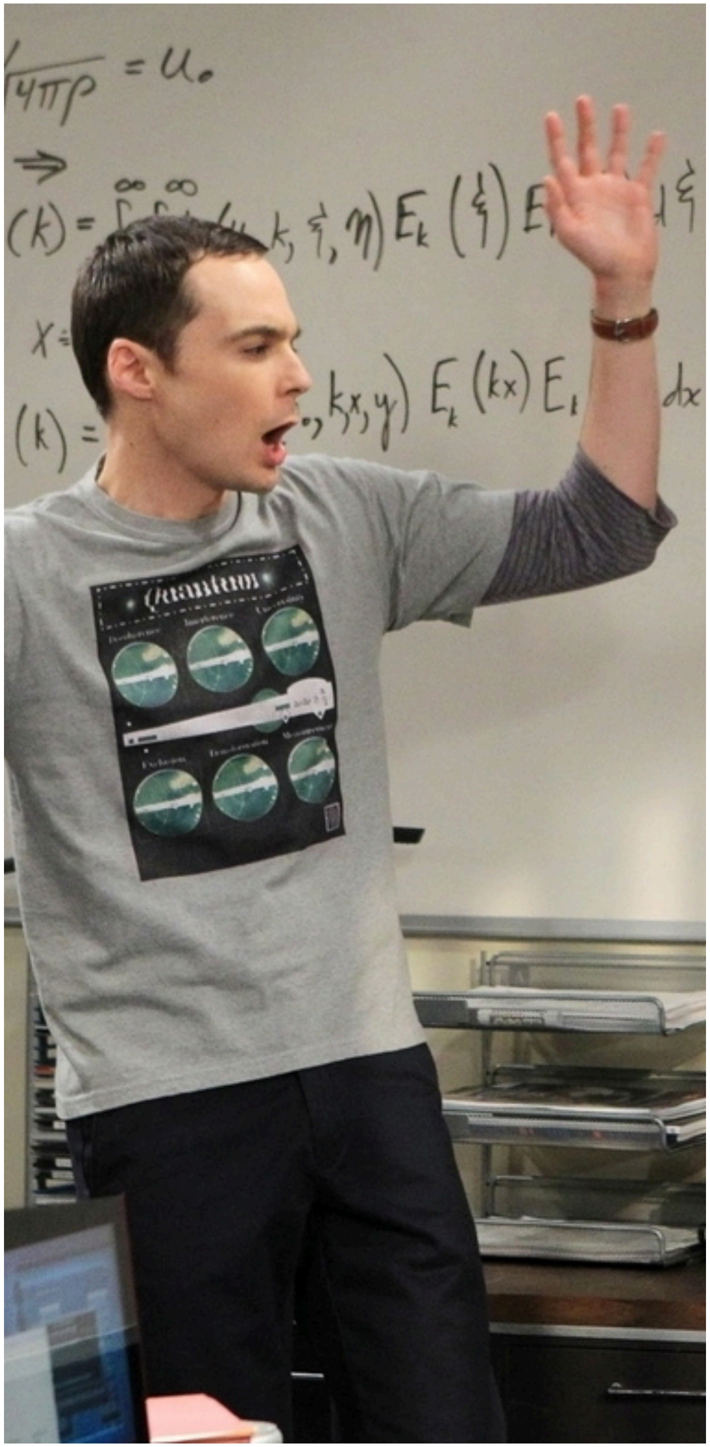
- **Theme Music: Queen**

  Under Pressure

- **Cartoon: Bill Watterson**

  Calvin & Hobbes



The Equation of the Day

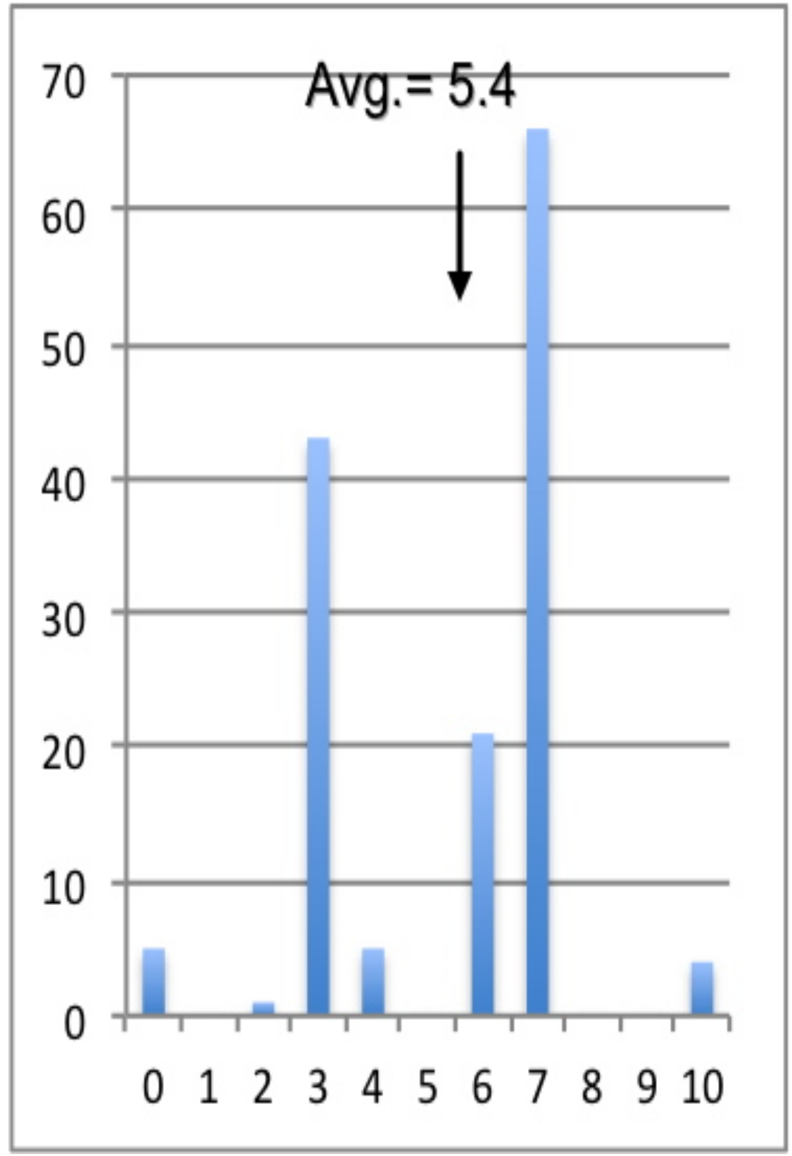
Ideal Gas Law

$$pV = nRT$$

$$pV = Nk_BT$$

