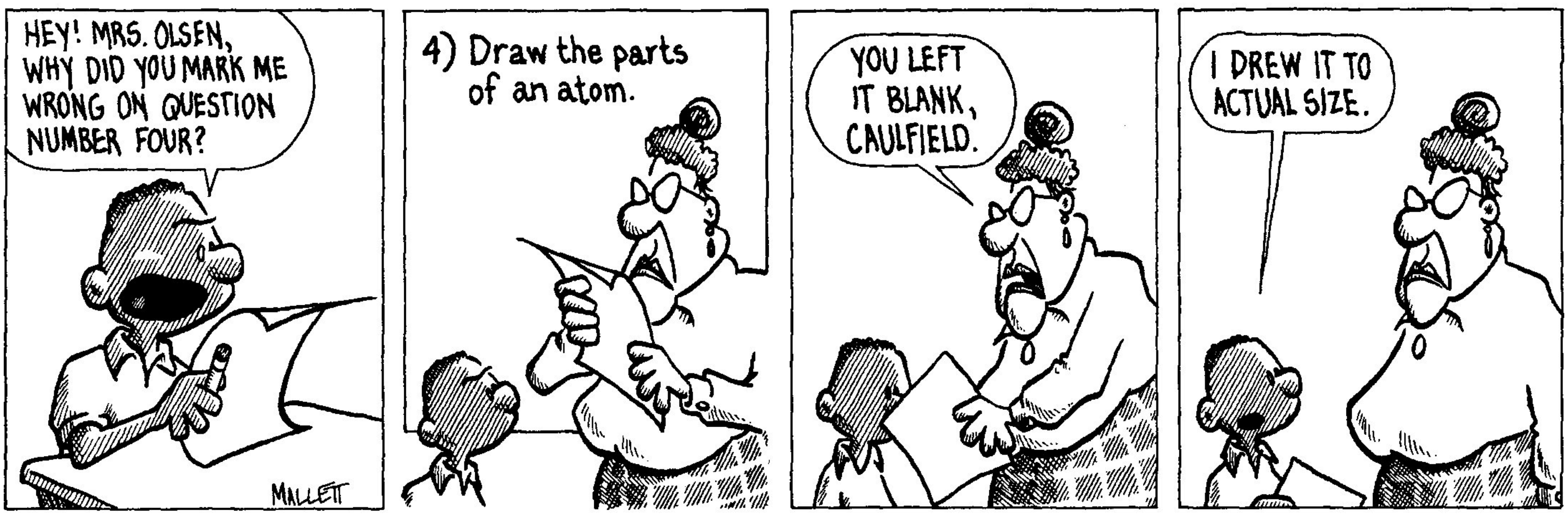
- **<u>Theme Music:</u> Mason Williams**

  Classical Gas

- **<u>Cartoon:</u> Jef Mallet**

  Frazz



Reading quetions

- In chaos theory, in an ideal situation where we could theoretically have the exact same initial conditions, would the object behave in the same way, or would they diverge in the same way that is observed when the initial conditions are at least slightly different?
- How can we say that most of the concept of Newton's law apply to microscopic elements when they're always in some sort of random motion unlike macro elements? Shouldn't there be some other principles guiding these micro elements?
- I'm having a hard time understanding why the Newtonian framework work is accurate at all if it does not account for the internal behaviors of objects.

Do Newton’s laws apply to our model of the microscopic motion of molecules?

1. Yes
2. No

What do you mean by “apply”?

