Get It Together

Program Type: Classroom Program	**_Audience Type:_** Grades 3–8

Description: Students will plan an efficient assembly line process to put together emergency supply kits.

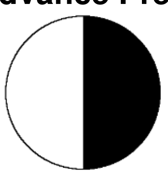
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- Students will test the efficacy of an assembly line process versus an individual one in making emergency supply kits
- Students will make an assembly process quicker and more efficient by testing different production arrangements

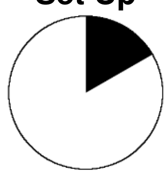
TIME REQUIRED

Advance Prep



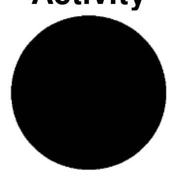
30 minutes

Set Up



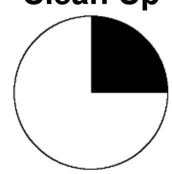
10 minutes

Activity



60 minutes

Clean Up



15 minutes

SITE REQUIREMENTS

- Five tables or large desks spaced around the room
- Space for students to gather and discuss (floor space is fine)

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	10 min
Assembly Trials	Large group activity	40 min
Wrap-Up	Large group discussion	10 min

SUPPLIES

Permanent Supplies	Amount	Notes
Large dry beans	¼ cup/person	Lima, kidney or similar
¼ cup measuring cups	3–4	Or small plastic cups
Reusable snack-size bags	1/person	
Plastic lunch trays	3–4	Any tray, plate, or shallow box to contain the beans
LED flashlights	1/person	Inexpensive LED flashlights with an on/off switch or a small bright item to represent a light
Wax paper sheets	1/person	Each sheet should be twice the size of the sandwich bag
Reusable sandwich bags	1/person	
Straws	1–2/person	
Connectors for straws	5/person	Ex: Strawbees.® See Note 1 below
String	1.5 ft/person	String, twine, or yarn
Cardboard pieces approx. 2"x3"	1/person	
Snap-together building tools	A few/person	See Note 2 below
Paper bags	1/person	Lunch bag size
Bin to store kits in	1	Medium–large storage bin
"Get it Together" Worksheet(s)	1 or 1/pair	*(Optional)* See Extension
Calculator(s)	1 or 1/pair	*(Optional)* See Extension
Pencils	1/pair	*(Optional)* See Extension
Whiteboard	1	*(Optional)* See Extension
Dry-erase marker	1	*(Optional)* See Extension
Document Camera and projector	1	*(Optional)* See Extension
Photos (in the *Background Information* section)	1 each	*(Optional)* Print or display digitally

Note 1: The straws and connectors are assembled to represent a multitool like a Swiss Army knife. An example is shown in the "Set-up" section. We used Strawbees® (www.strawbees.com), but you can also use binder clips, paper clips and/or pipe cleaners.

Note 2: The snap-together building tools represent a crank-operated radio. An example is shown in the "Set-up" section. We used K'NEX® building rods and connectors, but this item could be made with any easy-to-assemble tools that connect in specific ways. LEGO® blocks would work, for example.

ADVANCE PREPARATION

- Cut wax paper into sheets that, folded in half, would fit snugly inside a sandwich bag
- Cut straws into pieces about 3”–4” long
- Cut string into 1.5-ft pieces
- Cut cardboard into approximately 2”x3” rectangles and then cut notches as shown in Figure 1 below:

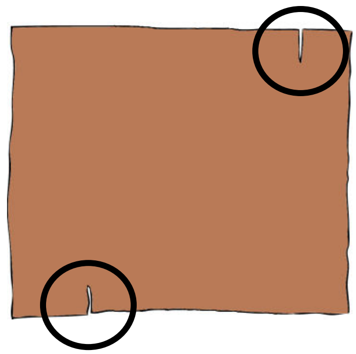
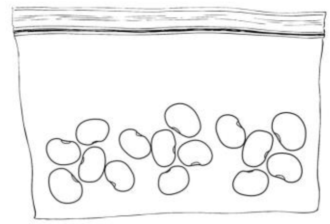
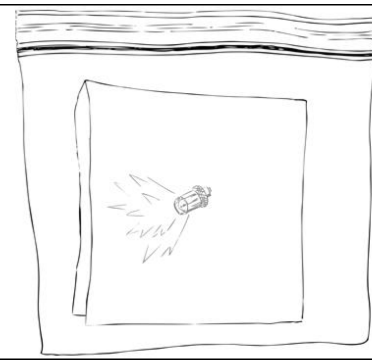
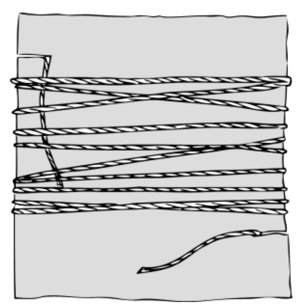
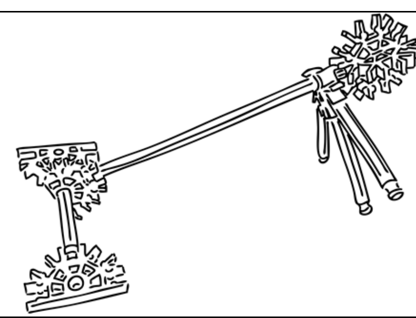
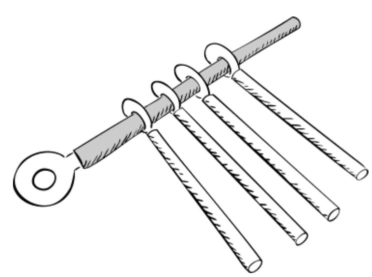


Figure 1: Cardboard notch placement.

SET UP

- In one paper bag, assemble an example kit with each of the materials in the table that follows.
- In a central, easy-to-access spot in the room, place a large storage bin to hold the completed emergency kits and the stack of empty paper bags.
- Set up five table stations—one for each type of item. Provide one pre-assembled item per table, to serve as a model. Tether it to the table with string, to ensure that nobody accidentally takes the example item to use in a new kit. Each station should have enough materials for each student to make 1 item.
- The stations listed in the following table are suggestions of types of materials you could use. However, you could create similar stations from any materials- the important part is that the item being made at each station requires multiple steps to build.
- *(Optional)* Set up the projector or document camera to show the images in the *Background Information* section or print photos to pass around.

Suggested Kit Supplies	Example Item
• <u>Station 1: Food</u> ❑ Container of beans ❑ Measuring cups ❑ Snack-sized bags ❑ Trays to contain the beans	
• <u>Station 2: Light</u> ❑ LED lights ❑ Sandwich bags ❑ Wax paper	
• <u>Station 3: Rope</u> ❑ String pieces ❑ Cardboard pieces with notches	
• <u>Station 4: Radio</u> ❑ Snap-together building tools	
• <u>Station 5: Multi-tool</u> ❑ Straws ❑ Connectors	

INTRODUCTION

10 minutes

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Look at one of your shoes. How many parts and different materials is it made of? How do you think those parts got made and put together, or assembled? The rubber sole had to be made and cut, the upper part had to be cut and sewn, and the laces or buckles had to be manufactured and put on. Think of all those steps.

Do you think a shoe is assembled by just one person?

What if someone needs to produce one thousand shoes? Would each worker make one whole shoe at a time? What about something even more complicated—like a bike, cell phone, or car?
It would be too complicated; you would have to know how to do everything.

When we need to make many of the same products, **industrial engineers** help design systems to make the process faster and more efficient. These systems are called assembly lines. Some parts may be automated (operated by machines) and some parts may be operated by people.

Today you will be industrial engineers, and you will have to create the best and most efficient way to produce a large number of something, making sure that each thing you create is exactly the same.

Introduce the activity using any large-scale recent natural disaster that students may be familiar with—or leave the introduction generic.

