Welcome to Physics 181

Today, we're going to go over:

- **The Philosophy and Information & Policies for the Course**

- **Textbook and MasteringPhysics: How to Register and Access**

  We will be using Learning Catalytics in MP for you to enter your answers. This is something that we will use in every class. Usually it will count for points; however for today, it doesn't count.

- **We will do the class on Chapter 1: Motion.**

- **Your homework for Wednesday is to:**
  - **Get registered for MasteringPhysics as soon as possible**
  - **Do the "Intro to MP" assignment on MP**
  - **Read Chapter 1 in your text and do HW 1 on MP**
  - **Read Sections 2.1-3 in Chapter 2.**
  - **Math Review – read over Appendix A and do "Physics Primer" on MP by next Wednesday (9/3)**

Brief Introduction to Physics

What is Physics?

"Physics is the process by which we attempt to *quantitatively* understand the Universe around us."

What, then, is Engineering?

"Engineering is using this process and knowledge of how the Universe works to improve our lives."

What about Chemistry?

"Chemistry is Atomic and Molecular Engineering."

*Note: this is a process or a **way of thinking** – Physics is much more than a body of knowledge or a set of equations.*

Where do we Begin our Study of Physics?

- Imagine for a minute that we are totally ignorant about how the Universe works.

- What single observation of our surroundings would be most revealing about this strange Universe?

- **Everything Moves*.**

(*if nothing moved, there would be no need for physics because nothing would change!)*

**Don't be deceived by your senses. Objects that appear to be motionless, have internal motions that we can't perceive with our senses.*

So, our First Goal in physics is to understand and describe motion:

How do we describe motion? **Kinematics** (position, velocity, acceleration, & time)

What causes motion? **Dynamics** (force, momentum, energy)

Chapter 1: Concepts* of Motion

(**Conceptual Kinematics*)

If you would ask a physics grad student (. . . like one of your TA's):

What is Kinematics?

The answer would likely be:

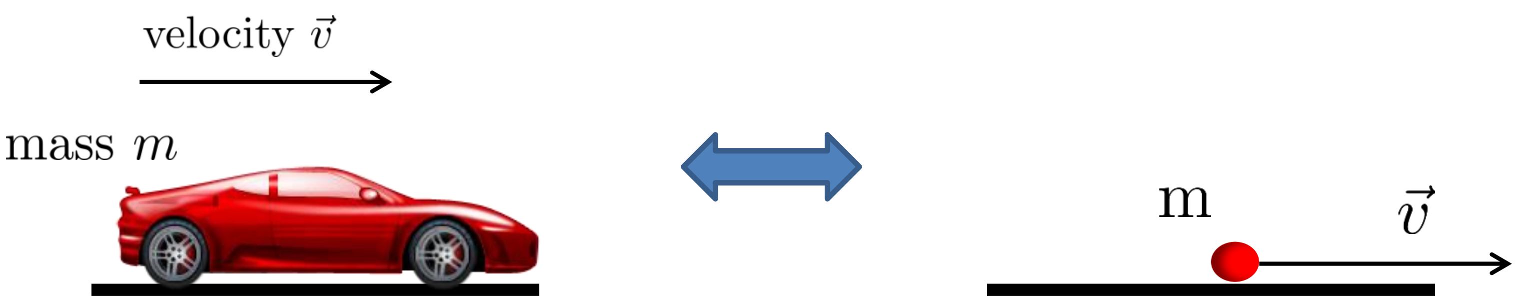
$$\text{“ } \vec{v} = \frac{d\vec{r}}{dt} \text{ ”} \qquad \text{and} \qquad \text{“ } \vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2} \text{ ”}$$

We'll get to this point in chapters 2, 3, & 4 – **but for now, in Chapter 1**, we just want to understand **very conceptually** what these things are.

The Particle Model

For many problems, we can study the motion of an object as if it was concentrated at point. Your author calls this the **Particle Model**.

