



## Teaching Guide

| Teaching Guide           |                                                                                                                                       |        |                      |           |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------|-----------|
| Identifying Data         |                                                                                                                                       |        |                      | 2023/24   |
| Subject (*)              | Kinematics and Dynamics of Industrial Robots                                                                                          |        | Code                 | 730497228 |
| Study programme          | Mestrado Universitario en Enxeñaría Industrial (plan 2018)                                                                            |        |                      |           |
| Descriptors              |                                                                                                                                       |        |                      |           |
| Cycle                    | Period                                                                                                                                | Year   | Type                 | Credits   |
| Official Master's Degree | 2nd four-month period                                                                                                                 | Second | Optional             | 3         |
| Language                 | Spanish                                                                                                                               |        |                      |           |
| Teaching method          | Face-to-face                                                                                                                          |        |                      |           |
| Prerequisites            |                                                                                                                                       |        |                      |           |
| Department               | Enxeñaría Naval e Industrial                                                                                                          |        |                      |           |
| Coordinador              | Ramil Rego, Alberto                                                                                                                   | E-mail | alberto.ramil@udc.es |           |
| Lecturers                | Ramil Rego, Alberto                                                                                                                   | E-mail | alberto.ramil@udc.es |           |
| Web                      |                                                                                                                                       |        |                      |           |
| General description      | Acquire the basic knowledge that allows a kinematics and dynamics of robotic manipulators. Develop applications using computer tools. |        |                      |           |

## Study programme competences

| Code | Study programme competences                                                                                                                                                                                                               |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| B1   | CB6 - Possess and understand knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, often in a research context.                                                                 |
| B2   | CB7 - That students know how to apply the knowledge acquired and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.                         |
| B6   | G1 - Have adequate knowledge of the scientific and technological aspects in Industrial Engineering.                                                                                                                                       |
| B13  | G8 - Apply the knowledge acquired and solve problems in new or unfamiliar environments within broader and multidisciplinary contexts.                                                                                                     |
| C1   | ABET (a) - An ability to apply knowledge of mathematics, science, and engineering.                                                                                                                                                        |
| C3   | ABET (c) - An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. |
| C8   | ABET (h) - The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.                                                                                    |
| C11  | ABET (k) - An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.                                                                                                                     |

## Learning outcomes

| Learning outcomes                                                                          | Study programme competences |                           |                    |
|--------------------------------------------------------------------------------------------|-----------------------------|---------------------------|--------------------|
| Acquire the basic knowledge that allows a kinematics and dynamics of robotic manipulators. |                             | BJ1<br>BJ2<br>BJ6<br>BJ13 | CJ1<br>CJ11        |
| Develop applications using computer tools.                                                 |                             | BJ2<br>BJ13               | CJ3<br>CJ8<br>CJ11 |

## Contents

| Topic | Sub-topic |
|-------|-----------|
|-------|-----------|



|                         |                                                                                                                                                                                                                                                          |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Introduction         | 1.1 Introduction<br>1.2 Classification of manipulators<br>1.3 Rotation matrices. Representation by means of axis-angle; Angles (Roll-Pitch-YaW); Euler angles and quaternions.<br>1.4 Homogeneous transformations.<br>1.5 Composition of transformations |
| 2. Direct Kinematics    | 2.1 Direct Kinematics.<br>2.2 Denavit-Hartenberg Convention.<br>2.3 Obtaining transformation matrices.<br>2.4 Speeds and rotations.<br>2.5 Jacobian of the manipulator.<br>2.6 Singularities.                                                            |
| 3. Manipulator Dynamics | 3.1 Dynamics of the manipulator.<br>3.2 Newton-Euler and Euler-Lagrange equations.<br>3.3 Movement control.                                                                                                                                              |
| 4. Reverse Kinematics.  | 4.1 Reverse Kinematics.<br>4.2 Ambiguities.<br>4.3 Application to an arm with 6 DOF.                                                                                                                                                                     |

| Planning                                                                                                                        |                        |                      |                               |             |
|---------------------------------------------------------------------------------------------------------------------------------|------------------------|----------------------|-------------------------------|-------------|
| Methodologies / tests                                                                                                           | Competencies           | Ordinary class hours | Student's personal work hours | Total hours |
| Guest lecture / keynote speech                                                                                                  | B6 C1 C8 C11           | 8                    | 16                            | 24          |
| Problem solving                                                                                                                 | B13 B6 C1 C11          | 4                    | 12                            | 16          |
| ICT practicals                                                                                                                  | B1 B2 B13 C3 C11       | 6                    | 12                            | 18          |
| Supervised projects                                                                                                             | B1 B2 B13 B6 C1 C3 C11 | 3                    | 12                            | 15          |
| Personalized attention                                                                                                          |                        | 2                    | 0                             | 2           |
| (*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. |                        |                      |                               |             |

