Introductory Physics -- PHY1031

1. What is **science**?

Latin:
scientia=knowledge

i) science vs. art
ii) natural vs. social sciences
iii) fundamental/pure vs. applied

2. What is a **scientific method**?

i) investigation/observation
ii) formulation and testing of hypotheses
iii) experiment/reproduction

3. What is a theory? (common language vs. **science**)

i) mathematical or logical explanation
ii) can be tested
iii) make predictions

Theories can be improved and replaced

Physics

What is physics? Study of matter, energy, and the interaction between them

Classical physics	and	Modern physics
up to the XIX		XX and XXI
Classical mechanics, Electromagnetism, Thermodynamics, Statistical Mechanics,		Relativity, Quantum Mechanics

What is the relation between physics and other fields?

Contributions to physics	from physics
Physiologist Luigi Galvani (book - page 4)	MRI
Botanist Robert Brown (http://en.wikipedia.org/wiki/Brownian_motion)	radiation therapy

Physics is…

Bohr and Einstein in Paul Ehrenfest's home, Brussels, 1930

Measurement and Uncertainty

Measurements - important part of physics
- have uncertainty associated
  (accuracy/limitations of instruments)

Estimated uncertainty $5.2 \pm 0.1\,\mathrm{cm}$

Percent uncertainty $$\frac{0.1}{5.2} \approx 0.02 = 2\%$$

Diamond $8.17 \pm 0.05\,\mathrm{g}$

How do we compute the percent uncertainty?

If we weigh it and get 8.09 g, could it be the same diamond?

a) 0.05/8.17 and NO
b) 0.05/8.17 and YES
c) 8.17/0.05 and YES
d) 8.17/0.5 and NO

Significant Figures

Significant figures **-** number of reliably known digits in a number

23.21 cm – four   23.210 cm - five

0.062 cm - two

80 km - one or two (80. km)   80.0 km - three

Do not keep more digits than justified

Area of rectangle: 11.3 cm by 6.8 cm

11.3x6.8=76.84, but 11.2x6.7=75.04 and 11.4x6.9=78.66

therefore the area is $77\,\mathrm{cm}^2$

Scientific Notation

General rule for the number of significant digits of a result:

Multiplication and division: as many digits as the number with the least number of significant figures

Addition and subtraction: result no more accurate than the least accurate number used

$$2355.242 + 23.57 = 2378.81\cancel{2}$$

Scientific notation – write numbers in powers of ten

$$2321 = 2.321\text{x}10^{3}; \quad 0.0062 = 6.2\text{x}10^{-3}$$

Depending on the accuracy

$$36900 \begin{cases} 3.69\text{x}10^{4} \\ 3.690\text{x}10^{4} \\ 3.6900\text{x}10^{4} \end{cases}$$

Units, Standards, and the SI System

Measurement is made relative to a **standard/unit**

The International System of Units (**SI system**)

Quantity	Unit name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol

Basic
vs.
derived
quantities

TABLE 1–1 Some Typical Lengths or Distances (order of magnitu

Length (or Distance)	Meters (approximate)
Neutron or proton (radius)	10^{-15} m
Atom	10^{-10} m
Virus [see Fig. 1–8a]	10^{-7} m
Sheet of paper (thickness)	10^{-4} m
Finger width	10^{-2} m
Football field length	10^{2} m
Height of Mt. Everest [see Fig. 1–8b]	10^{4} m
Earth diameter	10^{7} m
Earth to Sun	10^{11} m
Earth to nearest star	10^{16} m
Earth to nearest galaxy	10^{22} m
Earth to farthest galaxy visible	10^{26} m

† Modern measurements of the Earth's circumference reveal that the intended length is one-fiftieth of 1%. Not bad!

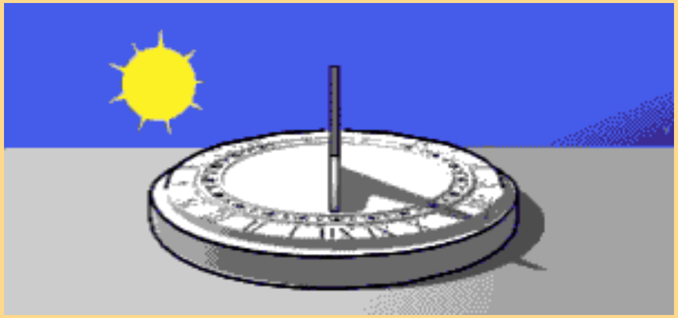
‡ The new definition of the meter has the effect of giving the speed of light the e 299,792,458 m s.

