

# Tutorial “Performance Evaluation Techniques”

## First Problem Sheet

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### Problem 1:

A medical laboratory makes blood tests to detect some specific illness. If a patient actually has the illness, the test result is with 95% probability positive. If the test is applied to a person not having the illness, it gives with 1% probability a positive result (so-called “false positives”). The overall fraction of people having the illness is 0.5%.

A person is tested positively. What is the probability that this person actually has the illness?

(Hint: Bayes Theorem)

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### Problem 2:

Be  $X$  a random variable with exponential distribution. The exponential distribution has the density function:

$$f(x) = \lambda e^{-\lambda x}$$

for  $x \geq 0$  and with  $\lambda > 0$  being a parameter.

1. Compute  $E[X]$  directly
2. Determine the moment generating function  $\mathcal{M}_X(z)$  and use this to find  $E[X]$  and  $\text{Var}[X]$ . (Hint: use substitution)

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**Problem 3:**

Be  $X$  a random variable with gamma distribution. The gamma distribution has the density function:

$$f(x) = \frac{\lambda(\lambda x)^{\alpha-1} e^{-\lambda x}}{\Gamma(\alpha)}$$

for  $x \geq 0$  with  $\lambda > 0$  and  $\alpha > 0$  being parameters, and  $\Gamma(x)$  being the well-known *Gamma function*:

$$\Gamma(t) = \int_0^\infty x^{t-1} e^{-x} dx$$

(which is like the factorial function for real numbers: for  $n \in \mathbb{N}$  we have  $n! = \Gamma(n + 1)$ ).

1. Compute the moment generating function  $\mathcal{M}_X(z)$ . (Hint: use clever substitution and the definition of the Gamma function).
2. For  $\alpha$  being an integer, compare the resulting  $\mathcal{M}_X(z)$  with that of the exponential distribution and give an interpretation.

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**Problem 4:**

Your software company has developed a CAD program. Due to various reasons the development team came up with two different user interfaces for the program, and the company wants to pick one for delivery to the customers. Your boss asks you to design a study giving a “good” answer to this question (with “good” meaning nothing specific, just “our customers will like us”). Make a proposal for the first steps of this study.

This is an “open” problem, there is no “right” or “wrong” solution; use your imagination. You should at least:

- clearly define the system under study
- define some performance measures (as a starting point: consider what a CAD program is actually used for)
- identify important input variables (technical ones like the expected user equipment [capabilities of graphics card, monitor etc.] as well as qualitative ones [how much knowledge about computers do users already have, etc.]
- decide on the factors and their levels
- Propose measurement or simulation setups studying these measures
- decide on an experimental design: which factor / level combinations should be investigated?

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