PHYS401 -- Introduction to Physics I --Summer 2004

What is Physics?

- Please read section 1.1 of C & J for a nice and brief description.
- Physics is a systematic investigation of quantitative laws of the nature that can be confirmed by observations or experiments.

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*** investigation -- problem solving**

- Physicists solve problems.
- That's why there are so many homework problems!
- Physical laws presented in textbooks are results of a long and complicated history of investigations.

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*** quantitative -- mathematical**

- Physics is NOT mathematics.
- Physics does use a lot of mathematics.
- Quantitative laws can be proved or disproved.
- Quantitative laws are much easier to apply and make predictions.

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*** systematic -- organized**

- Simple is beautiful.
- Fewest fundamental laws that can deduce largest volume of specific laws for different situations (elementary particles, nuclei, atoms, fluids, solid, Earth, space, cosmos,…).
- Classic mechanics is somewhere in between.

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*** observations/experiments -- based on reality**

- No experiments, no physics.
- That's why we do labs --- but that's just a taste of it --- more realistic experiments are much more time consuming.
- Based on reality -- can have applications in the real world.

Units and Dimensions

Every physical quantity has a dimension.

- Not to be confused with spatial dimensions!
- Basic dimensions: mass [M], length [L], time [T]
- Basic dimensions can be combined to form new dimensions, e. g.:
  - * speed has the dimension of [L/T]
  - * accelaration has the dimension of $[L/T^2]$
  - * energy has the dimension of $[M\ L^2\ /\ T^2]$
- Dimensionless is a special dimension: [1], e. g.:
  - * a ratio between two lengths has a dimension of [L/L]=[1]

Units and Dimensions

A dimension can have different units.

- possible units for [L]: meter (m), centimeter (cm), foot (ft),...
- possible units for [M]: kilogram (kg), gram (g), slug (sl), ...
- possible units for [T]: second (s), minute, hour, ...
- a system of units is a consistent choice of units, e. g.,
  - * SI units: use meter-kilogram-second for [L]-[M]-[T]
  - * CGS units: use centimeter-gram-second for [L]-[M]-[T]
- dimensionless quantities can have unit too, e. g.,
  - * percent (% = 0.01) is a common unit for ratio.
  - * angle is dimensionless but can be measured in degree or radian (rad).

Units and Dimensions

Algebraic rules about units.

- a physical quantity is specified by a number *times* a unit.
- you should *always* carry units in calculations and answers.
- units in an equation behave like algebraic quantities.
- you can add two quantities by adding their numbers *only* if they are in the same unit, e. g.,
  - * 1 apple + 1 orange ≠ 2
  - * 1 m + 1 m = 2 m
- you can add two quantities *only* if they have the same dimension
  - * 1 kg + 2 g = 1 kg + 2 (0.001 kg) = 1.002 kg
  - * 2 m + 3 s ≠ 5
- *always* check your calculations to see if the units are correct.

Units and Dimensions

The conversion of units

- physical quantities having the same dimension but different units can be converted into the same unit.
- converting standard prefixes, e. g.,
  * 1 kg = 1 (10^3)g = 1000 g
  * 1 cm = 1 (10^{-2})m = 0.01 m
- conversion using inverse, e. g.,
  * 1 hour = 3600 s $\Rightarrow$ 1 s = 1 hour/3600 = 2.78×10^{-4} hour
- conversion by looking up tables, e. g.,
  * 65 miles/ hour =

$$65\left(\frac{\text{miles}}{\text{hour}}\right)\left(\frac{1.609\ \text{km}}{1\ \text{mile}}\right)\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{hour}}{3600\ \text{s}}\right) = 29.1\ \text{m/s}$$

Units and Dimensions

Dimensional analysis

- only quantities with the same dimension can be added (or equal to each other.
- can check if an equation is correct, e. g.,
  * check $x = vt^2$: $[L] \neq [L/T][T]^2 = [L][T]$
- may determine unknown power, e. g.,
  * find n such that $x = vt^n$ is dimensionally correct:
  $[L] = [L/T][T]^n = [L][T]^{n-1} \Rightarrow n - 1 = 0$, or $n = 1$
  i. e., $x = vt$ is dimensionally correct.

Do 1.CQ.001-005

Writing Numbers

Scientific notation (see Appendix A of C & J)

- e. g., $1234 = 1.234 \times 10^{3}$
  $0.0001234 = 1.234 \times 10^{-4}$

Significant figures (see Appendix B of C & J)

- e. g., l230 has 3 significant figures
  but 1.230×10^{3} has 4 significant figures.
- usually in WebAssign and Exams, only 3 significant figures are required in the final answer.
- keep as many significant figures as allowed in your calculator during the intermediate steps of a calculation.

Round off

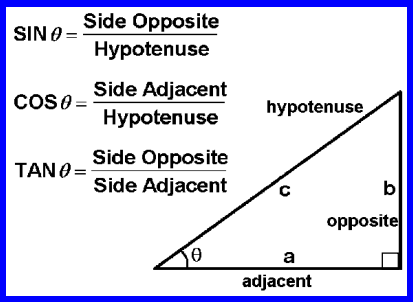
- e. g., round of 12.3456 to 3 significant figures: 1.23×10^{1}
  to 4 significant figures: 1.235×10^{1}

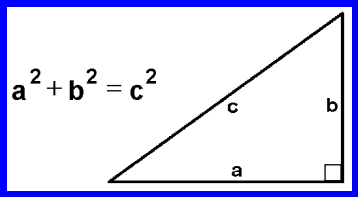
Basic Mathematics

Algebra (see Appendix C of C & J)

Exponents and Logarithms (see Appendix D of C & J)

Geometry and Trigonometry (see Appendix E of C & J)





PYTHAGOREAN THEOREM

important applications: $a = c \cos\theta$, $b = c \sin\theta$, $\theta = \tan^{-1}(b/c)$

- see Examples 3 and 4 of C & J

* figures fromhttp://abe.www.ecn.purdue.edu/~agen215/trig.html

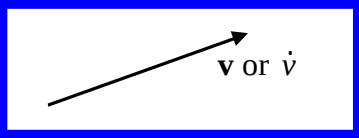
Scalars and Vectors

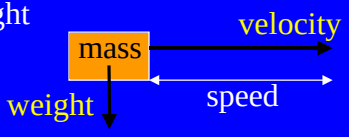
Scalars

- A scalar is a quantity that can be described by a single number (including units), e. g., speed, mass

Vectors

- A vector is a quantity which requires not only a number, but also a direction, e. g., velocity, weight





- The length of a vector is proportional to its magnitude.
- Two vectors equal each other if they have the same magnitude and the same direction.

Do CYU 1.1 and 1.CQ.008-009

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