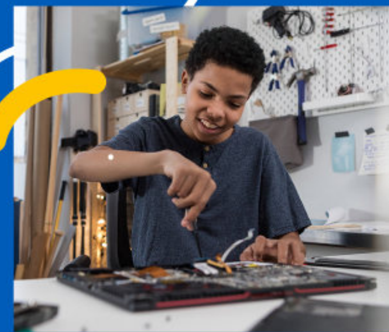
NEXT ENGINEERS

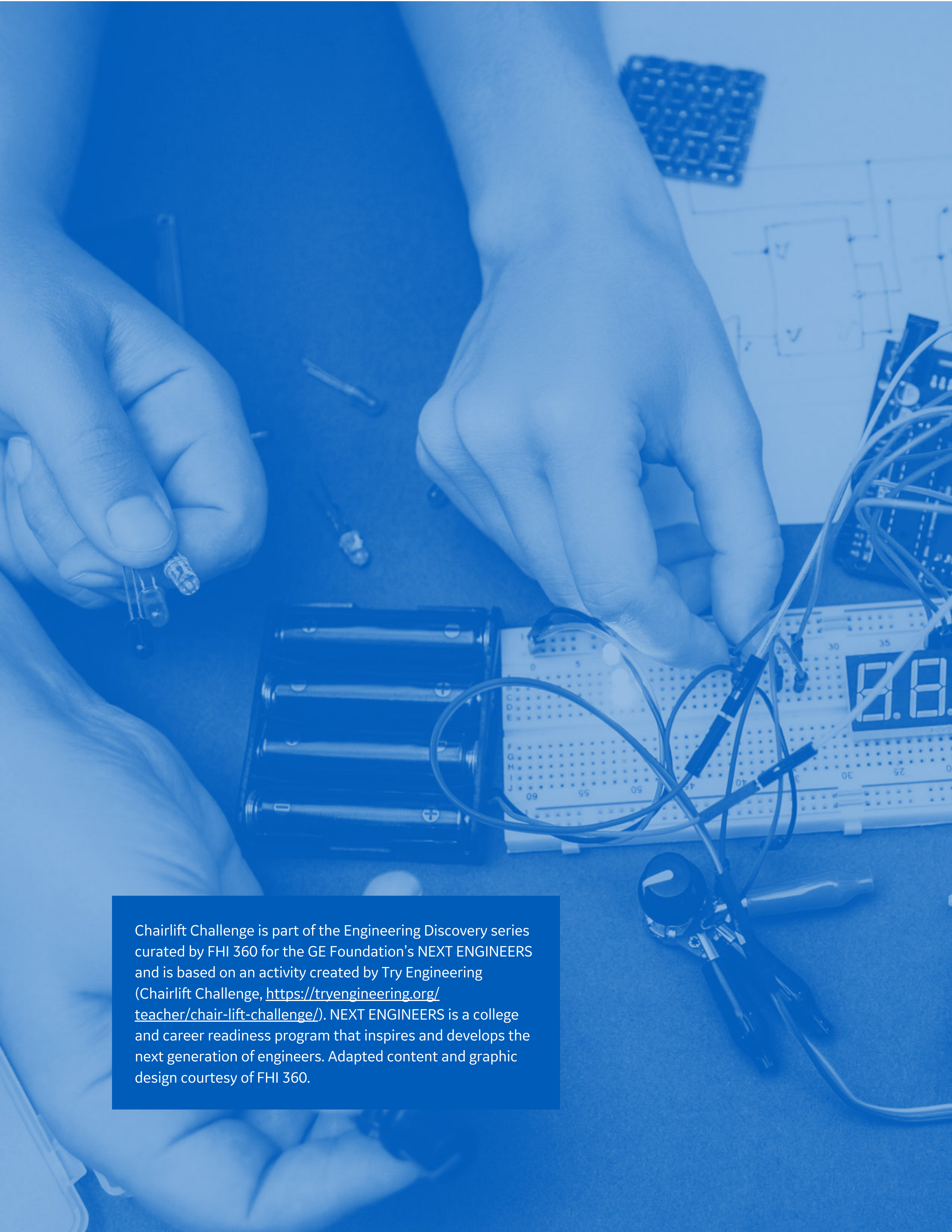


ENGINEERING DISCOVERY

Chairlift Challenge

Topics:
Transportation Engineering
Mechanical Engineering
Civil Engineering

GE Foundation



Chairlift Challenge is part of the Engineering Discovery series curated by FHI 360 for the GE Foundation's NEXT ENGINEERS and is based on an activity created by Try Engineering (Chairlift Challenge, https://tryengineering.org/teacher/chair-lift-challenge/). NEXT ENGINEERS is a college and career readiness program that inspires and develops the next generation of engineers. Adapted content and graphic design courtesy of FHI 360.

