Introduction To Engineering Design

Module Outline

- Unit 1: Introduction to the Engineering Design Process
  - Section 1: The Work of Engineers
  - Section 2: Block Diagrams in Engineering Designs
- Unit 2: Careers in Engineering

Unit 1: Introduction to the Engineering Design Process




Unit 1: Objectives

- Students will learn about what engineers do and how they work.
- Students will examine and use the nine steps in the engineering design process.
- Students will understand and use block diagrams.

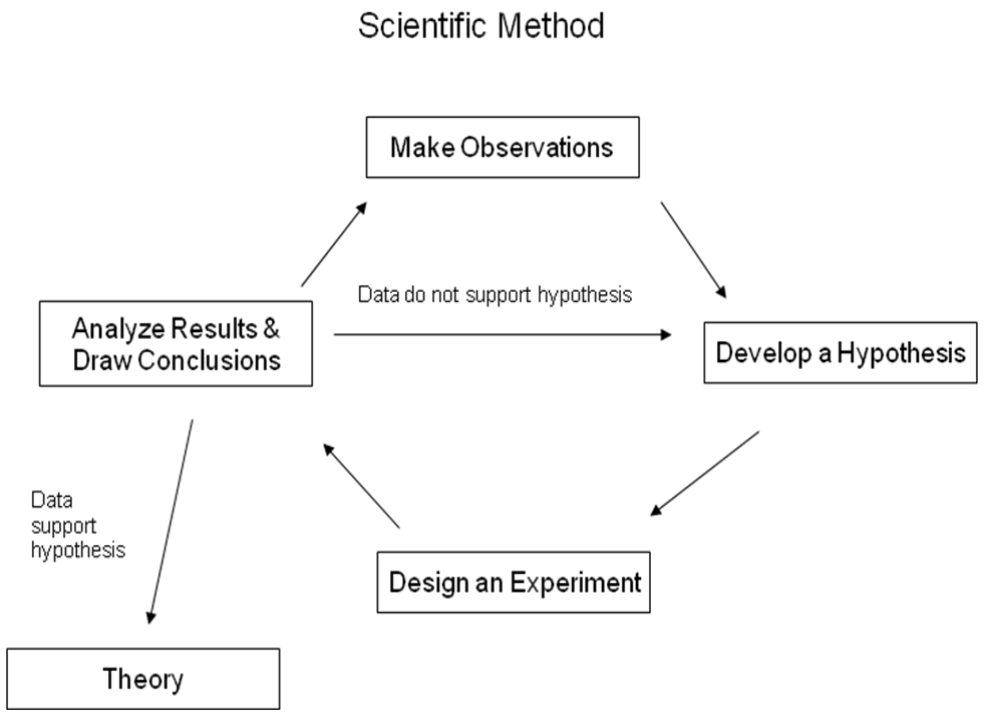
Section 1:
The Work of Engineers

Introduction

- Engineers have existed for centuries in many cultures and designed all the products around you.
- Engineers use creativity, as well as their knowledge of math and science, to invent products that help people fill a need.
- Engineers work with businesspeople, mathematicians, scientists, and others to achieve their goals.

Scientific Method

Scientists use the scientific method to discover new facts about how the natural world works. These facts are helpful to engineers.






Role of Engineers

- Engineers design new products to solve some problem or to meet some human need.

- Like scientists, engineers follow a series of steps to design products. There are nine steps in the engineering design process.

Engineering Design Process

1. Identify a problem or need.
2. Identify design constraints.
3. Gather information necessary to develop designs.
4. Develop several possible designs.
5. Analyze the solutions to determine which will work.
6. Choose the best solution based on your analysis.
7. Build a prototype of the selected design.
8. Test the prototype and evaluate its design.
9. Repeat any or all steps as needed.

1. Identify a problem or need

- It is hard to solve a problem without knowing what the problem is, so the first thing an engineer does is define the problem he or she will attempt to solve.
- The engineer may be given information about a potential problem that comes from business and consumer research—that is, businesspeople will find out if users have identified a problem with an existing product, or if people have expressed a wish for a new product, and share this with engineers.
- From here, the engineer has to identify the exact problem or objective in order to develop a useful product.

