# Mechanical Engineering 2900
# Introduction to Design in Mechanical Engineering
# Arduino Lab 5 - Open-Ended Prototype Project

**Objectives:**

1. Put the various techniques you have practiced over the last four weeks to use.
2. Practice identifying and solving problems in different situations.

**Directions:**

1. During the last three weeks of the Arduino labs, create a functional prototype that solves an interesting problem.
2. Fully document the design and development process.
3. Write a clear and concise report about your prototype.
4. **Demonstrate your prototype's operation** to an instructor **by the end of open lab (by 6:30 PM) on Monday, October 16.**
5. Upload **your report and a video of your prototype** to YouTube **by Monday, October 16 at 11:59 PM.** Include the link to your YouTube video somewhere in your report.

## 0 Introduction to the Project and the Design Process

You will work on this project for three weeks in lab. The purpose of this project is to introduce you to the design process and allow you to creatively use the tools and techniques you have learned over the past few weeks in solving a problem.

The **design process** involves many steps. It typically starts by identifying some sort of problem or inconvenience faced by a group of people. This requires a great amount of **research** in order to fully understand specific types of issues and inconveniences people are facing. Designers collect information about the way people function and the way they use or misuse products. It may involve going to the workplaces, the homes, or other activities and observing the target user.

After identifying and understanding the problem, designers more clearly define the project by creating a **persona**, a hypothetical person who fully illustrates the problem at hand and represents a typical member of the population who would benefit from a solution to this problem. Throughout the design process, designers reference the persona to ensure that the solution stays on track.

After creating the persona, designers start to **brainstorm** solutions. In this step, the goal is to come up with as many ideas as possible. In brainstorming, no idea is too strange. As this process progresses, the most bizarre ideas often lead to more practical yet unique solutions.

Next, it's time to select and combine the best and most practical ideas into a **prototype idea**. This is usually a very rough concept of the solution. This step may involve testing out various technologies or building rough **"physical proof-of-concept"** of the idea, exploring how it might be implemented.

Once the team is happy with the direction the project is going, designers will usually develop a more refined prototype. This process will continue until the designers or clients are happy with a final, completely functional prototype. For some projects, this might be a near "production-quality" level. For others, the final prototype will be a bit rougher. **The point is that the prototype must adequately define the physical configuration, operation and feedback of the actual product.**

For this project, you will identify a known problem or a list of requirements, and you will develop a functional prototype. Your prototype should following the NUN criteria of patenting: it should be **new**, **useful**, and **non-obvious**. The prototype can be rough and made from scarp parts (not what you would be using in the actual product), but should resemble the final product and function exactly how the final product should. **Your final prototype should not simply be a bunch of wires and components connected to your breadboard and Arduino.** For example, if you are creating an automated dog door, you could create a scaled model of a house to demonstrate how your prototype functions.

## 1 Selecting your project

In order to create this prototype, begin by developing the problem that your prototype will solve and identify what requirements your prototype must meet in order to solve this problem. Perhaps you have encountered a common problem at home that you would like to solve with an Arduino. Or maybe you've always wanted to create some invention that you think would be useful to someone else. Clearly define the problem and build a solution using your Arduino.

You will be submitting prototype proposals to your lab instructors and they will meet with you individually to discuss whether your proposal is a viable option.

