COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	**National University of Science and Technology Politehnica Bucharest**
1.2 Faculty	**Electronics, Telecommunications and Information Technology**
1.3 Department	**Applied Electronics and Information Engineering**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Applied Electronics

2. Date despre disciplină

2.1 Course name (ro) (en)				Grafică 3D 3D Graphics			
2.2 Course Lecturer				S.l./Lect. Dr. George Valentin STOICA			
2.3 Instructor for practical activities				S.l./Lect. Dr. Elena Cristina STOICA, S.l./Lect. Dr. George Valentin STOICA			
2.4 Year of studies	4	2.5 Semester	I	2.6. Evaluation type	V	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.07.O.509		2.10 Tipul de notare	Nota

3. Total estimated time (hours per semester for academic activities)

3.1 Number of hours per week	3.5	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	1.5
3.4 Total hours in the curricula	49.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	21
Distribution of time:					hours
Study according to the manual, course support, bibliography and hand notes Supplemental documentation (library, electronic access resources, in the field, etc) Preparation for practical activities, homework, essays, portfolios, etc.					45
Tutoring					0
Examinations					6
Other activities (if any):					0

3.7 Total hours of individual study	51.00
3.8 Total hours per semester	100
3.9 Number of ECTS credit points	4

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Object-Oriented Programming

4.2 Results of learning	General programming, object oriented programming, C/C++/C#/Java programming languages

5. Necessary conditions for the optimal development of teaching activities (where applicable)

5.1 Course	The course will take place in a room equipped with video projector and computer
5.2 Seminary/ Laboratory/Project	The laboratory will take place in a room with specific equipment, which must include: computer, monitor

6. General objective *(Reffering to the teachers' intentions for students and to what the students will be thought during the course. It offers an idea on the position of course in the scientific domain, as well as the role it has for the study programme. The course topics, the justification of including the course in the currcula of the study programme, etc. will be described in a general manner)*

The course's objective consists in a good understanding of the base concepts and specific techniques regarding the computer graphics domain. The course presents the aspects of the three-dimensional geometrical transformations, of the transformations ranging from object modeling to image generation on the computer's display. The course continues with the advanced techniques for image generation and high realistic graphical applications: shading, lighting, natural phenomena, anti-aliasing, texturing.

The applications have the purpose to practice the concepts learned during the courses. The experiments are based on development of graphical applications using different technologies: either using OpenGL graphical library combined with C++ language and GLUT toolkit, either using Java and Java3D technologies. The students could experiment the all the concepts presented during the courses.

7. Competences *(Proven capacity to use knowledge, aptitudes and personal, social and/or methodological abilities in work or study situations and for personal and proffesional growth. They refflect the empolyers requirements.)*

Specific Competences	Application of fundamental knowledge, concepts and methods regarding the architecture of computing systems, microcontrollers, programming languages and techniques. Development of complex software systems: database systems, parallel and distributed systems, multimedia systems, man/machine interfaces.
Transversal (General) Competences	The ability to make decisions in order to solve current or unpredictable problems that arise in the process of operating the systems calculation. Ability to ensure planning and management of information engineering projects. The ability to constantly inform and document for personal and professional development by reading specialized literature.

8. Learning outcomes *(Synthetic descriptions for what a student will be capable of doing or showing at the completion of a course. The learning outcomes reflect the student's acomplishments and to a lesser extent the teachers' intentions. The learning outcomes inform the students of what is expected from them with respect to performance and to obtain the desired grades and ECTS points. They are defined in concise terms, using verbs similar to the examples below and indicate what will be required for evaluation. The learning outcomes will be formulated so that the correlation with the competences defined in section 7 is highlighted.)*

