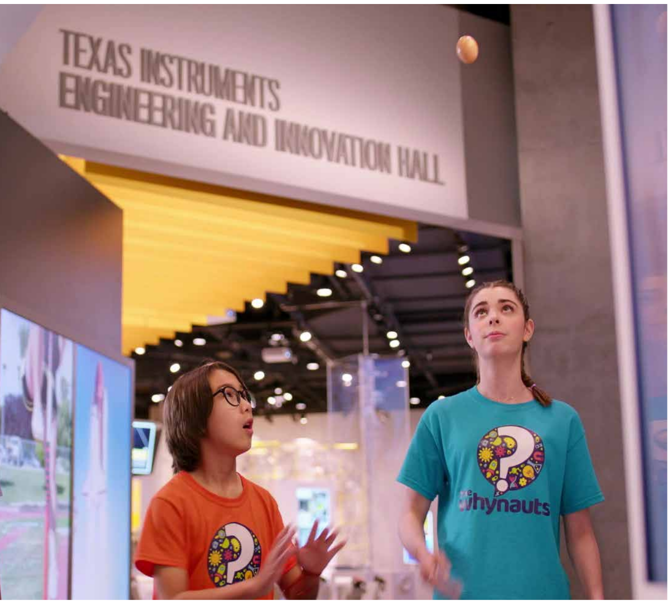
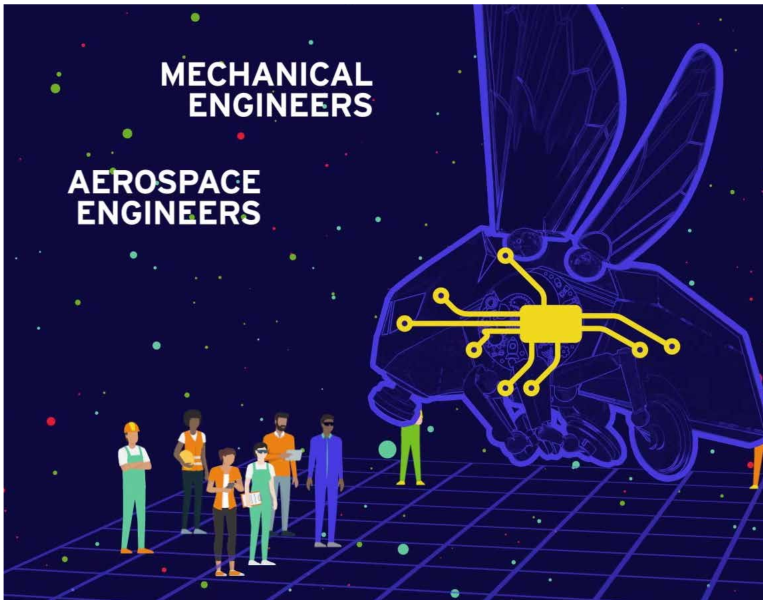
THE WHYNAUTS:

Episode 5: Engineer It!

EDUCATOR GUIDE SUGGESTED GRADE LEVELS 3-5





The whynauts

Perot Museum of Nature and Science

Table of Contents

INTRODUCTION

HOW TO USE THIS GUIDE

The Whynuats **"Engineer It!"** Video explores how engineers use the Engineering Design Process to solve problems. This guide is designed to help you incorporate the video into a complete learning experience for your students. It is composed of three main sections:

The **Viewing Strategies and Tools** section includes suggested discussion questions, a student viewing journal, and a pre- and post-assessment to track student learning.

The **Supplemental Activities** section includes four activities which can be used in any order or combination.

The **Additional Resources** section includes a glossary, reading list, and links to continue learning.

LEARNING OBJECTIVES

Students will be able to:

- Describe what engineers do, how they work together, and why they are important to our everyday lives.
- Explain how engineers use the Engineering Design Process to identify problems and develop solutions.
- Apply what they know about force and motion to an engineering design challenge.

TEKS ALIGNMENT

3.7A. Demonstrate and describe forces acting on an object in contact or at a distance, including magnetism, gravity, and pushes and pulls.

3.7B. Plan and conduct a descriptive investigation to demonstrate and explain how position and motion can be changed by pushing and pulling objects such as swings, balls, and wagons.

4.7. Plan and conduct descriptive investigations to explore the patterns of forces such as gravity, friction, or magnetism in contact or at a distance on an object.

5.7B. Design a simple experimental investigation that tests the effect of force on an object in a system such as a car on a ramp or a balloon rocket on a string.

NGSS ALIGNMENT

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

BACKGROUND INFORMATION

What is Engineering?

Engineers use science and math to solve problems and develop solutions to meet human needs and wants. These solutions could be objects, processes, or systems. Sometimes engineers improve existing technologies, and sometimes they develop new ones. To be successful, engineers must be skilled in problem solving, critical thinking, teamwork, and communication.

Different types of engineers use their knowledge of science and math in different ways:

- **Civil engineers** use what they know about physical and natural environments to design solutions such as roads, bridges, airports, and dams.
- **Mechanical engineers** use principles of force, motion, and energy to design solutions such as engines, generators, and elevators.
- **Aerospace engineers** use their knowledge of aerodynamics to design solutions such as airplanes, helicopters, rockets, and spacecraft.
- **Electrical engineers** use the principles of electricity to design solutions such as circuits, robots, and cell phones.
- **Chemical engineers** use their knowledge of chemistry to design solutions such as new materials, medicines, and fuels.

These are just a few examples – there are many other fields of engineering, including environmental, agricultural, biomedical, and software engineering. Even though most engineers specialize in a particular field, it takes teams of different types of engineers working together to identify problems and develop solutions. Each team member contributes different skills, knowledge, and experiences.

The Engineering Design Process

The **Engineering Design Process** is a series of steps that help engineers identify problems and develop solutions.

Steps of the Engineering Design Process:

ASK: What is the problem you are trying to solve?

- Before beginning to design a solution, it is important to understand the **problem** – what is the need or want being addressed?
- What are the **criteria** – the requirements for a successful design?
- What are the **constraints** – limitations such as materials, time, and cost?

IMAGINE: Brainstorm possible solutions.

- How well is each possible solution likely to meet the criteria and constraints?

PLAN: Choose a solution.

- Sketch a schematic or diagram of the design and make a list of materials.

CREATE: Follow your plan to build a working model, or **prototype**.

- Models can be used to investigate how a design works, communicate the design to others, and compare different designs.

TEST: Try it out! Test and evaluate your prototype.

- What are the strengths and weaknesses of your design?
- Failure is part of the process! Failure points can help identify which parts of your design can be improved.

IMPROVE: Redesign and retest your prototype as needed.

