Physics 101: Lecture 03
Kinematics

Today's lecture will cover
Textbook Sections 3.1-3.3
(and some Ch. 4)

Announcements

- HW 1 is due Tuesday February 1st at 6 am.
- No clicker points for Lect. 2? Re-register for this course!
- Office hours start Friday.
- Read the course description & FAQ on the course web site!

Force at Angle Example

- A person is pushing a 15 kg block across a floor with $\mu_k = 0.4$ at a constant speed. If she is pushing down at an angle of 25 degrees, what is the magnitude of her force on the block?

x- direction: $\Sigma F_x = ma_x$

$F_{push} \cos(\theta) - F_{friction} = 0$

$F_{push} \cos(\theta) - \mu F_{Normal} = 0$

$F_{Normal} = F_{push} \cos(\theta) / \mu$

y- direction: $\Sigma F_y = ma_y$

$F_{Normal} - F_{weight} - F_{Push} \sin(\theta) = 0$

$F_{Normal} - mg - F_{Push} \sin(\theta) = 0$

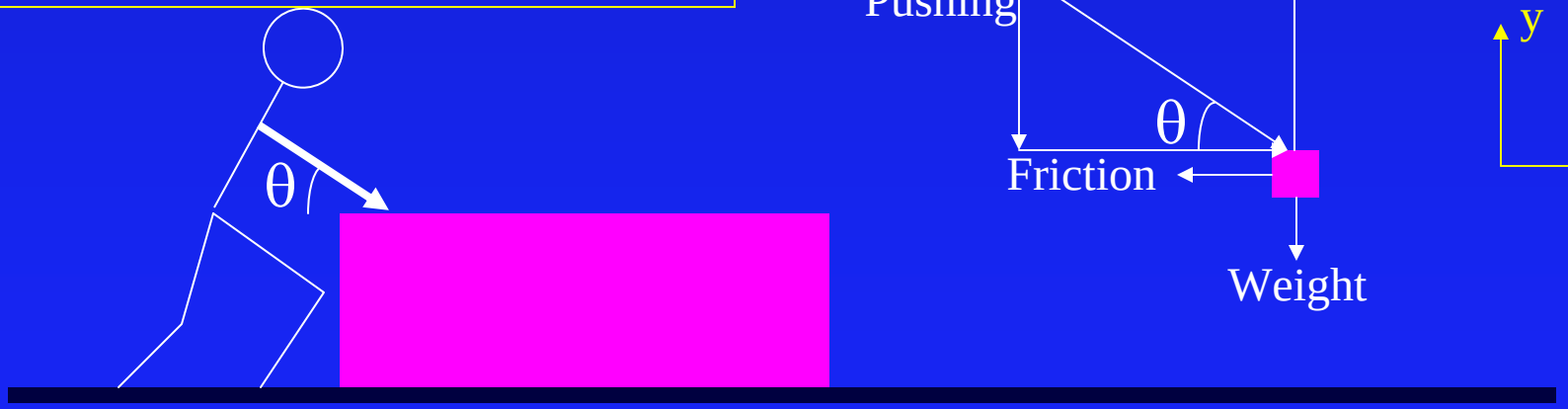
Combine:

$F_{push} \cos(\theta) / \mu - mg - F_{Push} \sin(\theta) = 0$

$F_{push} (\cos(\theta) / \mu - \sin(\theta)) = mg$

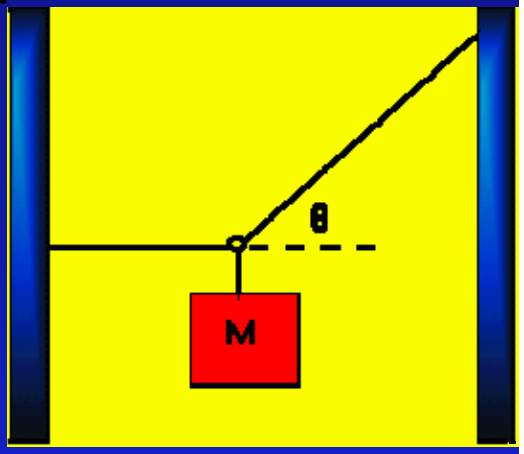
$F_{push} = m g / (\cos(\theta)/\mu - \sin(\theta))$

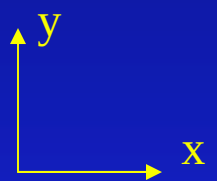
$F_{push} = 80$ N



Homework 2 Example

- Calculate the tension in the left string.

