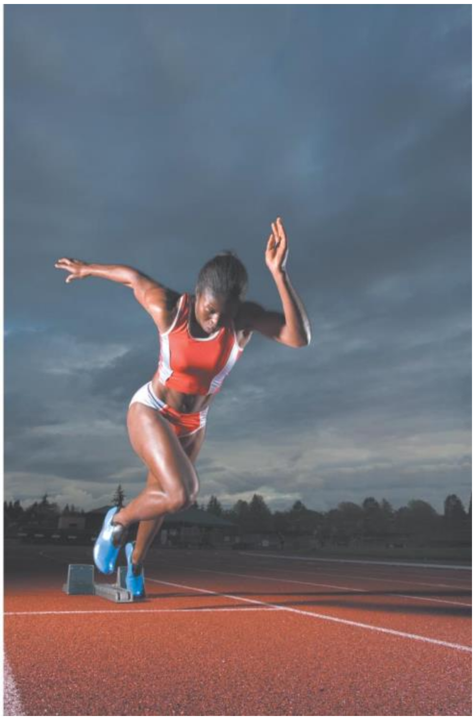
PHY131H1F
Class 4

Today, Chapter 2, Sections 2.1 to 2.4

- Uniform Motion
- Average velocity / Instantaneous Velocity
- Differentiating position to get velocity
- Integrating velocity to get position
- Equations of Constant Acceleration



Clicker 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

Class 4 Preclass Quiz on MasteringPhysics

- Student comment:
- *"If a straight line is uniform motion in a position-time graph, then does stationary not count as a straight line? they both are technically straight... except one line is horizontal and the other is on an angle. but they are both "straight" aren't they??"*
- **Harlow answer:** Yes, stationary is a straight line. I agree! Also, "zero" is a constant velocity! It's just a very specific constant velocity.

Class 4 Preclass Quiz on MasteringPhysics

- This was due this morning at 8:00am
- 986 students submitted the quiz on time
- 74% answered correctly: If the position-versus-time graph is a straight line, it means it has uniform motion. (Note: a ***horizontal*** straight line means it is stationary.)
- 75% answered correctly: Speeding up when velocity is in the negative direction means **negative** acceleration.
- 84% answered correctly: The area under a velocity-versus-time graph is the **displacement** of the object (it can be negative or positive, indicating direction)
- 92% answered correctly: The slope of a position-versus-time graph is the object's **velocity** (it can be negative or positive, indicating forward or backward direction in 1D)

Class 4 Preclass Quiz on MasteringPhysics

- Some common student comments/feedback:
- *"Does infinite speed count as uniform motion?"*
- **Harlow answer:** Not allowed! In physics, no speed can be greater than the speed of light, which is 3 x 10^8 m/s. (more about this in PHY132)
- *Lots of nerves about calculus and integration*
- **Harlow comment:** Remember, this is a calculus-based course. We use derivatives and integrals in our descriptions of concepts. However, you will not be asked to perform an integral on a test. (but maybe the occasional derivative of a simple polynomial, for example)

Class 4 Preclass Quiz on MasteringPhysics

- *Lots of people admitting they didn't do the reading.*
- **Harlow comment:** I appreciate your honesty, however… The entire point of these pre-class quizzes is to force you to do the reading before coming to class. The clicker questions are meant to be times to discuss what everyone here has already read.
- […Although, if you were at the Black Keys concert last night, that is an excellent excuse. How was it? *jealous*]
- *"this one was pree eeezz dawg :) tanks for the marks doe"*
- **Harlow comment:** Google translate could not detect the language

Class 4 Preclass Quiz on MasteringPhysics

- *"how strict you are about notation? Do we have to use the exact same notation demonstrated in the book?"*
- **Harlow answer:** Not strict at all! You should be able to reason properly without making mistakes and get to the correct answer (ie that the ball took 4.5 seconds to hit the ground). Whether you call the initial velocity v_0 or v_i or v_1 or w_Bieber, I don't care!

