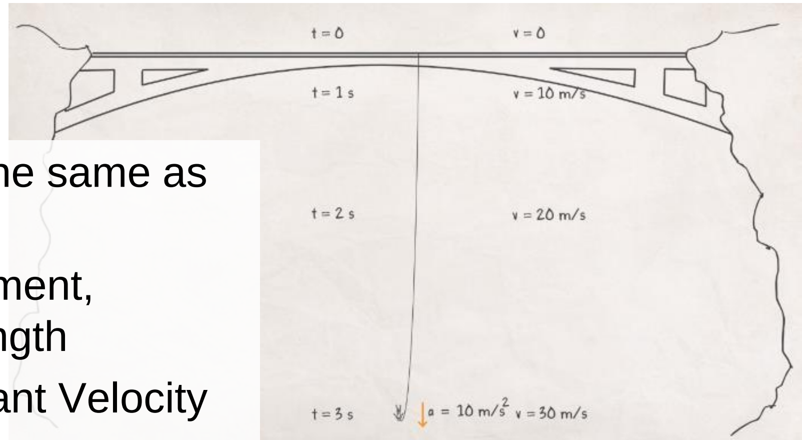
PHY131 F   Fall 2020
Class 3



- 2.3 Vector Math (not the same as regular math!)
- 2.4 Position, Displacement, Distance and Path Length
- 2.6 Motion with Constant Velocity
- 2.7 Motion with Constant Acceleration

1

Learning Assistant Alliance Email

- You should have received an email by now from the Learning Assistance Alliance.
- They will be administering the Pre and Post diagnostic tests for this course, which you do online.
- This first test (FCI) is about physics, and the second (CLASS) is about your attitudes about science in general.
- These help us get to know you and also help us understand how much you will gain from this semester, especially in the new fully-online format.

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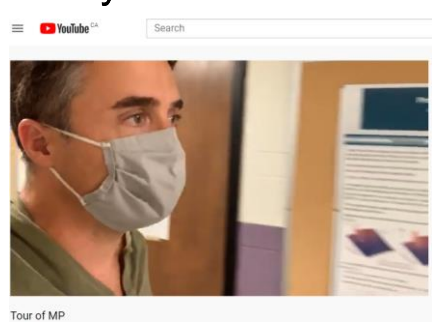
Learning Assistant Alliance Email

- Both tests are optional, and your accuracy on the tests will not affect your mark in the course in any way.
- The deadline for the pre-course tests is **this Friday**.
- To encourage you to do the tests, you will receive 1 homework credit for doing each of the pretests, and 1 homework credit for doing each of the post-tests at the end of the semester, for a total possible of 4 homework credits.
- You get the credit for participation in the surveys; accuracy does not matter, but I encourage you to do your best.

3

Video Tour of Physics Building

- Just for fun, I walked around the building today and took a 7 minute video with my iPhone.
- It is totally optional, and not course-related, but will give you an idea of where I am.
- There’s a link on the same page where you find the notes and recordings of classes
- https://youtu.be/ubJ2f3Q7I6s



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Last day I asked at the end of class:

- Does constant velocity imply constant acceleration?
- ANSWER: **YES**, and even more, it implies zero acceleration! (zero is a constant!)
- Does constant acceleration imply constant velocity?
- ANSWER: **NO!** Unless that constant happens to be zero! Constant acceleration normally means constantly *changing* velocity!

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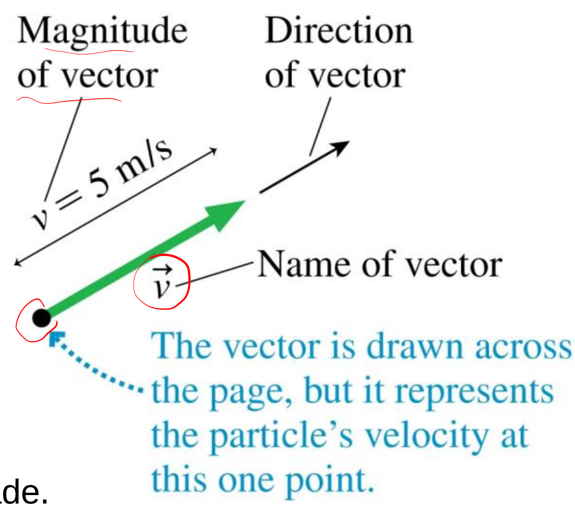
Vectors

