Physics 131- Fundamentals of Physics for Biologists I

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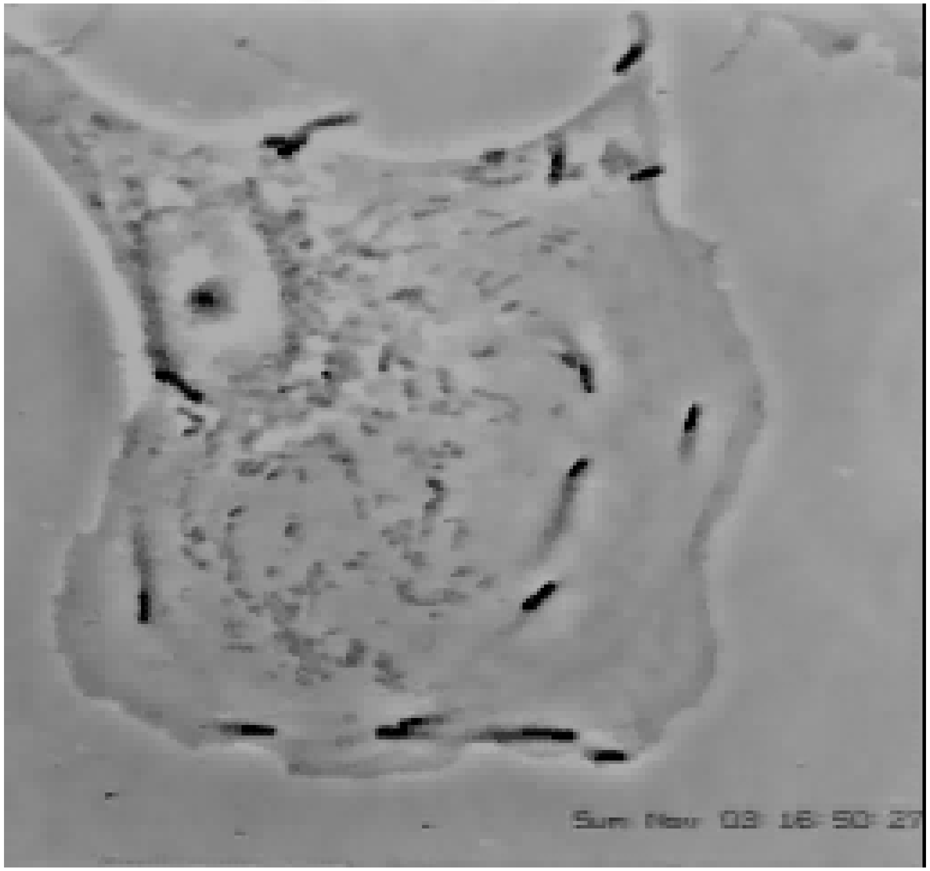


Discuss Quiz!

Topics

- Estimation
- Modeling the world
- Math in science
- Units and dimensions
- Scaling

Foothold ideas: Dimensional and unit analysis

We label the kinds of measurement that go into assigning a number to a quantity like this:

[x] = L	means "x is a length"
[t] = T	means "t is a time"
[m] = M	means "m is a mass"
[v] = L/T	means "you get v by dividing a length by a time

Models allow us to think about how numbers fit together.

A first check on any model: dimensional analysis

Only quantities of the same type may be equated (or added) otherwise an equality for one person would not hold for another. Equating quantities of different dimensions yields nonsense.

A dollar and a penny

- A student makes the following argument:
  "I can prove a dollar equals a penny.
  Since a dime (10 cents) is one-tenth
  of a dollar, I can write:

$$10¢ = 0.1\ \$$$

- Square both sides of the equation.
  Since squares of equals are equal,

$$100\ ¢ = 0.01\ \$.$$

- Since 100 ¢ = 1 \$ and 0.01 \$ = 1 ¢
  it follows that 1\$ = 1 ¢."
- What's wrong with the argument?

