ENGAGING YOUTH THROUGH ENGINEERING™

Drop, Stop, Don't Pop! Launching into Engineering Design

A Middle School Launcher

***from* Engaging Youth through Engineering (EYE)**

2013 (Complimentary Version)

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Launcher Materials List

Materials to be used by 1 Math and 1 Science teacher over multiple class periods by teacher			
Material Description	**Math**	**Science**	**Total**
Bags, plastic or paper (Teacher provided)	8	8	16
Binder clips, small	18	16	18
Electrical conduit (PVC), 5-foot length†, approx. ¾" – 1 ¼" diameter	8	8	8
Marker, permanent (Teacher provided)	1	0	1
Ping pong balls	16	16	16
Poster, Engineering Design Process	1	1	2
Scissors (Teacher provided)	16	16	16
Tape, masking or cellophane	8	8	8
Materials needed for each class period			
Cups, Styrofoam, 6-8 oz capacity	24	24	48
File folders	24	24	48
Index cards, 3" x 5"	32	0	32
Paper, 8.5" x 11" *	16	16	32
Straws, drinking (any style)	80	80	160

* Paper may be scrap sheets or newspaper. Use a 2-page spread of newspaper for every 2 sheets of 8.5" x 11" paper.

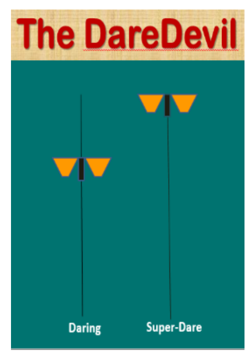
† PVC electrical conduit can be purchased in 5' lengths at home improvement stores for about $1 each. Ten-foot lengths are more commonly available. A hacksaw can easily cut the PVC. The exact diameter does not matter within the suggested range, but all conduits should have the same diameter.

EYE Launcher: Introducing Engineering Design

This launcher is a two-part lesson that frames the year's EYE engineering experience and heightens student awareness of effective teamwork. It also helps students appreciate the ties between engineering and math and science. It is intended primarily for students with some familiarity with the Engineering Design Process presented in the lessons. Note that the approach of teaching one day of this lesson in math class and the other in science class can help math and science teachers get comfortable with the idea of working on a common interdisciplinary project.

Overview

The Launcher lessons introduce the new or intermediate middle school student to an engineering classroom. Over the course of two class sessions (one in math and one in science) students engage in a brief, yet appealing, design challenge. This design challenge serves a number of purposes – first, to launch the engineering program for the school year; secondly, to orient students to the mindset of an engineer and the way engineers tackle and solve problems. They refer to an 8-step description of the engineering design process (EDP) to better understand problem-solving. It also helps students see connections between engineering and science, and engineering and math. In addition, students become aware of and discuss the importance of setting and committing to norms as they embark on creative thinking and learning within a team.



The design challenge is to alter the basic idea for an amusement park ride, the DareDevil, so that the riders will be safe but will still experience a thrilling, fast ride. The ride, modeled in the classroom, consists of a long, vertical pole and passenger baskets (cups) that connect to a central, hollow tube (a cup with a hole cut out of the bottom.) Ping pong balls serve as model riders. The riders in their baskets are dropped from a height on the pole. When they land they pop out of the baskets. Student teams must design alterations so that the ride is as fast as possible, but the ping pong balls do not pop out of the basket. ("Drop, Stop, Don't Pop!") However, the riders must not be restrained in any way. Thus—although this is not made explicit to the students--the speed of the ride and/or the impact must be manipulated.

Launcher Learning Objectives

As a result of this launcher, students will be able to:

- recognize an 8-step Engineering Design Process (EDP) as a way of solving engineering problems.
- relate the 8-step EDP to their own design process.
- use questions to help define a design problem's parameters.
- recognize the importance and value of redesign.
- Identify at least one way in which math and/or science connects to this design challenge.
- identify their own behaviors within a group.
- articulate challenges they encounter and develop ways to positively address these challenges.
- set norms as part of a team and monitor and evaluate individual and team performance in honoring these norms.

