GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	3D Graphics, PG_00058858					
Field of study	Informatics					
Date of commencement of studies	February 2025		Academic year of realisation of subject		2024/2025	
Education level	second-cycle studies		Subject group		Optional subject group Specialty subject group Subject group related to scientific research in the field of study	
Mode of study	Full-time studies		Mode of delivery		at the university	
Year of study	1		Language of instruction		Polish	
Semester of study	1		ECTS credits		3.0	
Learning profile	general academic profile		Assessment form		exam	
Conducting unit	Department of Intelligent Interactive Systems -> Faculty of Electronics, Telecommunications and Informatics					
Name and surname of lecturer (lecturers)	Subject supervisor		dr inż. Jacek Lebiedź			
	Teachers		dr inż. Jacek Lebiedź mgr inż. Jerzy Redlarski			

Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	15.0	0.0	0.0	30
	E-learning hours included: 0.0						

Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
	Number of study hours	30	6.0	39.0	75

Subject objectives	The purpose of education is to acquire the skills to design and implementation of 3D graphics systems.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_U08] while identifying and formulating engineering tasks specifications and solving these tasks, can: - apply analytical, simulation and experimental methods, - notice their systemic and non-technical aspects, - make a preliminary economic assessment of suggested solutions and engineering work	The student uses various methods when formulating specifications for graphics software and is also able to make a preliminary economic evaluation of it.	[SU2] Assessment of ability to analyse information
[K7_U01] can apply mathematical knowledge to formulate and solve complex and non-typical problems related to the field of study by: - appropriate selection of source information and its critical analysis, synthesis, creative interpretation and presentation, - application of appropriate methods and tools	Student knows the mathematical foundations of 3D graphics and is able to use them for 3D graphics rendering.	[SU3] Assessment of ability to use knowledge gained from the subject [SU2] Assessment of ability to analyse information [SU1] Assessment of task fulfilment
[K7_W01] knows and understands, to an increased extent, mathematics to the extent necessary to formulate and solve complex issues related to the field of study	Student analyzes the problems and develop appropriate models, data structures and numerical and heuristic algorithms for 3D graphics applications.	[SW1] Assessment of factual knowledge
[K7_U02] can perform tasks related to the field of study as well as formulate and solve problems applying recent knowledge of physics and other areas of science	The student selects the model of visualized object and image generation method, uses specialized libraries for data processing and visualization.	[SU4] Assessment of ability to use methods and tools [SU1] Assessment of task fulfilment

Subject contents	1. Rules of credit for a course, bibliography 2. Rendering pipeline – concept, stages 3. Surface modeling – representations: polygon mesh surfaces, parametric surfaces (Bézier and B-splines surfaces), quadric surfaces 4. Parametric cubic curves and their matrix representation: Hermite curves, Bézier curves – definitions and properties 5. Cubic uniform nonrational B-splines, nonuniform rational B-splines (NURBS), β-splines – definitions and properties 6. Catmull-Rom splines, Kochanek-Bartels splines – definitions and properties 7. Solid modeling – representation comparison criterions, solid representations: analytical, primitive instancing, sweep representation 8. Solid boundary representation (b-rep) – Euler's formula, regularized Boolean set operations 9. Solid spatial-partitioning representation: cuberille (array of voxels), octrees, BSP trees; constructive solid geometry (CSG) – object tree 10. Coordinate systems in 3D space, homogeneous coordinates 11. Affine transformations and their matrix representation: translation, scale, rotation; quaternions representation of rotations 12. Projections: parallel, perspective 13. Visible-surface determination – image-precision algorithms, properties; painter's algorithm 14. Depth-buffer (z-buffer) image-precision algorithm 15. Visible-surface ray tracing 16. Scan-line visible-surface determination algorithm 17. Warnock's algorithm based on 2D spatial partitioning performed by quadtrees 18. Visible-surface determination algorithm for surface defined by function of two variables z = f(x,y) 19. Visible-surface determination – object-precision algorithms, properties; back face culling 20. Ricci's object-precision algorithm 21. Appel's object-precision algorithm 22. Nonrefractive filtered transparency 23. Nonrefractive interpolated transparency, screen-door transparency 24. Refractive filtered transparency – Snell's law, total internal reflection 25. Texturing: concept of texel, texture mapping, perspective correction, procedural textures, volumetric textures, compression of textures 26. Sprites (billboards), multitexturing, environment mapping, bump mapping, displacement mapping 27. MIP mapping, texture filtering: isotropic (bilinear, trilinear, mipped bilinear), anisotropic 28. Phong illumination model: ambient, diffuse (Lambert's law) and specular reflection; reflection coefficients 29. Light-source attenuation, Warn's model for directional light 30. Cook-Torrance model 31. Concept of shading, Mach band effect 32. Gouraud shading – algorithm 33. Gouraud shading – properties and examples 34. Phong shading – algorithm 35. Phong shading – properties and examples 36. Comparison of shading methods 37. Global illumination, rendering equation 38. Recursive ray tracing, primary and secondary rays, depth of analysis 39. Distributed ray tracing, other refinements of ray tracing 40. Radiosity method, radiosity equation 41. Computing form factors in radiosity equation 42. Radiosity method with progressive refinement 43. Advanced shaders: pixel shaders, vertex shaders, geometry shaders, hull shaders, and domain shaders 44. Pixel shaders 45. Vertex shaders
Prerequisites and co-requisites	No requirements

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Written exam	53.0%	50.0%
Practical exercise	60.0%	50.0%

Recommended reading

Basic literature	1. Angel E.: Interactive Computer Graphics. A Top-Down Approach Using OpenGL (3rd Edition). Addison Wesley 2003. 2. Foley J. D., van Dam A., Feiner S. K., Hughes J. F.: Computer Graphics: Principles and Practice, (2nd Edition). Addison-Wesley, Reading 1990. 3. Hill F. S. jr., Kelley S. M.: Computer Graphics using OpenGL (3rd Edition). Pearson Education 2007. 4. Pharr M., Humphreys G.: Physically Based Rendering. From Theory to Implementation (2nd Edition). Morgan Kaufmann 2010. 5. Schneider Ph. J., Eberly D. H.: Geometric Tools for Computer Graphics. Morgan Kaufmann 2003.
Supplementary literature	1. Shreiner D., Sellers G., Kessenich J., Licea-Kane B.: OpenGL Programming Guide. The Official Guide to Learning OpenGL, Version 4.3 (8th Edition). Addison-Wesley 2013. 2. Varcholik P.: Real-Time 3D Rendering with DirectX and HLSL: A Practical Guide to Graphics Programming (Game Design). Addison-Wesley 2014.
eResources addresses	Adresy na platformie eNauczanie:

Example issues/ example questions/ tasks being completed	Implementation of a simple 3D game (e.g. Tetris) using given base program.
Work placement	Not applicable