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 1

- 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

- This was due this morning at 8:00am
- 899 students submitted the quiz on time
- 63% 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.)
- 72% answered correctly: Speeding up when velocity is in the negative direction means **negative** acceleration.
- 76% answered correctly: The area under a velocity-versus-time graph is the **displacement** of the object (it can be negative or positive, indicating direction)
- 88% 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:
- *"The integral explanations were very confusing, we never learned integrals as it was not part of my grade 12 Ontario curriculum, and we haven't learned them yet in MAT135."*
- *"Integrals make me dizzy (why stop the running joke now?)"*
- Harlow and Meyertholen say: "We will not expect you to perform integrals on a test or exam. We use the language of calculus to describe concepts in this course, but the math you are required to do is limited to algebra, and maybe differentiation, at the most."
- From https://piazza.com : *"Is it OK to write the derivative of a function as **f ' (x)**? Instead of **d / dt**?"*

Class 4 Preclass Quiz on MasteringPhysics

- You don't need to know this for this course, but in upper level physics courses and research, the tradition is to use primes for spatial derivatives, and dots for time derivatives..

$$y' \equiv \frac{dy}{dx} \qquad \dot{y} \equiv \frac{dy}{dt}$$

$$y'' \equiv \frac{d^2y}{dx^2} \qquad \ddot{y} \equiv \frac{d^2y}{dt^2}$$

- Feel free to use these notations if you wish; I'm sure the graders and TAs in this course will understand what you mean.

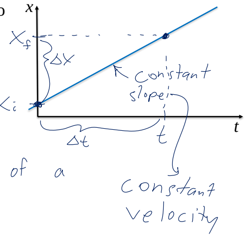
Last day I asked at the end of class:

- 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

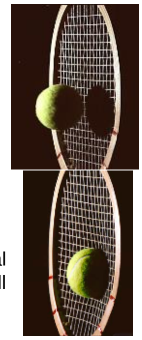
$x_f = x_i + v_x t$

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



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

Velocity is the slope of a position vs. time graph.



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

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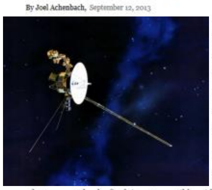
- The farthest manmade object from Earth.
- Currently 125 A.U. from the Sun (Earth is 1 A.U.)
- Moving at a constant velocity in a straight line of 17 km/s through interstellar space

http://articles.washingtonpost.com/2013-09-12/national/42010179_1_heliosphere-solar-particles-charged-particles

The Washington Post

After 36 years, Voyager 1 goes interstellar

By Joel Achenbach, September 12, 2013



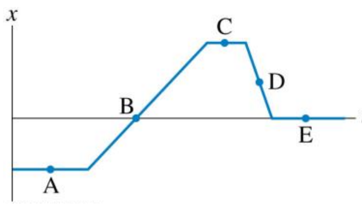
The tireless Voyager I spacecraft, launched in the disco era and now more than 11 billion miles from Earth, has become the first man-made object to enter interstellar space, scientists said Thursday. Interstellar space, scientists now know with certainty, is dense with particles, and the place is literally hissing. Or maybe you could say it's whistling in the dark.

"It's almost a pure tone. Like middle C. But slightly varying, like your piano is not quite tuned right," said Donald Gurnett, a University of Iowa physicist who has been working on the Voyager mission most of his adult life.

Gurnett is the lead author of a paper published Thursday in the journal Science that provides what seems to be the final, incontrovertible evidence that NASA's Voyager I has crossed into a realm where no spacecraft has gone before.

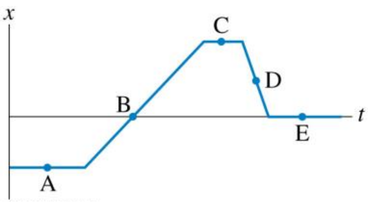
Clicker Question 2

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

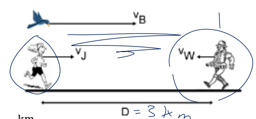


Clicker Question 3

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



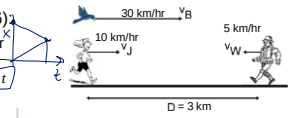
From a Past PHY131 Test (2006):



- 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 $D = 3$ 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 (2006):

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



At $t = 0$ $x_J = 0$

$x_W = +3$ km

$x_J = 0 + v_J t$

$x_W = 3 - v_W t$

When they meet, $x_J = x_W$

$v_J t = 3 - v_W t$

$v_J t + v_W t = 3$

$(v_J + v_W) t = 3$

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

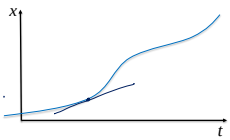
$t = \frac{3}{15} = 0.2$ hr

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

Curved Line = Not-Constant Velocity

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

= slope of the tangent to the graph.

