# General Physics -- PHY1051

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 up to the XIX | and | Modern physics 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** $5.2 \pm 0.1\,\text{cm}$

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

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

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 $77\text{cm}^2$

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 = 2378.812

# Scientific Notation

**Scientific notation –** write numbers in powers of ten

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

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 magnitud

| 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 ex 299,792,458 m s.

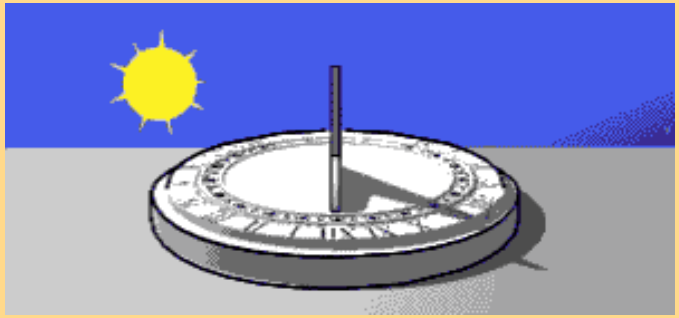


## TABLE 1–4 Metric (SI) Prefixes

| 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† | $\mu$ | $10^{-6}$ |
| nano | n | $10^{-9}$ |
| pico | p | $10^{-12}$ |
| femto | f | $10^{-15}$ |
| atto | a | $10^{-18}$ |
| zepto | z | $10^{-21}$ |
| yocto | y | $10^{-24}$ |

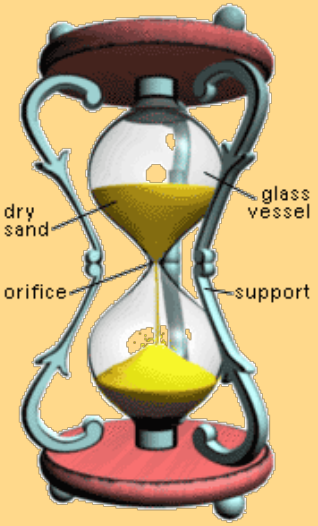
† $\mu$ is the Greek letter "mu."

# 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)**

$$2\,\text{min} = (2\,\text{min})(1) = (2\,\text{min})\left(\frac{60\text{s}}{1\text{min}}\right) = 120s$$

# 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

$$\begin{cases} 1 \text{ piece of paper} \rightarrow x \\ 250 \text{ pieces} \rightarrow 2\text{cm} \end{cases}$$

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

# 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 $m/s^2$

~~$v = at^2$~~ 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; **significant figures**
**Scientific notation**
**Units, SI:** meter, kilogram, second
**Converting units**

**Dimensional Analysis**

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 $m/s^2$

~~$v = at^2$~~ Dimensionally **WRONG!**

$v = at$ Dimensionally **right**