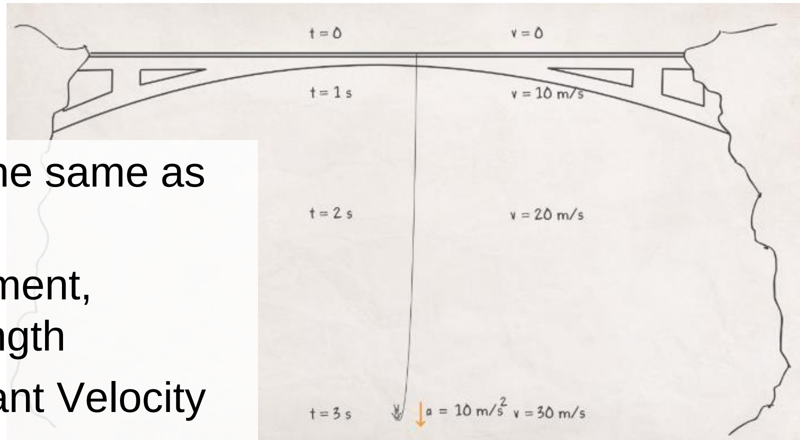
PHY131 F   Fall 2020
Class 3



- 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

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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.

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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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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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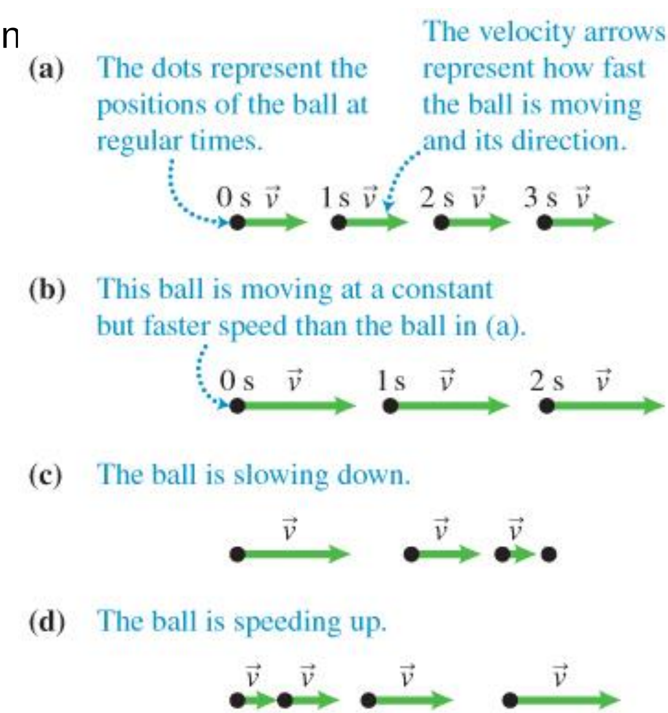
2.2 A Conceptual Description of Motion



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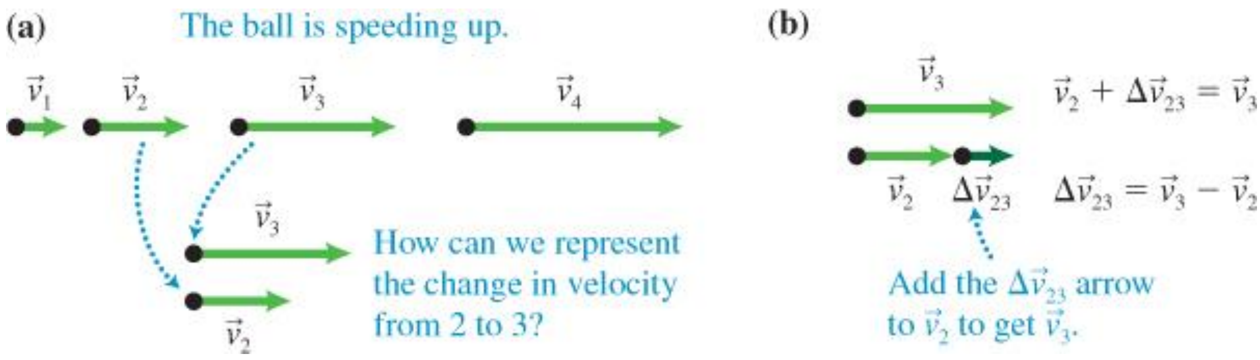
Velocity change arrows



$$\vec{v}_2 + \Delta\vec{v}_{2_3} = \vec{v}_3$$

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2.3 Operations with Vectors

- The length of a vector arrow is the vector’s magnitude.
- The orientation of each vector is determined by the direction of the arrow.
- A vector has a *tail* (the point where it originates) and a *head* (the tip of the arrow).
- The minus sign used in front of a vector means the vector has the same magnitude as a positive vector but points in the opposite direction.

