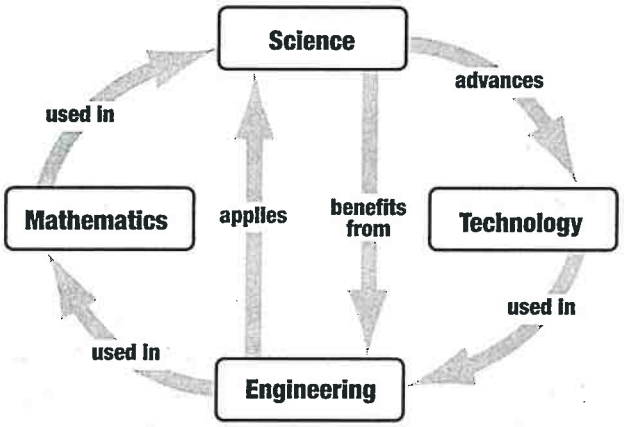
What Is the Engineering Design Process?

Engineering

Engineering is the application of science, mathematics, and technology to design, test, and build machines, structures, processes, and systems that solve human problems. Engineers solve a variety of problems, from designing more fuel-efficient aircraft to developing earthquake-resistant building materials. There are many branches of engineering, including civil, mechanical, electrical, chemical, and aeronautical engineering. Engineers design and build bridges, cars, circuit boards, chemical compounds, and aircraft. Engineering is introduced to students in many education curriculums through STEM programs. STEM is an acronym for science, technology, engineering, and math.



The Engineering Design Process

The engineering design process is the method that engineers use to solve a problem. The end result of the engineering design process is the development of a new machine, structure, process, or system.

The engineering design process begins with identifying a need. What is the problem that needs to be solved? Engineering problems are varied and can range from a need for better glass recycling technology to building a bridge to connect two points. Once the problem has been identified, research should be conducted into the problem. What is the status of other research into the problem? What are the constraints for solving the problem?

After the problem has been identified and researched, the next step is to brainstorm possible solutions. How could the problem be solved? Multiple solutions should be brainstormed to provide options for further evaluation. Promising solutions can be developed further, including adding drawings and illustrations of the solutions.

A solution based on all available information should be selected from all the ideas developed. Which idea best solves the problem? Which solution meets all of the constraints? Designing the actual solution should include building a model or prototype of the solution.

Once the model or prototype is built, the next step is to test and evaluate the solution. Were the results of the solution expected? The prototype should be evaluated against the problem to be solved and the constraints that were identified.

After evaluating the solution, improvements should be made. What changes could be made to provide better results? The solution can be redesigned, and the new model or prototype can be tested and evaluated. The process of redesign and evaluation is iterative, meaning it should be repeated until a satisfactory solution is achieved.

Defining and Delimiting a Problem

Possibly the most important step in the engineering design process is the definition of the problem to be solved and the development of design constraints. This is also known as defining and delimiting the problem. Having a clearly defined problem and a set of clearly delimited constraints will make the engineering design process easier, and solutions will be more applicable.

Problems with a narrower definition will be easier to solve than problems with a broader definition. For example, it will be easier to design a car engine that is 10% more fuel efficient than it will be to design a "better" car engine. The term "better" is too broad and will result in too many possible solutions that will be hard to narrow down.

Constraints are conditions that a design must meet. Constraints are used to refine and narrow the list of possible solutions to a problem. There are a wide variety of constraints that can be placed on an engineering problem. Sometimes constraints are mandatory, such as a size constraint. If you are designing a new car engine, there will be a mandatory constraint on how large the engine can be because it will have to fit in a designated space.

One of the greatest constraints can be safety. Engineers are responsible for designing and building bridges, buildings, and machines that the general public uses daily. This means engineers are responsible for the safety of many people.

Scientific principles can be used to specify constraints, and this is one of the many areas in which science and engineering overlap. As more constraints are added to a problem, the list of possible solutions becomes smaller and smaller. Eventually, there may only be a few, or possibly no, solutions which can meet all constraints and satisfactorily solve the problem.

Name _____ Date _____

What Is the Engineering Design Process?

Write the answers to the questions on the lines below.

1. What is engineering?

2. What are constraints?

3. What is the engineering design process?

4. What does STEM stand for?

5. Why are engineers often responsible for the safety of the general public?

6. What happens after a model or prototype is built during the engineering design process?

7. Name four branches of engineering.

8. **Vocabulary** Write a paragraph describing the engineering design process using the terms *engineer*, *problem*, and *constraint*.

Name _____ Date _____

9. **Main Idea** What are two factors that can make a problem easier to solve using the engineering design process?

10. **Reading Skill: Main Idea and Details** What is the end result of the engineering design process?

11. **Critical Thinking: Analyze** What is meant by the statement that the engineering design process is an iterative process?

12. **Inquiry Skill: Infer** What could engineers do if no solution were found to a problem that met all design constraints?

13. **Test Prep** Which of the following is **NOT** a step in the engineering design process?

A defining a problem

B creating a problem

C evaluating the solution

D brainstorming solutions

How Are Engineering Design Solutions Evaluated?

The Engineering Design Process

The world is full of problems that can be solved. Humans have been using engineering techniques to solve problems for thousands of years. Even the use of simple levers and pulleys is considered to be an application of engineering principles.