- A quantity that is fully described by a single number is called a **scalar quantity** (i.e., mass, temperature, volume).
- A quantity having both a magnitude and a direction is called a **vector quantity**.
- The *geometric representation* of a vector is an arrow with the tail of the arrow placed at the point where the measurement is made.



- We label vectors by drawing a small arrow over the letter that represents the vector, i.e.,: $\vec{r}$ for position, $\vec{v}$ for velocity, $\vec{a}$ for acceleration.

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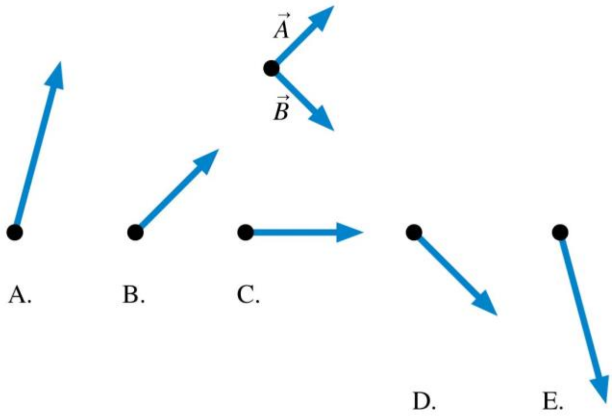
Poll Question

Which of the vectors in the second row shows $\vec{A} + \vec{B}$?



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Poll Question

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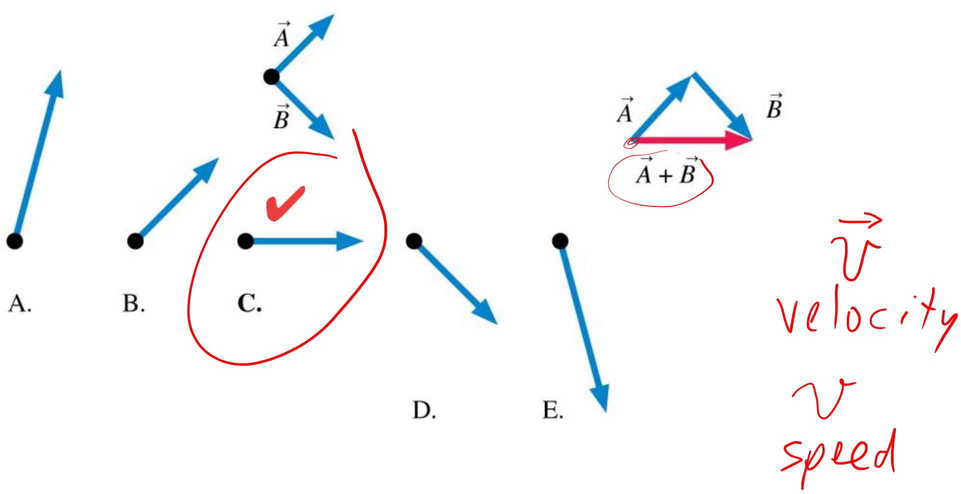

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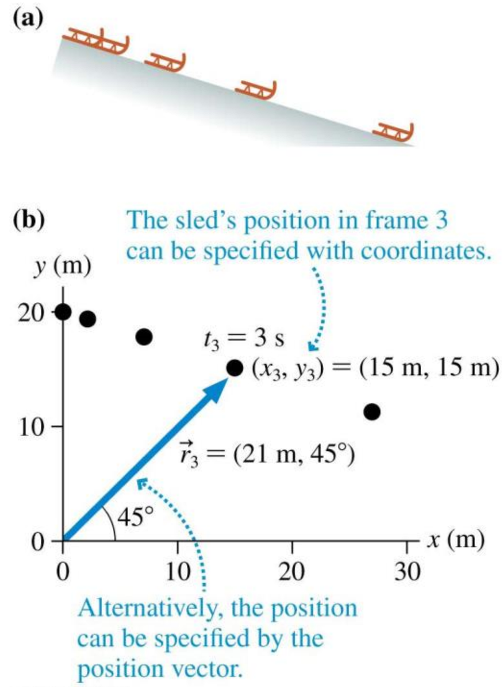
2.2 A Conceptual Description of Motion