You can probably all remember a recent natural disaster that destroyed people's homes and made it hard for them to get food and supplies. In the past few years, there have been earthquakes, hurricanes, tsunamis, and floods in the United States and in other countries around the world. Today, we will be working as industrial engineers helping aid organizations get emergency supplies to people who have lost their homes and belongings in a disaster. In our scenario, one million people had to leave their homes and need your help! Our aid organization needs to make one million survival kits, and we engineers need to figure out the fastest, best way to do it. These are the survival kits that we will be making today.

Show the example bag and have student volunteers pull items out of the bag one at a time. Show each item to the group and explain what it is (or what it represents).

Each survival kit should have a bag of beans for food, a lantern, rope, a multi-tool, and a crank-powered radio.

There are __ students in here, so we will time ourselves to see how long it takes to make __ kits. First, each one of us will make one kit, and then we will come together and see if we can engineer a better process for making the kits.

In order to get this activity to work, we will need to listen to each other's ideas and communicate our own ideas very clearly!

Once a kit is ready and has been checked, it should be deposited in the large bin in the middle of the classroom.

GROUP ACTIVITY

Assembly Trials

5-30 minutes

Take a moment to go over each of the stations and demonstrate how to assemble each item.

To assemble a kit, you will need to visit each station to assemble each item, put all your items in a brown paper bag, and drop it off in the bin. We will start the timer when I say GO and stop the timer as soon as the last kit is in the bin.

Gather students into a line by the place where the brown paper bags are. Before starting the timer, instruct them that they will need to take one paper bag and encourage them to divide themselves evenly among each of the different stations. If possible, keep at least one facilitator by the turn-in bin to inspect kits as they are dropped off, or assign this task to the student who finishes assembling his or her kit first.

Round 1 – Test, Debrief, and Reset

Start the timer and instruct students to begin assembling their kits. Stop the timer when the last kit is turned in. Report to students the number of seconds it took.

If using the “Get it Together” worksheet (see *Extension*) calculate how many days it would take to assemble 1 million kits.

Gather the students to discuss how to improve the process to speed up the kit assembly.

- **What was the fastest item to assemble? What was the slowest?**
- **How could we speed up the process?**
- **What process could we engineer to make everyone’s time more efficient?** *Distribute people at each table; have someone open bags, have someone fill bags, have someone collect the items from each table and put one in each bag, etc.*
- **Is there a better way to organize the room?**

When students start talking about an assembly line or describing the assembly line process, and as they begin to develop a plan, begin asking questions to clarify their planning process.

- **What are the “jobs” each person will have?**
- **How many people will be at each station?**
  - **Which stations should have more people?**
  - **Which ones could get by with fewer?**
- **How will we know when we have made enough kits?**
- **How will we make sure that each kit is complete?**

Help students agree on a process for assembling the kits. Remind them they will be making the same number of kits as before. Suggest they move around the room and mime steps to clearly communicate their ideas.

<u>Note on clean up:</u>
Disassembling the kits after the first iteration can be a time-consuming process. Here are some options for facilitating this transition:

- If materials allow, consider providing enough supplies for each student to make two kits.
- Alternatively, if there is a second adult in the room, have them disassemble the kits during the calculations and planning discussion with the students.
- You can also streamline the process by assigning 2–3 students to each station. Those students can take the supplies for their station from the pile of assembled kits and be in charge of taking apart the materials and returning the station to its original state.

<u>Round 2 – Test and Debrief</u>

Do a second timed trial with students using an assembly line process. Share the new time and compare to the old; did you improve? If using the work sheet, calculate once again the time it would take to make one million kits.

Discuss if there are ways to speed up the process even more without compromising quality.

- **What steps go into making each item?**
- **Will dividing steps between multiple people make the assembly go faster?**
- **What other ways could we work together to assemble each item?**

If time allows, do a third timed trial and compare how long each trial took.

Repeat this process as many times as desired (or as many times as the schedule permits), trying different sizes of groups, different order of tasks, and rearranging stations.

