

CM.L1.4 | 1-D Conservation of Momentum | Challenge Homework

Submit a digital copy (PDF, jpg, etc.) to gradescope.com. Every page should be labeled on the top left with the question code (e.g. GR.L1.4-01). If there are more than one question, they should be in order. If a solution takes more than one page, be sure to label that it is a continuation of the previous page's solution (e.g. GR.L1.4-01 continued). Challenge homework for a given week are due the following week by Tuesday at midnight. If data is needed to complete a problem, be sure to cite the source you've acquired your data from. See the course website for further details.

You will be asked to apply sense-making in most problems. Use the list below as a reference to the different sense-making techniques. More information about sense-making can be found on the BoxSand menu under Math Tools => [Sense-making](#).

- *Sign*: Check the **sign** of each quantity makes sense.
- *Dimensionality*: Check the **dimensionality** and units of each quantity makes sense.
- *Order of Magnitude*: Check the **order of magnitude** of the final answer and other important quantities is within a a factor of 10 of what you think it should be.
- *Graphical Analysis*: Use a **graph** to see if the behavior of a solution makes sense.
- *Proportionality*: Using a symbolic solution, check the behavior of the answer when you change a given quantity on which it is dependent. Does the answer vary **proportionally** to what you expect?
- *Special Cases*: Check the behavior of a derived equation in limiting (**special**) cases makes sense, e.g. as x goes to 90 degrees in $\sin(x)$.
- *Self-consistency*: Check derived equations, functions, or values, are **self-consistent**, e.g. check that the slope of a derived position plot matches the values of the given velocity plot
- *Known Values*: Compare given or derived quantities with common well **known values**.
- *Related Quantities*: Compare the relative magnitude of two **related quantities**.

CM.L1.4-01

You are a world-famous physicist-lawyer defending a client who has been charged with murder. It is alleged that your client, Mr. Lawton, shot the victim, Mr. Cray. The detective who investigated the scene of the crime, Mr. Dinby, found a second bullet, from a shot that missed Mr. Cray, that had embedded itself into a chair. You arise to cross-examine the detective.

You: In what type of chair did you find the bullet?

Dinby: A **wooden** chair.

You: How massive was this chair?

Dinby: It had a mass of 20 kg.

You: How did the chair respond to being struck with a bullet?

Dinby: It slid across the floor.

You: How far?

Dinby: Three centimeters. The slide marks on the dusty floor are quite distinct.

You: What kind of floor was it?

Dinby: A **wood** floor.

You: What was the mass of the bullet you retrieved from the chair?

Dinby: Its mass was 10 g.

You: Have you tested the gun you found in Mr. Lawton's possession?

Dinby: I have.

You: What is the muzzle velocity of bullets fired from that gun?

Dinby: The muzzle velocity is 450 m/s.

With only slight hesitation, you turn confidently to the jury and proclaim, "My client's gun did not fire those shots!"

- (a) How are you going to convince the jury and judge?
- (b) Choose one part of your solution and perform a sense-making analysis. Clearly state which sense-making analysis you've chosen and why.