General Physics I

Displacement, Vectors & Velocity, Acceleration in 1-D

Ch 1, Secs 3-6

Ch 2, Sec 1

Day 2, Video 1

Introduction to Vectors

Question #1

If an equation is dimensionally correct, does that mean the equation is true?

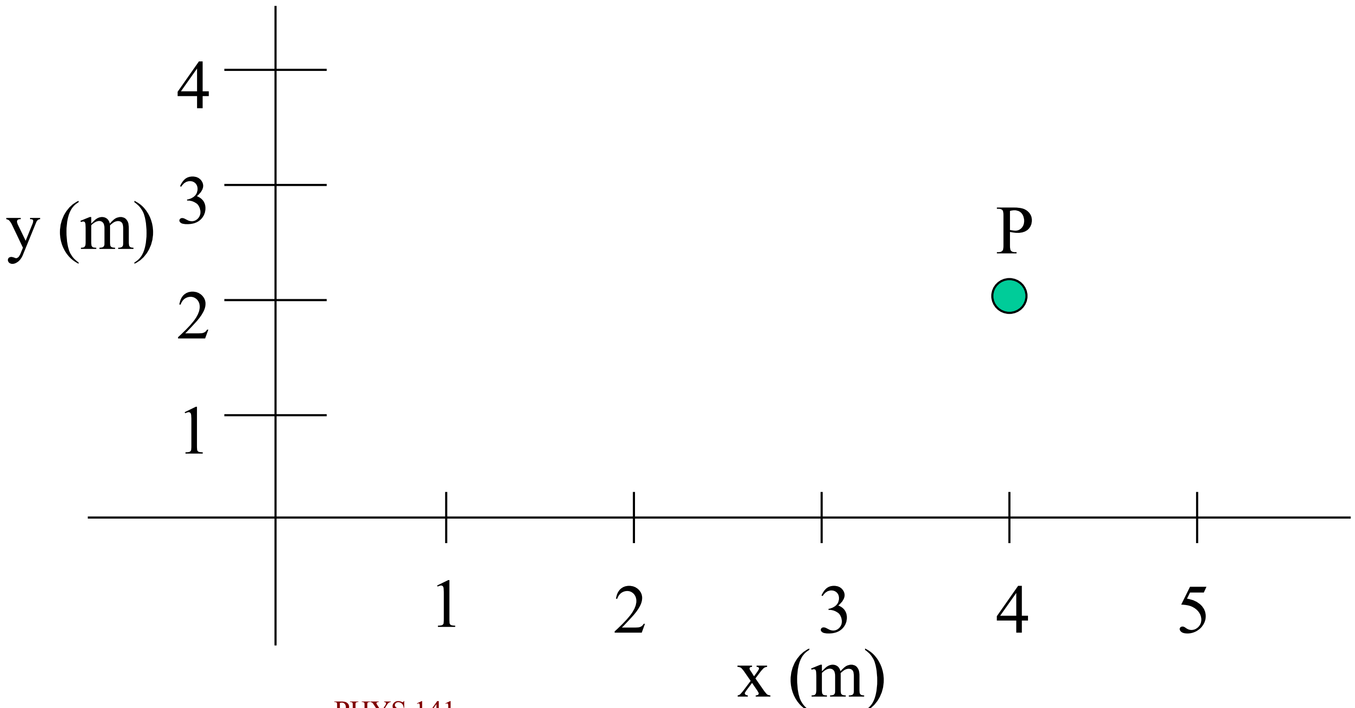
A. Yes

B. No

Question #2

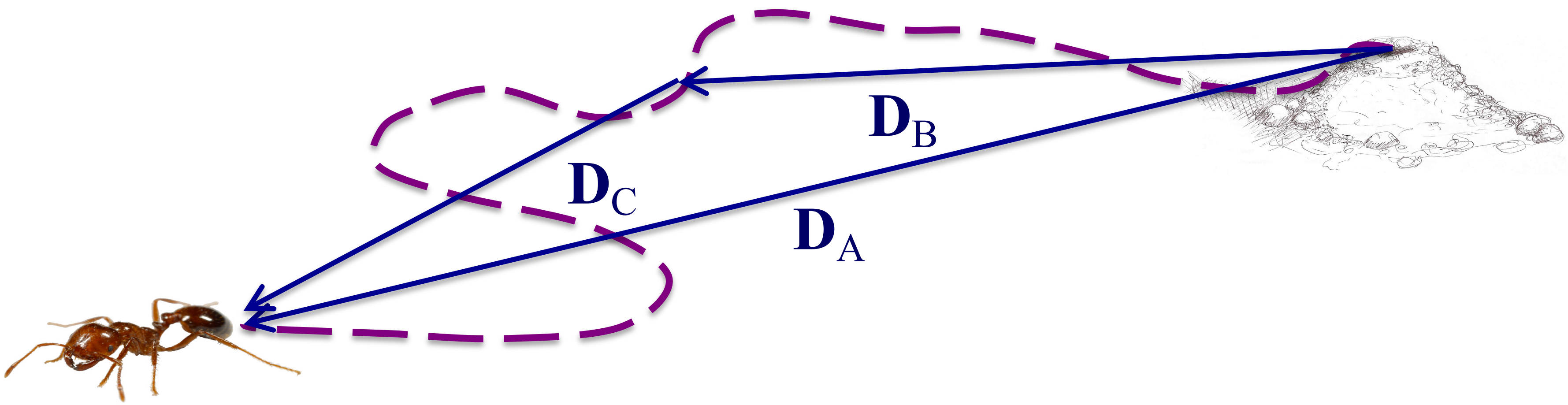
How far from the origin is point P?

