

PROJECT 1 ENGINEERING 101

WELCOME TO ENGINEERING! You are beginning an adventure that explores the fun and rewarding field of engineering. Because engineering is not a class most kids see on their school schedules, we'll start with a crash course in Engineering 101.

WHAT IS ENGINEERING?

Engineering is work that uses science, math, and technology to create products and processes. The mission of engineering work is to help humanity and our world. Many times, the goal is to solve an urgent problem, such as building a bridge or setting up a communications network after a disaster. Sometimes, the goal of engineering is to help other living creatures, such as developing *prosthetic* (artificial) legs for a dog born with missing or malformed limbs. Other times, the goal of engineering is to make a process work better and faster, such as scheduling the gates that airplanes use in an airport.



Courtesy of 3D Systems

WHERE DO ENGINEERS WORK?

Engineers work in all types of settings, all over the world. Sometimes engineers work inside, using a computer to design a product. Sometimes they work outside, using special construction equipment to build a structure. Sometimes they work alone, but most of the time engineers work in teams.

6 PROJECT 1 ENGINEERING 101

Engineers share information with each other when the knowledge and experience of one group can help another group. This was the case when NASA engineers helped the government of Chile rescue 33 miners who were trapped underground. NASA's experience working in hard-to-reach places and in creating rescue capsules contributed to the success in saving the miners.



Courtesy of Hugo Infante/Government of Chile

WHAT ARE SOME ENGINEERING FIELDS?

Many types of engineering exist, and each field offers exciting challenges to solve. Here are a few engineering fields and the products or processes with which they work:

- » **Aerospace:** Build airplanes and spacecraft
- » **Architectural:** Construct buildings, skyscrapers, and landmarks
- » **Biomedical:** Build devices that function with living bodies
- » **Chemical/materials:** Create new products such as medicines, plastics, and fuels
- » **Civil/structural:** Build dams, roads, and bridges
- » **Computer:** Make computers and smart devices
- » **Electrical:** Build electronic equipment; generate and distribute electricity to homes and factories
- » **Environmental:** Focus on pollution control and recycling

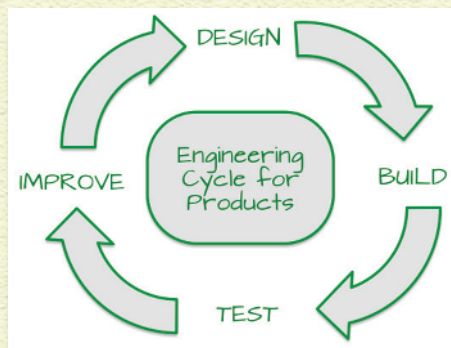
- » **Entertainment:** Build amusement parks and movie sets
- » **Industrial:** Find ways to speed up and improve production lines
- » **Marine/ocean:** Design systems to operate in coastal or ocean waters
- » **Mechanical:** Design and build machines, including robots
- » **Mining/geological:** Focus on mining and earthquakes
- » **Nuclear:** Build systems that use the energy of atomic radiation
- » **Petroleum:** Find, get, and use oil and natural gas for energy



The Grand Challenges of Engineering are some of the most important work engineers will need to do to help humanity. Learn about them at www.engineeringchallenges.org.

WHAT IS THE ENGINEERING DESIGN CYCLE?

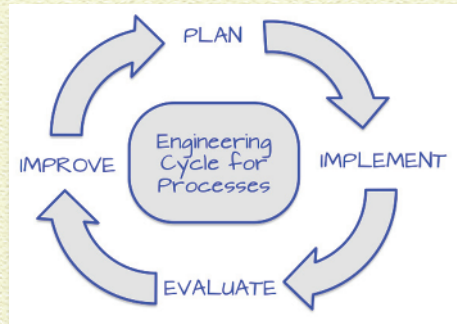
The *Engineering Design Cycle*, or simply, the *Engineering Cycle*, is a set of steps an engineer follows to go from an idea or a need to a manufactured product or a process. When an engineer makes a *product*, such as a spacecraft to go to Mars or a roller coaster, he or she follows this cycle:



- » **Design:** Start with information about a need or a problem, brainstorm ideas on how to solve it, choose one, and then draw how you will make your product in real life.

- » **Build:** Use tools and materials to construct your product. A *prototype* is the first build of a product, before it is perfect.
- » **Test:** Use your product to find out how well it works.
- » **Improve:** Make changes to your product to fix the parts that don't work well.

When an engineer creates a *process*, such as cleaning an ocean oil spill or speeding up the way people move across a bridge, he or she follows this cycle:



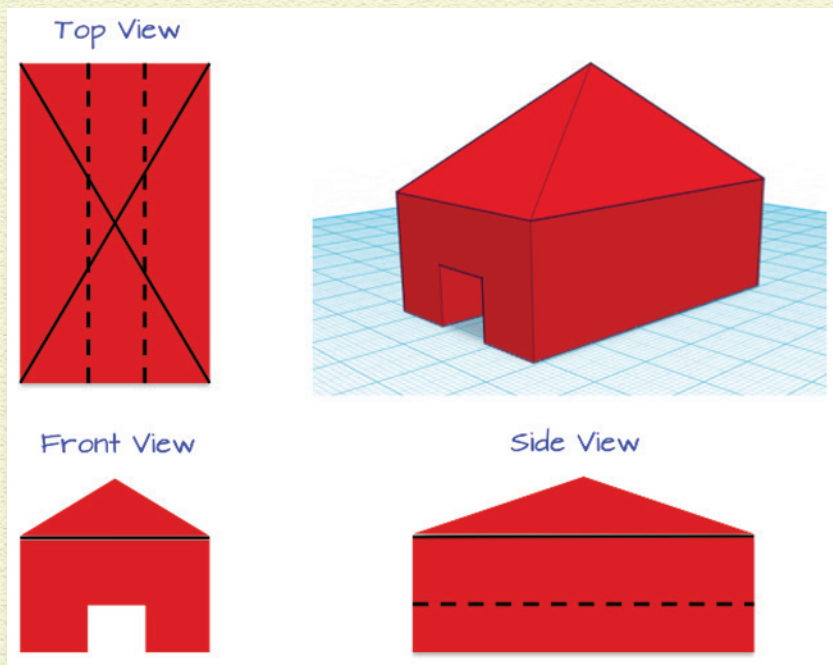
- » **Plan:** Start with information about the problem or need, brainstorm ideas about how to address the need, choose one, and then write down the steps for how you will make your proposed process work, start to finish, in real life.
- » **Implement:** Perform your process using the steps of your plan.
- » **Evaluate:** Decide how well your process works.
- » **Improve:** Make changes in your process to speed up or simplify the parts that don't work well.

The Engineering Cycle is a cycle because you continue looping through the steps to constantly improve your product or process.

WHAT DOES A DESIGN LOOK LIKE?

Engineers have special ways of drawing or sketching their designs. They use engineering drawings that show the top, front, and side views of products they build. An example of the top, front, and side views of a proposed building design is shown

here. You can use the same method of drawing in your design notebook.



Inventors protect their works by filing patent applications. They include patent drawings like the top-front-side sketches you see here!

Practicing engineering design drawing will be helpful when you create products for 3D printing (see Project 6). A great online game you can play to better understand top, front, and side views is Point of View, which is located at <http://pbskids.org/cyberchase/math-games/point-out-view/>.



WHAT IS THE GOLDEN RULE OF ENGINEERING?

The *Golden Rule of Engineering* is “keep it simple and double-check your work.” This means that the simplest design or plan that meets all the criteria is the best, and that you should carefully check your work before building a design or implementing a plan.

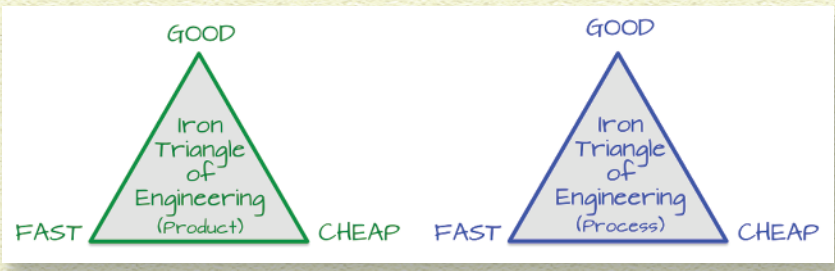
Catching a mistake on paper before it happens in the real world can save money, time, and lives. For example, NASA accidentally burned up its \$327 million Mars Climate Orbiter in the atmosphere of the Red Planet when engineers incorrectly used English units instead of metric. The headline in *Wired* magazine read: “Metric Math Mistake Muffed Mars Meteorology Mission.”

WHAT IS THE IRON TRIANGLE OF ENGINEERING?

The *Iron Triangle of Engineering* describes three factors engineers must think about when building a product or implementing a process. They must consider:

- » **Time:** How fast do they have to get the project done?
- » **Features and quality:** How good does the finished product or process have to be?
- » **Cost:** How cheap must they be in moving from the idea or need to the completed product or process?

These three factors are related, and it is hard to complete an engineering project that is fast, good, and cheap. Engineers can usually do two of these at one time but not all three, which is typically known as “pick any two.”



For example, if you want to build a great house quickly, you will have to put more workers on the job, which will cost more money. Or you can make a cheap personal music player and get it in stores fast, but you probably won't have time to perfect it — so quality and reliability may suffer, or it won't as have many features as an expensive music player. As a junior engineer, you consider the Iron Triangle of Engineering in all projects you work on in this book.

MINI PROJECT

CLASSIC POCKET ROCKET

THE CHEMICALLY PROPELLED LAUNCH VEHICLE IS AN OLDIE BUT A GOODIE – AND FUNDAMENTAL TO EVERY KID'S ENGINEERING STUDIES.

Materials: 35mm film canister; water; 6 cm diameter foam circle; goggles; foam triangles, protective gloves, and mask (optional).

Materials to be supervised: Alka-Seltzer tablet; low-temp hot-glue gun and glue; scissors.

Design: Sketch the rocket in your design notebook. Your rocket needs a fuel chamber (film canister) and a nose cone to reduce drag during flight. Try different nose cone designs to see how they affect flight! If you want, you can also add fins made from foam triangles.

Warning: Wear goggles (and, optionally, gloves and mask) when working with sharp tools, chemicals, and hot materials!

Build: Construct the nose cone by cutting and removing a wedge from the foam circle. Rotate and hot-glue the cut sides to overlap in a cone, then hot-glue the cone to the rocket at the canister base.

Test: Crumble one Alka-Seltzer tablet and place it in the canister. In an open area outside (and wearing your goggles!), add water to the canister and then quickly cap it. Shake the rocket once and position it upright. Step back a few feet. In 10 to 20 seconds, you'll see an exciting launch! Repeat using different amounts of water to see which makes your rocket go the highest.

Tip: Mixing water and Alka-Seltzer releases carbon dioxide. The gas fills the canister, pushing against the cap to create liftoff.

