■ CE89 - Computer Graphics

GENERAL

SCHOOL	EXACT SCIENCES		
DEPARTMENT	MATHEMATICS		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	CE89	**SEMESTER**	H
COURSE TITLE	COMPUTER GRAPHICS		

INDEPENDENT TEACHING ACTIVITIES	**WEEKLY TEACHING HOURS**	**ECTS**
Lectures	4	6

COURSE TYPE	Skills Development
PREREQUISITE COURSES	Introduction to Programming Linear Algebra I-II
LANGUAGE OF TEACHING AND EXAMINATIONS	Greek/English
THE COURSE IS OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	http://eclass.uowm.gr/

LEARNING OUTCOMES

Learning Outcomes

The course aims to familiarize students with the basic concepts of computational graphics, modeling of 2D and 3D objects, application of geometric algorithms/computational geometry, linear algebra and techniques in graphics, development of simple applications using basic algorithms, and using graphical programming interfaces to access the hardware.

Upon successful completion of the course, the student will be able to:

- understand the basic concepts related to Computer Graphics,

- understand the basic concepts and operations of vectors, matrices, signs and the relationships between them,
- be familiar with coordinate systems and their use in graphics, line and ellipsoid algorithms, frame and depth memories,
- understand the basics of color models and their variations, as well as the effects of different choices on each other,
- become familiar with the basic geometric transformations in 2 and 3 dimensions,
- understand and apply 2D and 3D object modeling techniques,
- be familiar with the practical use of the concepts of inner and outer products, perpendicular vectors, vector normalization, locating visible surfaces, and tilting surfaces with respect to light sources.
- understand the orthogonal, side-parallel and perspective projections of objects in space,
- become familiar with basic lighting models, camera parameters, as well as photorealistic techniques based on ray tracing and emitted radiation methods,
- collaborate, where appropriate, with fellow students to create and present simple applications that demonstrate the concepts of each module.

General Competencies

- Independent Work.
- Team work.
- Project Planning and Management.
- Criticism and self-criticism.
- Promotion of free, creative and inductive thinking.

CONTENT OF THE COURSE

The course presents fundamental concepts of graphics, both for 2 and 3 dimensions. Basic concepts of linear algebra and computational geometry are covered for modeling objects in 2D or 3D space. There is an extensive description of the techniques of applying basic transformations, as well as calculating the necessary elements for lighting and determining the visibility of objects. Lighting models are covered, combined with the visible surfaces. The various views used in practice are analyzed. Photorealistic rendering techniques are introduced, which are used both in motion graphics and now in original real-time form. In this context the concept of energy transfer in space is covered.

More specifically, the content of the course covers the following:

<u>Section 1:</u> Concept of vector and point. Operations between vectors and vectors and points. Calculation of inner and outer products. Vector normalization. Vector view. Relationship of inner products and normalization with angles. Relationship of outer factors with left-handed and right-handed systems. Coordinate reference systems. 3x3 and 4x4 matrices. Actions between matrices and matrices-points.

<u>Section 2:</u> Basic color models and actions that reduce color depth. The effects of various options on models and color depths.

<u>Section 3:</u> Frame and depth memories. Mesh description of line segments and

ellipsoids. Relationship between visible and active frame memories. Using depth memory to calculate the visible elements of visualizations.
Section 4: Modeling objects in 2 and 3 dimensions. Lattice model descriptions and parametrics. Description of models based on points/seats and points/sides/seats. Perpendicular vectors of vertices and bases, and use of outer products and Gouraud's method.
Section 5: Basic geometric transformations in 2 and 3 dimensions such as scaling, translation, rotation, warping. Matrix concatenation and complex geometric transformations. Orthogonal, side-parallel and perspective views of spatial objects.
Section 6: Clipping geometric descriptions outside the truncated cone of vision and non-visible seats.
Section 7: Lighting models such as ambient lighting, diffuse lighting, specular lighting, Phong model, intensity fading, spotlights. Refraction and transparent or semi-transparent materials. Surface slope and lighting.
Section 8: Photorealistic graphics with techniques based on casting and ray tracing, as well as emitted radiation.

TEACHING AND LEARNING METHODS - EVALUATION

TEACHING METHOD	In the classroom and computer-lab.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY	Use of specialized software for editing and writing computer graphics applications. Use of e-class. Communication through face-to-face discussions and e-mails.
TEACHING ORGANIZATION	(see table below)
STUDENT EVALUATION	Written final exam (100%) which includes: -Short answer questions,

Activity	**Semester Workload**
Lectures	26 hours
Laboratory Exercises	26 hours
Small Individual Projects	15 hours
Team Project	13 hours
Individual Study	70 hours
Course Total (25 hours per ECTS)	150 hours

	-Problem solving, -Optional exercises and tasks, individual or group, -Comparative evaluation of theory elements. During the semester, individual assignments or group exercises and assignments, as well as a larger optional group assignment covering several subject areas simultaneously, are given to students.

RECOMMENDED BIBLIOGRAPHY

1. Hearn D and Baker MP. 2018. Computer Graphics with OpenGL. 3rd Improved Edition. Greece, Tziola Publications.
2. Theoharis T, Papaioannou G, Platis N and Patrikalakis NM. 2015. Graphics and Visualization: Principles and Algorithms. Greece, Symmetria Publications.
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4. Hughes JF, van Dam A, McGuire M, Sklar DF, Foley JD, Feiner SK and Akeley K. 2013. Computer Graphics: Principles and Practice. 3rd ed. USA, Addison-Wesley.
5. Lengyel E. 2011. Mathematics for 3D Game Programming and Computer Graphics. 3rd ed. USA, Cengage Learning PTR.
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7. Kessenich J, Sellers G and Shreiner D. 2016. OpenGL Programming Guide: The Official Guide to Learning OpenGL, Version 4.5 with SPIR-V. USA, Addison-Wesley.
8. Luna FD. 2016. 3D Game Programming with DirectX 12. USA, Mercury Learning & Information.
9. Haines E and Akenine-Möller T. 2019. Ray Tracing Gems: High-Quality and Real-Time Rendering with DXR and Other APIs. USA, APress.
10. Pharr M, Humphreys G and Jakob W. 2016. Physically Based Rendering: From Theory to Implementation. 3rd ed. USA, Morgan Kaufmann Publishers Inc.
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