Knowledge	*The result of knowledge aquisition through learning. The knowledge represents the totality of facts, priciples, theories and practices for a given work or study field. They can be theoretical and/or factual.* By graduating this course the students will learn the computer graphic's basic and advanced concepts. These concepts combined with the practical applications allow students to develop complete solutions for computer graphic based applications: graphical applications, virtual reality applications, etc. Students also could develop techniques and methods for modeling, generation and visualization of 3D objects and complex scenes.
Skills	*The capacity to apply the knowledge and use the know-how for completing tasks and solving problems. The skills are described as being cognitive (requiring the use of logical, intuitive and creative thinking) or practical (implying manual dexterity and the use of methods, materials, tools and intrumentation).* Students could develop techniques and methods for modeling, generation and visualization of 3D objects and complex scenes.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Select appropriate bibliographic sources and analyze them. • Respect the principles of academic ethics, correctly citing the bibliographic sources used. • Demonstrates responsiveness to new learning contexts. • Demonstrates collaboration with other colleagues and teaching staff in carrying out teaching activities • Demonstrates autonomy in organizing the learning situation/context or the problem situation to be solved • Demonstrates social responsibility through active involvement in student social life/involvement in academic community events • Promotes/contributes through new solutions related to the specialized field to improve the quality of social life. • Realizes the value of his contribution in the field of engineering to the identification of viable/sustainable solutions to solve problems in social and economic life (social responsibility). • Apply principles of professional ethics/deontology in the analysis of the technological impact of the proposed solutions in the specialized field on the environment.

9. Teaching techniques *(Student centric techniques will be considered. The means for students to participate in defining their own study path, the identification of eventual fallbacks and the remedial measures that will be adopted in those cases will be described.)*

Starting from the analysis of students' learning characteristics and their specific needs, the teaching process will explore both expository (lecture, exposition) and conversational-interactive teaching methods, based on discovery learning models facilitated by direct exploration and indirect of reality (experiment, demonstration, modelling), but also on action-based methods, such as exercise, practical activities and problem solving.

In the teaching activity, lectures will be used, based on Power Point presentations or various 3D simulations that facilitate the understanding of theoretical notions. Each course will start with a recap of the chapters already covered, with an emphasis on the concepts covered in the last course.

The presentations use images, graphic examples and diagrams, so that the information presented is easy to understand and assimilate.

This discipline covers information and practical activities designed to support students in their learning efforts and the development of optimal collaborative and communicative relationships in a climate conducive to discovery learning.

It will be considered the practice of active listening and assertive communication skills, as well as feedback construction mechanisms, as ways of regulating behavior in various situations and adapting the pedagogical approach to the students' learning needs.

The ability to model and 3D representation of objects and graphic phenomena will be practiced.

Teamwork skills will be practiced to solve different learning tasks.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction to 3D graphics 1.1. Preview of the 3D graphic domain 1.2. The components of a 3D generation system	2
2	Graphical libraries. OpenGL 2.1. Reference systems, coordinate systems, color systems 2.2. The OpenGL graphical library. The GLUT toolkit 2.3. The OpenGL‘s components. Basic operations. Basic objects.	2
3	Object modeling 3.1. Modeling techniques 3.2. Polygonal model: polygon representation, polyhedron representation, polygonal model implementation	4
4	Geometric transformations 4.1. Vector based operations 4.2. Three-dimensional geometric transformations 4.3. Three-dimensional primitive transformations: translation, rotations, scaling 4.4. Homogenous coordinate system. Transformation definitions 4.5. Geometric transformations composition. Inverse Transformations. Reference systems changing 4.6. Modeling transformations	4
5	Viewing systems 5.1. Viewing systems definition 5.2. Viewing transformation 5.3. Projection transformation: parallel projection, perspective projection 5.4. Normalized coordinate system 5.5. 3D screen coordinate transformation 5.6. Rasterization: line generation, polygon generation	4
6	Optimization techniques 6.1. Object Clipping: the definition of clipping, two-dimensional clipping. „Sutherland-Hodgman” clipping method. Viewing volume clipping 6.2. Hidden-surface removal: hidden-surface removal in object space, hidden-surface removal in object space - Z-buffer algorithm, culling, hidden coplanar surfaces	4

7	Reflection and lighting models 7.1. Theoretical aspects of light reflection. Phong reflection model 7.2. Shading models. Gouraud shading model. Phong shading model. 7.2. Natural phenomena generation	2
8	Bump mapping 8.1 Bump mapping technique Ray-tracing 9.1 Ray tracing algorithms Anti-aliasing 10.1. Theoretical aspects of aliasing 10.2. Anti-aliasing techniques	2
9	Texture mapping 11.1. Texture mapping 11.2. Texture filtering	2
10	Final test	2
	Total:	28

