|  |  |  |
| --- | --- | --- |
|  | [**DOING PHYSICS WITH MATLAB**](http://www.physics.usyd.edu.au/teach_res/mp/mphome.htm)  **THERMAL PHYSICS**  **SECOND LAW OF THERMODYNAMICS**  **Arrow of time**      Ian Cooper  School of Physics, University of Sydney  ian.cooper@sydney.edu.au    [**DOWNLOAD DIRECTORY FOR MATLAB SCRIPTS**](http://www.physics.usyd.edu.au/teach_res/mp/mscripts)    **tp\_equilibrium.m**  The mscript is for a simulation of the release of “perfume molecules” from a corner of a room and predicting how these gas molecules will distribute themselves throughout the room. The motion of the gas molecules can be saved as an **animated gif**.        **SECOND LAW OF THERMODYNAMICS**     The **Second Law of Thermodynamics** can be stated as:  Natural process in an isolated system will always spontaneously evolve to  states of greater disorder (states of greater entropy)  We can think of the concept of **entropy** as a **measure of the disorder of a system**.  *But what do these statements mean?*  We will consider the act of releasing a small quantity of perfume into a fully closed room from one location within the room. Immediately after the perfume is released, we can conclude that the perfume molecules are in an **orderly** state (state with the **lowest entropy**) since all the molecules are located within a small volume element of the room. After some time interval, we know that the perfume can be detected through the room and the perfume molecules will be uniformly spread around the room. This is the most **disordered** state (state of **maximum entropy**). If we continuously monitor the motion of all the perfume molecules we will never detect all the molecules again located in the small volume element that they were released from, although in terms of the principles of conservation of energy and momentum this state is not forbidden. Why? because if all the perfume molecules suddenly were found within the initial volume element it would be a violation of the Second Law ofThermodynamics.  We can help clarify the meaning of order / disorder and entropy by using a simple model to account for the behavior of the perfume gas molecules. We will consider the gas to be enclosed within an area *A* = 10x10 a.u., that is, we will consider the behavior of *N* gas molecules from a two-dimensional point of view. The enclosure is divided into 100 equal size boxes of area *Abox* = 1x1 a.u. At time *t* = 0 all the gas molecules are within the box (outlined in red ) located near the origin (0, 0) as shown in figure 1.    Fig. 1. The two-dimensional close enclosure of the gas has an area *A* = 10x10 a.u. The area is subdivided  into 100 boxes of area *Abox* = 1x1 a.u. At time *t* = 0, all the gas molecules (*N* = 1000) are released from the  box outlined in red. One of the gas molecules is marked so that you can track its movements. **tp\_equilibrium.m**  The initial state of the gas at *t* = 0 has the most order since the molecules are located into the smallest volume element and there is only one arrangement possible for this as all the molecules are in one of the boxes. After the gas is released, each molecule moves in a random distance and direction. We are interested in how the molecules arrange themselves in the 100 boxes as time flows. The movement of the gas molecules is shown in animations below.    aass |  |