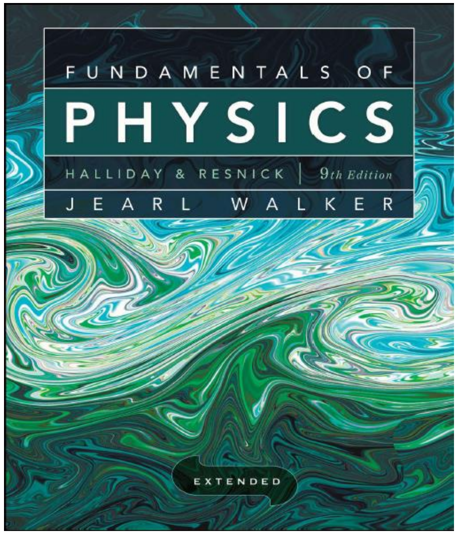
FİZ 137 - PHYSICS 1

CHAPTER 1

MEASUREMENT



Dr. Şeyda ÇOLAK

2018 - 2019

FALL SEMESTER

REFERENCES

1. FUNDAMENTALS OF PHYSICS: HALLIDAY, RESNICK, WALKER, 5th ed.

2. UNIVERSITY PHYSICS: SEARS & ZEMANSKY

3. COLLEGE PHYSICS: SERWAY, VUILLE

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Course Activities	Number	Percentage
Attendance	14	2
Laboratory	-	-
Application	-	-
Field activities	-	-
Specific practical training	-	-
Assignments	4	8
Presentation	-	-
Project	-	-
Seminar	-	-
Midterms	2	2 x 20 = 40
Final exam*	1	50
Total		100
Percentage of semester activities contributing grade succes		**50**
Percentage of final exam contributing grade success.		**50**
Total		**100**

EXAMINATION DATES

1. **MIDTERM: 29.11.2018 – Thursday (13:00 – 14:50)**

2. MIDTERM: 03.01.2019 – Thursday (13:00 – 14:50)

FINAL EXAMINATION: 22.01.2019 – Tuesday (13:00 – 15:00)

1. **MAKEUP MIDTERM: 10.01.2019 – Thursday (10:00 – 11:50)**

2. MAKEUP MIDTERM: 10.01.2019 – Thursday (14:00 – 15:50

Chapter 1

Measurement

In this chapter we will explore the following concepts:

1. **Measurement of a physical parameter**
2. **Units, Systems of units**
3. **Basic Units in Mechanics**
4. **Changing units**
5. **Significant figures**

In Physics we carry out experiments in which we measure physical parameters. We then try to deduce the relationship between the measured quantities.

We usually express this relationship in the form of a mathematical equation which we call the ***"physical law***" that describes the phenomenon under study.

For every physical parameter we will need appropriate units.

We use a `standard` in determination units by which we carry out the measurement by comparison to the standard.

QUANTITY	UNIT	SYMBOL	DIMENSION	DEFINITION (STANDARDS)
1. Length	meter	m	L	Equal to 1,650,763.73 wavelengths in vacuum of the orange-red line of the krypton-86 spectra.
2. Mass	kilogram	kg	M	Cylinder of platinum-iridium alloy kept in France and a number of copies. (May be replaced by an atomic standard within the next ten years.)
3. Time	second	s	T	Time for 9,192,631,770 cycles of resonance vibration of the cesium-133 atom.
4. Temperature	kelvin	K	K	Absolute zero is defined as 0 kelvin. 0 degrees Celsius equals 273.16 kelvins.
5. Luminosity	candela	C	C	Intensity of a light source (frequency 5.40×10^{14} Hz) that gives a radiant intensity of 1/683 watts/steradian in a given direction.
6. Electric current	ampere	A	I	Current that produces a force of 2.10^{-7} newtons per meter between a pair of infinitely long parallel wires 1 meter apart in a vacuum.
7. Amount of substance	mole	mol	–	Number of elementary entities of a substance equal to the number of atoms in 0.012 kg of carbon 12.