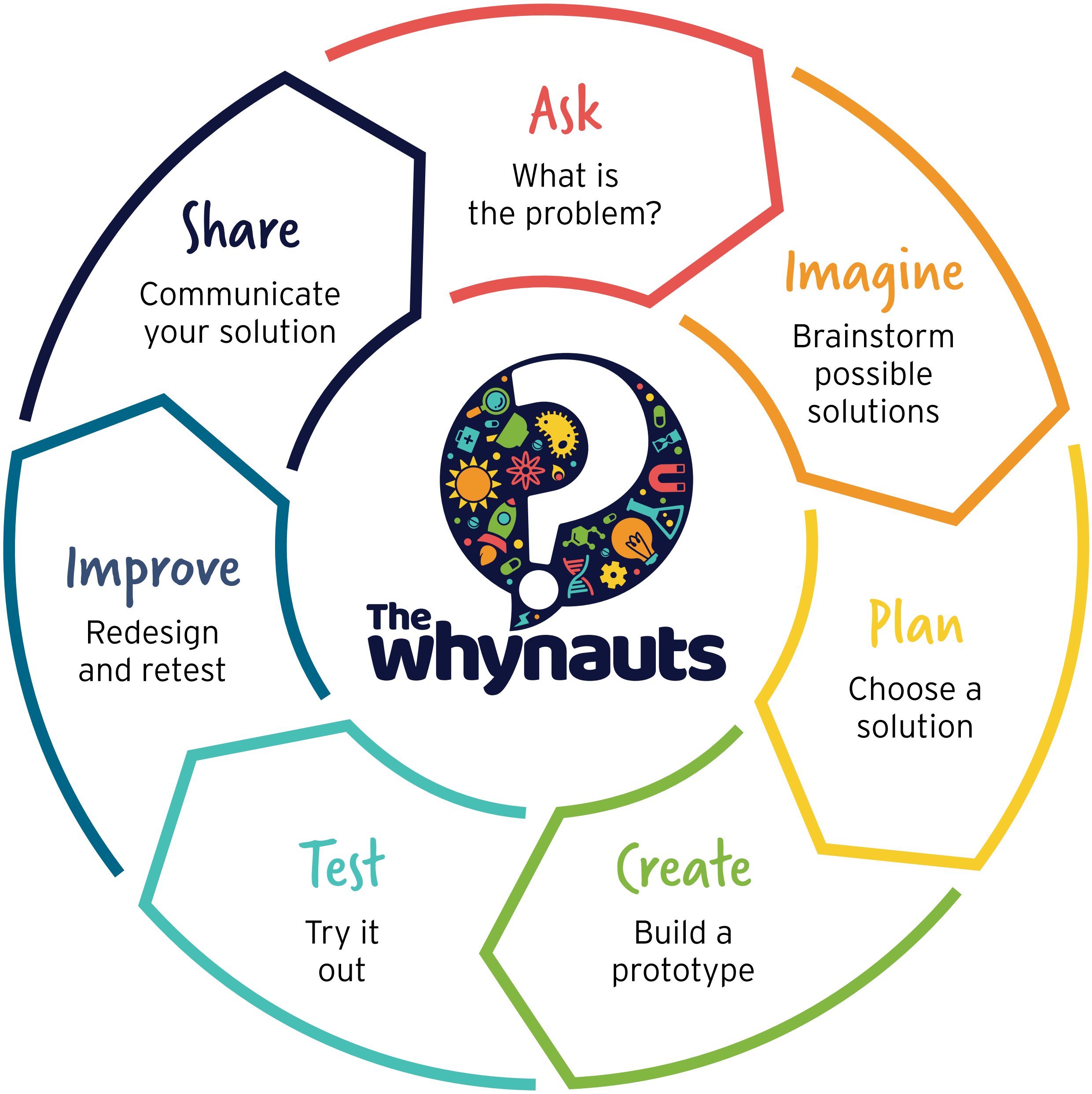
- Engineering design is **iterative** – you repeat these steps as many times as needed to come up with the solution that best solves the problem, keeping in mind the criteria and constraints.

SHARE: Communicate your solution and get feedback.

- This isn't necessarily the last step of the process! After sharing, you may need to revisit other steps.
- It is important to communicate during every stage of the process, as shared ideas can lead to more successful designs.

The Whynaut's Engineering Design Process may look slightly different than other versions. Not everyone approaches engineering design in the exact same way – and that's okay! The number of steps and the order they are used may vary from engineer to engineer.

The Engineering Design Process



Ask

What is the problem?

Imagine

Brainstorm possible solutions

Plan

Choose a solution

Create

Build a prototype

Test

Try it out

Improve

Redesign and retest

Share

Communicate your solution

The whynauts

The Egg Drop Challenge

In the "Engineer It!" episode, the Whynauts design a solution to protect a falling egg. This simple challenge can represent more complex engineering problems, like designing a rover that can safely land on another planet, or safety equipment to protect people from falls or collisions.

The Egg Drop Challenge also involves many principles of force and motion. **Motion** is a change in an object's position relative to a reference point. Some ways to describe an object's motion include:

- **Distance** – how far an object has moved.
- **Speed** – how fast an object is moving.
- **Velocity** – an object's speed in a particular direction.
- **Acceleration** – the rate at which an object's velocity changes.

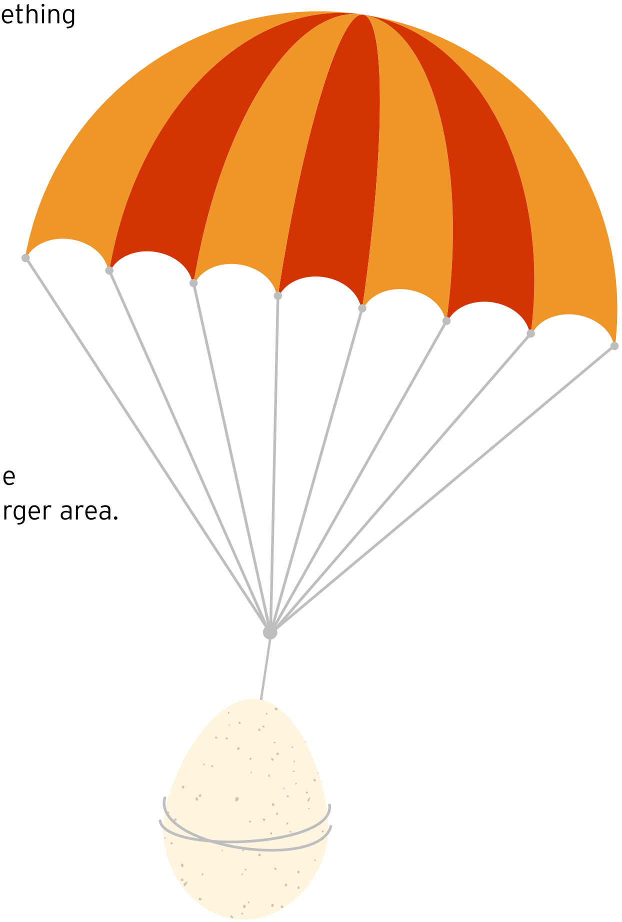
Forces affect an object's motion. A **force** is a push or a pull. Pushing or pulling on an object can make the object start or stop moving, or change the speed or direction of its motion. A bigger push or pull results in a bigger change.

Some forces that act on objects include:

- **Gravity** – a force of attraction between two objects; gravity pulls objects towards the center of the Earth.
- **Friction** – a force that opposes motion between surfaces that are in contact.
- **Air resistance** – a frictional force between the air and something moving through it, slowing down an object as it falls.

Several forces are at play when an egg is dropped from a height. The force of gravity pulls the egg towards the Earth. When the egg hits the ground it exerts a force, and the ground exerts the same amount of force back on the egg. This is what causes a dropped egg to break! The faster the egg falls, the greater the force.

In order to prevent the egg from breaking, you must decrease the amount of force exerted on it. One way to do this is to add a parachute, which increases the amount of air resistance and slows the egg down as it falls. Another possible solution is to cushion the egg to distribute the force over a larger area.



VIEWING STRATEGIES AND TOOLS

DISCUSSION QUESTIONS

You can choose to have students watch the Whynauts "Engineer It" video in one sitting, or break it up into sections. Pause the video after each section for discussion and to check for understanding.

SECTION 1: WHAT IS ENGINEERING? [BEGINNING – 3:40]

1. Engineers design solutions for human needs and wants. What is the difference between a need and a want? What is an example of a need that engineers could address? What about a want? A need is something you must have to survive, such as access to clean water. A want is something you would like to have, but would be able to live without, such as a video game.

