Boğaziçi University
Department of Physics

Phys 442 — Spring 2012

Problem Set #1

Due on March 21st, 2012

Problem 1: [*10 pts.*]
Show that the standard deviation of binomially distributed parent population is given by:

$$\sigma_B^2 = np(1-p)$$

where n is the number of trials (measurements) and p is the probability of having outcome-1 for a single trial.

Problem 2: [*10 pts.*]
Show that the standard deviation of poisson distribution for the parent population is given by:

$$\sigma_P^2 = \mu$$

where μ is the mean value of the parent distribution.

Problem 3: [*80 pts.*]
Assume that you are to measure the oscillation frequency, ω, of a physical quantity y. It is expected to obey the following relation:

$$y = [A\sin(\omega x + \phi)]^2$$

What you measure is the number of counts, say N, for a preset x value. Assume that x is exact for all practical cases. The relation between N and y is simply given by:

$$y = 5N.$$

You repeat this experiments 75 times for varying x values, and the raw data you gather are as follows:

x	N	x	N	x	N	x	N	x	N
0.00	1	11.25	3	22.50	12	33.75	26	45.00	46
0.75	90	12.00	124	23.25	168	34.50	210	45.75	252
1.50	372	12.75	435	24.00	475	35.25	544	46.50	595
2.25	624	13.50	746	24.75	908	36.00	929	47.25	962
3.00	1115	14.25	1212	25.50	1221	36.75	1392	48.00	1414
3.75	1548	15.00	1518	26.25	1642	37.50	1683	48.75	1801
4.50	1848	15.75	1808	27.00	1878	38.25	1906	49.50	1975
5.25	1983	16.50	2054	27.75	1981	39.00	1931	50.25	1964
6.00	1943	17.25	1917	28.50	1865	39.75	1856	51.00	1855
6.75	1763	18.00	1783	29.25	1663	40.50	1580	51.75	1514
7.50	1434	18.75	1410	30.00	1264	41.25	1272	52.50	1134
8.25	1096	19.50	1015	30.75	890	42.00	842	53.25	705
9.00	653	20.25	560	31.50	535	42.75	395	54.00	360
9.75	267	21.00	232	32.25	184	43.50	125	54.75	118
10.50	58	21.75	32	33.00	14	44.25	8	55.50	1

Flip the page...

a) Make a new table with three columns: x, y, σ_y.

b) Make a plot showing y vs. x, with error bars (σ_y). You will notice 5 peaks on this graph.

c) Take the data point with highest value of the first peak and 4 more data points around it (two an the left, two on the right), and fit these 5 points to a 2^{nd} degree polynomial. [Do not ignore the errors.] Find

- Polynomial coefficients a_0, a_1, a_2,
- Measure of quality: $\frac{\chi^2}{\text{d.o.f.}}$, and
- Errors on the coefficients σ_{a_0}, σ_{a_1}, σ_{a_2}

for this fit.

d) Find the position of the maxima for this polynomial and its error. Call it $x_1 \pm \sigma_1$.

e) Find $x_i \pm \sigma_i$ for the rest of the peaks ($i = 1, 2, 3, 4, 5$). [Simply repeat part c and d for the rest of the peaks.]

f) Make a plot of $x_i \pm \sigma_i$ vs. i for these 5 peaks with error bars.

g) Perform one last χ^2 minimization and fit these into a line. Find

- Interception $n \pm \sigma_n$,
- Slope $m \pm \sigma_m$, and
- $\frac{\chi^2}{\text{d.o.f.}}$

of the fit.

h) The slope is going to give you the period (T) of the oscillations. Using $\omega = \frac{2\pi}{T}$ relation find the frequency ω and its associated error σ_ω. $\omega \pm \sigma_\omega$ is what you were trying to measure.