Faculty of Engineering – Ain Shams University Mechatronics Engineering Department

MCT411 – Hybrid Control Systems

Fall 2025

Major Task: Furuta Pendulum

Description:

You are required to make a **Furuta Pendulum (Rotary Pendulum) as shown below in Figure 1.**

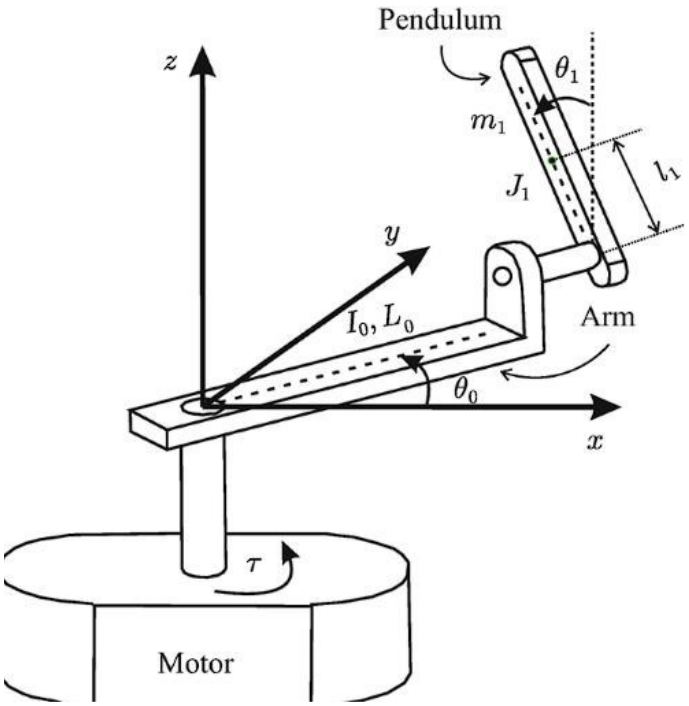
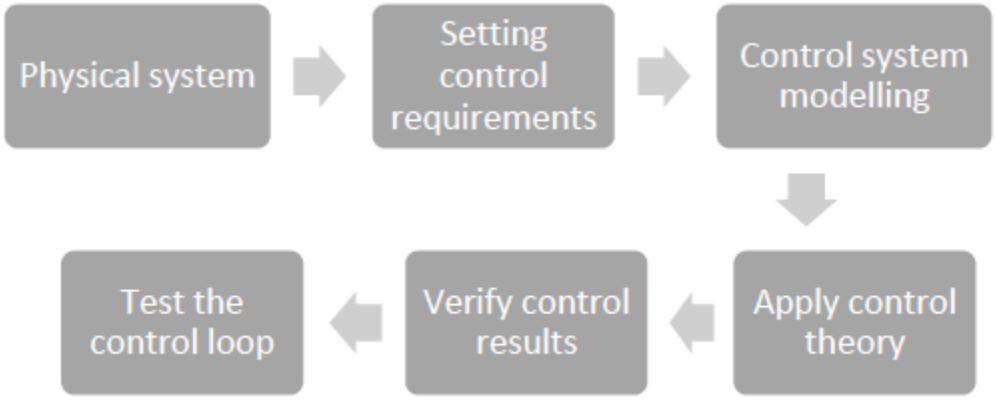


Figure 1-Furuta Pendulum

Requirements

1- Use pole placement / LQR techniques to control the pendulum. (using PID will result in deduced points)
2- Control the angle θ_1 to be zero. So, the pendulum stands in the upright position.
3- Overcome any disturbances that may affect the pendulum. So, the pendulum should maintain its upright position and don't fall.
4- Follow the standard procedure for performing a control task to design a controller to regulate the system's output according to the set control requirements.



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Quick bullets you need to care for:

- You need one motor equipped with an encoder to control *theta0* and one encoder (at least 360 pulses/revolution) for *theta1*.
- Wires should be hidden as much as you can, and All components must be fixed well.
- You can choose any platform that can be connected to the MATLAB from the below list in **Figure 2.**
- You **must** build and control your model on MATLAB/SIMULINK.
- You must implement HIL (Hardware in the loop) using SIMULINK