- To use a motion diagram, you would like to know *where* the object is and *when* the object was at that position.
- Position measurements can be made by laying a coordinate-system grid over a motion diagram.
- To illustrate, the figure shows a sled sliding down a snow-covered hill.
- (b) shows a motion diagram for the sled, over which we've drawn an xy-coordinate system.



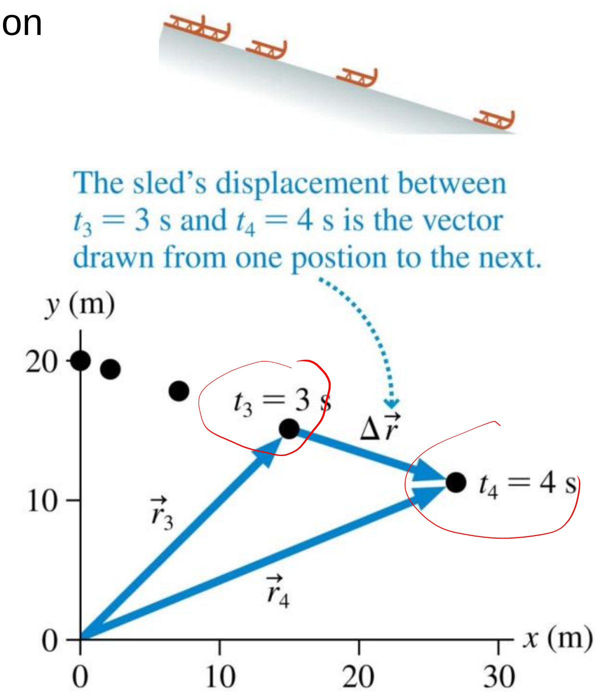
2.2 A Conceptual Description of Motion

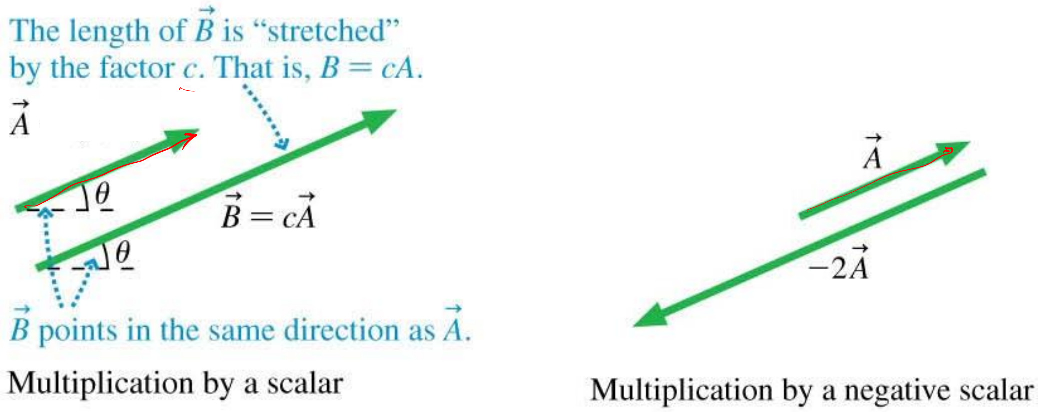
- We said that motion is the change in an object's position with time, but how do we show a change of position?
- Shown is the motion diagram of a sled sliding down a snow-covered hill.

