NILE UNIVERSITY of NIGERIA

FACULTY OF ENGINEERING

GET 101 2021. 2nd Intake. Introduction to Engineering.
Presentation 7 - FUNDAMENTAL DIMENSIONS AND BASE UNITS

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بسم الله الرحمن الرحيم

1. INTRODUCTION

1. INTRODUCTION

Introduction to Dimensions & Units

- **Dimension** is a measurable physical idea
    - consists solely of a word description with no numbers

- **Unit** allows us to quantify a dimension
    - to state a number describing how much of that dimension exists in a specific situation
    - Units are defined by convention and related to an accepted standard.

1. INTRODUCTION

Introduction to Dimensions & Units

- Length is a dimension
    - mile,
    - foot
    - meter
    - light- year
    - fathom.

1. INTRODUCTION

Introduction to Dimensions & Units

- Time is a dimension
    - second
    - minute
    - hour
    - day
    - fortnight
    - year
    - century.

1. INTRODUCTION

Introduction to Dimensions & Units

- Temperature is a dimension
    - Celsius
    - Fahrenheit
    - kelvin.

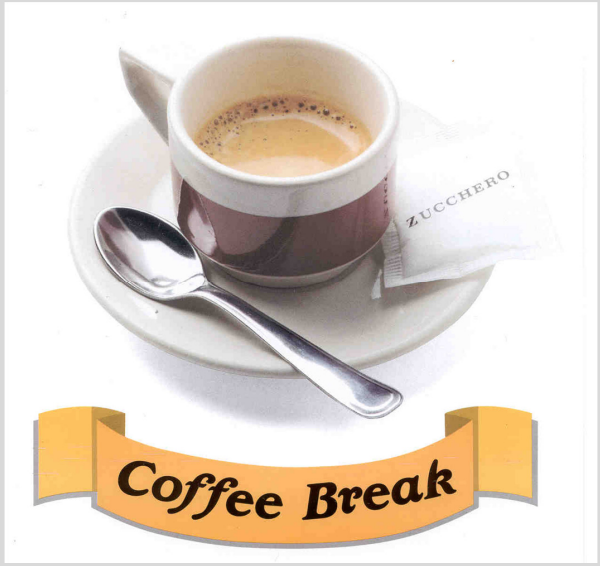
1. INTRODUCTION

Introduction to Dimensions & Units

- The dimensions of length, time, and temperature are familiar to us, but in reality, we do not often use these words since they are fairly vague.

We do not say . . .	We do say . . .
It is really a long **length** to Lumberton.	Lumberton is about 175 **miles** away.
Bake the cake for a **time**.	Bake the cake for 35 **minutes**.
Set the oven to a high **temperature**.	Set the oven to 450 **degrees Fahrenheit**.

- The difference between the left and the right columns is that
  - the statements on the left refer to dimensions and
  - those on the right refer to established standards or units.


ZUCCHERO
Coffee Break

2. THE METRIC SYSTEM

The Metric System

- The SI system (Le Système International d'Unités)
- is the standard set of units for most of the world.
- Originally developed by French scientists under King Louis XVI,
- the SI system was finalised by the international scientific community as the standard unit system in 1971.
- This system defines seven base units, from which all others are derived.
- Table 7-1 below shows the seven base units and their corresponding fundamental dimensions.

2. THE METRIC SYSTEM

The Metric System

Table 7-1 Fundamental dimensions and base units

Dimension	Symbol	Unit	Symbol
Length	L	meter	m
Mass	M	kilogram	kg
Time	T	second	s
Temperature	Θ	kelvin	K
Amount of substance	N	mole	mol
Light intensity	J	candela	cd
Electric current	I	ampere	A

2. THE METRIC SYSTEM

The SI Prefixes

- The SI system is based upon multiples of 10
- By using an **SI prefix** when reporting numbers, we avoid scientific notation or long strings of zeros
- For example, instead of saying, "The distance to Atlanta is 198,000 meters," we would say, "The distance to Atlanta is 198 kilometers."
- For a list of SI prefixes, refer to Table 7-2 below:
- Note that the abbreviations for all SI prefixes
    - from kilo- down to yocto- are lowercase,
    - whereas from Mega- up to Yotta- are uppercase

2. THE METRIC SYSTEM

The SI Prefixes

Table 7-2 SI prefixes (example: 1 millimeter [mm] = 1×10^{-3} meters [m])

