Boğaziçi University
Department of Physics

Phys 442 Spring 2011

Exam

May 18th, 2011 – 90 minutes

Problem 1 – *10 pts*
Assume that, you measure a known quantity in the laboratory for calibration purposes using two different setups and analysis methods. The value of the quantity is known to be

$$m_Z = 91.1876 \pm 0.0021 \text{ GeV/c}^2.$$

to the best of our knowledge. What you measure are:

Setup 1) You measure this quantity as $m_1 = 91.2 \pm 0.1$ GeV/c^2.
Setup 2) You measure this quantity as $m_2 = 91.42 \pm 0.01$ GeV/c^2.

Answer the following questions:

a) Which setup yields more accurate result, Setup-1 or Setup-2. Explain briefly.

b) Which setup yields more precise result, Setup-1 or Setup-2. Explain briefly.

c) Explain under which conditions each setup may be desirable. State your answer as "*We prefer to use Setup-1 if ... On the other hand, we prefer to use Setup-2 if ...*"

Problem 2 – *20 pts*
You have three data points shown as below which is expected to have a linear relation between x and y, as $y = a_0 + a_1 x$. Use matrix notation to solve this problem.

x	y	σ_y
-1	-8	1
0	6	$\sqrt{2}$
1	12	1

a) Find $a_0 \pm \sigma_{a_0}$

b) Find $a_1 \pm \sigma_{a_1}$

c) Find χ^2/d.o.f

d) Is it a good fit, explain.

(Note that you can solve this question without using a calculator!)

Problem 3 – *20 pts*
Let's assume that the probability distribution of the age of population in Turkey is given by

$$P(x) = C\, x\, e^{-x/10} \qquad \text{for } 0 \le x \le \infty$$

where x is the age. (This is a justified approximation as this function yields very small probability for the age $x > 100$.)

a) Find constant C,

b) Mean age $\langle x \rangle$,

c) An expression for median age x_{median} (you'll get bonus, if you can estimate this),

d) Standard deviation of age σ_x.

e) Make a sketch of the probability distribution and show the quantities asked above.

[You may use $\int_0^\infty x^n e^{-x}\, dx = n!$ and $\int x e^{-x}\, dx = -(x+1)e^{-x}$]

Problem 4 – *10 pts*
You are to integrate a function that behaves like a sin function with half period in the region of integration. Estimate the number of numerical integration points you need in order to have 0.1% error if you have to use Simpson's generalized sum rule.

Flip the page...

Short Questions About the Experiments

(5 pts each)

Problem 5
Consider an electron between two large plates separated with a small distance and kept at a potential difference V_o. If the electron is released at a point near the center of the low-potential plate, show that its kinetic energy will be $K = e \cdot V_o$ by the time it reaches the high-potential plate. [Hint: You may use the work done by the electric field.]

Problem 6
A laser beam is used for photoelectric effect.

a) we have to decrease the wavelength (increase the energy/photon) of the laser beam,

b) we have to increase the intensity of the laser beam,

c) both of the above.

in order to increase the current.

Problem 7
If we would be using a non-crystalline target in the "X-ray experiment", what would be the spectrum as a function of θ. Make a sketch.

Problem 8
Explain, how are we charging the electroscope in the "Radioactive decay experiment". What is the source of charge. Explain briefly.

Problem 9
"When $\mu \gg 1$, Poisson distribution with μ looks like a Gaussian distribution with μ and $\sigma = \sqrt{\mu}$." This statement is

a) True

b) False

Problem 10
Sketch the scattering of a ball from a hard-core cylinder as in the "2D scattering experiment." Indicate the impact parameter, and all relevant angles.

Problem 11
Estimate the force between the small and large balls in the Cavendish experiment. What is the fraction when you compare this with the weight of the large ball?

Problem 12
Assume that we removed mercury droplets from the tube: What would you see in the I-vs-U_2 plot in the "Frank-Hertz experiment"?