WRAP-UP

10 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

Calculate how much time was saved by implementing the new assembly process.

[time from Trial 2] - [time from Trial 1] = time saved

Why do we care about saving time when making emergency kits?
Because the faster you can make and distribute the kits, the sooner they can help people in need. If students completed calculations, emphasize that their engineering skills got supplies to the disaster zone 10, or 20, or however many days sooner; that's a big deal for people experiencing an emergency!

How could we use other engineering processes to make it even faster?

Can you think of any other situations where an assembly line process would be a good idea?

OPTIONAL EXTENSION

For a math extension, use the “Get it Together” worksheet” after each trial to calculate how long it would take to assemble 1,000,000 kits. Students can work in pairs, or you can work as a class using a document camera. (If no document camera is available, write and solve the equation on a white board or poster).

[time in seconds] ÷ [number of kits completed] x 1,000,000 kits
= time in seconds to assemble 1,000,000 kits

Convert final time to hours/days/weeks/years.

[Time in seconds] ÷ 3,600 = [Time in hours]
[Time in hours] ÷ 24 = [Time in days]

Example: For a class of 35 students that took 5 minutes to make 35 kits:

5 minutes = 300 seconds

300 ÷ 35 students x 1,000,000 = 8,571,428 seconds

8,571,428 seconds ÷ 3600 = 2,381 hours
2,381 hours ÷ 24 = 99 days to make 1 million kits

CLEAN UP

- Disassemble the kits and put away the materials

BACKGROUND INFORMATION

Prior to the industrial revolution, almost all manufactured goods were made one at a time by a single person, or a small group of people. Beginning around the turn of the 20th century, various industries started to experiment with the assembly line process, where each worker would complete one step of the manufacturing process before passing the product on to the next worker, who would complete the next step, and so on. One of the first industries to apply the assembly line process was the meatpacking industry. Later, Henry Ford famously set up an assembly line process at his motor vehicle plant, allowing Ford Motor Company to produce Model Ts at a remarkable rate (see Figure 2).

Modern factories continue to rely on assembly lines and industrial engineers to create things that consumers enjoy, like clothing, food, and even pharmaceuticals. Assembly line techniques have also been adopted by disaster relief organizations, who rely on speed and quantity to effectively reach all of the people who are affected by natural disasters.

Industrial engineers are the people who design these systems. They also imagine and implement other innovations that help industries produce goods more quickly, safely, and cost-effectively.

Figure 2: Workers at a Ford assembly line, 1913. Each worker completes just one step before the unfinished product moves on. (Image: Wikimedia Commons).

Figure 3: The US Marines help Red Cross volunteers load completed kits for Hurricane Harvey relief in Texas. (Image: US Marines website: www.marines.mil).

Figure 4: A Red Cross volunteer distributes cleaning supply buckets to a Texas community after a storm in 2008. (Image: www.fema.gov).

NEXT GENERATION SCIENCE STANDARDS

	Practices
✓	Asking questions and defining problems
✓	Developing and using models
	Planning and carrying out investigations
	Analyzing and interpreting data
✓	Using mathematics and computational thinking
✓	Constructing explanations and designing solutions
	Engaging in argument from evidence
	Obtaining, evaluating, and communicating information

	Crosscutting Concepts
	Patterns
✓	Cause and effect
✓	Scale, proportion, and quantity
✓	Systems and system models
	Energy and matter
	Structure and function
	Stability and change

	Disciplinary Core Idea	3	4	5	MS
Physical Science					
PS1	Matter and Its Interaction	n/a	n/a		
PS2	Motion and Stability: Forces and Interactions		n/a		
PS3	Energy	n/a			
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	
Life Science					
LS1	From molecules to organisms: Structures and processes				
LS2	Ecosystems: Interactions, Energy, and Dynamics		n/a		
LS3	Heredity: Inheritance and Variation of Traits		n/a	n/a	
LS4	Biological Evolution: Unity and Diversity		n/a	n/a	
Earth & Space Science					
ESS1	Earth's Place in the Universe	n/a			
ESS2	Earth's Systems				
ESS3	Earth and Human Activity				
Engineering, Technology, and Applications of Science					
ETS1	Engineering Design	✓	✓	✓	✓