2. Identify design constraints

- The engineer must also develop a list of **constraints** that the design must meet in order to be useful. Constraints are requirements that limit how engineers design their products.
- Cost, design time, and available materials are among the most frequent constraints. For example, a cell phone with many functions may be too expensive, so an engineer might reduce the number of functions and, thus, the cost.
- It is also important to know that there is no right answer to an engineering design problem. The solution, in the form of the design developed in response to the problem, is variable and limited only by the design constraints and the creativity of the engineer.

3. Gather information

- Engineers use this information to help them in future steps.
- They have to find out if their problem reflects a real consumer need, if a solution has already been designed and might be improved, and look for potential solutions if one doesn't exist.
- They may read about the basic scientific research done in the field. This often includes researching physical, chemical, or biological properties of potential solutions.
- They may also research similar products to find out what worked and what didn't.




4. Develop several possible designs

- In this step, an engineer uses his or her problem, constraints, research, and creativity to generate as many ideas as possible to solve the design problem.
- He or she might bring together a group of engineers from his or her own engineering discipline or from other disciplines to expand the possibilities.
- Analysis and testing of the ideas will come later—for now, the engineer can be inventive and take risks.




5. Analyze the solutions

- Engineers will select the solutions with the greatest potential from the list developed in step four and evaluate them for safety, cost-effectiveness, and functionality. Safety is of particular concern for consumer products.

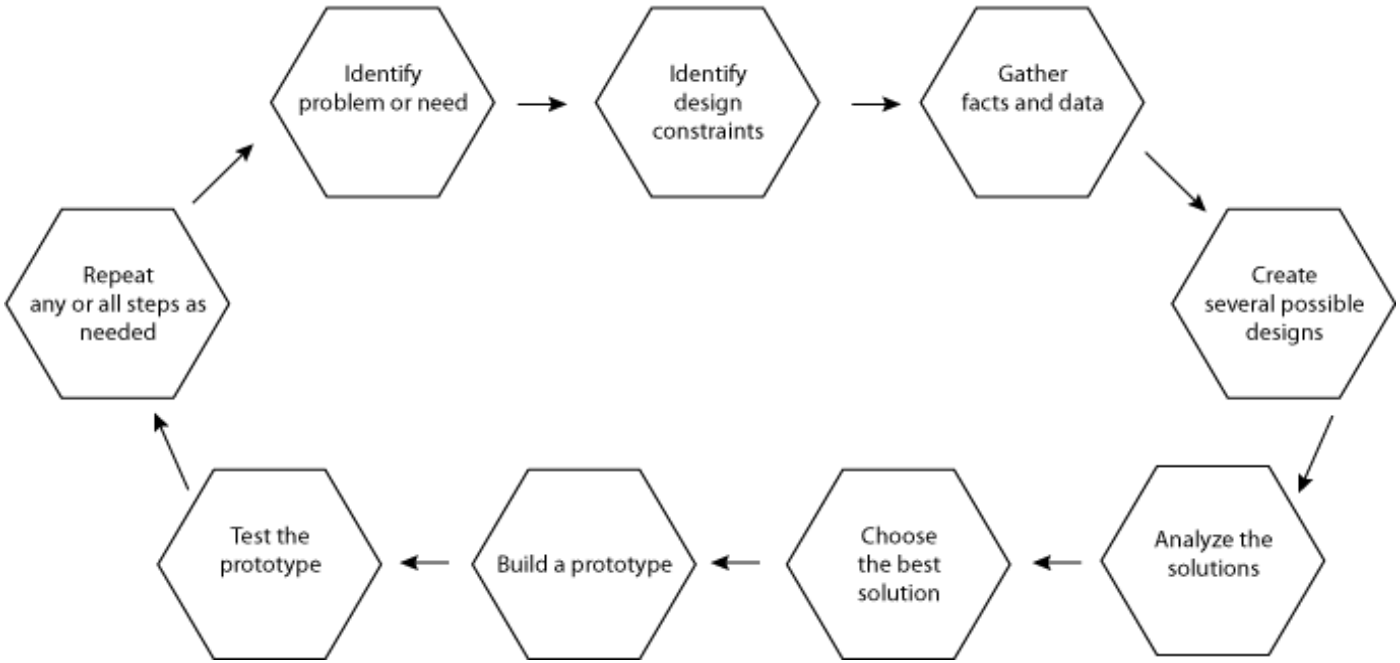
- Computer models may be used during this phase to evaluate the design before the prototype is built.

