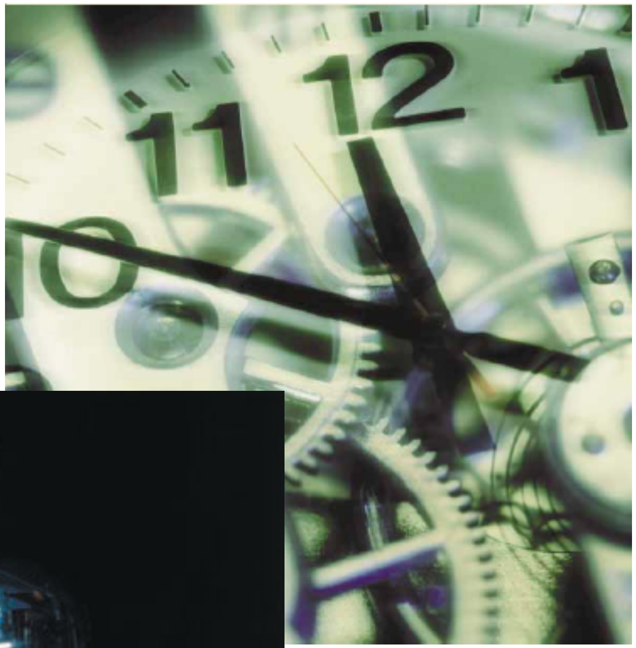
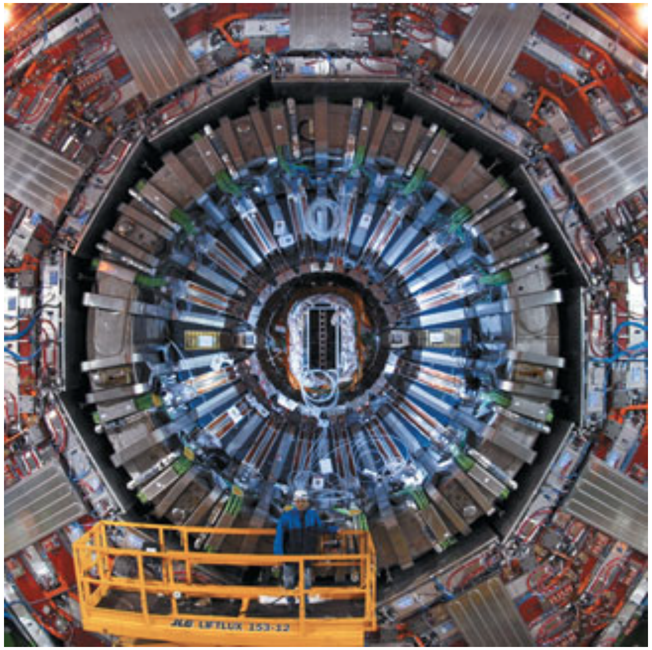
FZM101 Fizik 1

Bölüm1 Fizik ve Ölçme

Chapter 1 Physics and Measurements

1.1 Standards of Length, Mass and Time
1.2 Matter and Model Building
1.3. Density and Atomic Mass
1.4 Dimensional Analysis
1.5 Conversion of Units
1.6 Estimates and Order of Magnitude Calculations
1.7 Significant Figures





Chapter 1 Physics and Measurements

Physics is an experimental science.

Observation the the phenomena of nature + Try the find a pattern relate to this phenomena = THEORY

To develop a scientific theory:

- Ask appropriate question
- Design experiments to try to answer the question
- Draw appropriate conclusions from experimental results

An Example: The legendary experiment of Galileo Galilei and his theory about the gravitation field.

