Studio 2: Representations of Motion

Choose your own seats today (still at tables 2, 3, 6, 7).

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.

From the Group Expectations Assignment

To complete this in-class assignment, you must come up with an agreement together with your group on how you plan to work on the project together. Fill out the questions provided based on group discussion. *Only one group member needs to fill this out.*

There are many different ways to plan together. It is your job as a group to negotiate how each member will contribute to the project, with regards to participation, communication, meeting together, individual conduct, handling conflict, and completing the project.

As you answer the prompts provided, think back on what has made your past group experiences positive, dreary, rewarding, frustrating, satisfying, stressful, etc. What qualities would you like to ideally have in how your group approaches this group project?

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.

Project Brainstorm

- With your neighbors, come up with as many creative ideas for projects as you can.

  - A proposed problem should relate to motion and things that affect motion.
  - Basic formats include written work and videos. Can you suggest an interesting subcategory of either of those formats, or perhaps a new format entirely?

- I will write as many ideas of yours as I can on this slide, along with the names of the people who came up with them.

Let us choose a standard coordinate system, with $\hat{y}$ pointing toward the top of the page, and $\hat{x}$ pointing to the right. We are allowed to place the origin at t_0, which I will do for simplicity and consistency. A small red set of axes will mark the origin.

My velocity vectors will be in blue, and my acceleration vectors in purple. The arrows only need to be qualitatively accurate for this activity, but the ones I did below are quantitatively accurate up to overall scaling.
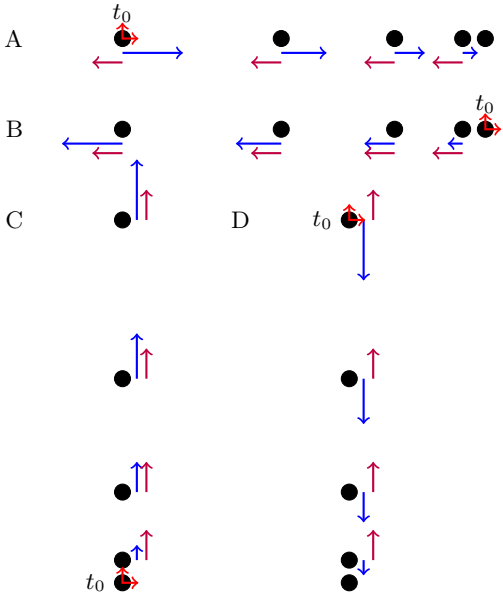
(A) Acceleration is negative, velocity is positive.

  • The object is slowing down.

(B) Acceleration is negative, velocity is negative.

  • The object is speeding up.

(C) Acceleration is positive, velocity is positive.

  • The object is speeding up.

(D) Acceleration is positive, velocity is negative.

  • The object is slowing down.

An object gains speed when $\vec{v}$ and $\vec{a}$ point in the same direction (both positive or both negative in 1-D), and it gets slower when $\vec{v}$ and $\vec{a}$ are in opposite directions. "Negative acceleration" does NOT mean slowing down!
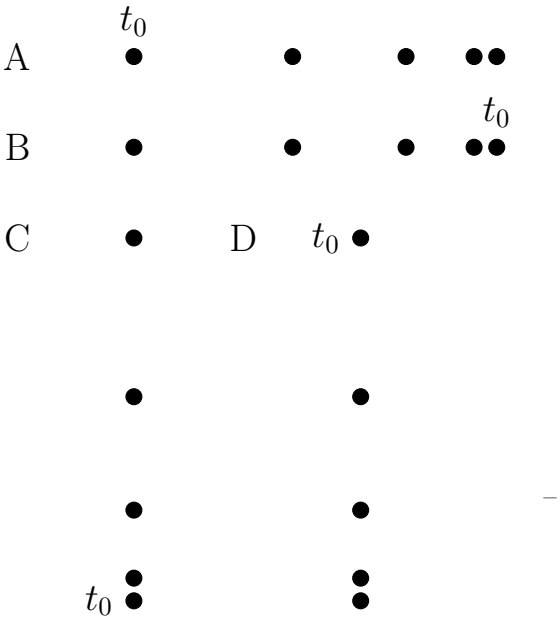
Position

Above, the given origins make position positive (or zero) for all points in A and C, and negative (or zero) for all points in B and D. Position is the only vector of the given three that depends on the origin. Moving the origin doesn't affect how the directions of velocity and acceleration are aligned with the axes.