Notes:

Math

Day 1: Math Lesson
Launch Engineering Design & Teamwork

Lesson Overview

The first day of this Launcher lesson will be conducted in math class. Students begin this lesson with a discussion of their understanding of engineers, what engineers do, and their own engineering experiences, both in and outside the classroom. Students then view a short video clip of young engineers characterizing engineering from their perspectives. Next, students engage in a brief, high interest design challenge to launch them into the mindset of an engineer and an engineering classroom. Student teams are challenged to design a thrilling, yet safe, amusement park ride. After testing their teams' rides, students reflect on the designs—as well as their teamwork process to get to the designs.

NOTE: At the end of class, each student prepares an index card with notes about teamwork. Be sure that students have time to complete the work that leads to these notes, and that they take these cards to science class to continue this launcher.

Lesson Vocabulary

Criteria
Engineering design process

Day 1: Math Lesson at a Glance

Outcomes	Details
Introduce the engineering classroom. (7 min.)	1. Engage students in thinking about engineering. 2. Place this day's lesson in the context of upcoming work throughout the academic year.
Present the engineering design challenge. (10 min.)	3. Establish the design challenge invitation and context. 4. Explain the design challenge: Student teams will design a ride that DROPS as fast as possible, yet keeps the riders safe. 5. Prompt students to generate questions about the design challenge (define the problem).
Lead teams to design and test their solutions. (15 min.)	6. Instruct the teams to begin discussing their ideas about the design challenge.
Debrief test results. (5 min.)	7. Engage the class in a discussion of the test results. 8. Briefly extend the debriefing discussion by raising the question of how math and science connect to engineering.
Prepare students for teamwork in the next launcher session. (8 min.)	9. Ask students to think about their team process. 10. Instruct students to bring their team process notes/index cards to science class.

Materials for This Lesson

Hard copies of teacher resources are in the Teacher Resources section of this module. Digital teacher resources may be obtained by calling the Mobile Area Education Foundation at 251-476-0002.

Teacher Resources

- ☐ PowerPoint presentation: *Day 1 Math Slides*
- ☐ *What Does Engineering Mean to You?* Teacher Tube video (see Slide #3)

AV and Computer Equipment

- ☐ Computer and projector
- ☐ Access to online video (TeacherTube.com)
- ☐ Engineering Design Process (EDP) poster

For one teacher across multiple classes

- ☐ 2 binder clips, small
- ☐ 3 cups, Styrofoam (6-8 oz.)
- ☐ 1 permanent marker that can write on plastic (Teacher provided)

For each team of 4 students:

- ☐ 1 plastic bag or basket (Teacher provided)
- ☐ 2 binder clips, small
- ☐ 3 cups, Styrofoam (6-8 oz)
- ☐ 1 section of electrical conduit PVC, 5 feet long
- ☐ 3 file folders
- ☐ 2 sheets of 8.5" x 11" paper **or** newspaper (2-page spread)
- ☐ 2 ping pong balls
- ☐ 2 pairs of scissors (Teacher provided)
- ☐ 10 straws
- ☐ 1 roll of tape

For each student

- ☐ 1 index card, 3" x 5"

Notes:

Preparation (25 min.)

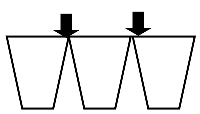
Prepare for leading learning. (5 min.)

1. Review the Math Slides presentation for this Day 1 Math Lesson.
2. Become familiar with the Day 2 Science Lesson and understand where this lesson should lead.

Prepare materials. (15 min.)

3. Make a mark on each 5-foot section of electrical conduit PVC to indicate the drop height for the Dare level of the ride (1.5 feet from top). Mark the top of the conduit with the word, "Top."

4. Prepare the "rider's baskets"—one per team, plus one for demonstration -- by attaching three cups in a line. Use binder clips to connect the rims of the cups. (Arrows in diagram below indicate clip locations.) It is okay if the cups are not exactly vertical, but they should be close.

   For your demonstration model only, cut out the bottom of the middle cup, so that the baskets can drop unimpeded.

5. Assemble the rest of the materials for each group and place everything but the PVC pole into a plastic bag for easy distribution.

6. Plan to distribute an index card to every student towards the end of this lesson. (See Procedures, Step 9.)

Prepare AV material. (3 min.)

