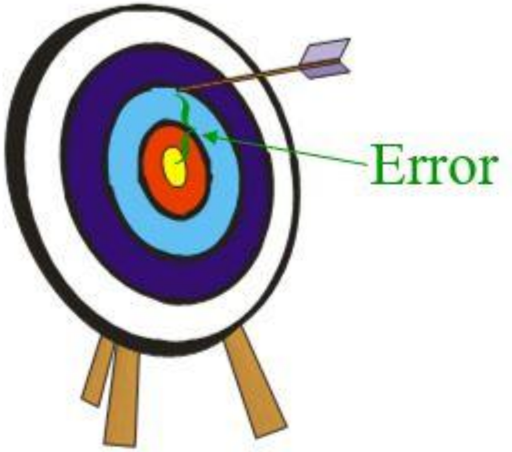
Alternatively,

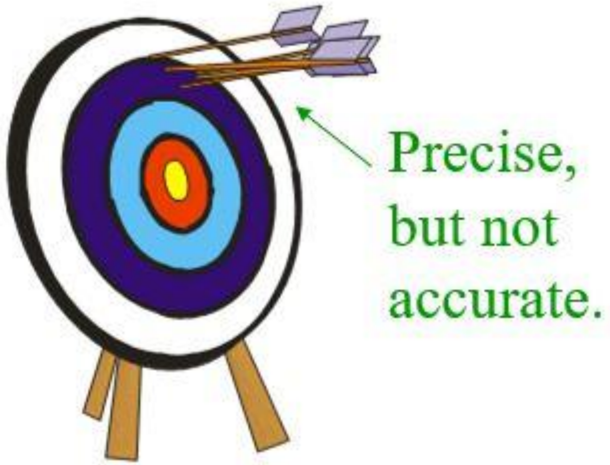
0.200 mA + 1.0 mA = 1.2 mA

Summary (18 of 27)

Error, Accuracy, and Precision

Experimental uncertainty is part of all measurements. **Error** is the difference between the true or best accepted value and the measured value. **Accuracy** is an indication of the range of error in a measurement. **Precision** is a measure of repeatability.





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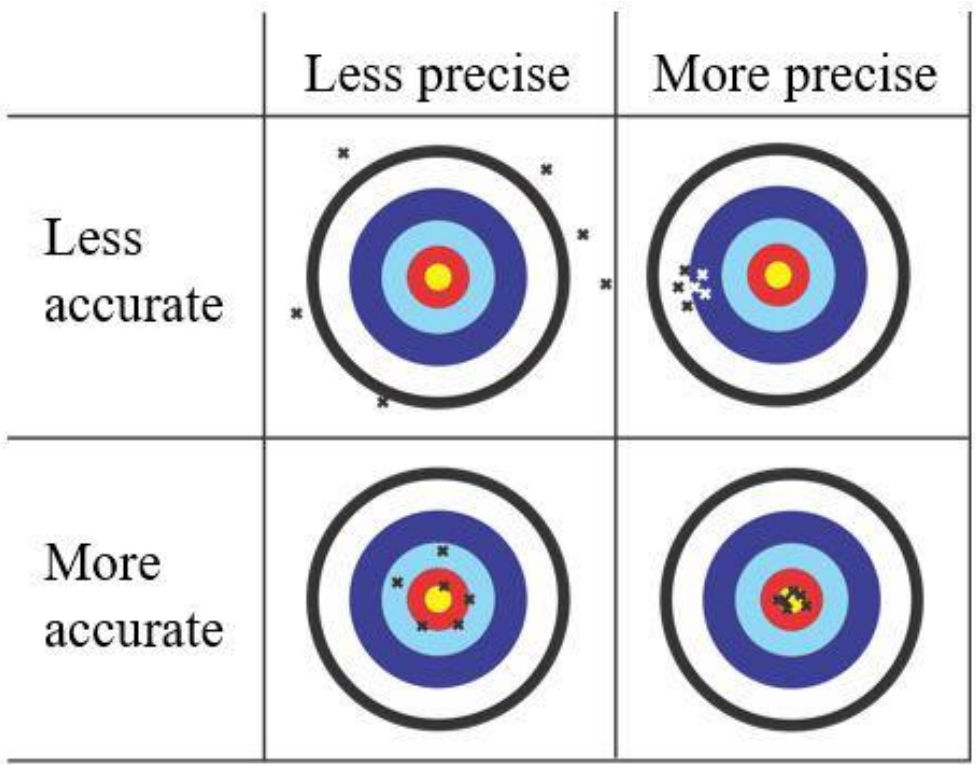
Error, Accuracy, and Precision

Assume the target shows accepted range of values; some possible outcomes of measurements are shown.