A. 4.0 m
B. 4.5 m
C. 5.0 m
D. 5.5 m



Displacement

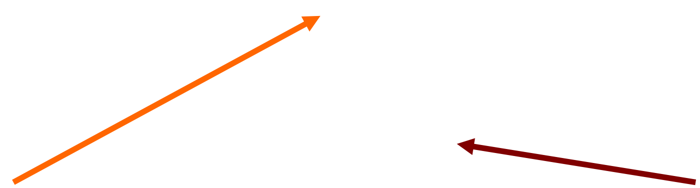
- Distance from beginning to end points
- Displacements must be added as vectors!



$$\mathbf{D}_A = \mathbf{D}_B + \mathbf{D}_C$$

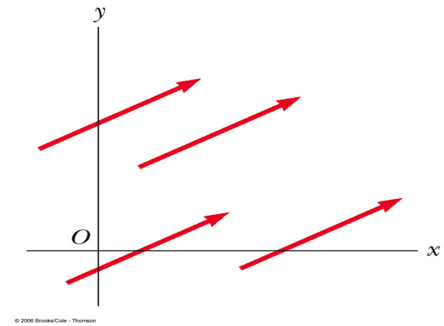
Vectors

- Scalars – magnitude or number only
  - Number of apples in a basket
  - Your age
  - Speed
- Vectors – magnitude and direction
  - Displacement
  - Velocity
  - Acceleration

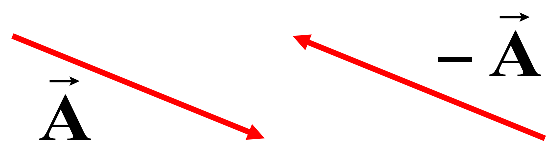


Vectors - Properties

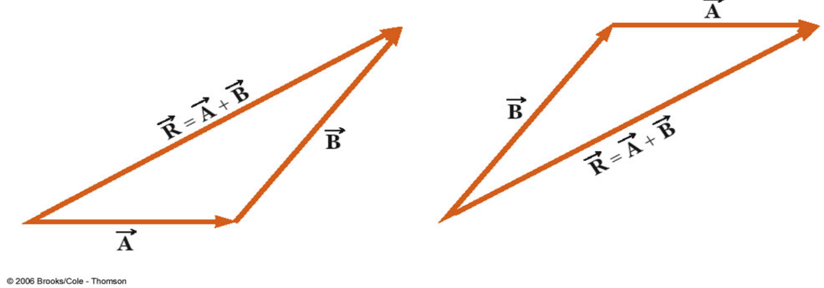
- Two vectors are equal if they have the same magnitude and direction

