PY 410, Statistical and Thermal Physics, Spring 2012

Syllabus
Lecture1
Lecture2
Lecture3
Homework 1 (Due Feb. 2^{nd}), problems from Reif: **1.1**; **1.4** (analyze the answer at large N), **1.5**, **1.9**, **1.10**, **1.12**, **1.14**
Additional Problem.* A person throws dice N times. Find the probability distribution of the maximum score for different N. Write down your results explicitly in a table for N=1,2,3 (use decimal numbers not fractions). Discuss the asymptotical form of this distribution when N is large. Solutions
Lecture4
Homework 2 (Due Feb 9^{th}), problems from Reif: 1.16, 1.17, 1.18, 1.23, 1.26*, 1.28*

M&M problem. This problem consists of three parts
1. Each of you will get a Pack of M&M mini. Each pack contains candies of six colors: Blue (Bl), Brown (Br), Green (G), Orange (O), Red (R) and Yellow (Y). You will need to count number of candies of each color and send the data to a designated person. The sample data you need to send should look like this

Bl – 27
Br – 23
G – 18
O – 25
R – 31
Y – 34

Please send the data by Thu, Feb. 2^{nd}. Please do not invent the data; it is important that you do actual counting.
2. Now you can eat your candies, discard them, or share with your friends.
3. After all data is collected you will get back a table containing the results from the whole group. Each of you need to independently perform the statistical analysis of the data and answer the following questions.

- Estimate the variance and the mean for the number of candies of each color. Are these results consistent with the Poisson distribution?
- Estimate the variance of the sum of B-candies (i.e. blue + brown). Is it approximately equal to the sum of variances? Are the blue and brown colors statistically independent?
- Estimate the variance of the total number of candies (i.e. blue + brown + green + orange + red + yellow). Are all colors statistically independent? Explain your result.
- Plot the distribution function (in mathematica, excel, or any other software) for all colors (or all colors except red) from all students, i.e. the horizontal axis should be the number of candies and the vertical axis is the normalized frequency of occurrence of this number. The total number of data points should be 6 x number of analyzed packs. Fit this distribution to the Poisson distribution and Gaussian distribution. Which if the distributions work better? Argue why.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Blue	43	26	27	24	25	27	32	35	31	27	38	27	25	27	3
Brown	28	38	30	42	30	29	36	30	31	34	27	39	40	34	3
Green	22	30	33	27	35	25	30	28	33	26	30	20	30	33	3
Orange	33	19	36	38	32	30	18	30	28	40	32	37	27	37	2
Red	43	46	41	39	41	54	47	34	35	41	45	36	47	41	3
Yellow	33	39	33	31	36	36	31	42	39	32	27	41	33	23	4
Total	202	198	200	201	199	201	194	199	197	200	199	200	202	195	19

note: 12/18 packs have red as max.!

Lecture5
Lecture6

Homework 3 (due Feb. 16th) problems from Reif: 2.1, 2.2, 2.4, 2.8,2.10

Lecture7

[Lecture8]

Homework 4 (due Feb. 23rd) problems from Reif: 3.1, 3.3, 3.4

*Repeat the following problem considered in the notes but for spin 1 particles. Assume that we have a system of large number N of noninteracting particles described by the Hamiltonian:

$H = -h\sum_i s_i$, where $s_i = \{-1,0,1\}$.

Find the approximate expressions for the density of states $\Omega(E)$ and then find the temperature as a function of the energy and the magnetic field. Invert this relation and express energy in the system as the function of temperature. Show that your result is consistent with the Boltzmann distribution where the probabilities of spins to be in one of the three possible states are $p_{+1} = Ce^{\frac{h}{T}},\ \ p_0 = C, p_{-1} = Ce^{-\frac{h}{T}},\ C^{-1} = 1 + 2\cosh\left(\frac{h}{T}\right)$

Hint: number of configurations such that N_1.spins have magnetization 1, N_2.- have magnetization 0, and N_3.have magnetization -1 is given by the polynomial distribution

$$\Omega(N_1, N_2, N_3) = \frac{N!}{N_1!\,N_2!\,N_3!},$$

where $N_1 + N_2 + N_3 = N$. Because the total energy is fixed $E = -h\,(N_1 - N_2)$ we have an additional constraint. Using the Stirling's approximation maximize the number of configurations with respect to the remaining variable. This is approximately $\Omega(E)$ you need to find.

[Lecture9]
[Lecture10]