1 Preparation, Properties, and Proportions

Student Group

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1. Preparation, Properties and Proportions

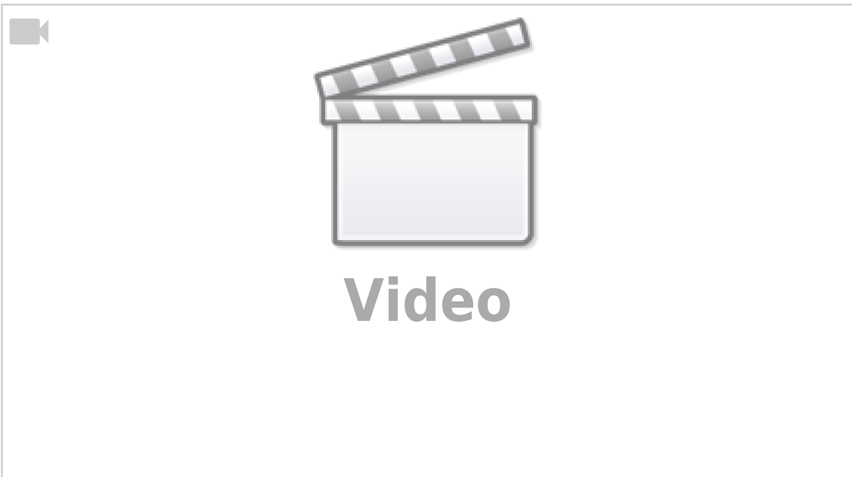
1.1 Physical Proportions

Learning Objectives

By the end of this section, you will be able to:

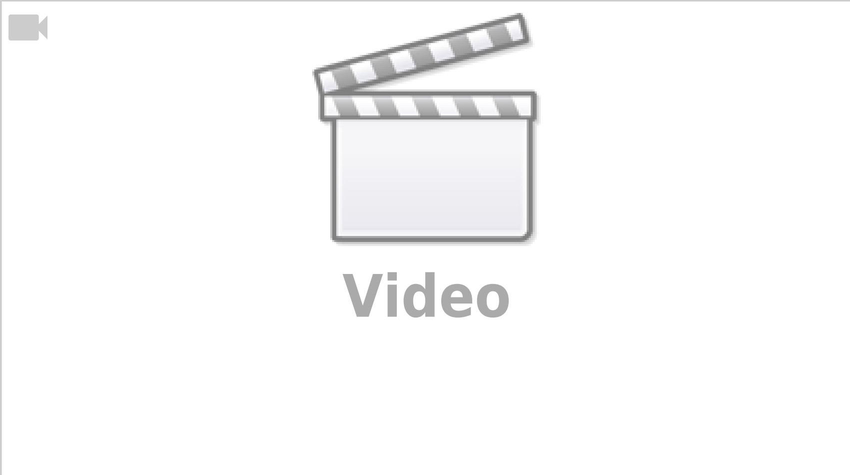
1. know the basic physical quantities and the associated SI units.
2. know the most important prefixes. Be able to assign a power of ten to the respective abbreviation (G, M, k, d, c, m, µ, n).
3. insert given numerical values and units into an existing quantity equation. From this you should be able to calculate the correct result using a calculator.
4. assign the Greek letters.
5. always calculate with numerical value and unit.
6. know that a related quantity equation is dimensionless!

A nice 10 minute intro into some of the main topics of this chapter



System of Units

Short presentation of the SI units



Base quantity	Name	Unit	Definition
Time	Second	s	Oscillation of Cs-Atom
Length	Meter	m	by s und speed of light
el. Current	Ampere	A	by s and elementary charge
Mass	Kilogram	kg	still by kg prototype
Temperature	Kelvin	K	by triple point of water
amount of substance	Mol	mol	via number of ^{12}C nuclides
luminous intensity	Candela	cd	via given radiant intensity

Tab. 1: SI-System

- For practical applications of physical laws of nature, **physical quantities** are put into mathematical relationships.
- There are basic quantities based on the SI system of units (French for Système International d'Unités), see below.
- In order to determine the basic quantities quantitatively (quantum = Latin for "how big"), **physical units** are defined, e.g. $metre$ for length.
- In electrical engineering, the first three basic quantities (cf. table 1) are particularly important. Mass is important for the representation of energy and power.
- Each physical quantity is indicated by a product of **numerical value** and **unit**:
  e.g. $I = 2 A$
  - This is the short form of $I = 2\cdot 1A$
  - I is the physical quantity, here: electric current strength
  - $\{I\} = 2 $ is the numerical value
  - $ [I] = 1 A$ is the (measurement) unit, here: Ampere

derived quantities, SI units and prefixes

- Besides the basic quantities, there are also quantities derived from them, e.g. $1{{m}\over{s}}$.
- SI units should be preferred for calculations. These can be derived from the basic quantities **without a numerical factor**.
  - The pressure unit bar (bar) is an SI unit.
  - BUT: The obsolete pressure unit "Standard atmosphere" ($=1.013 bar$) is **not** an SI unit.
- To prevent the numerical value from becoming too large or too small, it is possible to replace a decimal factor with a prefix. These are listed in table 2.