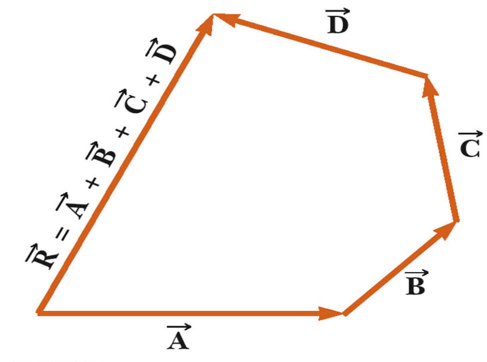


- Negative of a vector = vector with same magnitude, opposite direction



- Vector addition – tip to tail

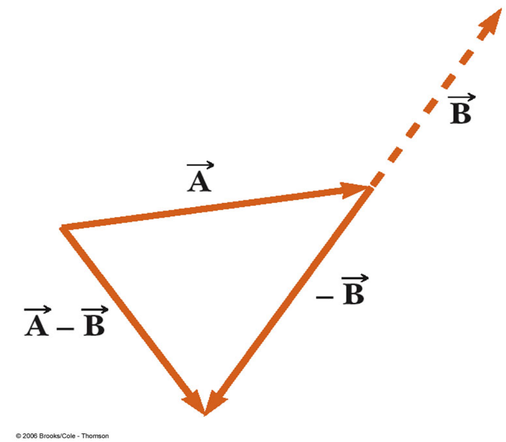




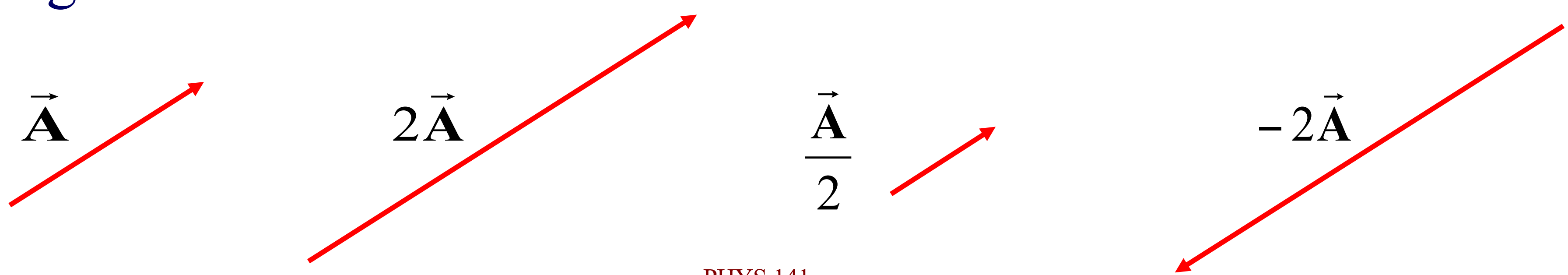
Vectors - Properties

- Vector subtraction – add the negative of the vector being subtracted

$$\vec{\mathbf{A}} - \vec{\mathbf{B}} = \vec{\mathbf{A}} + (-\vec{\mathbf{B}})$$



- Multiplication / division by a scalar – magnitude of vector multiplied / divided by scalar. Direction is flipped if scalar is negative

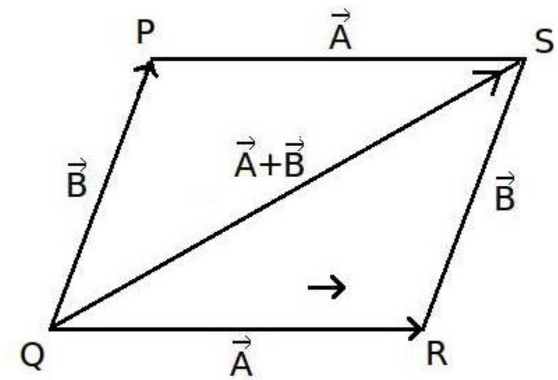


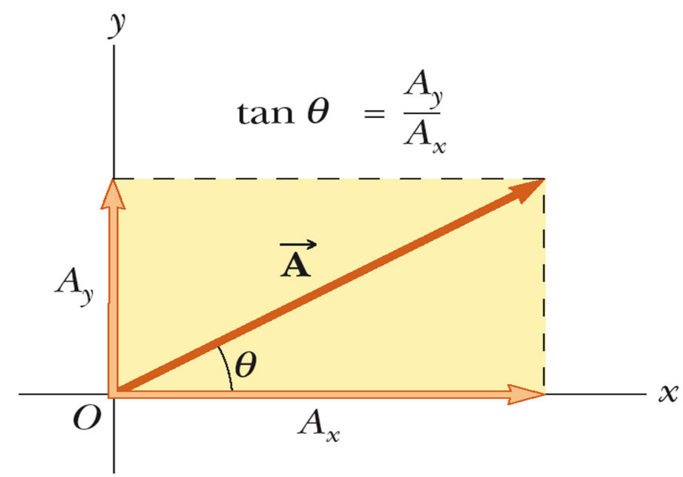
Day 2, Video 2

Adding Vectors by Components

Vector Components

- Tip-to-tail method good way to conceptualize vector addition
  - Calculation only as accurate as the picture drawn
  - Very accurate drawings can be time consuming
- For actual calculations, faster and more accurate to break vectors into components
  - Choose convenient coordinate system & put vector tail at origin
  - Break vectors into component vectors parallel to coordinate axes





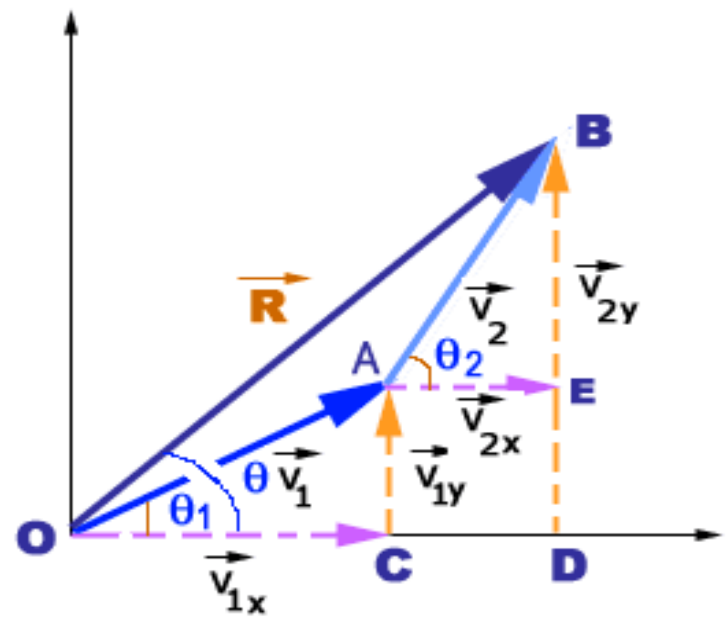
Vector Components

- Component method cont.
  - Break vectors into component vectors parallel to component axes
  - Add together parallel components

$$\vec{\mathbf{R}} = \vec{\mathbf{A}} + \vec{\mathbf{B}} \qquad \begin{aligned} R_x &= A_x + B_x \\ R_y &= A_y + B_y \end{aligned}$$