Chairlift Challenge

HANDS-ON ACTIVITY

Time	Ages	Cost	Group size (teams)	Activity type
65 minutes	8 - 15	Low	3 - 4 students	Hands-on Activity
Engineering Areas				
• Transportation Engineering • Mechanical Engineering		• Civil Engineering		

Activity Description

This activity focuses on transportation engineering and devising solutions to problems such as transporting skiers or hikers safely to the top of a mountain or moving people around congested urban centers. Students will work in teams to design a 'chairlift' out of everyday items that can transport a ping pong ball in a chair of their own design from the bottom of a 'valley' to the top of a 'mountain' and back again along a wire without the ball falling out.

STUDENT DISCOVERIES

Students will:

- Know more about engineering and engineering careers
- Learn the about the Engineering Design Process
- Participate in a team-based learning experience
- Learn about transportation and manufacturing
- Have fun experiencing engineering

About the Engineering Design Challenge

Students design and construct a model chairlift out of everyday materials. The 'chairlift' must carry a ping pong ball up a line from the 'valley' to the top of the 'mountain' and back down again without the ball falling out of the chair. The one-way distance to be travelled should be at least 3 m (10 feet).

Success Criteria

- The chairlift must carry the ball up a line and back down without the ball falling out of the chair.

Constraints

- Students may only use the materials provided.
- Any unused materials may be shared or traded with other teams.

Materials

The following minimum materials will be required **per group** for this activity:

- 1 ping pong ball (or small, light object)
- 15 m (50 ft) of string
- 5 pipe cleaners (or easily bendable wire)
- 5 straws
- 3 paper towel tubes
- 8 paper clips
- 2 pulleys or thread spools to make a pulley

Materials, continued

- 4 balloons
- 4 sheets of foil or plastic wrap
- 1 copy of the Engineering Design Process Summary (below)
- 1 copy of the Student Worksheet (below)

The following additional materials are required for **testing** the chairlifts:

- Desks and/or chairs
- Duct tape (or other strong adhesive tape)

Facilitation Principles

Working with Youth: Facilitation Tips
(https://www.nextengineers.org/resource/working-youth-facilitation-tips) is a handy summary of the key facilitation principles that volunteers need to keep in mind when facilitating any activity with students.

Facilitator Preparation

1. Read the step-by-step instructions.
2. Collect the materials.
3. Practice doing the activity yourself to identify where students may struggle.
4. Plan when and how you will share your story and career journey in a relevant and personal way. Try to integrate your story into the demonstration as much as possible. You can find the following volunteer resources for how to tell your story on the Next Engineers website:
    a. **I'm an Engineer! Storytelling Worksheet** (https://www.nextengineers.org/resource/im-engineer-storytelling-worksheet)
    b. **I Work with Great Engineers! Storytelling Worksheet** (https://www.nextengineers.org/resource/i-work-great-engineers-storytelling-worksheet)
5. Practice asking and answering questions students may ask. See **Frequently Asked Student Questions** (https://www.nextengineers.org/resource/frequently-asked-student-questions).
6. Print out copies of the Student Worksheet for each group.
7. Set up each group's materials before the start of the activity.

KEY WORDS

- Ropeway
- Constraints
- Criteria
- Engineering Design Process (EDP)
- Engineering Habits of Mind (EHM)
- Engineers
- Iteration
- Prototype

Step-by-Step Instructions

Time	Instructions	Materials
2 min	**Welcome & Introductions** • Welcome students to the activity and briefly introduce yourself, noting what kind of engineer you are. • Briefly describe what a chairlift is using the information contained in the Activity Background section.	Activity Background
3 min	**Pre-Challenge Exploration** • Ask students if they have been in a chairlift, ski lift, or similar kind of aerial transportation. What was the experience like? • Ask students what challenges they think are involved in designing and building such systems. • Ask students where they think chairlift systems could be useful in moving people or goods around.	Activity Background
5 min	**Challenge Overview** • Give students their engineering design challenge and show them the materials that they will have to work with. • Briefly describe the engineering design process that teams will follow using the Engineering Design Process Summary.	Engineering Design Process Summary

