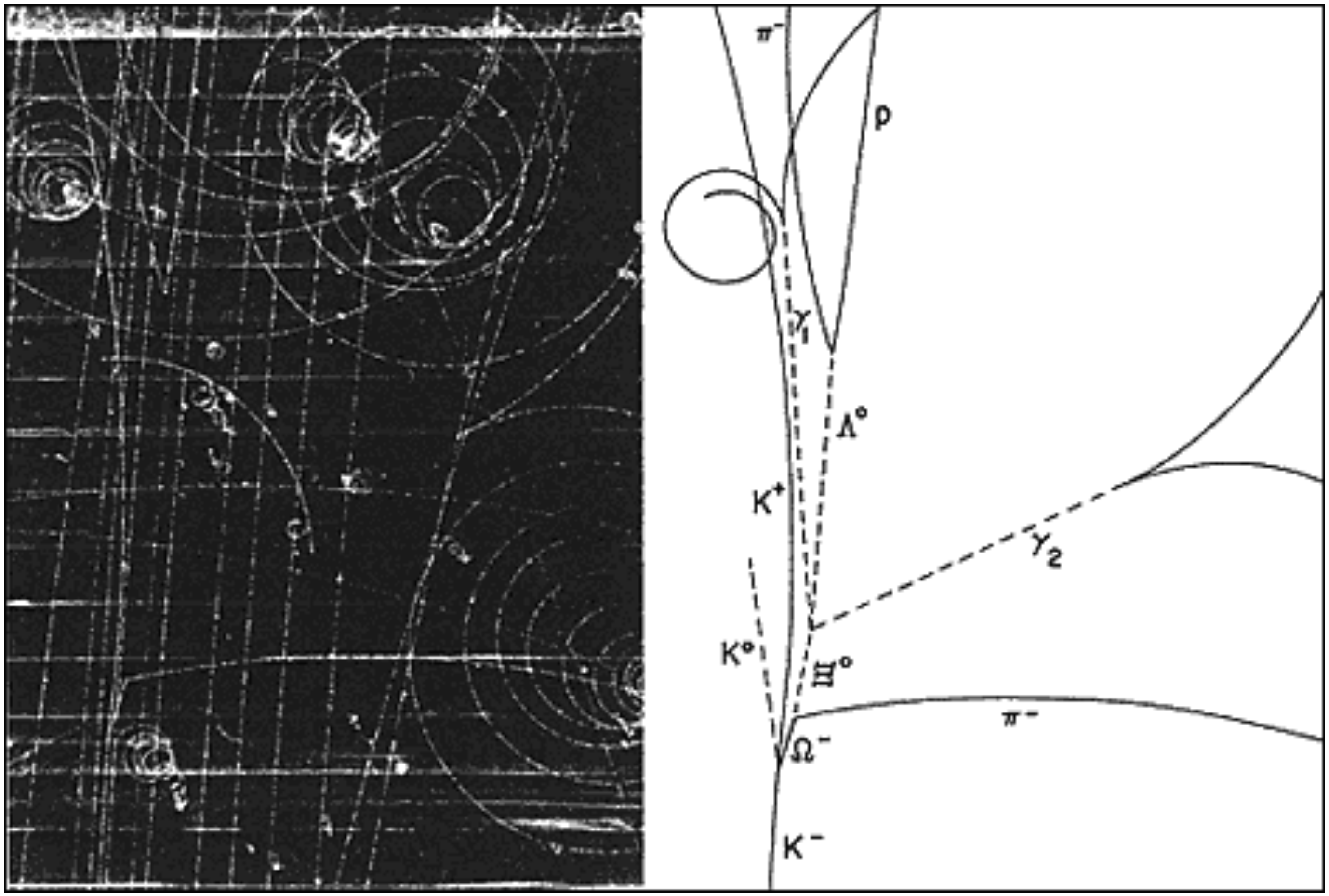
Physics 121.
Lecture 02.



Credit: Brookhaven National Laboratory, NY, USA
http://www.bnl.gov/bnlweb/history/Omega-minus.asp

The bubble chamber picture of the first omega-minus. An incoming K^- meson interacts with a proton in the liquid hydrogen of the bubble chamber and produces an omega-minus, a K_0 and a K^+ meson which all decay into other particles. Neutral particles which produce no tracks in the chamber are shown by dashed lines. The presence and properties of the neutral particles are established by analysis of the tracks of their charged decay products and application of the laws of conservation of mass and energy.

Hans Brinker

Spaarndam

Physics 121.
Lecture 02.

- Today's topics:
  - Physics 121 website, and homework
  - Introduction to Poll Everywhere.
  - Chapter 2: Describing One Dimensional Motion:
    - Position
    - Velocity
    - Acceleration

Physics 121.
Course Information.

- I do not use BlackBoard!

