# Mechanical, Automotive, & Materials Engineering

University of Windsor

## Course Title: Remote Experimentation with Robots

### Course Description:

The robotic course is based on passive and active learning methods. While students can passively learn from lectures and demonstrations, active learning through exercises provides them a unique opportunity to practice the theoretical concepts. After successfully implementing their codes in the ROS (Robot Operating System) and MATLAB Simulink simulation environments, students will remotely connect to real robots (robotic arm and mobile robot) in the laboratory, run their codes and observe the results via surveillance cameras, installed in the laboratory site. This course covers prerequisites such as Linux, MATLAB and Python programming. It also teaches ROS and its application in robotics. Plus, fundamental topics in robot manipulator and mobile robots are presented using Universal robot and QCar, respectively.

Instructor:

Shahpour Alirezaee  
Office hours location: Mechatronics Lab, 1133 Engineering Department

Office hours: Monday-Friday

Email: [s.alirezaee@uwindsor.ca](mailto:s.alirezaee@uwindsor.ca)

Teaching Assistants:

Saeed Mozaffari

Email: [saeed.mozaffari@uwindsor.ca](mailto:saeed.mozaffari@uwindsor.ca)

Sooraj Sunil

Email: [sunil11@uwindsor.ca](mailto:sunil11@uwindsor.ca)

Haoyang Ke

Email: [hke@uwindsor.ca](mailto:hke@uwindsor.ca)

Nesrin Awad

Email: awadn@uwindsor.ca

### Course Content and Lectures:

Since this is an online course, all of the course material will be made available through the course site. All lectures are presented in Microsoft Power Point. In addition, course lectures were recorded, and video files are available. Plus, each course module has exercises and sample exams.

Recommended Textbook:

This course consists of several modules. The main textbook of each module is as follows:

Textbook 1- The Linux Command Line: A Complete Introduction, 2nd Edition

*William Shotts*, ISBN:9781593279523, No Starch Press, 2019.

Textbook 2-A Beginners Guide to Python 3 Programming

*John Hunt*, ISBN:9783030202897, Springer, 2019.

Textbook 3-Robot Operating System for Absolute Beginners: Robotics Programming Made Easy

*Lentin Joseph*, ISBN: 9781484234044, Apress, 2018.

Textbook 4-ROS Robot Programming

*YoonSeok Pyo, HanCheol Cho, RyuWoon Jung, and TaeHoon Lim*, ISBN: 9791196230715, ROBOTIS Co.,Ltd., 2017.

Textbook 5-Introduction to Robotics: Analysis, Control, Applications, Third Edition

Saeed B. Niku, ISBN: 9781119527626, Wiley, 2020.

Textbook 6- Introduction to Autonomous Robots: Kinematics, Perception, Localization and Planning

*Nikolaus Correll*, ISBN:9780692700877, Magellan Scientific, 2016.

Additional Resources:

1- Linux Essentials

*Christine Bresnahan* and *Richard Blum*, ISBN:9781119092063, Wiley, 2015.

2-ROS Robotics By Example

*Carol Fairchild* and *Thomas L. Harman*, ISBN: 9781782175193, Packt, 2016.

3-Programming Robots with ROS

*Morgan Quigley, Brian Gerkey*, and *William D. Smart*, ISBN:9781449323899, O'Reilly, 2015.

4-Introduction to Robotics, Second Edition

*S K Saha*, ISBN: 9332902801, McGraw Hill, 2014.

Evaluation:

Homework 20%

Projects 30%

Midterms 20%

Final exam 30%

### Course Learning Outcomes:

At the end of the course, students will be able to:

* Install a virtual machine (VM) and install Linux on the VM.
* Use command lines in shell to navigate in the system and manipulate files and directories.