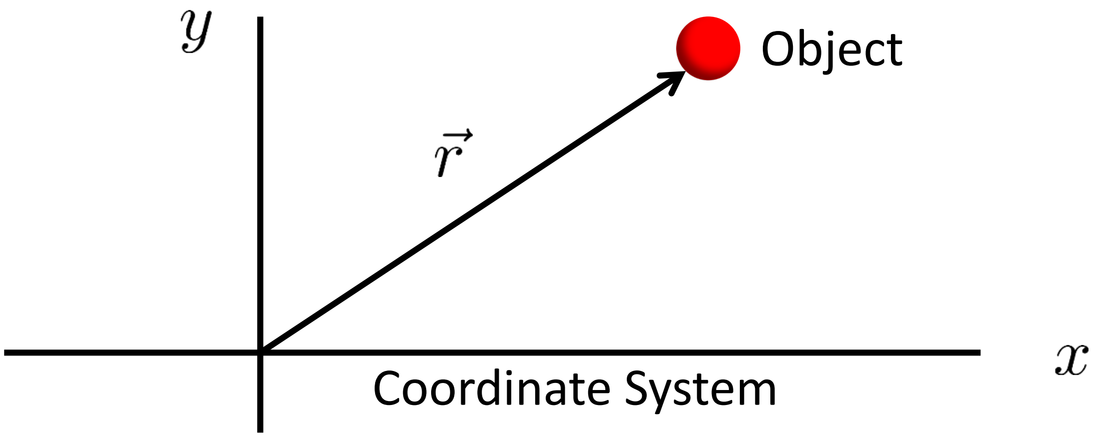
For Example: A Car



If we're only concerned about describing the car's motion along the highway, its shape, composition, cool appearance, and internal processes are not important.

So, we can treat it as a point particle of mass m.

Position, Velocity, and Acceleration (and Time)



The **position** of the object is defined by:

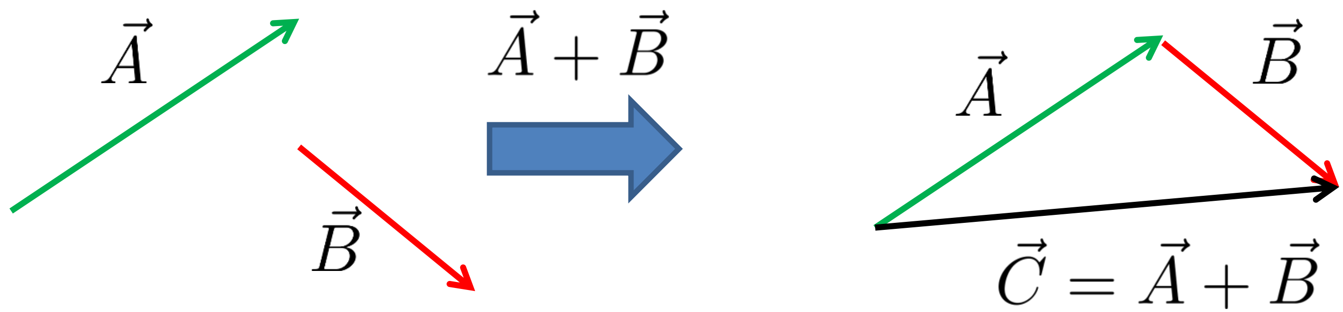
$\vec{r}$ = **position vector*** of the object relative to the origin of some arbitrary coordinates

*A Vector *is a quantity that has both magnitude and direction – really important in all of physics and engineering. We'll cover the details in Chapter 3. For now, all we need to know is how we add and subtract Vectors that are represented as Arrows.*

Vector Addition and Subtraction . . . With Arrows

Quantities that have magnitude and direction, **vectors**, can be represented as arrows. The length of the arrow is the magnitude and the direction is the direction that the arrow points.

