Chapter C2: Introduction to Momentum

C2.3: Interactions and Motion

Four important assertions:

1.

2.

3.

4.

C2.4: Speed

It's ok to interchange dr and Δt.

A note on notation: $\equiv \neq =$.

- "$\equiv$" means "is defined to be."
- "$=$" means is equal to.

C2.5 & C2.6: Operational Definition of Mass

Algebra and Stuff: For situation in Fig. C2.4 (p. 19):

Initial Momentum of system =

Final Momentum of system =

Use Conservation of Momentum to Solve for m:

C2.7: Momentum and Direction

1. The momentum of an object is given by its mass times its velocity.

2. Any interaction between two objects always acts on them in such a way as to keep the value of their total momentum fixed.

3. **Arrow Model:** For now, think of the arrow model as being equivalent to saying that "momentum adds like arrows." The process of adding arrows is illustrated in Fig. C2.6 on p. 20. In one dimension the main consequence of this arrow picture is that momentum can be positive or negative. In two dimensions, as you'll soon find out) the scenario gets a little more complicated.

Quantitative Skill: Dimensional Analysis

In physics (or any quantitative science) most numbers carry units. For example, the momentum of a cart is not 5, but 5 kg m/s. (See the discussion on *Unit Consistency* on the bottom of p. 23.) For an equation to make sense, the units must be the same on each side. The equation

$$4\text{kg} = 4\text{m} \tag{1}$$

makes no sense. The number 4 equals the number 4, but saying that four kilograms is the same as four meters is clearly wrong. Said another way, we are not free to add any two physical quantities together; it is only meaningful to add (or subtract) quantities that have the same units.

When dealing with algebraic, as opposed to numeric expressions, what matters is the quantity's *dimension*. The term dimension here is used in the following way. If a variable x represents a an area, then we say it dimensions of length squared. Speed has dimensions of length/time.

Examining the dimensions of an algebraic equation give us a useful way to check the results of an algebraic calculation. As an example of this, consider Eq. (C2.3).

Practice: In the following, let x, y, z, r, and R all stand for lengths. Which of the following formula represent a length? Area? Volume? Which are nonsense?

1. $4\pi r^2$.
2. $\frac{4}{3}\pi R^3$
3. xy
4. $x(y+z)$
5. $x(1+y)$
6. $x+y+z$
7. $x(1+\frac{y}{z})$
8. x^x
9. $R^{\frac{x}{y}}$

More practice:

1. Steve Katona weighs 180 lbs. How many kilograms is this?
2. How many meters are in a mile?
3. How many square meters in a square mile?
4. Convert 95 mi/hr to m/s.
5. How many cubic inches are in one cubic meter?

even more practice:

A cart with a mass of 1.5 kg moving with an initial speed $v_0 = 3$ m/s hits a cart of mass 3 kg at rest. The carts stick together. What is the velocity of the two carts after the collision?