

When solving a problem, almost everyone follows a process similar to the one outlined above, even if they only do it subconsciously. Every time they are asked to make a decision, they run through this process without even realizing it. The [design](#) process can be accomplished with varying degrees of formality, ranging from the subconscious process everyone does in their head to the highly documented process used in corporate engineering.

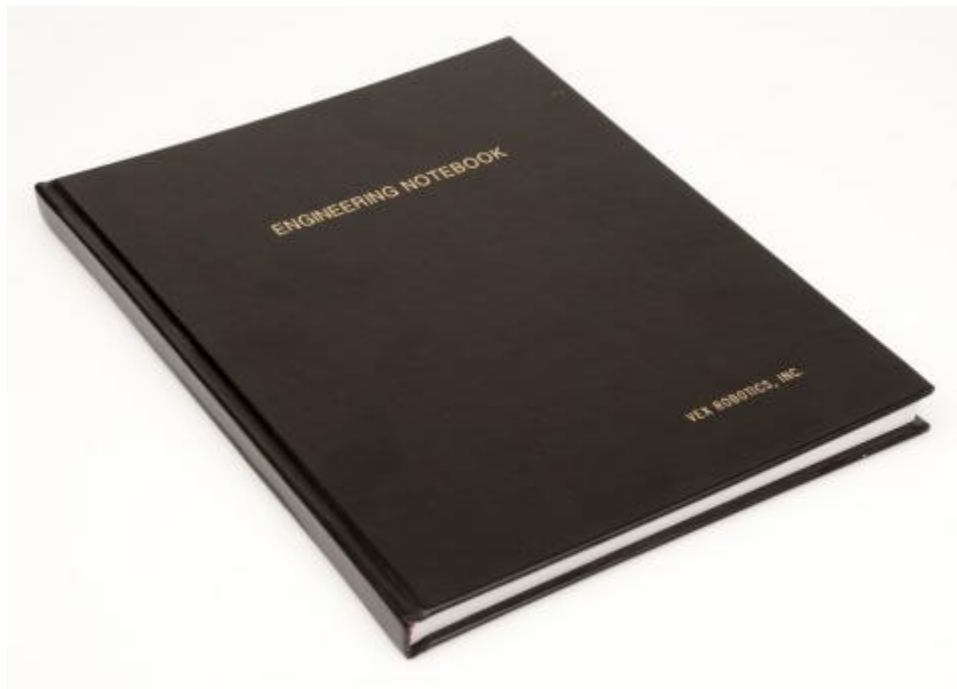
Designers must determine what degree of detail and documentation is needed for their specific process. Many designers are tempted to do everything in their head, thinking that documentation will only slow them down. In truth, a more formalized process will produce a better result. Formalization will promote thoroughness; additional documentation will help prevent mistakes.

In competition robotics it is useful to keep documentation of the design, though the extent of this documentation is sometimes limited by the time available. However, as described above a documented process is a more methodical process. The notes can also be useful when explaining the design to competition judges and they will serve as good documentation for future team members who want to understand the process used.

For the purposes of this class, students should document almost everything in their engineering notebooks.

