Phys_151 (Sections 1-5)
Lecture 3

Announcements :

- Lectures posted on: www.phys.uconn.edu/~dutta/151_2006
  - » more to come (HW assignments, solutions etc.)
- Homework #1: due: Fri. 9/8; 5:00 pm EST on WebAssign
  –> NO LATE HWs
- Each student needs to register at WebAssign. Registration fee is $10. Go to http://www.webassign.net and register using:
  - ID: first initial + last name (James S. Clark => jclark)
  - **Institution:** UConn
  - **Password:** your PeopleSoft ID (last 6 digits, no first 0 !)
  - » Let me know (sinkovic@uconn.edu) if you have problems.

Today's Topic :

- Problem Solving / Ch. 1 & 2
- Review of Vectors (Chapter 3)
  - Coordinate systems
  - Math with vectors
  - Unit vectors

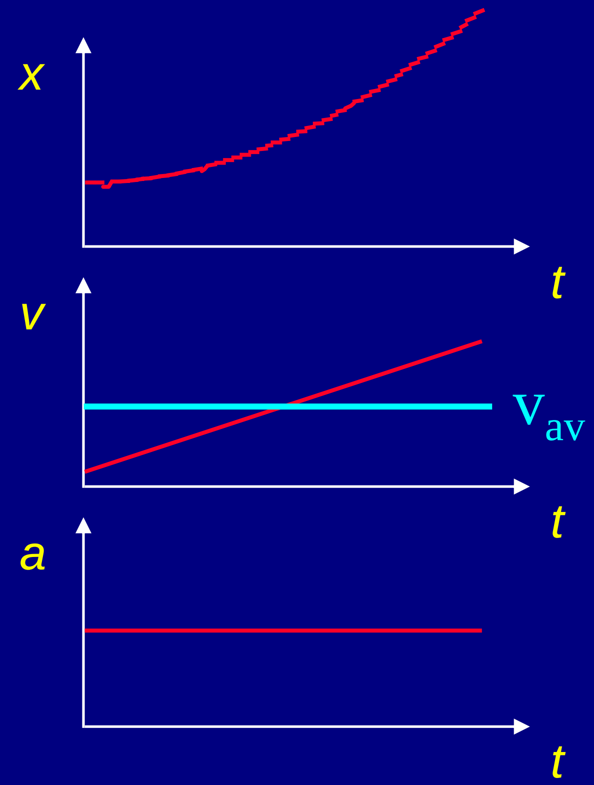
Review (Chapter 2):

- For constant acceleration we found:

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$v = v_0 + at$$

$$a = const$$



- A few other useful formulas :

$$v_{av} = \frac{1}{2}(v_0 + v)$$

$$v^2 - v_0^2 = 2a(x - x_0)$$

Lecture 3, *ACT 1*

A particle moving along the x axis has a position given by $x = (24t - 2.0t^3)$ m, where t is measured in s. What is the magnitude of the acceleration of the particle at the instant when its velocity is zero?

a. 24 m/s^2

b. zero

c. 12 m/s^2

d. 48 m/s^2

e. 36 $m/^2$

Lecture 3, *ACT 2*

Two identical balls are at rest and side by side at the top of a hill. You let one ball, A, start rolling down the hill. A little later you start the second ball, B, down the hill by giving it a shove. The second ball rolls down the hill along a line parallel to the path of the first ball and passes it. At the instant ball B passes ball A, ball B has :

a. the same position and the same velocity as A.

b. the same position and the same acceleration as A.

c. the same velocity and the same acceleration as A.

d. the same displacement and the same velocity as A.

e. the same position, displacement and velocity as A.

Lecture 3, *ACT 3*

The velocity at the midway point of a ball able to reach a height y when thrown with velocity v_0 at the origin :

a. $v_0/2$

b. $(v_0^2 \ 2gy)^{1/2}$

c. $(v_0^2 /2)^{1/2}$

d. $(v_0^2 + 2gy)^{1/2}$

e. gy

Problem #1

- You are writing a short adventure story for your English class. In your story, two submarines on a secret mission need to arrive at a place in the middle of the Atlantic ocean at the same time. They start out at the same time from positions equally distant from the rendezvous point. They travel at different velocities but both go in a straight line. The first submarine travels at an average velocity of 20 km/hr for the first 500 km, 40 km/hr for the next 500 km, 30 km/hr for the next 500 km and 50 km/hr for the final 500 km. In the plot, the second submarine is required to travel at a constant velocity, which you wish to explicitly mention in the story.