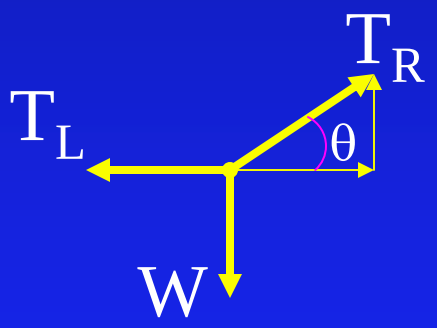




x-direction: $\Sigma F=ma$

$-T_L+T_R \cos(\theta)= 0$

$T_L = T_R \cos(\theta)$



y-direction: $\Sigma F=ma$

$T_R \sin(\theta) - Mg = 0$

$T_R = Mg / \sin(\theta)$

Combine:

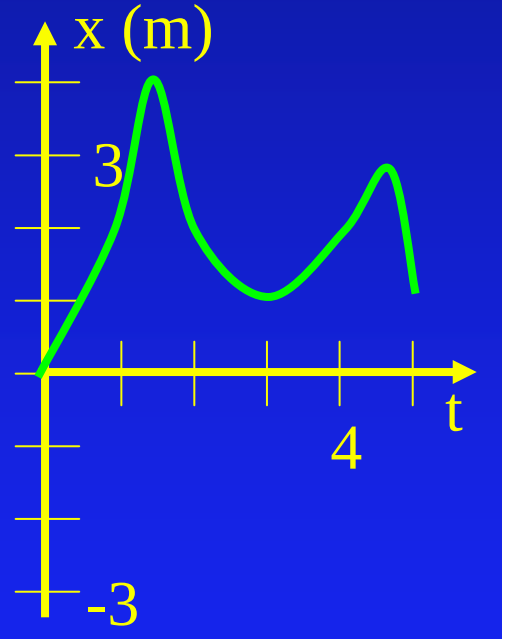
$T_L = Mg \cos(\theta)/\sin(\theta)$

Overview

- Kinematics: Description of Motion
  - ➔ Position and displacement
  - ➔ velocity
    - » average
    - » instantaneous
  - ➔ Acceleration
    - » average
    - » instantaneous
  - ➔ Relative velocity (first pass)

Position vs Time Plots

- Gives location at any time.
- Displacement is change in position.
- Slope gives instantaneous velocity.



Position at t=3, x(3) = 1

Displacement between t=5 and t=1. Δx = -1.0 m

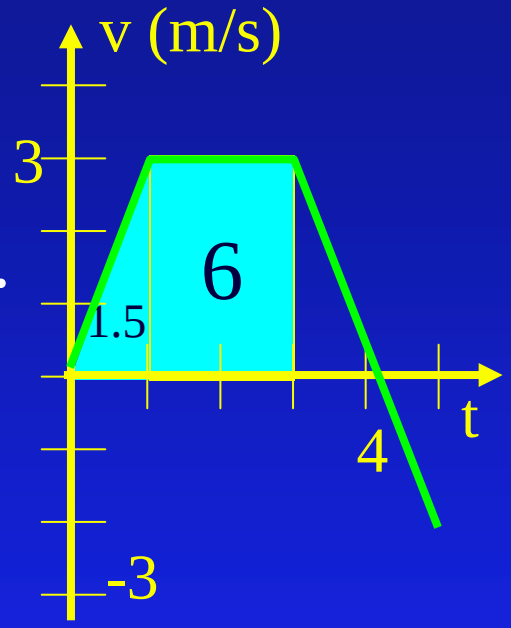
1.0 m - 2.0 m = -1.0 m

Average velocity between t=5 and t=1. v = -0.25 m/s

-1 m / 4 s = -0.25 m/s

Velocity vs Time Plots

- Gives velocity at any time.
- Area gives displacement
- Slope gives instantaneous acceleration.