7. Prepare to show the Day 1 Math Slides, checking that the AV system works. Prepare the video *What Does Engineering Mean to You?* for playing; open in a new window, advance it beyond the advertisement and press pause.

8. Display the Engineering Design Process poster so all students can see it.

Prepare the classroom. (5 min.)

9. Plan to have students work in teams of four at tables. If you do not have tables, arrange desks so that they are as close to a table arrangement as possible, with two students on each side of the "table."

Procedures (45 min.)

Introduce the engineering classroom. (7 min.)

1. **Engage students in thinking about engineering.**
   Show **Slide # 2** to lead students to tap into their prior knowledge of engineering, based on earlier classroom experiences with engineering design challenges and/or other life experiences. **Ask:**

   How would you explain what engineering is to a fifth-grader?
   What are some things engineers do?

   Allow students a few moments to discuss their recollections in their team. Invite a couple of groups to share highlights of their discussion.

   Provide access to young engineers' perspectives on engineering. Show **Slide # 3**, which provides a link to a short video clip (*What Does Engineering Mean to You?*) in which college engineering students describe their understandings of engineering.

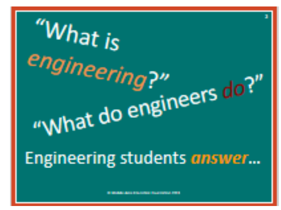
   At the conclusion of the video, ask students to compare their ideas with those from the video.

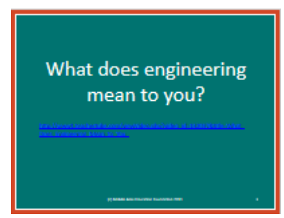
2. **Place this day's lesson in the context of upcoming work throughout the academic year.** Explain to students that throughout the course of this school year they will work on engineering design challenges (just as they may have done in prior grades if their schools are implementing EYE). Students will be engineers and do what engineers do: use math and science, and work together in teams to design and improve solutions to problems. They will learn to think creatively and work collaboratively.

   Tell students that, like engineers, they will find there is more than one correct way to solve a problem. They will enjoy learning to consider many different ideas. Stress that good communication and effective teamwork are extremely important for the success of any design.

   Show **Slide #4** (the Engineering Design Process graphic). Go over the Engineering Design Process (EDP) briefly with the class. At this time it is not necessary to define all of the steps. Focus on reminding students

This launcher assumes that students have had some prior experience with EYE or other engineering design challenge curricula. If this is not the case, you may need to adapt the introduction slightly. For example, there are a few instances when students are "reminded" of their experiences. You may need to approach these parts of the discussion differently.





that engineers typically use these steps as they design solutions to problems, although they may not always use them in this order.

Present the engineering design challenge. (10 min.)

3. **Establish the design challenge invitation and context.** Tell students that Amusements, Inc., a local amusement park, needs their help. Project **Slide # 5**. Explain to the class that Amusements, Inc. has a great idea for an amusement ride. Unfortunately they haven't been able to get it to work yet. The company is hoping the class can help! The ride is called the DareDevil's Drop, Stop, Don't Pop ride.

4. **Explain the design challenge: Student teams will design a ride that DROPS as fast as possible, yet keeps the riders safe.** Show **Slide # 6** as you give this explanation: The riders cannot have seat belts, any type of cover, or any other type of restraint. The riders must stay safely in the carriage when it STOPS at the bottom and not POP out. (Stopping at the "bottom" means that the bottom of the baskets must be no more than 1 inch above the ground.)

Show **Slide # 7**. Advise students that teams can choose to design a Daring ride or a Super-Dare ride. Both rides have the same *criteria*, or requirements for what this design must do. Go over these criteria with the students:

- When the basket stops, the bottom of the baskets can be no more than 1 inch above the ground.
- The riders (ping pong balls) must stay safely inside the basket (Styrofoam cup) from the time the ride begins until it comes to a stop at the bottom.

Conduct a demonstration using the materials you prepared to help students understand the setup of the ride. Explain that the PVC pole is a model of the amusement park ride pole. Every foot of PVC represents ten feet in the real ride. The pole is 5 feet long, so the real Super-Dare ride begins 50 feet above ground – about the height of a 5-story building.

