Computer Graphics

- Cartesian, barycentric, polar, spherical, and homogeneous coordinates. Affine transformations, translation, scaling, sheering. Rotations: Rodrigues' formula, quaternions. Projective transformations.
- Incremental image synthesis, graphics pipeline. Model, view, and projective transformations. Cohen-Sutherland algorithm. Clipping, occlusion, shading. Framebuffer and deferred shading. Shadow map and shadow volume algorithms.
- Ray-surface intersections with plane, triangle, sphere, polygon, AAB. Möller–Trumbore algorithm. Point in polygon problem. Reflected and refracted ray directions.
- Human vision, color perception, computer color systems and coordinates, tone mapping. Physics of light: spectrum, photoelectric effect, wave-particle duality, blackbody radiation, polarization, Michelson–Morley experiment, speed-of-light implications.
- Rendering equation, measuring light intensity, integrating on the unit sphere, integration transform, the fundamental law of photometry, BRDF and its properties, Lambert model, Fresnel reflection, Cook–Torrance model.
- Global illumination methods. Radiosity, form factors, visibility problem. Raycasting, raytracing, path tracing. Monte Carlo raycasting, importance sampling. Light map, photon map.
- Visibility problem: Painter algorithm, Z-buffer, early-Z, Backface- and frustum culling. Spatial data structures, bounding volumes, BVH, uniform grids. Quadtree and octree, KD-tree, BSP-tree, portal culling.
- Comparison of GPU and CPU. Memory handling, caches. Multiscalar architectures, pipelines, lock-step execution, latency hiding. OpenGL or other graphics API. Vertex, tessellation, geometry, and fragment shaders. Compute shaders. Ray tracing and mesh shaders.
- Textures, texture mapping techniques, normal-, bump-, environment-, displacement- mapping. Texture compression, texture antialiasing techniques, mipmapping, anisotropic filtering, Summed Area Table. Texture interpolation methods. Procedural and volume textures. Macrogeometry rendering, per-pixel displacement mapping.
- Volume rendering: participating material, light scattering theory, in-/out-scattering. Transmittance, optical depth, Beer-Lambert law. Phase function, Rayleigh, geometric, and Mie scattering. Real-time implementations, slicing, front-to-back, back-to-front with alpha blending, and transfer functions.
- Curves. Parametric form, Frenet frame. Bézier curves, Bernstein basis, de Casteljau algorithm, properties. Rational Bézier and B-spline curves. Path animation, forward animation, kinematics.
- Geometry representations: surface-, volume-, implicit, parametric models, subdivision surfaces. Winged edge and half-edge mesh representations. CSG, primitives, set-operations. Tensor-product surfaces, Bézier patches, NURBS.

- Farin, G., *Curves and Surfaces for CAGD. A Practical Guide*, 5th ed., Morgan Kaufmann (2002)
- Foley, J. D., van Dam, A., Feiner, S. K., Hughes, J. F., *Fundamentals of Computer Graphics*, 2nd ed., Addison-Wesley (1995)
- Hoffmann, C. M., *Geometric and Solid Modeling: An Introduction*, 2nd. ed., Morgan Kaufmann (1992)
- Akenine-Möller, Tomas; Haines, Eric; Hoffman, Naty (2018). *Real-Time Rendering* (Fourth ed.). ISBN 978-1-1386-2700-0.
- Bálint, Csaba, *Advanced Computer Graphics Slides*, ELTE IK Kari Digitális Könyvtár (2022), https://www.inf.elte.hu/karidigitaliskonyvtar
- Szirmay-Kalos, László, *Számítógépes grafika*, ComputerBooks (2000)
- Szirmay-Kalos, László, *Háromdimenziós grafika, animáció és képszintézis*, ComputerBooks (2003)