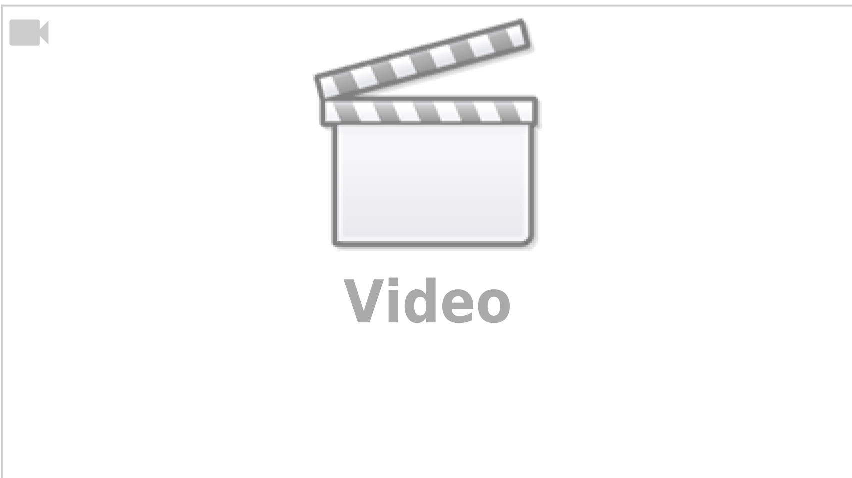
prefix	prefix symbol	meaning
Yotta	Y	10^{24}
Zetta	Z	10^{21}
Exa	E	10^{18}
Peta	P	10^{15}
Tera	T	10^{12}
Giga	G	10^{9}
Mega	M	10^{6}
Kilo	k	10^{3}
Hecto	h	10^{2}
Deka	de	10^{1}

Tab. 2: Prefixes I

prefix	prefix symbol	meaning
Deci	d	10^{-1}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	u, μ	10^{-6}
Nano	n	10^{-9}
Piko	p	10^{-12}
Femto	f	10^{-15}
Atto	a	10^{-18}
Zeppto	z	10^{-21}
Yocto	y	10^{-24}

Tab. 2: Prefixes II

Importance of orders of magnitude in engineering (when the given examples in the video are unclear: we will get into this.)



Physical equations

- Physical equations allow a connection of physical quantities.
- There are two types of physical equations to distinguish (at least in German):
    - Quantity equations (Größengleichungen)
    - Normalized quantity equations (also called related quantity equations, normierte Größengleichungen)

Quantity equations

The vast majority of physical equations result in a physical unit that is not equal to 1.

Example: Force $F = m \cdot a$ with $[F] = kg \cdot {{m}\over{s^2}}$

- A unit check should always be performed for quantity equations
- Quantity equations should generally be preferred

normalized quantity equations

In normalized quantity equations, the measured value or calculated value of a quantity equation is divided by a reference value. This results in a dimensionless quantity relative to the reference value.

Example: Efficiency $\eta = {{P_{out}}\over{P_{in}}}$

As reference value are often used:

- Nominal values (maximum permissible value in continuous operation) or
- Maximum values (maximum value achievable in the short term)

For normalized quantity equations, the units should **always** cancel out.

Example for a quantity equation

Let a body with the mass $m = 100kg$ be given. The body is lifted by the height $s=2m$. What is the value of the needed work?

physical equation:

Work = Force $\cdot$ displacement
$W = F \cdot s \quad\quad\quad\;$ where $F=m \cdot g$
$W = m \cdot g \cdot s \quad\quad$ where $m=100kg$, $s=2m$ and $g=9.81{{m}\over{s^2}}$
$W = 100kg \cdot 9.81{{m}\over{s^2}} \cdot 2m $
$W = 100\cdot 9.81 \cdot 2 \;\; \cdot \;\; kg \cdot {{m}\over{s^2}} \cdot m$
$W = 1962 \quad\quad \cdot \quad\quad\; \left(kg \cdot {{m}\over{s^2}} \right) \cdot m $

> $W = 1962 Nm = 1962 J $

Letters for physical quantities

In physics and electrical engineering, the letters for physical quantities are often close to the English term.

Thus explains C for **C***apacity*, Q for **Q***uantity* and ε_0 for the **E***lectical Field Constant*. But, maybe you already know that C is used for the thermal capacity as well as for the electrical capacity. The Latin alphabet has not enough letters to avoid conflicts for the scope of physics . For this reason, Greek letters are used for various physical quantities (see table 4).

Especially in electrical engineering, **upper/lower case letters** are used to distinguish between

- a constant (time-independent) quantity,
  e.g. the period T
- or a time-dependent quantity,
  e.g. the instantaneous voltage $u(t)$