- To show how the sled's position changes between $t_3 = 3$ s and $t_4 = 4$ s, we draw a vector arrow between the two dots of the motion diagram.
- This vector is the sled's **displacement,** which is given the symbol $\Delta\vec{r}$

$\Delta\vec{r} = \vec{r}_4 - \vec{r}_3$

$\vec{r}_4 = \vec{r}_3 + \Delta\vec{r}$





When a vector is multiplied by a scalar, the result is a vector parallel or antiparallel to the original vector whose magnitude equals the product of the magnitude of the original vector and the magnitude of the scalar.

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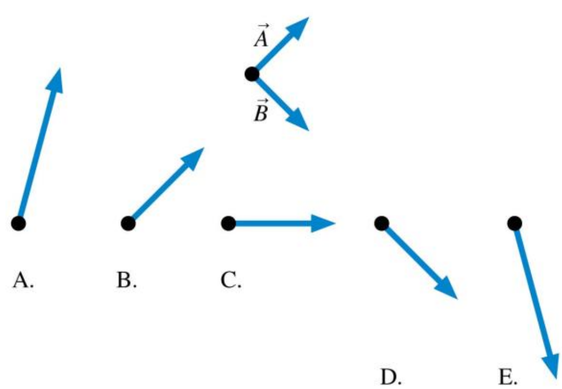
Poll Question

Which of the vectors in the second row shows $2\vec{A} - \vec{B}$?



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Poll Question

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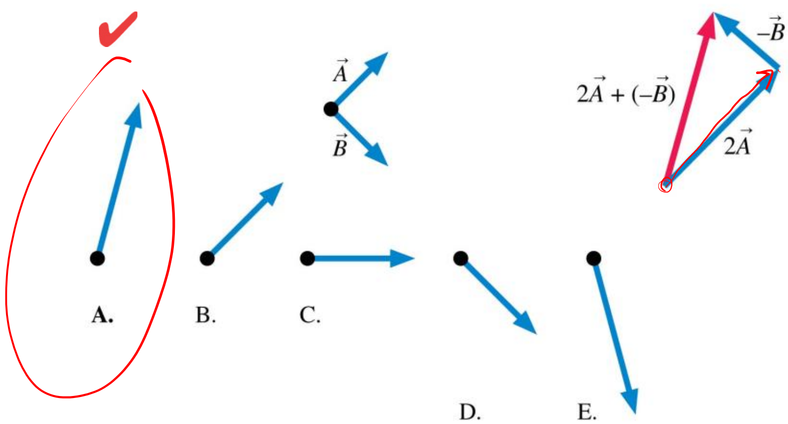

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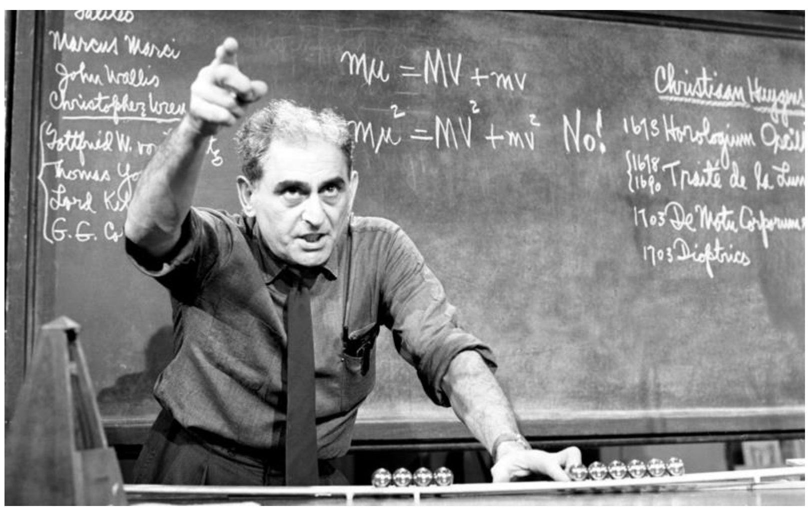
Is physics scary?



