

Exam Topics
for the entrance exam for master's program
"Aerospace Engineering and Communications"

1. Mechanics. Principles of dynamics in classical mechanics. Kinetic and potential energy. Momentum. Angular momentum. Conservation Laws in Mechanics. Types of forces.
2. Electric field. Electrostatics. Electrical capacity. Laws of direct current.
3. Magnetic field. Lorentz force. Motion of charged particles in electric and magnetic field.
4. Electromagnetic induction. Faraday's Law. Maxwell's equations.
5. Electromagnetic waves in isotropic media. Propagation velocity, wavelength, wave number. Dielectric materials: permittivity, refractive index. TEM transmission lines – coaxial lines.
6. Direct current circuits. Kirchhoff's law. Voltage dividers. Wheatstone Bridge. Thevenin's theorem. Norton's theorem. RC-circuits, charging and discharging a capacitor. L-R circuits.
7. AC circuits. Signal periodicity concepts. Frequency, waveform. Average signal value, peak-to-peak value and signal rms value. Impedance. LRC-circuits. Resonance. Quality factor. Concept of internal resistance of a signal source and effect of its load.
8. Semiconductor elements. Semiconductor diodes. Types of diodes. Varicap diodes, zener diodes, rectifier diodes, PIN-diodes, LEDs. Characteristics. BJT transistors. Principle of operation and characteristics. Current gain. FET transistors, characteristics, types and parameters. Concept of integrated circuit.
9. Amplifiers. Classification of amplifiers. Class A, B, C. Input and output impedance of amplifiers. Frequency response of amplifiers. Bandwidth. Feedback – positive and negative feedback. Transistor amplifiers. Equivalent circuits, h-parameters. Basic circuits of connection – common emitter, common base, common collector. Determination of the operating point and DC operation mode of the amplifier.
10. Operational amplifiers. Integrated circuit definition, symbols and pinouts. Amplification with and without feedback. Input and output resistance. Parameters – bandwidth, offset voltage, SR, CMRR. Gain and bandwidth - relation via GBW. Connection circuits - inverting and non-inverting amplifier. Symmetry improvement and bandwidth limiting.
11. Logic schemes. Combinational and sequential logic. Truth tables of basic logic circuits. Buffers, inverters, AND circuits, OR, exclusive OR. Bistable circuits. RS-flip-flops, JK-flip-flops, T-flip-flops, D-flip-flops. Counters. Families of logic integrated circuits. TTL and CMOS logic. Logic levels of individual logic ICs and noise margin.

12. Complex numbers. Real and imaginary part, absolute value and phase. Geometric representation. Euler's formula. Product and quotient of complex numbers. Complex functions.

13. Differential and integral calculus. Growth of a function, differential, derivatives. Geometric meaning of the derivative at a point. Integration of a function: indefinite and definite integrals, geometric meaning of the definite integral. Newton-Leibnitz formula. Taylor's series.

14. Linear algebra. Matrices, vectors. Product of matrices, product of matrix and vector. Determinants. Matrix equations. Inverting matrices. Matrix invertibility condition. Methods for inverting matrices: Gaussian elimination, LU-decomposition, adjoint quantity. Eigenvalues and eigenvectors of a matrix.

15. Vector and scalar fields. Vector operations, cross and scalar product. Vector analysis: gradient, divergence, curl. Integration of vector fields.

16. Fourier transform. Real and complex Fourier series. Spectrum, amplitudes, fundamental frequency, harmonic frequencies.

Literature

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- [3] R. Feynman, R. Leighton, M. Sands, *The Feynman Lectures on Physics Vol 2*, https://www.feynmanlectures.caltech.edu/II_toc.html
- [4] I. Lalov, *Electricity, magnetism, optics – the first grand unified theory*, St. Kliment Ohridski University Press, Sofia, 2001, 2008 (in bulgarian)
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- [7] M. Tooley, *Electronic Circuits: Fundamentals and Applications*, 2nd ed. Newnes, 2002.
- [8] G. Strang, *Introduction to Linear Algebra*, 4th ed. Wellesley-Cambridge Press, 2009.
- [9] Edwin Herman, Gilbert Strang, *Calculus*, vol. 1, OpenStax, 2018.
- [10] J. Brown, Ruel V. Churchill, *Complex Variables and Applications*, 8th ed. McGrawHill, 2009.
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- [13] Mary L. Boas, *Mathematical methods in the physical sciences*, 3rd Ed