- Engineers also consider the importance of each factor listed above. For airplane engines, low cost may not be as important as functionality. For a child's toy, safety and low cost may be very important.

6, 7, 8 and 9. Choose the best solution; build and test a prototype. Repeat.

- After analyzing the solutions, the engineers will pick the one that they consider to be the best. They build a prototype based on this solution. A prototype is a working model of the chosen design.
- The prototype will go through testing to see if the product performs well in real-world scenarios.
- Any problems found in this stage will go through their own version of the engineering design process, with new solutions researched, proposed, evaluated, and built into the prototype.

Engineering Design Process



At any point in the process, an engineer might have to go back to the beginning.

Designing the Laptop Computer

- **Identify a problem or need.** The goal was to build a computer that people could carry with them and that worked just like a desktop computer.
- **Identify design constraints.** Some constraints for the laptop may have included:
  - Make it lightweight and small enough so that it is easy to carry and will sit comfortably on a person's lap
  - Make it large enough to have a standard keyboard, a screen that is easy to read, and a CD-ROM drive
  - Develop a battery that can last for 2–3 hours before being recharged
  - Keep the computer cool enough so it does not burn the user's skin or overheat and shut off
  - Make the laptop relatively inexpensive so that people will purchase it.

Example 1.1 *cont.*

- **Gather information.** Engineers would have researched ways to address each of the constraints listed above. They identified the best materials to use to make the laptops sturdy, lightweight, and inexpensive. They determined what size the laptop should be so that it was easy to use but not too big to carry. Engineers also developed batteries that would last for a few hours before they had to be recharged.

- **Build and test designs.** Several possible designs would be developed and discussed with a team of engineers. Some of the designs were built and tested to see if they met the design constraints listed above. The best designs were produced in large numbers and sold.

Science and Engineering Are Interdependent

- Scientists use the technology developed by engineers to perform their experiments. As scientists make new discoveries, engineers often use these discoveries to build new products.

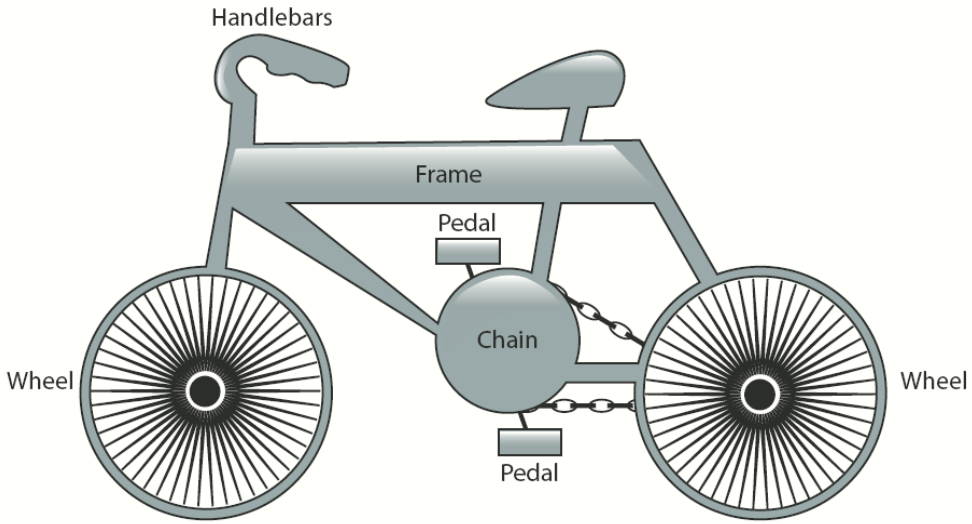
- For example, scientists wanted to collect data from inside hurricanes so they could make better weather predictions. However, it was incredibly dangerous for humans to enter hurricanes in airplanes. Engineers helped solve this problem by building small remote-controlled airplanes called drones. The drones could measure wind speeds, temperatures, and air pressures inside hurricanes and send the data back to Earth using satellites.