### Course Outline:

Module 1: Linux

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No | Unit | Textbook sections | Lectures | Video clips |
| 1 | Installing Ubuntu | Textbook 3- Chap 1 | Linux for Robotics | Linux- Clip 1-14 |
| 2 | Introduction to Shell | Textbook 1- Chap 1 | Linux for Robotics | Linux- Clip 15 |
| 3 | Navigation | Textbook 1- Chap 2-3 | Linux for Robotics | Linux- Clip 16-19 |
| 4 | Manipulating files | Textbook 1- Chap 4 | Linux for Robotics | Linux- Clip 22-23 |
| 5 | Working with commands | Textbook 1- Chap 5 | Linux for Robotics | Linux- Clip 17 |
| 6 | Redirection | Textbook 1- Chap 6 | Linux for Robotics | Linux- Clip 30 |
| 7 | Permissions | Textbook 1- Chap 9 | Linux for Robotics | Linux- Clip 25-26 |

Module 2: Python Programming

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No | Unit | Textbook sections | Lectures | Video clips |
| 1 | Introduction to Python | Textbook 2- Chap 1-3 | Python for Robotics | Python- Clip 1-4 |
| 2 | Variables | Textbook 2- Chap 4-5 | Python for Robotics | Python- Clip 5-6 |
| 3 | Set | Textbook 2- Chap 32 | Python for Robotics | Python- Clip 7 |
| 4 | Dictionary | Textbook 2- Chap 33 | Python for Robotics | Python- Clip 8 |
| 5 | List | Textbook 2- Chap 31 | Python for Robotics | Python- Clip 9 |
| 6 | Tuple | Textbook 2- Chap 31 | Python for Robotics | Python- Clip 10 |
| 7 | If and while flow of control | Textbook 2- Chap 6 | Python for Robotics | Python- Clip 11-16 |
| 8 | For loop | Textbook 2- Chap 7 | Python for Robotics | Python- Clip 17-18 |
| 9 | Error and Exception Handling | Textbook 2- Chap 24 | Python for Robotics | Python- Clip 19 |
| 10 | Functions | Textbook 2- Chap 14 | Python for Robotics | Python- Clip 20-21 |
| 11 | Classes | Textbook 2- Chap 17-20 | Python for Robotics | Python- Clip 22-25 |
| 12 | Files | Textbook 3- Chap 3 | Python for Robotics | Python- Clip 25-26 |
| 13 | Module | Textbook 2- Chap 25 | Python for Robotics | Python- Clip 27-28 |

Module 3: Robot Operating System

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No | Unit | Textbook sections | Lectures | Video clips |
| 1 | Introduction to ROS | Textbook 3- Chap 3 | ROS- Part 1 | ROS- Clip 1-4 |
| 2 | ROS installation | Textbook 3- Chap 4 | ROS- Part 1 | ROS- Clip 5 |
| 3 | ROS Architecture | Textbook 3- Chap 4 | ROS- Part 1 | ROS- Clip 6 and 9 |
| 4 | Basic examples | Textbook 3- Chap 4 | ROS- Part 1 | ROS- Clip 7-8 and 10 |
| 5 | ROS commands | Textbook 4- Chap 5 | ROS- Part 1 | ROS- Clip 11-13 |
| 6 | ROS graphical tools | Textbook 4- Chap 6 | ROS- Part 1 | ROS- Clip 14-15 |
| 7 | Configuring the ROS | Textbook 4- Chap 4 | ROS- Part 2 | ROS- Clip 17-18 |
| 8 | ROS nodes | Textbook 4- Chap 4 | ROS- Part 2 | ROS- Clip 19 |
| 9 | Nodes communication | Textbook 4- Chap 4 | ROS- Part 2 | ROS- Clip 20 |
| 10 | ROS topic | Textbook 4- Chap 7 | ROS- Part 2 | ROS- Clip 21-24 |
| 11 | ROS service | Textbook 4- Chap 7 | ROS- Part 2 | ROS- Clip 25-27 |
| 12 | ROS action | Textbook 4- Chap 7 | ROS- Part 2 | ROS- Clip 28-31 |
| 13 | ROS launch | Textbook 4- Chap 7 | ROS- Part 3 | ROS- Clip 32 |
| 14 | Turtlebot3 | Textbook 4- Chap 10 | ROS- Part 3 | ROS- Clip 33-34 |
| 15 | SLAM | Textbook 4- Chap 11 | ROS- Part 3 | ROS- Clip 35-37 |
| 16 | PoenCV | Textbook 4- Chap 8 | ROS- Part 3 | ROS- Clip 38-41 |

