KING SAUD UNIVERSITY. DEPARTMENT OF PHYSICS

MODERN PHYSICS LAB (HW№1)

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PROBLEM (1) DEALING WITH DATA

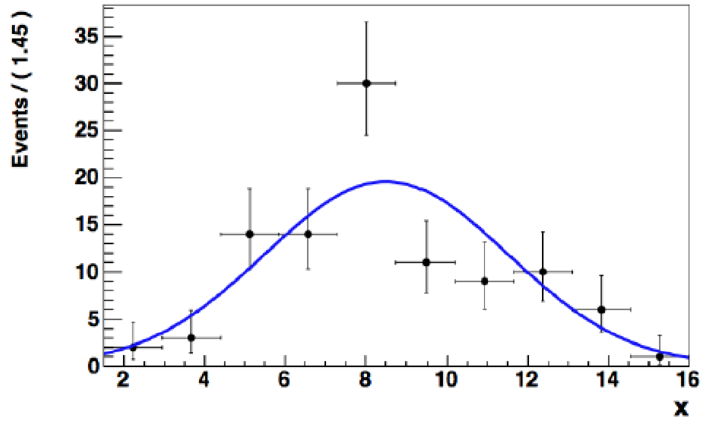
You are given a table of % of students marks in some subject.

ID	Course-work	Final
1	98%	90%
2	83%	65%
3	73,3%	40%
4	86,7%	57,5%
5	95%	95%

1. Add another column cantoning the total, and classify the student who fail or pass the course if the passing mark was 75%.
2. Compute the mean value and standard deviation for each column.
3. Plot the data (course-work and final), using a scatter plot, then fit the data to a line. (you may draw it manually or by computer program.
4. Study the slop of the line drawn, is the slope positive or negative. Can you conclude that the course-work marks are correlated with the final marks ?

PROBLEM (2) NORMAL DISTRIBUTION

You have the Gaussian plot (normal distribution) of some data collected from particle collisions at CERN.



1. What is the mean-value of the this distribution?
2. measure the width of this distribution, then find its standard-deviation.
3. Write the mathematical expression for this curve.

PROBLEM (3) ERROR PROPAGATION FORMULA

If we have a function of several random variables $f(x_1, x_2, \ldots x_n)$, and we know the 'uncertainty' for each of these variables σ_{x_i} then the uncertainty of the function f is given by **the error propagation formula**

$$\sigma^2(f(x_1, x_2 \ldots)) = \sum_{i=1}^{n} \frac{\partial^2 f}{\partial x_i^2} \sigma_{x_i}^2 \tag{0.1}$$

The relativistic relation between energy, momentum and mass is given by

$$E^2 = (mc^2)^2 + p^2 c^2 \tag{0.2}$$

We could measure p and E using a *calorimeter*, with uncertainties σ_p and σ_E, respectively. What is the uncertainty in the mass σ_m ?

PROBLEM (4) ABSOLUTE AND RELATIVE ERRORS

We measured the radioactivity of Po^{210} and U^{ore} sources, we got the following intensities $[I]$ = count /min Calculate the absolute ε and relative η errors.

Source Intensity (count/min)	I_1	I_2	I_3
Po^{210}	130	145	140
U^{ore}	100	98	99

PROBLEM 5) THE Z BOSON

(This is a bonus question) In 1983, an interesting particle was discovered at CERN, called the Z boson. The discovery was made via colliding electron and anti-electron together at a very high energy. Sometimes, from these collisions the Z boson will be produced, and then quickly decay via the processes shown the diagram. Sometimes the Z boson decays into two

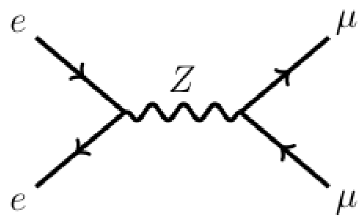


Figure 0.1: The event $e^+e^- \rightarrow Z \rightarrow \mu^+\mu^-$

(heavier) versions of the electron and anti-electron called the muon particle μ^-. Others, it decays into more complicated pattern of particles composed of other particles called Hadrons [1] The shape of data collected from CERN UA(1) and UA(2) experiments that discovered the Z is given in the following figure .

1. What is the charge of the Z ?
2. Using the figure 0.2, what is the mass if the Z in GeV ?
3. Consider the distribution of the Z mass as a Gaussian, what is the width $\Gamma(Z \rightarrow \text{Hadrons})$ and $\Gamma(Z \rightarrow \mu\mu)$. Then calculate the total width. This was a very important measurement that you have reproduced !
4. The width of the Z help us understand the current model of particle physics and know the number of neutrino families, what is the number of neutrino families ?

[1] The proton is a hadron, it is composed of 3 subnuclear particles called quarks, the Z boson would decay into hardons made from quark and anti-quark

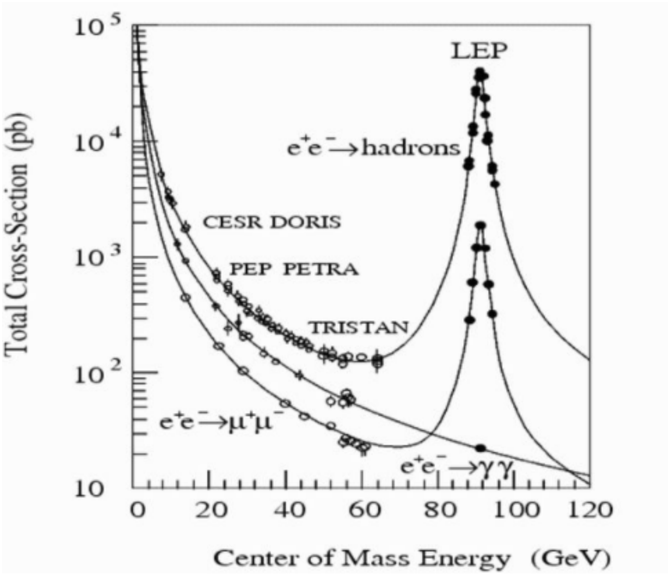


Figure 0.2: UA(1) and UA(2) experiments data showing the Z boson discovery

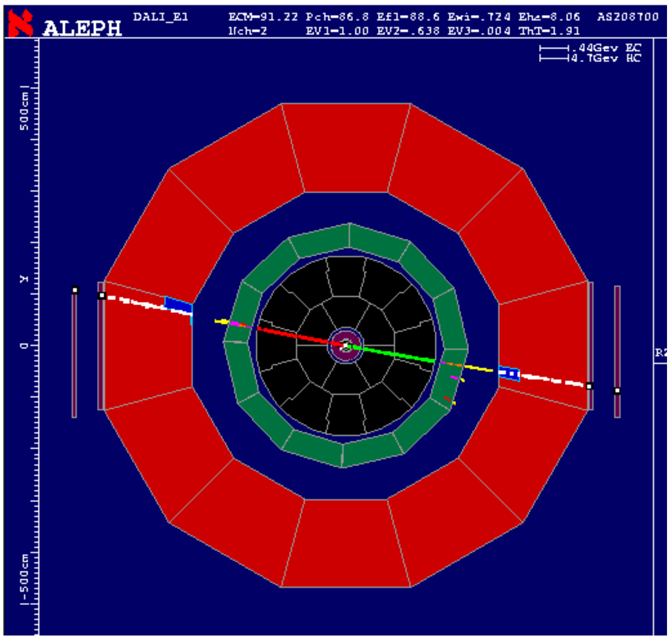


Figure 0.3: An actual $Z \to \mu\mu$ event detected at the ALEPH experiment at LEP-CERN