Section 2: Block Diagrams in Engineering Designs

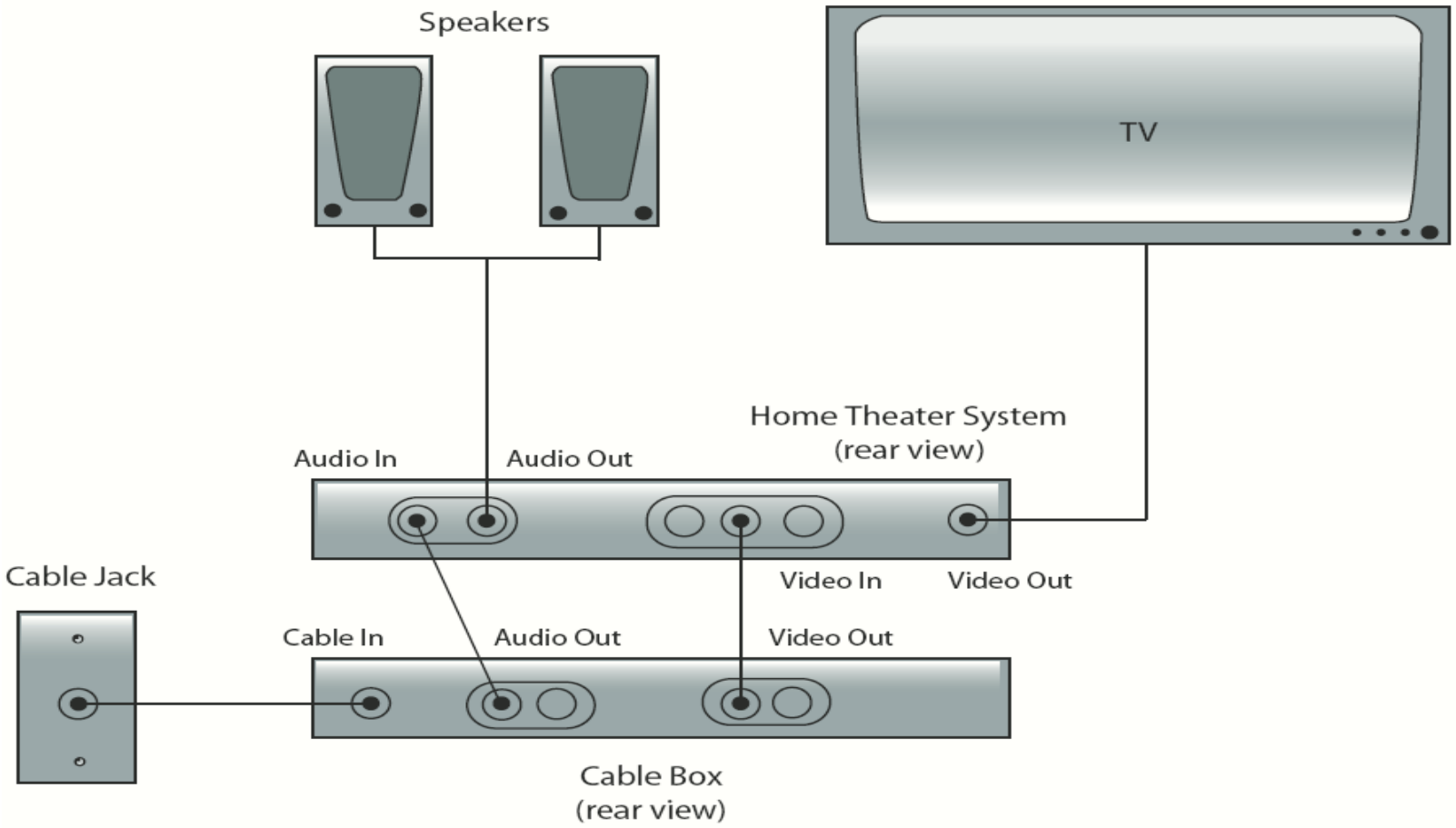
Block Diagrams

- Most products have many interconnected parts. Engineers use block diagrams to show these connections.