  - Find magnitude and direction of sum vector

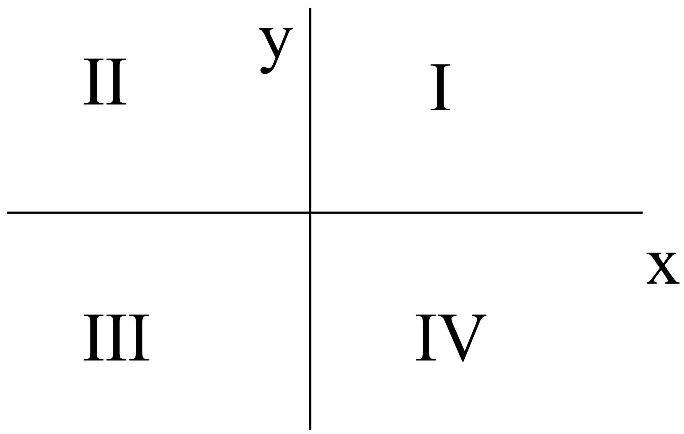
$$R = \sqrt{R_x^2 + R_y^2} \qquad \theta = \tan^{-1}\left(\frac{R_y}{R_x}\right)$$



Question #3

Vector **A** lies in the x-y plane. Put the tail of vector **A** at the origin. In which quadrant will the tip of vector **A** lie for both components to be negative?

A. Quadrant I
B. Quadrant II
C. Quadrant III
D. Quadrant IV



Day 2, Video 3

Vector Addition Example

Example 1

A boat travels 100 m south, then 200 m at 20° south of east Then 50 m at 10° north of east. What is the resultant displacement?

Question #4

If vector **B** is added to vector **A**, the resultant vector **A**+**B** has a magnitude A+B when **A** and **B** are

A. Perpendicular to each other
B. Oriented in the same direction
C. Oriented in opposite directions
D. None of the above

Question #5

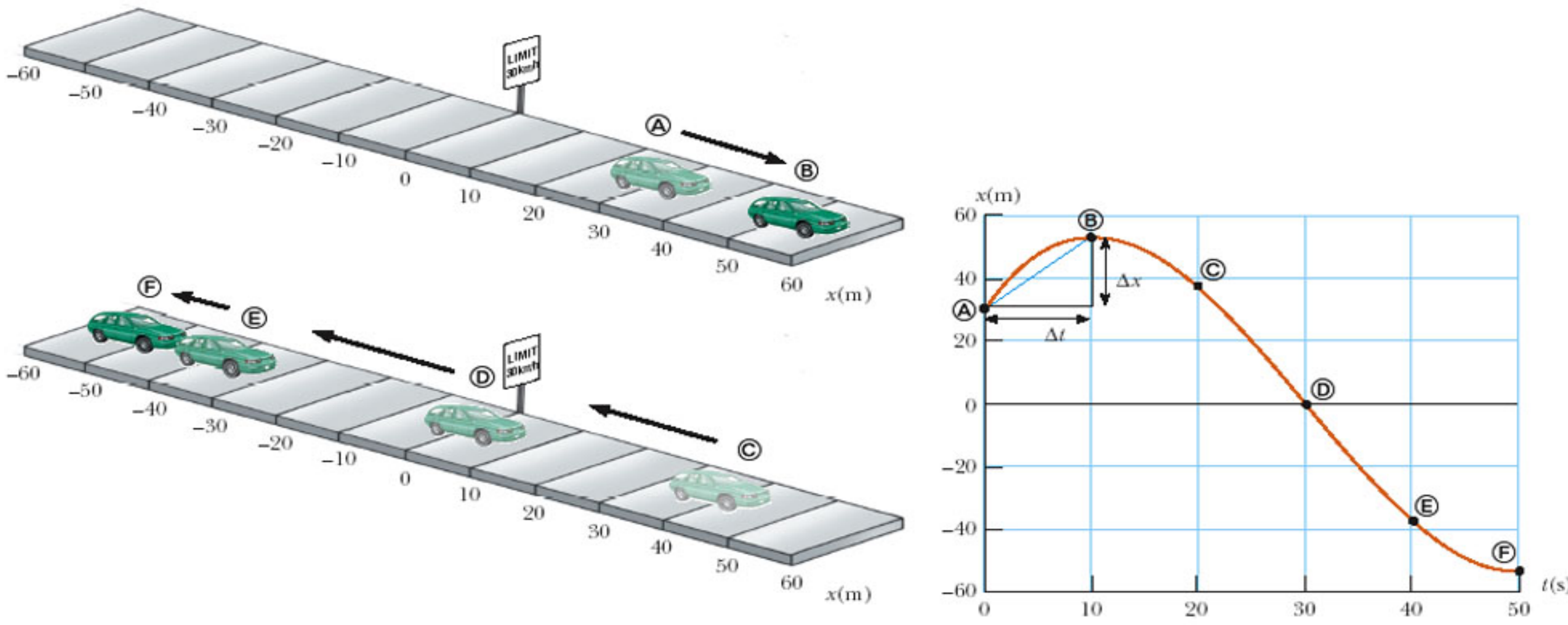
The magnitudes of two vectors **A** and **B** are 12 units and 8 units, respectively. What are the largest and smallest possible values for the magnitude of the resultant vector **R** = **A** + **B**?

