A03P Manufacturing

An **individual** submission to be submitted on Github Classroom & Gradescope.

**Github Classroom assignment:** <https://classroom.github.com/a/f3ixWh2r>

Remember to read the [ESE5160 S24 Assignment README](https://docs.google.com/document/d/1pPXQByy8eTxTJ--3vO8KpTjMk5yBHF8wQXoLJ55w5a8/edit) before starting!

If you need to use a late day, you must submit using [this form](https://docs.google.com/forms/d/e/1FAIpQLSd2hfFc7tIAqP-B1GouC5sP6Zbl59p7JXJa_yGTR60CJHRU3A/viewform).

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# Learning Outcomes

* Understand the relationship between mechanical and electrical engineering when designing a product.
* Learn the basics of a Mechanical CAD tool, SolidWorks.
* Learn what resources UPenn Engineering has available for building custom designs.
* Understand how a circuit board is manufactured and assembled in factories - and how our Altium design will affect the success of its manufacturability!

# 1. Casework Description

Engineering projects require you to think outside of your specific field. When designing PCBAs, for example, you’ll need to consider the user interface, user experience, casework, and functionality of a device. In ESE5160, you’ll be creating a final demo for your product - we want you to have some basic mechanical CAD (MCAD) skills and resources to help make something memorable.

Penn has excellent resources for you to build things. Generally, you just need to take a fairly quick safety exam. Review the resources below

* [Garage Lab](https://meamlabs.seas.upenn.edu/garage-lab-and-tool-library/) for:
  + Hand tools: Screwdrivers, Hammers, Wire Cutters and Strippers, Drills, Impact Drivers, Rotary tools (Dremels), Orbital Sanders
  + Power tools: Belt Sanders, Drill Press, Bandsaw, Miter Saw, Buffing Wheel, Sandblasting Cabinet
* [RPL – MEAM Labs](https://meamlabs.seas.upenn.edu/rapid-prototyping-lab/) for laser cutting and 3D printing
  + You can get access to use the laser cutters & 3D printers yourself, you need to pass the [training](https://meamlabs.seas.upenn.edu/rapid-prototyping-lab/training/).
  + Or, you can just submit 3D files for printing using these [instructions](https://meamlabs.seas.upenn.edu/rapid-prototyping-lab/makerfleet/).
* Tangen Hall [Fabrication Studios](https://venturelab.upenn.edu/fabrication-studios)
  + Laser cutting, 3D printing, CNC operations, mechatronics lab
* ESE Makerspace / Detkin has a few 3D printers available as well

Note: If you’d like to gain access to any of these labs, make sure to apply sooner than later. It takes a bit of time to get you enrolled.

After reviewing the resources available, take a few minutes to describe your ideal enclosure for your ESE5160 prototype. Include one or more sketches. Questions to think about include:

1. Are you mounting your casework to anything? (Ex: bike or helmet mounted device)
2. Will you need one or multiple cases?
3. Will you have cables connected to peripheral devices?
4. What materials might work well for your needs?
5. What manufacturing techniques will you use? (Ex: 3D printed case, laser cut acrylic plastic, wood cut with a bandsaw, etc.)

**Submission:** Update your README.md with a description of your physical enclosure. Describe which manufacturing techniques you expect to use. Include one or more rough sketches of your idea.

# 2. SolidWorks Tutorial

Though mechanical computer aided design (MCAD) is not the focus of this course, it helps to have a basic understanding as you design caseworks and develop empathy for the mechanical engineers you’ll work with in industry.

Most engineering lab computers have SolidWorks - or you can install it on your Windows computer following [these instructions](https://cets.seas.upenn.edu/answers/solidworks.html). **Please use SolidWorks 2023 (not 2024) for this assignment.** Follow this tutorial and submit the final 3D object for review - it should take ~20-30 minutes:

[Ultimate SolidWorks Tutorial for Absolute Beginners- Step-By-Step](https://www.youtube.com/watch?v=qtgmGkEPXs8)

Note: Altium has the [**MCAD CoDesigner** software](https://www.solidworks.com/media/altium-mcad-codesigner-overview) for working with MCAD tools, such as SolidWorks. If you’re interested in a more tightly coupled design experience, you can review and use this tool.

**Submission:** The SolidWorks part file (.SLDPRT) from the tutorial video in your Github repository. Name it **pennkey\_a03.sldprt** (example: nmcgill\_a03.sldprt).

# 3. PCBA Manufacturing

An important part of learning PCB Design is to understand how PCBs are manufactured. As a hardware engineer, it is vital to understand how PCBs are fabricated and PCBAs assembled. If you do not understand the process, you might make a board that passes muster in Altium, but is unmanufacturable!

Review the following two videos. They are very informative and will explain to you the PCB manufacturing process.

**Manufacturing:** [PCB production technology (full movie)](https://www.youtube.com/watch?v=Su0PIw5OaYQ)

**Assembly:** [Inside a PCB Soldering Factory - in China](https://www.youtube.com/watch?v=24ehoo6RX8w&feature=youtu.be)

Answer these questions in your own words with what you learned from the videos – a simple one sentence answer is enough!

## Manufacturing

1. Why are manufacturing files reviewed? What are the reviewers checking?
2. How is the design placed into the copper boards? What is Photoresist?
3. You can see boards are made in copper pairs. How are they glued together? Why are multiple stacks of copper-fr4-copper stacked together to make a PCB?
4. The boards are stacked up (depending on their layer count) and then drilled. What are these drillings (vias) for?
5. What is AOI (Aided/Automatic Optical Inspection)?
6. What is the Solder Mask (green layer in video) for? (<https://www.eurocircuits.com/sm-solder-mask/>) What is the silkscreen?
7. What is the surface treatment for the copper used for?
8. What is the V-Score?
9. What are they testing on the flying lead process (test at the end of the first video)

## Assembly

1. What is a solder paste stencil used for?
2. What is a pick and place machine?
3. What happens in the reflow oven?
4. After the reflow oven, on the AOI stage, why does the operator place inspection arrows? What is tombstoning?
5. Why did they use X-RAY to inspect a BGA component?
6. How were through hole components assembled in the video?
7. How does the wave soldering machine work?
8. What is the testing jig, or bed of nails, for?

**Submission:** Update your README.md with these answers.

# Rubric

While the rubric attempts to capture all assignments details, points assigned may vary based on submission quality and teaching team review. Please ensure you read the assignment carefully so as not to miss details and lose points. Poor readability / formatting can lose you points on any assignment.

**For all questions, 0 points will be awarded if the submission is non-existent, very poorly done, or doesn’t compile (for firmware assignments).**

| **Points** | **Question** | **How to achieve full credit** |
| --- | --- | --- |
| 10 | 1. Casework Description | Casework is described in words and at least once sketch. The manufacturing techniques to build this casework are mentioned. |
| 5 | 2.SolidWorks Tutorial | The SolidWorks part is created as in the tutorial and submitted correctly. |
| 10 | 3. PCBA Manufacturing | All questions are answered and adequate knowledge of the subject is portrayed. |
| 25 |  | Total Achievable Points |