Numbers Less than One			Numbers Greater than One		
Power of 10	Prefix	Abbreviation	Power of 10	Prefix	Abbreviation
10^{-1}	deci-	d	10^{1}	deca-	da
10^{-2}	centi-	c	10^{2}	hecto-	h
10^{-3}	milli-	m	10^{3}	kilo-	k
10^{-6}	micro-	μ	10^{6}	Mega-	M
10^{-9}	nano-	n	10^{9}	Giga-	G
10^{-12}	pico-	p	10^{12}	Tera-	T
10^{-15}	femto-	f	10^{15}	Peta-	P
10^{-18}	atto-	a	10^{18}	Exa-	E
10^{-21}	zepto-	z	10^{21}	Zetta-	Z
10^{-24}	yocto-	y	10^{24}	Yotta-	Y

2. THE METRIC SYSTEM

The SI Prefixes - Scientific & Engineering Notation

- Determining the appropriate SI prefix to use becomes simple when the number is placed in engineering notation:
    - just examine the exponent.
- **Scientific notation** is
    - typically expressed in the form #.### × 10^N,
        - where the digit to the left of the decimal point is the most significant nonzero digit of the value being represented.
    - Sometimes, the digit to the right of the decimal point is the most significant digit instead.
    - The number of decimal places can vary, but is usually two to four.
    - *N* is an integer, and multiplying by 10^N serves to locate the true position of the decimal point.

2. THE METRIC SYSTEM

The SI Prefixes - Scientific & Engineering Notation

- **Engineering notation**
  - is expressed in the form ###.### × 10^{M},
    - where *M* is an integer multiple of 3, and
    - the number of digits to the left of the decimal point is 1, 2, or 3
    - as needed to yield a power of 10 that is indeed a multiple of 3.
  - The number of digits to the right of the decimal point is typically between two and four.

2. THE METRIC SYSTEM

Example 7.1 - The SI Prefixes

Express the following values using scientific notation, engineering notation, and using the correct SI prefix.

Standard
(a) 43,480,000 m
(b) 0.0000003060 V
(c) 9,860,000,000 J
(d) 0.0351 s

2. THE METRIC SYSTEM

Example 7.1 - The SI Prefixes

Solution

Standard	Scientific	Engineering	With Prefix
(a) 43,480,000 m	4.348×10^{7} m	43.48×10^{6} m	43.48 Mm
(b) 0.0000003060 V	3.060×10^{-7} V	306.0×10^{-9} V	306.0 nV
(c) 9,860,000,000 J	9.86×10^{9} J	9.86×10^{9} J	9.86 GJ
(d) 0.0351 s	3.51×10^{-2} s	35.1×10^{-3} s	35.1 ms

Note that

- the numeric values of the mantissa are the same in the last two columns, and
- the exponent in engineering notation specifies the metric prefix.

2. THE METRIC SYSTEM

The Official SI Rules

When reporting units using the SI system, follow these official rules.

1. If a unit abbreviation appears as a capital letter, it has been named after a person; all other abbreviations appear as lowercase letters.
2. Symbols of units are not shown as plural.
3. Symbols are not shown with a period unless they appear at the end of a sentence.
4. Symbols are written in upright Roman type (m, k, L) to distinguish them from mathematical variables (*m*, *k*, *l*), which are indicated by italics.

2. THE METRIC SYSTEM

The Official SI Rules

5. One space separates the number and symbol, except with the degree symbol referring to an angle.
6. Spaces or commas may be used to group digits by threes.
7. Symbols for derived units formed by multiple units are joined by a space or interpunct (the center dot). Care must be taken to avoid confusing SI prefixes with units.
8. Symbols for derived units formed by dividing units are joined by a virgule (the “slash” /) or shown with a negative exponent.
9. Do not combine prefixes to form compound prefixes. Use the single correct prefix.

2. THE METRIC SYSTEM

The Official SI Rules

When reporting units using the SI system, follow these official rules.

1. **If a unit abbreviation appears as a capital letter, it has been named after a person; all other abbreviations appear as lowercase letters.**
    - For example, the abbreviation "N" stands for "newton," the SI unit of force named after Isaac Newton.
        - Correct: The book weighs 5 N.
        - Incorrect: The book weighs 5 n.
        - Correct: The rod is 5 m long.
        - Incorrect: The rod is 5 M long.
    - The one exception to this rule is the volumetric unit of liter.
        - The abbreviation is shown as L,
        - since a lowercase l can be confused with both the number 1 and the uppercase letter I.