velocity at t=2, v(2) = 3 m/s

Displacement between t=0 and t=3: Δx= 7.5 m

t=0 to t=1: ½ (3m/s) (1 s) = 1.5 m

t=1 to t=3: (3m/s) (2 s) = 6 m

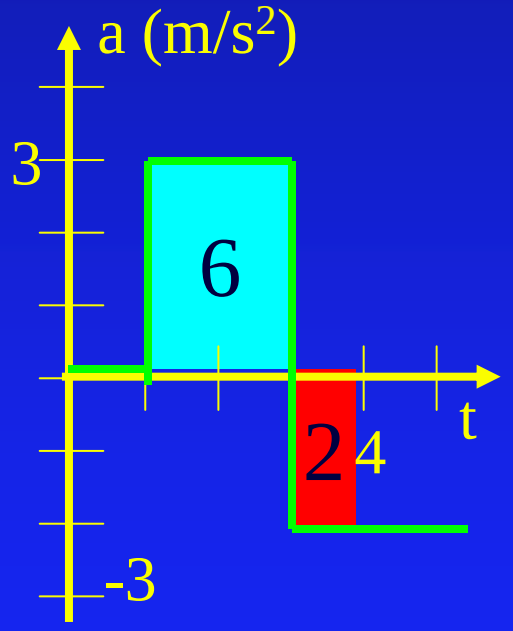
Average velocity between t=0 and t=3? v= 7.5 m / 3s = 2.5 m/s

Change in v between t=5 and t=3. Δv = -2 m/s – 3 m/s = -5 m/s

Average acceleration between t=5 and t=3: a =-5 m/s / (2 s) = -2.5 m/s^2

Acceleration vs Time Plots

- Gives acceleration at any time.
- Area gives change in velocity



Acceleration at t=4, a(4) = -2 m/s^2

Change in v between t=4 and t=1. Δv = +4 m/s

t=1-3: $\Delta v = (3 m/s^2)(2s) = 6$ m/s

t=3-4: $\Delta v = (-2 m/s^2)(1s) = -2$ m/s

Acceleration Preflights

Is it possible for an object to have a positive velocity at the same time as it has a negative acceleration?

88% 1 - Yes

12% 2 - No

"the object could be slowing down."

If the velocity of some object is not zero, can its acceleration ever be zero ?

87% 1 - Yes

13% 2 - No

"The velocity could be non-zero and constant. A constant velocity has no acceleration.."

Velocity ACT

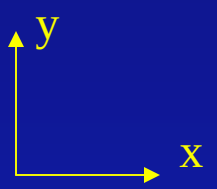
If the average velocity of a car during a trip along a straight road is positive, is it possible for the instantaneous velocity at some time during the trip to be negative?

A - Yes

B - No

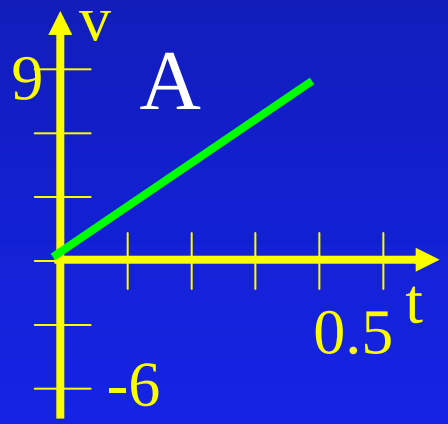
Drive north 5 miles, put car in reverse and drive south 2 miles. Average velocity is positive.

