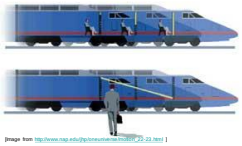
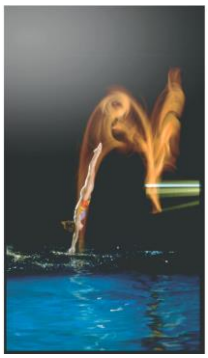
PHY131H1F - Class 7

Today, Chapter 4, sections 4.1-4.4:

- Kinematics in One Dimension
- Kinematics in Two Dimensions
- Projectile Motion
- Relative Motion



[Image from http://www.nap.edu/jhp/newmenu/newtech/ch22-22.html]



Clicker Question 1

- A car starts from rest, then drives to the right. It speeds up to a maximum speed of 30 m/s. It coasts at this speed for a while, then the driver hits the brakes, and the car slows down to a stop.
- While it is speeding up, the acceleration vector of the car is

A. to the right.

B. to the left.

C. zero.

Clicker Question 2

- A car starts from rest, then drives to the right. It speeds up to a maximum speed of 30 m/s. It coasts at this speed for a while, then the driver hits the brakes, and the car slows down to a stop.
- While it is coasting, the acceleration vector of the car is

A. to the right.

B. to the left.

C. zero.

Clicker Question 3

- A car starts from rest, then drives to the right. It speeds up to a maximum speed of 30 m/s. It coasts at this speed for a while, then the driver hits the brakes, and the car slows down to a stop.
- While it is slowing down, the acceleration vector of the car is

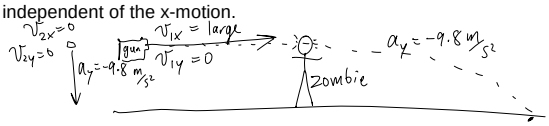
A. to the right.

B. to the left.

C. zero.

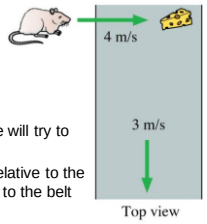
Last Class I asked:

- One bullet is fired horizontally at a very high speed. The other bullet is initially at rest, but is dropped at the exact same moment the first bullet is fired. Which bullet hits the ground first?
- ANSWER: They both hit the ground at exactly the same time (assuming flat ground)! The y-motion is totally independent of the x-motion.



Class 7 Preclass Quiz on MasteringPhysics

- This was due this morning at 8:00am
- 920 students submitted the quiz on time
- 86% answered correctly: Both bullets hit the ground simultaneously!
- 69% answered correctly: Bullet hits the coconut (We will try to demonstrate this today)
- 72% answered correctly: The speed of the mouse relative to the floor is the **vector sum** of the mouse speed relative to the belt and the belt speed relative to the floor (5 m/s)

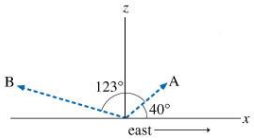


Class 7 Preclass Quiz on MasteringPhysics

- Some common or interesting student comments/feedback:
- *"The projectile motion was very interesting and I hope it will be useful in playing Angry Birds."*
- *"Acceleration was pretty interesting stuff, especially while watching the finale of Breaking Bad! :)"*
- *"I really like how physics is honing my desert island hunting skills."*
- *Frames of reference, relative motion [Lots of comments]*
- *"The shooting of the coconut. Why would anyone shoot a coconut?????"*

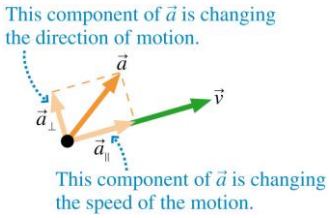
Problem Set 2 on MasteringPhysics

- This was due last night at 11:59pm
- 929 students did the problem set by the deadline
- It took an average of 50 minutes for students to complete the problem set
- The average for the 929 students who submitted on time was 99.5%.
- The most difficult problem seemed to be "Tracking a Plane"



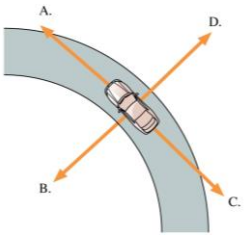
Analyzing the acceleration vector

- An object's acceleration can be decomposed into components parallel and perpendicular to the velocity.
- $\vec{a}_{\parallel}$ is the piece of the acceleration that causes the object to change **speed**
- $\vec{a}_{\perp}$ is the piece of the acceleration that causes the object to change **direction**
- An object changing direction *always* has a component of acceleration perpendicular to the direction of motion.



Clicker Question 4

A car is traveling around a curve at a steady 45 mph. Which vector shows the direction of the car's acceleration?

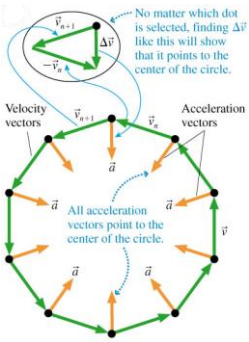


E. The acceleration is zero.

Slide 4-29

Uniform Circular Motion

Speed is constant.