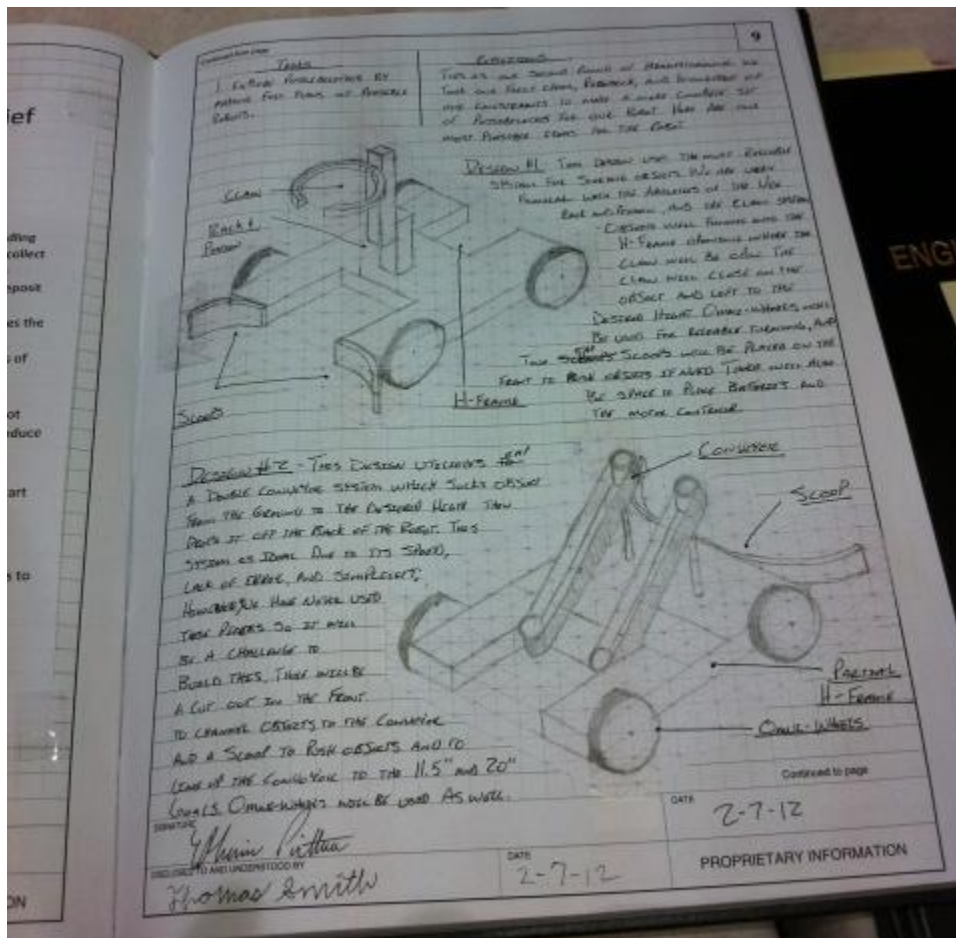
Engineering Notebooks

An Engineering Notebook is a record of the design process; it is basically a "diary" that designers keep as they progress through the process.



Engineering Notebooks come in many different formats, but they should detail each step of the process. They should combine a narrative of the progress, concept sketches, engineering calculations, pictures of prototypes, test procedures, and more. Some of the most important things to record are the decisions made, and the reasoning behind these decisions. Later on in the design process, if a designer runs into a problem and does not remember why something was done a certain way, the notebook will provide a good reference. A Design Notebook should serve as a roadmap such that any outsider can follow the designer's process, understand the choices made by the designer, and end up with the same result.

If a designer gets transferred to a different team in the middle of a project, someone else should be able to read his or her Engineering Notebook and pick up right where they left off.



Every notebook entry should be dated and signed by the designer to provide proof of when the documented work was done; this comes in handy during any patent or intellectual property debates that occur over the design (obviously this typically doesn't apply to the work done by competition robotics teams).

ENGINEERING TOOLS:

Engineers use a variety of tools to help them during the completion of a design process and the solving of a problem. One of these tools is the Engineering Notebook, which was described previously. If robotics teams want to take their Engineering Notebooks to the next level, they can use digital design

tools to enhance their work and save valuable production time. One useful tool for digital design creation and documentation is Sketchbook. Autodesk® SketchBook® software allows students to document their robot design ideas, not only in the classroom, but also wherever and whenever they like using the mobile app. During the modeling, testing and developing stages of the design process, students are able to revisit their original concepts in Sketchbook, and quickly modify and save as a new design. This produces a comprehensive log for their Engineering Notebook that records their decisions throughout the design process.

Engineers often also use something called [Computer Aided Design \(CAD\)](#) software to help them in the virtual creation and visualization of their designs. Autodesk's industry leading CAD programs and mobile apps make the modeling, simulation and visualization of competition robot designs quick and easy. Autodesk® Inventor®, Autodesk® Fusion 360™, and Autodesk® ForceEffect™ software are available to students and educators at no charge. Inventor will be used by students in this class, with Fusion as an optional tool for flexibility.

Autodesk Inventor

Autodesk® Inventor® Professional software simplifies the transition from 2D and 3D mechanical design, using intuitive sketching, direct manipulation, product simulation, and design communication. Inventor takes you beyond 3D to Digital Prototyping by enabling a designer to produce an accurate 3D model that can help with the design, visualization, and simulation of the robot before it's built. Digital Prototyping with Inventor will help students design a winning robot, by guiding them through assembly creation and ensuring that all parts and components fit correctly.

Autodesk Fusion 360

Autodesk® Fusion 360™ software is a cloud-based 3D CAD/CAM tool that enables fast and easy exploration of design ideas with an integrated concept-to-production platform. You can quickly iterate on design ideas with sculpting and modeling tools, create assemblies, and produce photorealistic renderings and animations. Make ideas a reality by creating toolpaths to machine your components or using the 3D printing workflow to create a prototype. Robotics teams can work together anytime, anywhere, using collaboration functionality in the cloud.

A mobile app which will support the design of a competition robot is Autodesk ForceEffect.

Autodesk ForceEffect & ForceEffect Motion

Autodesk® ForceEffect and ForceEffect Motion™ engineering apps are purpose-built tools used to quickly and easily simulate design options. ForceEffect enables students to perform static systems analysis using free body diagrams. ForceEffect Motion is ideal for developing mechanical systems with moving parts. Unlike the traditional approach of using paper, pencil, and a calculator to develop equations for design options, Autodesk ForceEffect and ForceEffect Motion do all the simulation and engineering calculations right on your mobile device, enabling designers to quickly and easily simulate options during the concept phase to determine if a design will work.