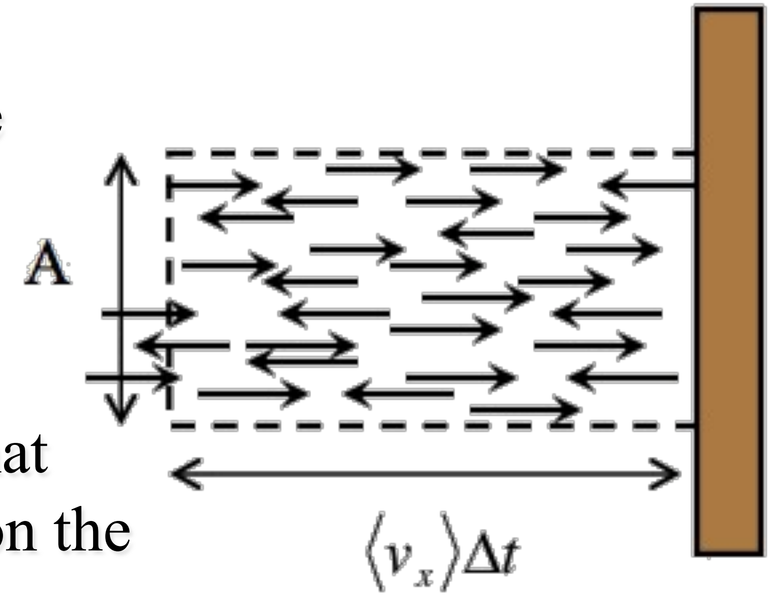
1. Are correct for describing the motions.
2. Are useful for describing the motions.
3. Something else.

Foothold ideas: Kinetic Theory I

- We model the gas as lots of tiny little hard spheres far apart (compared to their size) and moving very fast.
- The motions are in all directions and change directions very rapidly. A model saying that on the average the total momentum is 0 (and stays 0 by momentum conservation) is a good one.
- Because there are some many particles and the collisions so sensitive to initial conditions, we can't predict the motion of individual particles for long.
- Dilute gases satisfy the Ideal Gas Law, $pV = n_{moles}RT$

Summarizing the model

- In between collisions each molecule moves in a straight line – ignoring gravity. (We've used N1!)
- Ignore up and down motions.
- Momentum change of a molecule that bounces off the wall exerts a force on the wall.
- The force on the wall will be the change in momentum of all the molecules that bounce off the wall in a time Δt divided by Δt.
- Calculate this using density.



$$F = \left(\frac{2mv_x}{\Delta t}\right)\left(\tfrac{1}{2} nAv_x \Delta t\right) = nmv_x^2 A$$

$$p = \frac{F}{A} = nmv_x^2 = \frac{N}{V} mv_x^2 = \frac{N}{V} \tfrac{1}{3} m \left\langle v^2 \right\rangle$$

$$F = \frac{dp}{dt}$$

Reading questions

- Why can we ignore the motion of molecules in the y and z motion and not the x motion? Why can't we just look at the y motion and ignore x and z?
- I don't understand why we can just ignore the y and z directions of gas molecules, but only consider the x direction. I understand that it may be for simplicity, but will we always be ignoring those two directions?

Foothold ideas: Kinetic Theory II

- Newton's laws tell us that motion continues forever unless something unbalanced tries to stop it, yet we observe motion always dies away.
- Our model of matter as lots of little particles in continual motion lets us "hide" the energy of motion that has "died away" at the macro level in the internal incoherent motion.
- The model unifies the idea of heat and temperature with our ideas of motion of macroscopic objects.

Interpreting

- The "physicist's form" of the ideal gas law lets us interpret where the *p* comes from and what *T* means.
- *p* arises from molecules hitting the wall and transferring momentum to it;
- *T* corresponds to the KE of <u>one</u> molecule (up to a constant factor).

$$p = Nmv_x^2 \qquad\qquad k_B T = \frac{2}{3}\left(\frac{1}{2}mv^2\right)$$

The Ideal Gas Law

Chemist's form

$$pV = n_{moles} RT$$

$$n_{moles} = \frac{N}{N_A}$$

$$R = k_B N_A$$

Physicist's form

$$pV = N k_B T$$

$$p = nmv_x^2$$

$$\tfrac{3}{2} k_B T = \tfrac{1}{2} m v^2$$