A. 14.4 and 4
B. 12 and 8
C. 20 and 4
D. None of the above

Day 2, Video 4

Displacement & Velocity

1D Motion – Displacement

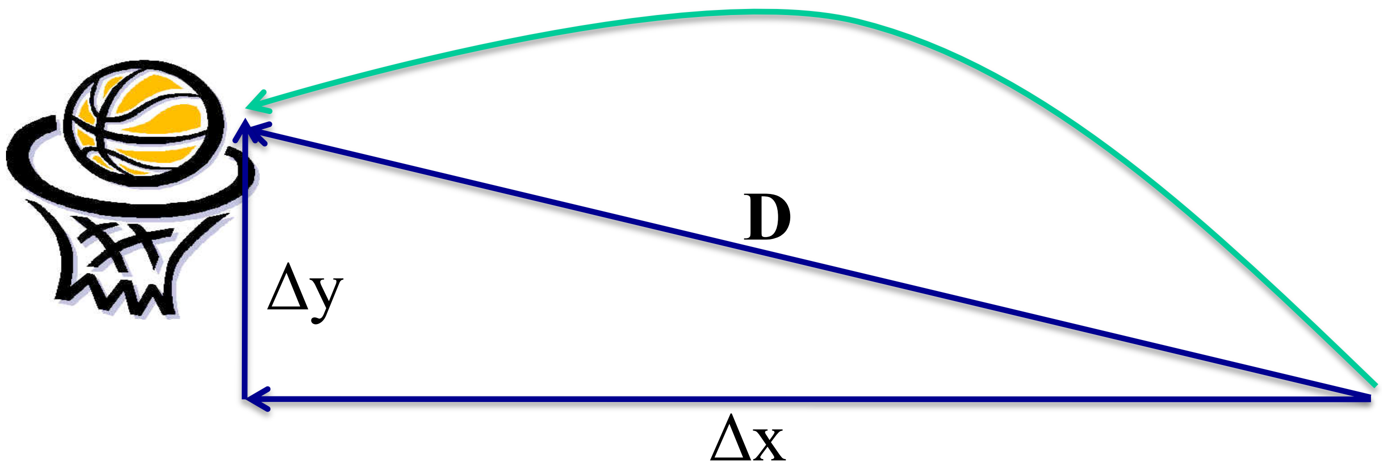


Velocity

- Change in displacement with time
- Vector (speed & direction)
  - changing either the speed or the direction changes the velocity

Average Velocity

$$\bar{v} = \frac{\vec{D}}{\Delta t}$$



Constant Velocity – 1D

- If objects are moving with constant velocity
  - Not speeding up, slowing down or changing direction
  - Motion in the x direction **D = Δx** = $x_f - x_0$

$$v = \frac{x - x_0}{\Delta t} = \frac{x - x_0}{t}$$

$$x = x_0 + vt$$

Example 2

Train A starts from Smalltown and heads East. At the same time, train B starts from Bigville and heads West. Assuming train A travels at 30 mph, train B travels at 40 mph and the towns are 100 miles apart, how far away from Smalltown do the two trains meet?

Question #6

If the average velocity of an object is zero in some time interval, what must be true about the displacement of the object during the time interval?

A. The object remains stationary
B. The object moves only forward
C. The object moves only backward
D. The object starts and stops at the same place

Day 2, Video 5

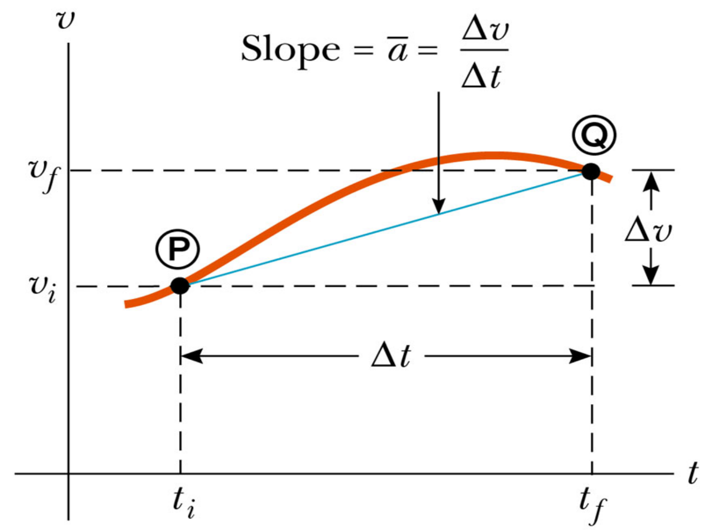
Acceleration

Acceleration

- Acceleration = change in velocity
  - Speeding up, slowing down, change in direction
  - Acceleration is a vector