Problem Solution Method:

Five Steps:

1) **Focus the Problem**
   - draw a picture – what are we asking for?
2) **Describe the physics**
   - what physics ideas are applicable
   - Picture $\rightarrow$ diagram
   - what are the relevant variables known and unknown
3) **Plan the solution**
   - what are the relevant physics equations
4) **Execute the plan**
   - solve in terms of variables
   - solve in terms of numbers
5) **Evaluate the answer**
   - are the dimensions and units correct?
   - do the numbers make sense?

Solution / Problem #1

a. Draw a diagram

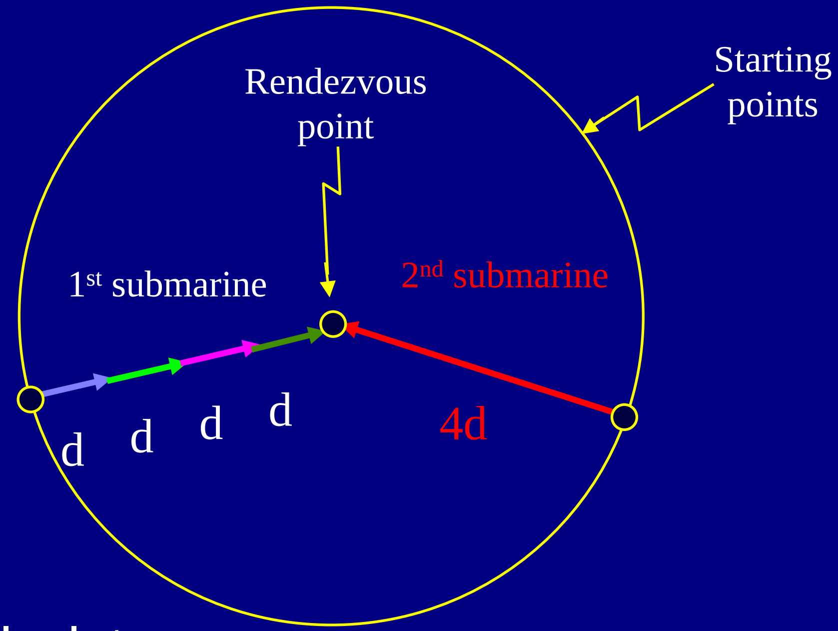
$d = 500$ km

$v_1 = 20$ km/hr

$v_2 = 40$ km/hr

$v_3 = 30$ km/hr

$v_4 = 50$ km/hr



b. What do you need to calculate

c. Which kinematics equations will be useful?

d. Solve the problem in terms of symbols.

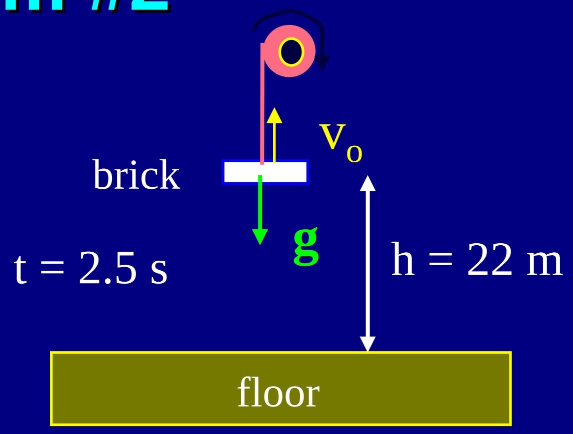
e. Does you answer have the correct dimensions ?

f. Solve the problem with numbers. 31 [km/hr]

Problem #2

- As you are driving to school one day, you pass a construction site for a new building and stop to watch for a few minutes. A crane is lifting a batch of bricks on a pallet to an upper floor of the building. Suddenly a brick falls off the rising pallet. You clock the time it takes for the brick to hit the ground at 2.5 seconds. The crane, fortunately, has height markings and you see the brick fell off the pallet at a height of 22 meters above the ground. A falling brick can be dangerous, and you wonder how fast the brick was going when it hit the ground. Since you are taking physics, you quickly calculate the answer.