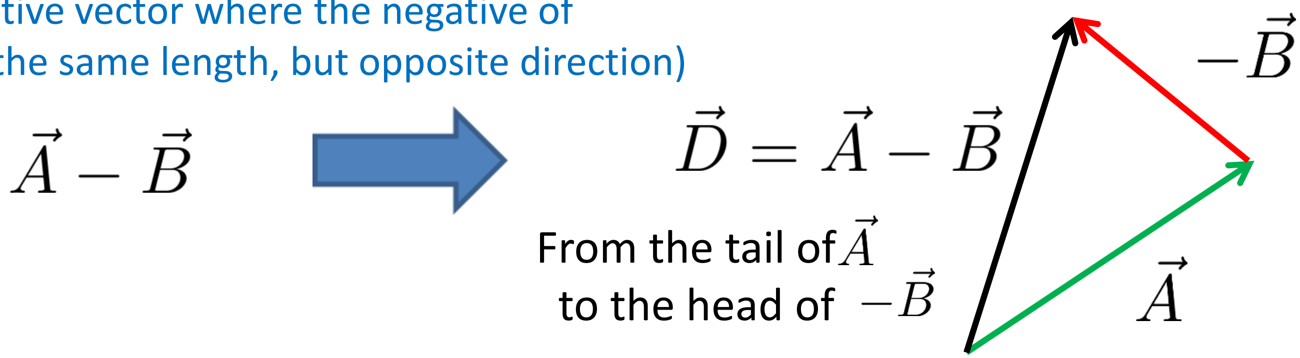
Vector Addition: move the vectors, don't rotate or stretch; place tails on heads.



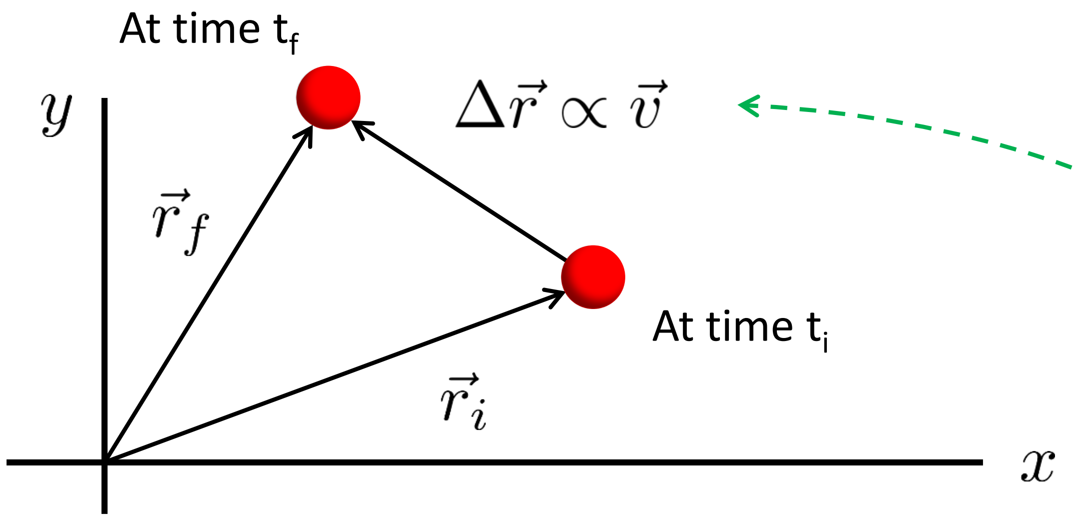
From the tail of $\vec{A}$ to the head of $\vec{B}$

Vector Subtraction: treat as: $\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$

(add the negative vector where the negative of a vector has the same length, but opposite direction)