Place a rider (one ping pong ball) in each cup. Point out the mark indicating the top end of the pole. Hold the cups at the Daring position so that the bottom of the cups is even with the line. (For the Super-Dare level, the bottom of the cups should align with the top of the pole.)

Drop the ride. Students will readily notice that the riders pop or tumble out of the baskets. Tell students they can decide to design a ride for either the Daring ride or the Super-Dare ride.

5. **Prompt students to generate questions about the design challenge (define the problem).** Show **Slide # 8.** Record all student questions on chart paper or the whiteboard. Tell students you will answer the questions after everyone has an opportunity to ask his or her question. Typical questions include:

What materials can we use?

- *1 roll of cellophane tape*
- *3 file folders*
- *10 straws*
- *2 pieces of 8 ½" x 11" paper or newspaper)*

How much time do we have? *(10 minutes plus time to test)*

Can we tape the Ping-Pong balls into the cups? *(No. The riders – Ping-Pong balls – cannot be restrained or covered in any way.)*

Lead teams to design and test their solutions. (15 min.)

6. **Instruct the teams to begin discussing their ideas about the design challenge.** Make sure students realize that the 10 minutes for design includes their discussion time and their construction time, and is beginning now. Distribute the materials while students are discussing in their teams. Circulate among the teams, resisting any urge to suggest how teams should solve the problem, but instead offering encouragement and asking questions if they appear truly stumped.

Remind students they have 10 minutes for this challenge. Give students a time reminder at the 5-minute mark.

At the end of 10 minutes, announce to the class that it is time to test their designs. Arrange the designs in a line or circle so all students can observe each test. Begin with teams that designed the Daring ride.

Testing Tip: Depending on the size of your class and the number of teams that attempt the different levels of challenge (Daring or Super-Daring), it may be helpful to separate the groups into smaller subsets, and test in rounds. However, this will take more time, so you will need to plan accordingly. One way to keep the pace moving is to discuss each challenge level before running the tests in multiple sub-groups.

Briefly lead this team to explain their designs. Discuss similarities and differences among these designs and ask the other teams to predict which designs they think will be successful (fast ride/safe passenger). **Ask:**

What is it about these designs that you think will be successful?

Remind students to line the bottoms of the cups to the Dare reference line. Commence a countdown from 3 to zero. At zero all teams should release their rides. Students should observe which rides land quickly, while keeping their riders safe.

Repeat the test preparation procedure with those teams that designed a Super-Dare ride. Ask – but keep the number of responses low according to the time:

What similarities and differences do you notice among these designs?

Which designs do you predict will meet the criteria?

Why do you think that?

Debrief test results. (5 min.)

7. **Engage the class in a discussion of the test results.** **Ask:**

What did you find most interesting or surprising about these results?

After watching all the tests, do you think there are any rules of thumb you want to keep in mind?

8. **Briefly extend the debriefing discussion by raising the question of how math and science connect to engineering.** **Ask:**

Engineers use math and science when they try to understand a problem, solve it, and test their solutions. What connections do you see between what you have done and math and science?

Note

Keep this discussion short because the question will be revisited in science. Instead of spending a long time on this part of the lesson, be sure to leave the full time allotted for the teamwork discussion. The teamwork discussion prepares students for the beginning of Day 2 of this launcher in science class.

Students may not immediately see connections between math and engineering or science and engineering in this challenge. If this is the case, there is no need to press them for responses; as noted above, this question will be revisited in science. Instead, let students know that they will have a chance to continue using their math and science ideas and skills to in science class to redesign the rides. Encourage them to continue thinking about these connections as they continue to work.

Prepare students for teamwork in the next launcher session. (8 min.)

9. **Ask students to think about their team process.** Remind them of the engineering discussion from the start of class, recalling that effective teamwork is part of engineering. **Ask:**

   What was going on in your team as you worked on this challenge? Did your team work smoothly? Did you encounter any problems?

   Suggest that when people work in teams, problems or challenges often arise. Tell them to think about their team today. Ask:

   Was there a problem or concern that surfaced for you?

   Direct students to note on an index card one problem that came up for them. Emphasize that this is for their private thinking and they should not put their names on the card. Instruct students to explain what was happening when the problem arose. You may want to offer some suggestions such as "One person hogged all the materials," or, "No one was listening to my ideas."