Summary (20 of 27)

Significant Digits

When reporting a measured value, one uncertain digit may be retained but other uncertain digits should be discarded. Normally, this is the same number of digits as in the original measurement.

Example Assume two measured quantities are 10.54 and 3.92. If the larger is divided by the smaller, the answer is 2.69 because the answer has the same uncertainty as the original measurement.

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Summary (21 of 27)

Significant Digits

Rules for determining if a reported digit is significant are:

1. Nonzero digits are always considered to be significant.
2. Zeros to the left of the first nonzero digit are never significant.
3. Zeros between nonzero digits are always significant.
4. Zeros to the right of the decimal point for a decimal number are significant.
5. Zeros to the left of the decimal point with a whole number may or may not be significant depending on the measurement.

Summary (22 of 27)

Examples

1. Nonzero digits are always considered to be significant.

   Example: **23.92** has four nonzero digits – they are all significant.

2. Zeros to the left of the first nonzero digit are never significant.

   Example: 0.00**276** has three zeros to the left of the first nonzero digit. There are only three significant digits.

3. Zeros between nonzero digits are always significant.

   Example: **806** has three significant digits.

4. Zeros to the right of the decimal point for a decimal number are significant.

   Example: **9.00** has three significant digits.

5. Zeros to the left of the decimal point with a whole number may or may not be significant depending on the measurement.

   Example: **4**000 does not have a clear number of significant digits.

Summary (23 of 27)

Rounding Numbers

Rounding is the process of discarding meaningless digits. Rules for rounding are:

1. If the digit dropped is greater than 5, increase the last retained digit by 1.
2. If the digit dropped is less than 5, do not change the last retained digit.
3. If the digit dropped is 5, increase the last retained digit <u>if</u> it makes it even, otherwise do not. This is called the "round-to-even" rule.

Summary (24 of 27)

Utility Voltages

Most laboratory equipment is connected to 240 Vrms at the plug. Wiring to the plugs generally uses three insulated wires which are referred to as the line (brown wire) [AKA live],  neutral (blue wire), and earth (green/yellow wire).  

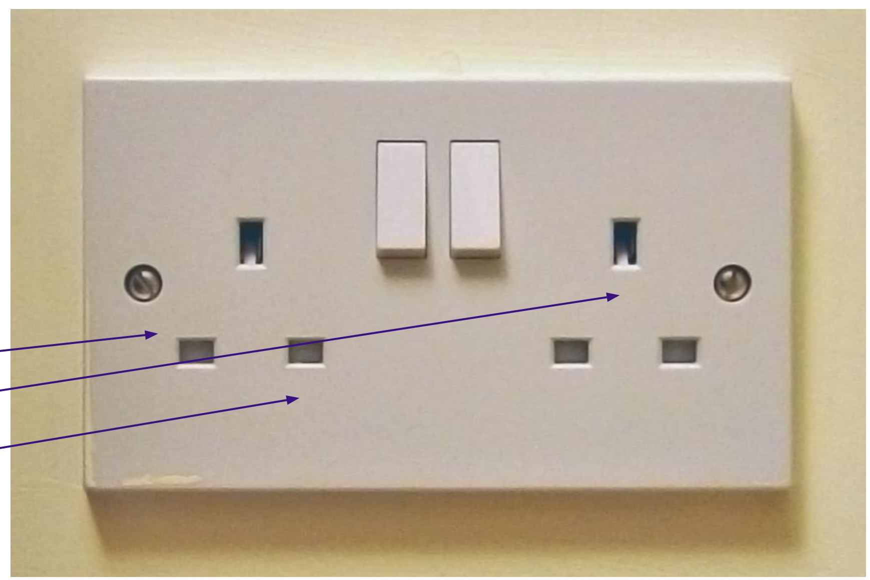

Figure 1.1 BS 1363 socket, L to R: neutral, earth, line

Summary (25 of 27)

R C B O

When there is a load, the line and neutral wires will have current, but the earth line should never have current. This safety wire is connected to the metal exterior of encased equipment, metal conduit, and metal receptacle boxes. Earth is connected to the neutral only at the service panel.