DCI Grade Band Endpoints

3-5 ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (By the end of Grade 5)

3-5 ETS1.B: Developing Possible Solutions

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (By the end of Grade 5)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (By the end of Grade 5)
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (By the end of Grade 5)

3-5 ETS1.C: Optimizing the Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (By the end of Grade 5)

MS ETS1.A: Defining and Delimiting Engineering Problems

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (By the end of Grade 8)

MS ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (By the end of Grade 8)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (By the end of Grade 8)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (By the end of Grade 8)
- Models of all kinds are important for testing solutions. (By the end of Grade 8)

MS ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (By the end of Grade 8)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (By the end of Grade 8)

Performance Expectations

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.
MS-ETS1-1.	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2.	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Get It Together
Appendix

Names ___________________________

Get it Together

How quickly can we make one million emergency kits?

	Time (seconds)		# of kits		Time in ***seconds*** to assemble 1 million kits		Time in ***hours*** to assemble 1 million kits		Time in ***days*** to assemble 1 million kits
Trial 1		÷		x 1,000,000		÷ 3600		÷ 24	
Trial 2		÷		x 1,000,000		÷ 3600		÷ 24	
Trial 3		÷		x 1,000,000		÷ 3600		÷ 24	

<u>Conclusion</u>

The faster you can make one million kits, the sooner the kits can be shipped to people in need. Using a new and improved assembly system, how much time did you save?

Nombres ___________________________

Get It Together
(Juntos ensamblamos)

¿Qué tan rápido podemos armar un millón de kits de emergencia?

	Tiempo (segundos)		Nº de kits		Tiempo en ***segundos*** para armar 1 millón de kits		Tiempo en ***horas*** para armar 1 millón de kits		Tiempo en ***días*** para armar 1 millón de kits
Prueba 1		÷		x 1,000,000		÷ 3600		÷ 24	
Prueba 2		÷		x 1,000,000		÷ 3600		÷ 24	
Prueba 3		÷		x 1,000,000		÷ 3600		÷ 24	

Conclusión

Contra más rápido armamos un millón de kits, más rápido podemos enviar estos kits a la gente que los necesita. ¿Cuánto tiempo ahorramos al mejorar el sistema de la línea de producción?

FACILITATION GUIDE

Get It Together!

Description: Students will plan an efficient assembly line process to put together emergency supply kits.

Promoting collaboration and organization

- Encourage the group to have planning conversations about the assembly line and express their ideas clearly and respectfully.
- During the large group discussion, encourage students to share with a partner before asking individual students to share out.
- Remind students that everyone needs to work together in order to minimize work time. It is important that everyone plays a role.
- Keep careless behavior in check by emphasizing that each kit needs to be exactly the same; if someone causes an accident by rushing too much it will slow everything down. Emphasize that round 1 (students assembling a kit individually) is not a competition.
- Use positive reinforcement: "I appreciate how careful you're being, putting things together the exact same way each time. You're making sure it will be fair for the people who will get these emergency kits."
- Before the timer starts, have each group member say out loud what he or she is going to do in the assembly line.

Encouraging iteration

- "How could you make that process more efficient?"
- "If two (or three) people worked together on this particular item, what could they each do to make the work go faster?"
- "Can you make sure that each item is exactly the same?"
- "After the first trial, what can we do differently to produce these kits in a shorter amount of time?"

Helping those who are stuck

- "Would it help to break this task up into smaller pieces?"
- "Is there a way to make the transitions between stations easier?"

Real-world applications

- A school cafeteria puts food on trays in an assembly line. Can you think of any other places where people use assembly lines to make a process go faster?
- Examine an everyday item. For example, a shoe has many different components: the sole, the insole, the laces, etc. How do you think a shoe is assembled?