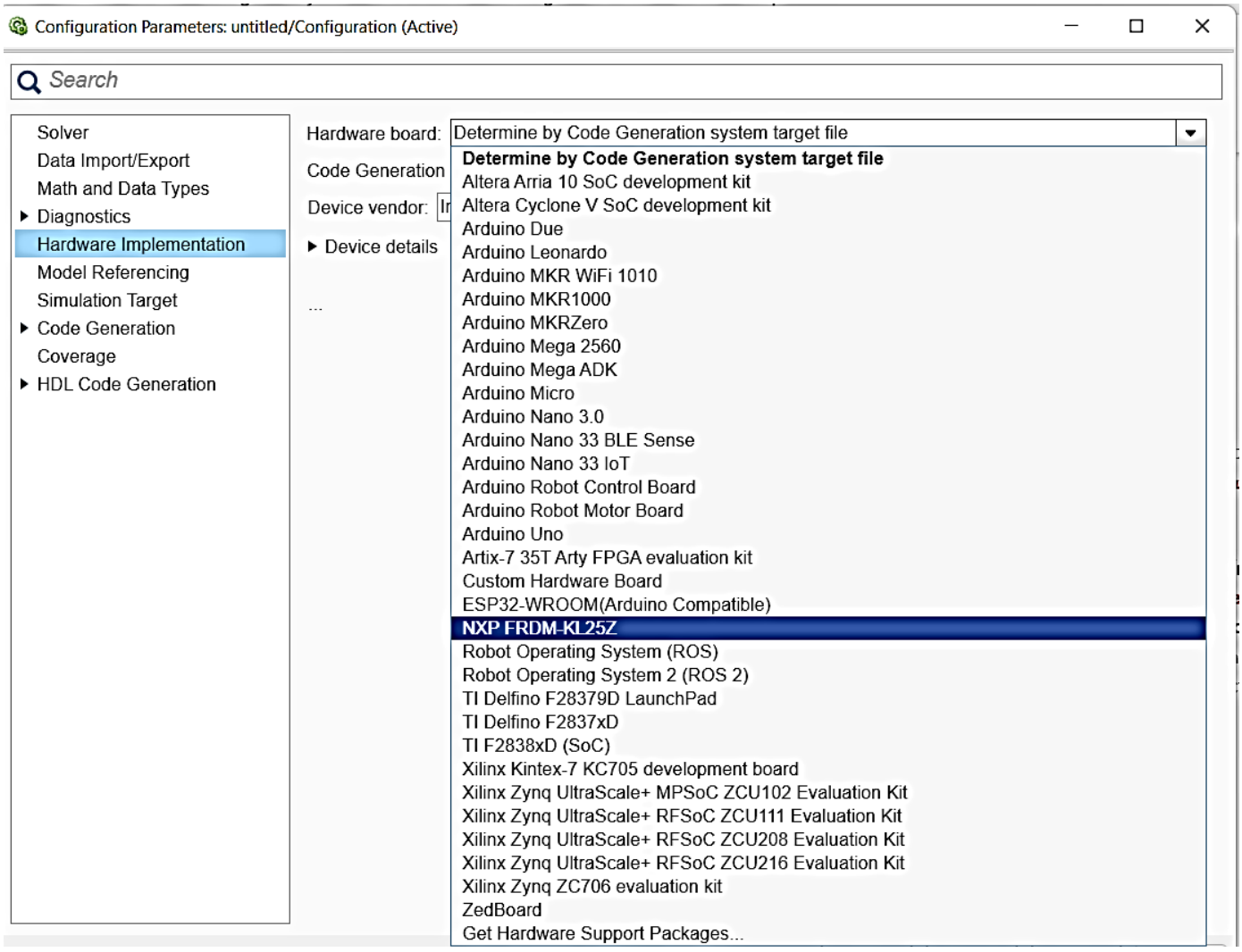

Figure 2 - Example of supported platforms

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Project Submission

- Working in the project should be in groups of 4 - 5 students.
- The project submission has 2 phases:
  - Phase #1: SimMechanics Model (Week 7)
    Deliver a MATLAB model of the pendulum system (preferably using SimMechanics) of your design of furuta pendulum + controller in simulation. (10%)
  - Phase #2: Final Submission (Week 13)
    Full project delivery according to the following table.
- Final Submission Form & Grading Scheme

#	Deliverable	Weight
1	Working prototype with a GUI to display pendulum angle (θ) and actuator signal (u) The prototype shall demonstrate robustness against disturbances **Note: Bonus points are awarded for swing up controller design (10%)**	20%
2	Technical Report including the following: 1- Contribution of each member of the group 2- Detailed discussion of the following - Modelling of the pendulum system - Method of controller design - Controller requirements - Implementation details - Simulation results - Detailed analysis of simulation vs actual results	20%
3	Oral discussion	20%
4	Simulation results and Controller implementation (Simulink model)	15%
5	Demo video (5 min's max) that contains A) Demonstration of a working prototype B) Brief discussion of controller design and simulation	15%