Stuck?
Try it with
10 cm = 0.1 m

A student measures distance x to be 5 meters and area A to be 25 ft^2. Discuss with neighbors which of the following are true; then vote

A. $[x^2] = [A]$

B. $[5x] = A$

C. $x^2 = [A]$

D. $x^2 = A$

E. All of the above

F. Some of the above

G. None of the above

Modeling in Physics

- Many of the models we use in intro physics are highly simplified (“**toy models**”) to let us focus on just a few properties.
  - Point masses
  - Rigid bodies
  - Perfect springs
- These models let us first get a clear understanding of the physics. Then, more complex systems can be treated by building around that understanding.

Outline

- **Models in Science and Physics**
- **Chapter 2: Kinematics:** Modeling Motion
  - » Coordinates
  - » Graphs
  - » Vectors

Cat television

- When we do science, we don't try to solve the entire universe at once.
- We restrict our considerations to a limited set of data and try to understand it. Only when we get it do we try to expand further to more situations.
- This is like looking out a window onto a small segment of the world. Since cats like to do this, we could call the process "choosing a channel on cat television."

The Main Question

(for this term, at least)

- Start by choosing a big question and then refining it:

<u>How do things move?</u>

Why choose this?

- **–concepts of measurement, rate of change, and force are basic – set frame for what are appropriate terms to use to think about motion.**
- **–ties to everyday experience so can use and learn to build/refine intuition**

Foothold ideas

- We may choose to use an idea for a while – as a “foothold,” to see how it works, and perhaps reject it later in favor of a replacement or refinement.
- These ideas become the basic principles we will use to reason – the “stakes in the ground” of our safety net.

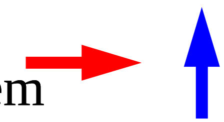
Foothold ideas: Measuring "where"

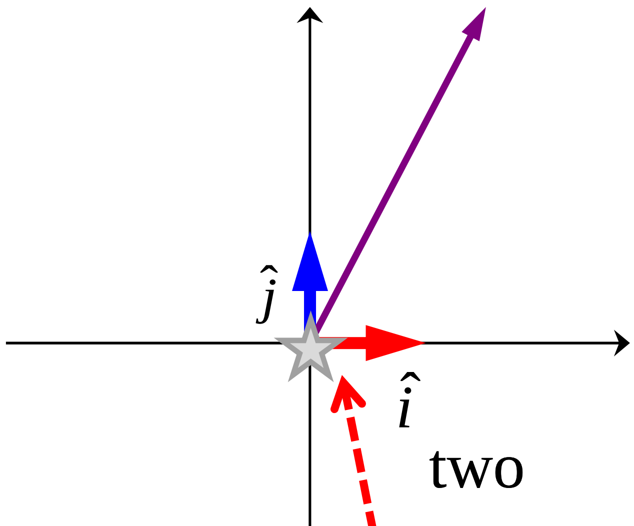
- In order to specify where something is we need a coordinate system. This includes:
  1. Picking an origin
  2. Picking perpendicular directions
  3. Choosing a measurement scale
- Each point in space is specified by three numbers: (x, y, z), and a position vector– an arrow showing the displacement from the origin to that position.
- Vectors add like successive displacements or algebraically by $\vec{A} = A_x\hat{i} + A_y\hat{j}$ $\quad\vec{B} = B_x\hat{i} + B_y\hat{j}$

$$\vec{A} + \vec{B} = \left(A_x + B_x\right)\hat{i} + \left(A_y + B_y\right)\hat{j}$$

Coordinates in space

To specify the position of something we need a coordinate system.

- The coordinate system includes:
  - Picking an ***origin*** 
  - Picking perpendicular directions for the axes of the coordinate system 
  - Choosing a ***measurement scale***



- Each point in space in then specified by two numbers: the x and y coordinates. These can be positive or negative
  (3 numbers in three dimensions)

