

# Course guide

## 240021 - 240021 - Geometry

**Last modified:** 16/05/2023

**Unit in charge:** Barcelona School of Industrial Engineering  
**Teaching unit:** 749 - MAT - Department of Mathematics.

**Degree:** BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Compulsory subject).

**Academic year:** 2023    **ECTS Credits:** 6.0    **Languages:** Catalan, Spanish

### LECTURER

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**Coordinating lecturer:** M.DEL CARMEN HERNANDO MARTIN - BERNAT PLANS BERENGUER

**Others:**

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

1. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.

### TEACHING METHODOLOGY

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Each 4h/week teaching time will be distributed in 2 h theory sessions and 2 h problems sessions.

Theory sessions will develop in large groups. In these sessions, the professor presents the subject's main concepts, and illustrates them with many examples and typical applications.

Problems sessions will develop in small groups. Problem's professor will announce in advance which problems will be discussed in class. Students should use this margin of time to try and solve part of these exercises on their own. This autonomous resolution can be individual, in group, or with the support of a mentor. Anyway, it is expected that by the end of the course each student is capable of solving part of the problems individually.

The problem's professor will discuss in class those proposed problems, this way students will be able to compare their solution with the professor's (based in major subject's practice and fluency) and can see how to overcome those parts in which he/she made any mistakes or got stuck.

An additional activity will take place during the problems sessions. This activity will consist in solving typical exercises of the topic by means of Octave/ MATLAB software. Students will have at their disposal autolearning material to consolidate the knowledgment of these tools. Students shall pass autovalidation tests in order to be evaluated for this part of the topic. This part is considered practicum and not subject to reevaluation.

As a complement to facilitate autonomous learning, students will be offered (by telematic means) more problems than those seen in class, together with collections of solved problems, subject's theory resume summaries, and a Octave/MATLAB guide to execute the most common calculations and graphic representations.



## LEARNING OBJECTIVES OF THE SUBJECT

The module's general objective is that the student learns the syllabus basic concepts, between Linear Algebra and Geometry, and applies them, manually or with a machine, for plane and spatial graphic representation, and other problems that can be represented using projection knowledge.

Specific objectives:

- Familiarise the student with numeric approximation based on orthogonal projection: minimum squares method. Prepare the student to use different reference systems, fix and mobile, in the plane and in space.
- Introducing differential varieties as points places in which links are accomplished and study them via linear approximation: tangent and normal spaces, linked extremes.
- Preparing the student for geometric modelling, presenting parametrization of curves and surfaces, splines, Bézier's curves and surfaces.

## STUDY LOAD

| Type              | Hours | Percentage |
|-------------------|-------|------------|
| Hours small group | 6,0   | 4.00       |
| Self study        | 90,0  | 60.00      |
| Hours large group | 54,0  | 36.00      |

**Total learning time:** 150 h

## CONTENTS

### 1.- Linear varieties

**Description:**

Plane's and space's affine geometry: straight lines, planes, implicit and parametric equations, coordinate systems.

**Related competencies :**

CE1. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.

**Full-or-part-time:** 13h

Practical classes: 3h

Self study : 10h

### 2.- Inner products and quadratic forms

**Description:**

1. Euclidean scale product.
2. Orthogonal projection.
3. Quadratic forms and symmetric matrices

**Related competencies :**

CE1. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.

**Full-or-part-time:** 30h

Theory classes: 7h

Practical classes: 5h

Self study : 18h



### 3.- Numeric linear algebra

**Description:**

1. Least squares.
2. Singular value decomposition (SVD).
3. Error propagation in linear systems.

**Related competencies :**

CE1. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.

**Full-or-part-time:** 23h

Theory classes: 3h  
Practical classes: 4h  
Self study : 16h

### 4.- Rigid motion

**Description:**

1. Isometries in plane and space.
2. Plane and spatial displacements.
2. Euler's angles.

**Related competencies :**

CE1. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.

**Full-or-part-time:** 31h

Theory classes: 5h  
Practical classes: 6h  
Self study : 20h

### 5.- Implicit varieties

**Description:**

1. Implicit equations, dimension, Tangent space and normal space. Singular points.
2. Linked extremes (Lagrange multipliers).

**Related competencies :**

CE1. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.

**Full-or-part-time:** 28h

Theory classes: 5h  
Practical classes: 5h  
Self study : 18h

## 6.- Parametrized varieties

### Description:

1. Parametrizations, tangent and normal space, regular curves. Implicite function theorem.
2. Conics.
3. Bézier curves and splines.
4. Spherical and cylindric coordinates.
5. Surfaces of revolution.

### Related competencies :

CE1. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.

### Full-or-part-time: 25h

Theory classes: 5h

Practical classes: 5h

Self study : 15h

## 7.- Curvature

### Description:

1. Curvature of plane curves. Osculating circle.
2. Curvature and torsion of space curves. Frenet's trihedron. Osculating plane and circle.

### Related competencies :

CE1. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.

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

Theory classes: 3h

Self study : 5h

## ACTIVITIES

### GEOMETRY PRACTICES WITH MATLAB

### Description:

Using MATLAB software to practise:

- Subject's calculations: distances, areas and volumes, least square approximation, SVD, motion.
- Calculations based on the subject: local extremes, regression lines, error propagation...
- Graphic representation of curves and surfaces.

### Full-or-part-time: 9h

Practical classes: 3h

Self study: 6h



## GRADING SYSTEM

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The student's final mark will be calculated by the following evaluation systems:

- Partial exam in the middle of the semester (mark=PAR).
- Octave/Matlab exam (mark=MAT).
- Final exam of the subject (mark=FI).

The formula which will determine the final mark will be:

$$\text{Final mark} = \max \{0.1 \cdot \text{MAT} + 0.3 \cdot \text{PAR} + 0.6 \cdot \text{FI}, 0.1 \cdot \text{MAT} + 0.9 \cdot \text{FI}\}$$

## EXAMINATION RULES.

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The student is allowed to take a subject's handwritten formulary to the partial and final exam.

To be eligible for the Octave/Matlab exam the student must have passed the autovalidation tests.

## BIBLIOGRAPHY

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### Basic:

- Hernández, Eugenio. Álgebra lineal y Geometría [on line]. 3a ed. Madrid: Pearson, 2012 [Consultation: 14/07/2022]. Available on: [https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB\\_BooksVis?cod\\_primaria=1000187&codigo\\_libro=1210](https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=1210). ISBN 9788478291298.

### Complementary:

- Palais, Richard S.. A modern course on curves and surfaces [on line]. Virtual Math Museum, 2003 [Consultation: 08/07/2022]. Available on: [http://virtualmathmuseum.org/Surface/a/bk/curves\\_surfaces\\_palais.pdf](http://virtualmathmuseum.org/Surface/a/bk/curves_surfaces_palais.pdf).
- Gallier, Jean. Geometric Methods and Applications For Computer Science and Engineering [on line]. 2nd ed. New York: Springer, 2011 [Consultation: 08/09/2020]. Available on: <https://doi.org/10.1007/978-1-4419-9961-0>. ISBN 9781441999603.

## RESOURCES

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### Other resources:

Students will have telematic access to:

- A summary of the subject's theory organized by topics.
- A collection of problems to do in class.
- A collection of additional problems to those done in class.
- A collection of resolution to some of these problems.
- A MATLAB function library to execute the subjects basic operations.

R.S. Palais' book can be legally and freely downloaded from the above editor's website.