- Our web site provides up-to-date course information:

  - The web site contains links to workshop and laboratory information.
  - The web site contains a link to our homework system and homework solutions (the solutions are password protected).
  - The web site contains links to practice exams and their solutions.
  - All lecture presentations, including video recordings, will be available on the web site shortly before or after class.

http://teacher.pas.rochester.edu/phy121/

Physics 121.
Course Information.

- Additional comments:
  - Homework set # 0 is now available; it is due on Saturday 1/31/26 at 8.30 am. This set is to make you familiar with WeBWorK and does not count toward your final grade. Make sure you verify that you can log in to WeBWorK.
  - Homework set # 1 will be available later this week and is due on Saturday 1/31/26 at 8.30 am. This set will be the first set that counts towards your final grade.

Correction! Missing square!
The weighted mean.

- When the data have different errors, we need to use the weighted mean to estimate the mean value.
- This procedure requires you to assign a weight to each data point:

$$w_i = \frac{1}{\sigma_i^2}$$

- Note: when the error decreases the weight increases.
- The weighted mean and its error are defined as:

$$\bar{y} = \frac{\sum_{i=1}^{N} w_i y_i}{\sum_{i=1}^{N} w_i} \qquad \sigma_{\bar{y}}^{2} = \frac{1}{\sum_{i=1}^{N} w_i}$$

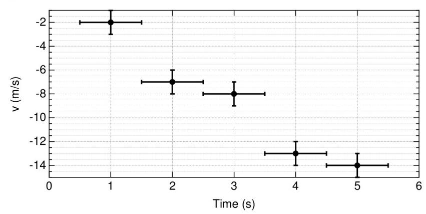
Physics 121 homework set # 1.
Due 1/31/26.

Frank Wolfs Physics 121, Spring 2008
Homework Set 01 Due date: 02/02/2008 at 08:30am EST

No idea why it shows 2008.

This assignment will be counted toward your final grade. You can attempt each problem 15 times; once you exceed this number of attempts, your solutions will not be recorded anymore. You may need to give 4 or 5 significant digits for some (floating point) numerical answers in order to have them accepted by the computer. Note: to use scientific notion, use a notion like xxE+yy. It is important that you use a capital E; answers with a lower case e will be evaluated differently

1. **(10 pts) type03/prob03.pg**
The measured velocity v of a car, moving with a constant acceleration a, is shown in the Figure. Note: the indicated error bars are $\pm$ 1 σ. Assuming that the measured velocity v is proportional to the measured time t (that is $v = at$) find the most probable value of the acceleration a. ____________



What is the standard deviation of the acceleration? ____________

Weighted mean of *v/t*.
Use spread sheets!

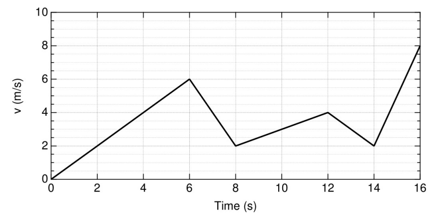
2. **(10 pts) type03/prob09.pg**
A horizontal beam of length L is supported at its ends, and is loaded in the center with a weight W. It can be shown that the deflection Y at the center of the beam is given by $Y = \frac{WL^3}{48EI}$ where E is the elastic modulus and I is the moment of inertia of the cross section about its center axis. The characteristics of the beam, E and I, are known with high precision, but only crude measurements of W and L are available: W = 97.0 $kg \pm$ 2.0 kg and L = 50.0 $m \pm$ 0.5 m (note: the listed errors are $\pm 1\sigma$). What is the fractional standard deviation of Y? ____________

Error propagation.

3. **(10 pts) type04/prob01.pg**
Rain is falling steadily, but there is no wind. You are on a bus that moves at 45.0 km/hr, and you see that the rain appears to be falling at an angle of 41° with respect to the vertical. What is the vertical velocity of the rain drops? ____________

Relative velocity.

4. **(15 pts) type05/prob03.pg**
How far does the runner, whose velocity versus time graph is shown in the Figure, travel in the first 15.3 s? ____________



What is the average velocity of the runner during the 16 s time interval shown in the Figure? ____________

Integrate *v* to find *d*.

5. **(15 pts) type05/prob05.pg**
A Cherokee Warrior can accelerate from rest to a ground speed of 75 knots in 29.7 s. What is the average acceleration of this airplane? ____________
The Warrior can take off when its airspeed (speed of the air flowing over the wing) is equal to 65 knots. What is the length of runway required for the plane to take off if there is a 25 knots head wind? Note: the shortest runway at the Rochester International Airport (runway 25) has a length of 4403 ft. ____________
What is the length of runway required for the plane to take off if there is a 25 knots tail wind? ____________

Relative velocity.

6. **(10 pts) type05/prob13.pg**
An object falls from a bridge that is 50 m above the water. It falls directly into a small boat moving with constant velocity that was 14 m from the point of impact when the object was released. What is the speed of the boat? ____________

Relative velocity.

7. **(10 pts) type05/prob38.pg**
An object is moving in a straight line with a constant acceleration. Its position is measured at three different times, as shown in the table below.