Solution / Problem #2



a. Draw a diagram

b. What do you need to calculate

c. Which kinematics equations will be useful?

d. Solve the problem in terms of symbols.

e. Does you answer have the correct dimensions ?

f. Solve the problem with numbers. =>> 21.3 m/s

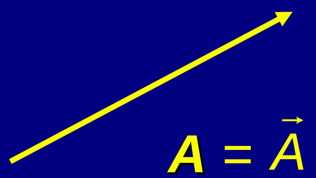
See text: 2-1

Vectors (Chapter 3) Review:

- In 1 dimension, we can specify direction with a + or - sign.

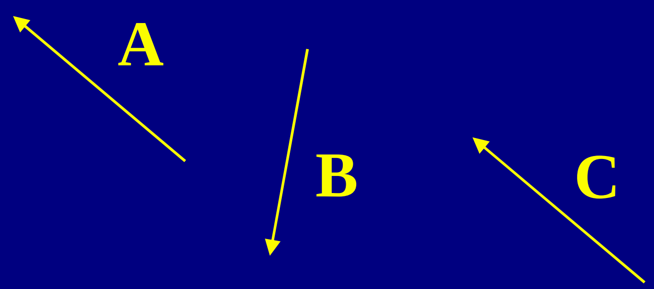
- In 2 or 3 dimensions, we need more than a sign to specify the direction of something:

- There are two common ways of indicating that something is a vector quantity:
  - Boldface notation: $\mathbf{A}$
  - "Arrow" notation: $\vec{A}$



Vectors: definition

- A vector is composed of a magnitude and a direction
  - examples: displacement, velocity, acceleration
  - magnitude of **A** is designated |**A**|
  - usually carries units
- A vector has no particular position
- Two vectors are equal if their directions and magnitudes match.

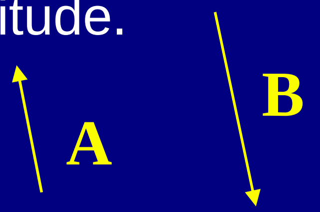


$$\mathbf{A} = \mathbf{C}$$

$$\mathbf{A} \neq \mathbf{B}, \quad \mathbf{B} \neq \mathbf{C}$$

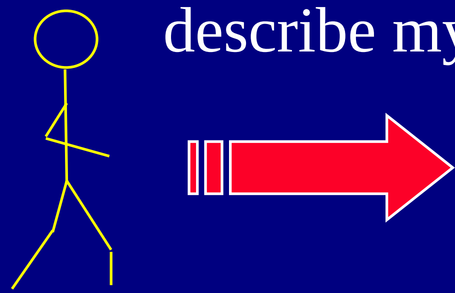
- The product of a vector and a scalar is another vector in the same direction but with modified magnitude.

$$\mathbf{A} = -0.75\,\mathbf{B}$$



Lecture 3, *ACT 1*
Vectors and Scalars

While I conduct my daily run, several quantities describe my condition



Which of the following is not a vector ?

A) my velocity (3 m/s)

B) my acceleration downhill (30 m/s^2)

C) my destination (the pub - 100,000 m)

D) my mass (150 kg)

Which answer has a reasonable magnitude listed ?

See text: 3-1

Coordinate Systems / Chapter 3

- In 1 dimension, only 1 kind of system,
  - Linear Coordinates (x) +/-
- In 2 dimensions there are two commonly used systems,
  - Cartesian Coordinates (x,y)
  - Circular Coordinates (r,θ)
- In 3 dimensions there are three commonly used systems,
  - Cartesian Coordinates (x,y,z)
  - Cylindrical Coordinates (r,θ,z)
  - Spherical Coordinates (r,θ,ϕ)

