

## Statistical and Thermal Physics: Homework 1

Due: 21 January 2015

Some homework problems and class exercises will use simulations developed by the text authors. These can all be run from a java “launcher.” You should first install the launcher on the computer that you are using. To do this:

1. Go to the following webpage: <http://www.compadre.org/STP/items/detail.cfm?ID=7308>.
2. Download the file called “download 3239kb.jar.” You may have to save it and then run it.

Running the file produces a “launcher” window (with the tab title `Open Source Physics: osp_stp.xset`) which lists a long collection of simulations for statistical and thermal physics these are sorted into folders in the directory on the left. Double click on any entry to run the relevant simulation.

General tips about running the simulations:

1. Clicking on a simulation in the “launcher” will produce documentation for the simulation in the launcher window.
2. The “launcher” usually opens a controller window but not necessarily the other windows associated with the simulation. The controller window lets you set parameters. Once you have done this clicking `Initialize` will open the simulation usually with some other graphical windows. Clicking `Start` will actually run the simulation.
3. Graphs and images can be save by following `Tools` → `Snapshot` . . . .
4. The data that is generated by the simulation can be accessed in tabular form by following `Tools` → `Data Tool`, selecting one of the starred objects and clicking `OK`. This contains a `Statistics` button that will computer averages and deviations. Data that goes into such a calculation can be selected by highlighting the relevant entries in the columns.

- 1 Gould and Tobochnik, *Statistical and Thermal Physics*, 1.2, page 10. Run the “launcher” and select `Approach to equilibrium` → `Particles in a box`. This will open a controller window where the number of particles can be adjusted by setting  $N$  in the relevant box (and hitting `Initialize`). Use  $N = 4, 40, 400$  in part b). The number can be updated using the button `New`.
- 2 Gould and Tobochnik, *Statistical and Thermal Physics*, 1.3, page 12. This refers to a box with two subdivisions.

### 3 Interacting systems in equilibrium

Much of thermodynamics deals with systems that interact. The usual consideration here, is that there are two isolated systems that are in equilibrium states. These are brought into thermal contact and they than reach a new equilibrium state. The issue is to find the

common property that describes this new equilibrium state. The simulation Identification of the Temperature explores this. Run the “launcher” and select Identification of the Temperature and, using the default parameters, click “Initialize.”

The simulation shows two systems, which by default are thermally isolated. They can be brought into thermal contact by clicking the “Contact” button.

- a) Run the simulation with the two systems isolated. The simulation will display fluctuating energies for both systems. By averaging over a reasonable duration, record the average kinetic and potential energies per particle for each system. Use these to determine the total energy for each subsystem. Are any of these quantities the same for each system?
- b) Without resetting, click the “Contact” button. Which of the energies change?
- c) After the systems have reached a common equilibrium record the average kinetic and potential energies per particle for each system. Use these to determine the total energy for each subsystem. Which way did energy flow?
- d) After the two systems have reached a common thermal equilibrium, which quantity is the same for the two systems? Given that the temperature of two systems in thermal equilibrium must be the same, which quantity best represents temperature?