33-341 — Thermal Physics I

Department of Physics, Carnegie Mellon University, Fall Term 2018, Deserno

Problem sheet #1

1. Getting started *(5 points, due on Tuesday)*

1. Log onto the course webpage (`http://www.andrew.cmu.edu/course/33-341/`) and read the syllabus.
2. Get hold of a version of `Python` that you can run. I recommend downloading `Anaconda` (free!), which is a distribution that contains the Python *language* (version 3.6), the *interpreter* `iPython`, the comfortable *integrated development environment* (IDE) `Spyder`, and various useful libraries, such as `NumPy`, `PyPlot`, and `SciPy`.
3. Run the program `OneDie_PARTIAL.py`, which you find on the course webpage. It simulates the rolling of a die for `trials` times, and prints out the number of occurrences of each face, followed by the *absolute* and *relative* deviation from the expected value. Change the parameter `trials`; describe and document (with data!) what you observe.
Note: don't worry if you do not understand all of the code immediately. `Python` is a very *intuitive language which you can learn as you go along. Often it suffices to change existing programs and adapt them to your needs. Also, you can very easily google how other things are done.*

2. Playing games with non-standard dice *(8 points, due on Wednesday)*

The picture on the right shows a curious quadruplet of dice: their faces are not labeled consecutively with the numbers one to six, but rather have the following numbers printed on them:

D_1:	{3,3,3,3,3,3}	(yellow)
D_2:	{0,0,4,4,4,4}	(red)
D_3:	{1,1,1,5,5,5}	(green)
D_4:	{2,2,2,2,6,6}	(blue)

We will assume that, like for an ordinary die, the likelihood of any of the six sides of any of the four dice coming up when we roll the die is $1/6$.
Assume now that two people are playing a game: each one picks one of the dice and then they roll them. Whoever gets the higher number wins the game. Since the dice are different, it is conceivable that the probability of winning depends on which die one chooses. There is no reason to believe it is still 50%, as it would be for normal dice!
Hence, let us introduce the following terminology: We call die A "stronger" than die B (or die B "weaker" than die A), when the probability of a roll of A beating a roll of B is larger than 50%. Let us formally write this as "$A > B$", or "$B < A$".

1. Show that $D_1 < D_2$, $D_2 < D_3$, and $D_3 < D_4$!
Hint: Of course you can do this by carefully calculating the probabilities of winning, but you don't <u>have</u> to do it that way. In all cases it is possible to give a simple (but stringent!) argument to show why one die is stronger than the other.
2. Based on the sequence you have just shown, do you expect $D_4 > D_1$? Check explicitly whether this holds!
3. How does D_1 compare to D_3, and how does D_2 compare to D_4?

3. Pairwise and mutual independence *(7 points, due on Friday)*

We flip a fair coin twice and see whether it falls head ("H") or tail ("T"). Let us look at the following three events: A: "There was a head in the first throw." B: "There was a head in the second throw." C: "The result was the same in the first and the second throw." Show that the three events A, B and C are *pairwise independent* but <u>not</u> *mutually independent*!