R C B O (Residual Current Circuit Breaker with Over Current Protection): A fault occurs when there is current in the earth line. In this case, the current in the line and the neutral are not equal as they should be and trips the R C B O.

Figure 1.2 Rail-mounted R C B O.

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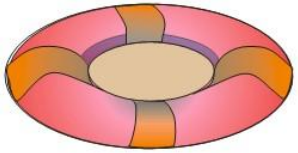
Electrical Safety



Safety is always a concern with electrical circuits. Knowing the rules and maintaining a safe environment is everyone's job. A few important safety suggestions are:

- Do not work alone, or when you are drowsy.
- Do not wear conductive jewellery.
- Know the potential hazards of the equipment on which you are working; check equipment and power cords frequently.
- Avoid *all* contact with energised circuits, even low voltage circuits.
- Maintain a clean workspace.
- Know the location of power shutoff and fire extinguishers.
- Don't have food or drinks in the laboratory or work area.

Summary (27 of 27)

Electrical Safety

Lockout/tagout: If one is working on a circuit that is connected to utility voltages, the service should be disconnected, a notice should be placed on the equipment or place where the service is disconnected, and a padlock should be used to prevent someone from accidentally turning on the power. This procedure is called *lockout/tagout* (L O T O) and is widely used in industry. There are Irish (34) and EU regulations (89/655) related to lockout/tagout.

Figure 1.3 Representative lockout/tagout notice and padlock.

Key Terms (1 of 2)

Engineering notation	A system for representing any number as a one-, two-, or three-digit number times a power of ten with an exponent that is a multiple of three.
Exponent	The number to which a base is raised.
Metric prefix	A symbol that is used to replace the power of ten in numbers expressed in scientific or engineering notation.
Power of ten	A numerical representation consisting of a base of 10 and an exponent; the number 10 raised to a power.

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Key Terms (2 of 2)

Scientific notation	A system for representing any number as a number between 1 and 10 times a power of ten.
Accuracy	An indication of the range of error in a measurement.
Precision	A measure of the repeatability (consistency) of a series of measurements.
Significant digit	A digit known to be correct in a number.

Quiz (1 of 11)

1. A number written as 2.59×10^7 is said to be in

   a. scientific notation

   b. engineering notation

   c. both of the above

   d. none of the above

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Quiz (2 of 11)

2. The electrical unit that is fundamental is the

    a. volt

    b. ohm

    c. coulomb

    d. ampere

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Quiz (3 of 11)

3. In scientific notation, the number 0.000 56 is written

   a. 5.6×10^{4}

   b. 5.6×10^{-4}

   c. 56×10^{-5}

   d. 560×10^{-6}

Quiz (4 of 11)

4. In engineering notation, the number 0.000 56 is written

   a. 5.6×10^{4}

   b. 5.6×10^{-4}

   c. 56×10^{-5}

   d. 560×10^{-6}

Quiz (5 of 11)

5. The metric prefix *nano* means

   a. 10^{-3}

   b. 10^{-6}

   c. 10^{-9}

   d. 10^{-12}

Quiz (6 of 11)

6. The metric prefix *pico* means

   a. 10^{-3}

   b. 10^{-6}

   c. 10^{-9}

   d. 10^{-12}

Quiz (7 of 11)

7. The number 2700 M W can be written

a. 2.7 T W

b. 2.7 G W

c. 2.7 k W

d. 2.7 m W

Quiz (8 of 11)

8. The value $68\ \text{k}\Omega$ is equal to

   a. $6.8 \times 10^4\ \Omega$

   b. $68{,}000\ \Omega$

   c. $0.068\ \text{M}\Omega$

   d. all of the above

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Quiz (9 of 11)

9. The sum of $330 \text{mW} + 1.50 \text{ W}$ is

   a. 331.5 m W
   b. 3.35 W
   c. 1.533 W
   d. 1.83 W

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Quiz (10 of 11)

10. Precision is a measurement of

a. the total error in a series of measurements
b. the consistency of a series of measurements
c. both of the above
d. none of the above

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Quiz (11 of 11)

Answers:

1.	a	6.	d
2.	d	7.	b
3.	b	8.	d
4.	d	9.	d
5.	c	10.	b

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