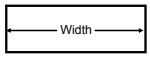
1.2 – Measurement

Opening Activity:

Measure the width of your desks without a conventional measuring device: no rulers, meter sticks, tape measures, etc.

Then determine the weight of your booklets without a conventional scale of any sort.

You have five minutes total for this mission!



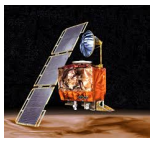
Desk Data

Booklet Data

Foundation of Physics: Measurement

Standard Unit: One that's accepted globally.
Why use standard units?

Mars Climate Orbiter story (P. 17 in book)



Exercise: Measure your hand spans, and pool the values on the board. Find maximum, minimum, average spans.

Whose would be best to use for advertising something's length?

Whose would be best if you had to pay $3 per hand span of something?

Systems of Measurement

Imperial, or British System – Feet, Pounds, etc.

Monetary Pound

Metric or S.I. (Système International des Unités) – known as MKS system (meters, Kelvins, seconds)

Units Matching Game

Base Units: Fundamental units(symbols)

meter (m) second (s) ampere (A)

kilogram (kg) Kelvin (K) mole (mol)

candela (cd)

luminous intensity | time | mass | electric current | length | temperature | amount of matter

Answers:
m = length, kg = mass, s = time, A = electric current, K = temperature, mol = amount of matter, cd = luminous intensity

These describe EVERYTHING measureable in the universe!

Systems of Measurement

Derived Units: Expressed in terms of combinations of base units.

Ex: liter – a unit of volume in SI system.
How much is a liter, about?
How can it be defined in terms of base units?

It equals 1000 cm^3, and equals the volume of this standardized testing cube.

The Meter

Originally 1/10,000,000 of the distance from the North Pole to the Equator, passing through Paris, and a 1.000 meter long bar of Pt-Ir alloy was made as a standard.

Now, a meter is defined to be the distance light travels in a vacuum in 1/299,792,458 ths of a second.

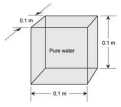
Why was the original definition changed?

c = speed of light =299,792,458 m/s (3.0 E 8 m/s works)

The Kilogram

Mass measures the amount of matter in something.

Originally, the standard was a cube of pure water 10 cm on a side at 4ºC.



Now it is a Pt – Ir cylinder kept at the International Bureau of Weights and Standards in France. There's one in the US too.

Factoid: The kilogram is the only SI base unit with a prefix as part of its name. It is also the only unit still directly defined by an artifact, rather than a fundamental physical property that can be reproduced in different laboratories.

Why "Kilogram"?

On 7 April 1795, the "gramme", upon which the kilogram is based, was decreed to be equal to "the absolute weight of a volume of pure water equal to a cube of one hundredth of a meter, at the temperature of melting ice".
Although this was the definition of the gram, trade and commerce required a more useful amount: a single-piece, metallic reference standard one thousand times more massive that would be known as "grave" (symbol G - from 'gravity').
The new metric system did not come into effect until after the French Revolution. The decision of the Republican government to name this new unit the "kilogramme" was politically motivated, because the name "grave" was at that time considered politically incorrect - it resembled the aristocratic German title of Graf, which means Count - a member of the aristocracy.
The name of the original "gramme", which was impractical, was adopted and the new prefix "kilo" was prefixed to it to form the name "kilogramme".

Mass vs. Weight

What's the difference? Anyone? How are they determined?

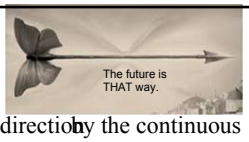
Mass = amount of matter in an object.

Weight = gravitational attraction of the Earth (or other body) to an object. Weight exerts a force on something.

Weight is proportional to mass, but not necessarily equal, depending on the measuring conditions.

Time

This is harder to define.



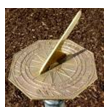
We observe time going in a forward direction by the continuous forward flow of events.

Spring – Summer – Fall – Winter
Events mark time measurements

How do you suppose time was first kept?

By the sun's apparent movement every day.

1 day = 24 hr = 1 440 minutes = 86 400 s
1 s = 1/86 400 ths solar day.