Julius Sumner Miller (1909-1987)

2.4 Quantities for Describing Motion

Time and time interval

- The **time** t is a clock reading.
- The **time interval** $(t_2 - t_1)$ or Δt is a difference in clock readings. (The symbol Δ (delta) represents "change in" and is the **final value** minus the **initial value**.)
- These are both scalar quantities.
- The SI units for both quantities are seconds (s).

A stopwatch is used to measure a time interval.

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2.4 Quantities for Describing Motion

Position, displacement, distance, and path length

- These quantities describe the location and motion of an object.
  - **Position** is an object's location with respect to a particular coordinate system.
  - **Displacement** is a vector that starts from an object's initial position and ends at its final position.
  - **Distance** is the magnitude (length) of the displacement vector.
  - **Path length** is how far the object moved as it traveled from its initial position to its final position.

Imagine laying a string along the path the object took. The length of the string is the path length.

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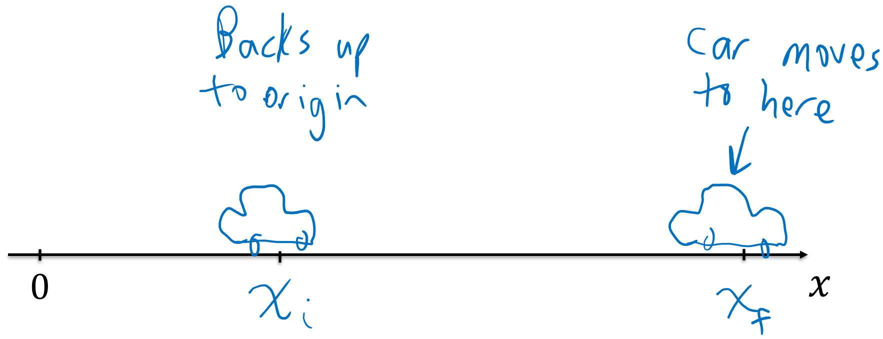
Example: A car backs up (moving in the negative direction) toward the origin of the coordinate system at $x = 0$. The car stops and then moves in the positive x-direction to its final position x_f.

Positions: x_i and x_f



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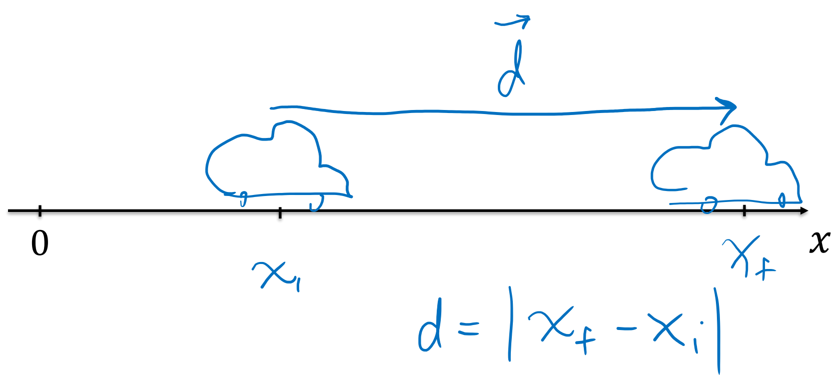
Example: A car backs up (moving in the negative direction) toward the origin of the coordinate system at $x = 0$. The car stops and then moves in the positive x-direction to its final position x_f.

Displacement: $\vec{d}$
and distance: d



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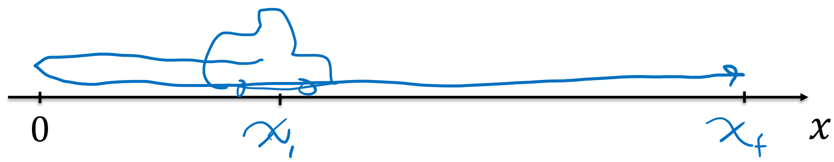
Example: A car backs up (moving in the negative direction) toward the origin of the coordinate system at $x = 0$. The car stops and then moves in the positive x-direction to its final position x_f.

