Introduction

Physics 211
Syracuse University, Physics 211 Spring 2016
Walter Freeman

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Physics 211
Forces and Motion

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Course webpage:

http://suphysics211.wikispaces.com

Overview of today

- Introduction to physics and mechanics
- Course organization / syllabus
- How to succeed in this course
- Describing motion: position and velocity

So what is this class?

Physics: what are the fundamental laws of nature?

These phenomena are all governed by the *same few principles*.

Mechanics

The most fundamental question physics asks:

“Why do things move in the ways that they do?”

The answer is given by Isaac Newton’s second law of motion:

“Objects accelerate when pushed by forces; they accelerate in the direction of the force, proportional to the size of the force divided by their mass.”

That’s it. We will spend much of our class talking about the meaning and consequences of this one statement.

The physicist's eye

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- "What phenomena are involved in this thing?"
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In this class, you'll learn about some of those simple pieces, but that's not the important thing.

You'll also learn the skill of asking those two questions, and develop a physicist's perspective for solving problems.

This will serve you well in whatever field you pursue, since the ability to quickly look at a problem and understand the crucial elements is universally helpful.

What is this (and how does it work)?

How it works: the physicist's perspective

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- ... but a computer can do it! (youtube link)

Three broad sections:

1. Kinematics (understanding the right hand side of $\vec{F} = m\vec{a}$)
    - How do we describe motion?
    - How do an object's position, velocity, and acceleration relate?
    - What about rotational motion?
    - How do we deal with things in two or three dimensions?

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2. Forces and motion (both sides of $\vec{F} = m\vec{a}$)
   - What kinds of forces are there?
   - Torque: a rotational counterpart to force, with an equivalent to $\vec{F} = m\vec{a}$
   - Understanding different physical situations using $\vec{F} = m\vec{a}$
   - Collisions and momentum: taking the integral of $\vec{F} = m\vec{a}$

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3. Two more topics
   - Energy: a way to simplify solving $\vec{F} = m\vec{a}$ when you don't care about time
   - How do forces cause torques?

Clickers

Starting next week, we'll start using clickers in class, and the week after that, your participation in clicker questions wil be graded.

- Clickers are little radio devices you can use to answer questions in class
- You can also use a smartphone or tablet

You will need to either:

- Buy a Turning Technologies clicker from the bookstore or elsewhere, or
- ... download the ResponseWare app on your smartphone, then set up an account and buy a license for $20 (cheaper than a clicker)

Mastering Physics

Mastering Physics is an online homework system. Due to negative feedback from students I don't require it, but it is still for sale in the bookstore; you do not need to buy it.

Grading

- Homework: 30% (submitted to your recitation TA)
- Exams: 50%
  - Each of the three sections has an exam
  - Every exam has a makeup given two weeks later
  - You can take both and keep the higher grade
- Class participation (clicker questions): 5%
- Computational projects (mostly done in recitation): 10%
- Recitation attendance: 5%
- Up to 2% extra credit for participation in course Facebook group
- Up to 2% extra credit for exceptional participation in recitations, etc.

The makeup for the third exam will be given during the final exam period. *There is no separate final.*

Recitations

- Discussion sections led by your TA
- Homework is submitted and returned in recitation
- **Crucial** for your success in this class
  - Ask general questions to your TA and your peers
  - Work on homework questions in groups
  - Work on recitation worksheets/questions, or problems from the workbook
  - Work on computational assignments (introduced next week)
- Physics is not about how much you know – it's about **what you can do**
- This class isn't about amassing facts; it's about solving problems
- This requires practice, and the recitations (and the homework) are where you get it
- The TA's this year are a fantastic bunch; make use of them!

The course webpage and Facebook page

- All notes, etc., will be posted on http://suphysics211.wikispaces.com (not Blackboard)
- I will also post course announcements there
- The syllabus is posted there
- ... so is some information on how to succeed in this class; you should read it!