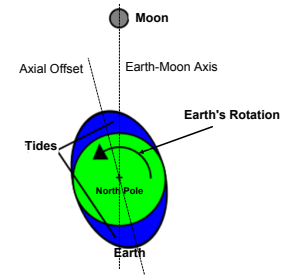


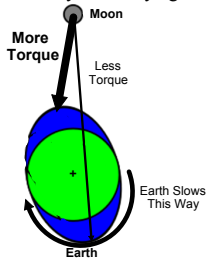
Time

Earth's day is gradually growing longer! Why?

Gravitational torque between the earth and the moon!

The moon slowly adopts a higher orbit (about 3.78 cm/year) in which it travels faster as the earth slows down.
Today will be longer by about 1.7 milliseconds than a day a century ago.





Newfangled Time Contraption

Now time is based on the oscillation frequency of an electron associated with an atomic transition of Cs-133 in devices called "Atomic Clocks".

In 1967, the best atomic clock was accurate to 1s/300 yr
In 1999, a newer one had accuracy of 1s/20 M yr!

Metric Prefixes

Resources Page 1 and 5.

Multiple	Prefix	Symbol
10 E12	tera	T
10 E 9	giga	G
10 E 6	mega	M
10 E 3	kilo	k
10 E 2	hecto	h
10	deka	da
10 E -1	deci	d

Multiple	Prefix	Symbol
10 E -2	centi	c
10 E -3	milli	m
10 E -6	micro	μ
10 E -9	nano	n
10 E -12	pico	p
10 E -15	femto	f
10 E -18	atto	a

Conversions

You will have to convert from one unit to anotherALL THE TIME in physics.

Please turn to Resources Page 5 for a conversions guide.

Example: Convert 438.6 seconds to minutes.

1. Needed relationship: 60 seconds = 1 minute

2. $438.6\,\cancel{s} \times \frac{1\ \text{min}}{60\,\cancel{s}} = \boxed{7.310\ \text{min}}$

Standard Problem Solving in Physics

Please turn to Resources Page 4.

With a table partner, pleases do the following problem. I will check it and see how you did:

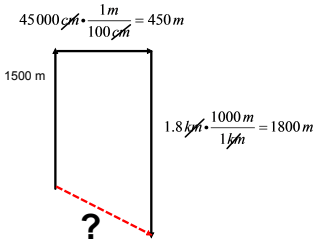
A man walks 1500 m due north, then 45,000 cm due east, then 1.8 km due south. How far from the original position is he?

Hint: Use the Pythagorean Theorem to solve this ($a^2 + b^2 = c^2$), and find a common unit for the three distances given and make conversions.

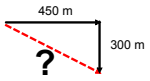
Answer

A man walks 1500 m due north, then 45,000 cm due east, then 1.8 km due south. How far from the original position is he?

$45000\,\cancel{cm} \cdot \frac{1\,m}{100\,\cancel{cm}} = 450\,m$



$1.8\,\cancel{km} \cdot \frac{1000\,m}{1\,\cancel{km}} = 1800\,m$



$? = \sqrt{450^2 + 300^2}$

$540\,m\,(3\,sig\ figs.)$

Density Problem

What is the density of a substance with a mass of 16 kg, and a volume of 0.0038 m^3?

Hint: the equation of density is on Page 2 of the resources.

Answer: $\rho = \frac{m}{v} = \frac{16\,kg}{0.0038\,m^3} = 4200 kg/m^3$

Another Problem

A car travels at 4.0 m/s for 15 seconds. It slows to 3.0 m/s and travels for 25 more seconds. How far did it go?

Hint: use the rate (the 'dirt') equation: distance = rate • time
(d = r•t)

Answer

A car starts travels at 4.0 m/s for 15 seconds. It slows to 3.0 m/s and travels for 25 more seconds. How far did it go?

Hint: use the 'dirt' equation: distance = rate • time (d = r • t)

$d = r \cdot t$ | Part 2 | $d = r \cdot t$

$d = 4.0\,m/s \cdot 15\,s$ | | $d = 3.0\,m/s \cdot 25\,s$

$d = 60\ m$ | | $d = 75\ m$

Total distance = 135 m

Homework

Read 1.1 - 1.7 in your book
1.2 Problems in your Booklet
Due: Next Class