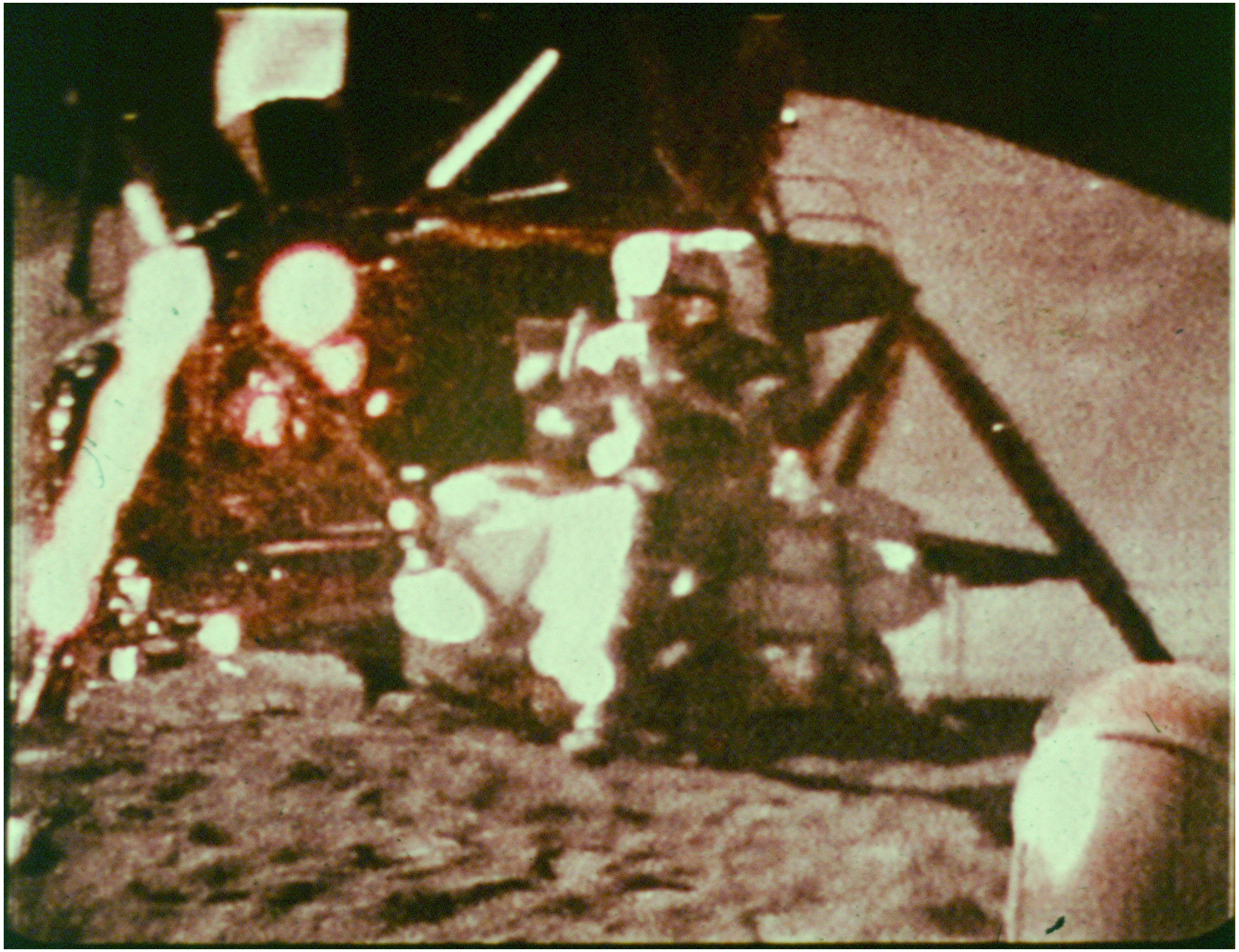
Physics is an experimental science.

Acceleration of a falling object
Is independent of its weight!

A Hammer and a feather reach the ground zero at same time ???????

Was Galileo wrong ????

Physics is an experimental science.

