**SE 423 – INTRODUCTION TO MECHATRONICS**
http://coecsl.ece.illinois.edu/se423
**SPRING 2023**
**Lecture M W 9:00AM to 9:50AM, Room 101 Transportation Building**
**Lab AB1 Wednesday 3:00PM to 5:50PM Room 302 Transportation Building**
**Lab AB3 Thursday 9:00AM to 11:50AM Room 302 Transportation Building**
**Lab AB2 Thursday 2:00PM to 4:50PM Room 302 Transportation Building**

**Instructor:** Dan Block — Email: d-block@illinois.edu
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**Office hours:** Monday 10AM-12PM and Tuesday 3:30-5PM in 302 TB and by appointment.

**TA:** Abbas Bataleblu — Email: abbasb2@illinois.edu
**Office hours:** TBD and by appointment
Saeid Bayat — Email: bayat2@illinois.edu
**Office hours:** TBD and by appointment

**Textbook:** NOT REQUIRED but recommended. Herbert Schildt, *Teach Yourself C, Third Edition*, Osborne McGraw-Hill. 1997. Or any other C teaching book.

**Prerequisite:** **SE 320** or equivalent Control Systems course, C programming experience is highly recommended.

**References:**

- J. Edward Carryer, R. Matthew Ohline and Thomas W. Kenny. *Introduction to Mechatronic Design.* Prentice Hall, 2011.
- David G. Alciatore and Michael Histand. *Introduction to Mechatronics and Measurement Systems, 2nd Edition*. McGraw-Hill, Boston, 2003. http://www.engr.colostate.edu/~dga/mechatronics/
- Thomas J. Bress. *Effective LabView Programming*, NTS Press. 2013.
- John Billingsley. *Essentials of Mechatronics*, Wiley-interscience. 2006.
- Roland Siegwart and Illah R. Nourbakhsh. *Introduction to Autonomous Mobile Robots*, MIT Press. 2004.
- Gene F. Franklin, J. David Powell and Abbas Emami-Naeini. *Feedback Control of Dynamic Systems*, Addison-Wesley Publishing Company.

**Due Dates:** **Homework** assignment due dates are listed below in the time schedule, but I may announce changes in these due dates as needed.
The **Lab** "check off" procedure will be explained thoroughly in your lab section.

**Quizzes:** I do not intend to have lecture quizzes/tests but that could change depending on class attendance in lecture.

**Semester Project:** This is where you will put it all together. I still have not made up my mind on the exact final project for this semester but it will be similar to previous semesters. See the listing on the right side of the screen at htttp://coecsl.ece.illinois.edu/se423. You will work in groups of 4 to complete the project. There will be specified "checkpoint" due dates to make sure you keep on the right track and do not wait until the last week to finish all the work.

Grading of this project is heavily focused on the amount of work you put into the project throughout the semester and not necessarily on the success of the project. Even though this is a group project, you will be graded individually on the amount of work you put into the project. Groups will have at least one weekly meeting with me (or one of the TAs) to demonstrate progress but I expect we will be meeting even more often as you have questions, etc. with your project.

**Grading:** All students are encouraged to attend every class period. The lecture content will follow the laboratory assignments in an obvious manner, so failure to attend a lecture will be a severe handicap in the lab. The semester project will represent the entire content of the class and is representative of a final exam grade. You are REQUIRED to attend the final project demonstration day which will be **May 12th from 11:00am to 2:00pm**. Make sure to write this date in your calendar for this semester.

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| Check-off on all labs | 30% |
| Homework | 25% |
| LABVIEW Assignments | 5% |
| Semester Project | 40% |

**Policy on cheating**

Students are encouraged to work together on homework assignments; however, original solutions are required. For homework, the threshold of cheating is defined as follows: If the person grading the assignments is able to identify students who have worked together by their solutions or specific aspects of their solution approach, then the solutions are not original! A homework or other assignment where cheating is found will automatically be given a zero grade

Copying of information from websites without proper citation is considered cheating. Any copying of information without proper citation will result in a zero grade for the assignment.

## SE 423 – Introduction to Mechatronics, Spring 2023

| Lecture Dates | Topics | Current Lab |
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| Wednesday January 18, 2023 | Introduction, What is Mechatronics? What parts are we focusing on? Walk through Syllabus. | |
| Monday, January 23, 2023 | - Look at the LaunchXL-F28379D board and the green expansion board. Start to understand the pinout. What are System and Peripheral Registers? Hex numbers and Bitwise operators.<br>- Code Composer Studio Development Environment<br>- Default starter code<br>- Timers and Digital I/O Pins | |
| Wednesday, January 25, 2023 | - Digital Outputs. Turn on and off an LED.<br>- Digital Inputs. Pull-up resistor. Passive Push Button.<br>- What is a peripheral register? How many I/O pins does the F28379D have? Talk about the pin multiplexer. | Lab #1/Finish Soldering |
| Monday, January 30, 2023<br><br>**HW#1 Due (Tues, Jan 31, 5pm)** | - What is a CPU interrupt? Timer interrupt functions.<br>- printf, sprintf, null terminated strings<br>- RS 232 Serial Port, The ASCII character set<br>- 16bit and 32bit integers and 2s compliment numbers | |
| Wednesday, February 1, 2023<br><br>**LabVIEW #1 Due (Thurs, Feb 2, 5pm)** | -What is a DAC and how does it work? What is an ADC and how does it work? F28379D ADC peripheral | |
| Monday, February 6, 2023 | - Continue with ADC peripheral. ADC Resolution. Successive Approximation Register (SAR) type of ADC.<br>- What is an Optical Encoder?<br>- What is a PWM signal? How to generate a PWM signal with the F28379D EPWM peripheral.<br>- H-bridge, Example circuit | |