“unit” arrows set the measurement scale

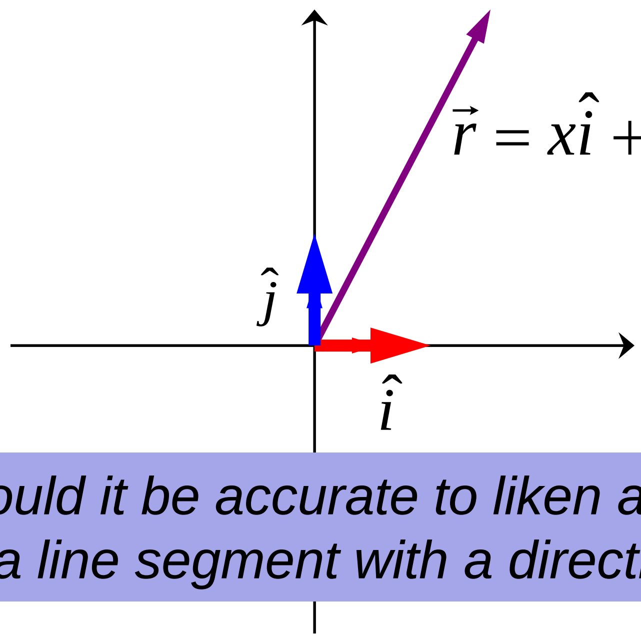
- We can draw a <u>position vector</u>– an arrow drawn showing the displacement from the origin to that position.

Why is there no mention of a third dimension if all physical objects in the world are not 2D but actually 3D?

2-dimensional coordinates

- We specify the direction and unit lengths of the two coordinate axes by writing $\hat{i}$ and $\hat{j}$
- A position a distance x from the origin is written as $x\hat{i}$
- Note that if x is negative, it means a vector pointing in the direction opposite to $\hat{i}$
- Vectors add algebraically:

$$\vec{r} = x\hat{i} + y\hat{j}$$



To move from start to end of vector $\vec{r}$ you need to take x steps in the $\hat{i}$ direction and y steps in the $\hat{j}$ direction

Would it be accurate to liken a vector to a line segment with a direction?

Coordinates/vectors - Reading questions

How exactly does a suppressed zero work and in what senses will it be useful/important?**

Can you give an example when a scientist used a suppressed zero to present misleading information?

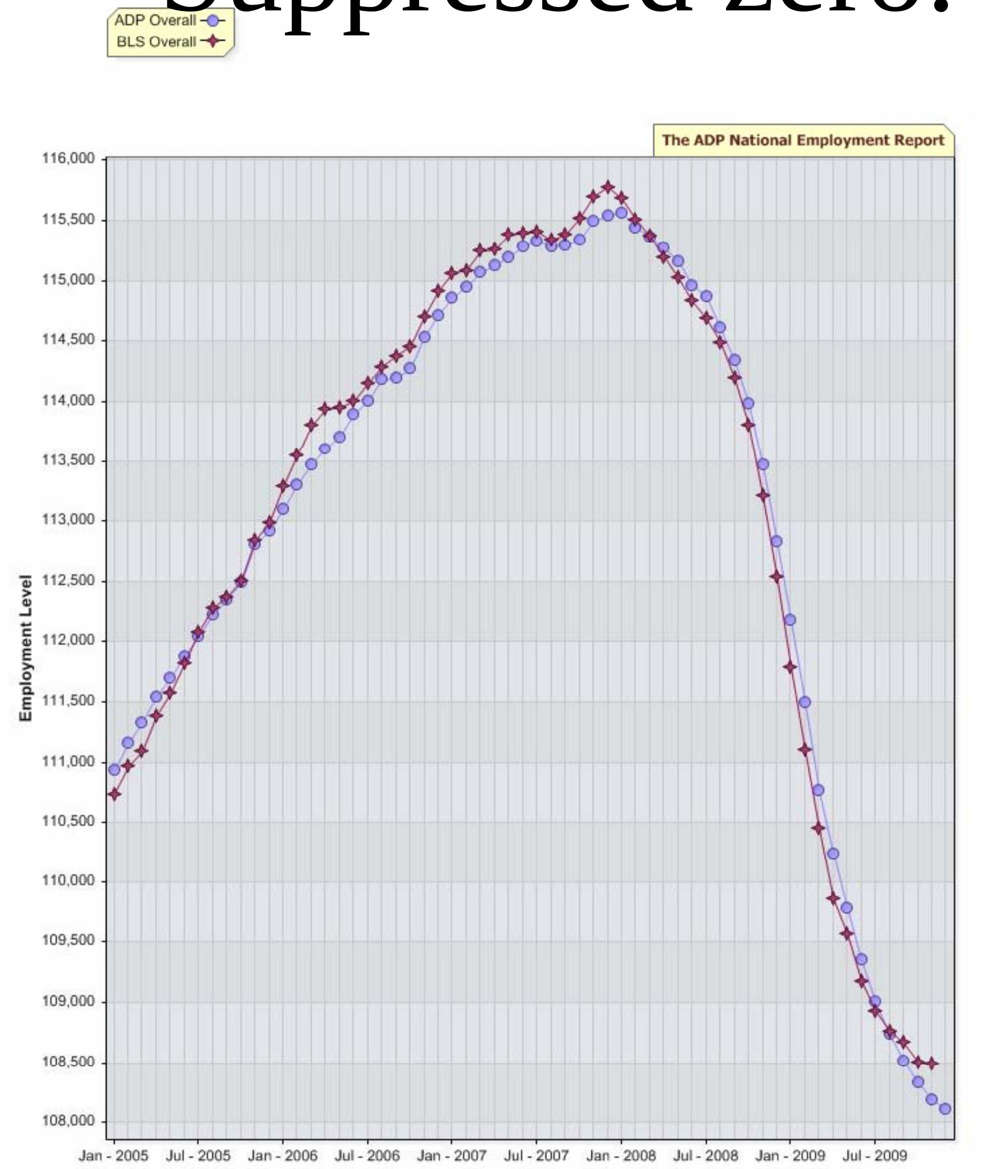
Why is the convention for there to only be the arrowhead at the positive end, and why are we taught to put the arrowhead at both ends in primary school?**