Path length: l



$$l = |x_i - 0| + |x_f - 0| = x_i + x_f$$

2.6 Constant Velocity Linear Motion

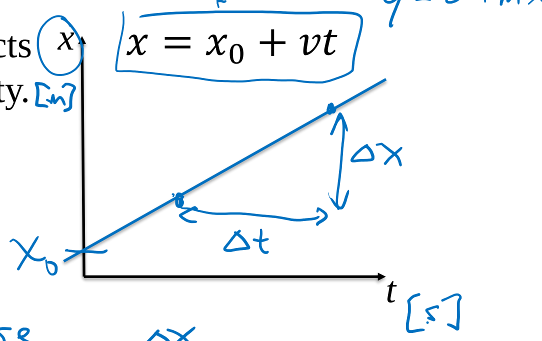
Velocity: Slope of the position-versus-time graph

$$v_x = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t} \qquad (2.1)$$

- If the slope is positive, the object is moving along the $+x$ axis.
- If the slope is negative, the object is moving along the $-x$ axis.
- The magnitude of the slope (which is always positive) is the speed of the object.
- The speed and the direction together are called the **velocity** of the object.

Uniform Motion = Constant Velocity

In the absence of friction, all objects tend to move with constant velocity. This is "Newton's First Law of Motion."



v_{avg} = slope = $\frac{\text{rise}}{\text{run}} = \frac{\Delta x}{\Delta t}$

units $\frac{m}{\text{seconds}}$ ← "metres per second".

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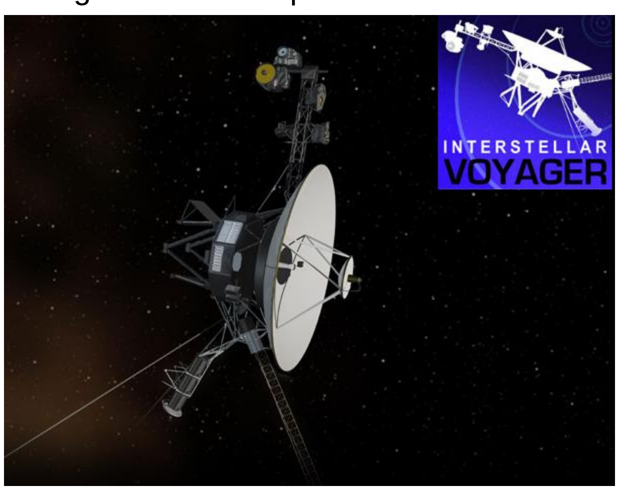
https://voyager.jpl.nasa.gov/mission/status/

- Voyager 1 is currently 150 A.U. from the Sun (Earth is 1 A.U., Pluto is 40 A.U.)
- It is drifting away at a constant velocity in a straight line of 15 km/s through interstellar space.



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Poll Question

- If the Position versus Time graph of an object moving in 1D is a straight line, what does this mean?

A. The object is not moving

B. The object is moving with a constant velocity

C. The object is moving with a constant acceleration

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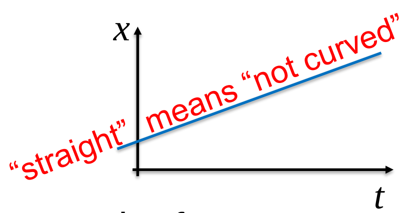
Poll Question



- If the Position versus Time graph of an object moving in 1D is a **straight** line, what does this mean?

A. The object is not moving

A. might be true, if the straight line is also **horizontal.**

B. The object is moving with a constant velocity

B. is the Best Answer

C. The object is moving with a constant acceleration

C. is technically also true, since the acceleration is zero (which is constant!)

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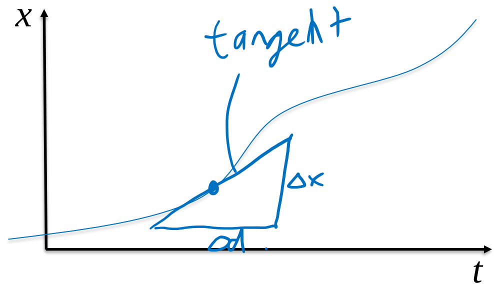
Curved Line = Not-Constant Velocity

$$v = \frac{dx}{dt}$$

↑ instantaneous velocity. a.k.a. "velocity"



v = slope of tangent to the curve.