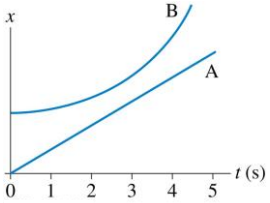


Velocity is the time-derivative of the position.

Clicker Question 4

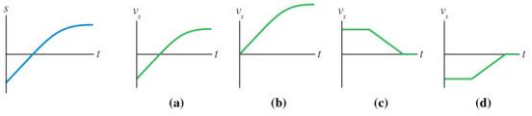
- When do objects A and B have the same velocity?

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 5

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 0.25%? Here are two make-up times to choose from:
- Tues Sept. 24 - 11:10 am in MP125C
  Wed. Sept 25 - 6:10 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 MP129 and fill out a form if you want to change Practical Sections. (or do the online form)
- If you've already switched Practicals on ROSI recently and you aren't sure if your new and old TAs have the updated information, please go to MP129 and ask April Seeley.

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!

Constant Acceleration

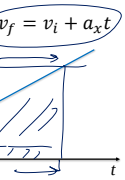
$$x_f = x_i + \int_0^t v\,dt$$

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

$$= x_i + \int_0^t v_i\,dt + \int_0^t at\,dt$$

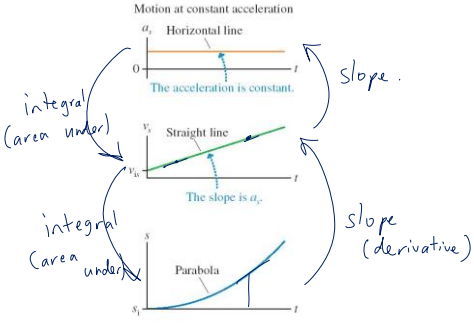
$$x_f = x_i + v_i t + \frac{1}{2}at^2$$

$v_f = v_i + a_x t$



Area of rectangle = $v_i t$

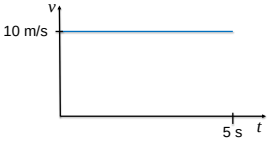
Area of triangle = $\frac{1}{2}\,t \cdot at = \frac{1}{2}at^2$



Clicker Question 6

- An object has a constant velocity of +10 m/s for 5 seconds.
- How far does the object travel over these 5 seconds?

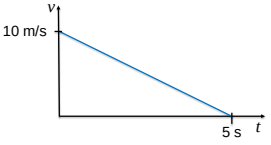
A. 10 m
B. 25 m
C. 50 m
D. 100 m
E. 500 m



Clicker Question 7

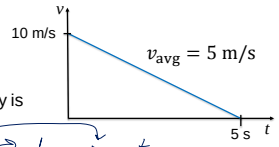
- An object has an initial velocity of +10 m/s.
- It is slowing down, with a constant value of acceleration.
- After 5 seconds, it has stopped.
- How far does the object travel over these 5 seconds?

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)



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

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

$d = v_{avg} \cdot t$

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

Useful eq. for mid short.

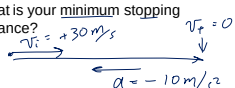
The 4 Equations of Constant Acceleration:

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.

Example.

- You are traveling at 30 m/s, and suddenly hit the brakes.
- Your maximum acceleration is 10 m/s².
- What is your minimum stopping distance?



Need Δx.

Don't care about t.

Use: $v_f^2 = v_i^2 + 2a(\Delta x)$

Solve for Δx.

$2a\,\Delta x = v_f^2 - v_i^2$

$\Delta x = \frac{v_f^2 - v_i^2}{2a}$

$= \frac{0^2 - 30^2}{2(-10)}$

$\Delta x = 45$ m

Clicker Question 8

- 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/2013/05/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?