M.Sc. Program in Internet and Multimedia Engineering
Polytechnic School – University of Genoa, Genoa, Italy

Expected Background Knowledge

Linear Algebra and Geometry. Linear algebra: matrices, linear systems, Gaussian elimination.
Vector spaces: Subspaces, linearly independent vectors, generators (spanning sets), bases, dimension.
Diagonal form of a matrix: eigenvalues, eigenvectors, eigenspaces.
Scalar products. Orthogonal vectors. Orthonormal bases. Orthogonal matrices. Spectral theorem (symmetric matrices are diagonalizable). Quadratic forms.
Analytic geometry of plane: conic sections.
Analytic geometry of space: lines, planes, distances, circles, spheres.

Mathematical Analysis. Numerical sequences. Real functions of one real variable: limits and continuity, infinitesimal order, derivatives and their applications, simple integrals and their applications.
Functions of several variables: continuity, partial derivatives and gradient, double integrals. Ordinary differential equations: linear equations.

Basic University-level Physics. Mechanics, Thermodynamics, Optics, Electro-magnetism.

Basic theory of deterministic analog signals and systems. Fourier transforms and series, linear time-invariant (LTI) systems, convolution operators, filters, power and energy spectral densities.
Minimum expected knowledge: [1], Chapters 2 and 3
More in depth: [4], Chapters 1, 2, 3, and 5

Digitization of analog signals. Sampling theory, pulse code modulation (PCM).
Minimum expected knowledge: [1], Sections. 6.1 and 12.1 (first subsection "PCM generation and reconstruction")
More in depth: [2], Sections. 4.1, 4.2, 4.3, and 4.4

Discrete signals and systems. Discrete Fourier transform (DFT), linear shift-invariant systems.
Minimum expected knowledge: [2], Sections 2.1, 2.2, 2.3, 2.4, 2.5, 8.5, 8.6, and 8.7
More in depth: [2], Chapters 2, 3, 5, 6, 8, and 9

Basic theory of stochastic signals. Probability theory, conditional probabilities, random variables, single-variate and bivariate distributions, moments, stochastic processes, power spectral density, noise
Minimum expected knowledge: [1], Chapters 8 and 9, [8], Chapter 2
More in depth: [5], Chapters 2, 3, 4, 5, 6, 7, and 10

Bandpass analog transmission. Bandpass signals and systems, linear and angular modulations, frequency division multiplexing (FDM)
Minimum expected knowledge: [1], Sections 4.1, 4.2, 4.4, 4.5, 5.1, 5.2 (first subsection "Transmission bandwidth estimates"), and 7.2 (first subsection "Frequency division multiplexing"), [8], Section 4.1

More in depth: [1], Chapters 4, 5, and 10

Optimum receiver theory. Orthonormal basis representation, Gram Schmidt procedure, optimum digital detection, Bayesian decision theory

Minimum expected knowledge: [1], Sections 16.4 and 16.5, [8], Section 4.2

More in depth: [3], Sections 2.1, 2.2, and 2.3

Networking. Network functional architecture and protocol stack. Architecture of the Internet. IP addressing scheme. IP and TCP protocols. Link-layer protocols. Ethernet and IEEE 802.3.

Minimum expected knowledge: network layering principles and architecture, packet switching basics, knowledge of IP, TCP and Ethernet, L2- and L3-switching principles, basic knowledge of application layer protocols.

More in depth: more detailed knowledge of routing principles and protocols, ICMP, TCP congestion control, WLAN and IEEE 802.11, more detailed knowledge of link-layer protocols (HDLC, PPP).

References: [6], [7]. A good (free) online book can be found at http://inl.info.ucl.ac.be/CNP3.

Electro-magnetism and EM Field Theory. It is assumed that all students attending these lectures have an adequate knowledge of transmission lines (telegraph equations in the time and in the frequency domain, voltage or current wave propagation, load and discontinuities, effects of losses, characteristic impedance, propagation, phase and attenuation constants, matched loads and matching networks, resonances), very basic concepts of electromagnetic fields (electric field, magnetic field, magnetic induction, electric displacement, electric current density, electric charge density, Maxwell's equations, Lorentz force equation, plane waves, Poynting and uniqueness theorems) and very basic concept of vector analysis (3D coordinate systems, gradient, divergence and curl operators, divergence and Stokes theorems).

References: [9], [10], [11].

References

[1] Carlson A. B., Crilly P. B., Rutledge J. C.: 2002, *Communication Systems*, 4th ed., Mc Graw-Hill.

[2] Oppenheim A. V., Schafer R. W., Buck J. R.: 1998, *Discrete-time signal processing*, Prentice Hall.

[3] Van Trees H. L.: 1968, *Detection, estimation and modulation theory*, Vol. I, Wiley.

[4] Papoulis A.: 1962, *Fourier integral and its applications*, Mc Graw-Hill.

[5] Papoulis A.: 1989, *Probability, random variables and stochastic processes*, 3rd ed., Mc Graw-Hill.

[6] Kurose J. F., Ross K. W.: *Computer Networking: A Top-Down Approach*, 6th ed. (or a previous one), Addison-Wesley, 2012.

[7] Forouzan B. A.: *TCP/IP Protocol Suite*, 4th ed. (or a previous one), McGraw-Hill, New York, NY, 2010.

[8] Proakis, J.G.: Digital Communications, 3rd Edition, Mc Graw Hill, New York, 1995

[9] Collin R. E.: *Foundations for Microwave Engineering*, McGraw-Hill, New York, 1992.

[10] Collin R. E.: *Field theory of guided waves*, McGraw-Hill, New York, 1960.

[11] Atwater H. A.: *Introduction to Microwave Theory*, McGraw-Hill, New York, 1962.