EXERCISE 1.1 : THE WORD OF ENGINEERS - KEY

Apply the engineering design process to the task of building a doghouse. Describe what you would need to think about or do for each step of the process. How could a scientist help?

Answer:

1. *Problem or Need: Build a doghouse to keep the dog cool, warm, and dry as the weather changes.*

2. *Constraints:*
   - *The inside of the doghouse should stay cool in the sun (or warm in the cold).*
   - *The materials should keep out the rain.*
   - *The doghouse should be large enough to fit the dog comfortably.*
   - *The cost of the materials to build it should be low.*

3. *Gather Information:*
   - *Measure the dog to determine how much space is needed inside the doghouse.*
   - *Identify materials that are inexpensive and will keep the dog comfortable.*
   - *Determine whether the doghouse should be painted. If so, what color?*

4. *Create Several Possible Designs: Design doghouses with different shapes, dimensions, and materials.*

5. *Analyze: Study the potential designs for cost, safety, and constraint compliance.*

6. *Choose the design based on your analysis.*

7. *Build a prototype of the chosen design.*

8. *Test the Design:*
   - *Monitor the temperature inside the doghouse while it sits in the sun or cold.*
   - *Spray the doghouse with a garden hose to see if there are any leaks.*

9. *Repeat any steps as necessary.*

The role of scientists may include identifying a temperature range that is most comfortable for dogs and studying how materials absorb or repel water, light, and heat.

ACTIVITY 1.2: WHEELCHAIR RAMP SAFETY – KEY

Objective

Students will:

1) Develop a working definition of *safe*
2) Design a method and collect data to determine the safest type of ramp using the definition of *safe*

Materials

- Two identical wooden ramps—one painted and one unpainted
- Toy cars, marbles, and blocks
- Rubber pieces that fit the ramp's surface
- Tape
- Metersticks or rulers
- Stopwatches
- Water bottles

Background

A new school is built in an area that receives large amounts of rain. A wooden wheelchair ramp is built at the front door so people with disabilities can enter the building. The principal worries that people will slip and fall down the ramp when it rains. He has considered painting the ramp or placing a thin rubber mat over the ramp if the bare wood is too slippery. He has asked your class to determine which type of ramp would be the safest.

Procedure

Your goal is to design an experiment to determine which ramp surface (bare wood, painted wood, or rubber mat) would be safest. With your partner, you will:

1) Design an experiment using the materials given
2) Determine what measurements you will make to identify the safest surface
3) Determine how you will take your measurements

NOTE: You do not have to use all of the materials. Select only the ones you need. Keep in mind the important parts of a good experiment. Refer to Section 1.1 of the reading if you need help.

Experimental Design

1) With your partner, discuss how you want to test the ramps to identify the safest design.
2) In the space below, describe the experiment your group designed. You may use a bulleted or numbered list if you wish. Be sure to clearly indicate which materials you plan to use, what you will measure, and how you will measure it.

   Answers will vary.

3) In the space below, draw a neat table for your data. Be sure to label the columns and rows, and include the units for all measurements.

   Answers will vary.

4) Now perform the experiment your team designed. Record your data in the table you drew.

   Answers will vary.

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Assessment

You will now write a business letter to the principal to explain which surface would be safest for the ramp. Include a brief description of the experiment you used to collect the data. Use your data to support your recommendation.

There are several different ways to write a business letter. You may select the format you like, but your letter must include the following:

- your information (name, grade, and teacher's name) in the heading
- the principal's information (name, school name, and address)
- today's date

Letters must be typed and single-spaced. Use a 12-point font and 1-inch margins. Remember to sign your name at the end of the letter.

Your letters will be graded using the rubric below. Be sure to read all of the instructions and the rubric before you write your letter.

	POINTS		
	4	**2**	**0**
Format	There are 0 errors in the business letter format.	There are 1–2 errors in the format.	There are 3–4 errors in the format.
Spelling & Grammar	There are 0–1 errors in spelling, grammar, or punctuation.	There are 2–3 errors in spelling, grammar, or punctuation.	There are 4 or more errors in spelling, grammar, or punctuation.
Presentation of Methods & Data	The experiment is clearly summarized AND the recommendation is supported by the data.	The experiment is clearly summarized OR the recommendation is supported by the data.	The experiment and data are missing OR they are not clearly presented.

ACTIVITY 1.3: DON'T SCRAMBLE THE EGGS! – KEY

Objective

Students will use the engineering design process to build a bungee cord that meets certain constraints.

Materials

- Nylon stockings
- Rubber bands
- Balloons
- String
- Tape, glue, paper clips, and staples
- Hole punch
- Metersticks or tape measures
- Raw eggs
- Drop cloths, plastic sheets, or other floor coverings for the drop areas
- Rags or paper towels for cleaning up broken eggs

Procedure

You will work in pairs to design a bungee cord from the materials above that will allow a secured, dropped egg to come within 5 centimeters of the ground when dropped from 1.5 meters. The egg must also rebound by at least 15 cm from its lowest point. You may only use the materials given to make the bungee cord.

