1. Exercise Sheet **Winter Term 2023/24**
Statistical Methods for Data Analyses B **Prof. W. Rhode**
Submission: 01.11.2022 23:59 **Dr. M. Linhoff**

Time	Group	Submission in Moodle; Mails with subject: [SMD2023]
Th. 12:00–13:00	A	tristan.gradetzke@udo.edu and samuel.haefs@udo.edu
Fr. 09:00–10:00	B	lucas.witthaus@udo.edu and david.venker@udo.edu

Exercise 1 *Error propagation* **5 p.**

The parameters of a regression line $y = a_0 + a_1 x$ were determined to be $a_0 = 1.0 \pm 0.2$ and $a_1 = 1.0 \pm 0.2$. The correlation coefficient is $\rho = -0.8$. Determine the uncertainty of a value y as a function of x.

(a) Determine the result analytically both considering the correlation and neglecting the correlation.

(b) Determine the result numerically with a Monte Carlo simulation. Visualise the parameters a_0 and a_1 in a scatter plot.

(c) Determine the predictions y (mean and standard deviation) for fixed $x = -3, 0, +3$ numerically as well as analytically and compare them.

Exercise 2 *Particle traces* **5 p.**

In a particle physics experiment, 2 planes of drift chambers are placed perpendicular to the z-axis at the positions z_1 and z_2. The detector is operating in a vacuum and the magnetic field is zero. You measure the respective x-position (x_1 and x_2) of a charged particle passing through with the errors σ_{x_1} and σ_{x_2} without correlation.

(a) Calculate the linear equation

$$x = az + b,$$

which describes the motion of the particle in the x–z-plane, as well as the errors, the covariance matrix and the correlation coefficients of a and b.

(b) The measurements in the two drift chamber planes at z_1 and z_2 are now used to predict the position of the particle in the next detector element. Let this be another drift chamber plane parallel to the first two at $z = z_3$. With the help of the equation determined in (a), calculate the position x_3 and its error at $z = z_3$.

(c) How does the error of x_3 change if you mistakenly do not take into account the correlation between a and b?