   Direct students to think about a strategy that could help prevent this problem. If students truly believe their teams worked well with few difficulties, ask them to write down what they think helped the team work so well. Distribute the index cards and allow students 2-3 minutes to document their thoughts.

10. **Instruct students to bring their team process notes/index cards to science class.** Emphasize that this will be their ticket for a second opportunity to design. Tell students that they will have an opportunity to discuss their team difficulties and their suggested strategies with a new team in science class. When they redesign, their strategies can work together in more effective teams.

Although the discussion of teamwork comes last in the lesson, it is one of the most important aspects of Day 1 math. Be sure to leave plenty of time (8 minutes) for students to engage in the reflection described in Steps 9 and 10.

The following quotes are from students who participated in this Launcher.

"I think things went well, but some people took over. To make it better, those people could ask the other people's opinions."

"Not everybody's ideas were put into it. Ask everyone what they wanted."

"We did great! We all shared ideas and cooperated."

Notes:

Science

DAY 2: SCIENCE LESSON REFOCUS ON TEAMWORK AND REDESIGN

Overview

The second day of this Launcher lesson will be conducted in science. Students expand upon the design work and teamwork begun in math class, further preparing them for successful engineering design experiences throughout the rest of this academic year. In addition, the lesson continues to address engineering connections with science and math. Students begin with a discussion within their new science teams, sharing problems that their previous (math) teams faced and suggesting strategies to prevent or resolve those problems. As a result of this discussion, each team develops norms – agreed-upon expectations for behaviors that every team member will use during work on the design challenge. Student teams then create and test new designs for the Super-Dare Ride. Finally, students reflect on the efficacy of their team norms and their personal commitments to those norms.

Lesson Vocabulary

norm

Lesson 2 Science at a Glance

Outcomes	Details
Help teams work from prior experience to establish team norms. (15 min.)	1. Bell Ringer: Instruct students to review their teamwork notes from math class. 2. Direct students to share their written comments with their new team members. 3. Instruct teams to use the conversation from Step 2 as a basis for setting their own team norms.
Set the stage for a second round of design. (5 min.)	4. Introduce the lesson in the context of the engineering design process (EDP) and the redesign step, in particular. 5. Remind students to maintain a teamwork focus as they redesign a ride.
Support teams as they design and test their solutions. (15 min.)	6. Provide 10 minutes for developing and constructing a ride to test. 7. Direct the class to test team redesigns.
Debrief test results, ties to math and science, and teamwork. (10 min.)	8. After all teams have tested their amusement rides, engage the class in an overall evaluation of their second design. 9. Help teams connect their engineering experience with math and science. 10. Lead the class in a discussion regarding team process and team norms.

Materials for This Lesson

Hard copies of teacher resources are in the Teacher Resources section of this module. Digital teacher resources may be obtained by calling the Mobile Area Education Foundation at 251-476-0002.

Teacher Resources

- ☐ PowerPoint Presentation: *Day 2 Science Slides*

AV and Computer Equipment

- ☐ Computer with projection system
- ☐ Engineering Design Process poster

For each team of 4-6 students

- ☐ 2 binder clips, small; may be re-used from math class
- ☐ 3 cups, Styrofoam, 6-8 oz. capacity
- ☐ 1 section of electrical conduit PVC, 5-foot length; may be re-used from math class
- ☐ 3 file folders
- ☐ paper, 2 8.5" x 11" sheets or newspaper (2-page spread)
- ☐ 2 ping pong balls; may be re-used from math class
- ☐ 2 pairs of scissors (Teacher provided)
- ☐ 10 straws
- ☐ 1 roll of tape; most likely may be used from math class

Notes:

Preparation (23 min.)

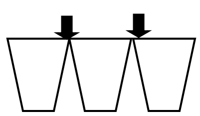
Prepare for leading learning. (5 min.)

1. Become familiar with the Day 1 launcher lesson from math so you can understand students' prior experiences with the challenge and teamwork discussions.

Prepare materials. (15 min.)

2. This launcher was written with the assumption that science teachers would have access to the non-consumable materials used in math class. If you are not using the PVCs from math, get enough 5-foot sections of electrical conduit PVC so that you have one section for each team and one for yourself. Put a mark on each PVC to indicate the drop height for the Dare level of the ride (1.5 feet from top). Mark the top of the conduit with the word, "Top."

