Lecture 2: Motion

From the Syllabus

Projects are assignments where you will demonstrate and synthesize what you have learned over many weeks. Projects may take many different potential forms, including written, visual, or video. Almost every week (except for weeks with ungrading), there will be some milestone to complete in this project, such as setting group expectations (if you work in a group), proposing a project, submitting a rough draft, peer reviewing other classmates' projects, and submitting a final draft. All project milestones are due on Fridays.

The standard format for projects that you can expect if you continue on to 212 is a group assignment (usually 3 students), consisting of a 10-15 minute video solution to a physics problem, with a full calculation, sensemaking, and reflection. You may choose to get used to this format in preparation for continuing on in the sequence, or you can take this opportunity to be more creative in how you approach the project. I vehemently encourage you to find some idea for a project that excites you, be it creating an educational video or report, performing research, melding physics with something artistic, or even something I haven't considered as a possible physics project yet.

Project Information

- Demonstrate and synthesize what you have learned over many weeks.
- Many possible forms, such as written, visual, or video.
- Milestones due Fridays at 8pm (almost) every week:
  - Setting group expectations (Week 2)
    - Once you have your group, you will work with them in lecture and studio.
  - Project proposal (Week 3)
  - Rough draft (Week 5)
  - Peer review (Week 6)
  - Final draft (Week 7)

What to Expect in PH 212

- 10-15 minute video presentation by group (usually 3 students)
- Solution to a physics problem, or presentation on self-taught topic (such as buoyant force or drag force)
- Calculation, sensemaking, and reflection

Your Options

- 212 format (get used to it for 212)
- Some other idea that excites you!
  - Educational video or report
  - Research
  - Melding physics with something artistic
  - Surprise me!
- If it doesn't involve enough calculation, sensemaking, and reflection, I may request modifications.

A Model for Motion

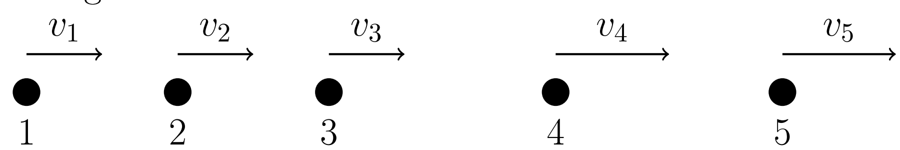
Quantities

- Position: $\vec{r}$
- Velocity: $\vec{v} = \frac{d\vec{r}}{dt}$
- Acceleration: $\vec{a} = \frac{d\vec{v}}{dt}$

Assumptions

- Use the Particle Model

Motion Diagram



Explanations
L2-1: Comparing Motion Diagrams
Principles

- $\vec{v}_{avg} = \frac{\Delta \vec{r}}{\Delta t}$
- For a motion diagram, the time intervals are the same.

Reasoning
Method 1:

Let us look at the beginning and end of the motion. Each object starts and ends at the same spot:

$$\Delta \vec{r}_1 = \Delta \vec{r}_2 = \Delta \vec{r}.$$

Object 2 takes more time to get to the final position:

$$\Delta t_2 > \Delta t_1.$$

Now we have

$$\vec{v}_{avg,1} = \frac{\Delta \vec{r}_1}{\Delta t_1}, \qquad \vec{v}_{avg,2} = \frac{\Delta \vec{r}_2}{\Delta t_2}.$$

Since $\Delta \vec{r}$ is the same for both, a larger number in the denominator gives a smaller overall number. Therefore

$$|\vec{v}_{avg,1}| > |\vec{v}_{avg,2}|.$$

Method 2:

Since the velocity appears to be constant (that is, $\Delta \vec{r}$ between two adjacent spots is the same), we can also look at individual positions.

For object 1, $\Delta \vec{r}$ between times 1 and 2 is greater than for object 2:

$$\Delta \vec{r}_1 > \Delta \vec{r}_2.$$

The time between these two points is the same for both objects:

$$\Delta t_1 = \Delta t_2 = \Delta_t.$$

Now we have

$$\vec{v}_{avg,1} = \frac{\Delta \vec{r}_1}{\Delta t}, \qquad \vec{v}_{avg,2} = \frac{\Delta \vec{r}_2}{\Delta t}.$$

