Thermal Physics Project Suggestions

(Be sure to read the explanations and notes on the reverse side.)

Topic	Problem number	Level	Notes
The virial expansion	1.17	15	C
Effusion	1.22	10	
The speed of sound	1.39	10	
Convection in earth's atmosphere	1.40	10	
Isothermal compressibilities	1.46	10	
Negative heat capacities of stars	1.55, 3.4, 3.15	15	
Black hole thermodynamics	2.42, 3.7, 7.53	15	
Thermodynamics of rubber	3.34	15	
Optimizing a Carnot engine for power	4.6	10	
Stirling engine	4.21	10	
Toward absolute zero	4.35, 4.36, 4.37	10	
Thermodynamics of muscle contraction	5.6, 5.7	10	
Partial derivative trickery	3.33, 5.12, 5.14	15	1
Thermodynamics of magnetic systems	5.17, 5.47	15–20	2
Grand free energy	5.23, 7.7	15	
Aluminosilicate phases	5.29, 5.39	15	
Ice engine paradox	5.33	10	
Relative humidity and cloud formation	5.42, 5.43, 5.44	15	3
Nucleation of cloud droplets	5.46	15	
Energy fluctuations at fixed temperature	6.17, 6.18, 6.19	10	
Anharmonic oscillators	6.21	10	C
Paramagnetism for higher spins	6.22	15	
Parahydrogen and orthohydrogen	6.30	15	C
A model of thermal expansion	6.32	15	
The Kac model	(not in book)	15	4
Cooperative adsorption in hemoglobin	7.2	10	
Semiconductor impurities	7.5	10	
An elementary model of fermions	7.16, 7.27	10–20	C
White dwarf stars	7.23	10–15	
Numerical treatment of a Fermi gas	7.32	15–20	C
Statistics of pure semiconductors	7.33, 7.34	15–20	
Paramagnetism in a Fermi gas	7.36	10–20	
Spontaneous and stimulated emission	7.41	10	
Formation of H atoms in the early universe	7.47	20	C
The cosmic neutrino background	7.48	10	
Electron-positron pairs in the early universe	7.49, 7.50	15–20	C,5
The greenhouse effect on Venus	7.56	10	
Spin waves in a ferromagnet	7.64	15	
Numerical calculations for a Bose gas	7.69, 7.70	15–20	C
BEC in a harmonic trap	7.73	10	
BEC in a harmonic trap, numerical treatment	7.74	20	C
Quantum gases in the high-T limit	7.75	20	

Explanations and Notes

The "level" is an estimate of the maximum number of percentage points toward your grade that this project would be worth. Where a range is given, the level varies depending on how many of the listed problems (or their parts) you include. In some cases there might be ways to raise the level by adding work that is not explicitly described in the problem statement. In all cases, please inquire if you are unsure of how much work is expected to earn a certain amount of credit.

Besides the recommended problems on this list, you may wish to explore some of the problems in sections of the book that we're not covering. You may also think of some other problem to solve that is not in the book. Either way, be sure to check with me at an early stage to be sure that the topic is appropriate for this assignment.

On one hand, I would encourage you to start browsing through these problems and thinking about project topics as soon as possible. On the other hand, since so many of the best project topics are found in Chapters 6 and 7, I would discourage you from settling on a topic too soon. The deadline for choosing a topic will be Wednesday, April 19.

The outcomes of your project will be: (1) a typed paper that motivates and presents your calculations and results, at a level that is suitable for your classmates to read; (2) a five-minute presentation to the class, including one or two slides (computer images or overhead transparencies). Your project grade will be based not only on the correctness of your results, but also on how effectively you communicate. Presentations will take place during our "final exam" session, 9:30 – 11:30 am on Thursday, May 4. (Refreshments will be served.) The final draft of your paper will be due at the beginning of that session, but I'll need your slides no later than 5:00 the previous afternoon, so I can put them in order for a smooth presentation session.

Notes

C: These problems require some nontrivial use of a computing environment such as a spreadsheet or Mathematica, at a level comparable to that of the assigned homework problems that make use of this software.

1: This set of problems uses the results of Problem 1.46. If you incorporate Problem 1.46 into the project, the level rises to 20.

2: These problems involve concepts of electromagnetic theory (as taught in Physics 3510).

3: Problem 5.44 makes use of the result of Problem 1.40. If you incorporate Problem 1.40 into the project, the level rises to 20.

4: This is a computer simulation exercise that gives an alternative approach to understanding the Maxwell speed distribution (Section 6.4). It would be a great project for someone who is also taking the Computer Simulations course. (No double-dipping: You can't use the same project for credit in both courses!)

5: These problems build on Problems 7.46(d) and 7.48, which you would have to work first (though not necessarily include in your paper and presentation).