Course guide
804232 - FIS2VJ - Physics II

Last modified: 15/09/2024

Unit in charge: Image Processing and Multimedia Technology Centre
Teaching unit: 804 - CITM - Image Processing and Multimedia Technology Centre.

Degree: BACHELOR'S DEGREE IN VIDEO GAME DESIGN AND DEVELOPMENT (Syllabus 2014). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** Catalan, English

LECTURER

Coordinating lecturer: Manel Rello

Others: Manel Rello
Eduard Garcia
Muriel Rovira
Christian Martínez

PRIOR SKILLS

Knowledge about Physics and coding.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Generical:
CGFC1VJ. Design, develop, select and evaluate applications and computer systems from 0 for video games, ensuring their reliability, security and quality, in accordance with ethical principles and current legislation and regulations.
CGFB2VJ. Interpret and master the basic concepts of the general laws of mechanics, thermodynamics, fields and waves and electromagnetism; and their application for solving engineering problems.
CGFB1VJ. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; integral and differential calculus; numerical methods; statistics.

Transversal:
05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

TEACHING METHODOLOGY

Theory classes consist of:

- Exposition of physics concepts, examples of application to video games.

- Physics exercises.

Practice classes consist of training exercises of the course APIs (Box2D).

The activity times will be modulated according to the complexity of the exercises and the corresponding contents.

Support material will be used and will be made available to the students through Atenea.

LEARNING OBJECTIVES OF THE SUBJECT

- Know and understand the principles of mechanics typically associated with video game development: direct and inverse kinematics; motion of rigid and articulated solids, deformation of solids and collision detection.

- Ability to create games based on 2D physics simulations.

- Be able to apply physics models to 2D video games and simulations.

- Understand the structure of the Box2D library.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	16,0	10.67
Self study	90,0	60.00
Hours large group	34,0	22.67
Guided activities	10,0	6.67

Total learning time: 150 h

CONTENTS

Physics and Maths Review

Description:
Review of the physical concepts given in Physics 1 and basics calculus tools:
- Overview on vector and differential calculus.
- Coordinate systems. Relative position of physical bodies in the 3D space and collisions.
- Kinematics 1D, 2D and 3D.
- Dynamics: motion under forces, non-frictional and frictional systems.
- Momentum balance and collisions 1D and 2D (purely elastic, inelastic, breakage).
- Integration and Transformations.

Full-or-part-time: 18h 50m
Theory classes: 3h 30m
Practical classes: 2h
Self study : 13h 20m

Rigid Body Dynamics

Description:
Description of kinematics and dynamics of the rigid body:
- Review on matrix calculus.
- Momentum conservation. Angular momentum.
- Center of mass. Inertia.
- Rotational movement 2D and 3D: Pure translation and pure rotation.
- Rotational dynamics 2D and 3D: forces and torques.
- Rigid body transformation: 2D and 3D displacement and rotation, deformation.

Full-or-part-time: 21h 40m
Theory classes: 4h
Practical classes: 2h 40m
Self study : 15h

Integrator and Framerate

Description:
Numerical integration methods:
- Implicit Euler.
- Symplectic Euler.
- Velocity-Verlet & Störmer-Verlet.
- High order Runge-Kutta.

Framerate control methods:
- Types: fixed, variable, hybrid.
- Sub-stepping and advanced methods.
- Multiplayer syncronicity.

Related activities:
Project Theory

Full-or-part-time: 23h 40m
Theory classes: 4h 20m
Practical classes: 4h 20m
Self study : 15h

Collisions

Description:
- Elastic vs dampening.
- Collision solving methods.
- Raycasting.

Related activities:
Project Theory

Full-or-part-time: 35h
Theory classes: 8h
Practical classes: 12h
Self study : 15h

Physics Forces

Description:
Main physics forces applied to videogames:
- Gravity: constant, scaled, lineal, universal law of gravitation, ropes and cables.
- Aerodynamics: lift, drag.
- Hydrodynamics: flotación, drag, sustentación.
- Oscillations: harmonic motion, springs.
- Electromagnetism and light.

Full-or-part-time: 27h 20m
Theory classes: 6h
Practical classes: 6h 20m
Self study : 15h

Box2D integration

Description:
- Analyzing the Box2D API.
- Integration plan.
- Binding creation.
- Collision detection.
- Physics simulation.

Full-or-part-time: 23h 30m
Theory classes: 6h 50m
Self study : 16h 40m

ACTIVITIES

Project Box2D (Pinball)

Description:
The objective is to learn to use the Box2D physics library.
- The students shall use Box2D as a physics engine to create a Pinball game.

Activities:
- Defining goals and limitations.
- Creating a environment for simulations.
- Coding the interactive elements.
- Victory conditions.

