08.128.140 Theoretische Physik 4: Statistische Physik
Theoretical Physics 4: Statistical Physics

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Homework set 9

Due January 15, 2024 by start of lecture.
Please note how long it took you to solve each problem.

For this homework, we will illustrate the principles of thermodynamics using physical systems besides the ideal gas. You should read through Chapter 17 of Blundell and Blundell.

9-1, 25 pts. *Thermodynamic system: elastic rod. Problem 17.1 of Blundell and Blundell.* For an elastic rod, show that

$$\left(\frac{\partial C_L}{\partial L}\right)_T = -T\left(\frac{\partial^2 f}{\partial T^2}\right)_L , \tag{1}$$

where C_L is the heat capacity at constant length L.

9-2, 25 pts. *Thermodynamic system: elastic rod. Problem 17.2 of Blundell and Blundell.* For an elastic rod, show that

$$\left(\frac{\partial T}{\partial L}\right)_S = -\frac{TAE_T\alpha_f}{C_L} . \tag{2}$$

9-3, 25 pts. *Thermodynamic system: liquid surface. Problem 17.4 of Blundell and Blundell.* Given $đW = \gamma dA$, where γ is the surface tension, and starting with $dU = TdS + \gamma dA$, show that

$$dU = C_A dT + \left[\gamma - T\left(\frac{\partial \gamma}{\partial T}\right)_A\right] dA . \tag{3}$$

9-4, 25 pts. *Third law of thermodynamics.* After reading Section 1.10 of Kardar and Chapter 18 of Blundell and Blundell, write a paragraph discussing the implications of the third law of thermodynamics regarding heat capacities and thermal expansivities, and sketch an argument why absolute zero is unobtainable by a finite number of isothermal and adiabatic transitions.