- There is also a course Facebook page at https://www.facebook.com/groups/1553254954993837/
- ... or search "Syracuse University Physics 211, Spring 2016"
- Joining the group doesn't mean anyone else can see your private posts etc.
- This is a great place to ask questions, get advice, and collaborate with your classmates
- Up to 2% extra credit for those who help their peers

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These things are skills, and they all require practice

... but they also require you to ask questions and ask for guidance!

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Some students might come to class, write down everything, go home and review, and then spend hours alone working on the homework...

... but this is not the best way to learn skills! Instead, I hope you will:

- Interrupt me in class and ask questions
- Ask me questions by email to **suphysics211@gmail.com**
  - I am often by a computer and you will often get a quick reply
  - You can take cellphone pictures of work and email them to me, too
- Ask questions on the Facebook group
- Come work with me and with your peers in my office hours
- Do your homework in the Physics Clinic when you can

Metaphors: sports and music

Learning physics is like learning to play a musical instrument.

The hard part isn't learning the notes – it's being able to play them, and tell a story with them.

How does studying the piano work?

- Your teacher shows you a few techniques, and gives you a piece to learn to play
- You take it home, practice it, and get stuck on difficult parts
- You ask your teacher for advice; she guides you
- You practice some more
- You repeat the previous steps until you've mastered the technique and the music

Learning a sport works the same way.

Physics is like this. We don't expect you to master everything immediately; physics takes practice, and it's okay to get stuck and ask questions. In fact, it's what I expect!

The Physics Clinic

The Clinic is in room 112; it's a large room with tables, boards, and (usually) a graduate teaching assistant.

You can go there whenever the building is open to work in groups on your homework, and ask each other and the GTA for help.

I also hold my office hours there.

This is an excellent resource for you to use; why do your homework alone when you can work with your peers and instructors?

Office hours

In the Physics Clinic:

- Mondays: 10-12 AM
- Tuesdays: 4-6 PM
- Thursdays: 1:30-3:30 PM
- Fridays: 2:00-4:00 PM

or by appointment.

Outside these times you might find me in the Clinic or in my office in room 215.

The beginning: describing motion (1-D)

Recall that at first, we are only concerned with describing motion.

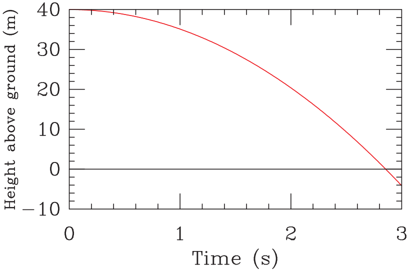
- Most fundamental question: “where is the object I’m talking about?”
- Quantify position using a “number line” marked in meters:
  - Choose one position to be the origin (“zero”) – anywhere will do
  - Choose one direction to be positive
  - Measure everything relative to that
  - Can measure in any convenient units: centimeters, meters, kilometers...
- You’re used to this already, perhaps:
  - Mile markers on highways
  - Yard lines in American football

Equations of motion

Complete description of motion: "Where is my object at each point in time?"

This corresponds to a mathematical function. Two ways to represent these. Suppose I drop a ball off a building, putting the origin at the ground and calling "up" the positive direction:

Graphical representation



Algebraic representation

$$y(t) = (40\,\mathrm{m}) - Ct^2$$

(C is some number; we'll learn what it is Thursday)

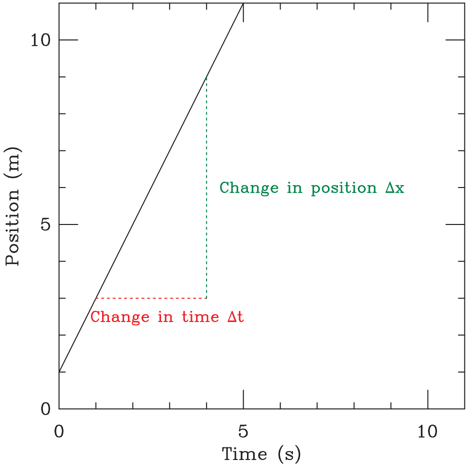
Both let us answer questions like "When does the object hit the ground?"

