Phys 201, Spring 2011  
Chapt. 1, Lect. 2

Chapter 1: Measurement and vectors

Reminders:
1. The grace period of WebAssign access is two weeks.
2. The lab manual can be viewed online, but you are recommended to buy a hard copy from the bookstore.
3. For honors credit, attend Friday’s 207 lecture, TOMORROW 12:05pm, (or write an essay later).

Review from last time:

→ Units: Stick with SI, do proper conversion. (in each equation, all terms must match!)
→ Dimensionality: any quantity in terms of $L, T, M$ (the dimension for basic units).
→ Significant figures (digits) and errors
→ Estimate (rounding off to integer) and order of magnitude (to 10’s power)

The density of seawater was measured to be 1.07 g/cm$^3$. This density in SI units is

A. 1.07 kg/m$^3$
B. $(1/1.07) \times 10^3$ kg/m$^3$
C. $1.07 \times 10^3$ kg
D. $1.07 \times 10^{-3}$ kg
E. $1.07 \times 10^3$ kg/m$^3$

An order of magnitude estimate: 1 tonne/m$^3$
If $K$ has dimensions $ML^2/T^2$, then $k$ in the equation $K = kmv^2$ must

A. have the dimensions $ML/T^2$.
B. have the dimension $M$.
C. have the dimensions $L/T^2$.
D. have the dimensions $L^2/T^2$.
E. be dimensionless.

If $K$ has dimensions $ML^2/T^2$, then $k$ in the equation $K = kmv^2$ must

A. have the dimensions $ML/T^2$.
B. have the dimension $M$.
C. have the dimensions $L/T^2$.
D. have the dimensions $L^2/T^2$.
E. be dimensionless.

Today: Vectors

• In one dimension, we can specify distance with a real number, including + or – sign (or forward-backward).
• In two or three dimensions, we need more than one number to specify how points in space are separated – need magnitude and direction.

Scalars, vectors:

Scalars are those quantities with magnitude, but no direction: Mass, volume, time, temperature (could have + or – sign) …

Vectors are those with both magnitude AND direction: Displacement, velocity, forces …

Denoting vectors

• Two of the ways to denote vectors:
  – Boldface notation: $\mathbf{A}$
  – “Arrow” notation: $\vec{A}$
Example: Displacement (position change)

Adding displacement vectors

“Head-to-tail” method for adding vectors

Vector addition is commutative

Vectors “movable”: the absolute position is less a concern.
Adding three vectors: vector addition is associative.

\[ \vec{A} + (\vec{B} + \vec{C}) = (\vec{A} + \vec{B}) + \vec{C} = \vec{A} + \vec{B} + \vec{C} \]

A vector’s inverse has the same magnitude and opposite direction.

\[ \vec{A} - \vec{A} = \vec{A} + (-\vec{A}) = 0 \]

Subtracting vectors

Example 1-8.
What is your displacement if you walk 3.00 km due east and 4.00 km due north?

Pythagorean theorem
Components of a vector along x and y

\[ A_y = A \sin \theta \]
\[ A_x = A \cos \theta \]

Components of a vector: along an arbitrary direction

\[ A_x = A \cos \theta \]
\[ A_y = A \sin \theta \]

Magnitude and direction of a vector

2.0 Km

\[ A = \sqrt{A_x^2 + A_y^2} \]
\[ \tan \theta = \frac{A_y}{A_x} \]
\[ \theta = \tan^{-1} \frac{A_y}{A_x} \]

Adding vectors using components

\[ C_x = A_x + B_x \]
\[ C_y = A_y + B_y \]
Unit vectors

A unit vector is a dimensionless vector with magnitude exactly equal to one.

The unit vector along x is denoted \( \hat{i} \) and along y is denoted \( \hat{j} \) and along z is denoted \( \hat{k} \).

For any vector \( \vec{A} \),

\[ \vec{A} = A_x \hat{i} + A_y \hat{j} + A_z \hat{k} \]

Which of the following vector equations correctly describes the relationship among the vectors shown in the figure?

A. \( \vec{A} + \vec{B} - \vec{C} = 0 \)
B. \( \vec{A} - \vec{B} + \vec{C} = 0 \)
C. \( \vec{A} - \vec{B} - \vec{C} = 0 \)
D. \( \vec{A} + \vec{B} + \vec{C} = 0 \)
E. None of these is correct.

Can a vector have a component bigger than its magnitude?

Yes
No
Can a vector have a component bigger than its magnitude?

- Yes
- No

The square of a magnitude of a vector $\mathbf{R}$ is given in terms of its components by

$$ R^2 = R_x^2 + R_y^2. $$

Since the square is always positive, no component can be larger than the magnitude of the vector.

Thus, a triangle relation:

$$ |\mathbf{A}| + |\mathbf{B}| > |\mathbf{A} + \mathbf{B}| $$

---

### Properties of vectors: summary

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Figure</th>
<th>Component Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equality</td>
<td>$\mathbf{A} = \mathbf{B}$ and thus $</td>
<td>\mathbf{A}</td>
<td>=</td>
</tr>
<tr>
<td>Addition</td>
<td>$\mathbf{C} = \mathbf{A} + \mathbf{B}$</td>
<td><img src="image2.png" alt="Figure" /></td>
<td>$C_x = A_x + B_x$ $C_y = A_y + B_y$</td>
</tr>
<tr>
<td>Negative of vector</td>
<td>$\mathbf{A} = \mathbf{B}$ and thus $</td>
<td>\mathbf{A}</td>
<td>=</td>
</tr>
<tr>
<td>Subtraction</td>
<td>$\mathbf{C} = \mathbf{A} - \mathbf{B}$</td>
<td><img src="image4.png" alt="Figure" /></td>
<td>$C_x = A_x - B_x$ $C_y = A_y - B_y$</td>
</tr>
<tr>
<td>Multiplication by a scalar</td>
<td>$\mathbf{C} = \mathbf{A}$ and the scale factor is $\mathbf{C}$</td>
<td><img src="image5.png" alt="Figure" /></td>
<td>$C_x = kA_x$ $C_y = kA_y$</td>
</tr>
</tbody>
</table>

**Note:** The scale factor $k$ is a real number.