Prefixes for SI Units

Factor	Prefix[a]	Symbol	Factor	Prefix[a]	Symbol
10^{24}	yotta-	Y	10^{-1}	deci-	d
10^{21}	zetta-	Z	$\mathbf{10^{-2}}$	**centi-**	**c**
10^{18}	exa-	E	$\mathbf{10^{-3}}$	**milli-**	**m**
10^{15}	peta-	P	$\mathbf{10^{-6}}$	**micro-**	**μ**
10^{12}	tera-	T	$\mathbf{10^{-9}}$	**nano-**	**n**
$\mathbf{10^{9}}$	**giga-**	**G**	$\mathbf{10^{-12}}$	**pico-**	**p**
$\mathbf{10^{6}}$	**mega-**	**M**	10^{-15}	femto-	f
$\mathbf{10^{3}}$	**kilo-**	**k**	10^{-18}	atto-	a
10^{2}	hecto-	h	10^{-21}	zepto-	z
10^{1}	deka-	da	10^{-24}	yocto-	y

[a]The most frequently used prefixes are shown in bold type.

In mechanics we need to define only three parameter

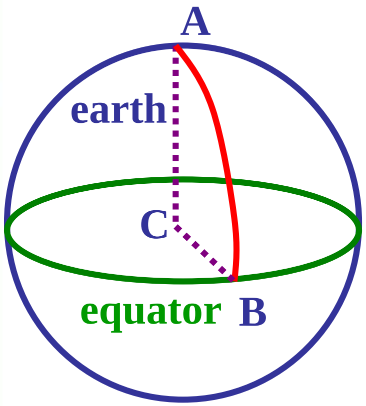
These parameters are: **Length , Time, Mass**

They are known as: **base quantities**

In this lecture we use the \`**International System of Units (SI)** \`

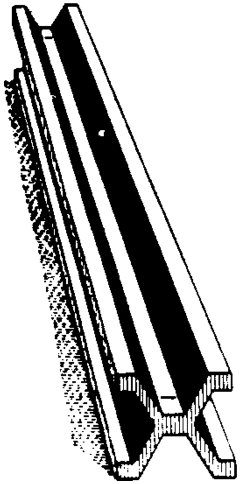
Parameter	**Unit Name**	**Symbol**
Length	meter	m
Time	second	s
Mass	kilogram	kg

The meter



• In 1792 the meter was defined to be one ten-millionth of the distance from the north pole to the equator.

$$1\,\mathrm{m} \equiv \frac{AB}{10^7}$$



• For practical reasons the meter was later defined as the distance between two fine lines on a **standard meter bar made of platinum-iridium.**

• Since 1983 the meter is defined as ***the length traveled by light in vacuum during the time interval of 1/299792458 of a second.*** The reason why this definition was adapted was that the measurement of the speed of light had become extremely precise.

Some Approximate Lengths

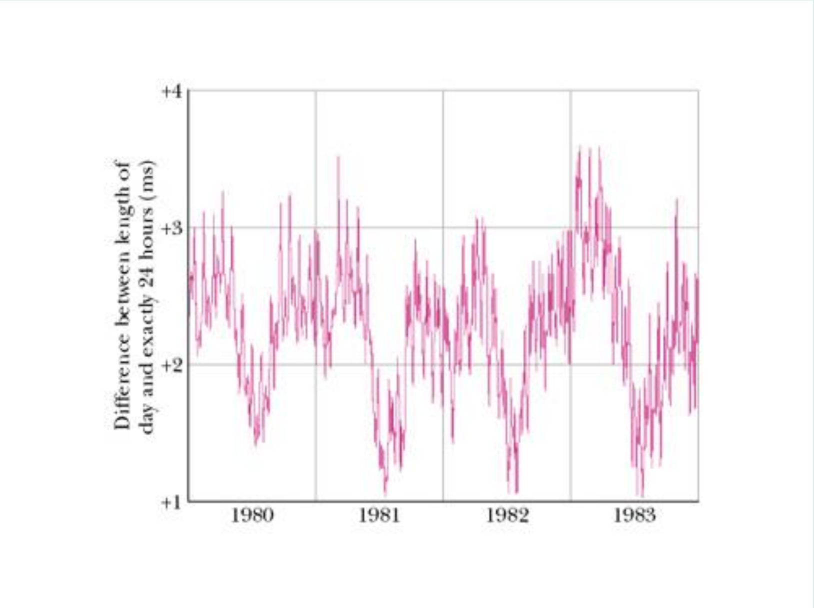
Measurement	Length in Meters
Distance to the first galaxies formed	2×10^{26}
Distance to the Andromeda galaxy	2×10^{22}
Distance to the nearby star Proxima Centauri	4×10^{16}
Distance to Pluto	6×10^{12}
Radius of Earth	6×10^{6}
Height of Mt. Everest	9×10^{3}
Thickness of this page	1×10^{-4}
Length of a typical virus	1×10^{-8}
Radius of a hydrogen atom	5×10^{-11}
Radius of a proton	1×10^{-15}