| Methodologies                  |                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Methodologies                  | Description                                                                                                                                                                                                                                                                                                                                                                                                    |
| Guest lecture / keynote speech | Oral presentation complemented with the use of audiovisual media to develop the program of the subject and make explanations and examples that allow the understanding of the principles of the subject to be able to apply them to practical examples.                                                                                                                                                        |
| Problem solving                | Resolution of problems corresponding to the different subjects of the program in order to understand the theoretical principles and know their practical application, comparing different methods highlighting the advantages of each.                                                                                                                                                                         |
| ICT practicals                 | Application of various computer applications to facilitate calculations in solving problems and illustrate the results with simulations of movements of different manipulators.                                                                                                                                                                                                                                |
| Supervised projects            | Objective test of resolution of a practical case of development of an application with the robot that allows a continuous evaluation of the degree of acquisition of the different competences including theoretical knowledge and the use of different computer applications. The student must follow a series of steps that will be supervised by the teacher, delivering each of them in electronic format. |

| Personalized attention |             |
|------------------------|-------------|
| Methodologies          | Description |



|                                                                                               |                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| ICT practicals<br>Problem solving<br>Supervised projects<br>Guest lecture /<br>keynote speech | It is recommended that all students attend tutorials to clarify issues related to the session as well as the solution of problems and supervised project. |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|

| Assessment          |                           |                                                                                             |               |
|---------------------|---------------------------|---------------------------------------------------------------------------------------------|---------------|
| Methodologies       | Competencies              | Description                                                                                 | Qualification |
| Problem solving     | B13 B6 C1 C11             | Orally and/or written presentation of problems proposed.                                    | 20            |
| Supervised projects | B1 B2 B13 B6 C1 C3<br>C11 | Delivery in electronic format of the solution of the different steps of the practical work. | 80            |

| Assessment comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Only students who do not deliver the supervised work will be classified as NOT PRESENTED.</p> <p>Academic dispensation is not allowed in this matter.</p> <p>The evaluation criteria for the 2nd chance are the same as for the 1st chance.</p> <p>The evaluation criteria of the advanced call will be the same as those of the 1st opportunity.</p> <p>The fraudulent performance of the tests or evaluation activities will directly imply the qualification of failure 0 in the matter in the corresponding call, thus invalidating any qualification obtained in all the evaluation activities for the extraordinary call</p> |

| Sources of information |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Basic                  | <ul style="list-style-type: none"><li>- Mark W. Spong, M. Vidyasagar (2006). Robot dynamics and control.. John Wiley &amp; Sons. New York</li><li>- Corke, Peter. (2017). Robotics, vision and control : fundamental algorithms in MATLAB.. Springer</li><li>- Siciliano, Bruno; et al. (2010). Robotics : modelling, planning and control. Advanced textbooks in control and signal processing. Springer</li><li>- Kevin Lynch, Frank C. Park (2017). Modern robotics : mechanics, planning, and control. Cambridge University Press</li><li>- Carl D. Crane III and Joseph Duffy (1998). Kinematic analysis of robot manipulators.. Cambridge University Press</li></ul> |



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|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Complementary</b> | <ul style="list-style-type: none"><li>- Tadej Bajd, Matjaz Mihelj, Marko Munih (2013). Introduction to robotics.. Dordrecht: Springer</li><li>- Siciliano, Bruno; Khatib, Oussama (2008). Springer handbook of robotics. Springer</li><li>- Craig, John J. (2005). Introduction to robotics: mechanics and control. . Pearson Educacion Internacional</li><li>- Asada, Haruhiko; Slotine, Jean-Jacques E. (1986). Robot analysis and control. . New York: John Wiley and sons</li><li>- Thomas R. Kurfess (2004). Robotics and Automation Handbook 1st Edition. . CRC Press</li></ul><br> |
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## Recommendations

### Subjects that it is recommended to have taken before

Biomechanics/730497227

### Subjects that are recommended to be taken simultaneously

### Subjects that continue the syllabus

### Other comments

&lt;p&gt;It must make a sustainable use of resources and the prevention of negative impacts on the natural environment.&lt;/p&gt;

(\*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.