

# Lab 1- Robot Programming I: UR3

## Scope & Objective

In Lab 2 and forward you will be using the Robot Operating System (ROS) environment to program the UR3. For this lab you will continue to program the UR3 using its Teach Pendant but perform a similar task that will be required in Lab 2, solving a three block Tower of Hanoi puzzle. In this lab, you will:

1. Move three stacked blocks from one position to another position using the rules specified for the Tower of Hanoi puzzle. Blocks should be aligned on top of each other.
2. Use high level "Move" commands to move the UR3's Tool Center Point in linear and circular motions
3. Time permitting play with other functionality of the teach pendant.

## Background

Robot programming is an integral part for the development of robot solutions. The developed program can be as simple as a "recipe" that provide the robot with instructions to accomplish specific task in a logical fashion. Some robot systems have built-in environment or interface for this purpose. The robot arm, UR3 used in this course has a Teach Pendant that support various standard operations of the robot arm as well as an interface for programming the robot for specific tasks.

## References

- UR3 Owner's Manual:  
<https://www.universal-robots.com/download/?option=52870#section52851>
- UR3 Software Manual:  
<https://www.universal-robots.com/download/?option=53077#section53064>
- Universal Robots Academy  
<https://www.universal-robots.com/academy/>
- Since this is a robotics lab and not a course in computer science or discrete math, feel free to Google for solutions to the Tower of Hanoi problem.<sup>1</sup> You are **NOT** required to implement a recursive solution.

## Pre-lab

Read in more detail the UR3 Software Manual chapters 13 and 14. Additionally if for some reason you have not completed the training videos, go through the training videos found at Universal Robots website <https://www.universal-robots.com/academy/>. These training sessions get into some areas that we will not be using in this class (for example you will not be changing safety settings), but go through all of the assignments as they will help you get familiar with the UR3 and its teach pendant. You also may want to reference these sessions when you are in lab.

## Lab Activities

The goal is to move a "tower" of three blocks from one of three locations on the table to another. An example is shown in Figure 1.1. The blocks are numbered with block 1 on the top and block 3 on the bottom. When moving the stack, two rules must be obeyed:

1. Blocks may touch the table in only three locations (the three "towers").
2. You may not place a block on top of a lower-numbered block, as illustrated in Figure 1.2.
  - i. Choose the three spots on the robot's table where blocks can be placed when solving the Tower of Hanoi problem.
  - ii. Use the provided colored tape to mark the three possible tower bases. You should initial your markers so you can distinguish your tower bases from the ones used by teams in other lab sections.
  - iii. Choose a starting position and ending position for the tower of three blocks. Future note: In Lab 2 the user will enter the start and stop positions.
  - iv. Using the Teach Pendant create a program that solves the Tower of Hanoi problem. Instead of using **MoveJ** moves like in Lab 1, experiment with using **MoveL** and **MoveP** moves. **MoveL** moves the Tool Center Point (TCP) along a straight line, and **MoveP** is a process move that keeps the TCP moving at a constant speed and allows you to move along circular arcs. Reference these three "How To" articles from Universal Robots on creating circular arcs:
    - <https://www.universal-robots.com/how-tos-and-faqs/how-to/ur-how-tos/circle-using-movec-16270/>
    - <https://www.universal-robots.com/how-tos-and-faqs/how-to/ur-how-tos/circular-path-using-movepmovec-15668/>
    - <https://www.universal-robots.com/how-tos-and-faqs/how-to/ur-how-tos/circle-with-variable-radius-15367/>
  - v. Your program must have at least one obvious linear move and one obvious circular move that completely encircles one of the block positions.

# Report

Each partner will submit a lab report using the guidelines given in the "ECE 470: How to Write a Lab Report" document. Please be aware of the following:

- Lab reports are due one week after the final session of Lab 1 - before your lab session!
- Lab reports will be submitted online at GradeScope. Your report should include the following:
  - Briefly explain the rules of Towers of Hanoi (Introduction/Objective)
  - Concisely explain your solution (Method)
  - Discuss your circular movement and how you implemented it (Method)
  - Note anything you learned about operating the robot (Conclusion)
- How did you keep your block stacks neat?
- Observations about **MoveJ**, **MoveL**, and **MoveP**?
- Make use of figures and tables as needed to aid in your explanation
- Read "ECE 470: How to Write a Lab Report" so you know all the requirements

## Grading

- 10 points, completed this section by the end of the two hour lab session.
- 70 points, successful demonstration.
- 20 points, report.

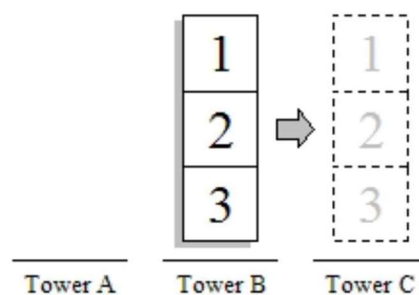


Figure 1.1: Example start and finish tower locations.

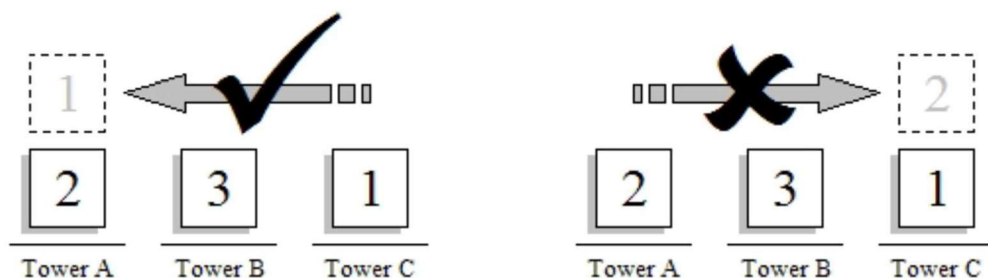


Figure 1.2: Examples of a legal and an illegal move.