Motion is the change of an object's position with time

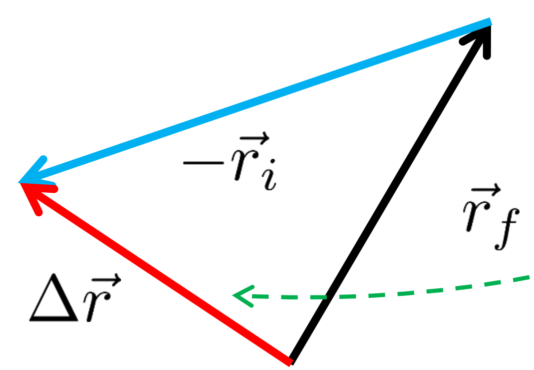


$$\text{Average Velocity, } \vec{v}_{\text{avg}} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\vec{r}_f - \vec{r}_i}{t_f - t_i} \text{ (call it just } \vec{v} \text{ for now)}$$

Δ means the change in a quantity
and is always final $-$ initial

Vector Subtraction:

$$\Delta\vec{r} = \vec{r}_f - \vec{r}_i$$

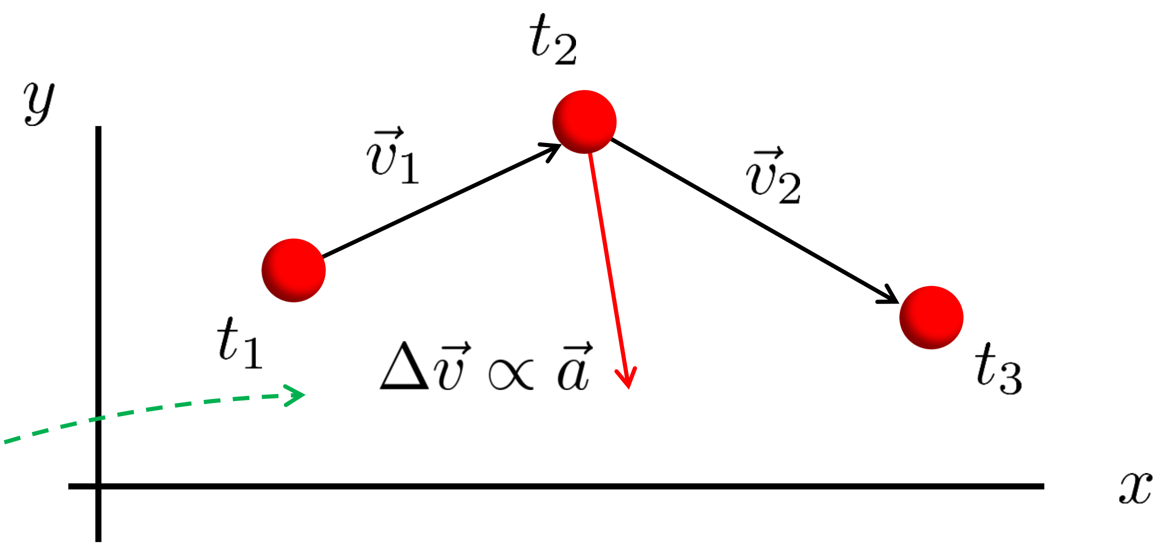


Whiteboard Problem: 1-1

A baseball player slides into second base. **Draw a motion diagram**, using the particle model, showing his position and his average velocity vectors from the time he begins to slide until he reaches the base.

Skip ahead a couple of slides to show what a motion diagram is.

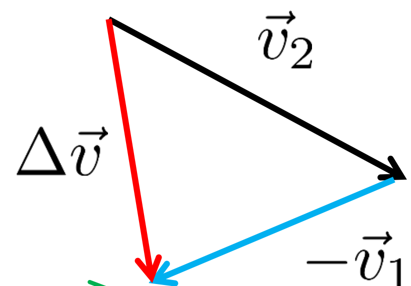
Acceleration is the change of an object's velocity with time



$$\text{Average Acceleration, } \vec{a}_{\text{avg}} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1} \text{ (call it just } \vec{a} \text{ for now)}$$

Vector Subtraction:

$$\Delta \vec{v} = \vec{v}_2 - \vec{v}_1$$



What do we mean by "Speed?" **Speed is the length (or magnitude) of the velocity vector (and is always > or = zero).**

PROBLEM-SOLVING STRATEGY 1.1

Motion diagrams

MODEL Determine whether it is appropriate to model the moving object as a particle. Make simplifying assumptions when interpreting the problem statement.