MacArthur Fellows Program

- Like an American version of the Nobel Prize (not quite as prestigious).
- About 30 winners per year; you get $625,000.
- My friend **Sara Seager** won it last week for her work on detecting and characterizing planets orbiting stars other than our Sun.
- She went to Jarvis Collegiate, and did her undergrad here at U of T at the same time as me.
- http://seagerexoplanets.mit.edu/

- She gives a pretty cool TED talk:
- http://www.tedxcambridge.com/portfolio-item/sara-seager/

Announcements

- The first term test will be on Tuesday, October 8, from 8:00pm to 9:30pm.
- The Room you write in will depend on your Practicals group. It will be announced on the Portal toward the end of this week.
- If you have a conflict at that time with an academic activity (test, lecture, tutorial, lab), you must register to write at the alternate sitting by filling and submitting the online form available on portal.
- The alternate sitting will be held on Wednesday morning, October 9, from **7:40am** to 9:00. The location will be emailed to registered students by the end of the day on October 4.
- The deadline for registration is Thursday, October 3.

What will the test cover?

- Test 1 covers:
  - Knight Chapters. 1-5
  - and the ***Error Analysis in Experimental Physical Science "Mini-Version"*** 10-page document available on portal.
- If it's in the above reading, on MasteringPhysics, done in classes, or done in Practicals, it is material that is **important** and that you should know for the tests and final exam.

Where to get extra help

- The Physics **Drop In Help Centre** opens on Friday Oct.4 in MP125 (BACK CORNER):
  - Monday to Thursday - 12:00 to 5:00 pm
  - Monday 6:00 to 7:00pm
  - Friday 11:00 am to 2:00 pm
- TA Office hours: Contact your Practicals TAs!! Office Hours where they can help with studying is part of their contract!
- My office hours in MP121B: T2, RF10.
- Meyertholen's office hours in MP129A: M2, R2, F12, F1
- **Academic Success Centre.** Test preparation session Tuesday Oct 1st, 3-5pm. In this session, Hui Guo is planning to discuss test prep strategies, review hard concepts and do some past test problems.

Projectile Motion

FIGURE 4.15 The parabolic trajectory of a bouncing ball.

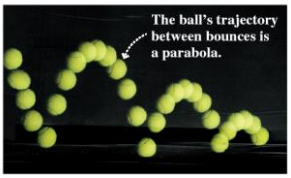
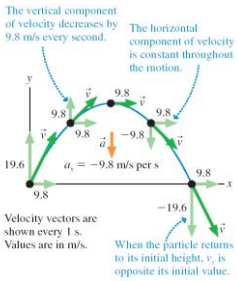


FIGURE 4.17 The velocity and acceleration vectors of a projectile moving along a parabolic trajectory.



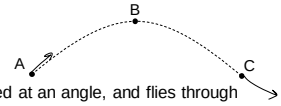
Projectile Motion

Projectile motion is made up of two **independent** motions: uniform motion at constant velocity in the horizontal direction and free-fall motion in the vertical direction. The kinematic equations that describe these two motions are

$$x_f = x_i + v_{ix}\,\Delta t \qquad y_f = y_i + v_{iy}\,\Delta t - \tfrac{1}{2}g(\Delta t)^2$$

$$v_{fx} = v_{ix} = \text{constant} \qquad v_{fy} = v_{iy} - g\,\Delta t$$

Clicker Question 5



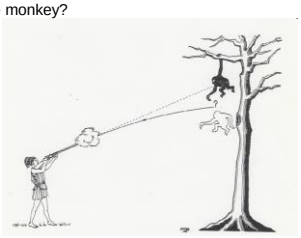
- A tennis ball is launched at an angle, and flies through the air in a parabolic path, as shown, A→ B → C.
- At point B

A. the velocity is horizontal, and the speed is maximum.
B. the velocity is horizontal, and the speed is minimum.
C. the velocity is horizontal, but the speed is neither a maximum nor a minimum.
D. the velocity is not horizontal, but the speed is minimum.
E. the velocity is not horizontal, and the speed is neither a maximum or minimum.

Monkey and Hunter Demonstration (and clicker question 6)

The classic problem: "A monkey hanging from the branch of a tree is spotted by a hunter. The monkey sees that the barrel of the gun is pointed directly at him. At the exact instant the gun is fired, the monkey lets go of the branch. Will the bullet (A) go above the monkey, (B) go below the monkey, or (C) hit the monkey?

Our demonstration uses a pressurized tennis ball launcher. The laser is aimed directly at the monkey, which is supported by an electromagnet. As the tennis ball leaves the launcher, it breaks a connection that releases the magnet.



Joke: Why Did the Chicken Cross the Road?

Aristotle (330 BC):
"Because it is the nature of chickens to cross roads."
Newton (1687):
"Because there is no external net force causing the chicken's velocity across the road to change."
Einstein (1905):
"Is the chicken crossing the road, or is the road moving under the chicken?"