- Block diagrams show pictures of the parts in a product and how the parts work together. A block diagram can be simple or complex.



Block Diagram of a Home Theater System






Unit 1: Wrap-Up

- Engineers are creative people who work with mathematicians, scientists, businesspeople, and others to solve human needs.
- The engineering design process provides a framework for inventing new products or improving existing ones.
- Engineers can use block diagrams to represent complicated systems.

Unit 2:
Careers in Engineering

Unit 2: Objectives

- Students will explore many different types of engineering careers.
- Students will take a survey to identify engineering professions in which they have an interest.
- Students will research a specific engineering career that interests them.

Careers in Engineering

Many people think that engineers only work with machines. This is not the case. There are many types of engineers; here are some of them.

- **Mechanical Engineers:** When we hear the word *engineer*, we commonly think of mechanical engineers. Mechanical engineers design products such as automobiles, refrigerators, and machines used in factories.
- **Electrical Engineers:** Electrical engineers design products that use or produce electricity. They design circuits used in TVs, computers, and cell phones. These engineers also build power plants and monitor electricity production.




Careers in Engineering

- **Civil Engineers:** Civil engineers design and build many different structures that usually benefit our whole society. These engineers build roads, bridges, and buildings.
- **Chemical Engineers:** Chemical engineers typically develop new substances from raw materials. For example, these engineers turn oil into gasoline and plastics.
- **Biomedical Engineers:** Biomedical engineers design products to improve human health. They design artificial limbs and organs, X-ray machines, wheelchairs, and contact lenses.
- **Aerospace Engineers:** Aerospace engineers design objects that fly into the air or outer space. This includes airplanes, space shuttles, and satellites.




Careers in Engineering

- **Computer/Software Engineers:** Computer engineers design the parts inside computers. Software engineers develop programs that run on computers.
- **Environmental Engineers:** Environmental engineers develop solutions to environmental problems, such as recycling and protecting wildlife from human activity.
- **Architectural Engineers:** Architectural engineers design buildings and often oversee their construction.
- **Industrial Engineers:** Industrial engineers work to improve the way things are done. They identify ways for factories to produce goods faster and cheaper.




Careers in Engineering

- **Materials Engineers:** Materials engineers develop substances with the specific properties required for a product. They develop lightweight, but strong metals used in airplanes. They design plastic cups that hold hot liquids without melting, and oven-safe glass dishes.

- **Agricultural Engineers:** Agricultural engineers design equipment used for farming and food production. They develop farm equipment, such as tractors and irrigation systems, as well as silos for storing grain.

- **Automotive Engineers:** Automotive engineers design the different components found in cars and trucks.

Careers in Engineering

- **Transportation Engineers:** Transportation engineers design streets, highways, and subway systems that allow people to travel more easily and safely.
- **Nuclear Engineers:** Nuclear engineers design products that safely use nuclear energy. They work on nuclear power plants or create technology using nuclear radiation to diagnose and treat medical problems.
- **Oceanographic Engineers:** Oceanographic engineers design products used in the ocean. They also develop ways to protect the erosion of coastlines and beaches during strong storms.

Careers in Engineering

- Different types of engineers must work together to complete projects.
- For example, an automotive engineer might have to work with a computer engineer in order to design computer systems that control a car. The automotive engineer might also have to work with an electrical engineer to develop the connections that keep the radio, lights, and other electronic components working. A mechanical engineer will be consulted to make sure the moving parts, such as the wheels and brakes, are designed properly.
- Engineers of all types must have a firm understanding of math and how to apply it to real-life situations.

Unit 2: Wrap-Up

- There are many different types of engineers who create a variety of different products.
- Engineers need creativity, math, and science to develop solutions to human needs.

Summary

- Engineers use math, science, and creativity to complete the engineering design process.
- For more information on engineering and the engineering design process, visit these Web sites:
  - http://www.bls.gov/oco/ocos027.htm
  - http://www.iisme.org/etp/HS%20Engineering-%20Engineering.pdf