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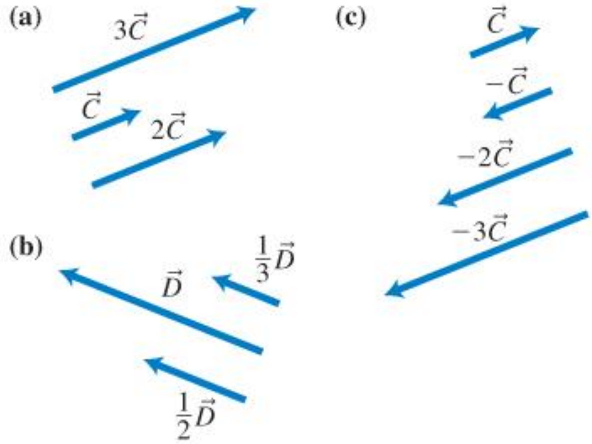


When a vector is multiplied by a scalar, the result is a vector parallel or antiparallel to the original vector whose magnitude equals the product of the magnitude of the original vector and the magnitude of the scalar.

2.4 Quantities for Describing Motion

- Motion diagrams represent motion qualitatively.
- To analyze situations, we need to describe motion quantitatively.
- These quantities are needed to describe linear motion:
  - Time and time interval
  - Position, displacement, distance, and path length
  - Scalar component of displacement for motion along one axis

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 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).

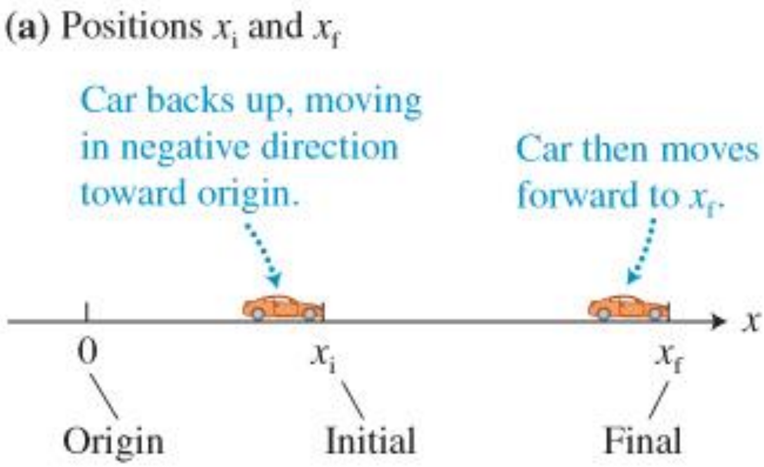
2.4 Quantities for Describing Motion

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.

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.



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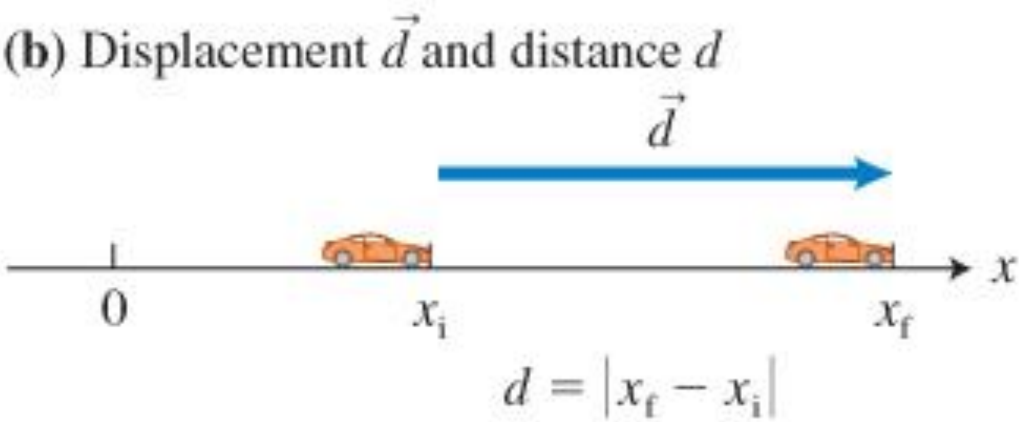

