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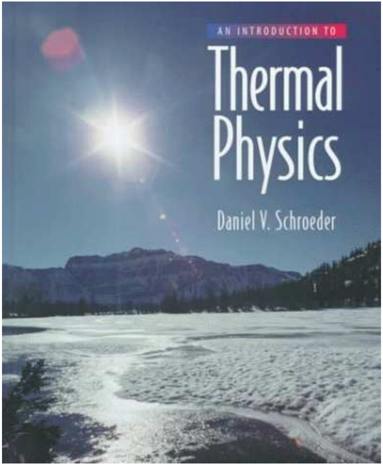
Our textbook



An Introduction to Thermal Physics

by Daniel V. Schroeder

Addison Wesley Longman
San Francisco, 2000
ISBN: 0-201-38027-7

Grading

See the course information sheet for more information.

One-hour exams	15% each
Homework	35% (incl. 7 points for explanations)
Exercises	10% (tentative)
Final exam	25%

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- I hope to do some in-class exercises. If their number ends up being significant (depends on how successful they are), 10 percentage points will be devoted to them. Otherwise, those points will be added to the homework weight.

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- All mixed up! Lose logical purity and distinction between them, but it's easier to learn how to calculate.

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  - Entropy is central but mysterious (there are no entropy meters)

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  - Entropy is central and clearly defined
  - Provides derivations of axioms of thermodynamics
  - Some calculations are intractable; thermodynamics may be easier

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- Even an "isolated" system may have external influences, such as being in a gravitational field.

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- Q: What about a bologna sandwich in a sealed, insulated box?
- Thermodynamics deals with equilibrium states. "Operationally a system is in an equilibrium state if its properties are consistently described by thermodynamic theory!"—Callen

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  - Diffusive contact: particles exchanged. Equal chemical potentials in equilibrium.

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This makes it possible to define temperature empirically: the third system is the “thermometer”. If, when placed in thermal contact with each of the other two systems and allowed to come to thermal equilibrium, it gives the same temperature, then the other systems are in thermal equilibrium with each other. Also the converse.

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See the text for some details on thermometry.

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Satisfies the familiar ideal gas law: $PV = nRT = NkT$. But what is P?

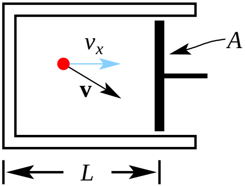
Homework

HW Problem
Schroeder problem 1.16, pp. 8–9.

HW Problem
Schroeder problem 1.17, p. 9.

A kinetic model for P

Consider a single particle in a container with a piston at one end:



We want the average pressure exerted by the molecule on the piston in a single round trip of the container. Pressure is force/area.

The average x component of the force exerted during the round-trip time Δt is:

$$\bar{F}_{x,\text{ on piston}} = -\bar{F}_{x,\text{ on particle}} = -m\left(\frac{\overline{\Delta v_x}}{\Delta t}\right)$$

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The round-trip time is just

$$\Delta t = 2L/v_x \, ,$$

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where $V = LA$.

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For many particles, we just add their contributions, obtaining

$$\bar{P}V = Nm\overline{v_x^2}\,.$$

Hmmm..., it looks like PV is related to kinetic energy.

Temperature and energy in the ideal gas

Now, if we knew the distribution of particle velocities as a function of T, we could calculate the average of v_x^2, obtaining the ideal gas law. But we can do something more devious: assume the ideal gas law as a known fact in order to relate the temperature to the kinetic energy:

$$PV = Nm\overline{v_x^2} = NkT \;\Rightarrow\; kT = m\overline{v_x^2}\,.$$

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The averages of v_x^2, v_y^2, and v_z^2 are all the same, and their sum is just the average of $\overline{v^2} = 3\overline{v_x^2}$, so

$$kT = \frac{1}{3}m\overline{v^2} \quad \text{or} \quad \frac{1}{2}m\overline{v^2} = \frac{3}{2}kT\,.$$

That is, the mean kinetic energy of this ideal gas is proportional to the temperature.

Homework

HW Problem

Schroeder problem 1.22, p. 14.