Time (s)	Position, (m)
40.90	8.400
42.80	15.439
44.70	29.338

Calculate the magnitude of the acceleration. ____________

Obtaining *a* from *x(t)*.

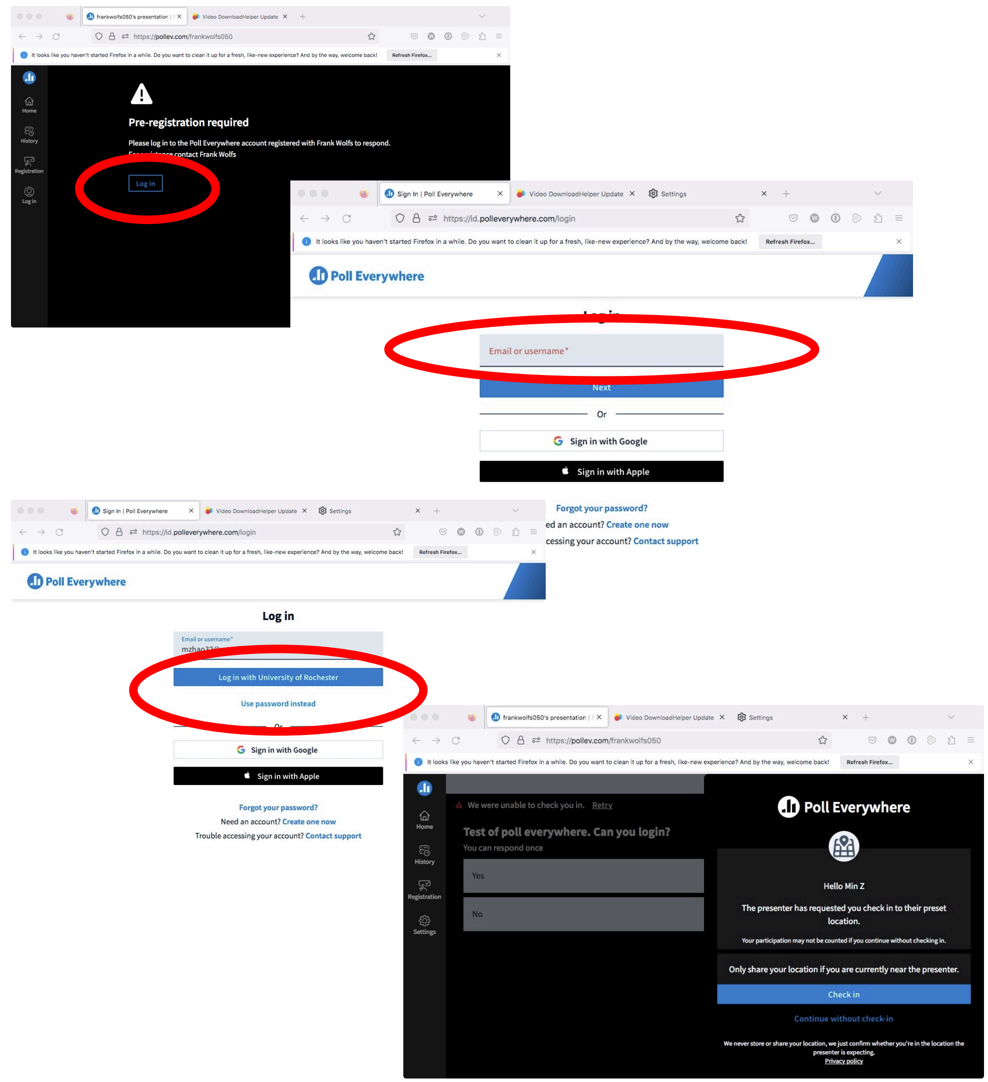
8. **(10 pts) type08/prob03.pg**
A rocket is launched from rest and moves in a straight line at 60.0 ° above the horizontal with an acceleration of 62.5 m/s^2. After 49.0 s of powered flight, the engines shut off and the rocket follows a parabolic path back to earth. Find the time of flight from launch to impact. ____________
What is the maximum altitude reached? ____________

Complicated projectile motion.

1

Introduction to Poll Everywhere. https://pollev.com/frankwolfs050

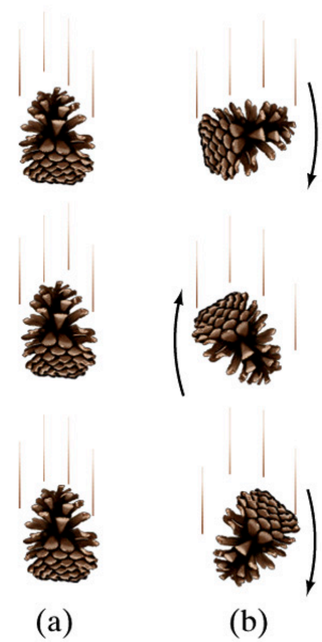
- Poll Everywhere is used to carry out in-class quizzes and concept tests.
- Quizzes will be recorded for credit. The concept tests are not.
- I invited all students that were registered as of 1/16/26. You should have received an email about this from the system.
- We will try it out now.