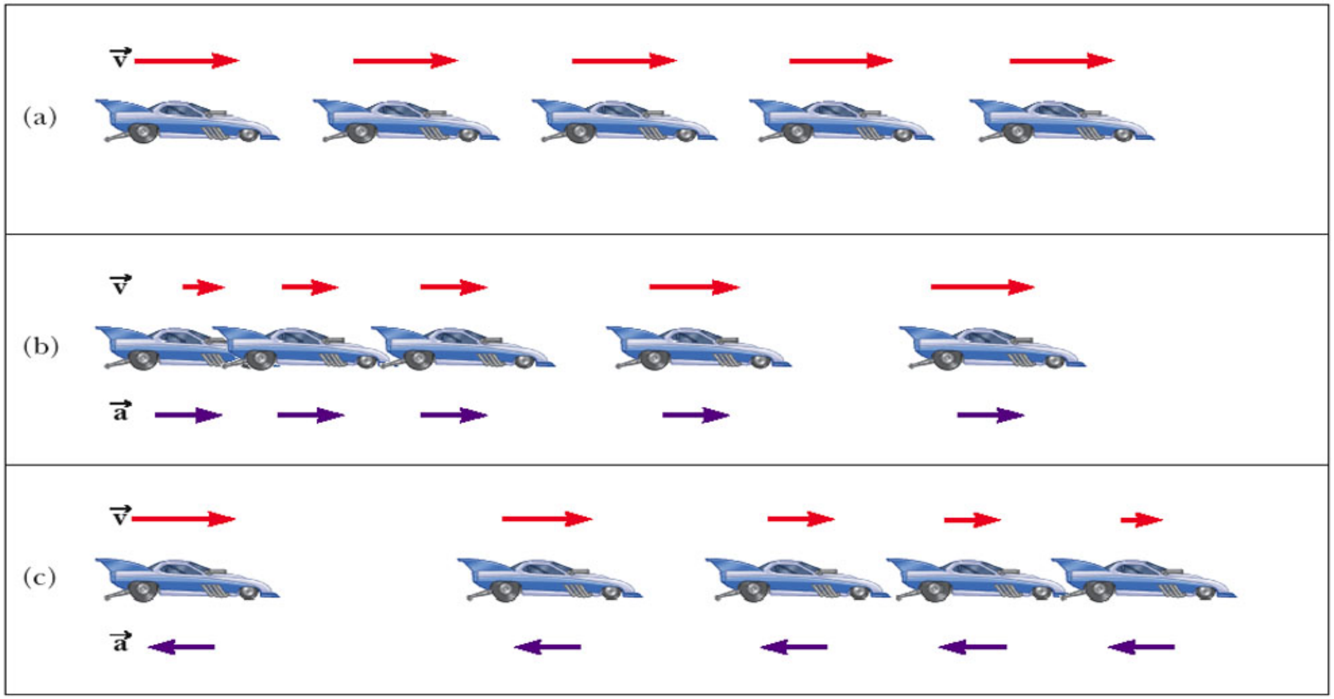
$$\text{Average acceleration} = \bar{\mathbf{a}} = \frac{\Delta \mathbf{v}}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

$$\text{units} \quad \frac{\text{m/s}}{\text{s}} = \frac{\text{m}}{\text{s}^2}$$



Acceleration

- Speeding up – **v** and **a** are in same direction and have same sign
- Slowing down – **v** and **a** are in opposite direction and have opposite sign



Question #7

If a car is traveling east, its acceleration must be eastward

A. True

B. False

Question #8

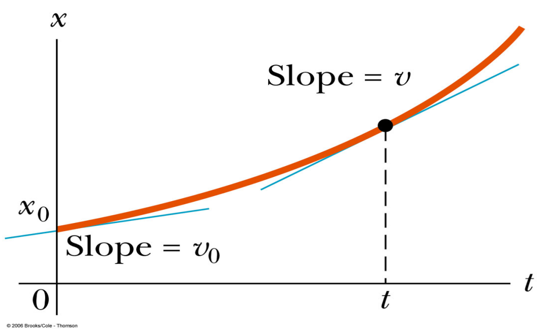
An object with constant, nonzero acceleration can never stop and stay stopped.

A. True

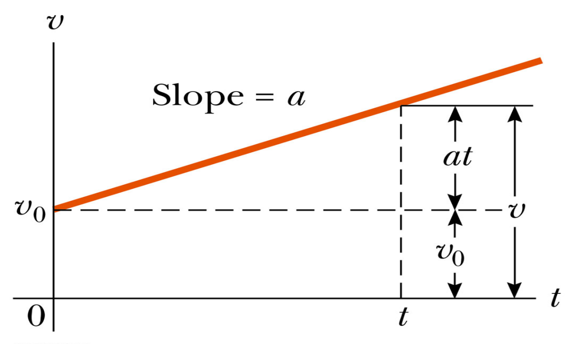
B. False

1-D Motion Graphs

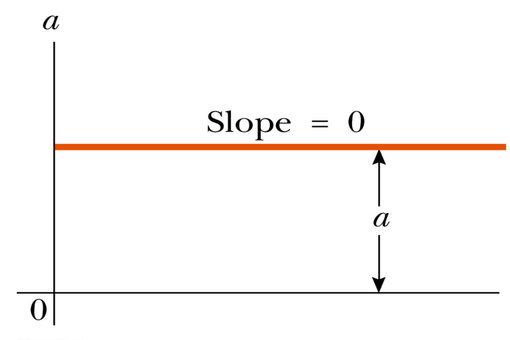
Displacement (x)



Velocity (v)



Acceleration (a)