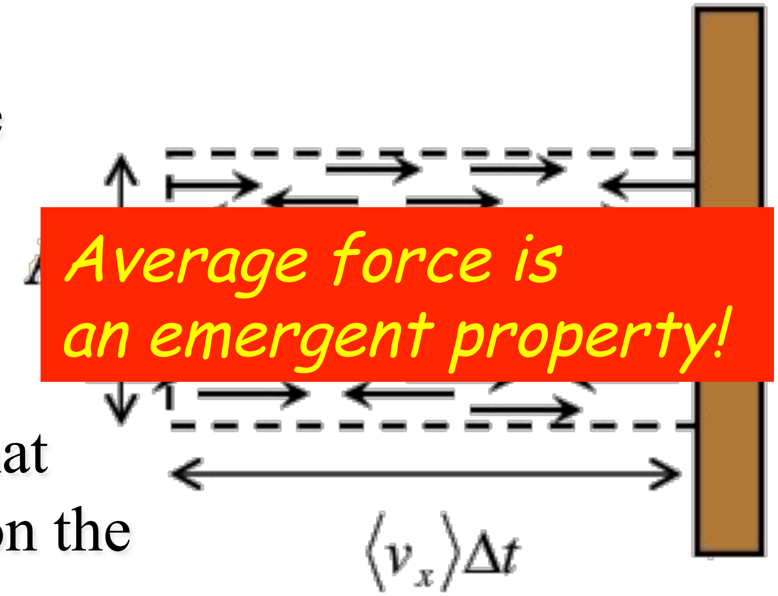
Quiz 7

	1	2	3
a	4%	3%	0%
b	**52%**	**76%**	6%
c	1%	3%	**91%**
d	19%	**6%**	3%
e	8%	0%	
ab	10%	0%	
bc	1%	11%	



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. $F = \frac{dp}{dt}$
- Calculate this using density.



