

## Adjustment Computations MSc

Exam topics and questions (50 points 60 minutes)

1. Sample characteristics: sample median, arithmetic mean, most frequent value concept, characteristics and their computation with formulas.
2. Dataset uncertainty as the value of a norm at the place of the minimum. L1, L2 and P1 norms: average deviation, standard deviation, uncertainty. Confidence intervals: interquartile and intersextile half range.
3. What is a statistical test? What is a statistic? Find empirical distribution of the statistic using a Monte Carlo procedure. Kolmogorov test of distributions. What is the statistic and distribution of the statistic of the Kolmogorov test? What is the procedure of testing two distributions (theoretical-empirical, empirical-empirical) by using quantile-quantile plots. Definition of a quantile of a distribution.
4. What does the IC function tell and what is IC curve for? Definition of asymptotic variance. What is the Cramér-Rao bound?
5. Define absolute efficiency of a statistical estimate and what is its practical significance? Define relative efficiency of two estimates. When can an estimation or an algorithm be considered robust?
6. What is the difference between frequentist and bayesian viewpoints on probability? State extended form of Bayes' theorem for a partition of the event space. State Bayes' theorem with probability densities. What does the likelihood function express and what are the prior and posterior? Define prior and posterior odds.
7. What events does extreme value theory (EVT) consider? How it is different from conventional statistics? What are the two basic approaches of EVT? What distributions are followed by blocks maxima and peaks over threshold? What are return levels and how they are plotted? What is a mean excess plot? How to pick a suitable threshold in the POT method?
8. How to pick a random sample from a non-uniform distribution? What is the basic idea of rejection sampling? What procedure is used for sampling from an arbitrary complicated distribution? How to propagate a distribution through a nonlinear system?
9. What are the steps of a Monte Carlo computation? How can it be used for the calculation of the most characteristic values and measurement uncertainties of the output quantities of a measurement procedure?
10. Define uncertainty of a measurement and give basic procedures for its evaluation using GUM. Give some examples of how to provide a measurement uncertainty. How can standard errors used in geodesy be considered from the viewpoint of GUM? What are expanded uncertainties and coverage intervals?
11. Briefly describe the general model of GNSS adjustment (functional and stochastic model). Why linearize the equations of the equation? What are the point standard error and the mean point standard error and how can they be determined in three dimensions using the covariance matrix for the point?
12. What is the integer least squares method and what is called a mapping function? Why is decorrelation needed to find the solution?
13. What adjustment procedure can be used if there are many more measurements than there are parameters? Describe briefly the essence of this procedure.

14. What is singular value decomposition (SVD)? What matrices can it be applied to and how is it related to eigenvalue decomposition? How can the least squares adjustment problem be solved using SVD decomposition?
15. Briefly describe the functional model and special cases and specific aspects of bundle adjustment.
16. Describe briefly the Baarda data snooping process. What is the basic idea behind the conjugate gradient method? What problems can the method be used to solve?
17. Recursive estimation of the arithmetic mean. Optimal combination of two measurements using recursive estimation. What is indirect state estimation? What is the difference between a static and a dynamic Kalman filter? What is the role of the Kalman gain matrix?
18. What is the extended Kalman filter? What is its fundamental flaw? What are the three steps of the filtering process?
19. What is the basic idea behind unscented Kalman filtering? What is the purpose of the sigma points? Why is an unscented Kalman filter preferable to an extended Kalman filter?
20. How can a stochastic process be characterised? (distribution functions, space average, auto and cross correlation functions) List some important types of stochastic processes.
21. What is the Nyquist criterion and what is its role in the frequency domain? Why filtering is needed before decimation of data?
22. Describe the concept of power spectral density (PSD). What is a one-sided PSD? How is PSD related to autocovariance and what are its important properties? List the most important procedures for PSD estimation.
23. What are the likelihood and loglikelihood functions? When is an estimate called unbiased or consistent? What is the principle and algorithm of the maximum likelihood method?
24. What is the M-estimate and how is it related to the maximum likelihood estimate? What is the purpose, effect and weight function of the M-estimate? How is a resistive M-estimation constructed?
25. Why is robust measurement processing important and what is its purpose? Briefly explain the concepts of robustness and resistance.
26. What is an outlier? What is the bias and breakdown point of an estimate?
27. What is called the marginal distribution for an estimate? State the law of large numbers and the central limit theorem. What are the important conditions for the validity of these theorems?
28. Describe the basic idea and process (main steps) of the RANSAC. What parameters are required for the procedure? What is the result of the estimation? Which RANSAC procedures can be used to estimate several models?
29. What regression procedures can be used when we have information about the form of the function? How can these tasks be grouped in terms of the known function? Briefly describe the procedure for fitting a straight line in the case where both coordinates can be considered to have errors.
30. What is the Levenberg-Marquardt method and how does it differ from the steepest descent and Gauss-Newton methods? What are the basic parameters to be taken into account when applying the procedure?
31. What is symbolic regression and what are the main steps in the process?