2. Engineers work together to solve problems. What is an example of a time when you were part of a team? How did you and your teammates work together?

3. The Whynauts are going to design a solution to keep an egg from breaking when it falls. How could this represent another problem an engineer might want to solve? This simple challenge can represent more complex engineering problems, like designing a rover that can safely land on another planet, or safety equipment to protect people from falls or collisions.

SECTION 2: FORCE AND MOTION [3:40 – 6:12]

1. How do you think the Whynauts will use what they know about force and motion to help design a solution to protect the egg?

2. What forces do you think will act on the egg as it falls? Gravity will pull the egg down towards the center of the Earth. Air resistance will slow the egg down as it falls.

SECTION 3: THE ENGINEERING DESIGN PROCESS [6:12 - END]

1. The Whynauts learned that failure is part of the engineering process.
   What is an example of a time when you learned from failure?

2. Jeri's favorite step in the Engineering Design Process is testing. What is your favorite step? Why?

3. If you could choose any problem to solve as an engineer, what would you choose? How would you use science and math to help you design a solution to your problem?

Student Viewing Journal

BEFORE YOU WATCH THE VIDEO:

Use the KWL chart to record what you **know** and what you **wonder** about engineering.

WHAT I KNOW	WHAT I WONDER	WHAT I LEARNED

AFTER YOU WATCH THE VIDEO:
Record what you **learned** in the KWL chart and complete these sentences:

This reminds me of

I was surprised by

The most interesting thing I learned was

Pre- and Post-Video Assessment

1. What does an engineer do?

2. True or False? Circle one.

- All engineers build structures.	TRUE	FALSE
- All engineers solve problems.	TRUE	FALSE
- Failure is part of the Engineering Design Process.	TRUE	FALSE
- Engineers do not need to be good communicators.	TRUE	FALSE

3. Which of the following is NOT a question that is asked during the "Ask" step of the Engineering Design Process?

A. What is the problem?

B. What materials do I need?

C. What are the criteria for success?

D. What are the constraints or limitations?

4. Give an example of a force and describe how it affects your everyday life.

Pre- and Post-Video Assessment

1. What does an engineer do?

An engineer uses science and math to solve problems. These solutions could be anything from buildings, to rockets, to computer programs, to chemicals!

2. True or False? Circle one.

- All engineers build structures. TRUE [✓ FALSE]
- All engineers solve problems. [✓ TRUE] FALSE
- Failure is part of the Engineering Design Process. [✓ TRUE] FALSE
- Engineers do not need to be good communicators. TRUE [✓ FALSE]

3. Which of the following is NOT a question that is asked during the "Ask" step of the Engineering Design Process?

A. What is the problem?

B. What materials do I need?

C. What are the criteria for success?

D. What are the constraints or limitations?

4. Give an example of a force and describe how it affects your everyday life.

Answers will vary. Forces could include gravity, friction, magnetism, or another push or pull. Examples of situations affected by these forces could include transportation, sports, or amusement park rides.

SUPPLEMENTAL ACTIVITIES

The Art of Communication

Engineering Design Process Scramble

Whynautcopter Investigation

Egg Drop Design Challenge

The Art of Communication

HOW WELL DO YOU COMMUNICATE AND COLLABORATE WITH OTHERS?

Objective:
Students will discover the importance of communication and collaboration by completing drawing challenges with a partner. They will also recognize that engineers must work together effectively to be successful.

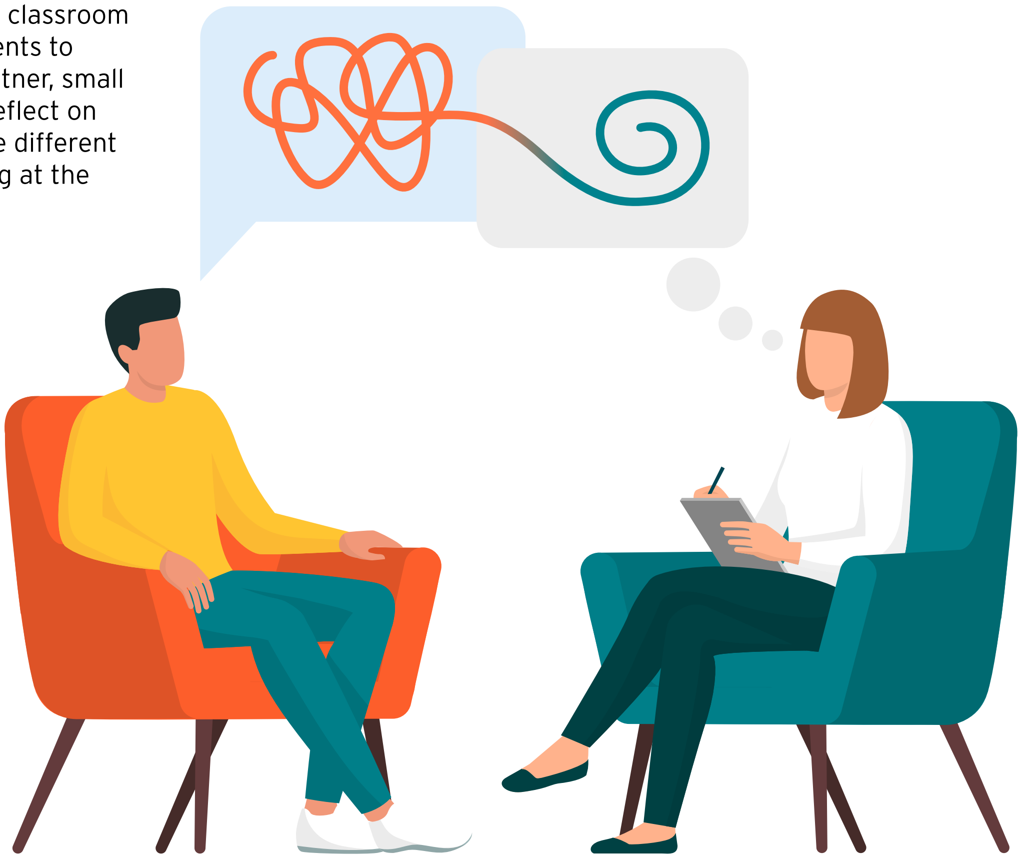
Materials:
- Two pictures of simple objects or scenes
- Paper
- Something to draw with (pencil, crayon, marker, etc.)

Lesson Outline:

1. Ask students to provide examples of times they had to work with others to achieve a common goal. What was challenging about working together?
2. Assign students a partner, or let them choose one. Instruct them to complete both drawing challenges and answer the reflection questions.
3. Have students share their drawings, stories, and reflections with the class.

Extensions:

- Art – Using butcher paper, have the whole class collaborate on a back and forth drawing to display in the classroom. Ask them to reflect on how they communicated and collaborated. Was it easier or harder working with a larger group? Why?
- ELAR – Have each student write their own story about the classroom collaboration. Allow students to read their stories to a partner, small group, or the full class. Reflect on how different people have different perspectives when looking at the same drawing.



The Art of Communication

HOW WELL DO YOU COMMUNICATE AND COLLABORATE WITH OTHERS?

Materials:

- Two pictures of simple objects or scenes
- Paper
- Something to draw with (pencil, crayon, marker, etc)

INTRODUCTION:

Engineers use science and math to solve problems and develop solutions. There are many different types of engineers, including:

- **Civil engineers** – use what they know about physical and natural environments to design solutions such as roads, bridges, airports, and dams.
- **Mechanical engineers** – use principles of force, motion, and energy to design solutions such as engines, generators, and elevators.
- **Aerospace engineers** – use their knowledge of aerodynamics to design solutions such as airplanes, helicopters, rockets, and spacecraft.
- **Electrical engineers** – use the principles of electricity to design solutions such as circuits, robots, and cell phones.
- **Chemical engineers** – use their knowledge of chemistry to design solutions such as new materials, medicines, and fuels.