The Second

Initially the second was defined as follows:

$$1 \text{ second} \equiv \frac{1}{24 \times 60 \times 60}$$

of the time it takes the earth to complete a full rotation about its axis



• The problem with this definition is that the length of the day is not constant as is shown in the figure.

• For this reason since 1967 the second is defined as ***the time taken by 9192631770 light oscillations of a particular wavelength emitted by a cesium-133 atom.*** This definition is so precise that it would take two cesium clocks 6000 years before their readings would differ more than 1 second.

Some Approximate Time Intervals

Measurement	Time Interval in Seconds
Lifetime of the proton (predicted)	3×10^{40}
Age of the universe	5×10^{17}
Age of the pyramid of Cheops	1×10^{11}
Human life expectancy	2×10^{9}
Length of a day	9×10^{4}
Time between human heartbeats	8×10^{-1}
Lifetime of the muon	2×10^{-6}
Shortest lab light pulse	1×10^{-16}
Lifetime of the most unstable particle	1×10^{-23}
The Planck time[a]	1×10^{-43}

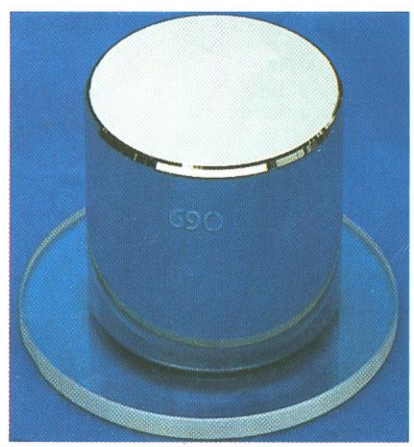
[a] This is the earliest time after the big bang at which the laws of physics as we know them can be applied.

The kilogram

- The SI standard of mass is a platinum-iridium cylinder shown in the figure.

- The cylinder is kept at the ***International Bureau of Weights and Measures*** near Paris and assigned a mass of 1 kilogram.

- Accurate copies have been sent to other countries.



Some Approximate Masses

Object	Mass in Kilograms
Known universe	1×10^{53}
Our galaxy	2×10^{41}
Sun	2×10^{30}
Moon	7×10^{22}
Asteroid Eros	5×10^{15}
Small mountain	1×10^{12}
Ocean liner	7×10^{7}
Elephant	5×10^{3}
Grape	3×10^{-3}
Speck of dust	7×10^{-10}
Penicillin molecule	5×10^{-17}
Uranium atom	4×10^{-25}
Proton	2×10^{-27}
Electron	9×10^{-31}

Changing Units

Quite often we have to change the units of a physical parameter. To do that we must have the conversion factor between one unit and the other.

Appendix D lists several conversion factors between SI units and other units

Example: Express the highway speed limit of 65 miles per hour in meters per second.

1 mile = 1609 m. The converion factors can be written as : $\dfrac{1\text{ mile}}{1609\text{ m}} = \dfrac{1609\text{ m}}{1\text{ mile}} = 1$

1 hour = 3600 s. The converion factors can be written as : $\dfrac{1\text{ hour}}{3600\text{ s}} = \dfrac{3600\text{ s}}{1\text{ hour}} = 1$

The method is called chain link conversion

We use one of the two forms of the conversion factor that eliminates the units we wish to change and introduces the new units.

