PHYS 1020 Final Exam

Monday, December 17, 6 - 9 pm

The whole course, **including ch. 14, sections 1 and 2**
30 multiple choice questions
Formula sheet provided

Seating for Final Exam

A - SIM: Brown Gym

SIN - Z: Gold Gym

Welcome to Physics 1020!

Instructors	Required Materials	Schedule	Policies/Evaluation	Suggested Problems	Formula Sheet
Answers to Even-Numbered Problems			Answers for tutorial test problems		
Answers for midterm test			Answers for final exam		
Marks files					

→ Mastering Physics Assignment #5 ←
Due Monday, December 3 at 11 pm

Information on "Mastering Physics"

→ Mastering Physics Survey ←

Wednesday
Review - send questions!

Ideal Gas Law

The behaviour of an ideal gas is described by the ideal gas law:

$$PV = nRT$$

n = number of moles of gas
R = universal gas constant = 8.314 J/(mol.K)
T in Kelvin

In terms of the number, N, of atoms or molecules of the gas:

$$PV = NkT$$

k = Boltzmann's constant = 1.38×10^{-23} J/K
$N = nN_A$, and $nRT = NkT$, so

$$k = \frac{R}{N_A}$$

Clickers!

Question: why do bubbles in a glass of beer grow larger as they move upward?

a) Temperature varies with height.
b) Pressure decreases with height.
c) The number of moles of gas in the bubbles increases with height.

$$V = \frac{nRT}{P}$$

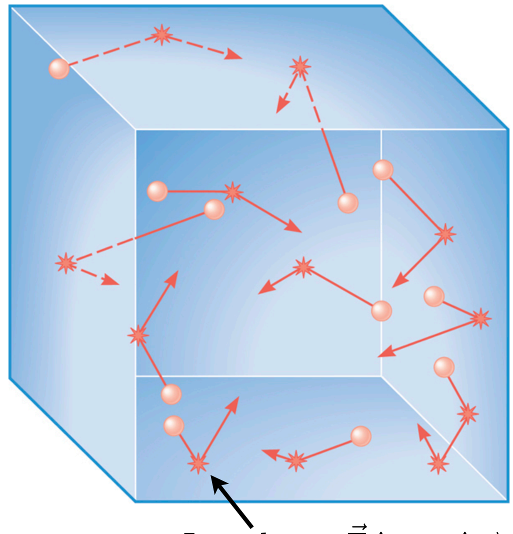
Physics can be fun...
See the UofM news story:
"Putting the fizz in physics"

http://myuminfo.umanitoba.ca/index.asp?sec=2&too=100&eve=1000&id=13340

Kinetic Theory of Gases

Ideal gas - particles (atoms or molecules) move freely and randomly in a container, impart an impulse to the walls of the container off which they bounce elastically.

The sum of the impulses of the particles bouncing off the walls generates the pressure force, which is proportional to the area of the walls.

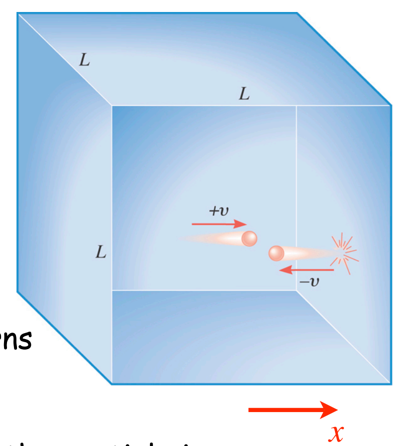


$$\text{Impulse} = \vec{F}\Delta t = \Delta \vec{p}$$

$$\text{Pressure} = \frac{\text{Total impulse per second}}{\text{Area of wall}}$$

Kinetic Theory of Gases

A particle: mass m, speed v in the x-direction, bounces off a wall. The particle recoils from the wall at speed –v.



Change in momentum of the particle is $\Delta p = mv_f - mv_i = -2mv$.

A time $\Delta t = 2L/v$ later, the particle returns and bounces off the wall again.