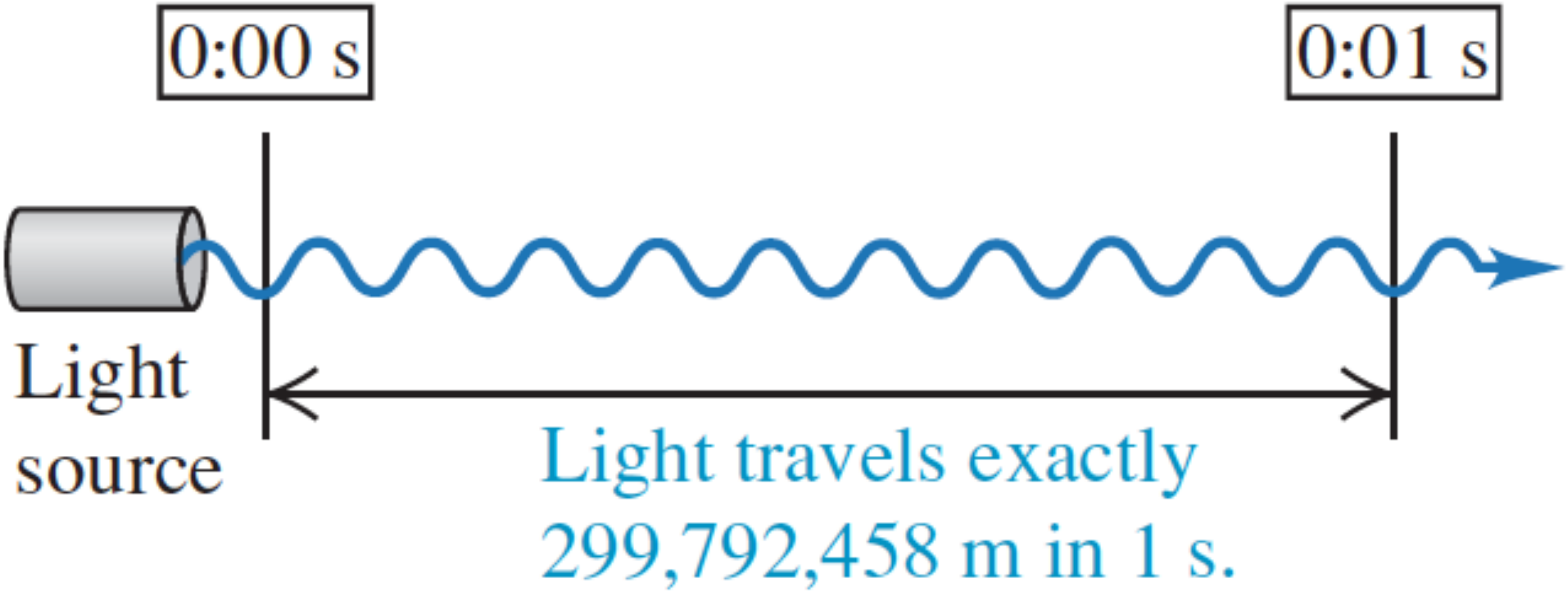


Chapter 1 Physics and Measurements
1.1 Standards of Length, Mass and Time

Physics is an experimental science. Experiments require measurements and generally the numbers are used to describe the results of measurements.

When we measure a quantity we always compare it with some reference standard.

LENGTH



One meter (abbreviated m) is the distance that light travels in vacuum in 1 / 299,792,458 second

Chapter 1 Physics and Measurements
1.1 Standards of Length, Mass and Time

Table 1.1

Approximate Values of Some Measured Lengths

	Length (m)
Distance from the Earth to the most remote known quasar	1.4×10^{26}
Distance from the Earth to the most remote normal galaxies	9×10^{25}
Distance from the Earth to the nearest large galaxy (M 31, the Andromeda galaxy)	2×10^{22}
Distance from the Sun to the nearest star (Proxima Centauri)	4×10^{16}
One lightyear	9.46×10^{15}
Mean orbit radius of the Earth about the Sun	1.50×10^{11}
Mean distance from the Earth to the Moon	3.84×10^{8}
Distance from the equator to the North Pole	1.00×10^{7}
Mean radius of the Earth	6.37×10^{6}
Typical altitude (above the surface) of a satellite orbiting the Earth	2×10^{5}
Length of a football field	9.1×10^{1}
Length of a housefly	5×10^{-3}
Size of smallest dust particles	$\sim 10^{-4}$
Size of cells of most living organisms	$\sim 10^{-5}$
Diameter of a hydrogen atom	$\sim 10^{-10}$
Diameter of an atomic nucleus	$\sim 10^{-14}$
Diameter of a proton	$\sim 10^{-15}$

