[MRC101] ROBOTICS: MECHANICS, MODELLING AND SIMULATION

GENERAL INFORMATION

Studies	Master's Degree in ROBOTICS AND CONTROL SYSTEMS			**Subject**	?
Semester	1	**Course**	1	**Mention / Field of specialisation**	
Character	COMPULSORY				
Plan	2023	**Modality**	Face-to-face	**Language**	CASTELLANO/EUSKARA
Credits	5	**Hours/week**	0	**Total hours**	50 class hours + 75 non-class hours = **125 total hours**

PROFESSORS

ANDONEGI ARTEGUI, IMANOL
RUIZ GARATE, VIRGINIA

REQUIRED PREVIOUS KNOWLEDGE

Subjects	Knowledge
(No specific previous subjects required)	[!] *Algebra lineal*

LEARNING RESULTS

LEARNING RESULTS	KC	SK	AB	ECTS
M1R210 - [!] *Modelar y simular la cinemática y la dinámica de robots de diferentes tipos en entornos industriales*			*x*	3,8
M1R223 - [!] *Capacidad de trabajar en equipos multidisciplinares y en un entorno multilingüe y de comunicar, tanto de forma oral como escrita, conocimientos, procedimientos, resultados e ideas relacionadas con los temas afines al máster*		*x*		0,32
M1R224 - [!] *Capacidad para ejercer su profesión con actitud cooperativa y participativa, y con responsabilidad social*		*x*		0,28
M1R229 - To possess the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous		*x*		0,6
			Total:	**5**

KC: Knowledge or Content / SK: Skills / AB: Abilities

SECONDARY LEARNING RESULTS

RA111 **[!]** ***Identifica y demuestra los fundamentos de modelado cinemático y dinámico y de simulación de robots asegurando su capacidad para adaptarse a situaciones donde se requieren nuevos conocimientos que se han de aprender, trabajando individualmente y en eq***

LEARNING ACTIVITIES	CH	NCH	TH
Development and writing of records, reports, presentations, audiovisual material, etc. on projects/work experience/challenges/case studies/experimental investigations carried out individually and/or in teams	8 h.	15 h.	23 h.
Conducting tests, giving presentations, presenting defences, taking examinations and/or doing checkpoints	4 h.	8 h.	12 h.
Computer simulation exercises, individually and/or in teams	8 h.	15 h.	23 h.
Presentation by the teacher in the classroom, in participatory classes, of concepts and procedures associated with the subjects	30 h.	37 h.	67 h.

EVALUATION SYSTEM	W
Reports on the completion of exercises, case studies, computer exercises, simulation exercises, laboratory exercises, term projects, challenges and problems	20%
Individual written and/or oral tests or individual coding/programming tests	80%

Comments: Reports on exercises, case studies, computer practices, simulation practices and laboratory practices are mandatory to take the written tests. All activities (control points, individual and group work, etc.) must have a minimum grade of 5 and an opportunity for recovery (except the PBL). In unapproved training activities (less than 5) the recovery is compulsory and the final grade will be the grade obtained in the recovery. In the activities carried out it is necessary to obtain a minimum mark of 4 to calculate the average mark of the learning result. Otherwise, the note of the learning result will be that of the suspended activity. The system will calculate the final grade with the RA, applying the percentages defined in IKOF.

MAKE-UP MECHANISMS

Individual written and/or oral tests or individual coding/programming tests

CH - Class hours: 50 h.
NCH - Non-class hours: 75 h.
TH - Total hours: 125 h.

CONTENTS

1 Introduction & Course Overview 2 Basic concepts for robotics I Mechanisms Definition Characterisics: payload, reach, precision, repeatability Anatomy of a robotic manipulator: Links, Joints, Actuators / Arm, wrist, end-effector Kinematic chain: serial/parallel, open/closed, planar chains Types of Industrial robots: cartesian/gantry, cyclindrical, spherical. SCARA, articulated/anthropomorphic Basic problems of Manipulation: defining FK, IK, VK and Dynamics Refreshment of maths: Cartesian space Vectors and unit vectors Scalar and vector product: rotations Representation of matrices 3 Basic concepts for robotics II Mobility: Grübler-Kutzbach formula Workspace: reachable vs dexterous Joint/configuration space, actuator space and Task/cartesian space: redundant robots 4 Rigid motion and homogeneous transformations I Representing Pose: vectors Right handed coordinate frame Displacement between frames Rotation between frames Rotation matrix: 2D &3D: dot product and properties Euler angles (ZXZ, ZYZ, ZYX) RPY from homogeneous transformation matrix Quaternions Composition of rotations(fixed vs consecutive frame) 5 Rigid motion and homogeneous transformations II Velocities and accelerations: Linear and angular velocities Accelerations Velocity propagation The Skew-symmetric matrix 6 Rigid motion and homogeneous transformations III Mapping of frames (rot+transl) Homegeneous transformations Inverse transformations Compound transformations (fixed vs consecutive frame) 7 Forward Kinematics I Goal of FK Trigonometric approach Compositions of homogeneous transformation matrices Intro to DH 8 Forward Kinematics II Exponentials formulation Definition 9 Forward Kinematics III Exponentials formulation Screw axes in the base frame Screw axes in the end-effector frame 10 Inverse kinematics I Goal of IK Introducing redundancy and solvavility Closed form solutions: analytical à algebraic & geometry Numerical (iterative) solution: Newton-raphson method – pinv (PBL) 11 Inverse kinematics II Jacobian-based solution (intro) 12 Velocity kinematics & Jacobian I Jacobian Differential motion Jacobian: manipulator, space and body Manipulability 13 Velocity kinematics & Jacobian II Singularities Implications Types: boundary and internal Analysis Glympse into statics: Jacobian for Force/Torque relationships 14 Trajectories Path & Trajectory Path selection Trajectory generator Path generation - Joint space Definition Smoothness Polynomial: cubic quintic Linear: parabolic blends Via points: blends, path motion 15 Joint space trajectories Path generation - Cartesian space Joint-interpolated movement Straight-line movement

LEARNING RESOURCES AND BIBLIOGRAPHY

Learning resources	Bibliography
Subject notes	http://katalogoa.mondragon.edu/janium-bin/janium_login_opac_re_lnk.
Technical articles	
Moodle Platform	
Specific Master Software	