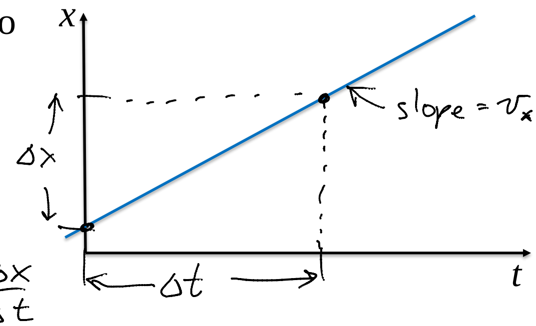
Last day I asked at the end of class:

- 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!

Uniform Motion = Constant Velocity

$$x_f = x_i + v_x t$$

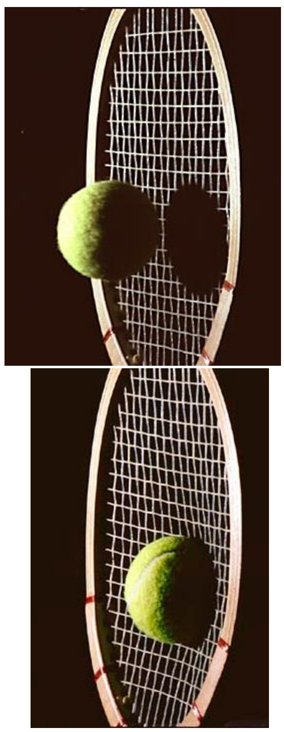
In the absence of friction, all objects tend to move with constant velocity.
This is "Newton's First Law of Motion."



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

No force | Not squished

External force on ball | Ball is squished



Images from http://people.rit.edu/andpph/exhibit-8.html ; taken by Andrew Davidhazy http://www.newscientist.com/article/dn26121-voyager-2s-view-of-solar-systems-edge-will-be-unique.html#.VBhrChYXOAZ

NewScientist Space

Voyager 2's view of solar system's edge will be unique

› 15:21 29 August 2014 by Rebecca Boyle
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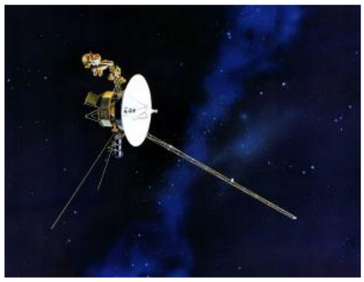
Earth's second emissary to interstellar space, Voyager 2, is phoning home with new views of the solar system's ragged edge. But what it sees could be very different to what its predecessor glimpsed, revealing new details of the sun's immediate neighbourhood.

Voyager 2 has reached the heliosheath, the beginning of the end of the solar system. If the experience of its twin, Voyager 1, is anything to go by, Voyager 2 is about two-thirds of the way to the heliopause – the outer edge of the sun's influence, also considered to be where interstellar space begins. Voyager 1 crossed this boundary two years ago this week, according to NASA and most Voyager scientists. Not everyone agrees, though, because readings sent back by Voyager 1 left a little room for doubt.

One clue that Voyager 1 had passed the heliopause was that its instruments measured a slowing, sparser solar wind. That's not happening yet for Voyager 2, says Rob Decker at Johns Hopkins University in Maryland.

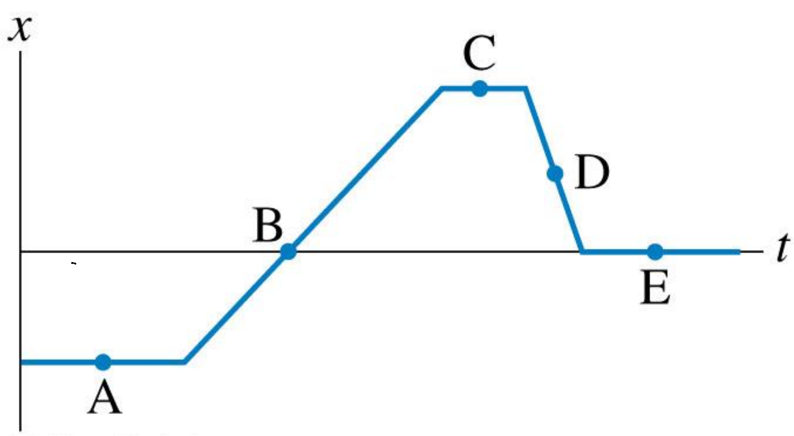


Still within the sun's grasp, but how long for?