v is the time-derivative of position

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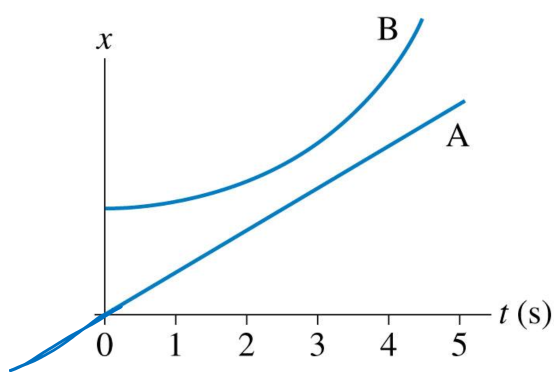
Poll Question



- When do objects A and B have the same velocity?

A. $t = 0$ s

B. $t = 1$ s

C. $t = 3$ s

D. $t = 5$ s

E. Objects A and B never have the same velocity

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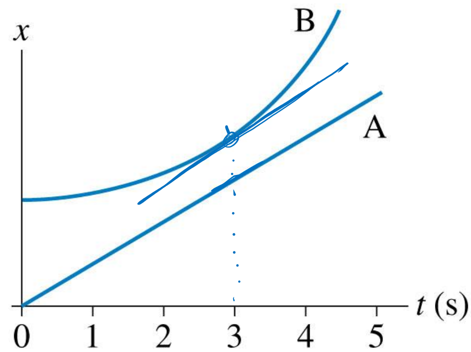
Poll Question



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Acceleration in 1-D (along a line)

- Velocity is the time-derivative of position. $\frac{m}{s}$
- Acceleration is the time-derivative of velocity.
- S.I. unit of acceleration is m/s ***per second***, also called m/s^2. $\frac{m}{s \cdot s} = \frac{m}{s^2}$
- Acceleration is like the "speed of the speed"
- Acceleration is "how fast fast changes!"
- It is possible to be momentarily stopped ($v = 0$) with a non-zero acceleration!

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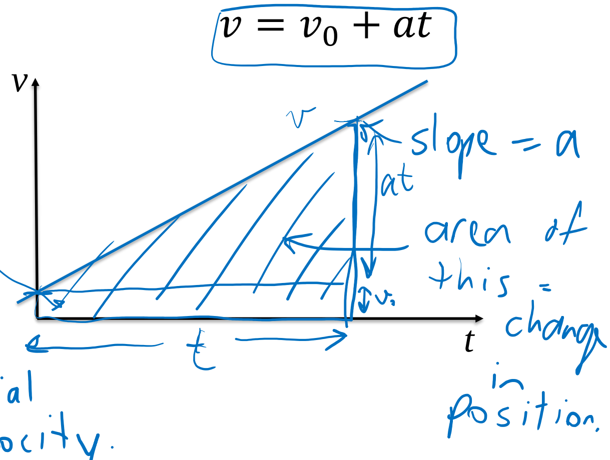
Constant Acceleration

$$x = x_0 + \int_0^t v\,dt$$

final position — initial position — area under v vs. t graph



$$x = x_0 + v_0 t + \frac{1}{2}t(\Delta v) = x_0 + v_0 t + \frac{1}{2}t(at)$$

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

area of rectangle

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Today’s Office Hour + Help Centre

- I will turn off the recording in 1 minute (after the next slide)
- I will linger in this zoom webinar for the next 20 minutes, dealing with Q&A.
- Feel free to raise your hand and I will unmute the raised hand at the top of my list
- At 12:20 I will shift over to gather.town for 10 minutes, at which point a TA from this course will be there for a PHY131 Help Centre from 12:30-1:30 today.

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Before Class 4 on Friday

1. Think of an example of an object with a negative acceleration which is speeding up.
2. Think of an example of an object with a positive acceleration which is slowing down.
3. Think of an example of an object with zero velocity which is accelerating!

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