The average force exerted on the wall by the particle is:

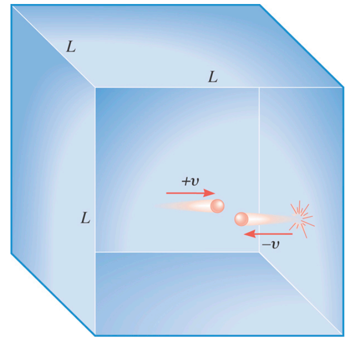
$$F = -\frac{\Delta p}{\Delta t} = \frac{2mv}{2L/v} = \frac{mv^2}{L}$$

The particles have a distribution of speeds. The average force is:

$$F = \frac{m\overline{v^2}}{L} \qquad \overline{v^2} = \text{mean square speed}$$

Kinetic Theory of Gases

$$F = \frac{m\overline{v^2}}{L} \qquad \overline{v^2} = \text{mean square speed}$$



If there are N particles in the box travelling in random directions, N/3 will be travelling in the x-direction.

So, the total force exerted on the wall is:

$$F = \left[\frac{N}{3}\right]\left[\frac{m\overline{v^2}}{L}\right] = \left[\frac{N}{3}\right]\left[\frac{mv_{rms}^2}{L}\right]$$

$$v_{rms} = \sqrt{\overline{v^2}} = \text{root mean square speed}$$

The pressure exerted on the wall is: $P = \frac{F}{A} = \left[\frac{N}{3}\right]\left[\frac{mv_{rms}^2}{L^3}\right]$

$$PV = \frac{N}{3}mv_{rms}^2 = \frac{2N}{3}\left(\frac{1}{2}mv_{rms}^2\right)$$

$A = L^2$ $L^3 = V$

Kinetic Theory of Gases

$$PV = \frac{N}{3}mv_{rms}^2 = \frac{2N}{3}\left(\frac{1}{2}mv_{rms}^2\right)$$ ← Looks like Boyle's law: PV = constant

$$PV = \frac{2N}{3}\overline{\text{KE}} \quad \text{as} \quad \frac{1}{2}mv_{rms}^2 = \overline{\text{KE}}$$ ← Average kinetic energy of the particles

Back to the ideal gas law:

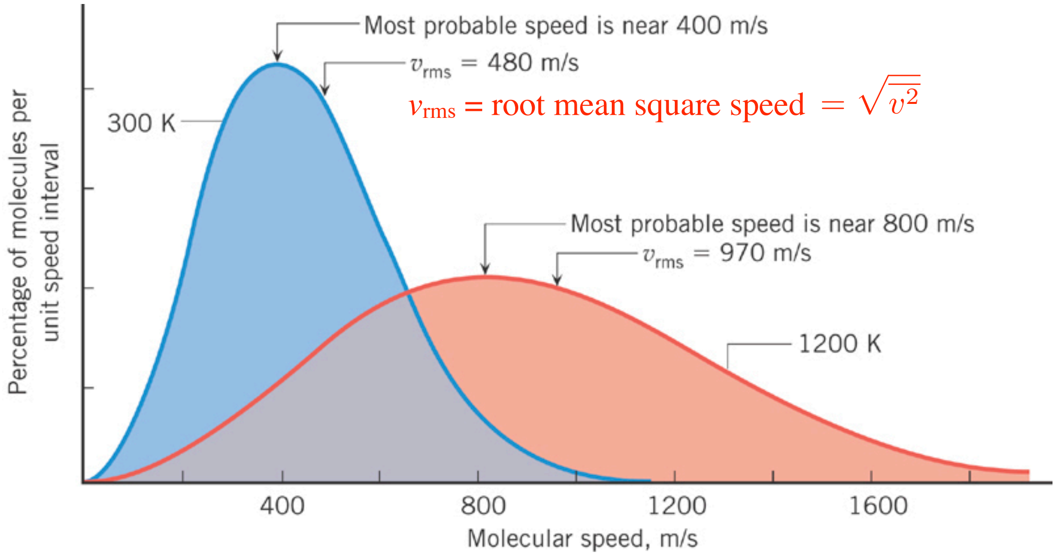
$$PV = NkT \qquad\qquad PV = \frac{2N}{3}\overline{\text{KE}}$$