- Currently 105 A.U. from the Sun (Earth is 1 A.U.)
- Moving at a constant velocity in a straight line of 15.428 km/s through interstellar space

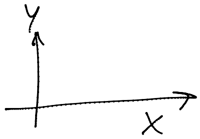
Clicker Question

- At which point is the object moving the fastest? (highest **speed**)

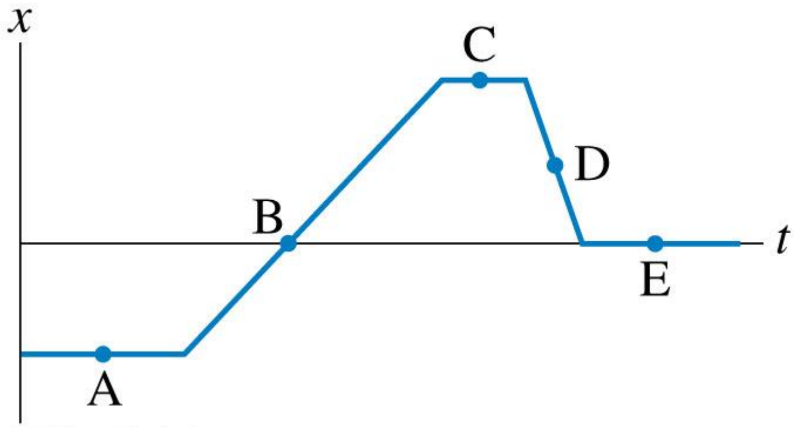


Clicker Question

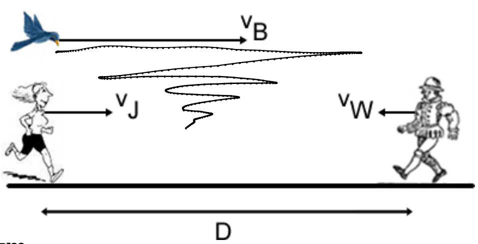
Define:



- At which point is the object moving the to the left?

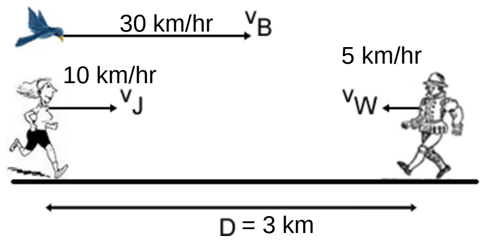


From a Past PHY131 Test:



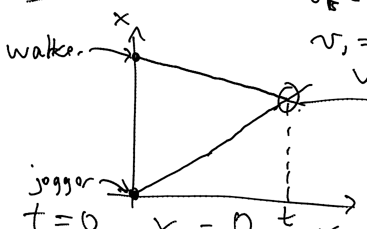
- A jogger runs at a constant velocity $\vec{v}_J = 10\ \frac{\text{km}}{\text{hr}}$ to the right.
- A walker walks at a constant velocity $\vec{v}_W = 5\ \frac{\text{km}}{\text{hr}}$ to the left.
- When the jogger and the runner are $D = 3\ \text{km}$ apart, a bird flying at a constant velocity $\vec{v}_B = 30\ \frac{\text{km}}{\text{hr}}$ to the right passes the jogger.
- When the bird reaches the walker, it turns around and flies back to the jogger at the same speed. When it reaches the jogger it turns around again and flies to the walker. It continues flying back and forth between the jogger and the walker.
- When the jogger and walker meet each other, how far has the bird flown?