2. THE METRIC SYSTEM

The Official SI Rules

2. **Symbols of units are not shown as plural.**
    - Correct: 10 centimeters = 10 cm
    - Incorrect: 10 centimeters ≠ 10 cms

3. Symbols are not shown with a period unless they appear at the end of a sentence.
    - Correct: The rod is 5 mm long.
    - Incorrect: The rod is 5 mm. long.

2. THE METRIC SYSTEM

The Official SI Rules

5. Symbols are written in upright Roman type (m, k, L)
    - to distinguish them from mathematical variables (*m*, *k*, *l*), which are indicated by italics.

6. One space separates the number and symbol, except with the degree symbol referring to an angle.
    - Correct: 5 mm or 5°
    - Incorrect: 5mm or 5 °

7. Spaces or commas may be used to group digits by threes.
    - Correct: 1 000 000 or 1,000,000

2. THE METRIC SYSTEM

The Official SI Rules

7. Symbols for derived units formed by multiple units are joined by a space or interpunct (the center dot).
    - Care must be taken to avoid confusing SI prefixes with units.
    - Correct: kg m or kg . m
    - Incorrect: kgm or mkg
    - This is particularly important when confusion might arise.
        - For example, “ms” stands for millisecond, but “m s” stands for meter second.
        - In cases like this, using a center dot is preferable since it is less likely to be misunderstood.

2. THE METRIC SYSTEM

The Official SI Rules

8. Symbols for derived units formed by dividing units are joined by a virgule (the "slash" /) or shown with a negative exponent.
    - Care must be taken to appropriately display the entire denominator.
    - Correct: $N/(m\ s^2)$ or $N\ m^{-1}\ s^{-2}$
    - Incorrect: $N/m\ s^2$

2. THE METRIC SYSTEM

The Official SI Rules

9. Do not combine prefixes to form compound prefixes.
    - Use the single correct prefix.
    - Correct: picojoules (pJ)
    - Incorrect: millinanojoules (mnJ)
    - Correct: Gigaseconds (Gs)
    - Incorrect: kiloMegaseconds (kMs)

2. THE METRIC SYSTEM

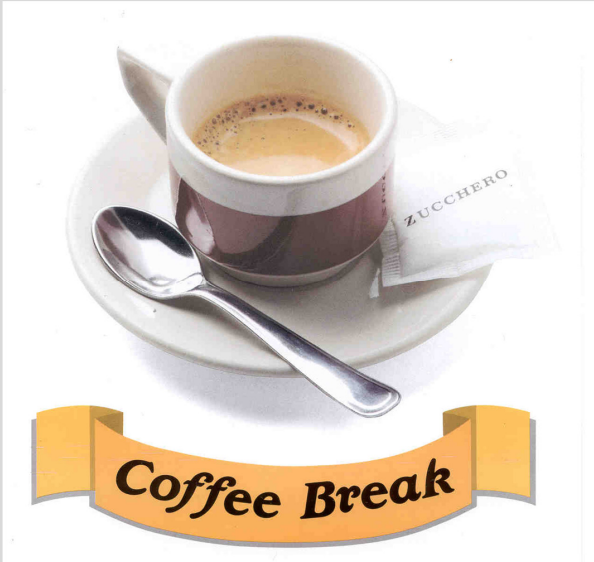
Example 7.2 - The Official SI Rules

Indicate if the following units are correctly expressed according to the official SI rules. If the unit is incorrectly displayed, show the correction.

a. Reading this sentence took 5 Secs.

b. The average person's pupils are 60mms. apart.

c. One gallon is the same as 380 microkiloliters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2. THE METRIC SYSTEM

The Other Unit Systems

- Several other systems of units
- The other countries that use non - SI units are USA, Liberia and Myanmar, Great Britain to some extent
- It is important to know how to convert between all unit systems.
    - Table 7-3 below compares several systems.
- The system listed as AES (American Engineering System)
    - in common use by the general public in the United States.
- The USCS (United States Customary System)
    - commonly called “English” units.

