Mathematics and Information Theory for Engineers, exam questions

1. Eigenvalues and eigenvectors of matrices, definite matrices. Matrix polynomials and power series. Singular and spectral decomposition of matrices.

2. Differentiability of multivariable functions, partial derivatives, Hessian and Jacobian. Taylor series expansion. Extremal points of multivariable functions, conditions of extrema. Examples.

3. General form of an optimization algorithm, line search, gradient method. Newton's and quasi-Newton methods.

4. Double integral and its properties, iteration of double integrals. Change of variables, polar coordinates. Cylindrical and spherical coordinates. Examples.

5. Laplace transform and its properties. Examples. Solution of linear differential equations using Laplace transforms.

6. Fourier transform and its properties. Examples. Discrete-time and discrete Fourier transform.

7. z-transform and its properties. Examples. Solution of linear difference equations using z-transforms.

8. Uniquely decodable and prefix codes. McMillan- and Kraft inequalities. Entropy, average codeword length and their relation. Block codes.

9. Optimal codes. Binary Huffman and Shannon-Fano codes. Examples. Entropy, conditional entropy, mutual information and their properties.

10. Noiseless and noisy channels, channel capacity. Examples. Lempel-Ziv algorithms, examples.

11. Quantization, optimal quantizers. Uniform and non-uniform quantizers. Lloyd-Max condition, Lloyd-Max algorithm. Companding and vector quantizers. Sampling, Nyquist-Shannon sampling theorem.

12. Transform coding, special transformations. Subband-, delta and predictive coding. DPCM, Jayant-quantizer, delta modulation.

13. Speech and audio compression.

14. Image and video compression.

Sándor Baran