From a Past PHY131 Test:



- How far has bird flown when Jogger and Walker meet? ← find d_B
- Bird has constant speed, so $d_B = v_B\, t$
- Need to find t.

Knowns: $v_B = 30\ \frac{km}{hr}$, $v_J = 10$ ", $v_W = 5$ "



At $t=0$, $x_J = 0$, $x_W = 3\ km$

$x_J = 0 + v_J t$

$x_W = 3 - v_W t$

set $x_J = x_W$

$x_J = x_W$

$0 + v_J t = 3 - v_W t$

Solve for t:

$t(v_J + v_W) = 3$

$t = \frac{3}{v_J + v_W} = \frac{3\ km}{(10+5)\frac{km}{hr}}$

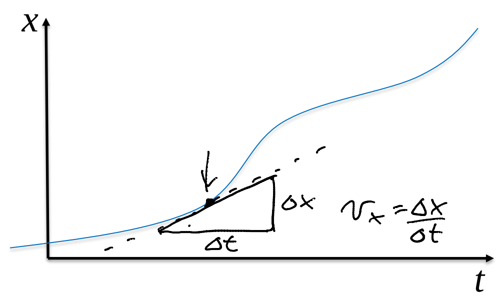
$t = \frac{3}{15} = 0.2\ hr$

$d_B = 30\ \frac{km}{hr}(0.2\ hr) = \boxed{6\ km}$

Curved Line = Not-Constant Velocity

$$v_x = \frac{dx}{dt}$$ ← instantaneous velocity.

= slope of tangent to the curved line.

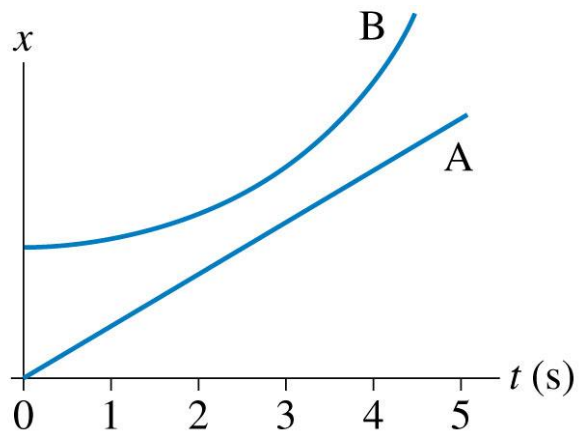


"Velocity is the time-derivative of position."

Clicker Question

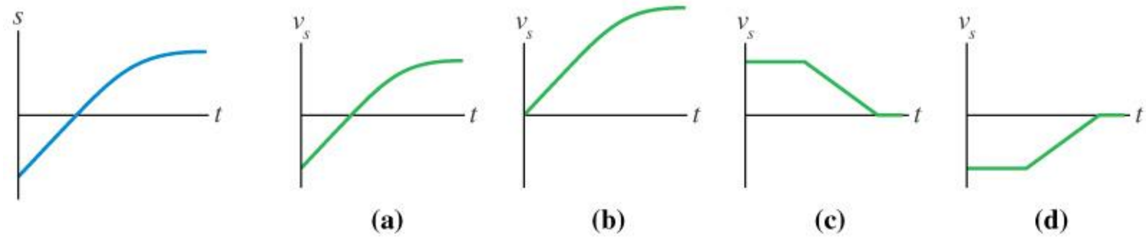
- When do objects A and B have the same velocity?

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



Clicker Question

Which velocity-versus-time graph goes best with the position-versus-time graph on the left?



Announcements

- Pre-course diagnostic quiz on mechanics done during zeroth practical last week.
- Did you miss it? Still want your 0.5%? Here are two make-up times to choose from:
- Tues Sept. 23 - 11:10 am in MP125C
  Wed. Sept 24 - 4:10 pm in MP125C

Announcements

- Don’t change your Practical Section on ROSI – your TAs will never know, and you won’t get your marks!
- You must go to portal and fill out an online form if you want to change Practical Sections.