Different types of engineers work together as a team to design solutions to problems. Each team member contributes different skills, knowledge, and experiences. In order to be successful, they must be able to communicate and collaborate effectively.

Find a partner and practice your own communication and collaboration skills with these drawing challenges!

CHALLENGE 1: DESCRIBE AND DRAW

PARTNER A

1. Find or draw a picture of a simple object or scene. Do not show your partner the picture!
2. Describe the picture to your partner so they can draw it. Do not say what the picture is or use any words that will give it away.
3. You can answer your partner's yes/no questions, but do not tell them if parts of their drawing are right or wrong.
4. Compare the picture to your partner's drawing.

PARTNER B

1. Draw the picture that your partner describes.
2. You can ask yes/no questions, but do not ask if parts of your drawing are right or wrong.
3. Compare your drawing to the picture.

Now switch roles!

ANSWER TOGETHER:

1. How did you and your partner communicate to recreate the picture?

2. What was challenging about working together?

3. How might you communicate better next time?

4. Why do you think it is important for engineers to communicate when trying to solve a problem?

CHALLENGE 2: BACK AND FORTH DRAWING

1. Partner A: draw one line or shape on the piece of paper, and then pass it to Partner B.
2. Partner B: add one line or shape to the paper, and then pass it back to Partner A.
3. Keep passing the paper back and forth, adding one line or shape each time.
4. Work together to create a story about the drawing you made.

ANSWER TOGETHER:

1. How did you and your partner collaborate to create your picture and story?

2. What was challenging about working together?

3. How might you collaborate better next time?

4. Why do you think it is important for engineers to collaborate when trying to solve a problem?

Engineering Design Process Scramble

WHAT ARE THE STEPS OF THE ENGINEERING DESIGN PROCESS?

Objective:
Students will become familiar with the steps of the Engineering Design Process. They will also come to understand that not everyone approaches engineering design in the exact same way.

Materials:

- Scissors
- Tape or glue

Lesson Outline:

1. Remind students that the **Engineering Design Process** is a series of steps that helps engineers identify problems and develop solutions.
2. Students may work individually, in pairs, or in small groups. Instruct students to cut out the names and descriptions for each step. They should then match each step to its description, and tape or glue them in the correct order in the diagram. It does not matter where they place the first step. You could also choose to have students recreate the diagram in a science notebook or on a piece of blank paper.
3. Have each student or group compare their diagram with others. Did they come up with the same order? If not, ask students to explain their reasoning for the order they chose.
4. Share with the class that not everyone approaches engineering design in the exact same way — and that's okay! The process is a tool to help engineers design solutions to problems, and tools are often used in different ways by different people. Various versions of the Engineering Design Process that students may see could have a different number of steps, different names, or different orders.

Extensions:

- ELAR – Read a story that features a character using the Engineering Design Process. Several examples are listed in the resources section of this guide. Ask students to identify each step of the process in the story. Or, have students write their own story about a character using the Engineering Design Process.
- Career Connection – connect your students with an engineer to learn how they use the Engineering Design Process in their work! You can reach out to engineers in your community, or check out the resources section of this guide.

Engineering Design Process Scramble

WHAT ARE THE STEPS OF THE ENGINEERING DESIGN PROCESS?

Materials:

- Scissors
- Tape or glue

INTRODUCTION:

The **Engineering Design Process** is a series of steps that helps engineers identify problems and develop solutions.

Can you unscramble the mixed up steps and descriptions of the Engineering Design Process?

PROCEDURE:

1. Cut out the names and descriptions for each step in the Engineering Design Process.
2. Match each step to its description.
3. Tape or glue the names and descriptions in the correct order in the diagram or on a separate piece of paper.

Engineering Design Process Scramble

Imagine

Create

Brainstorm possible solutions.

Plan

Try it out! Test and evaluate your prototype.

Communicate your solution.

Share

Test

Choose a solution. Draw a diagram and make a list of materials.

Follow your plan to build a prototype.

Improve

Ask

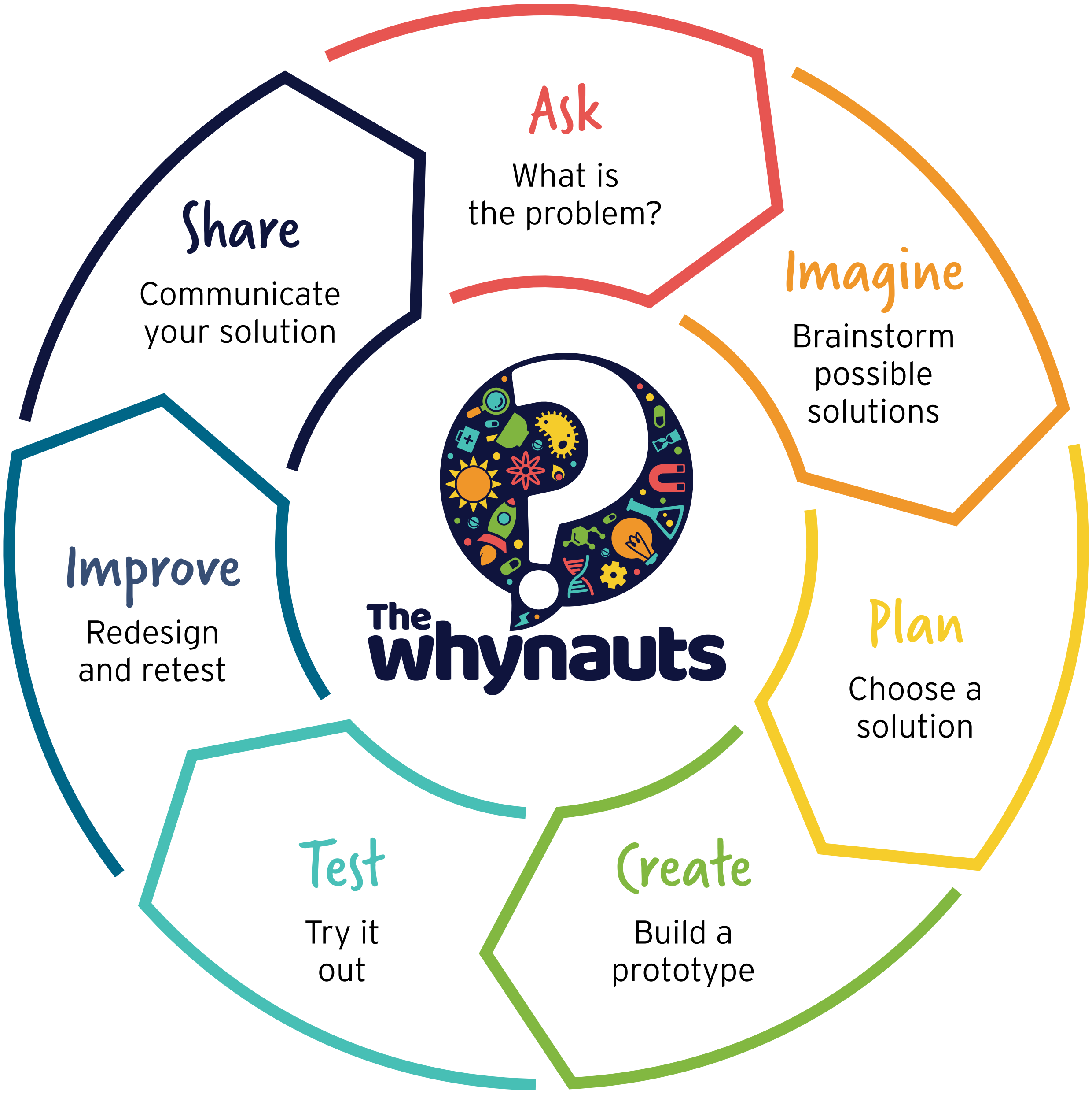
What is the problem?