$\rightarrow$ ... the curve's x-intercept

$\rightarrow$ ... when $y(t) = 0$

Velocity: how fast position changes

The slope of the position vs. time curve has a special significance. Here's one with a constant slope:



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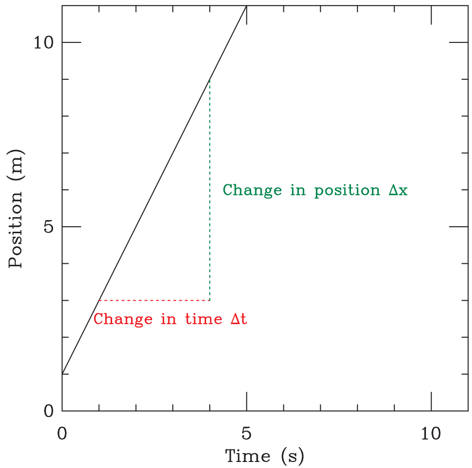

Slope is $\frac{\text{rise}}{\text{run}} = \frac{\Delta x}{\Delta t} = \frac{2\,\text{m}}{1\,\text{s}} = 2$ meters per second (positive; it could well be negative!)

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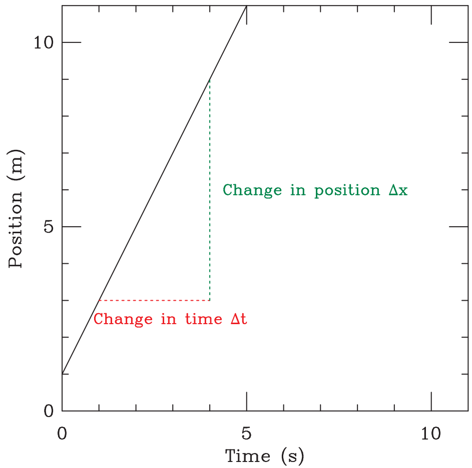

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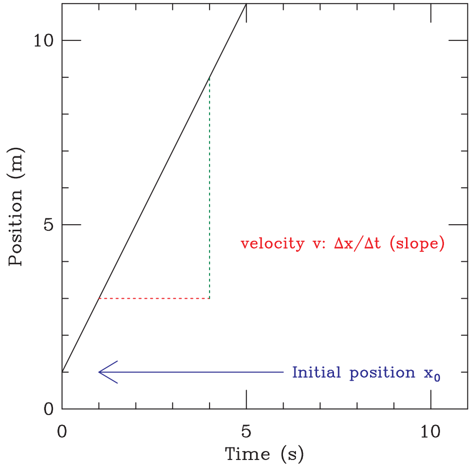
→ The slope here – change in position over change in time – is the **velocity**! Note that it can be positive or negative, depending on which way the object moves.

Constant-velocity motion: connecting graphs to algebra

If an object moves with constant velocity, its position vs. time graph is a line:



We know the equation of a straight line is is $x = mt + b$ (using t and x as our axes).

- m is the slope, which we identified as the velocity
- b is the vertical intercept, which we recognize as the value of x when $t = 0$

We can thus change the variable names to be more descriptive:

$$x(t) = vt + x_0 \text{ (constant-velocity motion)}$$

Going from "equations of motion" to answers

$x(t) = vt + x_0$ is called an *equation of motion*; in this case, it is valid for constant-velocity motion.

It gives you the same information as a position vs. time graph, but in algebraic form.

To solve real problems, we need to be able to translate physical questions into algebraic statements:

- "If a car starts at milepost 30 and drives at 50 mph, where is it an hour later?"

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- "When do two moving objects meet?"

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- "When do two moving objects meet?"
  - Write down $x_1(t)$ and $x_2(t)$, then ask "At what time does $x_1 = x_2$?"

A rough problem-solving guide for constant-velocity motion

A general framework for solving constant-velocity problems algebraically:

1. Decide on a coordinate system: where is $x = 0$, and which way is positive?
2. Write down the equation of motion $x(t) = x_0 + vt$ for each object
3. Ask "How can I translate the thing I'm looking for into an algebraic statement?"
4. Do the algebra!