MASS

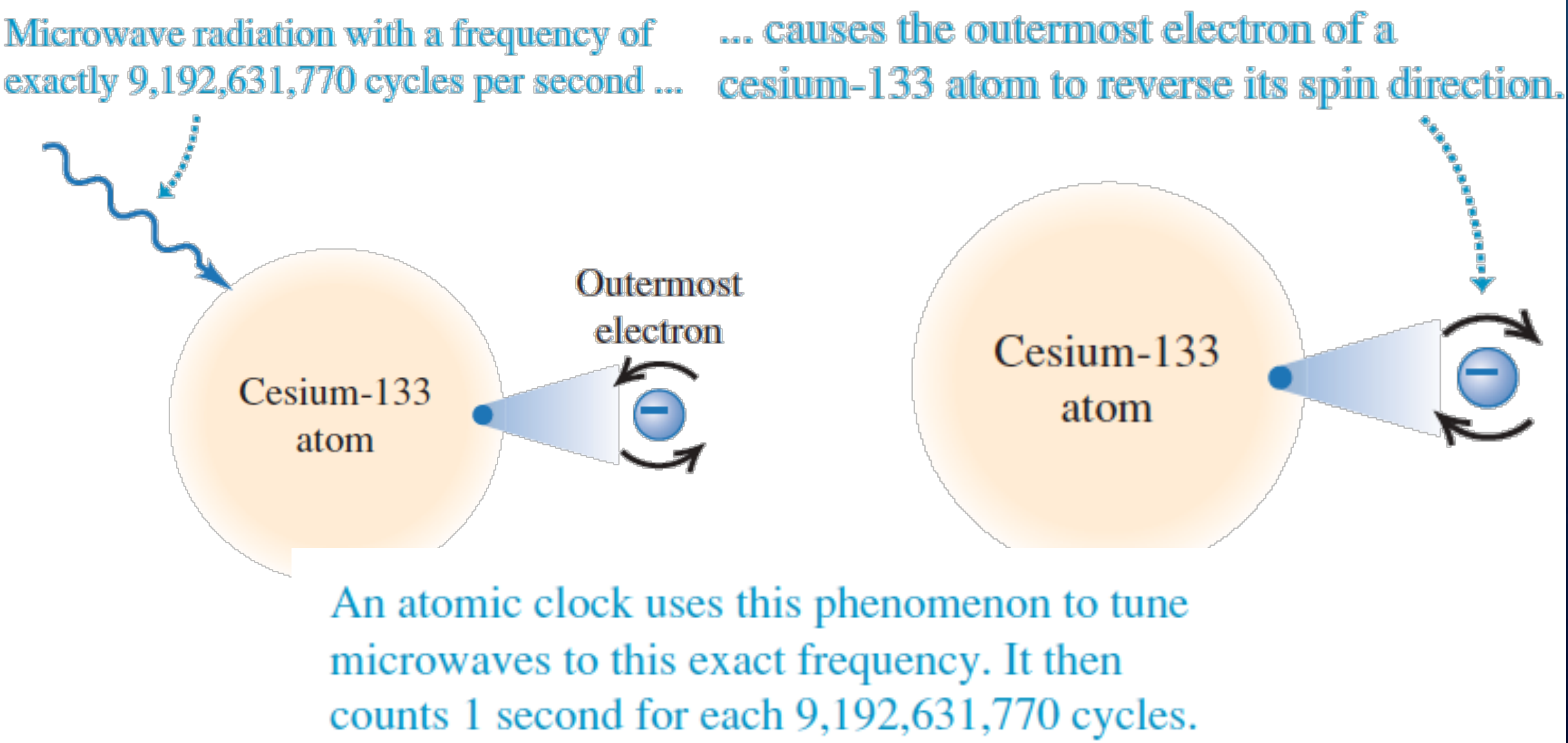
One kilogram (abbreviated kg), is defined to be the mass of a particular cylinder of platinum–iridium alloy kept at the International Bureau of Weights and Measures at Sèvres, near Paris

Table 1.2

Masses of Various Objects (Approximate Values)

