**Theoretical questions for the first midterm test**

**Probalility Theory and Mathematical Statistics**

1. The concept of classical probability space.
2. The concept of $\sigma$-algebra.
3. The concept of probability space (Kolmogorov's probability space).
4. The properties of the probability. (Finite additivity, monotonicity, Poincare formula for 2 events, Poincare formula for 3 events).
5. Drawing a ball from an urn without replacement.
6. Drawing a ball from an urn with replacement.
7. Concept of conditional probability.
8. Concept of partition of $\Omega$.
9. Total probability theorem.
10. Bayes formula, and Bayes theorem.
11. Concept of independence of two events.
12. The pairwise and complete independence of a sequence of events.
13. Concept of probability variable.
14. Concept and properties of the distribution function of a probability variable.
15. Concept of discrete and absolutely continuous probability variables.
16. Distribution of a discrete random variable, density function of an absolutely continuous random variable.
17. Expected value of discrete, and absolutely continuous probability variable.
18. Properties of the expected value. (additivity, and homogenity).
19. The concept of the variance of probability variable, and its calculation.
20. Properties of the variance of probability variable. (positive semidefiniteness, and homogeneity)
21. Some famous discrete random variables: Bernoulli, geometric, hypergeometric, binomial, Poisson.
22. Some famous absolutely continuous random variables: uniform, exponential, standard normal, normal.

**Theoretical Questions for the 2nd midterm exam**

**Probability Theory and Mathematical Statistics**

1. Definition of a 2-dimensional random vector.
2. Definition of the joint distribution function of a 2-dimensional random vector.
3. Properties of the joint distribution function of a 2-dimensional random vector (4 properties).
4. Definition of a 2-dimensional discrete random vector.
   What is the range and the joint distribution of such a random vector?
5. Definition of a 2-dimensional absolutely continuous random vector.
   What do we mean by the joint density function of such a random vector?
6. Definition of the expectation vector and the variance matrix of a 2-dimensional random vector.
7. Definition of independence and uncorrelatedness of two random variables; the relationship between independence and uncorrelatedness.

8 How do we define the correlation coefficient of two random variables?

9 State the Cauchy–Bunyakovsky–Schwarz inequality.

10. How do we determine the marginal distributions of a two-dimensional discrete random vector?
11. How do we determine the marginal density functions $f_1$ and $f_2$ of a $(\xi_1, \xi_2)$ two-dimensional absolutely continuous random vector from the joint density function $f$?
12. When do we say that $\xi_1, \xi_2, \ldots, \xi_n$ is an independent sample?
13. State the weak law of large numbers (either version: the relationship between the sample mean and the theoretical expectation, or the relationship between the relative frequency and the theoretical probability).
14. State the Central Limit Theorem.
15. Define the sample mean. What is it used for?
16. What are the empirical variance and the corrected empirical variance? What are they used for?
17. How do we compute the median ($\text{med}(\xi)$) and the median absolute deviation ($\text{MAD}(\xi)$) of a sample $\xi = \xi_1, \xi_2, \ldots, \xi_n$?
18. How do we construct a 95% confidence interval for the unknown expected value $\mu$ when $\xi_1, \xi_2, \ldots, \xi_n$ is a sample from a $\mathcal{N}(\mu, \sigma^2)$ distribution, where $\sigma^2$ is known?
19. How do we construct a 95% confidence interval for the unknown expected value $\mu$ when $\xi_1, \xi_2, \ldots, \xi_n$ is a sample from a $\mathcal{N}(\mu, \sigma^2)$ distribution, where $\sigma^2$ is unknown?
20. Describe the u-test.
21. Describe the t-test.