See text: 3-1

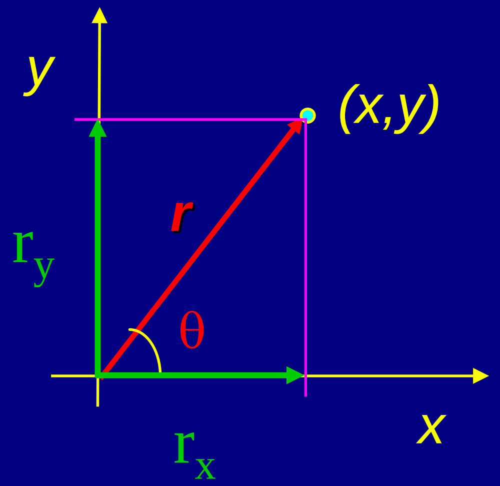
Converting Coordinate Systems

- In circular coordinates the vector **R** = (r,θ)
- In Cartesian the vector **R** = $(r_x,r_y) = (x,y)$

- We can convert between the two as follows:

$$r_x = x = r\cos\theta$$
$$r_y = y = r\sin\theta$$

$$r = \sqrt{x^2 + y^2}$$
$$\theta = \arctan(y / x)$$

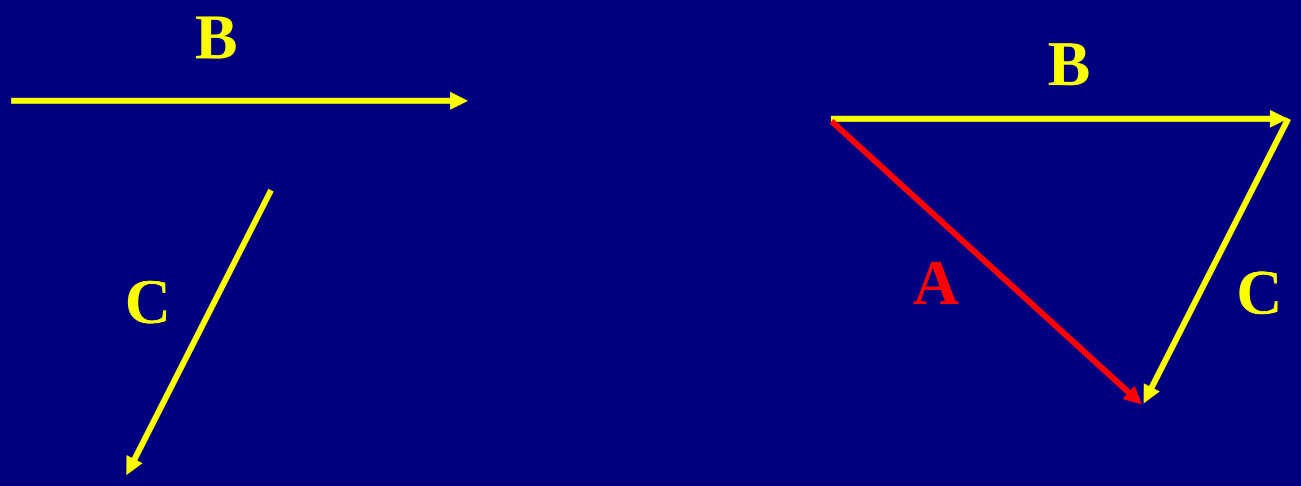


- In cylindrical coordinates, r is the same as the magnitude of the vector

Vector addition:

- The sum of two vectors is another vector.