	Mass (kg)
Observable Universe	$\sim 10^{52}$
Milky Way galaxy	$\sim 10^{42}$
Sun	1.99×10^{30}
Earth	5.98×10^{24}
Moon	7.36×10^{22}
Shark	$\sim 10^{3}$
Human	$\sim 10^{2}$
Frog	$\sim 10^{-1}$
Mosquito	$\sim 10^{-5}$
Bacterium	$\sim 1 \times 10^{-15}$
Hydrogen atom	1.67×10^{-27}
Electron	9.11×10^{-31}

TIME



One second (abbreviated s) is defined as the time required for 9,192,631,770 cycles of this microwave radiation

Chapter 1 Physics and Measurements
1.1 Standards of Length, Mass and Time

Table 1.3

Approximate Values of Some Time Intervals

	Time Interval (s)
Age of the Universe	5×10^{17}
Age of the Earth	1.3×10^{17}
Average age of a college student	6.3×10^{8}
One year	3.2×10^{7}
One day (time interval for one revolution of the Earth about its axis)	8.6×10^{4}
One class period	3.0×10^{3}
Time interval between normal heartbeats	8×10^{-1}
Period of audible sound waves	$\sim 10^{-3}$
Period of typical radio waves	$\sim 10^{-6}$
Period of vibration of an atom in a solid	$\sim 10^{-13}$
Period of visible light waves	$\sim 10^{-15}$
Duration of a nuclear collision	$\sim 10^{-22}$
Time interval for light to cross a proton	$\sim 10^{-24}$

Table 1.4

Prefixes for Powers of Ten

Power	Prefix	Abbreviation
10^{-24}	yocto	y
10^{-21}	zepto	z
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z
10^{24}	yotta	Y

An example of derived quantity is density:

$$\rho \equiv \frac{m}{V}$$

Table 1.5

Densities of Various Substances

Substance	Density ρ (10^3 kg/m^3)
Platinum	21.45
Gold	19.3
Uranium	18.7
Lead	11.3
Copper	8.92
Iron	7.86
Aluminum	2.70
Magnesium	1.75
Water	1.00
Air at atmospheric pressure	0.0012

The numbers of protons and neutrons in the nucleus of an atom of an element are related to the atomic mass of the element, which is defined as the mass of a single atom of the element measured in atomic mass units (u) where

$$1 \text{ u} = 1.660\,538\,7 \times 10^{-27} \text{ kg}.$$

Example How many Atoms in the Cube

A solid cube of aluminum (density 2.70 g/cm^3) has a volume of 0.200 cm^3. It is known that 27.0 g of aluminum contains 6.02×10^{23} atoms. How many aluminum atoms arecontained in the cube?

$$m = \rho V = (2.70 \text{ g}/\cancel{\text{cm}^3})(0.200 \, \cancel{\text{cm}^3}) = 0.540 \text{ g}$$

Example How many Atoms in the Cube

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Solution

Because density equals mass per unit volume, the mass of the cube is

$$m = \rho V = (2.70 \text{ g}/\cancel{\text{cm}^3})(0.200 \cancel{\text{cm}^3}) = 0.540 \text{ g}$$

$$\frac{0.540 \text{ g}}{27.0 \text{ g}} = \frac{N_{\text{sample}}}{6.02 \times 10^{23} \text{ atoms}}$$

$$N_{\text{sample}} = \frac{(0.540 \text{ g})(6.02 \times 10^{23} \text{ atoms})}{27.0 \text{ g}}$$

$$= 1.20 \times 10^{22} \text{ atoms}$$

Dimension denotes the physical nature of a quantity.

Whether a distance is measured in units of feet or meters or fathoms, it is still a distance. We say its dimension is length.

Length : $[L]$ L

Mass : $[M]$ M

Time : $[T]$ T

→

$$[v] = L / T$$

$$[A] = L^2$$

1.4 Dimensional Analysis

In many situations, you may have to derive or check a specific equation. A useful and powerful procedure called dimensional analysis can be used to assist in the derivation or to check your final expression.