Comparing: $\frac{2N}{3}\overline{\text{KE}} = NkT$

Therefore: $\overline{\text{KE}} = \frac{3}{2}kT$

$$\overline{\text{KE}} = \frac{1}{2}mv_{rms}^2 = \frac{3}{2}kT$$

Kinetic Theory of Gases

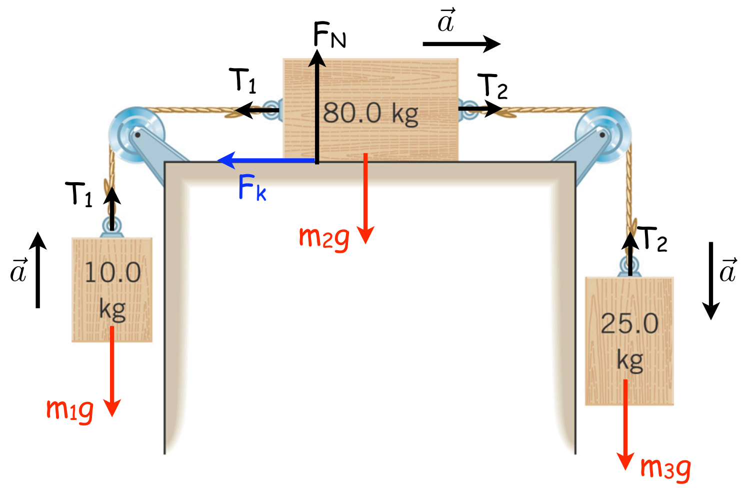


The plots above are for O_2 at 300 K and 1200 K.

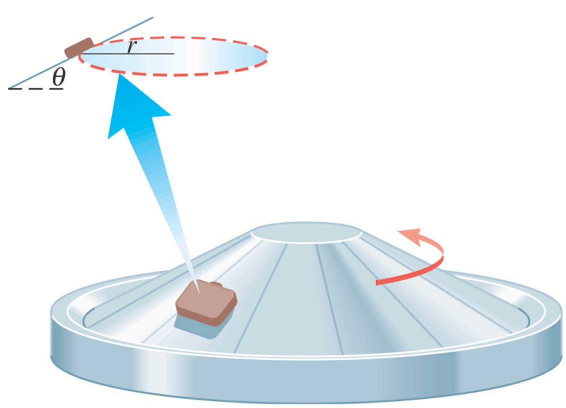
14.57/25: A spherical balloon is made from a material whose mass is 3 kg. The thickness of the material is negligible compared to the 1.5 m radius of the balloon. The balloon is filled with helium at a temperature of 305 K and just floats in the air, neither rising nor falling. The density of the air is 1.19 kg/m^3. Find the absolute pressure of the helium gas.

4.109: The coefficient of kinetic friction between the block and the table is 0.1.

a) What is the acceleration of the three blocks?
b) Find the tension in the two strings.

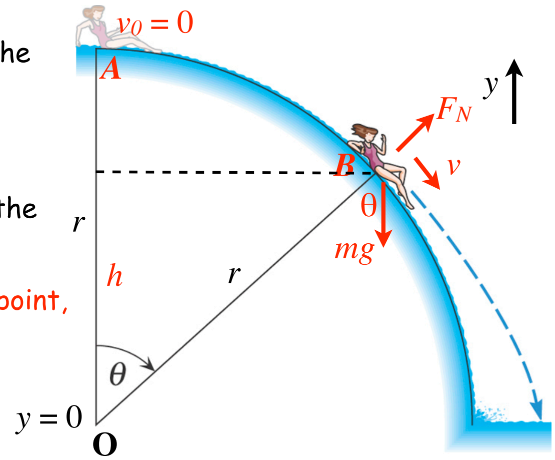


5.26: Your suitcase is moving at constant speed on a circular baggage carousel of radius 11 m and is not quite sliding down the slope of the carousel, which makes an angle of 36^0 to the horizontal. The coefficient of static friction between your suitcase and the carousel is 0.76. How long does it take your suitcase to go once around the carousel?



6.44/78: A person starts from rest at the top of a large frictionless spherical surface and slides into the water below.

At what angle θ does the person leave the surface?
(the normal force must be zero at that point, at B).



Conservation of mechanical energy: $KE_A + PE_A = KE_B + PE_B$

$$0 + mgr = KE_B + mgr\cos\theta \quad (= mgh)$$

$$\text{So,} \quad KE_B = mgr(1 - \cos\theta) = mv^2/2 \qquad \times 2/r$$

Net force toward O: $F_{net} = mg\cos\theta - F_N = mv^2/r$ (centripetal force)

If $F_N = 0$: $mv^2/r = mg\cos\theta = 2mg(1 - \cos\theta)$

So, $3\cos\theta = 2 \rightarrow \theta = 48°$