Related competencies :
CGFB1VJ. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; integral and differential calculus; numerical methods; statistics.
CGFB2VJ. Interpret and master the basic concepts of the general laws of mechanics, thermodynamics, fields and waves and electromagnetism; and their application for solving engineering problems.
CGFC1VJ. Design, develop, select and evaluate applications and computer systems from 0 for video games, ensuring their reliability, security and quality, in accordance with ethical principles and current legislation and regulations.
05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

Full-or-part-time: 11h
Self study: 8h
Guided activities: 3h

Project Box2D (Raging Game)

Description:
The objective is to learn to use the Box2D physics library.
- The students shall use Box2D as a physics engine to create a Racing car game (or alike).

Activities:
- Definition of the goals and limitation of racing games.
- Creating the environment for the simulations.
- Car creation.
- Victory conditions.

Related competencies :
CGFB2VJ. Interpret and master the basic concepts of the general laws of mechanics, thermodynamics, fields and waves and electromagnetism; and their application for solving engineering problems.
CGFC1VJ. Design, develop, select and evaluate applications and computer systems from 0 for video games, ensuring their reliability, security and quality, in accordance with ethical principles and current legislation and regulations.
CGFB1VJ. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; integral and differential calculus; numerical methods; statistics.
05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

Full-or-part-time: 16h
Self study: 12h
Guided activities: 4h

GRADING SYSTEM

The grade of the course will be obtained following a continuous evaluation system. The weight of each part is as follows:

Theory: 45%.

- Continuous evaluation: 10%.
- Midterm exam: 15%.
- Final exam: 20%.

Laboratory: 45%

- Pinball project: 15%
- Pinball Project Presentation: 5%
- Racing Game Project: 20%
- Presentation of Racing Game Project: 5%.

Participation and attitude towards learning: 10% (5% theory, 5% practice).

Students who fail will have the chance to take the reevaluation exam. The mark of this exam will replace the mark of the midterm and final exams and, in case of passing the course, the maximum final mark will be 5.

Irregular actions that may lead to a significant variation of the grade of one or more students constitute a fraudulent performance of an evaluation act. This action entails the descriptive grade of failure and a numerical grade of 0 for the ordinary global evaluation of the course, without the right to re-evaluation.

If the lecturers have indications of the use of AI tools not allowed in the evaluation tests, they may summon the students concerned to an oral test or a meeting to verify the authorship.

EXAMINATION RULES.

In-class exercises:
During the lectures, students will develop exercises to be discussed and solved in the same lecture. These exercises will be useful to do the projects.

Projects:
The projects will be done in groups and they will be delivered before the established deadline. The delivery includes de developed code, a functional release of the game, and a technical report if necessary.

BIBLIOGRAPHY

Basic:
- Eberly, David H. Game Physics. 2nd ed. Morgan Kaufmann, 2010. ISBN 978-0123749031.
- Bourg, David M. Physics for game developers . 2nd ed. Beijing: O'Reilly, 2013. ISBN 978-1449392512.

Complementary:
- Palmer, Grant. Physics For Game Programmers. 1st ed. Apress, 2005. ISBN 978-1590594728.
- Millington, Ian. Game Physics Engine Development. 2nd ed. CRC Press, 2017. ISBN 1138403121.
- Parberry, I. Introduction to game physics with Box2D. 1st ed. Boca Raton: CRC Press, 2013. ISBN 9781466565760.
- Szauer, Gabor. Game Physics Cookbook. 1st ed. Packt Publishing, 2017. ISBN 978-1787123663.
- van den Bergen, Gino. Game Physics Pearls. 1st ed. CRC Press, 2010. ISBN 978-1-56881-474-2.
- Ericson, Christer. Real-Time Collision Detection. 1st ed. Morgan Kaufmann, 2005. ISBN 978-0080474144.
- Emperore, K; Sherry, D. Unreal Engine Physics Essentials. 1st ed. Packt Publishing, 2015. ISBN 978-1-78439-490-5.
- Harbour, Jonathan S. Multi-Threaded Game Engine Design. 1st ed. Course Technology PTR, 2010. ISBN 1435454170.
- Sanglard, Fabien. Game Engine Black Book: Doom. Version 1.1. Independently published, 2019. ISBN 978-1099819773.
- Sanglard, Fabien. Game Engine Black Book: Wolfenstein 3D. Version 2.1. Independently published, 2019. ISBN 978-1070515847.

RESOURCES

Hyperlink:
- GDC (Game Developer's Conference). https://www.youtube.com/c/Gdconf- SIGGRAPH (Association for Computing Machinery's (ACM) Special Interest Group on Computer Graphics and Interactive Techniques). https://www.youtube.com/user/ACMSIGGRAPH