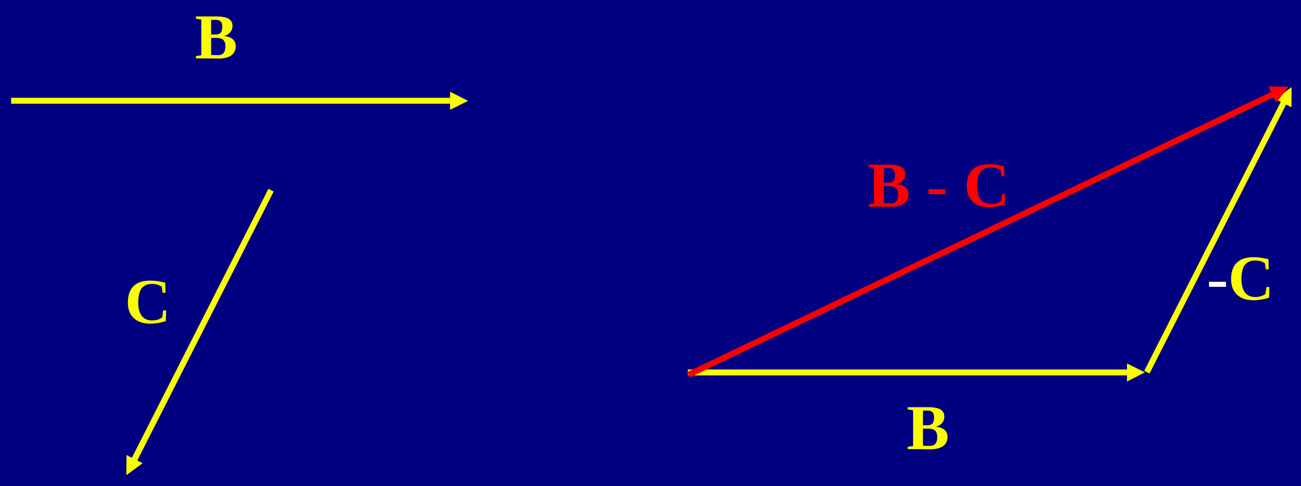
$$\mathbf{A} = \mathbf{B} + \mathbf{C}$$



Vector subtraction:

- Vector subtraction can be defined in terms of addition.

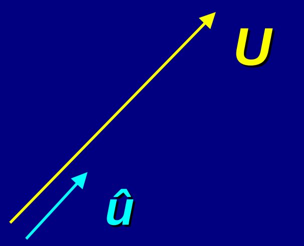
$$\mathbf{B} - \mathbf{C} = \mathbf{B} + (-1)\mathbf{C}$$



See text: 3-4

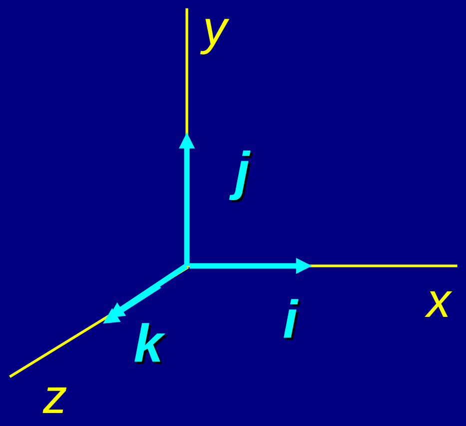
Unit Vectors:

- A **Unit Vector** is a vector having length 1 and no units.
- It is used to specify a direction.
- Unit vector ***u*** points in the direction of ***U***.
  - ⇐ Often denoted with a "hat": ***u* = *û***



- Useful examples are the cartesian unit vectors [***i, j, k***]
  - ⇐ point in the direction of the *x*, *y* and *z* axes.

$$R = r_x\mathbf{i} + r_y\mathbf{j} + r_z\mathbf{k}$$



Lecture 3, *ACT 2*
Vector Addition

- Vector **A** = {0,2,1}
- Vector **B** = {3,0,2}
- Vector **C** = {1,-4,2}

What is the resultant vector, **D**, from adding **A**+**B**+**C**?

(a) *{3,-4,2}*

(b) *{4,-2,5}*

(c) *{5,-2,4}*

See text: 3-4

Vector addition using components / Review

- Consider $\mathbf{C} = \mathbf{A} + \mathbf{B}$.

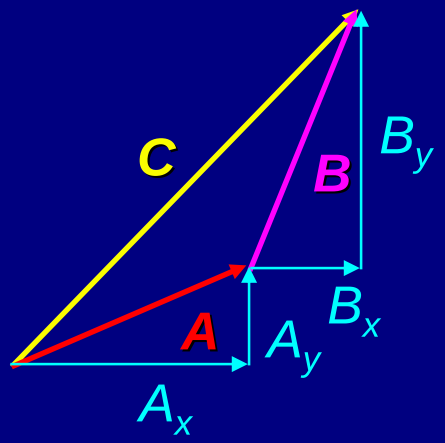
(a) $C = (A_x\,\mathbf{i} + A_y\,\mathbf{j}\,) + (B_x\,\mathbf{i} + B_y\,\mathbf{j}\,) = (A_x + B_x\,)\mathbf{i} + (A_y + B_y\,)\mathbf{j}$