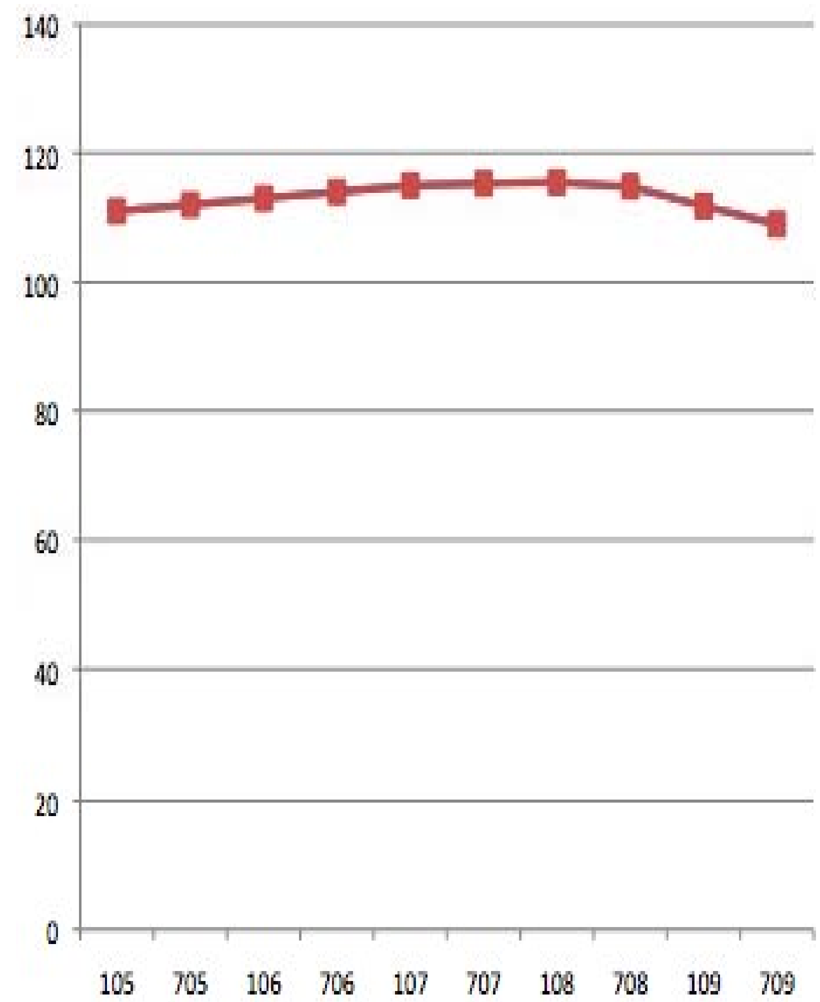
How do you depict the additional axis in a 3D spatial coordinate system?**