If, for example, I shifted the origin in D to the right, then the position vectors in D wouldn't have a well-defined sign at all. We can use sign to indicate direction only when a vector is aligned with a coordinate axis.

S2-1: Strobes and Origins

The initial position in each strobe diagram is labeled t_0. For each case:

  • Choose a coordinate system (use the same system for all cases).

  • Sketch velocity vectors for each point.

  • Sketch acceleration vectors for each point.

  • Identify whether each of the following is positive or negative:

    – Position

    – Velocity

    – Acceleration

From the acceleration graph, we can tell things about both the position and velocity graphs.

- The velocity graph is piecewise linear. It will have corners where the acceleration graph has jump discontinuities, but everywhere the acceleration graph is constant, the velocity graph will be linear with a slope corresponding to the value of the acceleration.

- The acceleration is the second derivative of position, so its sign characterizes the concavity of the position graph. Where a_x is positive, the position graph will be concave up, and where a_x is negative, the position graph will be concave down.

The acceleration does not tell us anything about the initial speed or initial position. I will demonstrate two graphs for v_x with two different initial speeds in two different colors. Changing the initial speed shifts the graph vertically, but does not change its shape.

v_x
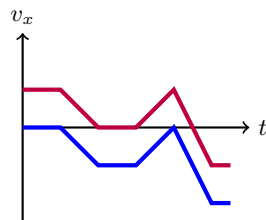
From this graph, we can learn even more about the position graph.

- The position graph is smooth, meaning its slope matches at every point and there are no corners. Since velocity is continuous, the derivative of position is well defined at every point.

- Where velocity is constant, the position graph is linear, and where velocity is linear and not constant, the position graph will be parabolic. When velocity is increasing, the slope of position is getting more positive (which mean getting steeper for positive slope, but flatter for negative slope), and when velocity is decreasing, the slope of position is getting more negative (which mean getting steeper for negative slope, but flatter for positive slope).

We can pick any initial position, but that just shifts the graph, so let's start it off at zero for simplicity. However, the choice of initial velocity affected the sign of the slope everywhere, so it actually has a radical effect on the graph's shape.

v_x
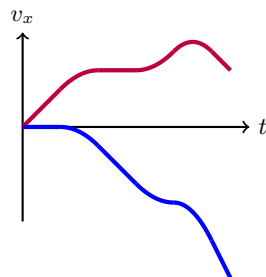
S2-2: Graphing Acceleration, Velocity, Position

Below is a graph of a vs. t for a car. Draw and label graphs of v vs. t and x vs. t for the car.

a_x
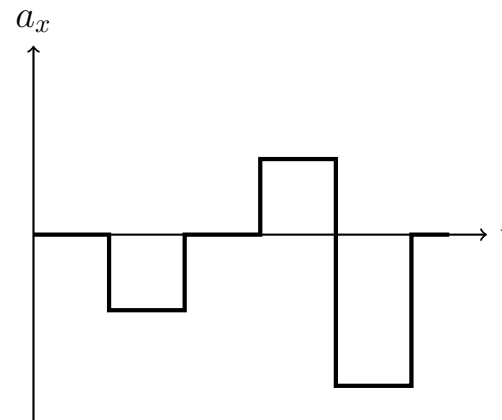
Main Ideas

- Speed increases when velocity and acceleration are in the same direction. Speed decreases when velocity and acceleration are in opposite directions.

- Position depends on the choice of origin.

- Acceleration tells you about the slope of the velocity graph and the concavity of the position graph, but it does not tell you about their initial values.

- Velocity tells you about the slope of the position graph. Changing the initial velocity shifts all of the values of velocity, which changes the overall shape of the position graph.