(b) $C = (C_x\,\mathbf{i} + C_y\,\mathbf{j}\,)$

- Comparing components of (a) and (b):

$\Leftarrow$ $C_x = A_x + B_x$

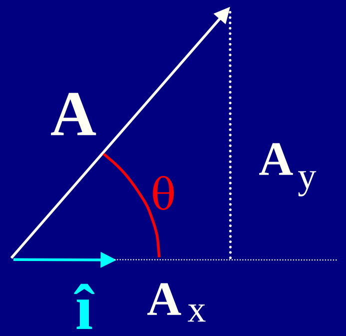
$\Leftarrow$ $C_y = A_y + B_y$



Scalar product

- Useful for performing projections.

$$\mathbf{A} \circ \hat{\imath} = \mathbf{A}_x$$



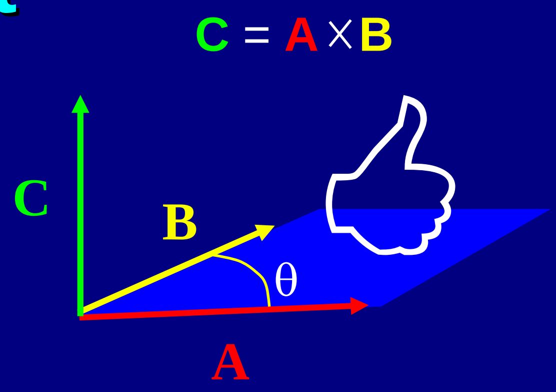
- Calculation is simple in terms of components.

$$\mathbf{A} \circ \mathbf{B} = (\mathbf{A}_x)(\mathbf{B}_x) + (\mathbf{A}_y)(\mathbf{B}_y)$$

- Calculation is easy in terms of magnitudes and relative angles.

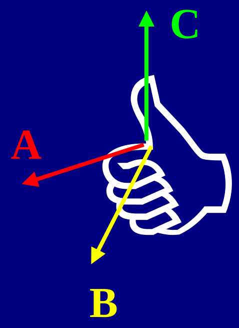
$$\mathbf{A} \bullet \mathbf{B} = |A||B|\cos(\theta)$$

Vector product



- Magnitude defined by:

$$|\mathbf{A} \times \mathbf{B}| = |\mathbf{A}|\,|\mathbf{B}|\,\sin(\theta)$$

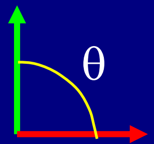


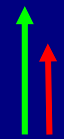
- Direction defined by the <u>"right-hand rule":</u>
  - perpendicular to both **A** and **B**;
  - extend fingers of right hand along direction of **A**;
  - face palm so that fingers bend into direction of **B**;
  - extended thumb points along direction of **A** x **B**.

Multiplication of vectors / Recap

- There are two common ways to multiply vectors
  - "scalar product": result is a scalar

$$\mathbf{A} \circ \mathbf{B} = |\mathbf{A}|\,|\mathbf{B}|\,\cos(\theta)$$

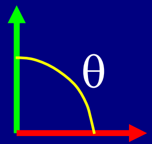


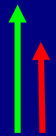


$\mathbf{A} \circ \mathbf{B} = 0$ $\quad$ $\mathbf{A} \circ \mathbf{B} = \not 0$

  - "vector product": result is a vector

$$|\mathbf{A} \times \mathbf{B}| = |\mathbf{A}|\,|\mathbf{B}|\,\sin(\theta)$$





$\mathbf{A} \times \mathbf{B} = \not 0$ $\quad$ $\mathbf{A} \times \mathbf{B} = 0$

Recap of today's lecture

- Problem solving (Chapter 2)
- Vectors, Chapter 3 (mathematical review)
- Reading for next class 9/5 (NO CLASS Labor Day):
    » Chapter 4: Sections 1-3
- Homework : Each student needs to register at WebAssign. Go to http://www.webassign.net and register using:
    - ID: first initial + last name (James S. Clark => jclark)
    - **Institution:** UConn
    - **Password:** your PeopleSoft ID (last 6 digits, no first 0 !)
        » Let Dr. Dutta know (nkd@phys.uconn.edu) if you have problems.
- Read instructions on WebAssign for additional info.