Does the horizontal axis always represent the length of distance traveled?**
Does time always go to the horizontal axis? **

Will we ever do curves in 3D as it would be more realistic?

Suppressed zero: good or bad?





Vector - Reading questions/comments

Good Summary: *For our purposes involving physical systems, we will simplify the idea to two spatial coordinates for now. This is the idea behind a typical graph in which a position is given by the 2 coordinates (x,y), where the first coordinate lies along the x-axis, and the second on the y-axis. We can think of these coordinates as the distance from our origin (which must remain fixed in order for the graph to be valid). Furthermore, the position that the aggregate of the coordinates describes can be considered a sort of displacement from the origin.*

Summaries/Qns that are inadequate

I didn't quite understand this page as the others!!!!

Try to figure out whether it is the MATH on this page, the CONCEPTS, or e.g. the WORDING, or something else.

I did not have any questions regarding this page. It is very well written.

Foothold ideas: Measuring "when"

- Time — if we're to describe something moving we need to tell <u>when</u> it is where it is.
- Time is a coordinate just like position
  - We need an origin (when we choose $t = 0$)
  - a direction (usually times later than 0 are +)
  - a scale (seconds, years, millennia)
- Note the difference between
  - clock reading, t
  - a time interval, Δt

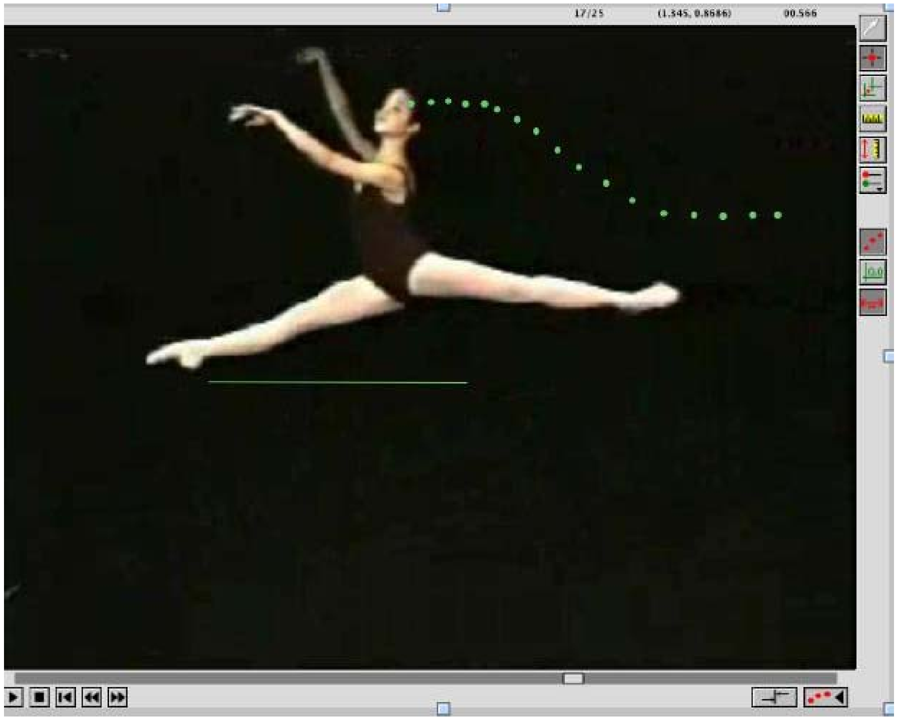
This is like the difference between position and length!