[image downloaded 6/30/2012 from http://stgp.tumblr.com/post/31266362611/when-the-chicken-crossed-the-road]

Relative Position

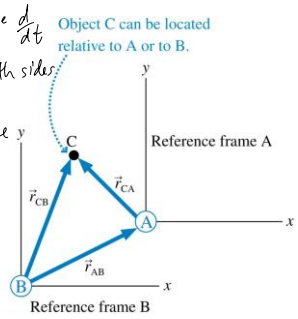
$$\boxed{\vec{r}_{CB} = \vec{r}_{CA} + \vec{r}_{AB}}$$

take $\frac{d}{dt}$ of both sides

$\vec{r}_{CB}$ = the position vector of object C in the reference frame with B at origin.

$\vec{r}_{CA}$ = position of C in reference frame of A

$\vec{r}_{AB}$ = position of A origin relative to B origin.



Relative Velocity

- Relative velocities are found as the time derivative of the relative positions.
- $\vec{v}_{CA}$ is the velocity of C relative to A.
- $\vec{v}_{CB}$ is the velocity of C relative to B.
- $\vec{v}_{AB}$ is the velocity of reference frame A relative to reference frame B.

$$\vec{v}_{CB} = \vec{v}_{CA} + \vec{v}_{AB}$$

- This is known as the **Galilean transformation of velocity.** This equation works when speeds are much less than the speed of light.

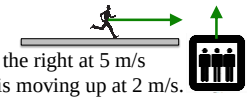
Relative Motion

- Note the "cancellation"
- $\vec{v}_{TG}$ = velocity of the **T**rain relative to the **G**round
- $\vec{v}_{PT}$ = velocity of the **P**assenger relative to the **T**rain
- $\vec{v}_{PG}$ = velocity of the **P**assenger relative to the **G**round
- Also: $v_{12} = -v_{21}$

$$\vec{v}_{PG} = \vec{v}_{PT} + \vec{v}_{TG}$$

Inner subscripts disappear

Clicker Question 7

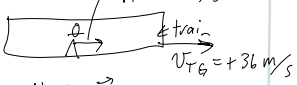


You are running toward the right at 5 m/s toward an elevator that is moving up at 2 m/s. Relative to you, the direction and magnitude of the elevator's velocity are

A. down and to the right, less than 2 m/s.
B. up and to the left, less than 2 m/s.
C. up and to the left, more than 2 m/s.
D. up and to the right, less than 2 m/s.
E. up and to the right, more than 2 m/s.

Example 1: A passenger walks toward the front of the train at 5 m/s. The train is moving at 36 m/s. What is the speed of the passenger relative to the ground?

$\vec{v}_{PT} = +5$ m/s



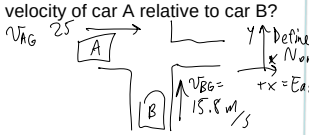
$v_{TG} = +36$ m/s

Need $\vec{v}_{PG}$

$\vec{v}_{PG} = \vec{v}_{PT} + \vec{v}_{TG}$
$= +5 + 36 = \boxed{41 \text{ m/s}}$

Example 2: Car A is traveling at 25.0 m/s E toward Bloor and Keele. Car B is traveling at 15.8 m/s N toward Bloor and Keele. Just before they collide, what is the velocity of car A relative to car B?

v_{AG} 25

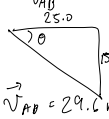


define +y = North
+x = East.

Need $\vec{v}_{AB} = \vec{v}_{AG} + \vec{v}_{GB}$

Note $\vec{v}_{GB} = -\vec{v}_{BG} = -15.8$

Components.	x	y
$\vec{v}_{AG}$	+25.0	0
$\vec{v}_{GB}$	0	−15.8
v_{AB}	25.0	−15.8



$|\vec{v}_{AB}| = \sqrt{25^2 + 15.8^2}$
$= 29.6$ m/s

$\theta = \tan^{-1}\left(\frac{15.8}{25}\right) = 32.3°$

$\vec{v}_{AB} = 29.6$ m/s, 32.3° South of East.

Clicker Question 8

- You are on an Eastbound subway train going at 20 m/s.
- You notice the Westbound train on the other track.
- Relative to the ground, that Westbound train has a speed of 20 m/s.
- What is the velocity of the Westbound train as measured by you?

A. 40 m/s, West
B. 20 m/s, West
C. zero
D. 20 m/s, East
E. 40 m/s, East

[image from http://www.cbc.ca/news/canada/toronto/tc-closes-downtown-subway-loop-for-the-weekend-1.1347619]

Before Class 8 on Wednesday

- Please finish reading Chapter 4
- Don't forget the pre-class quiz due Wed. at 8am.
- Something to think about: Consider a wheel that is rotating, and speeding up. Is a point on the edge of the wheel accelerating toward the centre? Is this point accelerating in the forward direction? Or is it doing both?