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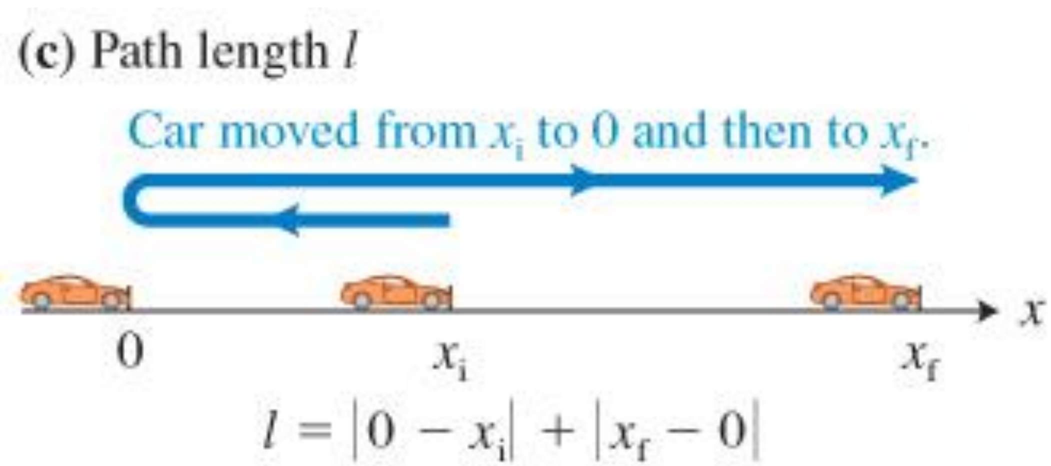

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2.6 Constant Velocity Linear Motion

Mathematics of linear motion

- A dependent variable, usually y, depends on the value of an independent variable, usually x.
- $y(x) = f(x)$ is an operation that one needs to do if x is an input and y is the output.
- For a straight line, $y(x) = kx + b$, where k is the slope and b is the y intercept; the value of y when $x = 0$.
- For motion along the x-axis, we write $x(t)$ to depict that the motion is dependent on time;
  $x(t) = kt + b$.

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2.6 Constant Velocity Linear Motion

Connecting graphical representations of linear motion to a mathematical representation

- A linear function is written: $x(t) = kt + b$
  - k is the slope of the line; it is the change in the dependent variable divided by the change in the independent variable.
  - The slope k can be found from

$$k = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}.$$

  - k has units of m/s and indicates how the position changes with time.
  - k can be positive or negative; it represents not only how fast, but also in which direction an object is moving.
  - b is the location of the object at $t = 0$; it is x_0.

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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.

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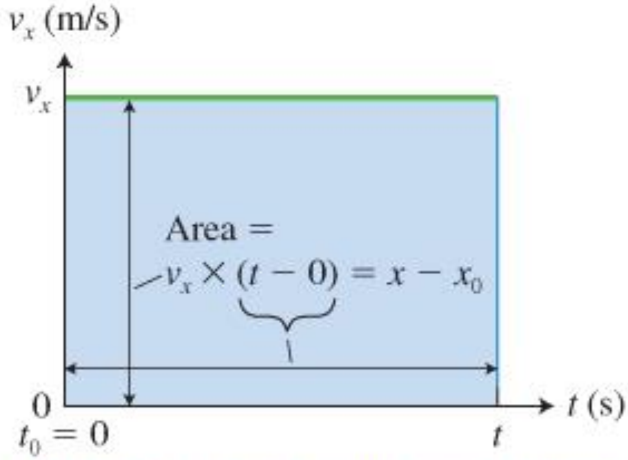
2.6 Constant Velocity Linear Motion

- Displacement $x - x_0$ between $t_0 = 0$ and time t is the **area** between the v_x-versus-t curve and the t axis.
- Area is width × height = $v_x(t - t_0)$
- Since $v_x = (x - x_0)/(t - t_0)$, $(x - x_0) = v_x(t - t_0)$



An object's displacement $x - x_0$ between $t_0 = 0$ and time interval $t - 0$ is the area between the v_x-versus-t curve and the t axis.

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2.6 Constant Velocity Linear Motion (8 of 9)

Finding displacement from a velocity graph

Displacement is the area between a velocity-versus-time graph line and the time axis For motion with constant velocity, the magnitude of the displacement $x_2 - x_1$ (the distance traveled) of an object during a time interval from t_1 to t_2 is the area between a velocity-versus-time graph line and the time axis between those two clock readings. The displacement is the area with a plus sign when the velocity is positive and the area with a negative sign when velocity is negative.