Redesign and retest your prototype as needed.

Engineering Design Process

Engineering Design Process

*Note: Different versions of the Engineering Design Process may slightly vary.
This is the process used throughout the Whynauts "Engineer It!" episode and Educator Guide.*



Ask
What is the problem?

Imagine
Brainstorm possible solutions

Plan
Choose a solution

Create
Build a prototype

Test
Try it out

Improve
Redesign and retest

Share
Communicate your solution

The Whynauts

Whynautcopter Investigation

HOW DO FORCES AFFECT A PAPER HELICOPTER'S MOTION?

Objective:
Students will observe forces acting on a paper helicopter, and then design an investigation to test how changing the paper helicopter affects how it falls.

Materials:

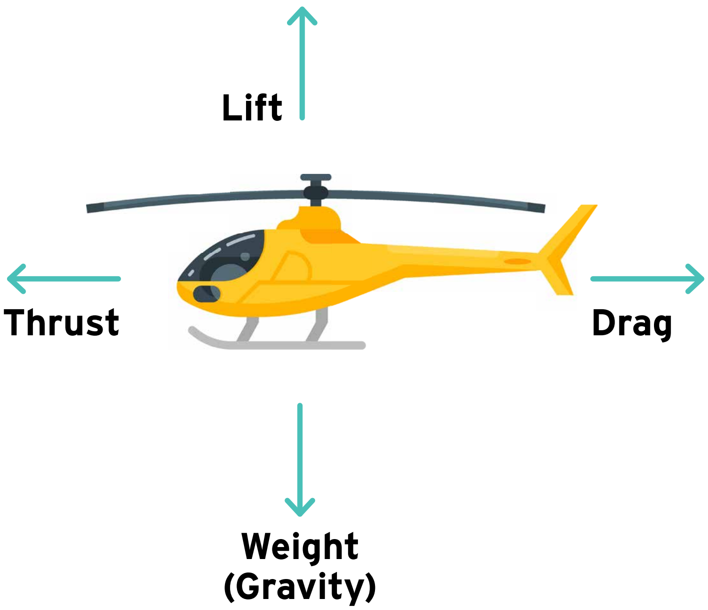
- Paper helicopter template (1 per student, plus extras for investigating)
- Scissors (1 per student)
- Paper clips (1 per student, plus extras for investigating)
- Stopwatch (1 per group)
- Optional: papers of varying thickness, ribbon

Background Information:
A force is a push or a pull. Four forces act on a helicopter in flight:

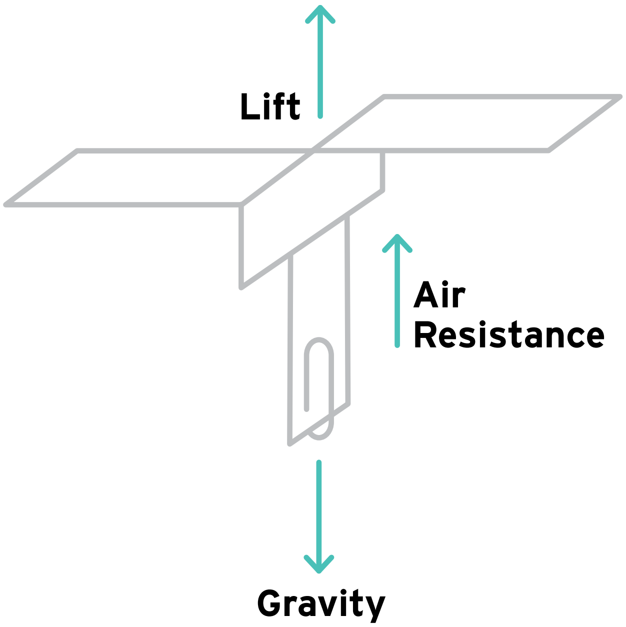
- **Lift** – upward force created by differences in air pressure.
- **Weight** – downward force caused by **gravity**.
- **Thrust** – force that moves an aircraft through the air.
- **Drag** – force that resists movement through the air.

Similar forces act on a paper helicopter as it falls from a height. The force of gravity pulls the paper helicopter down, and the force of **air resistance** pushes up against the blades, causing them to slant. As the air passes by the blades it pushes them sideways, making the paper helicopter spin as it falls.

Forces Acting on a Helicopter in Flight



Forces Acting on a Falling Paper Helicopter



Lesson Outline:

1. As a class, review forces such as gravity and friction. Ask students to explain what kind of forces they think are acting on the Whynautcopter as the Whynauts fly around town.

2. Show students an example of a paper helicopter. Drop the paper helicopter from a height and ask students what they observe.

- Why do you think the paper helicopter falls to the ground?
- Why do you think the paper helicopter spins?
- What forces are acting on the paper helicopter?

3. Pass out the paper helicopter template and instructions. Give students time to create their own paper helicopter and test it out.

4. Tell students that they will be working in groups to design an investigation that tests how changing something about the paper helicopter affects how it falls. For younger students, you may wish to design the investigation together as a class. Before they begin, discuss:

- What are some things we could change about the helicopter? These are called variables.
  Examples include: the size of the helicopter, shape of the wings, type of paper, or number of paper clips.
- Why is it important to only test one variable at a time?
  Changing one variable at a time allows you to determine if that change is what causes the effect you see, and not something else
- What data could we collect or measure?
  Examples include: the time it takes for the helicopter to fall, or the number of times the helicopter spins (this is easier to see if you attach ribbon to the end of the paper clip and see how many times it winds around).

5. Have each group demonstrate their helicopter, explain the change they investigated, and share what they learned from the investigation. Encourage students to use what they know about force and motion to communicate their conclusions.
Example conclusion: Smaller helicopters fall faster than larger helicopters because they have less surface area to experience the push from the air (air resistance).

Extensions:

- ■ Math – Have students make a graph of their data.
- ■ Engineering Design – Challenge students to design a paper helicopter that falls as slowly as possible. Ask students to compare and contrast the process they used for the paper helicopter investigation and the Engineering Design Process.

Whynautcopter Investigation

HOW DO FORCES AFFECT A PAPER HELICOPTER'S MOTION?

Materials:

- Paper helicopter template (printed or recreated on scrap paper)
- Scissors
- Paper clip
- Optional: stopwatch

INTRODUCTION:

While you may not have your own Whynautcopter to fly around town, why not create your own paper helicopter to investigate force and motion!