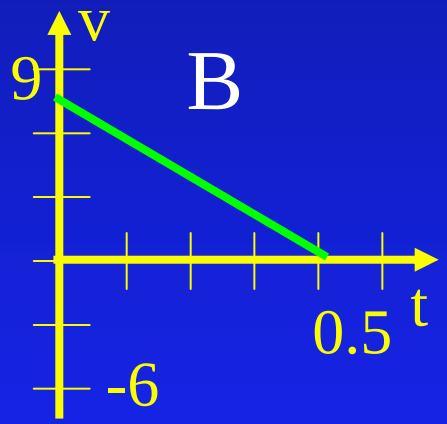
Dropped Ball

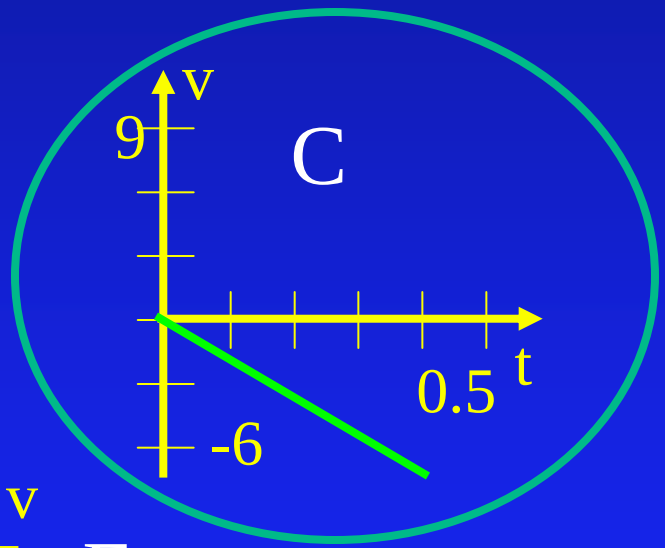


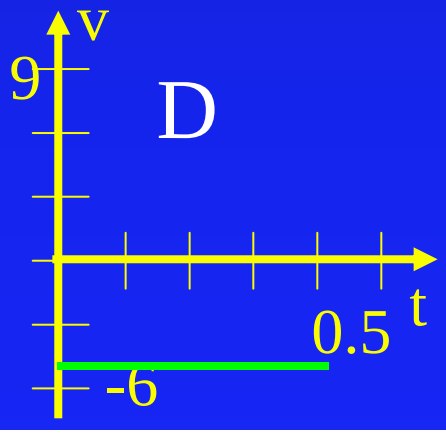
•A ball is dropped from a height of two meters above the ground.

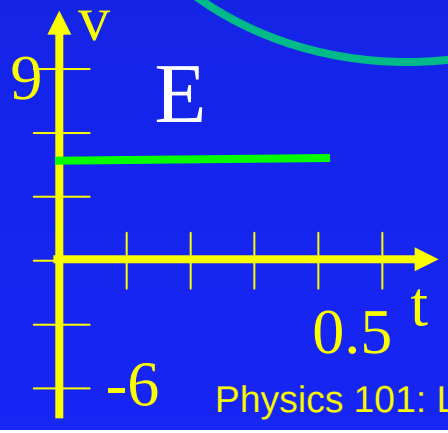
- Draw v_y vs t







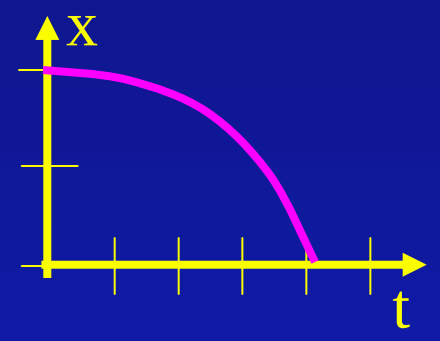


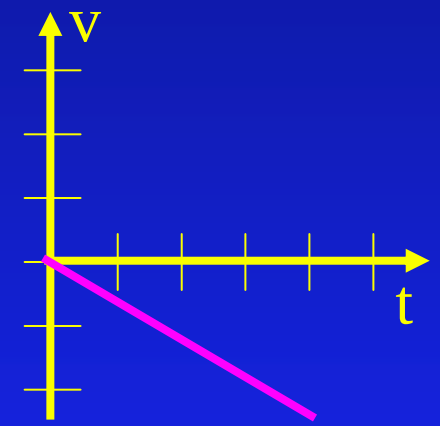


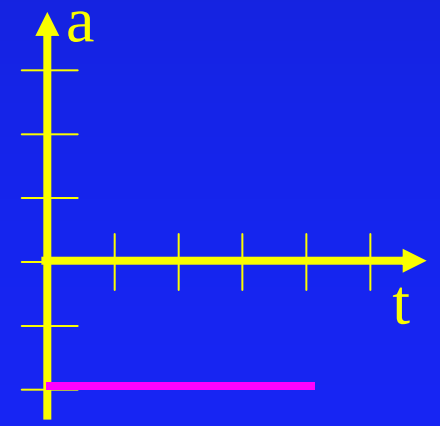
Dropped Ball

A ball is dropped for a height of two meters above the ground.