TABLE 1–4 Metric (SI) Prefixes

Prefix	Abbreviation	Value
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	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro†	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
zepto	z	10^{-21}
yocto	y	10^{-24}

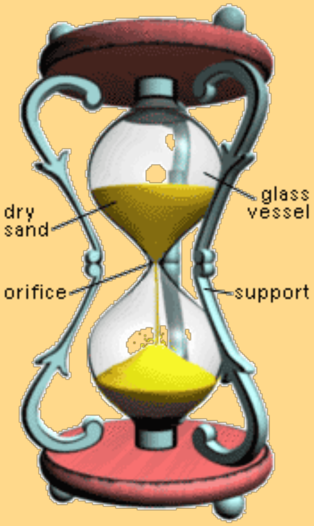
† μ is the Greek letter "mu."

Time



Sundial: 16th century BC, Egypt

Sandglass: 14th century (Europe)



Time

1s

1s=frequency of radiation emitted by cesium atoms between two particular states

There are 60s in one minute (min)
and
60 min in one hour (h)

Converting Units

Conversion factors:

1 km = 1000 m
1 h = 3600 s
1 mi = 1609 m (mi – miles)
1 in. = 2.54 cm (in. – inches)
1 ft = 12 in. (ft – foot)
1 mi = 5280 ft

Example:
Convert 55 mi/h (or mph) to meters per second (m/s)

$$55\,\frac{\text{mi}}{\text{h}} = \left(55\,\frac{\text{mi}}{\text{h}}\right)\left(\frac{1609\text{m}}{\text{mi}}\right)\left(\frac{\text{h}}{3600\text{s}}\right) = 25\,\frac{\text{m}}{\text{s}}$$

In class:
convert 5.0 m/s to km/h

$$5\,\frac{\text{m}}{\text{h}} = \left(5\,\frac{\text{m}}{\text{s}}\right)\left(\frac{0.001\,\text{km}}{\text{m}}\right)\left(\frac{3600\text{s}}{\text{h}}\right) = 18\,\frac{\text{km}}{\text{h}}$$

Order of Magnitude

Rough estimate made by
rounding off all numbers to one significant figure

1. Estimate the volume of our textbook

   width: 20 cm   height: 30 cm   depth: 2 cm

$$V \approx (20\text{cm})x(30\text{cm})x(2\text{cm}) = 1x10^{3}\text{cm}^{3}$$

2. Estimate the thickness of a piece of paper of our textbook

   1 piece of paper = 2 pages
   book has around 500 pages and is about 2 cm thick

$$\left\{\begin{array}{l} 1 \text{ piece of paper} \rightarrow x \\ 250 \text{ pieces} \rightarrow 2\text{cm} \end{array}\right.$$

$$\boxed{x = \frac{2\text{cm}}{250} = 0.008\text{cm} \sim 0.1\text{mm}}$$

Dimensional Analysis

Dimensional analysis

useful technique to check if a relationship is incorrect

Position x is given in m

Time t is given in s

Velocity v is given in m/s

Acceleration a is given in m/s^2

$\cancel{v = at^2}$ Dimensionally **WRONG!**

$v = at$ Dimensionally **right**

Extra problems

1. Exercises

A: Calculate the area of a rectangle 4.5 cm by 3.25 cm

B: Do 0.00324 and 0.00056 have the same number of significant figures?

C: How many significant figures are in 1.23, 0.123, 0.0123

2. Would a driver at 15m/s in a 35mi/h zone be exceeding the speed limit?

Revision of Chapter 1

Measurement – uncertainty; **<u>significant figures</u>**
<u>Scientific notation</u>
<u>Units, SI:</u> meter, kilogram, second
<u>Converting units</u>
Order of magnitude

<u>Dimensional Analysis</u>

useful way to find out if an equation is **INCORRECT**

Time t is given in s
Velocity v is given in m/s
Acceleration a is given in m/s^2

$\cancel{v = at^2}$ Dimensionally **WRONG!**

$v = at$ Dimensionally **right**