# Assignment: Final Project

## Purpose:

In this assignment, you will leverage what we learned throughout the semester to program your robot to autonomously navigate through an unknown robot obstacle course towards a target.

## Learning Objectives:

- Recall how infrared (IR) sensors work
- Apply knowledge of IR sensors to program a robot to detect objects
- Apply knowledge of gyroscopes to program a robot to autonomously navigate towards a goal location
- Implement an obstacle avoidance strategy based on IR sensor readouts
- Demonstrate ability to program an autonomous robot mission

## Task 1: Read Data from IR Sensors

You have two types of IR sensors: analog and digital. Mount both sensor types on your robot chassis. Once the sensors are mounted to your robot, determine how to read the data from both sensors and write a simple Arduino sketch to display the **raw measurement** received from these sensors on the liquid crystal display (LCD).

### Submission Details:

- Upload two short videos highlighting the outcome of this task. Each video should include a brief description of your hardware setup (i.e., sensor placement), your test environment (e.g., obstacle(s) used for testing, approximate sensing range, etc.), and a closeup of the LCD displaying the raw measurement value obtained with a static test object and a dynamic (i.e., moving) test object. To obtain full credit, the videos must contain an audio description of the hardware setup and test environment. Two videos should be uploaded for this task, one for the analog sensor and one for the digital sensor. Make sure that your file naming convention clearly identifies which video corresponds to which sensor (e.g., TeamA_Task1_DigitalSensor).

## Task 1 Grading Rubric:

| Description | | Possible Points |
|---|---|---|
| Analog Sensor | | |
| | Submitted video | 0.5 |
| | Described hardware setup | 2 |
| | Described test environment | 2 |
| | Displayed raw measurement value on LCD from static object | 4 |
| | Displayed raw measurement value on LCD from dynamic object | 4 |
| Digital Sensor | | |
| | Submitted video | 0.5 |
| | Described hardware setup | 2 |
| | Described test environment | 2 |
| | Displayed raw measurement value on LCD from static object | 4 |
| | Displayed raw measurement value on LCD from dynamic object | 4 |
| | **TOTAL** | **25** |

# Task 2: Calibrate IR Sensor

As mentioned in the previous task, you have two types of IR sensors: analog and digital. One of these IR sensors can be used to determine the distance to a nearby object and the other can be used to detect the presence of nearby objects. Your first subtask will be to identify which of the sensors can measure the distance to an object. This can be done by reviewing the sensor specifications or experimentally.

Once you have identified the sensor capable of measuring distance, you will need to calibrate the sensor using a process like that used in the motor calibration task in the dead reckoning assignment. Specifically, you will need to measure the raw sensor output at a minimum of 8 different distances and fit a curve to this data. It is critical that all the distances you choose for this calibration activity are within the range of the sensor (as specified in the data sheet). When you have collected all your measurements, plot the sensor reading vs. distance (in inches), fit a curve to the collected data, calculate the $R^2$ value of the curve fit (a $R^2$ value closer to 1 indicates a better fit), and find the equation to convert the sensor readout into distance (in inches).

## Submission Details:

- Submit a plot that contains the raw data, fitted curve, $R^2$ value of the fitted curve, and equation to convert the sensor readout into distance. To receive full credit, the plot must be appropriately labeled.

## Task 2 Grading Rubric:

| Description | Possible Points |
|---|---|
| Correctly identified ranging/distance sensor | 5 |
| Collected data for at least 8 different distances | 5 |
| Collected data within range of sensor | 5 |
| Fitted regression curve to data | 5 |
| Calculated $R^2$ value of curve fit | 5 |
| Determined equation to convert raw sensor reading into distance | 5 |
| Submitted plot that contains raw data, fitted curve, $R^2$ value of fitted curve, and equation used to convert the sensor readout into distance | 10 |
| **TOTAL** | **40** |

# Task 3: Generate Pseudocode for an Autonomous Robot Mission

Your final demonstration will require your robot to autonomously navigate through an unknown robot obstacle course towards a target, such as that shown in Figure 1. To do this, your robot will need to use its inertial sensors to keep a heading and its IR sensors to detect obstacles in the path of your robot. Using your robot's sensors, your overall objective is to develop a strategy to reach the goal location while avoiding obstacles detected along its path. The number (1 -3), placement, and type of IR sensor(s) used to accomplish this objective is up to you.