- Draw v vs t
- Draw x vs t
- Draw a vs t

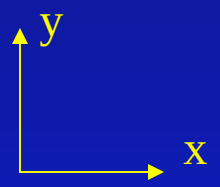




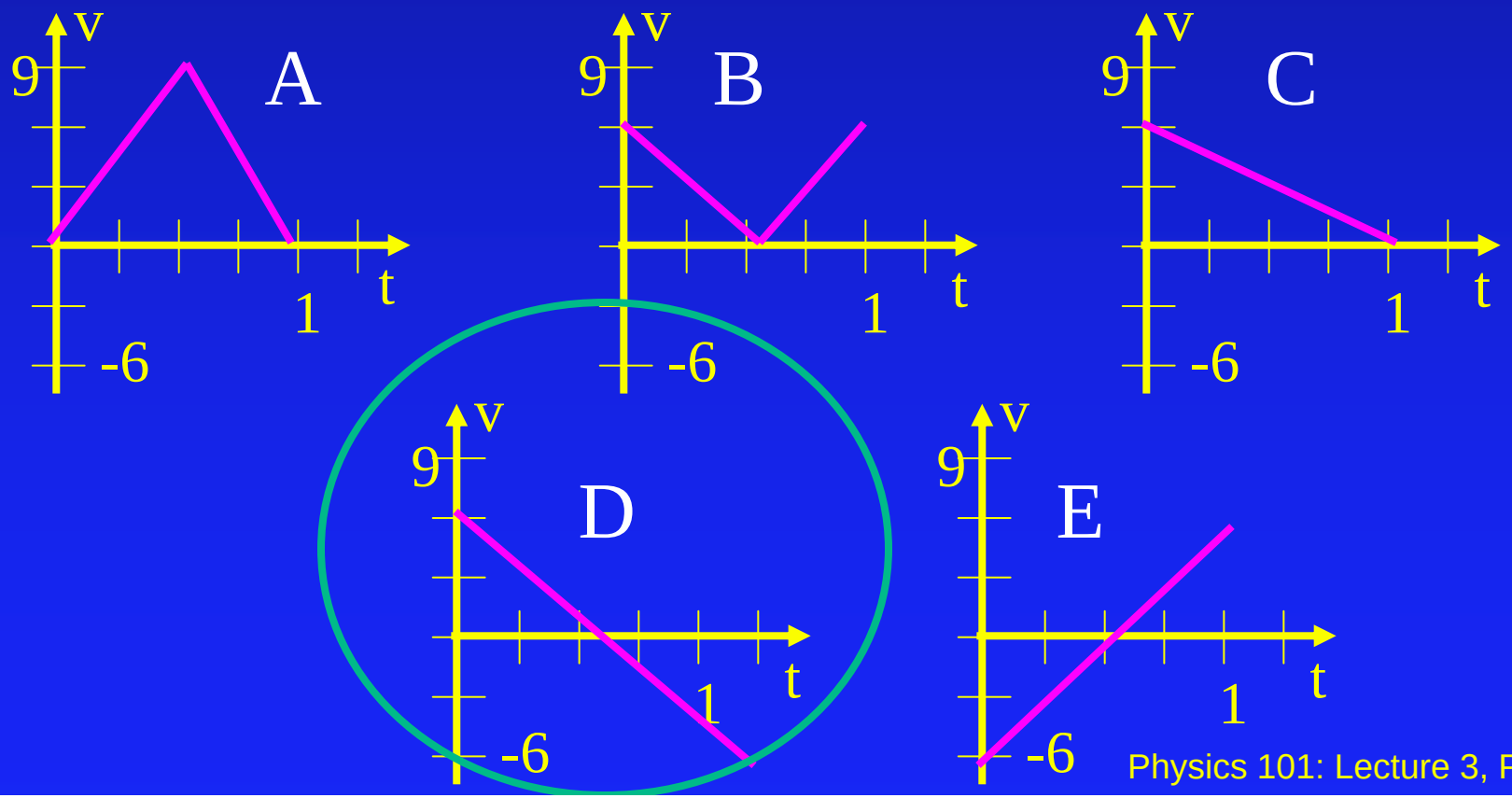


Tossed Ball

•A ball is tossed from the ground up a height of two meters above the ground. And falls back down