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| Wednesday, February 8, 2023 | - Examples using the EPWM peripheral. The RCservo Motor.<br>- What is an Optical Encoder Sensor? Calculating velocity.<br>- Friction Compensation | Lab #2 |
| Monday, February 13, 2023 | - Filter design and implementation, Filter Examples in Matlab.<br>- Use DMA to store ADC samples. Using the FFT algorithm to find signal's dominant frequencies. Ping/Pong Buffer. | |
| Wednesday, February 15, 2023 | - Continue Filter Design and FFT algorithm. | Lab #3 |
| Monday, February 20, 2023<br>**HW#2 Due (Tues, Feb 21, 5pm)** | - Review three serial ports UART, SPI, I2C. SPI 4 clock modes. F28379D SPI peripheral registers. | |
| Wednesday, February 22, 2023<br><br>**LabVIEW #2 Due (Thurs, Feb 23, 5pm)** | - Review the DAN28027 SPI interface datasheet. Connecting multiple slave devices to one SPI serial port. Understand the F28379D's SPI Receive and Transmit FIFO | Lab #4 |
| Monday, February 27, 2023 | - PID controller.<br>- Integral Windup. Rollover issues.<br>- Robot's speed control algorithm with steering. | |
| Wednesday, March 1, 2023 | - Developing Linux applications for Embedded Linux devices. Why use Linux. Discuss Multiple Threads/Processes/Applications.<br>- Review what Lab #5's LabVIEW application is to display. | Lab #4 |
| Monday, March 6, 2023 | - Review Tasks<br>- CAN IR Sensor<br>- The Rate Gyro<br>- The LIDAR (Laser Range Finder)<br>- Wall-following, Inner-loop and Outer-loop controllers<br>- Review what is expected with your LABVIEW application. | |
| Wednesday, March 8, 2023<br><br>**LabVIEW #3 Due (Thurs, Mar 9, 5pm)** | - Coordinate Transformations<br>- Dead-Reckoning<br>- Dealing with the Drift of the integral of the rate gyro<br>- Finding Landmarks with the different distance sensors. | Lab #5 |
| Monday, March 13, 2023 | Spring Break | Spring Break |
| Wednesday, March 15, 2023 | Spring Break | Spring Break |
| Monday, March 20, 2023<br><br>**HW#3 Due (Tues, Mar 21, 5pm)** | - Talk about the LIDAR. How it works and How we interface with it.<br>- Understand the data received by the LIDAR. | |
| Wednesday, March 22, 2023 | - Review SPI serial interface and how to communicate with the MPU-9250 IMU chip. | Lab #6 |
| Monday, March 27, 2023 | Revisit developing Linux applications. Deciding what processes can run in a non-real-time environment and what processes need to run in a real-time environment. | |
| Wednesday, March 29, 2023 | - Introduce Vision Processing<br>- CMOS Cameras and the BAYER format.<br>- Centroid calculation<br>- RGB color space<br>- HSV color space<br>- Vision algorithm finding multiple blobs. | Lab #6 |
| Monday, April 3, 2023<br>**HW#4 Due (Tues, April 4, 5pm)** | - Introduce the OpenMV camera module.<br>- Robot following Flash light / Bright Color | |

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| Wednesday, April 5, 2023<br>**LabVIEW #4 Due (Thurs, Apr 6, 5pm)** | - Using camera to calculate distance to an object.<br>- Using Landmarks to update robot's position | Lab#6 (RC Servo Extra Exercise) |
| Monday, April 10, 2023 | - Path Planning.<br>- Bug Algorithms for avoiding obstacles in robot's path.<br>- A* (A star) path planning algorithm | |
| Wednesday, April 12, 2023 | - A* (A star) path planning algorithm | Lab #7 |
| Monday, April 17, 2023<br><br>**HW#5 Due (Tues, Apr 18, 5pm)** | - A* (A star) path planning algorithm | |
| Wednesday, April 19, 2023 | - A* (A star) path planning algorithm | Lab #7 |
| Monday, April 24, 2023 | - Dead-Reckoning<br>- Using Landmarks to update robot's position<br>- Using Kalman filtering to help mix OptiTrack motion capture data with Dead-Reckoned robot position. | Semester Project |
| Wednesday, April 26, 2023 | - More on Kalman Filtering.<br>- Go through Kalman filtering code. | Semester Project |
| Monday, May 1, 2023 | - Go through Kalman filtering code.<br>- Go through move to XY point code. | Semester Project |
| Wednesday, May 3, 2023<br>**HW#6 Due (Fri, May 5, 5pm)** | - Go through move to XY point code. | Semester Project |
| **Friday, May 12, 2023<br>11:00AM-2:00PM** | | **Project Presentations** |