



## Course guides

### 804231 - MAT2VJ - Mathematics II

**Last modified:** 14/09/2021

**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:** 2021    **ECTS Credits:** 6.0    **Languages:** Catalan, Spanish, English

#### LECTURER

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**Coordinating lecturer:** Angulo Bahon, Cecilio

**Others:** Cayero Becerra, Julián Francisco  
Pfeiffle, Julian

#### PRIOR SKILLS

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Basic knowledge in linear algebra

#### REQUIREMENTS

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None

#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Generical:**

CGFB1VJ. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; integral and differential calculus; numerical methods; statistics.

**Transversal:**

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

07 AAT N2. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.

04 COE N1. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 1. Planning oral communication, answering questions properly and writing straightforward texts that are spelt correctly and are grammatically coherent.

CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

#### TEACHING METHODOLOGY

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Lectures, Practical classes and code labs



## LEARNING OBJECTIVES OF THE SUBJECT

- Describe and manipulate 2D and 3D geometric objects. Points, lines and planes.
- Transform geometric objects by translations, rotations and symmetries.
- Projection of 3D objects on a plane.
- Build geometric elements and define trajectories of animations in a 3D space.
- Interpret the conical and cylindrical perspectives.
- Know and use tools for 3D graphical production.
- Use differential equations for problems model and resolution, in particular those related with physical simulation.

## STUDY LOAD

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

**Total learning time:** 150 h

## CONTENTS

### Vectors. 2D and 3D Geometry

**Description:**

Vectors in  $R^2$ . Scalar product in  $R^2$ . Vector product in  $R^2$ : rotations. Complex numbers.

Vectors in  $R^3$ . Scalar product in  $R^3$ . Vector product in  $R^3$ .

Matrices. Matrices and vector products in  $R^3$ .

Determinants, inverse and adjoint matrices.

**Related competencies :**

CGFB1VJ. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; integral and differential calculus; numerical methods; statistics.

**Full-or-part-time:** 6h

Practical classes: 2h

Self study : 4h

### Differential calculus with several variables.

**Description:**

Functions in several variables. 2D objects given by contour lines. 3D objects given by level surfaces.

Vector-valued functions. Parameterized curves. Curvature and torsion.

Functions in several variables with vectorial values. Parameterized surfaces.

Coordinate systems.

**Full-or-part-time:** 8h

Theory classes: 4h

Practical classes: 4h

### Geometric transformations in 2D and 3D.

**Description:**

Linear transformations.  
Scale transformations.  
Orthogonal matrices. Orientation  
Rotations. Derivation of the rotation matrix. Euler's theorem.

**Full-or-part-time:** 48h

Theory classes: 10h  
Practical classes: 6h  
Guided activities: 2h  
Self study : 30h

### Geometry for lighting and shading.

**Description:**

Blinn-Phong lighting model.  
Diffuse reflection. Specular reflection. Reflection of the environment and emissivity.  
Tangent space. Calculation of tangent vectors. Construction of relief map.  
Normal vector to a surface.

**Full-or-part-time:** 14h

Theory classes: 4h  
Practical classes: 2h  
Self study : 8h

### Interpolation (I)

**Description:**

Interpolation between two points.  
Weighted means and affine combinations.  
Three points Interpolations. Barycentric coordinate system.  
Bilinear interpolation. Projected convexity's condition. Inverse of bilinear interpolation.

**Full-or-part-time:** 18h

Theory classes: 8h  
Practical classes: 2h  
Guided activities: 2h  
Self study : 6h

### Interpolation (II): Bézier curves, B-Splines, NURBS.

**Description:**

Bézier curves.  
Particular case of Bézier curves for degree 3.  
Method of De Casteljau.  
Recursive subdivision.

**Full-or-part-time:** 16h

Theory classes: 6h  
Practical classes: 2h  
Guided activities: 2h  
Self study : 6h



### Ray-Tracing. Intersections

**Description:**

Basic Ray-Tracing  
Intersection with rays.

**Full-or-part-time:** 14h

Theory classes: 4h  
Practical classes: 2h  
Guided activities: 2h  
Self study : 6h

### Animation

**Description:**

Animation of position.  
"Ease in": fixed object.  
"Ease in": moving object.  
Application of orientation representations in animation.

**Full-or-part-time:** 8h

Theory classes: 2h  
Practical classes: 2h  
Self study : 4h

### Kinematics

**Description:**

Articulated rigid joints.  
Direct kinematics.  
Inverse kinematics.

**Full-or-part-time:** 18h

Theory classes: 8h  
Practical classes: 2h  
Guided activities: 2h  
Self study : 6h

## GRADING SYSTEM

The final qualification will be calculated from the different evaluation items:

- Virtual class exercises: 10%
- Laboratory exercises (4): 30%
- Project: 15%
- Partial exam: 15%
- Final Exam: 30%

If the pass mark is not obtained, there is the possibility of a reevaluation exam. The qualification of this examen will substitute those of the partial and final exams (45% of the final qualification). The maximum mark to be obtained in the reevaluation is 5.

## EXAMINATION RULES.

All the activities and deliveries will be mandatory, if not completed they will be graded 0.



## BIBLIOGRAPHY

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### Basic:

- Dunn, F.; Parberry, I. 3D math primer for graphics and game development. 2nd ed. Boca Raton, Florida, EUA: CRC Press, 2011. ISBN 9781568817231.
- Gortler, Steven J. Foundations of 3D computer graphics. Cambridge, MA: MIT Press, 2012. ISBN 9780262017350.
- Buss, Samuel R. 3-D computer graphics: a mathematical introduction with OpenGL. Cambridge [etc.]: Cambridge University Press, 2003. ISBN 0521821037.
- Lengyel, Eric; Smith, Emi. Mathematics for 3D game programming and computer graphics, third edition. 3rd ed. Boston: Cengage Learning, 2011. ISBN 1435458869.