VISUALIZE A complete motion diagram consists of:

- The position of the object in each frame of the video, shown as a dot. Use five or six dots to make the motion clear but without overcrowding the picture. More complex motions may need more dots. **(Equal times between dots)**
- The average velocity vectors, found by connecting each dot in the motion diagram to the next with a vector arrow. There is *one* velocity vector linking each *two* position dots. Label the row of velocity vectors $\vec{v}$.
- The average acceleration vectors, found using Tactics Box 1.3. There is *one* acceleration vector linking each *two* velocity vectors. Each acceleration vector is drawn at the dot between the two velocity vectors it links. Use $\vec{0}$ to indicate a point at which the acceleration is zero. Label the row of acceleration vectors $\vec{a}$.

Since we don't know Δt, the velocities and accelerations are only relatively correct.

$$\text{i.e. } \vec{v} \propto \Delta\vec{r} \text{ and } \vec{a} \propto \Delta\vec{v}$$

Whiteboard Problem: 1-2

The figure shows the first three points of a motion diagram.

a) **Draw and label the complete motion diagram on LC, showing the velocity vectors and acceleration vector at point 1.**

b) **Is the object's average speed between points 1 and 2 greater than, less than, or equal to its average speed between points 0 and 1 (LC)?**

Problem Solving Strategy

GENERAL PROBLEM-SOLVING STRATEGY

MODEL It's impossible to treat every detail of a situation. Simplify the situation with a model that captures the essential features. For example, the object in a mechanics problem is often represented as a particle.

VISUALIZE This is where expert problem solvers put most of their effort.

- Draw a *pictorial representation*. This helps you visualize important aspects of the physics and assess the information you are given. It starts the process of translating the problem into symbols.
- Use a *graphical representation* if it is appropriate for the problem.
- Go back and forth between these representations; they need not be done in any particular order.

SOLVE Only after modeling and visualizing are complete is it time to develop a *mathematical representation* with specific equations that must be solved. All symbols used here should have been defined in the pictorial representation.

ASSESS Is your result believable? Does it have proper units? Does it make sense?

More

Problem Solving Strategy

"Doing Physics is Doing Physics Problems," Prof. Perry Rice, MU PHY

I would add to your author's strategies:

Under mathematical representation:

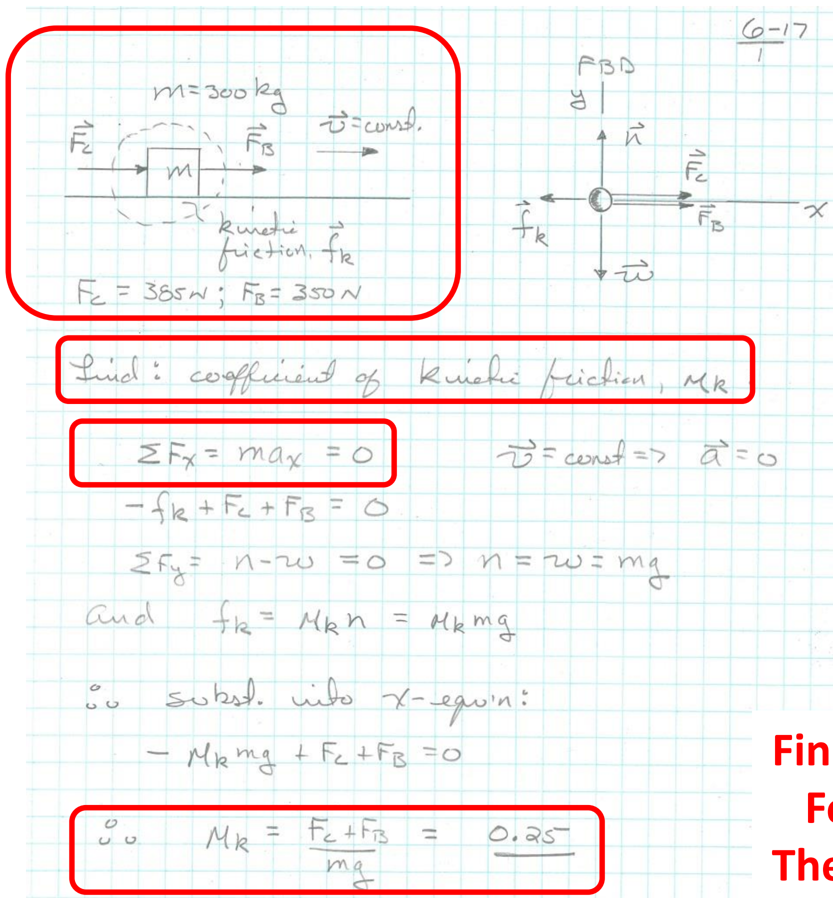
- Start with a general physical relation (from the equation sheet? **Yes!**), and then apply it to the special case of your problem.
- **Do the algebra symbolically – don't put the numbers in immediately. i.e. Algebraically s**olve for the desired quantity in terms of the symbols of the known quantities, and then plug the numbers into your calculator to get your answer. *(This is really important!)*