The denominators are the same, so having a larger number in the numerator gives a larger overall number. Therefore

$$|\vec{v}_{avg,1}| > |\vec{v}_{avg,2}|.$$

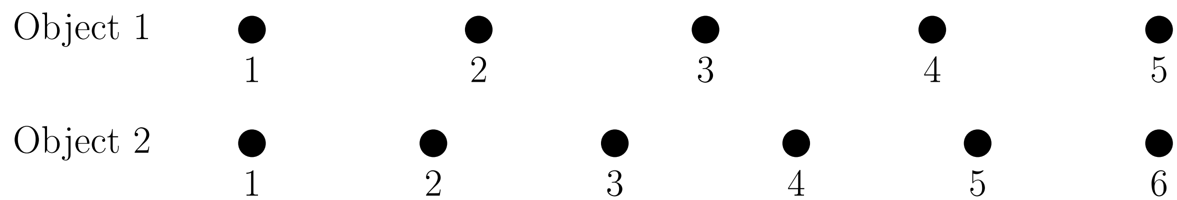
Conclusion

The average speed of object 1 is <u>greater than</u> the average speed of object 2:

$$|\vec{v}_{avg,1}| > |\vec{v}_{avg,2}|.$$

L2-1: Comparing Motion Diagrams

The diagrams below show the motion of two different objects. Is the average velocity of the upper object greater than, less than, or equal to the average velocity of the lower object? Explain your reasoning.



Explanations in Physics

1. **Principles** – what fundamental physics concepts, laws, or definitions did you start with?
2. **Reasoning** – explain all the reasoning steps to go from your starting point to your conclusion.
3. **Conclusion** – state your conclusion clearly.

L2-2 Thrown Ball

The ball goes up, slows down, comes to a brief stop, turns around, and falls back down, increasing in speed.

Analyze and Represent

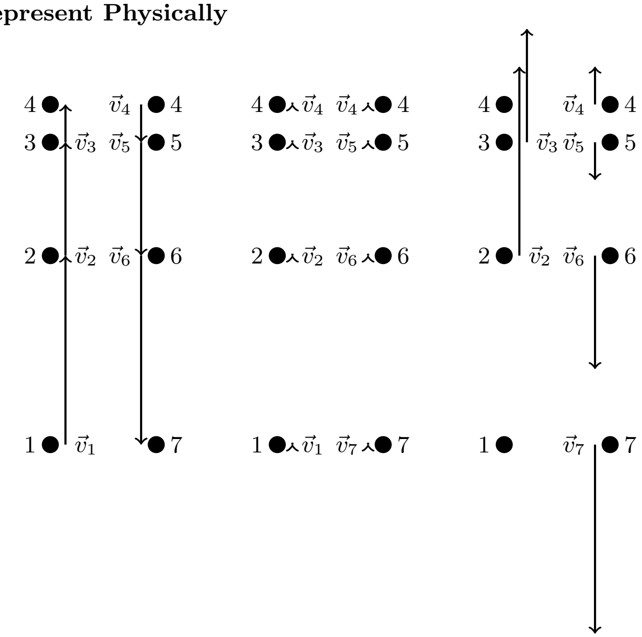
1a: Understand the Problem

- $\vec{r}$: position of the ball
- t: time
- $\vec{v}_i$: initial velocity

1b: Identify Assumptions

- The ball is thrown in a straight line.
  - This simplification allows us to consider motion in only one dimension.
- The ball is released and caught at the same spot.
  - An actual toss and catch isn't going to be perfect, but small, random differences in starting and ending height are a minor detail that we don't need to bother with when looking at this general sort of motion.
- Particle model.
  - This assumption allows us to ignore any ambiguity in the object's position (we don't have to decide to measure from the center, top, or bottom), and to ignore any rotational motion the object may have about its own axis.

1c: Represent Physically



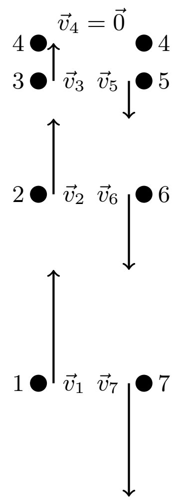
L2-2: Thrown Ball

A ball is thrown straight into the air.

- Describe the motion in words (use complete sentences).
- Identify any quantities of interest with a symbol.
- Draw a motion diagram for the ball.
- Discuss any assumptions or idealizations you want to make.

1. Analyze and Represent

1a. **Understand the problem** – identify quantities by symbol and number.
1b. **Identify Assumptions** – identify important simplifications and assumptions.
1c. **Represent physically** – draw and label one or more appropriate diagrams and/or graphs that might help you solve the problem.


$\vec{v}_4 = \vec{0}$
4
4
3
$\vec{v}_3$
$\vec{v}_5$
5
2
$\vec{v}_2$
$\vec{v}_6$
6
1
$\vec{v}_1$
$\vec{v}_7$
7

Main Ideas

- The motion of an object can be characterized by quantities like position, velocity, and acceleration.
- Velocity is defined as the time rate of change of position.
- Acceleration is defined as the time rate of change of velocity.