Graphing Position

- Describe where something is in terms of its coordinate at a given time.

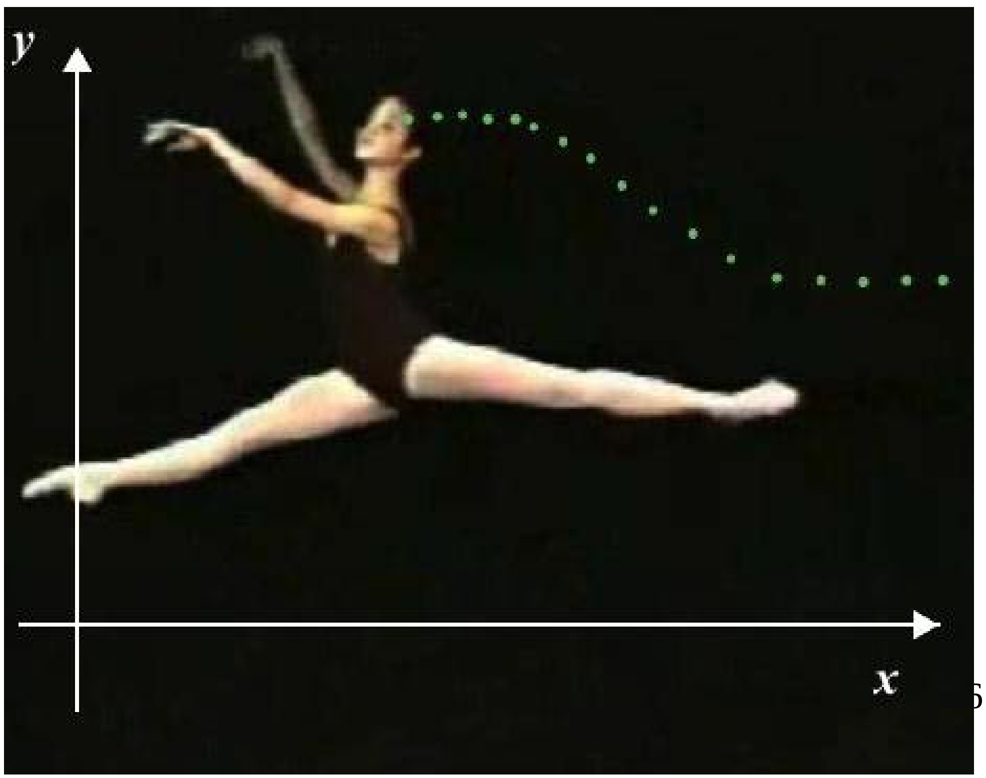
Set up Coordinates

- o Choose origin
- o Choose axes
- o Choose scale
- o Set scales on graph
- o Take data from video
- o Construct different graphs
- o Fit the graphs with math functions