- Draw v vs t



Tossed Ball

•A ball is tossed from the ground up a height of two meters above the ground. And falls back down

- Draw v vs t
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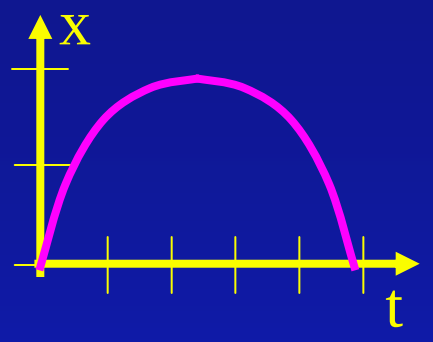
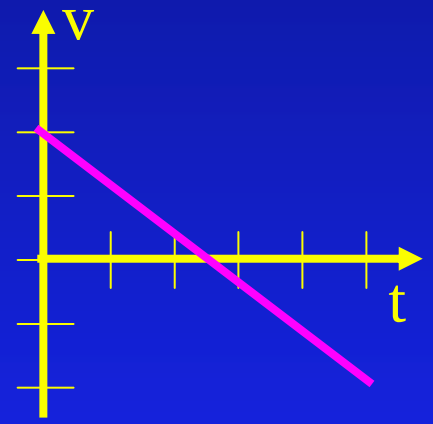
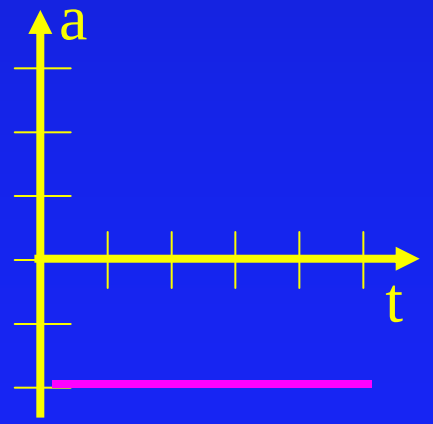






ACT

A ball is thrown straight up in the air and returns to its initial position. During the time the ball is in the air, which of the following statements is true?

A - Both average acceleration and average velocity are zero.
B - Average acceleration is zero but average velocity is not zero.
C - Average velocity is zero but average acceleration is not zero.
D - Neither average acceleration nor average velocity are zero.

$V_{ave} = \Delta Y/\Delta t = (Y_f - Y_i) / (t_f - t_i) = 0$

$a_{ave} = \Delta V/\Delta t = (V_f - V_i) / (t_f - t_i)$

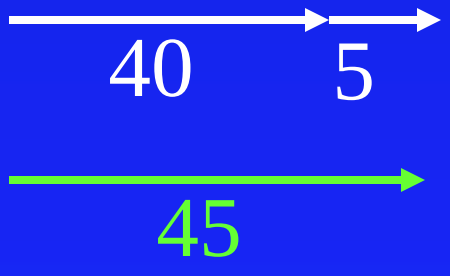
Not 0 since V_f and V_i are not the same !

Relative Velocity (first pass)

You are on a train traveling 40 mph North. If you walk 5 mph toward the front of the train, what is your speed relative to the ground?

A) 45 mph B) 40 mph C) 35 mph

40 mph N + 5 mph N = 45 mph N

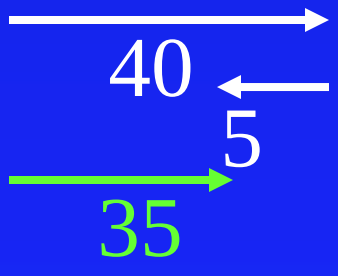


Relative Velocity

You are on a train traveling 40 mph North. If you walk 5 mph toward the rear of the train, what is your speed relative to the ground?