3. Prepare the "rider's baskets", one per team, by attaching three cups in a line. Use binder clips to connect the rims of the cups. (Arrows in diagram below indicate clip locations.) It is okay if the cups are not exactly vertical, but they should be close.



4. Assemble the rest of the materials for each group and place everything but the PVC pole into a plastic bag or basket for easy distribution.

5. Preview the Day 2 science slides to ensure that your AV system works properly.

6. Post the Engineering Design Process (EDP) poster in a prominent place where all students will be able to see it.

Prepare AV material. (3 min.)

7. Plan to project the Bell Ringer slide so that students will see it as they walk into the room.

Prepare the classroom. (5 min.)

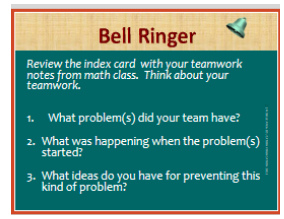
8. Plan to have students work in teams of four. Seat each team it a table. If you do not have tables, arrange desks so that they are as close to a table arrangement as possible, with two students on each side of the "table."

Procedures (45 min.)

Help teams work from prior experience to establish team norms. (15 min.)

1. **Bell Ringer: Instruct students to review their teamwork notes from math class.** As students enter the classroom, display the Bell Ringer, **Slide # 2**, and ask them to think about the questions:
   - *What problem(s) did your team have?*
   - *What was happening when the problem(s) started?*
   - *What ideas do you have for preventing this kind of problem?*

   As soon as the bell rings, ask students to now jot down things that went *well* in their team during math.



2. **Direct students to share ideas for improving teamwork with their new team members.** Advise students that each member of the team should take 1 minute to describe a problem encountered during the first design session and to recommend solutions to that problem. Suggest to the class that this group conversation should provide the team with plenty of ideas for avoiding problems in today's team work.

It is important that every team member have a chance to share the information and ideas about teamwork prepared at the end of math class and in this lesson's Step 1. Depending on your particular class' experience with team discussions, you may need to keep time (1 minute) and signal when it is another team member's turn to share.

3. **Instruct teams to use the conversation from Step 2 as a basis for setting their own team norms.** After all team members have had an opportunity to share, the team should spend a couple of minutes establishing a set of appropriate team expectations for behaviors (called norms) that will help the team function well. Team members should develop these norms for themselves. (These will likely relate to their discussion and experiences.) Norms might include ideas such as: *Give everyone a chance to talk. Share the work and the materials. Don't take over*.)

   Impress upon the teams that each team member needs to take responsibility for making sure their agreed-upon norms are being practiced as they work together today. Advise students that you will check in with teams during and after the design work to see how effectively team members are using their norms. (Be sure to follow through as the lesson progresses.)

Cars provide a great example of engineers improving upon and changing other engineers' designs. Over more than 100 years, the design of the automobile has changed tremendously, one car "generation" at a time.

Set the stage for a second round of design. (5 min.)

4. **Introduce the lesson in the context of the engineering design process (EDP) and the redesign step, in particular.** Refer to the EDP poster and remind students that they have already participated in one round of design. Take this opportunity to remind students that engineering design involves math and science throughout the cycle, and encourage them to try to find how they are using math and science as they continue their design experience today.

   Choose one or two steps and ask a couple of volunteers to provide an example of how their teams in math used those steps. ("We asked questions about the challenge"; "At the end, tested our ideas by we letting the baskets drop and watching what happened.") Remind students that one important feature of engineering is redesign. Engineers often seek to improve their first design, or improve other engineers' designs.

FYI

Some teams may find that their science teams will try to achieve a different performance level (Dare or SuperDare) than they did in math. Other teams may find they are working on a totally different design approach. Because of these changes, some teams may wonder if they are engaged in redesigning the original ride or in designing something new.

In this case, the idea of "Redesign" is broadly interpreted to include the idea of drawing from past experience with the same basic challenge - to make a thrilling but safe ride based on dropping the riders' baskets down a pole - to create a new solution. In this sense, students may not be working directly on their own prior ideas, but their efforts involve re-thinking their original ideas and incorporating them into a new version of the technology. This qualifies their efforts as a redesign.