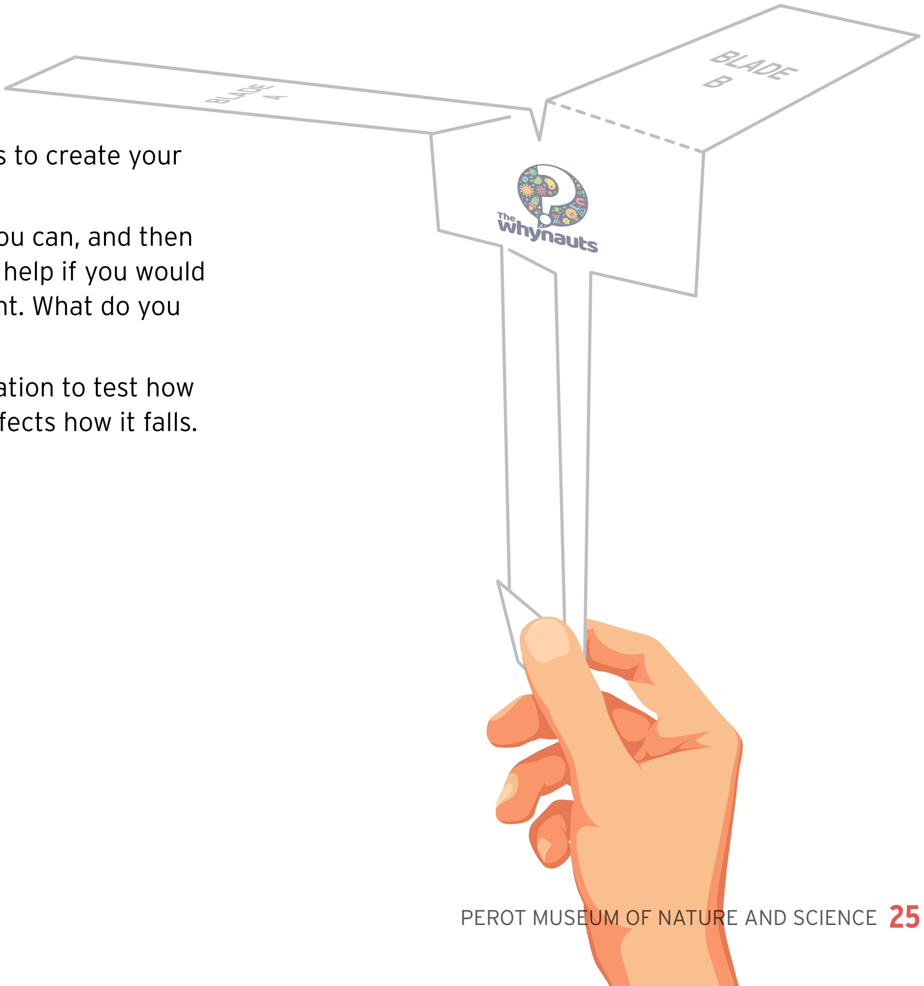
A **force** is a push or a pull. What forces do you think act on a helicopter when it flies? When the helicopter rotates its blades, air pushes up against them, generating an upward force called **lift**. The force of gravity also pulls the helicopter down towards Earth. In order to fly, the helicopter must generate enough lift to overcome the force of **gravity**.

What forces do you think act on a paper helicopter when it falls? Gravity pulls the paper helicopter down, and air pushes up against the blades, causing them to slant. As the air passes by the blades, it pushes them sideways, making the paper helicopter spin as it falls.

In this activity, you will create a paper helicopter and observe the forces acting on it. Then, you will design an investigation to test how changing the paper helicopter affects how it falls. What can this tell us about how forces affect a paper helicopter's motion?

PROCEDURE:

1. Use the template and instructions to create your paper helicopter.
2. Raise the helicopter as high as you can, and then let go to drop it. Ask an adult for help if you would like to drop it from a higher height. What do you observe?
3. Design and complete an investigation to test how changing the paper helicopter affects how it falls.



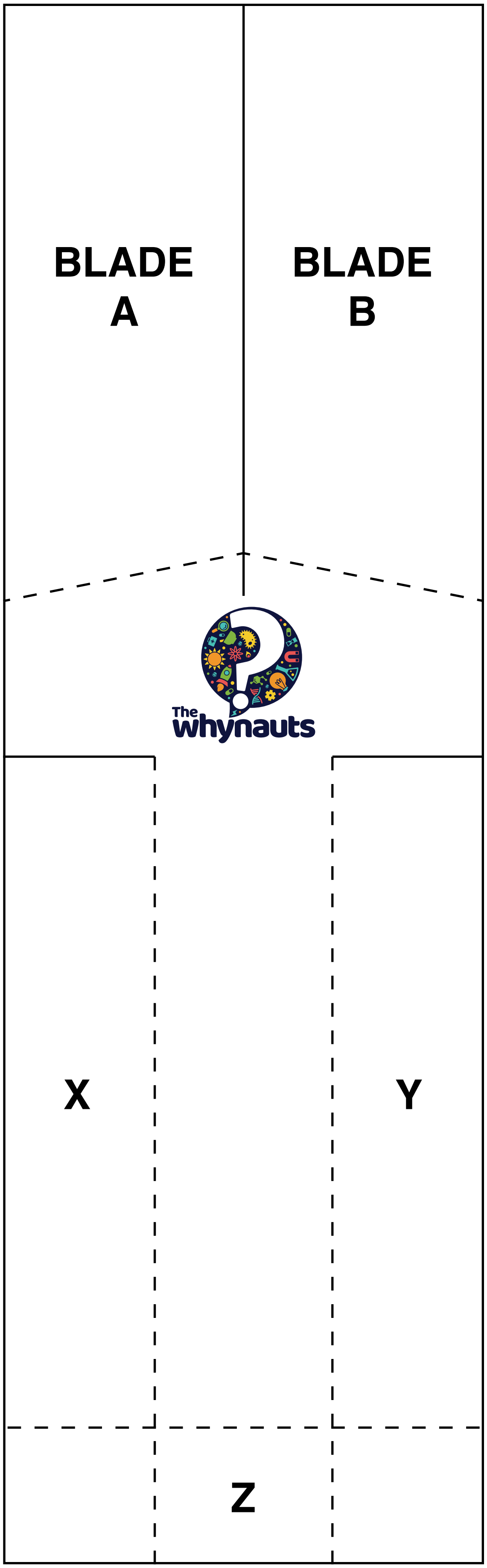
Whynautcopter Investigation

PAPER HELICOPTER TEMPLATE

1. Cut along the solid lines of the template.

2. Fold along the dashed lines:

- Fold Blades A and B in opposite directions – one towards you and one away from you.
- Fold sections X and Y towards the center to form the body of the helicopter.
- Fold section Z upward to add rigidity. Secure with a paper clip.



Whynautcopter Investigation

PAPER HELICOPTER INVESTIGATION

QUESTION

What do you think will happen? Why?

PREDICTION

How does ______________________________ affect ______________________________?

EXPERIMENT

What variable will you change?

What variables will you keep the same?

What will you measure?

RESULTS

What happened? Record your data and observations.

CONCLUSION

Use your results to answer the question you investigated:

How does ______________________________ affect ______________________________?

Was your prediction correct? Why or why not?

How did your investigation show how forces affect the helicopter's motion?

Egg Drop Design Challenge

CAN YOU PREVENT A FALLING EGG FROM BREAKING WHEN IT HITS THE GROUND?

Objective:
Students will work through the Engineering Design Process to develop a solution that protects an egg dropped from a height.

Materials:
- Raw or boiled eggs (at least 1 per group, plus extras)
- Building materials such as tape, glue, paper straws, rubber bands, cotton balls, coffee filters, yarn, etc.
- Engineering Design Process Workbook

Background Information:
The **Engineering Design Process** is a series of steps that helps engineers identify problems and develop solutions. The egg drop is a simple challenge that can represent more complex engineering problems, like designing a rover that can safely land on another planet, or designing safety equipment to protect people from falls or collisions.

Several **forces** are at play when an egg is dropped from a height. The force of **gravity** pulls the egg towards the Earth. When the egg hits the ground it exerts a force, and the ground exerts the same amount of force back on the egg. This is what causes a dropped egg to break! The faster the egg falls, the greater the force.

