Physics 140 – Fall 2007
Lecture 2 : 6 Sep

Items of note:

- guest lecturer (Brian Nord) next Tuesday, 11 Sep
- lecture grading begins Tuesday, 11 Sep
- sign up for Mastering Physics

    Assignments #1+2 closes 18 Sep, 11:59pm
- my Help Room hours: M, 12-1 and W, 12-1
- lecture notes posted on CTools syllabus after each lecture

please do your reading (and brush your teeth!)

before *coming to lecture!*

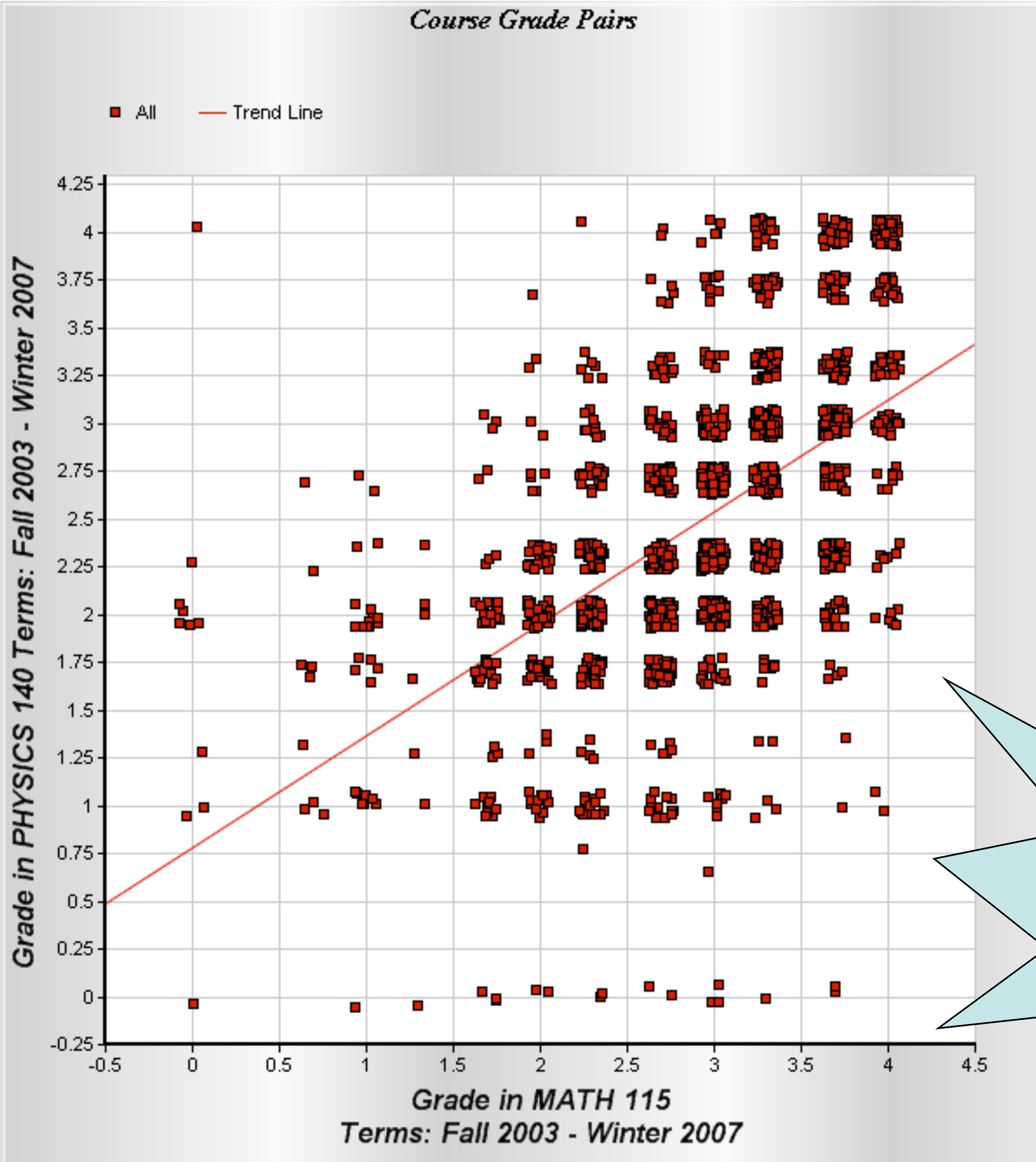
P. B. MacCready, 81, Inventor, Dies

By DOUGLAS MARTIN
Published: August 31, 2007
New York Times

Source: NASA

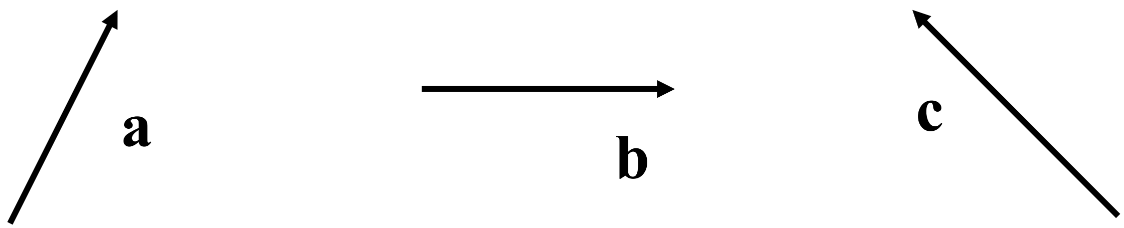
Source: NASA

The Gossamer Albatross crossed the English Channel in 1979.



Importance of math skills in physics is reflected in the correlation of grades between Math 115 and Physics 140.

Math skills rusty?
Prepare to practice
and seek help.
Speak with your
Discussion Instructor!



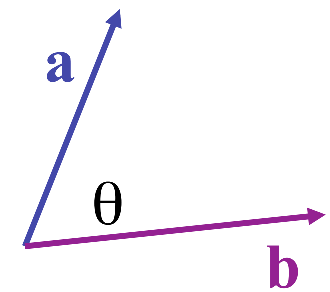
Consider the three vectors drawn above. Which of the following describes their relationship?

1. **a + b = c**
2. **b - a = c**
3. **a - b = c**
4. **c + a = b**

summary of vector multiplication

scalar product: work (Ch 6)

vector product: torque (Ch 10)



	scalar (or dot) product, a · b	**vector (or cross) product, a x b**
type of result	scalar	vector (perpendicular to **a**&**b** by Right Hand Rule)
magnitude	|**a**| |**b**| cos θ	|**a**| |**b**| sin θ
zero result when	**a** and **b** are perpendicular	**a** and **b** are parallel
polarity	**a · b = b · a**	**a** x **b** = − (**b** x **a**)

basic kinematics: describing motion in one dimension

Suppose you want to describe the motion of a superhero walking a tightrope. What do you need to know?

Answer: His position x as a function of time t. The result is (in principle) a real, continuous function $x(t)$.

But how do I measure x and t ?

Answer: **YOU** need to choose the ***coordinate frame***, meaning **YOU** have the responsibility of choosing where $x = 0$ lies and when $t = 0$ occurs.

Kinematics is very democratic. (Galileo)

You'll also need a set of units to define length and time intervals. To communicate effectively with others, you should adhere to a (*sigh!*, one of several) common standard: the *Systeme Internationale* (SI) unit set.

[length] = meter (m)   [time] = second (s)

basic kinematics: velocity and acceleration

The businessman is unlikely to stand still forever, so his position along the tightrope will change.

This motivates you to think of a measure for how fast his position is changing in time:

velocity = (change in position) / (time interval)

Similarly, his velocity can change in time (he can speed up, slow down, reverse direction, ...). To capture that, use:

acceleration = (change in velocity) / (time interval)

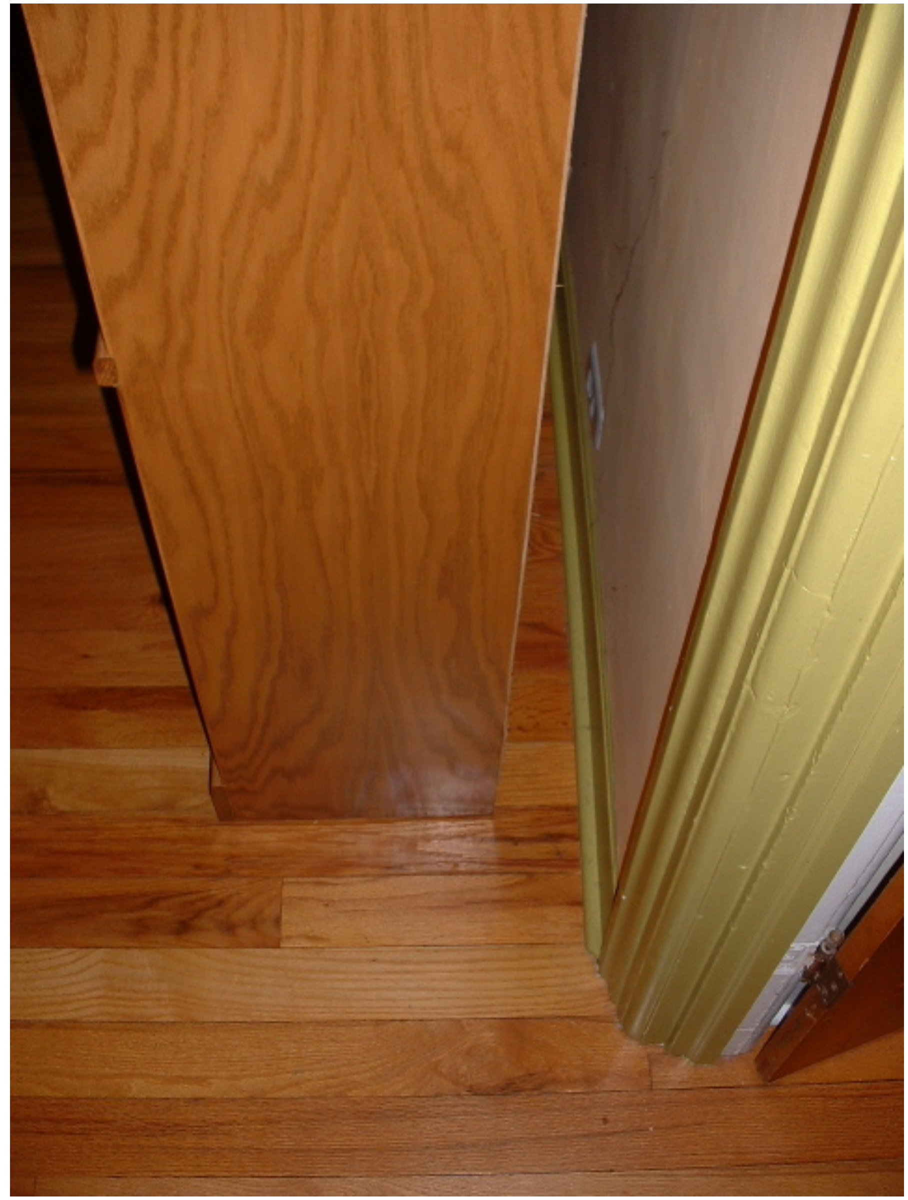
If you're ambitious, you can keep going to the next level

jerk = (change in acceleration) / (time interval)

but it turns out that nature is kind to us.

The **position**, **velocity** and **acceleration** are the key attributes we'll use to describe translational motion.

This bookshelf in my home's office started out flush against the wall, then slowly `walked' about four inches from the wall over a three-week interval. What was the average velocity of the bookshelf during this period?



1. 10^{-3} m/s
2. 10^{-5} m/s
3. 10^{-7} m/s
4. 10^{-9} m/s

formal definitions of velocity and acceleration

Average velocity:

$$v_{av} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

Unit: $[v_{av}]$ = m/s

Average acceleration:

$$a_{av} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

Unit: $[a_{av}]$ = m/s^2

Instantaneous velocity:

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

Unit: $[v]$ = m/s

Instantaneous acceleration:

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

Unit: $[a]$ = m/s^2

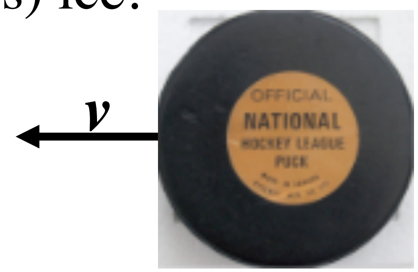
most useful when describing ***dynamics***

examples of simple motions : how position depends on time

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

Constant velocity: Hockey puck on slippery (frictionless) ice.

($a = 0$)



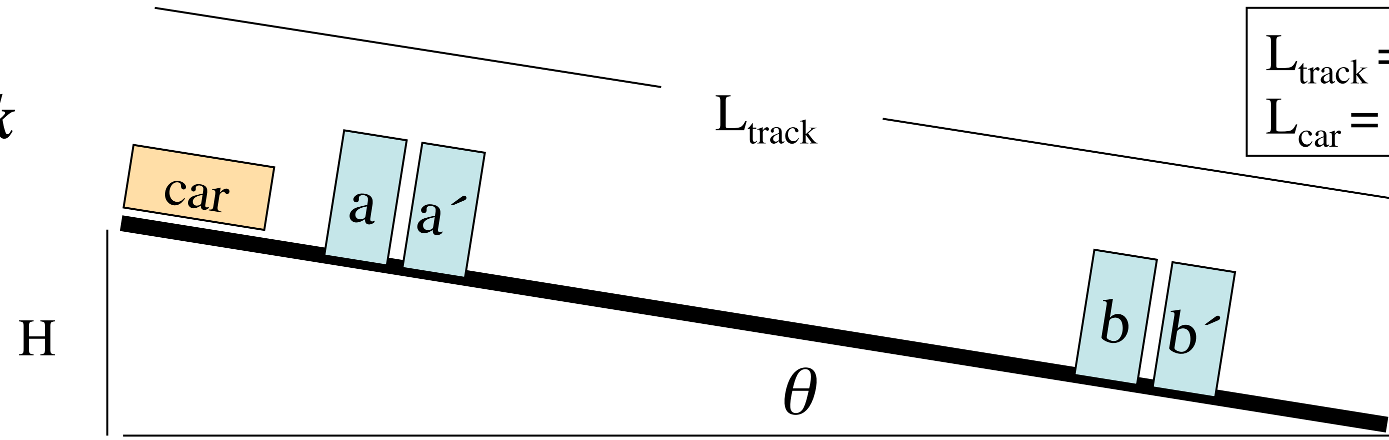
$$x = x_0 + v_0 t$$

Constant acceleration: bowling ball falling vertically downward

(take $+y$ up => $a = -g$)

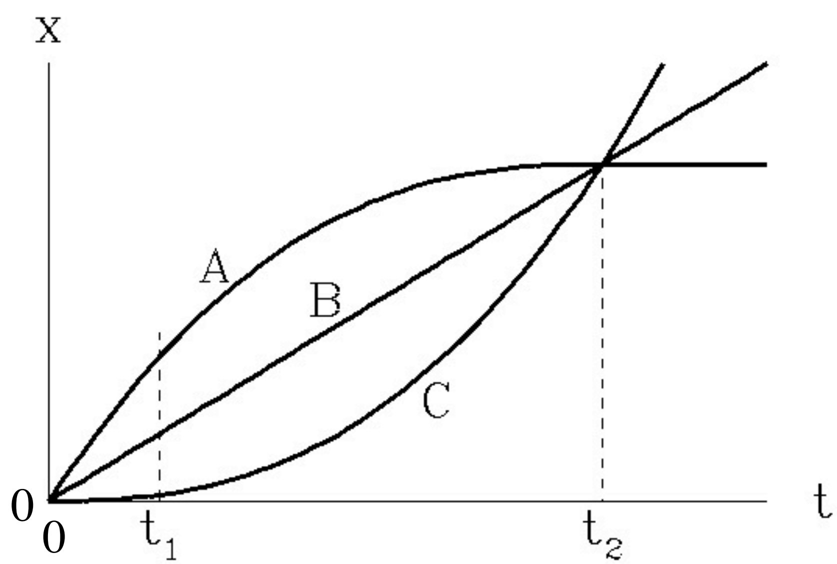
$$y = y_0 + v_0 t - \tfrac{1}{2} g t^2$$

Car on airtrack demo



L_{track} = 1.3m
L_{car} = 12 cm

quantity	9am H=1.3cm	10am H=2.6cm	11am H=3.9cm	description
Δt_a (s)	0.75	0.5	0.32	time for car length to pass through gate a
v_a (cm/s)	16.0	24.0	37.5	$= L_{car} / \Delta t_a$
Δt_b (s)	0.28	0.18	0.15	time for car length to pass through gate b
v_b (cm/s)	42.8	66.7	80.0	$= L_{car} / \Delta t_b$
$\Delta t_{a'b'}$ (s)	6.24	4.25	3.22	time elapsed between gates a/a´ and b/b´
a (cm/s^2)	4.3	10.1	13.2	$= (v_b - v_a) / \Delta t_{a'b'}$



The graph above displays trajectories of three different cheese rounds – A, B, C – that exhibit one-dimensional motion (sliding on icy ramps in a refrigerated room?). Which of the following statements is ***false***?

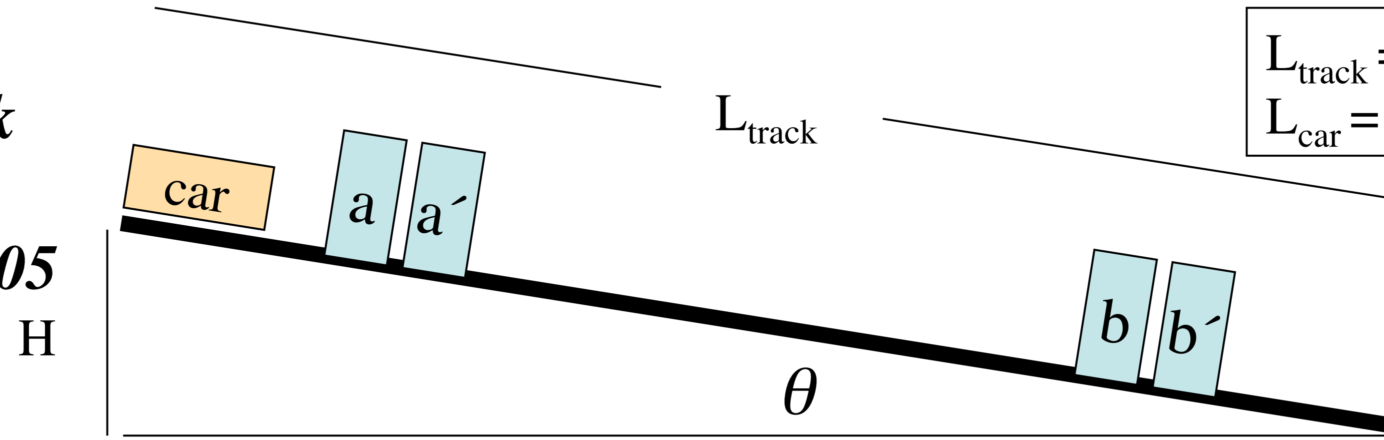
1. All cheeses have the same displacement between t=0 and t=t_2.
2. Cheese A has negative acceleration between t_1 and t_2.
3. Cheese C has positive velocity at times t_1 and t_2.
4. At time t_1, the speed of cheese C is smaller than that of B.
5. At time t_1, the acceleration of cheese B is larger than that of C.

Practice reading graphs of 1D kinematics

Exercise:
Play with the MOVING MAN applet on the PhET site

http://phet.colorado.edu/index.php

Car on airtrack demo Fall 2005



L_{track} = 1.3m
L_{car} = 12 cm

quantity	9am H=1.3cm	10am H=2.6cm	11am H=3.9cm	**description**
Δt_a (s)	0.56	0.38	0.31	time for car length to pass through gate a
v_a (cm/s)	21.4	31.6	38.7	$= L_{car} / \Delta t_a$
Δt_b (s)	0.28	0.19	0.15	time for car length to pass through gate b
v_b (cm/s)	42.9	63.2	80.0	$= L_{car} / \Delta t_b$
$\Delta t_{a'b'}$ (s)	2.41	1.65	1.37	time elapsed between gates a/a´ and b/b´
a (cm/s^2)	8.9	19.1	30.1	$= (v_b - v_a) / \Delta t_{a'b'}$