45 min	**Engineering Design Challenge**
	• Divide the group into teams of three or four and hand each team their materials. Tell them that they are welcome to trade with or donate materials to other teams.
	• Have students work through the engineering design process to design, build, and test their chairlifts.
	• Assist teams with timekeeping by announcing when they should move on to each part of the Student Worksheet.
	    ○ Research and planning – 3 min
	    ○ Design – 7 min
	    ○ Build it! Test! – 35 min
	• While teams are working, set up the test site. Make sure that there is some elevation between the two start and end points and that they are at least 3 m (10 feet) apart.
		Building Materials
		
		Student Worksheet
		
		Testing Materials

TIPS FOR WORKING WITH STUDENTS

- Help students stay on track with time during the group challenge.
- Move around the learning space and provide support when necessary.
- Encourage all students to participate.
- Provide support and answer questions, as needed.

	• While teams work, circulate and ask students what they have discovered. Where you see teams struggling, suggest some approaches they might not have thought of, but remember not to tell them what to do. The process of learning through failure is valuable. • As teams are ready, invite them to come and test their chairlifts. If the test fails, remind teams to fail productively by asking themselves what they can improve on.	
10 min	**Reflection and Closing** • Ask teams to answer the reflection questions at the end of their Student Worksheets. • After about 5 min, bring the groups together again to discuss their answers to these reflection questions.	Student Worksheet

TIPS FOR MAKING CONNECTIONS

Encourage students to:

- Ask open-ended question to support student reflection and discussion.
- Summarize what students have learned.
- Encourage all students to participate.
- Provide support and answer questions, as needed.

Extension

This activity can be extended in the following ways:

- Substitute the ping pong ball with a golf ball, tennis ball, cricket ball, baseball, etc.
- Design a system that has two seats able to carry two balls at once.
- Design a system that has one seat going up while another seat comes down.

Key Words

- **Ropeway:** An aerial cable moved by a stationary engine and used to transport goods or people. The ends of the cable are almost always joined to form a continuous loop.

- **Constraints:** Limitations of materials, time, budget, size of team, etc.
- **Criteria:** Conditions that the design must satisfy to be considered successful.
- **Engineering Design Process (EDP):** The process engineers use to solve problems and design solutions.
- **Engineering Habits of Mind (EHM):** Six unique ways that engineers think.
- **Engineers:** Inventors and problem-solvers of the world. Twenty-five major specialties are recognized in engineering (have a look at the infographic at https://tryengineering.org/wp-content/uploads/18-EA-381-InfographicEngineering_R2-6.pdf).
- **Iteration:** The process of repeated design, testing, and redesign.
- **Prototype:** A working model of the solution to be tested.

Activity Background

A chairlift (or aerial lift) is an elevated passenger ropeway which consists of a continuously circulating steel cable loop strung between two end terminals and usually over intermediate towers, carrying a series of chairs. They are used extensively at ski areas but are found at amusement parks as well. Depending on carrier size and loading efficiency, a passenger ropeway can move up to 4,000 people per hour, and the swiftest lifts achieve operating speeds of up to 12 m/s (43.2 km/h or 26.8 mph).

Chairlifts are an increasingly popular means of transportation in which cabins, cars, or open chairs are hauled above the ground by means of one or more cables. These are becoming popular in urban environments where ground space is at a premium. Over 600 years ago, aerial systems were used in China to help move people and goods over streams. During the 1800s, the technology was improved by the mining industry to assist in the transport of minerals over difficult terrain. Chairlifts are being installed in some cities to assist with urban transportation.

Safety is always a concern on chairlifts, which is why engineers have incorporated many safety features into them, including lift bars (which provide the passenger with a horizontal bar to hold onto) and locking devices so the cable cannot move backwards.

The mechanism at the top of a chairlift allows for the steel rope to wind horizontally, returning empty chairs down a mountain.

Additional Resources

- Arial People Movers
  http://aerialpeoplemovers.com/
- Garaventa
  http://www.doppelmayr.com
- How seats are heated on Okemo's Sunburst Six orange-tilted bubble chairlift
  https://youtu.be/orwm0r0Yh-0
- Behind the Scenes - How Detachable Ski Lifts Work
  https://youtu.be/589uRMy4Ty4

References

This activity is based on **Chairlift Challenge** originally created by **Try Engineering** and available at https://tryengineering.org/teacher/chair-lift-challenge/.

Visit the **Try Engineering** (https://tryengineering.org/) website for a host of other great engineering activities and resources.