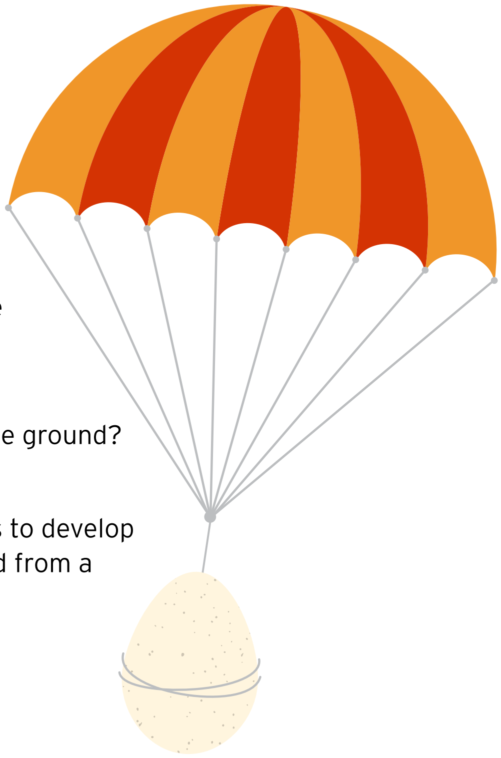
In order to prevent the egg from breaking, you must decrease the amount of force exerted on it. One way to do this is to add a parachute, which increases the amount of **air resistance** and slows the egg down as it falls. Another possible solution is to cushion the egg to distribute the force over a larger area.

Lesson Outline:

1. Prior to the lesson:
- Identify a location for the egg drop.
- Decide on **constraints**, such as the amount of time students have to work on each step, or what materials they can use.

2. Demonstrate what happens when you drop an egg on a table or the floor. Ask students:
- What forces did you observe?
- How could you reduce the force exerted on the egg when it hits the ground?

3. Tell students that they will be using the Engineering Design Process to develop a solution that can prevent an egg from breaking when it is dropped from a height, just like the Whynauts did in the "Engineer It!" episode.



4. Break students into small groups. Remind them that engineers collaborate on projects, and that shared ideas can lead to better solutions. You may wish to assign roles to group members, such as recorder, time keeper, materials manager, builder, or reporter.

5. Instruct groups to use the Engineering Design Process Workbook to complete the first 3 steps: **Ask**, **Imagine**, and **Plan**. They will need to have their plan approved before they begin building a **prototype**. Once their plan is approved, they can move on to the next step: **Create**.

6. When everyone is ready or time is up, have each group **Test** their prototype. Remind students that failure is an important part of the Engineering Design Process, and that they should not be discouraged if their first design doesn't protect the egg. Have a class discussion about their observations. Ask students:

- What did you notice about the designs that protected the egg?
- Why do you think these designs were successful? Try to include what you know about force and motion in your explanation.
- What did you notice about the designs that did not protect the egg?
- Why do you think these designs were not successful? Try to include what you know about force and motion in your explanation.

7. Instruct groups to return to their workbooks to record their observations and move on to the next step: **Improve**. Allow them to improve and test as many times as they need to design a successful solution, or until they run out of time.

8. Ask groups to complete the last section of the workbook: **Share**. Have each group share out their solution to the class.

9. End the lesson with a class discussion. Ask students:

- What did you find challenging?
- How did you and your group members communicate and collaborate?
- How could the egg drop represent a different problem an engineer might want to solve?

Extensions:

- Math – Assign monetary values to each material. For example, you may decide that 1 foot of tape costs $0.10 or each coffee filter costs $0.50. Give your students a budget that they are not allowed to exceed.
- Ask students to choose their problem that they would like solve. Have them use the Engineering Design Process Workbook to develop a solution.

Egg Drop Design Challenge

CAN YOU PREVENT A FALLING EGG FROM BREAKING WHEN IT HITS THE GROUND?

Materials:

- Raw or boiled eggs
- Building materials from around the classroom or home. Be sure to ask a teacher or parent for permission first! *Examples: tape, glue, straws, rubber bands, cotton balls, coffee filters, yarn*
- Engineering Design Process Workbook

INTRODUCTION:

In the "Engineer It!" episode, the Whynauts designed a solution to protect a falling egg. This simple challenge can represent more complex engineering problems, like designing a rover that can safely land on another planet, or safety equipment to protect people from falls or collisions.

Several **forces** are at play when an egg falls to the ground. The force of **gravity** pulls the egg towards the Earth. When the egg hits the ground it exerts a force, and the ground exerts the same amount of force back on the egg. This is what causes a dropped egg to break! The faster the egg falls, the greater the force.

Now it's your turn! You will use the **Engineering Design Process** to develop a solution that can protect a falling egg. Be sure to think about ways to decrease the force exerted on the egg when it hits the ground.

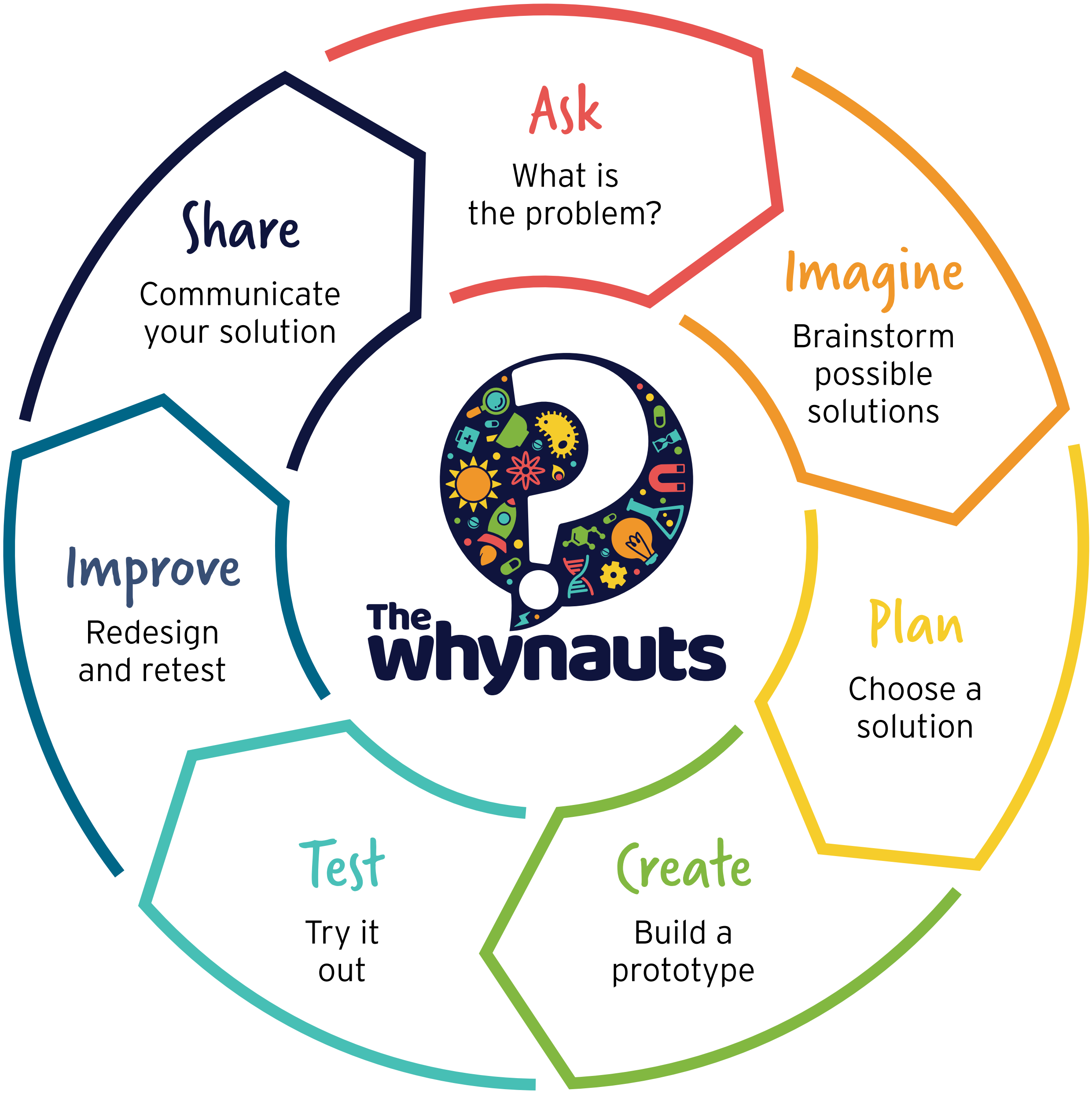
PROCEDURE:

First, identify the location where you will drop the egg.