Bibliography:
- Stoica George Valentin, Note curs Grafica 3D, https://curs.upb.ro/2021/course/view.php?id=9124
- Felicia Ionescu, *Grafica in Realitatea Virtuala*, Editura Tehnica, Bucuresti 2000.
- A. Watt, 3D Computer Graphics, Addison-Wesley, 1992.
- OpenGL, GLUT: http://www.opengl.org/documentation/.
- Java 3D: http://java.sun.com/products/java-media/3D/
- Felicia Ionescu, Valentin Stoica: Indrumar de laborator de Grafica 3D

LABORATORY		
Crt. no.	**Content**	**No. hours**
1	Graphical libraries: OpenGL	3
2	Object modeling	3
3	Viewing systems	3
4	Reflection and lighting models	3
5	Texture mapping	3
6	Virtual scenes modeling and rendering 1	3
7	Practical evaluation	3
	Total:	21

Bibliography:
- Stoica George Valentin, Note curs Grafica 3D, https://curs.upb.ro/2021/course/view.php?id=9124
- Felicia Ionescu, *Grafica in Realitatea Virtuala*, Editura Tehnica, Bucuresti 2000.
- A. Watt, 3D Computer Graphics, Addison-Wesley, 1992.
- OpenGL, GLUT: http://www.opengl.org/documentation/.
- Java 3D: http://java.sun.com/products/java-media/3D/
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11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	knowledge of fundamental theoretical notions knowledge of techniques and algorithms for generating 3D images	Final test during the semester, the topics cover the whole field, providing a synthesis of comparative theoretical material, covering and explaining the exercises and problems of application patterns.	60%
11.5 Seminary/laboratory/project	Knowledge of commonly used 3D graphics technologies and their practical application.	Practical activity evaluation - comprehensive practice when a component is assessed by verifying the implementation, testing and operation regarding specific practical problems in 3D graphics programming.	40%
11.6 Passing conditions			
0% of total grades.			

12. Corroborate the content of the course with the expectations of representatives of employers and representative professional associations in the field of the program, as well as with the current state of knowledge in the scientific field approached and practices in higher education institutions in the European Higher Education Area (EHEA)

Computer graphics is a technology that has changed and continues to change the approach in many practical applications such industry, medicine, education, research, arts and entertainment.

The graphics using calculation allows the generation of images from three-dimensional models of objects that make up the virtual scene. Two performance requirements of graphics systems are vital: realism and generate the images in real time. These requirements involve both software issues, the selection of the most appropriate algorithms for image generation and hardware issues, achievement of modern equipment to ensure realism and speed of generating images in 3D graphics. Multiprocessor Workstations and implementing hardware graphics accelerators imager algorithms are based on virtual reality equipment and technological developments have allowed the use of a huge number of virtual reality applications , available now for various categories the user .

Computer graphics has a multitude of applications: making user interfaces developed in many utilities and programming environments, computer-aided design (CAD - Computer Aided Design), graphical presentations, interactive scientific data visualization, multimedia technology.

The course combines theoretical aspects and implementation of graphics image generation three-dimensional virtual objects and scenes. In the early hours are presented basic operations in computer graphics: modeling three-dimensional objects, geometric transformations in space visualization systems, raster transformation. It also presents advanced aspects of image generation three-dimensional (anti - aliasing, shading, texturing), both from a theoretical perspective and the approach in programming. Resume the practice of all these aspects of image generation in terms of programming, using graphics library OpenGL, GLUT and system development in virtual reality modeling language VRML.

After completing this course, students are learning the basics and the advanced three-dimensional graphics. This knowledge combined with laboratory applications covering gives the opportunity to develop complete applications for three-dimensional graphics, virtual reality, or, more generally, a wide range of graphics applications.

Also , students will be able to develop techniques and methods for modeling , generation , three-dimensional visualization of objects or scenes

Date	Course lecturer	Instructor(s) for practical activities
25.10.2024	S.l./Lect. Dr. George Valentin STOICA	S.l./Lect. Dr. Elena Cristina STOICA
		S.l./Lect. Dr. George Valentin STOICA

Date of department approval	Head of department
	Conf. Dr. Bogdan Cristian FLOREA

Date of approval in the Faculty Council	Dean
	Prof. Dr. Ing. Radu-Mihnea UDREA