Powered by IEEE TRY Engineering

Chairlift Challenge

Student Worksheet

Challenge Overview[1]

You are part of a team of engineers who have been given the challenge of building a chairlift to carry a ping pong ball up the mountain (from the floor of your classroom to the top of a desk or chair), a distance of at least 3 m, (10 feet) using materials provided to you. Your lift must both carry the ball up the mountain and back down without the ball falling out.

Success Criteria

- The chairlift must carry the ball up a line and back down without the ball falling out of the chair.

Constraints

- You may only use the materials provided.
- Any unused materials may be shared or traded with other teams.

How you design your chairlift that will carry the ball and what materials you use are up to you!

Total Time: 45 minutes

Research & Planning (3 minutes)

Think about the kind of people that might benefit most from this kind of device.

- Where do they live?
- What shape and size does the chairlift need to be?
- What safety concerns might people riding the lift have?
- What materials might work best?

Design Phase (7 minutes)

Before you start building anything, share ideas about how you might design your device. The more ideas, the better. Remember crazy ideas are allowed. They are often the launchpad to the winning idea.

You have been provided with many materials with which to design and build your own chairlift and chair. Consider which materials you would like to use and list them on a piece of paper. Then, on a piece of paper, draw a diagram of the system you intend to build.

Build it! Test it! (35 minutes)

Next, build your chairlift and test it. You may share or trade unused building materials with other teams. Be sure to watch what other teams are doing and consider the aspects of different designs that might be an improvement on your team's plan.

[1] This activity is based on Chairlift Challenge originally developed by Try Engineering.

You may decide to completely change your design during the build process. You may also ask for additional materials or try different solutions as you build.

When you are ready to test your chairlift, bring your prototype to the facilitator.

Reflection

As a team, discuss the following questions:

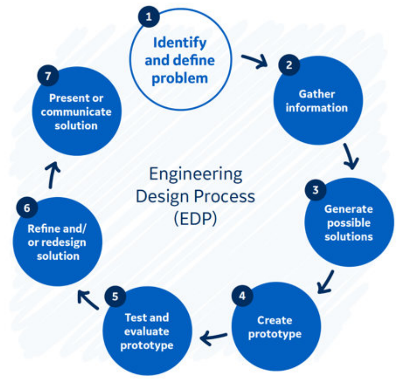
1. How similar was your original design to the actual chairlift your team built?
2. If you found you needed to make changes during the build phase, why did your team decide to make these changes?
3. Was your chairlift able to carry the ping pong ball up and down the mountain without it falling out of the chair you designed?
4. Which chairlift system that another team developed was the most effective or interesting to you? Why?
5. Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?
6. If you could have used one additional material (tape, glue, wood sticks, foil -- as examples) which would you choose and why?

The Engineering Design Process

Student Handout

The engineering design process (EDP[1]) is the key process engineers follow when they solve problems and design solutions.

1. Identify and define the problem



Engineers start by asking lots of questions. What problem must be solved? Who has the problem? What do we want to accomplish? What are the project requirements? What are the limitations? What is the goal? Through this process, engineers start to identify the **criteria** (the conditions the solution must satisfy to be considered successful) and the **constraints** (the limitations they need to design within).

2. Gather information

Engineers dig deep into the problem by collecting **information and data** about the problem and any existing solutions that might be adaptable. They talk to people from many different backgrounds and specialties to assist with this research.

3. Generate possible solutions

Now the fun really starts! Engineers start to **brainstorm** ideas and develop as many solutions as possible, sometimes even crazy ones. This is the time for wild ideas and deferred judgment. It is important to build on the ideas of others while staying focused on the core problem and keeping the criteria and constraints in mind. For example, if there is a budget, can the potential solution be developed within that budget?

4. Create a prototype

Engineers choose one or more of the most promising solutions to **prototype**. A prototype is a working model to be tested.

5. Test and evaluate the prototype

Most prototypes **fail**, but that is good. It tells engineers which ideas they should focus on. Engineers also need to decide if the design really does solve the original problem.

6. Refine and/or redesign the solution

After learning through testing, engineers **redesign and retest** until they have the best solution possible – one that balances the criteria and constraints.

7. Present or communicate the solution

Finally, engineers reach a point where they are satisfied with their solution. It does not need to be perfect, but it should '**satisfice**' - meet the criteria within the constraints. Engineers now communicate their solution to others.

[1] Adapted from https://www.teachengineering.org/design/designprocess