Example 1 Analysis of Power Law

Suppose we are told that the acceleration a of a particle moving with uniform speed v in a circle of radius r is proportional to some power of r, say r^n, and some power of v, say v^m. Determine the values of n and m and write the simplest form of an equation for the acceleration.

$$a = kr^n v^m$$

Example Analysis of Power Law

Suppose we are told that the acceleration a of a particle moving with uniform speed v in a circle of radius r is proportional to some power of r, say r^n, and some power of v, say v^m. Determine the values of n and m and write the simplest form of an equation for the acceleration.

Solution

$$a = kr^n v^m \quad \Rightarrow \quad \frac{\mathrm{L}}{\mathrm{T}^2} = \mathrm{L}^n \left(\frac{\mathrm{L}}{\mathrm{T}}\right)^m = \frac{\mathrm{L}^{n+m}}{\mathrm{T}^m}$$

$$n + m = 1 \qquad \text{and} \qquad m = 2$$

$$a = kr^{-1}v^2 = k\frac{v^2}{r}$$

Sometimes it is necessary to convert units from one measurement system to another, or to convert within a system, for example, from kilometers to meters.

$$1 \text{ mile} = 1\,609 \text{ m} = 1.609 \text{ km} \qquad 1 \text{ ft} = 0.304\,8 \text{ m} = 30.48 \text{ cm}$$

$$1 \text{ m} = 39.37 \text{ in.} = 3.281 \text{ ft} \qquad 1 \text{ in.} = 0.025\,4 \text{ m} = 2.54 \text{ cm (exactly)}$$

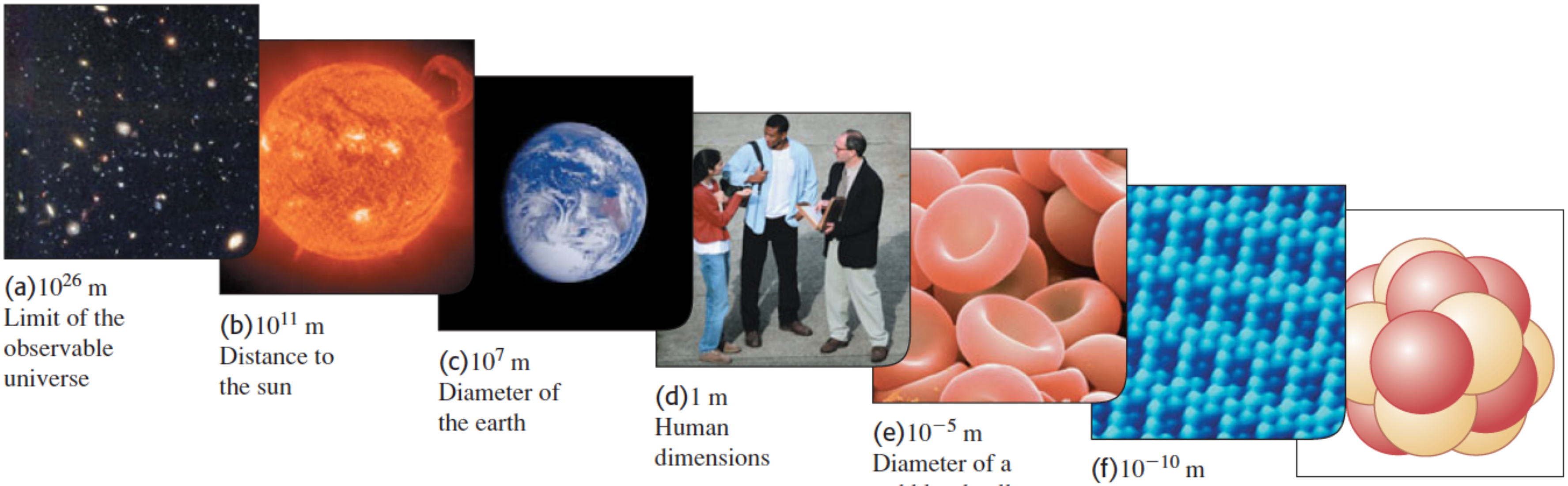
Homework 1

The world land speed record is 763.0 mi/h, set on October 15, 1997, by Andy Green in the jet-engine car Thrust SSC. Express this speed in meters per second and kilometer per second.