Prompt student teams to review the key details of the design challenge among themselves. Direct students to consider questions such as: *What must the Daredevil amusement ride be able to do (what are the design criteria)? What limits or constraints are there in this design challenge?* Let the class know that you will be asking each team to contribute to this class review of the challenge. Give teams 1 minute to discuss.

After team discussion, ask teams to share the information they reviewed. Important points that should emerge include:

- The Daredevil ride must be fast, yet keep its riders safe.
- The Ping-Pong balls (riders) must stay in their baskets (Styrofoam cups).
- When the ride stops, the bottoms of the baskets can be no farther from the floor than 1 inch.
- The riders cannot be covered or restrained in any way.
- The central cup may be altered.
- Teams must complete this challenge in 10 minutes.
- The materials are: paper, file folders, tape, straws, and scissors.

5. **Remind students to maintain a teamwork focus as they redesign a ride.** Remind students that teams spent important time coming to agreement on certain team norms they will practice during their work today. Prompt students to be mindful of those behaviors as they work together as a team on a redesign. Acknowledge that even experienced teams sometimes have difficulty remembering their norms once they start their creative work.

Support teams as they design and test their solutions. (15 min.)

6. **Provide 10 minutes for developing and constructing a ride to test.** Inform the class that teams will have 10 minutes to design their ride. Distribute the materials to each team. As students are working, circulate around the room, taking note of the level of team work and cooperation. About 5 minutes into the design work, get the attention of all teams and have them do a quick check within their team. **Ask:**

   How is your team doing complying with your norms? Do you need to make any changes or adjustments? (Do not discuss as a class.)

   At the 7 minute mark, let students know they have 3 minutes remaining to work on their design. At the end of 10 minutes, announce to the class that it is time to test their designs.

7. **Direct the class to test team redesigns.** Instruct half of the teams to prepare to test first. Arrange these teams in a line so the students not testing can observe the tests. Ask students what differences they

Listen for these engineering themes and insights during Steps 8-9.

- *The role of materials in whether a design works. If a material is too rigid, too flexible, too easily torn, etc., it might not work the way the engineers want it to.*
- *Manipulating materials (folding, bending, etc.) can change how that material behaves. Example: Folding paper makes it stronger. Accordion-folding it can make it elastic, so it compresses and rebounds.*
- *It's important to understand the problem clearly and correctly in order to solve it.*
- *Using models can help test ideas without risking waste of materials or injury..*
- *There are usually multiple ways to solve a problem. No one way is the "right" way.*
- *Once engineers solve a problem, it's easy to start adding new criteria (things you want or need the design to do) but it's not always necessary to do so.*
- *Things that don't work in a first design can sometimes lead to a better design in the long run.*

notice from the first designs created in math class. Invite students to predict which designs they think will be successful (fast ride/safe passenger). **Ask:**

What is it about these designs that you think will be successful?

Tell teams that you will begin a countdown from 3 to zero; at zero all testing teams should release their rides. Tell students who are observing to note which rides land quickly while keeping their riders safe.

Run the test.

Repeat the testing procedure with the remainder of the teams.

Debrief test results, ties to math and science, and teamwork. (10 min.)

8. After all teams have tested their amusement rides, engage the class in an overall evaluation of their second design. **Ask:**

    Overall, how did the redesigned rides perform compared to the rides you saw in your math class?

    Did any particular design's performance surprise you? Why?

    Tell students that these types of questions are important considerations in all engineering design projects. Refer students to the EDP poster. **Ask:**

    Think about the engineering design process. Which parts of the process seemed most important in helping your team reach success?

    If relevant, note any broad engineering insights that came out of this discussion (see sidebar) and tell students that they will see these ideas come into play in future design challenges during the school year.

9. Help students connect their engineering experience with math and science. **Ask:**

    Engineers use math and science throughout the engineering design process, to understand problems, solve them, and test the

results. What connections to math and science do you see in your design process with the amusement park ride?

As necessary, help students identify a few (not all possible) connections. Ask one or two of the following questions, based on what you think connect more strongly to the students' experiences.

Try to keep in mind that the point of Step 9 is not to go into detail about the math and science content. Instead, it is to raise awareness of the interconnections between engineering design and math and science. Briefly attending to one or two of the suggested questions should be enough to raise this awarenesss.