Introduction to Poll Everywhere.
https://pollev.com/frankwolfs050

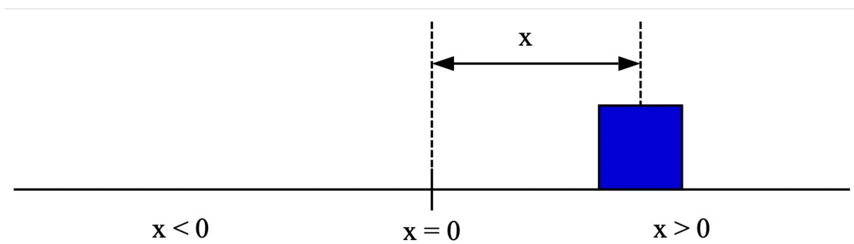
Describing motion in one dimension.

- There are different ways in which we can describe the motion of an object.
- In Chapter 2 we will focus on describing motion along a straight line, or one-dimensional motion.
- The direction of motion is not limited to the horizontal direction, but for example can also be in the vertical direction (e.g. free fall).
- One dimensional motion can be simply translational but may also include rotational motion.



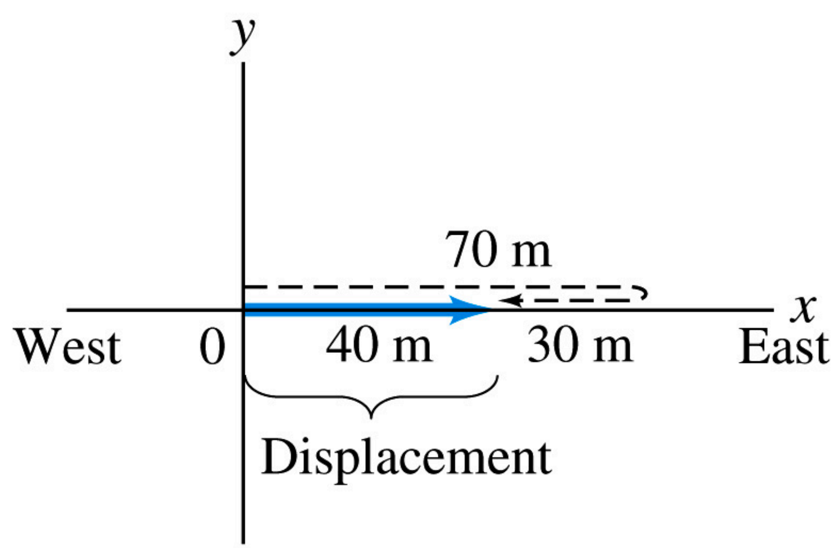
Describing motion in one dimension.

- When we limit ourselves to pure translational motion, we in general can describe the motion in terms of three parameters:
  - The position $x(t)$: units m.
  - The velocity $v(t)$: units m/s.
  - The acceleration $a(t)$: units m/s^2.
- To specify the position x of an object we need to define the origin (the point where $x = 0$ m) of our coordinate system.



Position.

- Two terms often confused when describing the motion of an object are:
  - **Distance traveled**: the total distance the object moved during the motion from its starting point to its end point. Note: depends on the exact path followed and is always positive.
  - **Displacement**: the change in the position of an object. Note: depends only on its starting point and its end point.

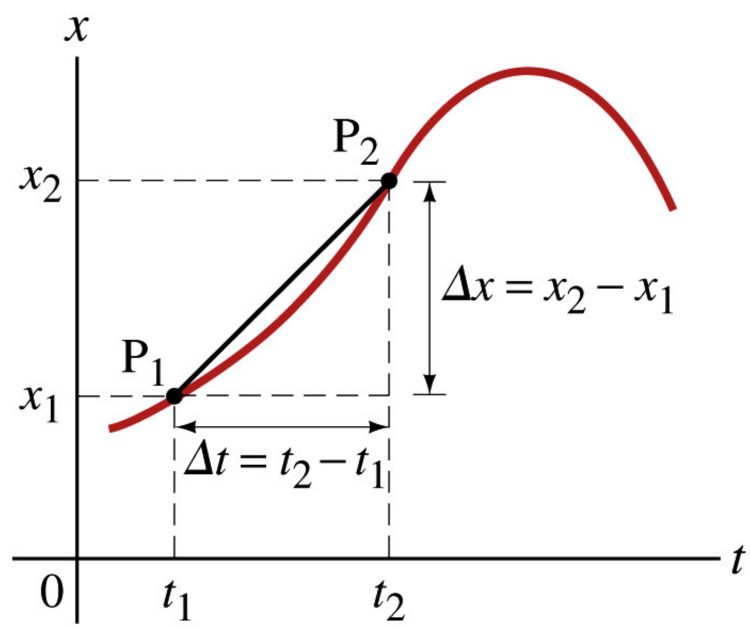


Position.

