

Data Analysis - 2020

Exercise sheet no 3:

13. October 2020

Population properties and systematic uncertainties

Remark: For this exercise, please implement mean, standard deviation etc. yourself as an educational exercise instead of using `np.mean` and `np.std`. This is an exception and should only be done here.

Exercise 1: Ironman II (7 Points)

Write a script that reads the file `ironman.txt` (see exercise sheet no. 1)

(a) calculates the mean, uncertainty of the mean, variance, and standard deviation of the

- age distribution
- total time distribution

directly from the data. (2 points)

(b) calculates the mean, variance and standard deviation of the distribution from a histogram. Compare the results with those you got in a). Use different bin widths and comment on what you observe. (2 points)

(c) calculates the covariance and correlation coefficient between

- the total rank and the total time
- the age (in 2010) and the total time
- the total time and the swimming time
- the cycling time and the running time

Take a look at the scatter plots from exercise sheet no. 1 and compare the results with the results you got. (2 points)

Convert the total time from minutes to seconds and calculate the covariance and correlation coefficient between the age and the total time again. Which of the two changes and which stays the same? (1 point)

Exercise 2: Weighted Average (4 Points)

You have been hired as a medical physicist, and your first task is to report on the level of radiation in the room where the containers of some radioactive sources, used for radiotherapy research, are stored.

You measure the data stored in `radiation.txt` which can be found on the webpage. The measurements are taken with different dosimeters, and under different conditions, and thus have different uncertainties (2nd column). Assume that all measurements are independent from each other. The level of radiation is measured in mSv/h, millisievert per hour¹.

¹The Sievert is the unit of ionizing radiation dose in the International System of Units, and it represents the effects of radiation on the human body.

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- (a) Calculate the average radiation level, in mSv per year, and the associated uncertainty. (3 points)
- (b) Based on your result, say if the level of radiation in that room is compatible with the natural background radiation, which has been measured to be 2.4 mSv/y. You can assume that the uncertainty on this value is negligibly small compared to the uncertainty on your measurements. (1 point)

Exercise 3: Common systematic uncertainty (3 Points)

You make three measurements of the electron charge. Each measurement has its own statistical uncertainty. In addition, there is a systematic uncertainty which is common to all three measurements. You can assume that the systematic uncertainty is independent of the central value of the results.

$$\text{Measurement 1 : } m_e = (1.39 \pm 0.20(\text{stat}) \pm 0.10(\text{syst})) \times 10^{-19} \text{ C}$$

$$\text{Measurement 2 : } m_e = (1.54 \pm 0.04(\text{stat}) \pm 0.10(\text{syst})) \times 10^{-19} \text{ C}$$

$$\text{Measurement 3 : } m_e = (1.47 \pm 0.10(\text{stat}) \pm 0.10(\text{syst})) \times 10^{-19} \text{ C}$$

Calculate the three correlation coefficients between the three pairs of measurements.

Exercise 4: Systematic uncertainties (6 Points)

Look at the lab experiment Schussgeschwindigkeit ("air gun muzzle velocity"). (http://www.physik.uzh.ch/%7Ematthias/espace-assistant/manuals/en/anleitung_sg_e.pdf) of the first year.

- (a) Think of possible systematic uncertainties and list at least three of them.
- (b) Do you expect the individual uncertainties to have a small or large impact on the final result? Note for each listed uncertainty your answer.
- (c) How would you estimate the uncertainties? Just give an idea.
- (d) How would you minimize or avoid your listed systematic uncertainties?

Deadline for submission: Friday, 23rd October 2020, 14:00 a.m.

Form: Submission of solutions as a single python script directly to da@physik.uzh.ch. Answers to question 4 can also written down and submitted as a separate PDF file.