Homework 2

The world's largest cut diamond 'First Star of Africa has the volume of1.84 cubic inches. What is its volume in cubic centimeters? In cubic meters?

Chapter 1 Physics and Measurements
1.6 Estimates and Order-of-Magnitude Calculations



(a) 10^{26} m
Limit of the observable universe

(b) 10^{11} m
Distance to the sun

(c) 10^{7} m
Diameter of the earth

(d) 1 m
Human dimensions

(e) 10^{-5} m
Diameter of a red blood cell

(f) 10^{-10} m
Radius of an atom

(g) 10^{-14} m
Radius of an atomic nucleus

When certain quantities are measured, the measured values are known only to within the limits of the experimental uncertainty.

Measurements always have uncertainties.

The value of this uncertainty can depend on various factors, such as the quality of the apparatus, the skill of the experimenter, and the number of measurements performed.

In many cases the uncertainty of a number is not stated explicitly. Instead, the uncertainty is indicated by the number of meaningful digits, or significant figures, in the measured value.

Example

As an example of significant figures, suppose that we are asked in a laboratory experiment to measure the area of a computer disk label using a meter stick as a measuring instrument. Let us assume that the accuracy to which we can measure the length of the label is $\mp$ 0.1 cm.

The measured length : 5.5 cm,

its length lies somewhere between 5.4 cm and 5.6 cm. ,

In this case, we say that the measured value has two significant figures.

Note that the significant figures include the first estimated digit.

Likewise, if the label's width is measured to be 6.4 cm, the actual value lies between 6.3 cm and 6.5 cm. Thus we could write the measured values as (5.5 $\mp$ 0.1) cm and (6.4 $\mp$ 0.1) cm

Example

Now suppose we want to find the area of the label by multiplying the two measured values. If we were to claim the area is

$(5.5\ \text{cm})(6.4\ \text{cm}) = 35.2\ \text{cm}^2$

our answer would be unjustifiable because it contains three significant figures, which is greater than the number of significant figures in either of the measured quantities.

When you use numbers that have uncertainties to compute other numbers, the computed numbers are also uncertain. **When numbers are multiplied or divided, the number of significant figures in the result can be no greater than in the factor with the fewest significant figures**.

When multiplying several quantities, the number of significant figures in the final answer is the same as the number of significant figures in the quantity having the lowest number of significant figures. The same rule applies to division.

$$\frac{0.745x2.2}{3.885} = 0.42187902 \rightarrow \frac{0.745x2.2}{3.885} = 0.42$$

$$1.32578 \times 10^{7} \times 4.11 \times 10^{-3} = 5.4489558 \times 10^{4}$$

$$\downarrow$$

$$1.32578 \times 10^{7} \times 4.11 \times 10^{-3} = 5.45 \times 10^{4}$$

When numbers are added or subtracted, the number of decimal places in the result should equal the smallest number of decimal places of any term in the sum.

$$27.153 + 138.2 - 11.74 = 153.613$$

$$= 153.6$$

Chapter 1 Physics and Measurements
Summary

- The three fundamental physical quantities of mechanics are length, mass, and time, which in the SI system have the units meters (m), kilograms (kg), and seconds (s), respectively.
- Prefixes indicating various powers of ten are used with these three basic units.
- The density of a substance is defined as its mass per unit volume. Different substances have different densities mainly because of differences in their atomic masses and atomic arrangements.
- The method of dimensional analysis is very powerful in solving physics problems. Dimensions can be treated as algebraic quantities. By making estimates and performing order-of-magnitude calculations, you should be able to approximate the answer to a problem when there is not enough information available to completely specify an exact solution.

Chapter 1 Physics and Measurements
Summary

- When you compute a result from several measured numbers, each of which has a certain accuracy, you should give the result with the correct number of significant figures.
- When multiplying several quantities, the number of significant figures in the final answer is the same as the number of significant figures in the quantity having the lowest number of significant figures. The same rule applies to division. When numbers are added or subtracted, the number of decimal places in the result should equal the smallest number of decimal places of any term in the sum.