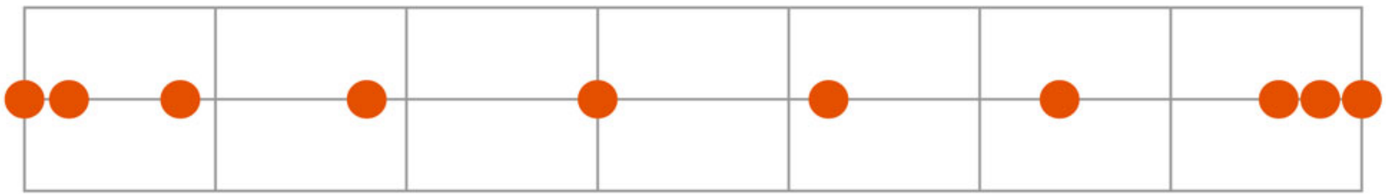


x → slope → v → slope → a

x ← Area under curve ← v ← Area under curve ← a

Actually, area under curve plus initial x or v

Question #9

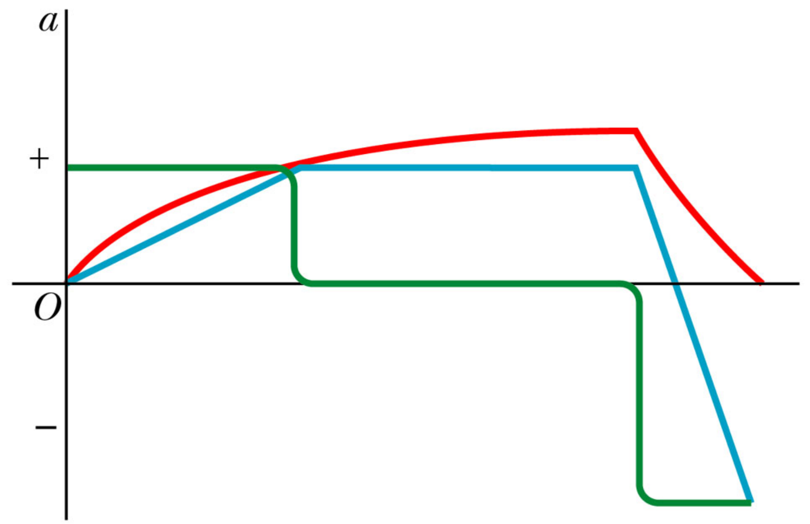


Above is a multiflash image of a puck's motion. Which line on the graph below shows best the puck's acceleration?