Your team will have 30 minutes to build and test your first design. As you develop your design, be sure to follow the sequence of steps in the Engineering Design Process described in the Student Manual. Once your bungee cord is ready, your teacher will help you test your design. You will perform two test drops and record the results in Part D. If the egg gets closer than 5 centimeters from the ground, or does not rebound 15 centimeters from the ground, then you will have to make some adjustments to your design. Make those changes and test your design again.

As you build and modify your designs, take notes so that you can remember what you did at each stage of the process. You will be asked to describe how you modified your design and why. You will also be asked to sketch your designs.

Data

1) In the space below, draw a diagram showing each version of the bungee cord you built. Label the parts of each diagram.

   Answers will vary.

2) Summarize your results in the table below. Place an *F* in the box if the bungee cord failed and an *S* if it succeeded.

   Answers will vary.

Bungee cord	Drop 1	Drop 2
1		
2		

Analysis

1) Describe the changes you made to your bungee cord and explain why you made those changes.

   Answers will vary.

2) Describe two design constraints your team considered before you modified your original bungee cord.

   Answers will vary.

EXERCISE 1.4 – BLOCK DIAGRAMS IN ENGINEERING DESIGN - KEY

1) Draw a block diagram to show:
   a. a piece of technology you use daily
   b. an item in your classroom
   c. a lamp

   Answers will vary. *Diagrams should be accurate and show clearly how the components fit together.*

2) After some products are sold, they are recalled, which means that consumers are asked to return them to the store because the products have flaws. How could a product still have a flaw in it after engineers tested it many times?

   Answer: *Engineers test products to see if they work under normal, everyday use. However, there are an infinite number of environments or conditions in which products may be used that engineers did not test. Flaws may appear in these untested environments.*

   Engineers run tests on their prototypes before the products are mass-produced. Flaws may be introduced during the manufacturing process.

EXERCISE 2.1 – CAREERS IN ENGINEERING KEY

Survey of Interests

Read the following statements. If a statement is true for you, write a *Y* on the line; if it is not true, write an *N*. There are no right or wrong answers; be honest about what you like to do.

___ 1. I keep up to date on cell phones, video game systems, and other new technologies.
___ 2. I would like to take apart a music player and see the circuits and wires.
___ 3. I would love to take a field trip to a local power plant and watch what happens.

___ 4. I often made buildings and other structures out of building toys when I was young.
___ 5. I have noticed different types of bridges and wondered how each was built.
___ 6. I like to read about roads and other types of transportation.

___ 7. I care deeply about the condition of the natural world.
___ 8. I am interested in building communities that respect wildlife.
___ 9. I strongly agree that we need more recycling programs and alternative fuels.

___ 10. I have studied carefully medical equipment that my family, friends, or I had to use.
___ 11. I have an interest in becoming a doctor, nurse, or technician.
___ 12. I would like to improve the lives of people who are sick or injured.

___ 13. I use a computer whenever I possibly can.
___ 14. I feel successful when I can make a computer program do what I want it to do.
___ 15. I would like to make computers better, faster, and smarter.

___ 16. I would like to build a rocket some day.
___ 17. I am fascinated by space travel and the universe.
___ 18. I am inspired by the ways humans have learned to fly.

___ 19. I have taken apart a device to see how it works.
___ 20. I find machines and their capabilities interesting.
___ 21. I have ideas on how to improve appliances I use daily.

Teacher: *The questions correspond to engineering professions as follows: 1–3 electrical engineering, 4–6 civil engineering, 7–9 environmental engineering, 10–12 biomedical engineering, 13–15 computer engineering, 16–18 aerospace engineering, 19–21 mechanical engineering. Assign students to research the profession in which they show the most interest.*

Research Your Career!

Use the Internet to research the engineering profession that best matches your interests from the survey. Use the questions below to guide your research. Create a table to summarize your findings. Remember to collect your data from reliable Web sites.

1) What types of classes do you have to take in college?
   Answers will vary.

2) What type of college degree do you have to earn?
   Answer: *I would need a minimum of a BA/BS.*

3) In what types of companies could you work?
   Answers will vary.

4) What would you do on a typical day?
   Answers will vary.

5) What is the most exciting thing you can do in your profession?
   Answers will vary.

6) Do you have to be licensed to work in your state?
   Answer (for most engineers): *You don't necessarily have to be licensed, but if you are not licensed, there are limits to what you can do professionally. Licensure is recommended.*

7) If you have to be licensed, how do you become licensed?
   Answer: *I'd have to earn a BA/BS, gain work experience, and take an exam.*

8) What is your average starting salary?
   Answers will vary.

Once you've gathered information about your profession, you and your group will develop a brief oral presentation for the class. Make sure to explain what you would do on a daily basis, what makes your job interesting, and steps you would take to become your type of engineer.

Answer: *Successful presentations will provide sufficient background on the profession but also explain the interesting aspects. Consider allowing students to present their information in the form of a role-play or skit, if they are interested.*