- Do we understand position versus time graphs and do we really understand the difference between distance traveled and displacement?
- Let's see: Concept Tests 2, Q 5 – 8.

Velocity.

- All information about the motion of an object is in principle contained in the time dependence of its position $x(t)$.
- Often it is useful to talk about the velocity v of the object, which is defined as the ratio of the change in position, Δx, and the change in time Δt.
- The velocity calculated in this manner is the average velocity over the time interval Δt.

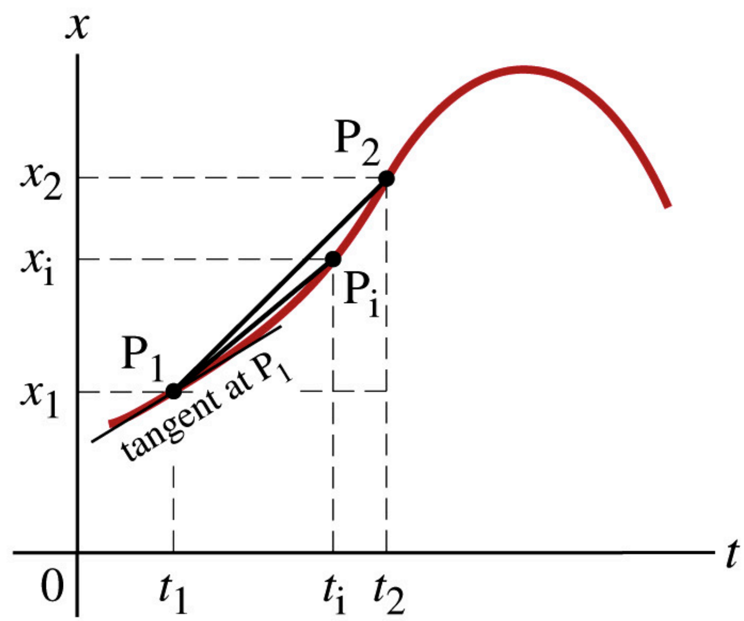


Velocity.

- Some remarks about velocity:
  - Velocity can be positive and negative. In our choice of coordinate system, a positive velocity corresponds to motion towards the right, and negative velocity corresponds to motion towards the left.
  - The sign of the velocity does not depend on the sign of the position.
  - The speed and velocity of an object are often confused. The speed of an objective is the magnitude of the velocity of the object. It is thus always positive!

Velocity.

- When the time interval Δt decreases, the average velocity approaches the instantaneous velocity.
- The velocity of the object is related to the slope of the position versus time graph:
  - A positive slope correspond to a positive velocity; a negative slope corresponds to a negative velocity.
  - When the slope increases, the velocity increases..



Velocity.

- Understanding velocity. Do you get it?
- Let's see: Concept Tests 2, Q 9 – 14.

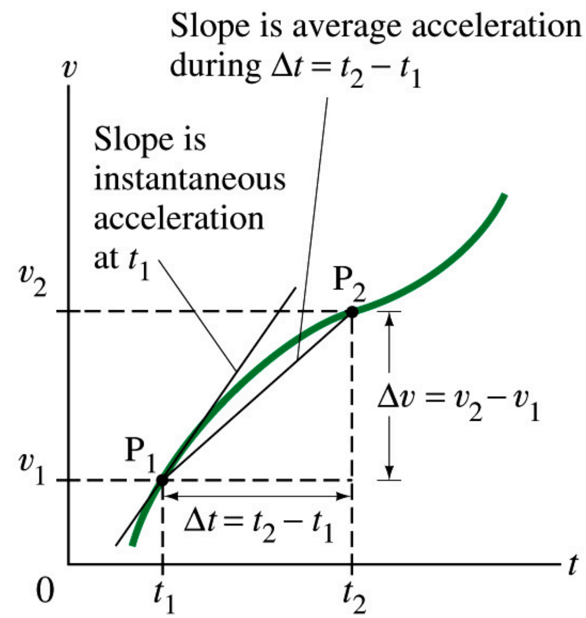
3 Minute 3 Second Intermission

- Since paying attention for 1 hour and 15 minutes is hard when the topic is physics, let's take a 3 minute 3 second intermission.

- You can:
  - Stretch out.
  - Talk to your neighbors.
  - Ask me a quick question.
  - Enjoy the fantastic music.
  - Solve a WeBWork problem.
  - Go asleep, as long as you wake up in 3 minutes and 3 seconds.

Acceleration.

- The acceleration of an object is defined at the ratio of the change of the velocity of an object, Δv, and the change in time Δt.
- The acceleration calculated in this manner is the average acceleration over the time interval Δt.
- The acceleration can be positive or negative depending on whether $\Delta v > 0$ m/s or $\Delta v < 0$ m/s.



Acceleration.