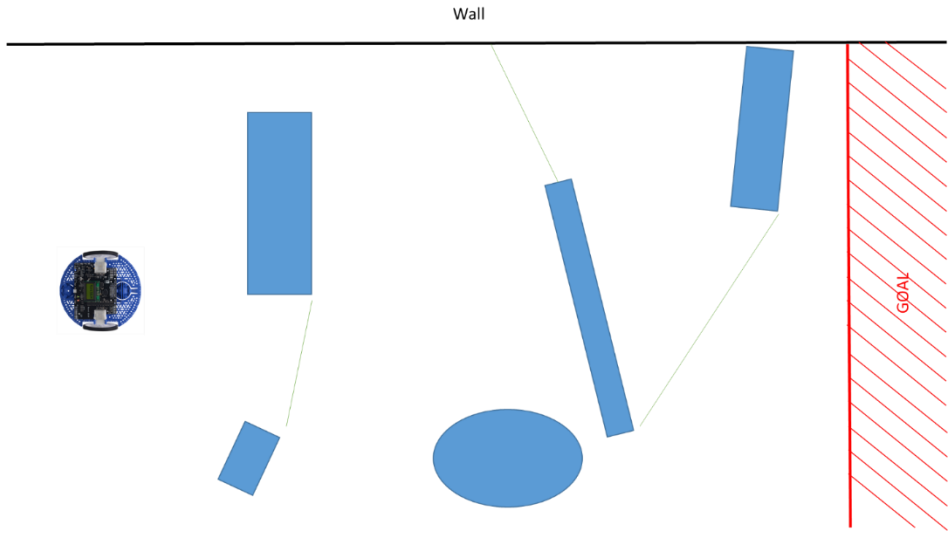


*Figure 1. Sample obstacle course. The robot start position is indicated by the robot on the left and the final robot goal is indicated by the red area on the right. Unknown obstacles are shown in blue and robot checkpoints are depicted as light green lines. The obstacle course that will be used for the final, in class demonstration will include more objects than that shown here.*

For this task, you will need to generate pseudocode to accomplish this autonomous robot mission. The pseudocode must satisfy the following requirements to receive full credit. Be detailed with your pseudocode as this will be the most complex program you have written to date.

1. The robot must navigate the course autonomously
2. The robot mission must be started using a button push
3. The robot must use heading to identify the goal region
    a. You can assume that goal region is directly in front of the robot at the start position (i.e., zero heading)
4. The robot must continuously try to reach the goal region
5. The robot must display the current heading, in degrees, on the first line of the LCD
6. The robot must display the current distance to an object, in inches, on the second line of the LCD
7. The robot must avoid hitting obstacles detected along its path
    a. It is up to you to determine the robot-object distance that should trigger your obstacle avoidance strategy
    b. If you plan on using multiple sensors, be sure to indicate which sensor on the robot triggers what robot behavior(s)
8. The robot must beep when it is avoiding an object that it believes to be in its path

## Submission Details:

- Submit a picture of the robot with IR sensor mounting locations and IR sensor type clearly identified.
- Submit the pseudocode associated with this task. Make sure that your pseudocode is detailed and clearly legible.

### Task 3 Grading Rubric:

| Description | Possible Points |
|---|---|
| Submitted a picture of the robot with IR sensor mounting locations and IR sensor type clearly identified | 5 |
| Submitted pseudocode | 1 |
| Determined initial heading | 1 |
| Waited until button pressed before started mission | 1 |
| Displayed current robot heading on line 1 of LCD | 1 |
| Displayed current distance to object on line 2 of LCD | 1 |
| Used robot heading to navigate towards goal region | 5 |
| Defined robot-object distance(s) that will trigger obstacle avoidance strategy/algorithm | 5 |
| Implemented obstacle avoidance strategy/algorithm | 10 |
| **TOTAL** | **30** |

## Task 4: Autonomous Robot Mission Demonstration

Write an Arduino sketch based on the autonomous robot mission described in Task 3. Your robot must complete the course during the in-class demonstration period. You can make up to two attempts at the course and the best score will count for your grade. If class time permits, additional attempts will be awarded.

### Submission Details:

- Submit the Arduino sketch associated with this task. The Arduino sketch should be commented to show what lines are associated with specific subtasks.

## Task 4 Grading Rubric:

| Description | Possible Points |
|---|---|
| Submitted code | 5 |
| Waited until button pressed | 2 |
| Displayed accurate heading on LCD | 3 |
| Displayed accurate robot-object distance on LCD | 3 |
| Beeped when avoiding object | 3 |
| Robot crosses 1st checkpoint | 10 |
| Robot crosses 2nd checkpoint | 8 |
| Robot crosses 3rd checkpoint | 8 |
| Robot reaches goal region | 8 |
| Robot hits obstacle | -10 pts (per obstacle) |
| Robot leaves course area | - 10 pts |
| **TOTAL** | **50** |

## Task 4 Extra Credit:

You will receive 10 points of extra credit if your robot uses only 2 IR sensors and crosses the 2nd checkpoint without hitting any objects. Note: the other sensor must be unplugged.

You will receive 20 points of extra credit if your robot uses only 1 IR sensor and crosses the 2nd checkpoint without hitting any objects. Note: the other sensors must be unplugged.