Egg Drop Location ______________________

Estimated Height ______________________

Now use the Engineering Design Process Workbook to guide you through the challenge!



Engineering Design Process Workbook

Name(s) ____________________

ASK

What is the problem you are trying to solve?

What are the criteria (requirements for success)?

What are the constraints (limitations like time or materials)?

IMAGINE

Brainstorm possible solutions:

PLAN

Choose a solution that you think will work best to solve the problem.
Don't forget the criteria and constraints!

Draw a diagram and label the different parts:

What materials will you need?

TEST

Try it out! Test and evaluate your prototype.

Record your observations:

Was your design successful? What worked? What didn't?

IMPROVE

Redesign and retest your prototype as needed.

What changes did you make to your design? What effect did they have?

SHARE

Communicate your solution.

What did you learn?

How did you communicate with others throughout the design process?

ADDITIONAL RESOURCES

GLOSSARY

Acceleration – the rate at which an object's velocity changes

Aerospace engineer – an engineer who uses their knowledge of aerodynamics to design solutions such as airplanes, helicopters, rockets, and spacecraft

Air resistance – a frictional force between the air and something moving through it, slowing down an object as it falls

Ask – step of the Engineering Design Process when engineers identify a problem that needs solving

Chemical engineer – an engineer who uses their knowledge of chemistry to design solutions such as new materials, medicines, and fuels

Civil Engineer – an engineer who uses what they know about physical and natural environments to design solutions such as roads, bridges, airports, and dams

Create – step of the Engineering Design Process when engineers build a prototype of their solution

Criteria – the requirements for a successful design

Constraints – limitations on design such as materials, time, and cost

Distance – how far an object has moved

Drag – force that resists movement through the air

Electrical engineer – an engineer who uses the principles of electricity to design solutions such as circuits, robots, and cell phones

Engineer – someone who uses science and math to solve problems and develop solutions

Engineering Design Process – a series of steps that help engineers identify problems and develop solutions

Force – a push or a pull

Friction – force that opposes motion between surfaces that are in contact

Gravity – a force of attraction between two objects; gravity pulls objects towards the center of the Earth

Iteration – the processes of repeating a process until a specific result is achieved

Imagine – step of the Engineering Design Process when engineers brainstorm possible solutions to a problem

Improve – step of the Engineering Design Process when engineers redesign and retest their prototype as needed

Lift – upward force created by differences in air pressure

Mechanical engineer – an engineer who uses principles of force, motion, and energy to design solutions such as engines, generators, and elevators

Motion – a change in an object's position relative to a reference point

Plan – step of the Engineering Design Process when engineers choose a solution to address a problem

Problem – a need or want that an engineer can address; engineers solve problems

Prototype – a working model of a solution used to explore and test a design

Share – step of the Engineering Design Process when engineers communicate their solution to a problem

Speed – how fast an object is moving

Test – step of the Engineering Design Process when engineers try out and evaluate their prototype

Thrust – force that moves an aircraft through the air

Velocity – an object's speed in a particular direction

Weight – downward force caused by gravity

READING LIST

- Barton, Chris. *Whoosh! Lonnie Johnson's Super-Soaking Stream of Inventions*. Charlesbridge, 2016.
- Beaty, Andrea. *Rosie Revere, Engineer*. Abrams Books for Young Readers, 2013.
- Biebow, Natascha. *The Crayon Man: The True Story of the Invention of Crayola Crayons*. Houghton Mifflin Harcourt Books for Young Readers, 2019.
- Dershewitz, Laura and Romberg, Susan. *The House That Cleaned Itself: The True Story of Frances Gabe's (Mostly) Marvelous Invention*. The Innovation Press, 2019.
- Dougherty, Rachel. *Secret Engineer: How Emily Roebling Built the Brooklyn Bridge*. Roaring Book Press, 2019.
- Fleming, Candace. *Papa's Mechanical Fish*. FSG Books for Young Readers, 2013.
- Grandin, Temple. *Calling All Minds: How to Think and Create Like an Inventor*. Philomel Books, 2019.
- Johnson, Steven. *How We Got to Now: Six Innovations That Made the Modern World*. Viking Books for Young Readers, 2018.
- Kamkwamba, William and Mealer, Bryan. *The Boy Who Harnessed the Wind: Picture Book Edition*. Penguin Young Readers Group, 2012.
- Larson, Kirsten W. *Wood, Wire, Wings: Emma Lilian Todd Invents an Airplane*. Calkins Creek, 2020.
- Mosca, Julia Finley. *The Girl With a Mind for Math: The Story of Raye Montague*. The Innovation Press, 2020.
- Sichol, Lowey Bundy. *From an Idea to LEGO: The Building Bricks Behind the World's Largest Toy Company*. Houghton Mifflin Harcout Books for Young Readers, 2019.
- Spires, Ashley. *The Most Magnificent Thing*. Kids Can Press, 2014.
- Spiro, Ruth. *Made by Maxine*. Yamada, Kobi. Dial Books for Young Readers, 2018.
- Yamada, Kobi. *What Do You Do With an Idea?* Compendium Inc, 2014.
- Yamada, Kobi. *Trying*. Compendium, 2020.

ONLINE RESOURCES

PEROT MUSEUM

- Amaze Your Brain at Home
- Science Spotlight – Visionary STEM Leaders

ENGINEERING

- American Society for Engineering Education | Engineering Go For It – lesson plans, activities, news, and resources to enhance K-12 STEM and engineering education
- Born to Engineer – news, resources, and stories that show the excitement of engineering
- Discover Engineering
  - What is Engineering?
  - Chats with Change Makers – interviews of STEM professionals working hard to make the world a better place
- NASA STEM Engagement – resources for K-12 students and educators
- National Academy of Engineering | EngineerGirl – resources to support girls and help them understand the opportunities available to them in engineering
- National Science Foundation | Understanding NSF Research: Engineering
- Sphero News | 5 Kid Inventors Who are Saving Lives
- Teach Engineering – digital library of STEM curriculum for K-12
- TED |Talks by Brilliant Kids and Teens
- TryEngineering – resources, lesson plans, and activities for teachers and students

FORCE AND MOTION

- DK findout! | Forces and Motion
- NASA Glenn Research Center | Newton's Laws of Motion

STEM NEWS

- Science Journal for Kids – peer-reviewed science research adapted for students and their teachers
- Science News for Students | Invention & Innovation Collection

STEM CARRERS

- IF/THEN Collection
- Skype a Scientist

KEY STAKEHOLDERS

SERIES SPONSORS

Perot Foundation

The Lamar Hunt Family

ADDITIONAL SERIES SUPPORT

LH LYDA HILL® PHILANTHROPIES

IF/THEN

City of Dallas | Office of Arts & Culture

For additional information, please email
schoolengagement@perotmuseum.org