- Some remarks about acceleration:
  - Acceleration can be positive and negative.
  - In our every day life, we often use the term **acceleration** when we speed up and **deceleration** when we slow down. This leads to the assumption that a positive acceleration implies an increase in speed while a negative acceleration corresponds to a decrease in speed. **THIS IS ABSOLUTELY WRONG!!!!!!!!!**
  - Negative acceleration implies that $\Delta v < 0$ m/s. This can be achieved in a number of different ways:
    - If $v_1 = 30$ m/s and $v_2 = 10$ m/s: a reduction in speed!
    - If $v_1 = -10$ m/s and $v_2 = -30$ m/s: an increase in speed!

Constant acceleration.

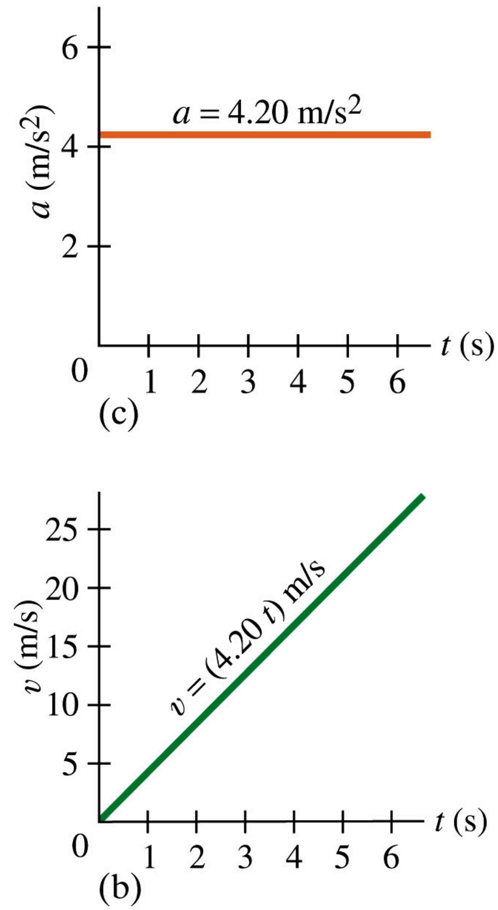
- Many important physics effects involve motion with constant acceleration.

- Constant acceleration implies that

$$a = \frac{dv}{dt} = \text{constant}$$

- In this case, the velocity will have a linear dependence on time:

$$v(t) = v_0 + at$$

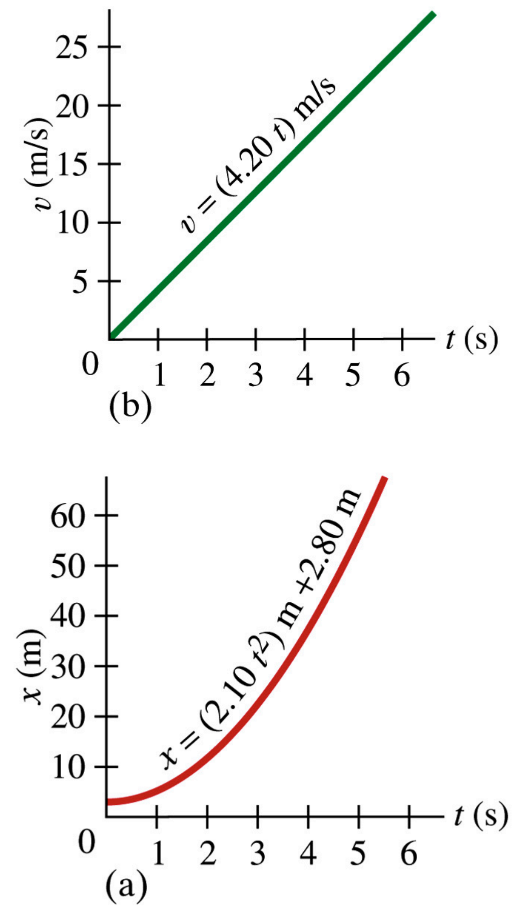


Constant acceleration.

- When the velocity of an object has a linear dependence on *t*, the position of the object will have a quadratic dependence on *t*:

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

- An important case of constant acceleration, is the vertical motion of objects under the influence of the gravitational force.



Constant acceleration.

- In order to fully define the motion of an object if we know its acceleration, we need to have more information:
  - We need to know v_0, which is the velocity of the object at time $t = 0$ s.
  - We need to know x_0, which is the position of the object at time $t = 0$ s.
- Make sure the signs are consistent!