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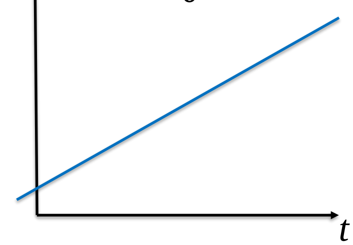
Uniform Motion = Constant Velocity

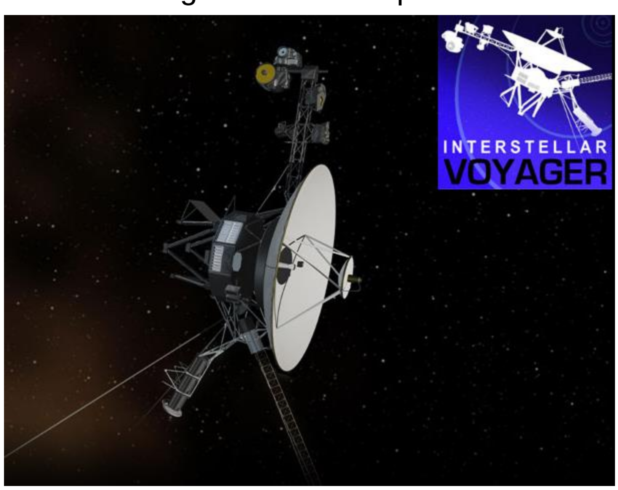
In the absence of friction, all objects tend to move with constant velocity. This is “Newton’s First Law of Motion.”

$$x = x_0 + vt$$



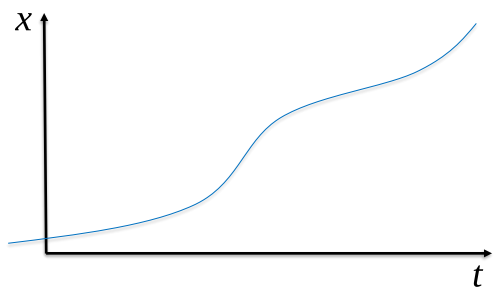
http://voyager.jpl.nasa.gov/

- Voyager 1 is currently 133 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 15.428 km/s through interstellar space.

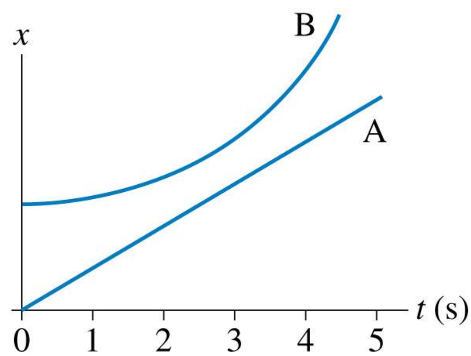


Curved Line = Not-Constant Velocity

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



Clicker 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

Acceleration in 1-D (along a line)

- Velocity is the time-derivative of position.
- Acceleration is the time-derivative of velocity.
- S.I. unit of acceleration is m/s ***per second***, also called 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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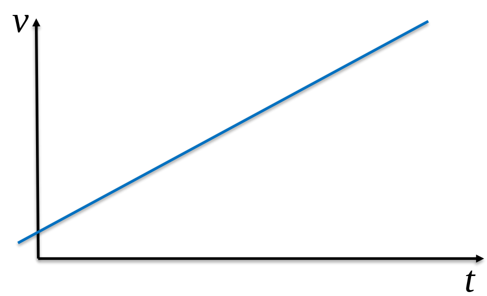
Constant Acceleration

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

$$v = v_0 + at$$



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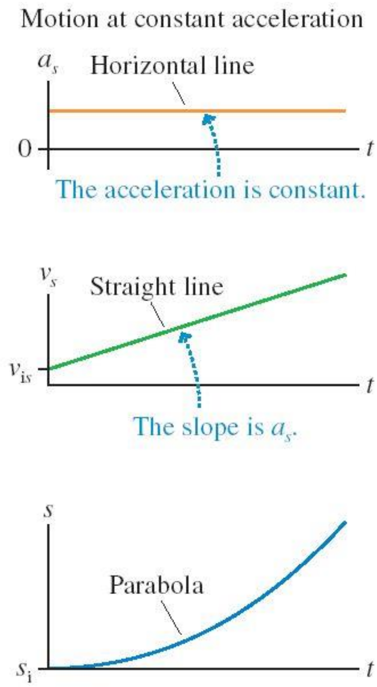

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Before Class 4 on Friday

- Give an example of an object with a negative acceleration which is speeding up.
- Give an example of an object with a positive acceleration which is slowing down.
- Give an example of an object with zero velocity which is accelerating!

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