2. THE METRIC SYSTEM

The Other Unit Systems

Table 7-3 Comparison of unit system, with corresponding abbreviations

Dimension	SI (MKS)	AES	USCS
Length {L}	meter [m]	foot [ft]	foot [ft]
Mass {M}	kilogram [kg]	pound-mass [lb_m]	slug
Time {T}	second [s]	second [s]	second [s]
Relative temperature {Θ}	Celsius [°C]	Fahrenheit [°F]	Fahrenheit [°F]
Absolute temperature {Θ}	kelvin [K]	Rankine [°R]	Rankine [°R]

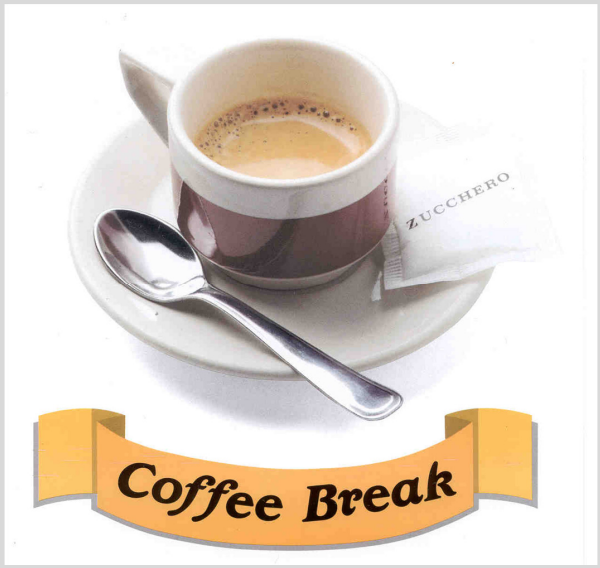
2. THE METRIC SYSTEM

The Other Unit Systems

- The units in Table 7-4 are not technically in the SI system,
  - but due to their common usage,
  - are acceptable for use in combination with the base SI units.

Table 7-4 Acceptable non-SI units

Unit	Equivalent SI	Unit	Equivalent SI
Astronomical unit [AU]	1 AU = 1.4959787×10^{11} m	day [d]	1 d = 86,400 s
Atomic mass unit [amu]	1 amu = $1.6605402 \times 10^{-24}$ g	hour [h]	1 h = 3,600 s
Electronvolt [eV]	1 eV = $1.6021773 \times 10^{-19}$ J	minute [min]	1 min = 60 s
Liter [L]	1 L = 0.001 m^3	year [yr]	1 yr = 3.16×10^7 s
		degree [°]	1° = 0.0175 rad or 1 rad = 57.3°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3. CONVERSION PROCEDURE FOR UNITS

Introduction

- Conversion factors are used to translate from one set of units to another.
- This must be done correctly and consistently to obtain the right answers.

3. CONVERSION PROCEDURE FOR UNITS

Unit Conversion Procedure

1. Write the value and unit to be converted.
2. Write the conversion formula between the given unit and the desired unit.
3. Make a fraction, equal to 1, of the conversion formula in Step 2, such that the original unit in Step 1 is located either in the denominator or in the numerator, depending on where it must reside so that the original unit will cancel.
4. Multiply the term from Step 1 by the fraction developed in Step 3.
5. Cancel units, perform mathematical calculations, and express the answer in "reasonable" terms (i.e., not too many decimal places).

3. CONVERSION PROCEDURE FOR UNITS

Unit Conversion Procedure

LENGTH

1 m = 3.28 ft

1 km = 0.621 mi

1 ft = 12 in

1 in = 2.54 cm

1 mi = 5,280 ft

1 yd = 3 ft

IMPORTANT CONCEPT - Be sure to *always* include units in your calculations *and* your final answer!

3. CONVERSION PROCEDURE FOR UNITS

Example 7.3 - Unit Conversion

Convert the length 40 yards [yd] into units of feet [ft].

Method	Steps
(1) Term to be converted	40 yd
(2) Conversion formula	1 yd = 3 ft
(3) Make a fraction (equal to one)	$\frac{3\text{ ft}}{1\text{ yd}}$
(4) Multiply	$\frac{40\text{ yd}}{}\left\lvert\frac{3\text{ ft}}{1\text{ yd}}\right.$
(5) Cancel, calculate, be reasonable	120 ft

3. CONVERSION PROCEDURE FOR UNITS

Example 7.4 - Unit Conversion

Convert the time 456,200 seconds [s] into units of minutes [min].