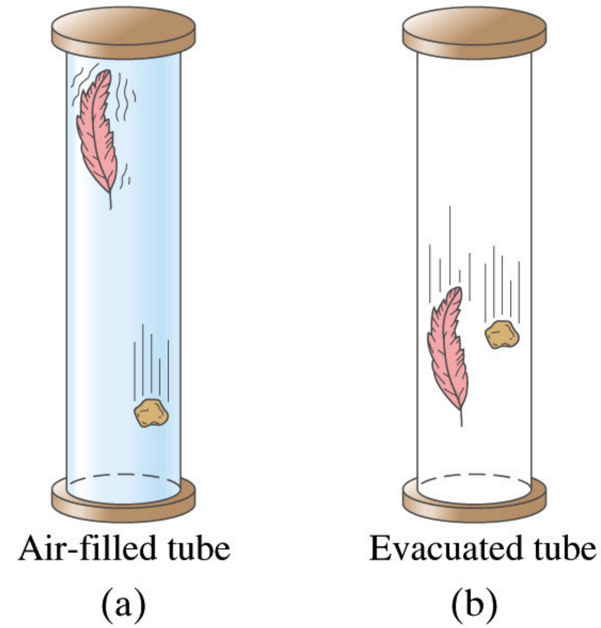
$$a = \frac{dv}{dt} = \text{constant}$$

$$v(t) = v_0 + at$$

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

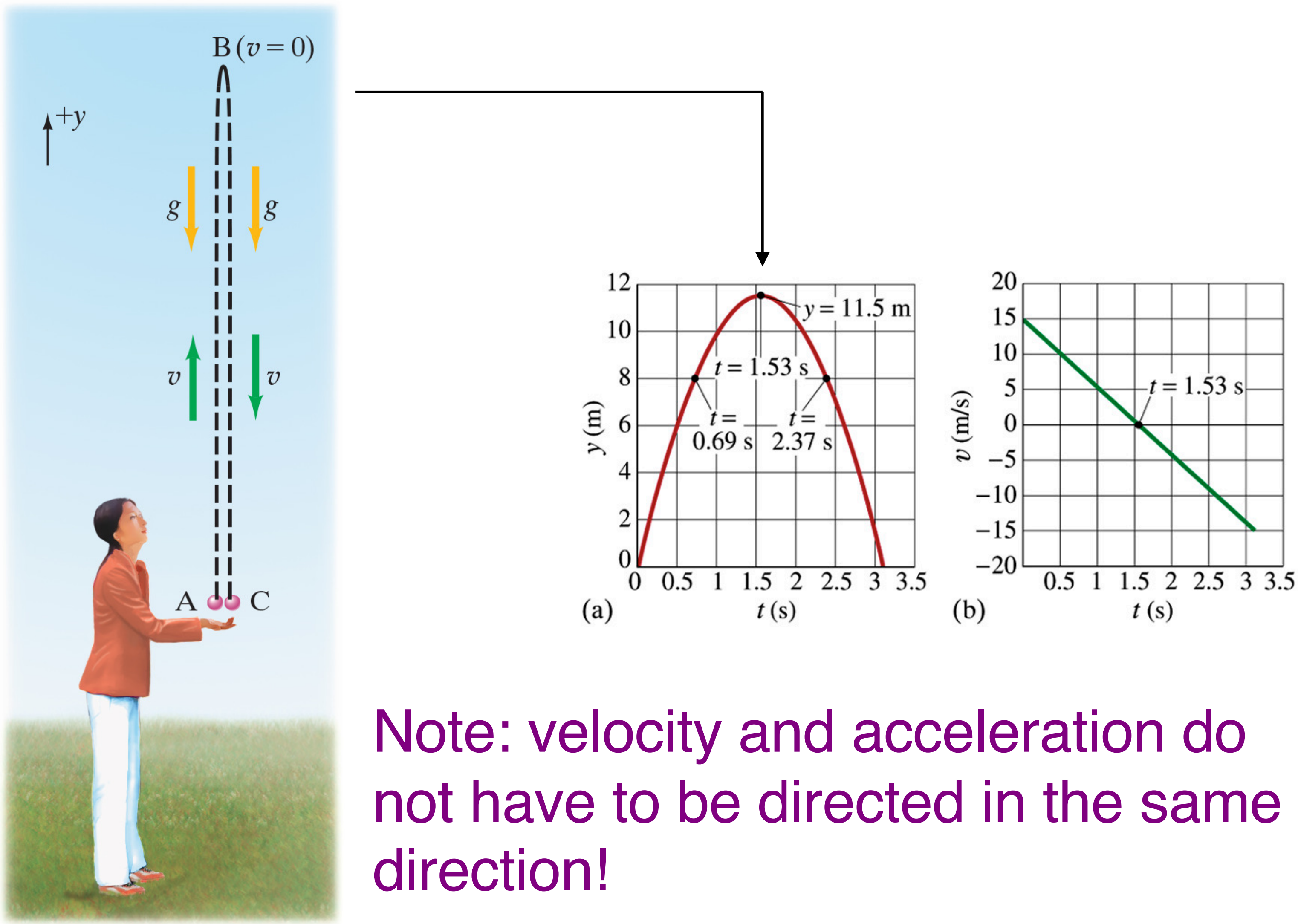
Constant gravitational acceleration.