Sample Questions to Choose From:

- *How did you know that some of the team's rides went faster or slower than others?* (By watching, observing, comparing.) *Takeaway*: Making comparisons is both a scientific and a mathematical skill.

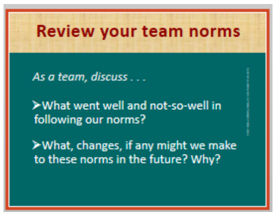
- *How did math help you understand the model ride and the real ride?* (We know that in the model, 1 foot is equal to 10 feet on the "real" amusement park ride. We were able to see how exciting the ride could really be by imagining the height of the real ride.)
  Takeaway: Math helps us understand how the size of a model relates to the real thing.

- *Why did the riders bounce out of the ride in the original model?* (The forward motion of the ride stopped abruptly but their bodies kept moving. The high speed impact caused them to hit the ground hard.)
  Takeaway: The challenge relates to the scientific principles of force and motion.

- *How did you decide which materials to use for different parts of the design?* (We knew we needed something kind of bouncy/stiff/flat/rough to cushion/support/catch the air/make friction.)
  Takeaway: Knowing what to expect of different materials, involves thinking about the properties of materials—a scientific idea.

- *Why did you choose [a parachute/to make padding/ to make the hole in the middle cup small] as part of your solution?* (Parachutes slow things down/padding absorbs the force/ the cup material causes friction with the pole.)
  Takeaway: Expecting the physical world to work a certain involves scientific knowledge.

Step 10 lays a critical foundation for the school year. Be sure to leave time for this discussion.



Congratulate students on their design work. Remind them that they will be working on additional engineering projects during the year. These will take place in math and science classes and will involve teamwork.

Direct them to set aside all materials before returning to their seats.

10. **Lead the class in a discussion regarding team process and team norms.** Instruct teams to spend a few moments reflecting on their team process and use of their team norms. Show **Slide # 3** to help direct their focus.

Invite students to comment. In addition to accepting responses from the team discussions, ask questions such as:

How did it go using team norms? Did you have enough norms? Too many?

What differences did you notice about how you team worked today compared to how your team worked during your first design?

Did you, personally, use any of the team norms? How did that contribute to the success of design?

What is one thing you might consider doing differently as a team member?

Suggest that students think about the value of creating norms to strengthen their teamwork as they tackle engineering design challenges throughout the year. If time allows, ask a students to suggest ideas for a *Top Ten Tips about Teamwork* list.

Glossary

Criteria (*plural*; *singular form*: **criterion**): the requirements of an engineering design; how the technology must perform and/or what it must incorporate in order to be considered successful.

Engineering design process (abbreviated EDP): a set of problem-solving actions that engineers and others use to develop or improve technologies. In the EYE programs, an 8-step summary of this process is used for common reference. The definitions below refer to the use of these terms as steps in this process:

- **Define the Problem:** to lay out the constraints and criteria of a design goal and the need or desire the design is intended address.
- **Research**: to investigate or otherwise gather information about the context, related science and math principles, materials, and ways in which similar design problems have been solved or addressed in prior circumstances.
- **Develop:** to brainstorm or imagine as many solutions to the problem as possible, usually as part of a collaborative effort; a part of the design in which evaluation of ideas is set aside in favor of getting all ideas on the table.
- **Choose:** often, to narrow down the set of possible solutions to one or a limited number that will be brought to fruition. Sometimes people don't develop multiple possible ideas, in which case, "choose" means deciding on one design idea to pursue.
- **Create:** to make a design idea into reality. Often, this means physically constructing a model or prototype, but when the design idea is for a process, it means setting up the process and working through it.
- **Test & Evaluate:** to collect information while trying out the design idea and see how well it meets criteria, and then analyze the results to decide what works and doesn't work well.
- **Communicate:** as a step in the design process, to share the results of the design process with others, explaining the design idea, the process of coming up with, creating, and testing it, test results test results and ideas for next steps.
- **Redesign:** improving a design by using information gathered about it so far and using the steps of the engineering design process to guide decisions about changes.

Norm: an agreed-upon behavior or expectation within a group or team.

Notes: