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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

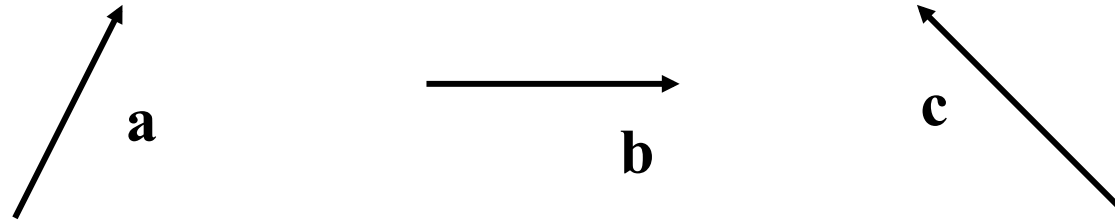


Source: NASA




Source: NASA

The Gossamer Albatross crossed the English Channel in 1979.



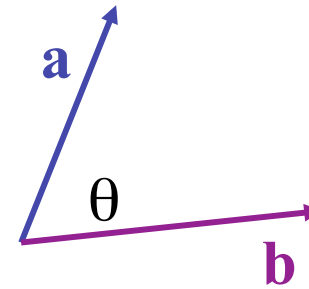
Consider the three vectors drawn above. Which of the following describes their relationship?

1. $\mathbf{a} + \mathbf{b} = \mathbf{c}$
2. $\mathbf{b} - \mathbf{a} = \mathbf{c}$
-  3. $\mathbf{a} - \mathbf{b} = \mathbf{c}$
4. $\mathbf{c} + \mathbf{a} = \mathbf{b}$

summary of vector multiplication

scalar product: work (Ch 6)

vector product: torque (Ch 10)



	scalar (or dot) product, $\mathbf{a} \cdot \mathbf{b}$	vector (or cross) product, $\mathbf{a} \times \mathbf{b}$
type of result	scalar	vector (perpendicular to a & b by Right Hand Rule)
magnitude	$ \mathbf{a} \mathbf{b} \cos \theta$	$ \mathbf{a} \mathbf{b} \sin \theta$
zero result when	a and b are perpendicular	a and b are parallel
polarity	$\mathbf{a} \cdot \mathbf{b} = \mathbf{b} \cdot \mathbf{a}$	$\mathbf{a} \times \mathbf{b} = -(\mathbf{b} \times \mathbf{a})$

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 $x(t)$** .

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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:

$$\text{velocity} = (\text{change in position}) / (\text{time interval})$$

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

$$\text{acceleration} = (\text{change in velocity}) / (\text{time interval})$$

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

$$\text{jerk} = (\text{change in acceleration}) / (\text{time interval})$$

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

Average acceleration:

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

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

Instantaneous velocity:

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

Unit: $[v] = \text{m/s}$

Instantaneous acceleration:

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

Unit: $[a] = \text{m/s}^2$

most useful when
describing *dynamics*

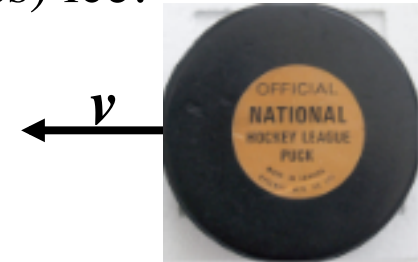
examples of simple motions : how position depends on time

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

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

($a = 0$)

$$x = x_0 + v_0 t$$



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Constant acceleration: bowling ball falling vertically downward

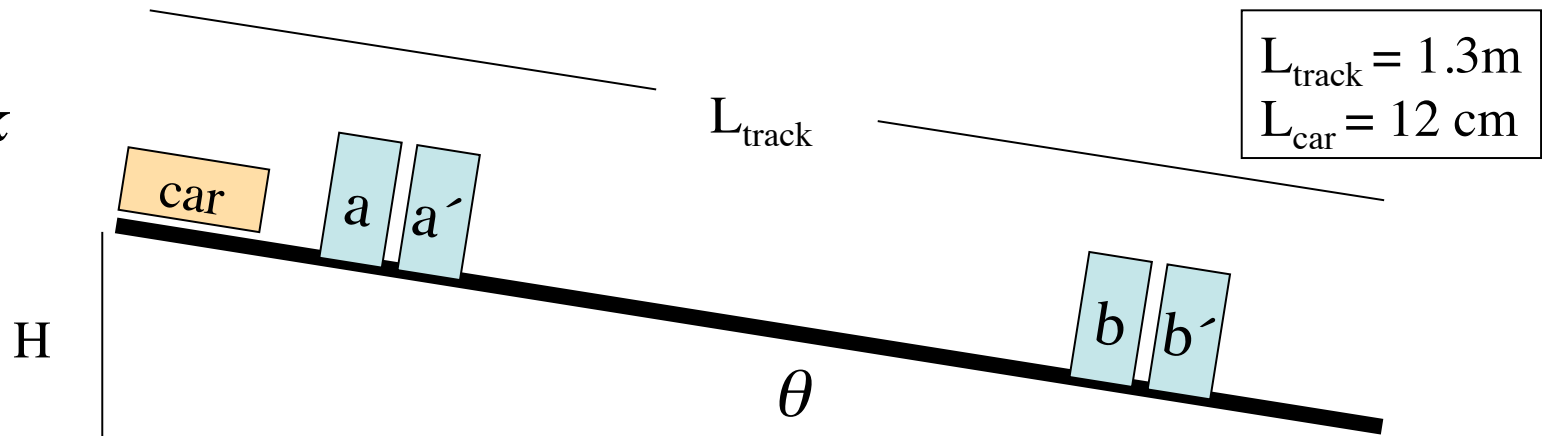
(take +y up => $a = -g$)

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

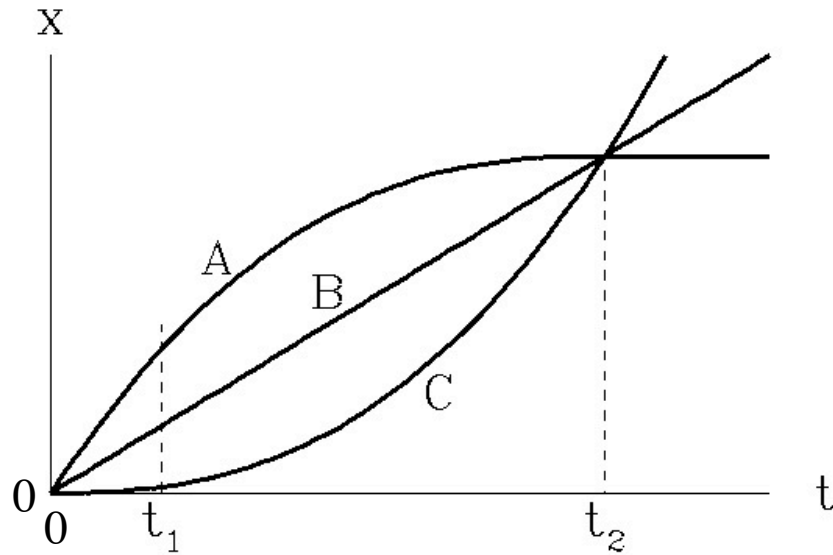


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**Car on
airtrack
demo**



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	$= L_{\text{car}} / \Delta t_a$
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	$= L_{\text{car}} / \Delta t_b$
$\Delta t_{a'b'}$ (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	$= (v_b - v_a) / \Delta t_{a'b'}$



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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:

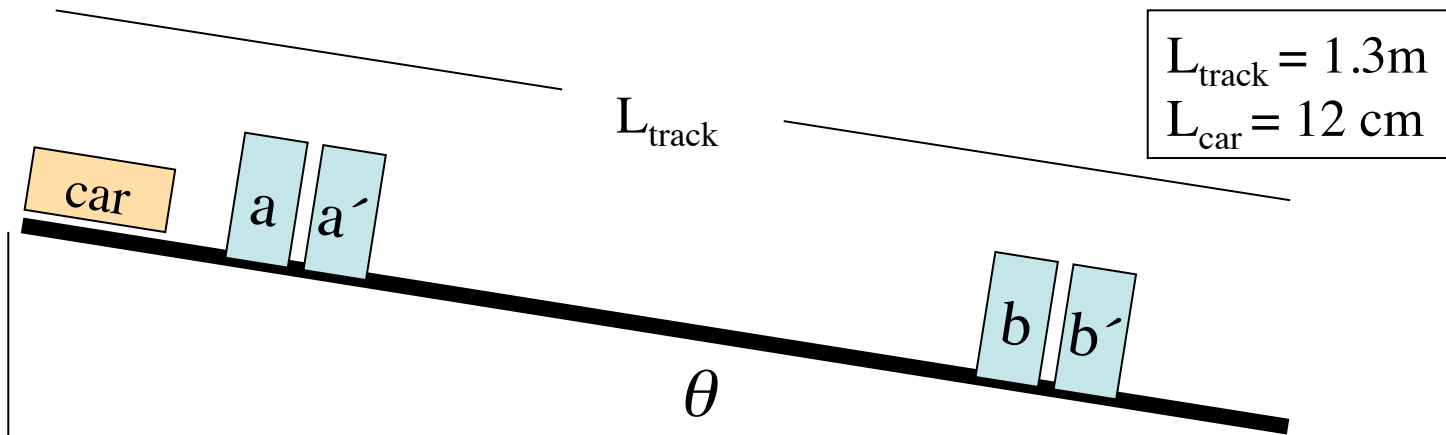
Play with the MOVING MAN applet on the PhET site

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

*Car on
airtrack
demo*

Fall 2005

H



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	$= L_{\text{car}} / \Delta t_a$
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	$= L_{\text{car}} / \Delta t_b$
$\Delta t_{a'b'}$ (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	$= (v_b - v_a) / \Delta t_{a'b'}$