- Objects moving in the vertical direction close to the surface of the earth experience a constant gravitational acceleration due to the gravitational force between the earth and the object.
- In the absence of other forces, such as the drag force due to the air, all objects will experience the same acceleration, independent of their mass or shape.
- The gravitational acceleration is $g = -9.8 \text{ m/s}^2$. The minus sign indicated that the acceleration is directed downwards.



Note: many people set $g = 9.8 \text{ m/s}^2$ and then use $-g$ to represent the gravitational acceleration.

Constant gravitational acceleration.



Note: velocity and acceleration do not have to be directed in the same direction!

Measuring the gravitational acceleration.

- There are many different ways in which we can measure the gravitational acceleration. In order to describe vertical motion, we usually use y coordinates.
- Let's consider an object falling from rest, from the origin of our coordinate system.
- The initial conditions are such that $v_0 = 0$ m/s and $y_0 = 0$ m.
- We conclude that y/t^2 equals $g/2$ and measuring the time required to fall a distance y allows us to calculate g. Let's do it!

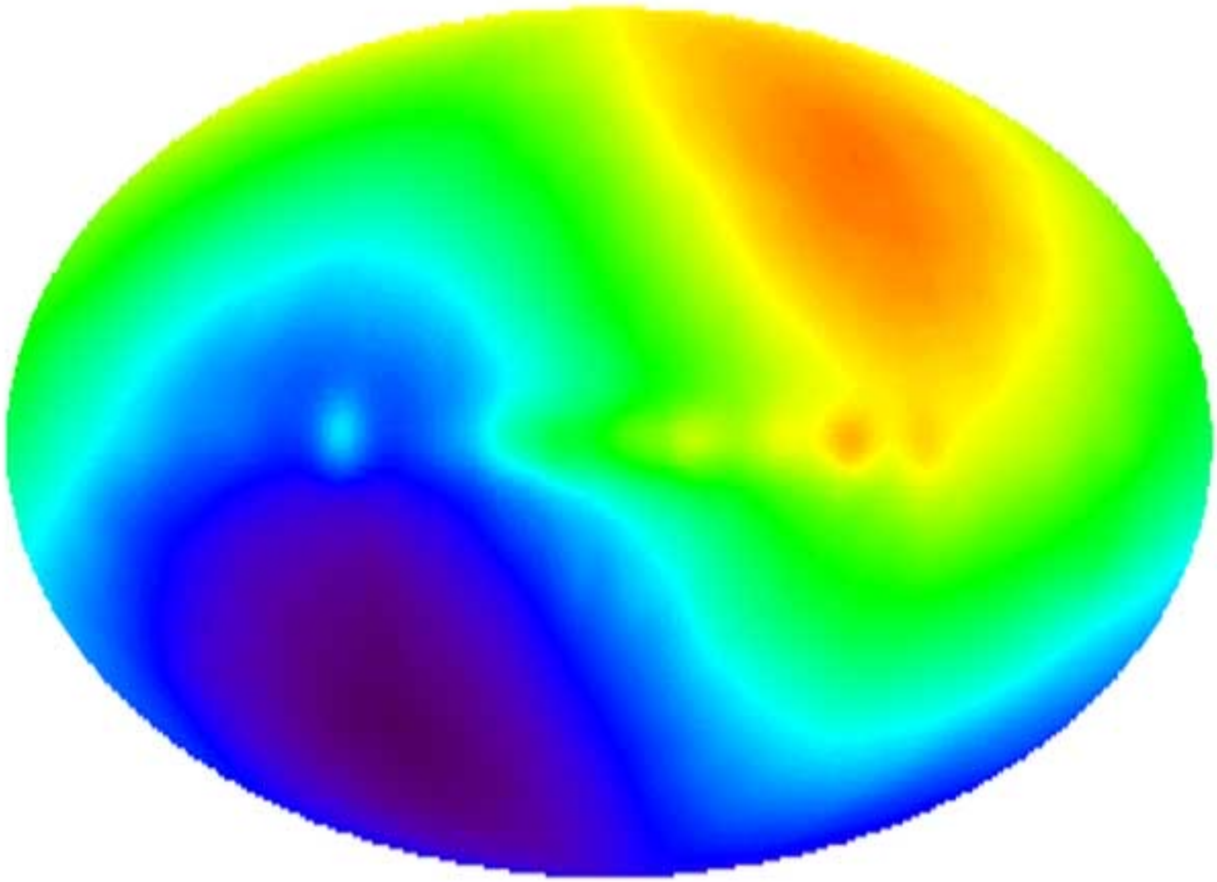
$$a = \frac{dv}{dt} = -g$$

$$v(t) = v_0 - gt$$

$$y(t) = y_0 + v_0 t - \frac{1}{2} g t^2$$

Note: in this format, g is assumed to be the magnitude of the gravitational acceleration.

We are done for today!
Please review Chapter 3 before the next class.



CMBR Dipole: Speeding Through the Universe
Credit: DMR, COBE, NASA, Four-Year Sky Map