# Introduction to the Engineering Design Cycle

Solving Everyday Problems Using the Engineering Design Process

#### What is the engineering design process?

A series of steps engineers work through in order to define and solve problems!

- 1. Identify
- 2. Define
- 3. Develop
- 4. Evaluate
- 5. Test
- 6. Optimize
- 7. Communicate



Psst... Keep an eye out for this symbol throughout the slides! It tells you which stage of the design process is being covered!

### *Definitions*: Identify and Define the Problem's Criteria and Constraints

Identify the problem: Identification occurs when someone realizes that a problem exists that needs to be solved. Define the problem: Definition occurs when someone realizes exactly what the problem is.

For example: Students realizing that they are not getting their work handed back from the teacher is a good example of problem identification. When students realize that they are not getting work handed back because the teacher's desk is too disorganized, they have begun to identify the problem.

#### **Criteria and Constraints**

- Criteria are the requirements the solution must meet, such as what it must do.
- Constraints are the limitations on the solution, such as a maximum size or budget.

#### Example: Identify a problem

- When you see a problem in the world, imagine how you might be able to solve it through engineering!
- So many problems can be solved through engineering.

Students in Mrs. Anderson's English class are frustrated because they never get their work handed back to them. They can see their grades online, but without getting their work back, they don't know how to improve!

By noticing that their work is not being handed back, Mrs. Anderson's students have identified a problem.

#### Example: Define/Specify Criteria and Constraints

One way to define this problem is by talking to Mrs. Anderson. When the students ask her why they aren't getting their work handed back, she apologizes and says that she has trouble keeping her desk organized, and sometimes misplaces assignments after they are graded.

By learning that organization is the reason they are not getting their work handed back, the students have defined the problem.

The students decide to help Mrs. Anderson by building her a desk organizer. Based on their discussion with Mrs. Anderson and their available resources, they develop a list of criteria and constraints for the organizer.



#### 1. Identified criteria:

- Must hold 700 papers (100 x seven classes)
- Must take up less than 16 x 12 inches surface area
- Must be moveable
- 2. Identified constraints:
  - Must cost less than \$5

#### **Definitions:** Develop and Evaluate Ideas

Engineers develop ideas by thinking of possible solutions to the problem.

Engineers evaluate ideas by considering the pros and cons of the possible solutions.

#### Brainstorming!

#### *Example*: Develop ideas

• What possible solutions can you come up with to Mrs. Anderson's problem?

Mrs. Anderson's students talked to each other and came up with a few different ideas, including a stack of baskets or drawers, and a box to organize file folders.

#### Example: Evaluate Ideas

- Building a stack of shelves or baskets is too expensive. The students realized this when they began looking at material prices. Since it would cost more than \$5, this solution did not meet the constraints.
- Students realized that they could afford to build a file folder organizer, that it would be easy to move, and would not take up much room on Mrs. Anderson's desk.



Based on their evaluation of their ideas, the students realized that the file folder organizer was a good solution to the problem.



Definitions: test and optimize solutions

Engineers test solutions by trying them out to see how well they work.

Engineers optimize solutions by paying attention to the details of their tests, and thinking of ways the design could be better.

#### *Example*: Test solutions

The first draft is a

plain wooden box

designed to hold

file folders upright.

 Using materials and tools given to them by the school's woodshop teacher, the students designed a small box to hold Mrs. Anderson's file folders. They gave it to her to try it out and see what she thought.

It is very wide and the sides are short; when Mrs. Anderson puts the files in, they flop over.

#### Example: Optimize the solution

 With feedback from Mrs. Anderson, the students realize that they need to redesign the box so that it holds file folders better. They made some changes:



#### **Definition:** Communicate Solutions

Engineers communicate their designs when they explain to others how they were designed, why they are useful, and how others might use them.

#### *Example*: Communicate Solutions

Mrs. Anderson loves her new desk organizer!

It was so easy and inexpensive to make that the students wondered why the school didn't provide them to all the teachers. They wanted to make more organizers for the rest of the teachers, but couldn't afford to buy all of the supplies on their own.

They created a presentation for the school principal in which they explained why their organizer was useful to teachers, and asked for the materials to build more for the rest of the faculty. The principal was impressed by the design and agreed to provide the materials.

## Some famous people who used the engineering design process

#### Katherine Johnson

- Katherine Johnson was sometimes called a "human computer" because she performed complex mathematical calculations for NASA to help people explore space!
- You might have seen her featured in the movie, *Hidden Figures*.
- She is responsible for identifying and working within mathematical and technological constraints.
- Her math was so accurate that John Glenn refused to launch until the computer's calculations had been tested against Johnson's math.



Katherine Johnson at NASA in 1966.

#### Lee Anne Walters and Marc Edwards

- When the city of Flint, MI, changed its water source, big problems began.
- The city identified the problem when it detected fecal coliform bacterium in the water. Lee Ann Walters, a local mother, also identified high levels of lead in her water. She noticed a problem when her twins broke out with red bumps after bath time.
- Walters teamed up with Marc Edwards, an engineering professor and expert in lead corrosion. After testing, he reported that the water in one in six Flint homes contained twice the usual amount of lead.
- The city identified the criteria and constraints when they realized that finding a new water source would cost more money than they had to spend.
- One solution was to install water filters in 400 homes, which would ensure safe drinking water in those homes and stay within the budget constraints. But when the filters were tested, 52% of them were found to be defective.
- Because they won a lawsuit, the city now has the funds it needs to replace the pipes. They should be installed by 2020.



Engineer Marc Edwards studied the water supply.



Dirty and clean water.

#### James E. West



- Inventor James West was born in Virginia, and although he had a knack for science and engineering, his family discouraged him from attending college because finding professional work was difficult for African Americans at that time.
- Nevertheless, West excelled in college and after graduating took a job at Bell Laboratories.
- Bell Laboratories noticed that the microphones in telephones weren't sensitive enough, so they asked West to design a better microphone.
- One major constraint of this project was that the microphone needed to be small enough to fit into a telephone.
- West, along with his partner, developed the foilelectret microphone in 1964, a small microphone technology that is still used in about 90% of the microphones made today.

#### Jorge Odón

- Jorge Odon is a 59-year-old Argentinian mechanic who thought of a lifesaving invention during a dream.
- He identified the problem—that forceps can damage babies' skulls during difficult births.
- He imagined that a vacuum-like device might be a safer alternative.
- He tested his idea by building a prototype and gently suctioning his daughter's doll out of a bottle.
- The device is now being manufactured by a medical supply company and will be available for use all around the world. Its low cost means that people in poor countries will have access to this important medical innovation.