For example, here's my solution for a problem that we'll do in a few weeks.

Whiteboard Prob. 6-?? (we'll do this problem in a few weeks)

Bonnie and Clyde are sliding a 300 kg bank safe across the floor to their getaway car. The safe slides with a constant speed if Clyde pushes from behind with 385 N of force while Bonnie pulls forward on a rope with 350 N of force. What is the safe's coefficient of kinetic friction on the bank floor?

Solution



Draw Pictures and define given information!

"If you can't draw it, you don't understand it."
Prof. Glenn Julian, MU PHY

What am I trying to find?

General Equation

Symbolic Math

Find a symbolic expression For your answer. Then plug in numbers.

Units

<u>We'll use SI (or mks) Units:</u> length = meters; mass = kilograms; time = seconds

However, be careful: your author loves to give quantities in problems in all kinds of units, especially using prefixes (see front flap of text which is the Constants and Conversion Sheet on our Canvas page) e.g.

$$\mathrm{cm} \Leftrightarrow 10^{-2}\ \mathrm{m}$$
$$\mathrm{nm} \Leftrightarrow 10^{-9}\ \mathrm{m}$$

Sometimes conversions are obvious. **If not, write it out; e.g.**

Atmospheric Pressure $= 14.7 \frac{\cancel{lb}}{\cancel{in}^2} \left(\frac{4.448\ N}{1\ \cancel{lb}}\right)\left(\frac{39.37\ \cancel{in}}{1\ m}\right)^2 = 1.013 \times 10^5 \frac{N}{m^2}$

<u>Significant Figures:</u> Read this section, and for MP, remember to round to the required number of significant figures at the end.

Order of Magnitude Estimates

Many times in science and engineering, if we don't have precise data or sufficient time, we can get a reasonable answer to within a power of ten, i.e. an order of magnitude estimate. In short:

"In any problem, you can usually get 90% of the answer with 10% of the effort"

Prof. Thomas York, PSU Aerospace Engr, 1975

For example, if you were to walk from Oxford, OH to Los Angeles, CA, **how many steps would you take?**

What is the distance from Oxford to LA? ~ 2000 miles

How many kilometers in a mile? 1 mile ~ 1.5 km

So, the distance is: ~ 3000 km = 3,000,000 meters

How long is an average step? ~ 1 meter

Therefore , you would take about 3,000,000 steps in the journey.

Whiteboard Problem: 1-3

Disposable diapers are widely used in this country, and are a significant fraction of waste in landfills.

Estimate the number of disposable diapers used in the United States during a single year knowing only that the current US population is ~330 million people. (LC)