Announcements

- The first term test will be on Tuesday, Sep 30, from 6:00pm to 7:30pm.
- Test 1 will cover chapters 1-3 plus the Error Analysis Mini-Document, plus what was done in Practicals
- You must bring a calculator and one 8.5x11' aid sheet which you prepare, double-sided
- 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 of this test by going to portal and filling out the online form no later than Sep. 25 by 4:00pm.

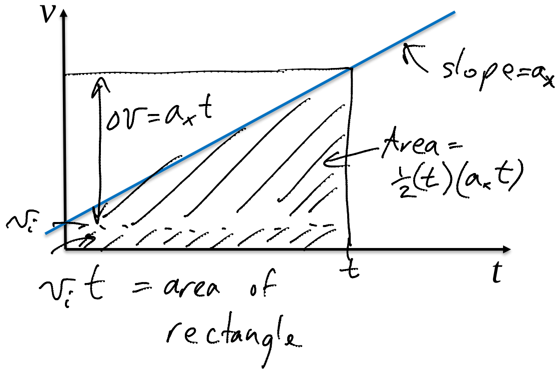
Acceleration in 1-D (along a line)

- Velocity is the time-derivative of position. $v_x = \frac{dx}{dt}$
- Acceleration is the time-derivative of velocity. $a_x = \frac{dv_x}{dt}$
- 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!

Constant Acceleration

$$v_f = v_i + a_x t$$

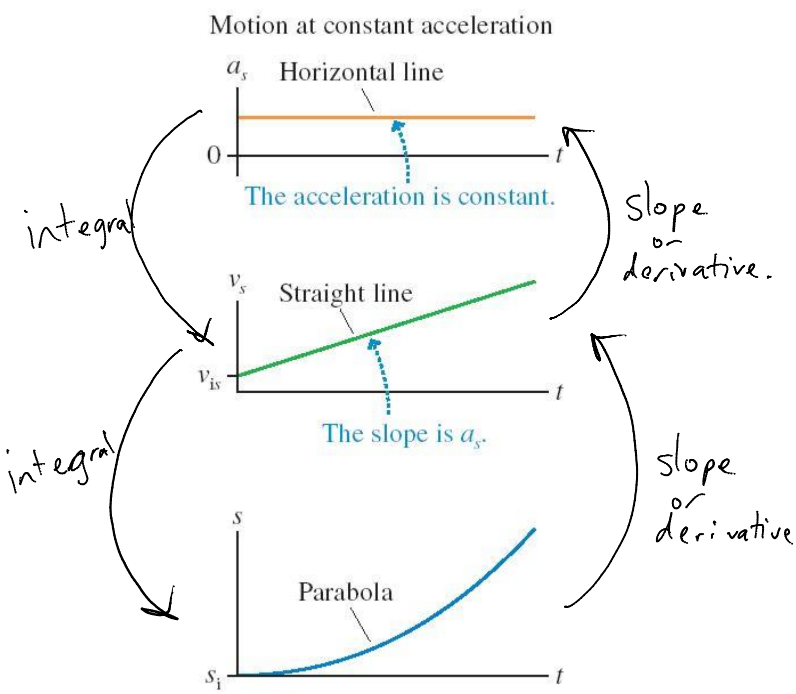
$$x_f = x_i + \int_0^t v\,dt$$



$$x_f = x_i + \int_0^t (v_i + a_x t)\,dt$$

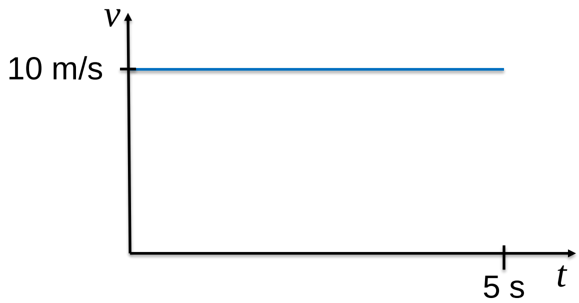
$$= x_i + \underbrace{\int_0^t v_i\,dt}_{\text{rectangle}} + \underbrace{\int_0^t a_x t\,dt}_{\text{triangle}}$$

$$\boxed{x_f = x_i + v_i t + \frac{1}{2} a_x t^2}$$ ← useful equation.