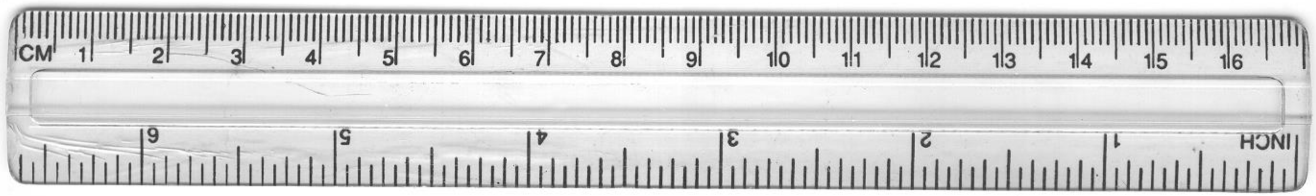
In our example:

$$65\ \frac{\text{miles}}{\text{hour}} = \left(65\ \frac{\text{miles}}{\text{hour}}\right)\left(\frac{1609\text{ m}}{1\text{ mile}}\right)\left(\frac{1\text{ hour}}{3600\text{ s}}\right) = 29\ \frac{\text{m}}{\text{s}}$$

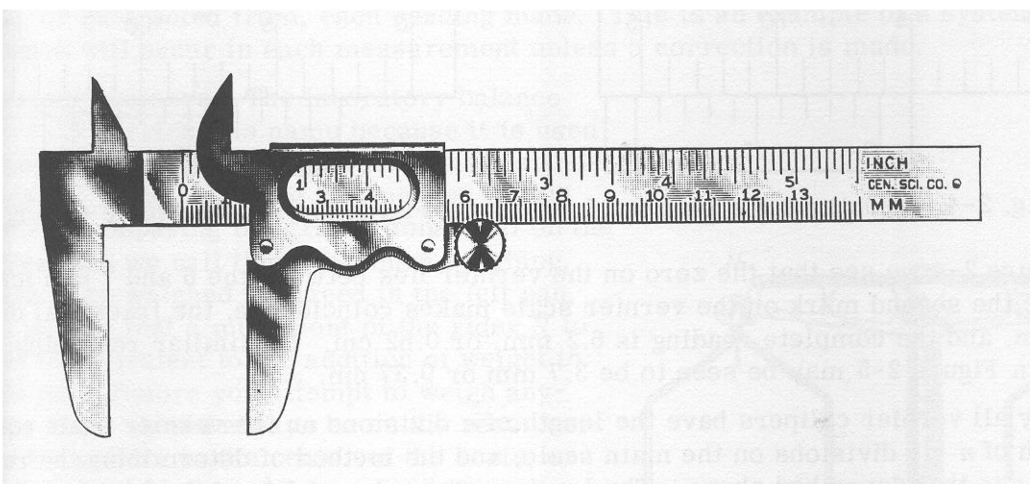
Significant Figures

A certain parameter, for example the length L of an object, can be determined with a varying degree of accuracy. The accuracy depends on the measurement method and the measuring instrument. If I measure L with a ruler (smallest division = 1 mm) I can write L as: $L = 1.234$ m. The length L is given with four significant figures. It would be meaningless to write L as: $L = 1.2345$ m because my ruler cannot measure a fraction of a millimeter. If on the other hand I use calipers that can measure with an accuracy of 0.1 mm, then I can write $L = 1.2345$ m, and L is given with five significant figures.

In a calculation the number of significant figures cannot be larger than the number of significant figures of the parameters used in the calculation



Ruler



Calipers

Example: A car traveling with constant speed v covers a distance d = 123 m in a time t = 7.89 s. The speed v is given by: $v = \frac{d}{t} = \frac{123\ \text{m}}{7.89\ \text{s}} = 15.5893536\ \text{m/s}$

It is meaningless to use 9 significant figures to express v because d and t used to determine v are known with an accuracy of only 3 significant figures

The correct way to express v is: $v = 15.6$ m/s i.e. with 3 significant figures.

Density

Density is the mass per unit volume.

$$\rho = \frac{m}{V}.$$

- Densities are typically listed in kilograms per cubic meter or grams per cubic centimeter.
- The density of water (1.00 gram per cubic centimeter) is often used as a comparison.
- Fresh snow has about 10% of that density; platinum has a density that is about 21 times that of water.