A. Red

B. Green

C. Blue



Constant Acceleration

Constant Acceleration Motion Equations

$$v = v_0 + at$$

$$\Delta x = \tfrac{1}{2}(v_0 + v)t$$

$$\Delta x = v_0 t + \tfrac{1}{2}at^2$$

$$\Delta x = \frac{v^2 - v_0^2}{2a}$$

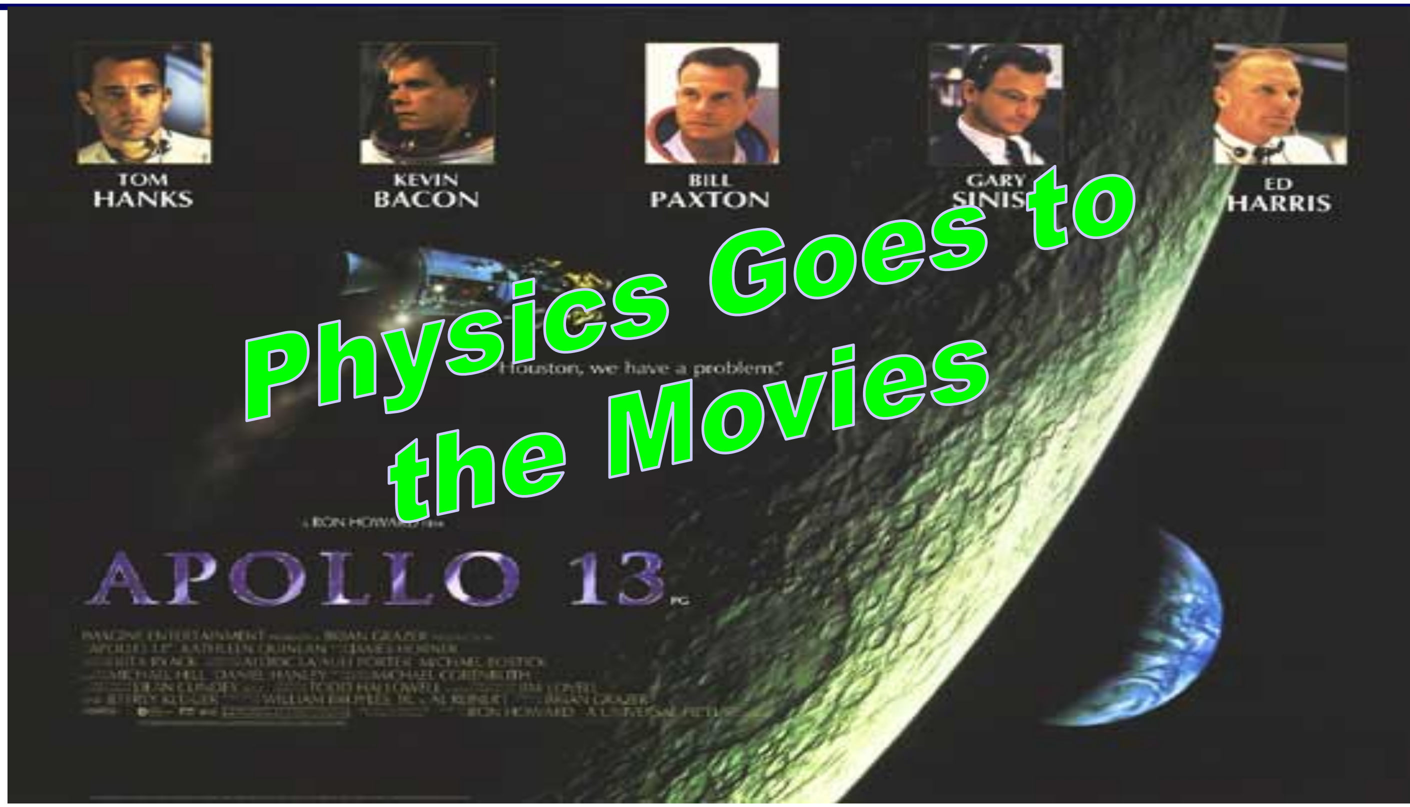
$$\bar{v} = \frac{v + v_0}{2}$$

- Problem solving steps
  - Draw picture of problem
  - Write down knowns
  - Write down unknowns
  - Select equations & solve for unknowns algebraically
  - Plug in knowns & calculate
- Usually more than 1 way to solve problems!

Day 2, Video 6

Acceleration Examples

Example 3



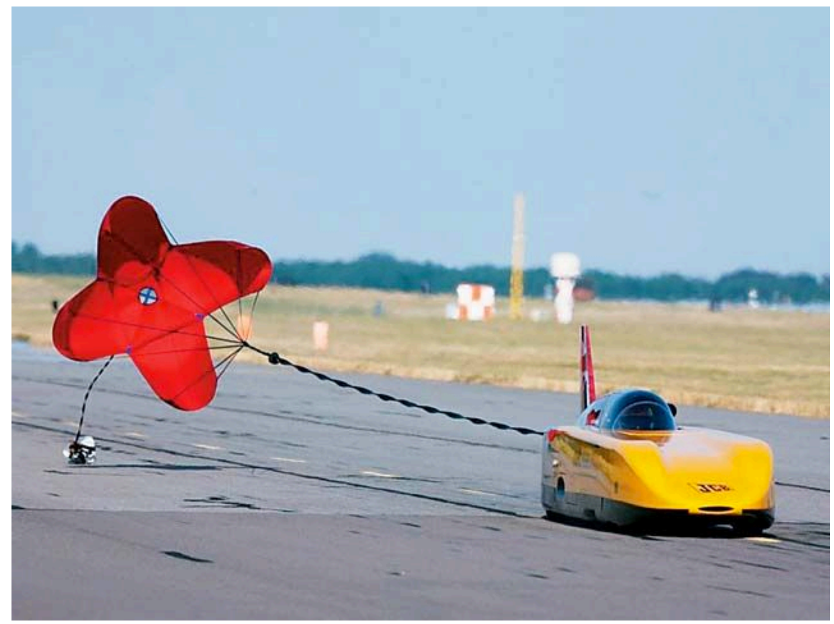
What is the acceleration that the astronauts experience?

Example 4

A racing car reaches a speed of 40 m/s. It begins uniform negative acceleration, using a parachute, and comes to rest 5.0 s later.

a) What is the acceleration?

b) How far does the car travel after acceleration starts?



Question #10

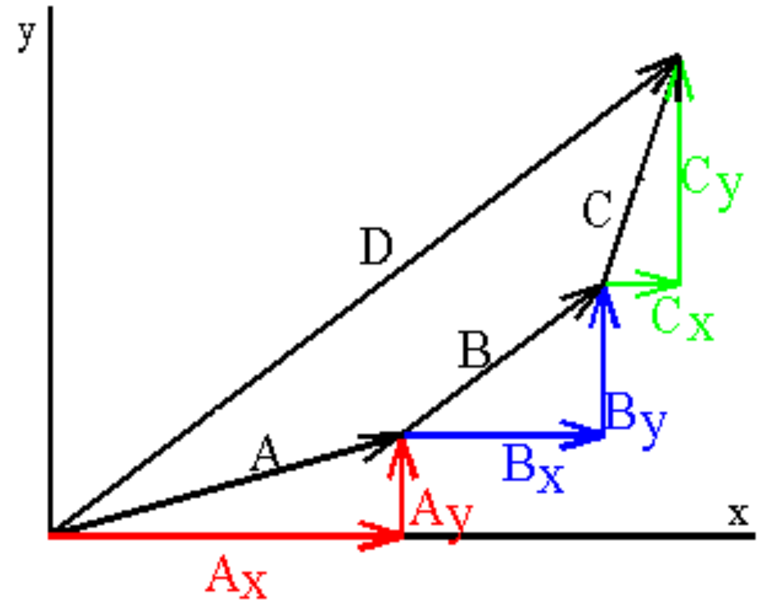
Two cars are moving in the same direction in parallel lanes along a highway. At some instant, the velocity of car A exceeds the velocity of car B. Does this mean that the acceleration of A is greater than that of B?

A. Yes

B. No

Big Ideas

- Displacement
  - Vector!
- Adding Vectors
  - Tip-to-tail method
  - Component method



Big Ideas

- Velocity
  - Speed plus direction (vector)
- Special Case: Constant velocity in 1-D

$$x = x_0 + vt \qquad \Delta x = vt$$

- Acceleration = change in velocity
- Special Case: Constant acceleration in 1-D

$$v = v_0 + at \qquad \Delta x = \tfrac{1}{2}(v_0 + v)t \qquad \Delta x = \frac{v^2 - v_0^2}{2a} \qquad \Delta x = v_0 t + \tfrac{1}{2}at^2 \qquad \bar{v} = \frac{v + v_0}{2}$$