A) 45 mph B) 40 mph C) 35 mph

40 mph N - 5 mph N = 35 mph N

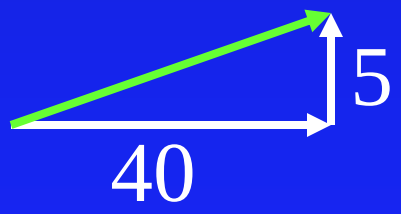


Relative Velocity

You are on a train traveling 40 mph North. If you walk 5 mph sideways across the car, what is your speed relative to the ground?

A) < 40 mph B) 40 mph C) >40 mph

40 mph N + 5 mph W = 41 mph N



$$|v| = \sqrt{40^2 + 5^2}$$

Relative Velocity

- **Sometimes your velocity is known relative to a reference frame that is moving relative to the earth.**
  - ➔**Example 1: A person moving relative to a train, which is moving relative to the ground.**
  - ➔**Example 2: a plane moving relative to air, which is then moving relative to the ground.**
- **These velocities are related by** vector addition:

$$\vec{v}_{ac} = \vec{v}_{ab} + \vec{v}_{bc}$$

- » **v_{ac} is the velocity of the object relative to the ground**
- » **v_{ab} is the velocity of the object relative to a moving reference frame**
- » **v_{bc} is the velocity of the moving reference frame relative to the ground**

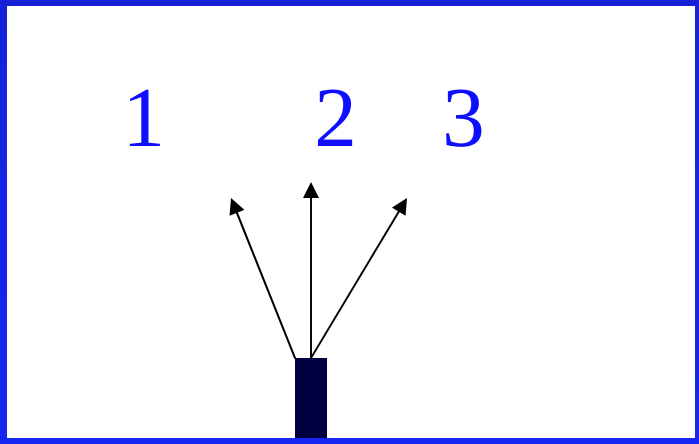
Tractor Demo 1

Which direction should I point the tractor to get it across the table fastest?

A) 30 degrees left

B) Straight across

C) 30 degrees right



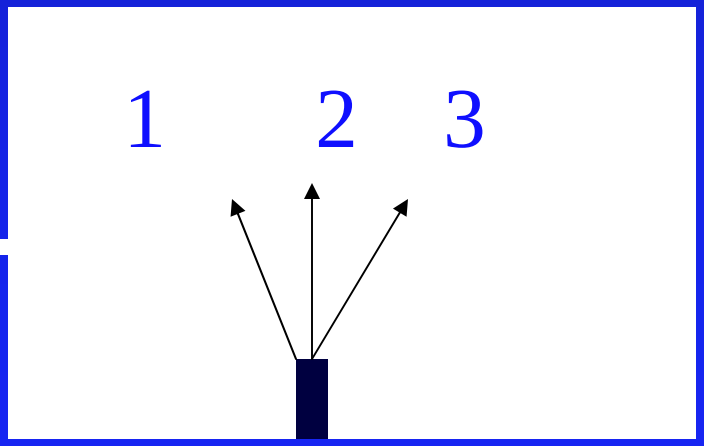
Tractor Demo (moving table)

- Which direction should I point the tractor to get it across the table fastest?

A) 30 degrees left

B) Straight across

C) 30 degrees right



Summary of Concepts

- kinematics: A description of motion
- position: your coordinates
- displacement: Δx = change of position
- velocity: rate of change of position
  - ➔ average : $\Delta x/\Delta t$
  - ➔ instantaneous: slope of x vs. t
- acceleration: rate of change of velocity
  - ➔ average: $\Delta v/\Delta t$
  - ➔ instantaneous: slope of v vs. t
- relative velocity: $v_{ac} = v_{ab} + v_{bc}$