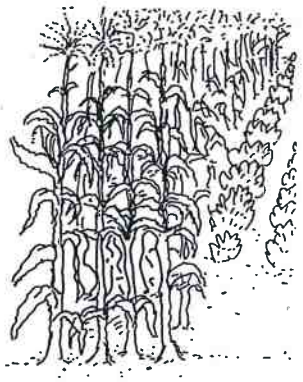
The engineering design process is the method that engineers use to solve a problem. The end result of the engineering design process is the development of a new machine, structure, process, or system. The process consists of an iterative cycle that should produce an optimal solution.

The engineering design process begins with identifying and researching a problem. Possible solutions to the problem are brainstormed and promising ideas are developed further. Part of the brainstorming process is identifying the constraints that will be placed on the solution, such as size or cost. Eventually, a model or prototype of the solution is built to test against solving the problem and meeting the constraints. The prototype is evaluated, possible changes to the solution are brainstormed and discussed, and a new model is built and evaluated. The process continues until a satisfactory solution is found.

Evaluating the Solution

Solutions that are developed at the model or prototype stage must be tested and evaluated against the requirements of the solution. The requirements include two factors: adequately solving the intended problem and meeting all constraints. Some solutions may do a good job of solving the problem, but a poor job of meeting the design constraints. For example, a light car body made of carbon fiber may solve the problem of designing a more fuel-efficient car, but it might not meet cost constraints, since carbon fiber is relatively expensive when compared to plastic components.

Solutions should not be subjected to only one test. Solutions should be tested in a manner that allows engineers to identify potential weaknesses or strengths in the design. This means engineers must think creatively when deciding which tests the solution will be subjected to. Chemical engineers may do all of their testing and evaluating in a laboratory. Bioengineered solutions, such as genetically modified plants, may be tested and evaluated in the field.



The Evaluation Process

The process of testing, evaluating, and redesigning a solution should be a systematic process in which data are carefully collected, recorded, and analyzed. This will allow the engineering design team to select the best solution design from all of the designs tested. Data can be recorded in tables. Advantages and disadvantages of each solution can be added to the table to help engineers make their final decision.

Often, there is not one design that performs best over all the given tests. Sometimes, components of different designs that perform better on certain tests can be added together. This creates a new design that is a combination of previous designs and performs better overall on all tests.

Optimizing the Solution

The engineering design process is iterative so that engineers can develop an optimal solution. Each time the solution is tested, evaluated, and redesigned, it should meet the constraints and solve the problem more successfully.

Optimizing the solution can also include reevaluating the problem statement or reevaluating the design constraints. After one or two rounds of testing and evaluating solutions, it may become evident that the problem should be more clearly defined. Beginning with a problem that is as clearly defined as possible will make the process much easier.

Constraints can include factors such as a required size, a limited cost, or an expectation of product lifetime. As solutions are tested, evaluated, and redesigned, it may also become evident that there are either too many or too few restraints or that some restraints can be changed to provide more flexibility in the design. For example, an original list of constraints may have stated that a product of a certain size must last for 5 years and be produced for a certain cost. During the design process, it may be discovered that no material could be found that would make the product at the given size and cost that would last for 5 years. At this point, engineers would have to decide which constraint to change or relax. Would it be better to spend more money for a better material that will last for 5 years? Will the product really need to last for 5 years? If not, then one of the already existing solutions may solve the problem.

It is common to seek outside opinions during the evaluation phase of the process. Unbiased opinions can provide insights for team members and may also provide new ideas for how to positively change the design to better solve the problem and meet the constraints.

Name _____ Date _____

How Are Engineering Design Solutions Evaluated?

Fill in the blanks.

1. Engineers build a model or _____ to test against the problem constraints.
2. The _____ is the method used by engineers to solve a problem.
3. Maximum size or expected product lifetime are examples of _____ placed on the solution of a problem.
4. The use of simple _____ and _____ is considered to be an application of engineering principles.
5. The engineering process begins with _____ and _____ a problem.
6. The engineering design process is a(n) _____ process.
7. The world is full of _____ that can be solved.
8. **Main Idea** How do engineers optimize the design solution?

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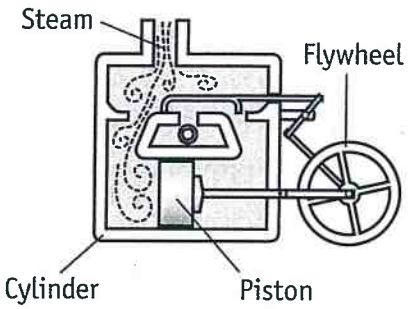

Name _____ Date _____

9. **Vocabulary** Write a paragraph describing how engineering design solutions are evaluated. Use the terms *model*, *prototype*, *constraint*, and *process*.

10. **Reading Skill: Main Ideas and Details** What are two examples of engineering solutions that humans have been using for thousands of years?

11. **Critical Thinking: Analyze** Why is it important that the testing and evaluation of design solutions be an orderly process?

12. **Inquiry Skill: Infer** What might a group of engineers do if two of their designs were deemed to be optimal solutions?

13. **Test Prep** Which of the following explains why engineering design solutions are evaluated?

A Solutions that are developed to the model or prototype stage must be tested and evaluated to define the problem.

B Solutions that are developed to the model or prototype stage must be tested and evaluated to define the constraints of the problem.

C Solutions that are developed to the model or prototype stage must be tested and evaluated against the requirements of the solution.

D Solutions that are developed to the model or prototype stage are not evaluated.