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

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

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

$$pV = Nk_BT$$

$$p = nmv_x^2$$

$$\frac{3}{2}k_BT = \frac{1}{2}mv^2$$

Foothold ideas: Pressure 1

- In a gas the molecules are moving very fast in all directions. On the average the momentum cancels out.
- If you put in a wall keeping the gas on only one side, only the momentum in one direction acts on the wall (N1, N2, N3), creating a force.
- In a non-flowing gas, the force/area is a constant, the pressure. It is proportional to the number of molecules and their mv^2.

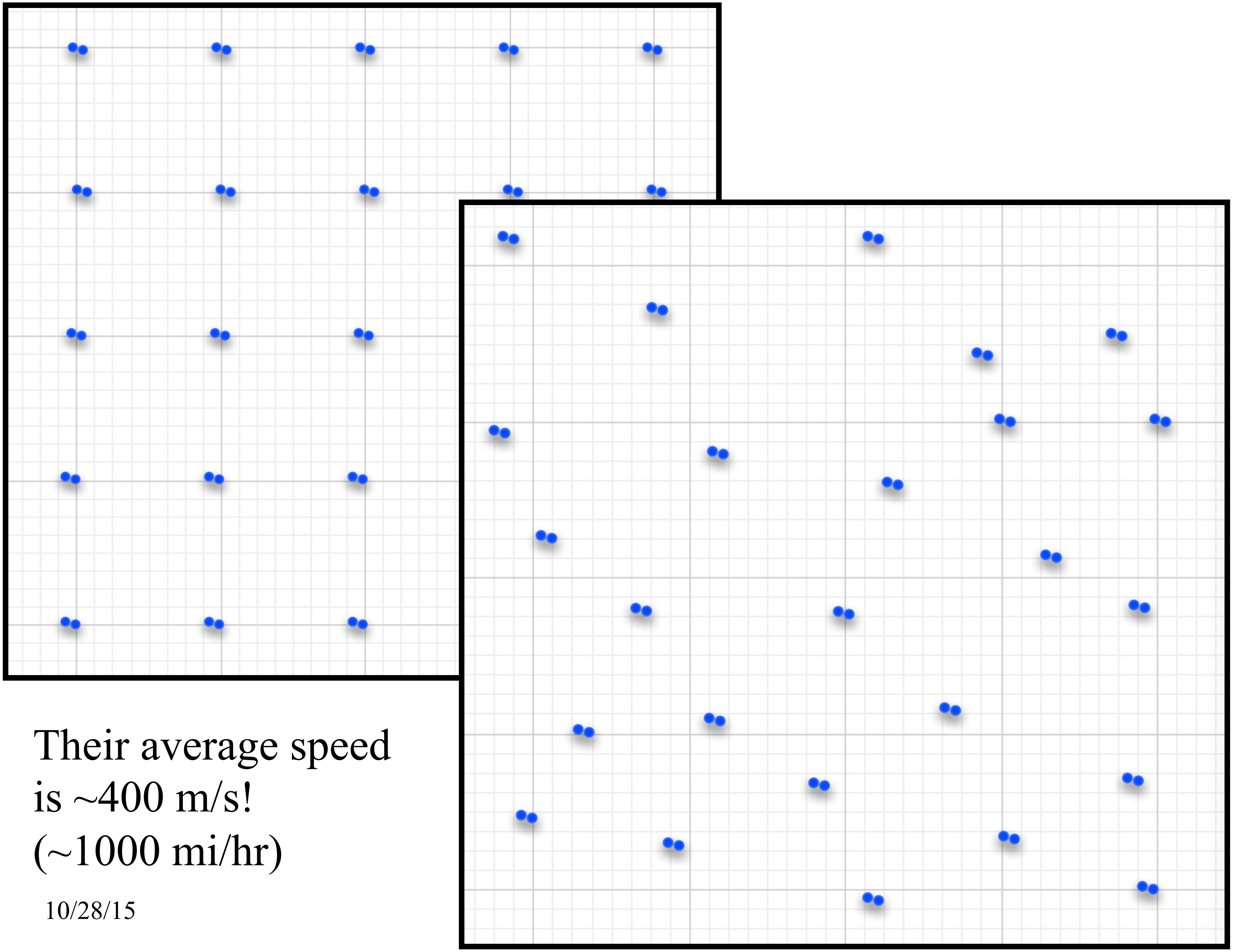
Foothold ideas: Gases – Kinetic Theory II

- 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 a wall and transferring momentum to it;
- *T* corresponds to the energy of motion of <u>one</u> molecule (up to a constant factor).

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



Their average speed
is ~400 m/s!
(~1000 mi/hr)

10/28/15