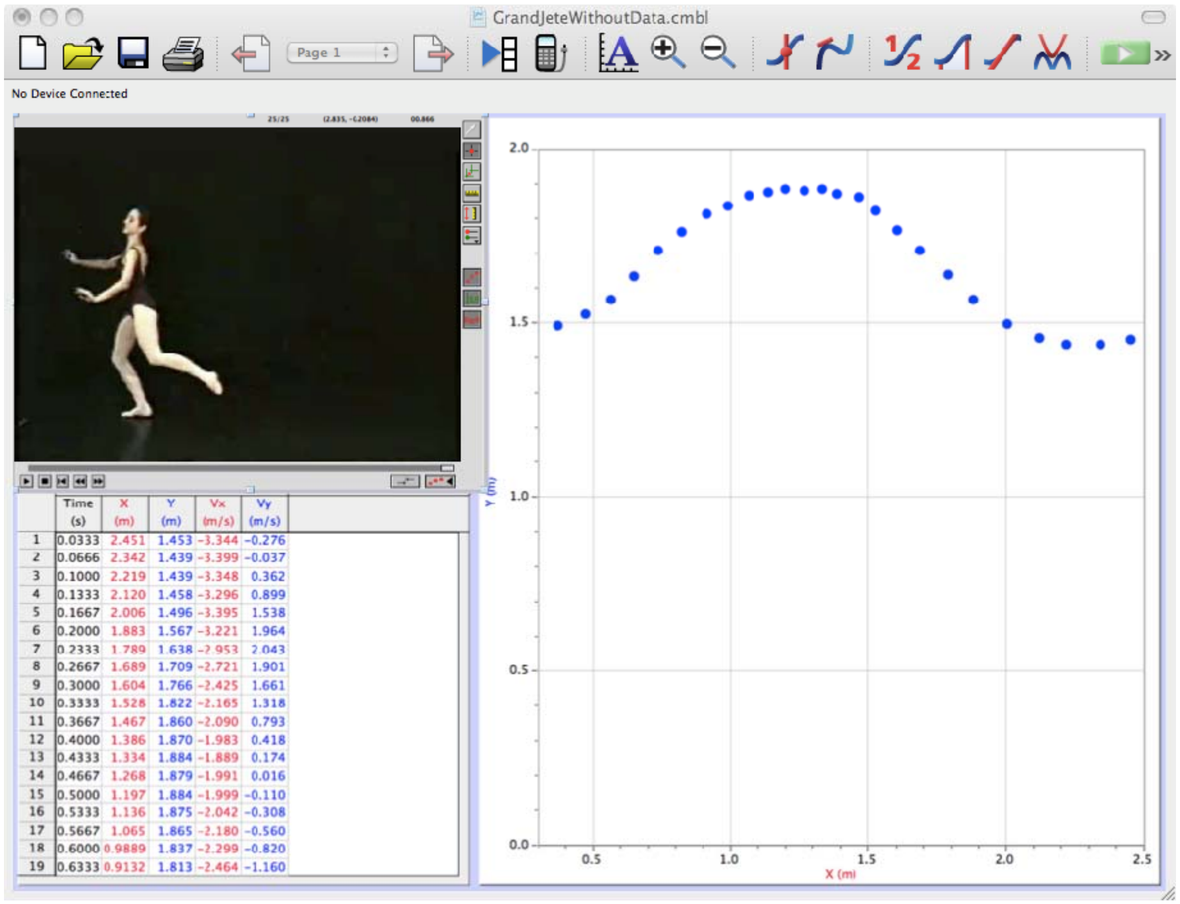
Reading questions

- If in the first graph, we only have information for the x-axis and the y-axis, how do we get the information for time in the second graph where we're only tracking the x values? Or was the information already available, but not represented in the first graph?



Run Logger Pro (No data)

On which side of the *x*-*y* graph is the initial time ($t = 0$)?



	Time (s)	X (m)	Y (m)	Vx (m/s)	Vy (m/s)
1	0.0333	2.451	1.453	-3.344	-0.276
2	0.0666	2.342	1.439	-3.399	-0.037
3	0.1000	2.219	1.439	-3.348	0.362
4	0.1333	2.120	1.458	-3.296	0.899
5	0.1667	2.006	1.496	-3.395	1.538
6	0.2000	1.883	1.567	-3.221	1.964
7	0.2333	1.789	1.638	-2.953	2.043
8	0.2667	1.689	1.709	-2.721	1.901
9	0.3000	1.604	1.766	-2.425	1.661
10	0.3333	1.528	1.822	-2.165	1.318
11	0.3667	1.467	1.860	-2.090	0.793
12	0.4000	1.386	1.870	-1.983	0.418
13	0.4333	1.334	1.884	-1.889	0.174
14	0.4667	1.268	1.879	-1.991	0.016
15	0.5000	1.197	1.884	-1.999	-0.110
16	0.5333	1.136	1.875	-2.042	-0.308
17	0.5667	1.065	1.865	-2.180	-0.560
18	0.6000	0.9889	1.837	-2.299	-0.820
19	0.6333	0.9132	1.813	-2.464	-1.160

1. On the left.
2. On the right.
3. There is not enough information given to decide.
4. I have no clue.

Run Logger Pro (With data)

Sketch what you think *x*-*t* and *y*-*t* plots would look like.