Clicker Question

- An object has a constant velocity of +10 m/s for 5 seconds.

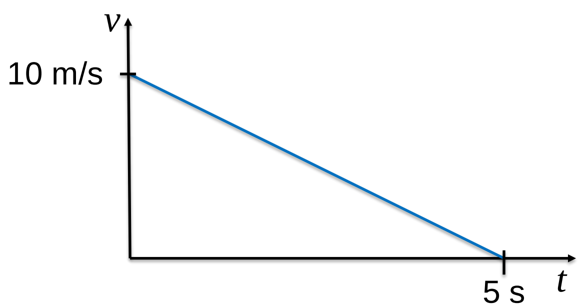


- How far does the object travel over these 5 seconds?

A. 10 m
B. 25 m
C. 50 m
D. 100 m
E. 500 m

Clicker Question

- An object has an initial velocity of +10 m/s.
- It is slowing down, with a constant value of acceleration.
- After 5 seconds, it has stopped.



- How far does the object travel over these 5 seconds?

A. 10 m
B. 25 m
C. 50 m
D. 100 m
E. 500 m

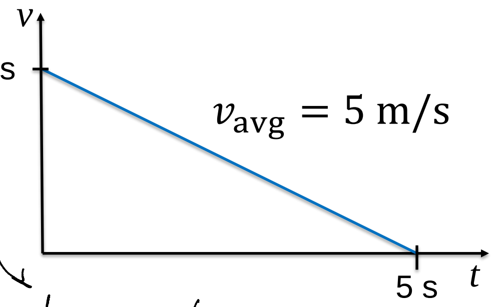
Average Velocity

- For 1D motion with constant acceleration, the average velocity is ½(initial velocity + final velocity)

$$v_{\text{avg}} = \frac{v_i + v_f}{2}$$

$$v_{\text{avg}} = \frac{d}{t}$$

$v_{avg} = \frac{d}{t}$



$d = v_{avg}\, t$

$$\Delta x = d = \left(\frac{v_i + v_f}{2}\right) t$$

useful equation

The 4 Equations of Constant Acceleration:

1. $v_f = v_i + a\Delta t$ — Does not contain position!

2. $x_f = x_i + v_i \Delta t + \frac{1}{2} a (\Delta t)^2$ — Does not contain v_f!

3. $v_f^{\,2} = v_i^{\,2} + 2a(x_f - x_i)$ — Does not contain Δt!

4. $x_f = x_i + \left(\frac{v_i + v_f}{2}\right)\Delta t$ — Does not contain a! (but you know it's constant)

Strategy: When a = constant, you can use one of these equations. Figure out which variable you don't know and don't care about, and use the equation which doesn't contain it.

Clicker Question

- You are driving along a straight highway at a steady speed.
- A driver in the left lane passes you at a steady speed.
- At the moment when the front of her car is exactly even with the front of your car, you both turn and your eyes meet briefly.
- At this instant, do you have equal velocities?

A. Yes
B. No
C. Not possible to determine with information given.

[image downloaded Sep.17 2013 from http://blog.famousfootwear.com/2013/03/save-your-car-and-money-with-driving-shoes/]

Before Class 5 on Monday

- If you haven't already done it, remember there is a MasteringPhysics.com problem set due this weekend! Please submit this before 11:59pm Sunday.
- Please finish reading Chapter 2 of Knight.
- Something to think about: Which is easier to **see**: velocity or acceleration? Which is easier to **feel**: velocity or acceleration?