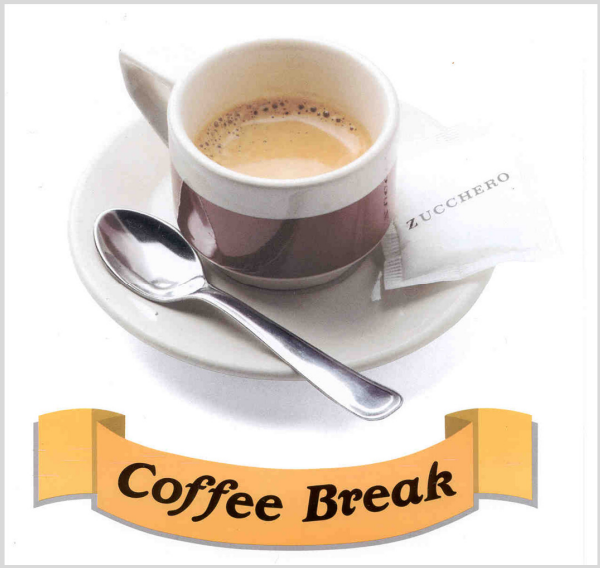
Method	Steps
(1) Term to be converted	456,000 s
(2) Conversion formula	$1\ \text{min} = 60\,\text{s}$
(3) Make a fraction (equal to one)	$\frac{1\ \text{min}}{60\,\text{s}}$
(4) Multiply	$\frac{456{,}000\,\text{s}}{} \left\vert \frac{1\ \text{min}}{60\,\text{s}} \right.$
(5) Cancel, calculate, be reasonable	7,600 min

3. CONVERSION PROCEDURE FOR UNITS

Example 7.5 - Unit Conversion

The highest mountain in the world is Mount Everest in Nepal. The peak of Mount Everest is 29,029 feet above sea level. Convert the height from feet [ft] to miles [mi].

To be considered a full time employee, companies in the United States required you work more than 30 hours in a week. Convert the time 30 hours [h] into units of minutes [min].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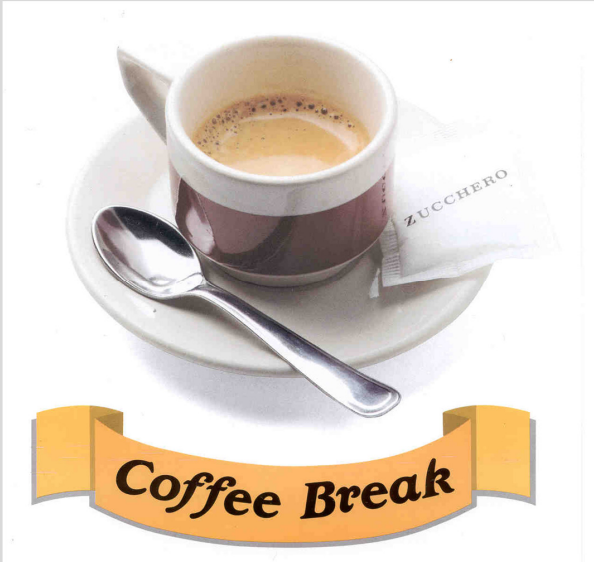
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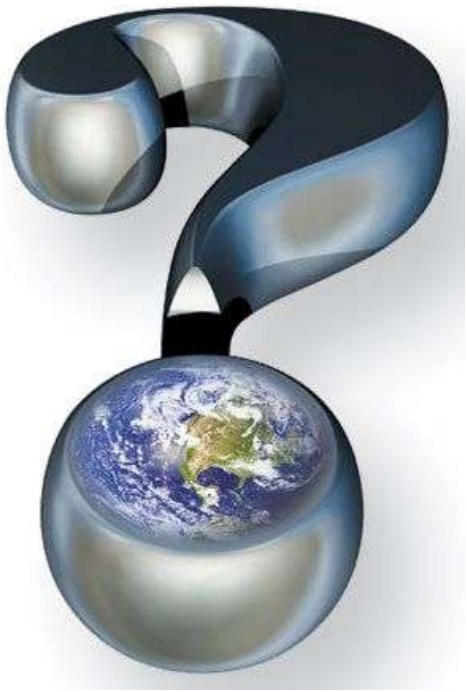
ANY QUESTION?




Thank You!

NEXT TOPIC

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