# Manchester Robotics / Tecnológico de Monterrey

# MC3001C: Cyber-Physical Systems I

## Introduction

This course, created by Manchester Robotics Ltd. (MCR2), aims to equip students with the required skills to understand manipulator dynamics and control to solve challenges in cyber-physical systems.

This course is divided into five sections, carefully designed for the user to learn about the different aspects of manipulators, from trajectory tracking and dynamic modelling to control and simulation of a real robot.

The first part of this course introduces the basic concepts and general knowledge of dynamical systems.

The second part of the course is dedicated to trajectory design and analysis.

The third section is dedicated to the dynamic modelling and simulation of manipulators.

The fourth section focuses on basic joint control for manipulators.

Finally, the last section is dedicated to the advanced control of manipulators.

This course will be based on challenges to make the student aware of the problems faced while implementing advanced intelligent algorithms in robotics.

## General Information

* MCR2 Person in Charge: Dr. Alexandru Stancu and Dr. Mario Martinez
* Tecnológico de Monterrey Person in Charge: Dr. Consuelo Rodríguez Padilla
* Duration 5 Weeks.
* Student counselling: Via appointment.
* Weekly Briefings: TBD.
* Classes: 5 sessions, 1 group.
  + Group 1: Wednesday, 3- 6 PM (Central Mexico Time)
* Starting: Monday, 1 April 2023
* Ends: Friday, 3 May 2023

## Requirements:

* Computer with access to Zoom (online classes).
* Computer with Ubuntu 20.04 and ROS Noetic or MCR2 Virtual Machine.
* Knowledge of Windows.
* Knowledge of ROS.
* Knowledge of Ubuntu.
* Understanding of robotics.

## Course Information

* Student Demographic: TBD
* Number of Professors: 1
* Grading: TBD
* Deliverables: TBD
* Final Challenge Deliverable: TBD.
* ZOOM Link Classes:
  + Group 405: [TBD](https://itesm.zoom.us/j/8207925594)
* ZOOM Link Briefings: TBD
* Student GitHub Link: [ManchesterRoboticsLtd/MR3001\_Design\_and\_Development\_of\_Robots\_II: This repository contains all the information regarding the subject of Desing and Development of Robots (github.com)](https://github.com/ManchesterRoboticsLtd/MR3001_Design_and_Development_of_Robots_II/tree/main)

## Week 1: Dynamic Systems – Fundamentals

This session will introduce the teaching team and the basics of dynamical systems.

## Session:

* Who are we?
* Introduction to robotics.
* Introduction to dynamical systems

### Activity 1: Exercises (Not Mandatory)

* Make the exercises in the PPT.

### Mini- Challenge

* Simulate a dynamical system (pendulum) using ROS.

### Requirements

* Computer with access to Zoom
* Ubuntu 18.04 or 20
* ROS Melodic /Noetic Installed (Full installation).
* If Ubuntu 18.04 or 20 cannot be installed, MCR2 offers a Virtual Machine with ROS preinstalled (installation instructions in Week 1 Folder).

## Week 2: Trajectory tracking

This week, the concepts of trajectory planning, boundary conditions and path planning will be covered.

### Session:

* Path planning
* Boundary Conditions
* Trajectory planning

### Activity 1: Trajectory definition

* Make a simple trajectory.

#### Mini-Challenges

* Create a trajectory in ROS.

**Requirements**

* Requirements of Session 1.

### Week 3: Robot Dynamics

This week will introduce the concepts of dynamical modelling and control of a nonlinear system.

### Session:

* Single link manipulator (SLM) state space modelling using Euler-Lagrange.
* Single link manipulator control
* Simulation.

### Activity 1: SLM Modelling

* Simulation of a single link manipulator.

#### Mini-Challenges

* Joint control of a SLM.

**Requirements**

* Requirements of Session 1.

### Week 4: Dual Link manipulator

This week, we will model a dual-link manipulator in state space using Euler-LaGrange and control it using a joint PID controller.

### Session:

* DLM modelling.
* Joint Control.

### Activity 1: Data Acquisition

* DLM manipulator ROS modelling.

#### Mini-Challenges

* **Joint Control of a DLM.**

**Requirements**

* Requirements of Session 1.

### Week 5: Advanced control for manipulators

This week, an implementation feedback linearisation controller will be used.

### Session:

* CTC control.
* Feedback linearisation control.

### Activity 1: DLM Manipulator control (PID)

* DLM manipulator control.

#### Mini-Challenge

* **Joint Control of a DLM using Feedback linearisation.**

**Requirements**

* Requirements of Session 1.

*\* Weeks may change due to material and laboratory sessions.*