## 2 Prototype Requirements

1. The sensors and actuators available in the lab have been divided into categories based on point value. When creating your prototype, fill out the "Prototype Components" sheet with all of the components you plan on using. Only the components that are **included and functional** in your final prototype will be awarded points (out of 10 points).
2. Out of the components you end up using in your final prototype:
    i. You must use at least one **sensor you have not used before in lab** (any electric component that the Arduino uses to sense it's environment) and **one actuator you have not used before in lab** (any electric component that the Arduino uses to affect it's environment). **Any components you use from lecture** must be used in a **new and different manner** than they were used in lecture.
    ii. There must be both **electrical** AND **physical** components. This could be valves, gears, buttons, levers, etc.
3. As mentioned previously, your prototype must have some level of polish. This is more than just a "proof of concept" prototype. I**t should adequately demonstrate the actual operation and usage of the finished product.** The grading scale for level of polish is listed below (out of 3 points):
    - **0 points:** Prototype includes only electronic components (breadboard, wires, sensors, actuators) and no other hardware.
    - **1 point:** Prototype includes electronic components as well as physical components that are not representative of the functionality and nature of the product.
    - **2 points:** Prototype includes electronic components and physical components that are representative of the functionality and nature of the product.
    - **3 points:** Prototype includes electronic components and the prototype form factor is nearly professional. This prototype is pre-production quality. See examples of pre-production quality below:
        - https://www.youtube.com/watch?v=u_NiY5naWHI
        - https://www.youtube.com/watch?v=bkUmcOLqxtk
        - https://www.youtube.com/watch?v=WtLp3SeZuEo&feature=youtu.be
4. Your prototype will also be graded for its level of **complexity in programming**. The following programming items will be graded (out of 12 points):
    - The use of user-defined functions in your prototype's Arduino sketch(es):
        - **0 points:** no user-defined functions with 5 or more statements
        - **2 points:** prototype includes one user-defined function with 5 or more statements

        - **+1 point:** user-defined function passes or returns values
        - **+1 point:** user-defined function passes and returns values
        - **+1 point:** prototype includes more than one user-defined function with 5 or more statements
    - The incorporation of new libraries:
        - **0 points:** no libraries incorporated into prototype
        - **2 points:** at least one library incorporated into prototype
    - The correct incorporation of several flow control structures (refer to Arduino Programming Notebook - includes if, if…else, for, while, do…while) in a useful way:
        - **0 points:** no flow control structures used in prototype
        - **1 point:** one type of flow control structure used in prototype
        - **2 points:** two or more different types of flow control structures used in prototype
    - Reliability and predictability of Arduino sketch(es):
        - **0 points:** Arduino sketch(es) do not work reliably and predictably
        - **3 points:** Arduino sketch(es) work reliably and predictably
5. You must document your process and solution as described on the following page in **Report Guidelines**. A video of your prototype and a demonstration of your prototype functioning to an instructor are also required.

## 3 Report Guidelines

The report should be professionally written, clear, and concise. Include all of the following information:

- **Introduction:**
  - An introduction to your prototype and the problem for which you developed a solution. Include the requirements that your prototype needed to meet in order to resolve the problem.
- **Idea Development Process:**
  - Discuss how you came up with your solution. Did you brainstorm, create a mind-map of your ideas, or draw sketches? Include the details of this process (i.e. a list of your brainstorming, scan your mind-map or sketches).
  - Include the other solutions your brainstorming or mind-mapping led to before you chose your final direction. This should include different options you considered for your prototype to solve the same problem such as different sensors and actuators, different programming logic, different physical elements, etc.
- **Discussion:**
  - Fully explain the operation and features of your finished prototype. What does your prototype do, and how does it work? Make sure that you address BOTH what your prototype does (how it functions) and the technical details of how it works.
- **Conclusion:**
  - In detail, describe at least one particularly interesting or successful feature of your prototype. What were you most proud of? A section of code? A mechanism?
  - Describe at least one particular difficulty you had in creating your prototype. What did you do to resolve this issue?
  - Describe at least one aspect of your prototype you would have changed/ improved given more time or resources.
- **Appendices:**
  - Photographs of your final prototype.
  - All relevant circuit schematics.
  - All relevant Arduino sketch/sketches.

## 4 Deliverables *(with deadline)*

- ☐ Prototype proposal *(already submitted)*
- ☐ Any non-cabinet components need to be submitted in the appropriate Canvas survey by *11:59 PM on Monday, October 2.*
- ☐ Confirm your functional prototype with an instructor *(end of open lab at 6:30 PM on Monday, October 16)*
- ☐ PDF of report in Carmen dropbox *(Monday, October 16 at 11:59 PM)*
- ☐ Video of functional prototype uploaded to YouTube *(Monday, October 16 at 11:59 PM)*
- ☐ PDF of Prototype Components sheet in Carmen dropbox *(Monday, October 16 at 11:59 PM)*