Module 4: Robot Manipulator

|  |  |  |  |
| --- | --- | --- | --- |
| No | Unit | Lectures | Video clips |
| 1 | Introduction to UR | Manipulator- Part 1 | Robot manipulator- Clip 1-2 |
| 2 | Moving the robot | Manipulator- Part 1 | Robot manipulator- Clip 3 |
| 3 | TCP | Manipulator- Part 1 | Robot manipulator- Clip 4 |
| 4 | Safety | Manipulator- Part 1 | Robot manipulator- Clip 5 |
| 5 | Inputs and Outputs | Manipulator- Part 1 | Robot manipulator- Clip 6 |
| 6 | Log files | Manipulator- Part 1 | Robot manipulator- Clip 7 |
| 7 | Running a program | Manipulator- Part 1 | Robot manipulator- Clip 8 |
| 8 | Waypoints | Manipulator- Part 2 | Robot manipulator- Clip 10-11 |
| 9 | Movement types | Manipulator- Part 2 | Robot manipulator- Clip 12-14 |
| 10 | Shared parameters | Manipulator- Part 2 | Robot manipulator- Clip 15 |
| 11 | Direction | Manipulator- Part 2 | Robot manipulator- Clip 16 |
| 12 | Wait | Manipulator- Part 2 | Robot manipulator- Clip 17 |
| 13 | Set | Manipulator- Part 2 | Robot manipulator- Clip 18 |
| 14 | Popup | Manipulator- Part 2 | Robot manipulator- Clip 19 |
| 15 | Halt | Manipulator- Part 2 | Robot manipulator- Clip 20 |
| 16 | Comment | Manipulator- Part 2 | Robot manipulator- Clip 21 |
| 17 | Folder | Manipulator- Part 2 | Robot manipulator- Clip 22 |
| 18 | Loop | Manipulator- Part 3 | Robot manipulator- Clip 24 |
| 19 | Subprogram | Manipulator- Part 3 | Robot manipulator- Clip 25 |
| 20 | Assignment | Manipulator- Part 3 | Robot manipulator- Clip 26 |
| 21 | If | Manipulator- Part 3 | Robot manipulator- Clip 27 |
| 22 | Event | Manipulator- Part 3 | Robot manipulator- Clip 28 |
| 23 | Scripts | Manipulator- Part 3 | Robot manipulator- Clip 29 |
| 24 | Switch | Manipulator- Part 3 | Robot manipulator- Clip 30 |
| 25 | Thread | Manipulator- Part 3 | Robot manipulator- Clip 31 |
| 26 | Home | Manipulator- Part 3 | Robot manipulator- Clip 32 |
| 27 | Seek | Manipulator- Part 4 | Robot manipulator- Clip 34-37 |
| 28 | Force | Manipulator- Part 4 | Robot manipulator- Clip 38 |
| 29 | Palletizing | Manipulator- Part 4 | Robot manipulator- Clip 39-41 |
| 30 | Conveyor tracking | Manipulator- Part 4 | Robot manipulator- Clip 42 |
| 31 | URcaps | Manipulator- Part 4 | Robot manipulator- Clip 43 |

Module 5: Mobile Robot

|  |  |  |  |
| --- | --- | --- | --- |
| No | Unit | Lectures | Video clips |
| 1 | Introduction to MATLAB | Mobile Robot- Part 1 | Mobile Robot- Clip 1-5 |
| 2 | Introduction to SIMULINK | Mobile Robot- Part 1 | Mobile Robot- Clip 6-8 |
| 3 | Point cloud generation | Mobile Robot- Part 1 | Mobile Robot- Clip 10 |
| 4 | Manual driving | Mobile Robot- Part 1 | Mobile Robot- Clip 11 and 14 |
| 5 | Autonomous driving | Mobile Robot- Part 1 | Mobile Robot- Clip 12-13 |
| 6 | Connecting to QCar | Mobile Robot- Part 2 | Mobile Robot- Clip 16-19 |
| 7 | SLAM in ROS | Mobile Robot- Part 2 | Mobile Robot- Clip 20-23 |
| 8 | SLAM in MATLAB | Mobile Robot- Part 2 | Mobile Robot- Clip 24-25 |