COLLEGE PHYSICS

Chapter 1 INTRODUCTION: THE NATURE OF SCIENCE AND PHYSICS

Lesson 1

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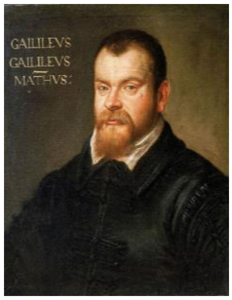
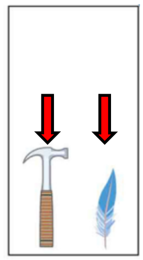
FROM NATURAL PHILOSOPHY TO MODERN PHYSICS

Galileo Galilei (1564–1642) laid the foundation of modern experimentation.



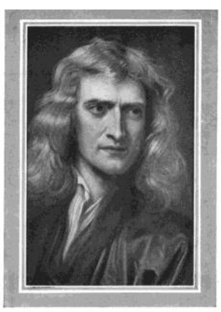


In a vacuum

Galileo's discoveries:

- Objects of different weight fall to the ground at the **same time** in the absence of air resistance.
- A moving object needs **no force** to keep it moving in the absence of friction.

FROM NATURAL PHILOSOPHY TO MODERN PHYSICS



Isaac Newton (1642–1727) wrote the Principia, which laid the foundations for classical mechanics.

The Principia included three laws of motion, and the law of universal gravitation, which states that all massive objects attract one another.

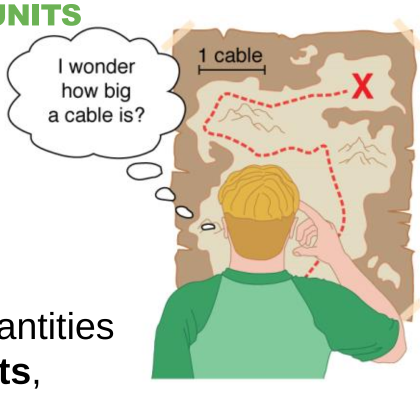
Newton's laws of motion and gravitation correctly predicted the observed motions of planets and comets in their orbits around the Sun.

THE SCIENTIFIC METHOD

1. Make careful observations of the world and ask good questions, so you are familiar with trends, repeatable phenomena, and previous discoveries. **Become an expert!**
2. Using mathematical models and theories, generate a **hypothesis**, and make predictions based on the hypothesis.
3. Perform **experiments** which test the hypothesis, and might disprove your theories.
4. Analyze the results, refine your theories and ask new questions. **Publish!**

PHYSICAL QUANTITIES AND UNITS

We define a **physical quantity** either by specifying how it is measured or by stating how it is calculated from other measurements.



Measurements of physical quantities are expressed in terms of **units**, which are standardized values.

Without standardized units, it would be extremely difficult for scientists to express and compare measured values in a meaningful way.

SI UNITS: FUNDAMENTAL AND DERIVED UNITS

SI units (Système International) includes four fundamental units:

Physical Quantity	SI Unit
Length	meter (m)
Mass	kilogram (kg)
Time	second (s)
Electric Current	ampere (A)

All other physical quantities can be expressed as algebraic combinations of length, mass, time and current.

Units for these quantities are **derived units**.

GIVE IT A TRY!

A football field has a length of $l = 100\ \mathrm{m}$, and a width of $w = 60\ \mathrm{m}$.

The equation for area is: $A = lw$. What is the area of the football field?

A. $A = 6000$

B. $A = 6000\ \mathrm{km}$

C. $A = 6000\ \mathrm{m}$

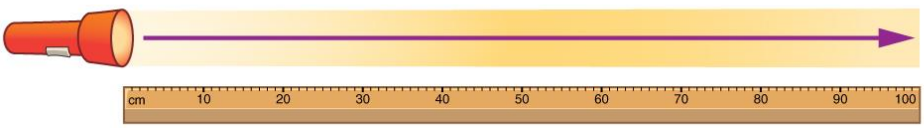
D. $A = 6000\ \mathrm{m}^2$

E. $A = 6000\ \mathrm{mm}$

THE SECOND

- An atomic clock such as this one uses the vibrations of cesium atoms to keep time .
- The fundamental unit of time, the second, is defined to be the time required for 9,192,631,770 of these vibrations.

THE METER



Light travels a distance of 1 meter
in 1/299,792,458 seconds

- The meter is defined to be the distance light travels in 1/299,792,458 of a second in a vacuum.
- Distance traveled is speed multiplied by time.

THE KILOGRAM

- The kilogram is defined to be the mass of a platinum-iridium cylinder kept at the International Bureau of Weights and Measures near Paris.

- Exact replicas of the standard kilogram are kept at various locations around the world, including the National Research Council Metrology Laboratory in Ottawa, Ontario.

METRIC PREFIXES

Each power of 10 in the metric system represents a different order of magnitude.

Prefix	Symbol	Value
giga	G	10^9
mega	M	10^6
kilo	k	10^3
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Example: 0.01 m = 10^{-2} m = 1 cm

UNIT CONVERSION

It is often necessary to convert from one type of unit to another.

For example, let's convert 80 meters (m) to kilometers (km).

A **conversion factor** is a ratio expressing how many of one unit are equal to another unit.

In this case, we know that there are 1,000 m in 1 km.

Write the units that we have and then multiply them by the conversion factor so that the units cancel out, as shown:

$$80\,\cancel{\text{m}} \times \frac{1\text{ km}}{1000\,\cancel{\text{m}}} = 0.080\text{ km}.$$

GIVE IT A TRY!

You know your height is 65 inches, and you want to convert to cm.

You know that 2.54 cm is the same as 1 inch.

Which of these is the conversion factor you would multiply your height in inches by to get your height in cm?

A. $\left(\frac{2.54\text{ cm}}{1\text{ inches}}\right)$

B. $\left(\frac{1\text{ inches}}{2.54\text{ cm}}\right)$