

ASSEMBLY LINE

Engineering Fields

- industrial engineering
- systems engineering

Engineering Concepts & Skills

- reverse engineering
- optimization/tradeoffs
- communication
- teamwork
- systems

Estimated time: 30-40 minutes

General Supplies

- timer, stopwatch, or clock with second hand

Supplies Per Family

(one set for each family or small group)

- *Assembly Line Data Sheet* (Appendix D)
- In a gallon-size resealable plastic bag
 - ☐ 5-6 identical retractable ballpoint pens that are easy to disassemble & re-assemble (Note: PILOT EasyTouch® Retractable Pens work well because they can be disassembled into 6 interchangeable parts and require 5 steps for assembly.)
 - ☐ 6 small paper plates (teams should have at least as many paper plates as pen parts)
 - ☐ pencil

How quickly can a team of workers assemble a product? Family members will reverse engineer a ballpoint pen to discover how it was designed and assembled. Then, working as a team, they will create an assembly line to optimize the process of correctly re-assembling all their ballpoint pens in the least amount of time.

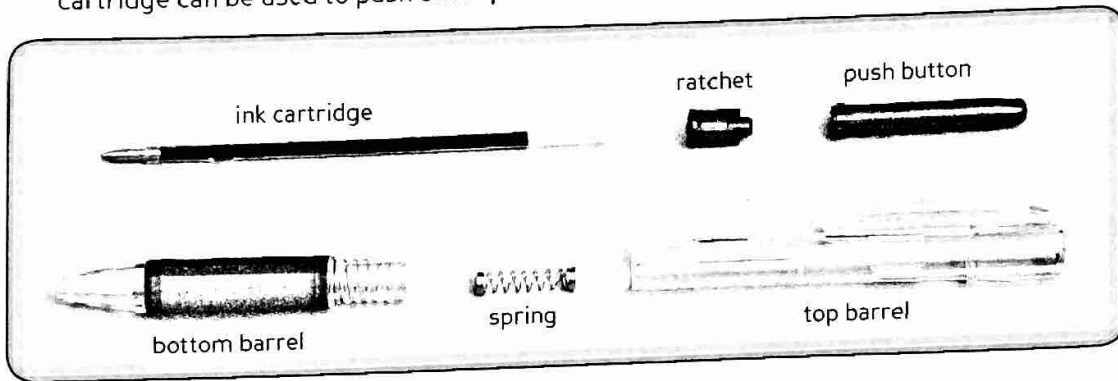
Advance Preparation

- Make copies of the *Assembly Line Data Sheet* (one per family).
- Disassemble and reassemble one retractable ballpoint pen to determine the number of parts and the number of steps that it will take to put the pen back together.
- Pre-package team materials for easy distribution. In a resealable bag, place ballpoint pens, paper plates, pencil, and a copy of the *Assembly Line Data Sheet*. The number of plates should match the number of pen parts when one pen is disassembled.
- *Event Tip:* Have additional pens available to quickly replace pens that break or lose a part during the activity.
- *Safety Note:* Remind families with small children to be sure that small pen parts are not put in children's mouths.

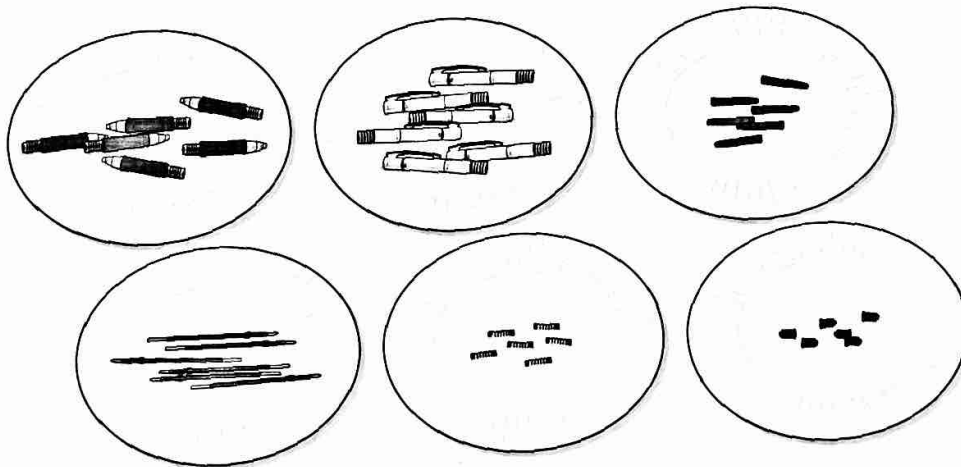
Activity Steps

1. Organize families into teams of 5-6 individuals. Be sure to have a mix of adults and children in each group.
2. Distribute the following materials to each family: 1 ballpoint pen per team member, 6 small paper plates, *Assembly Line Data Sheet*, and pencil.
3. Have the families distribute one ballpoint pen to each family member, and place the paper plates in the middle of their table to store pen parts.

4. Have everyone carefully disassemble their pens to determine the total number of separate parts. There should be 5-6 individual parts—e.g. the ink cartridge, the spring, the top barrel of the pen, the bottom barrel of the pen, the push button, and the ratchet. The long ink cartridge can be used to push other parts out of the pen if necessary.



5. Ask families to discuss what each part is used for, and how it contributes to the way the pen works. Explain that this process is a form of **reverse engineering**—taking apart an object to see how it works. Next ask families to think about what steps they will need to take to re-assemble their ballpoint pens. Allow time for families to practice re-assembling their ballpoint pens.
6. Announce to the group that their first team challenge will be to see how fast each member of the group can re-assemble their own ballpoint pen. Ask everyone to disassemble their pens again and place all like parts in separate paper plates (parts bins) in the middle of their table. For example, all the ink cartridges will be together on one paper plate.



7. Have teams identify one family member to serve as their recorder. Inform the teams that you will call out the time every 5 seconds as teams get close to finishing. The recorder should write down the time closest to the moment when all the team's pens are re-assembled in working order.
8. When all pens have been disassembled, start the assembly process by saying "GO!" Begin timing the process using the stopwatch or clock. Each individual on a team should get parts from the parts bins in the middle of the table and re-assemble his/her own pen. Each team member should only work on one pen. As families get close to completing the task, announce the time every five seconds until all of the pens are assembled. When all the members on a team have completed assembling their pens, the team should raise their hands. The recorder for that team should then record the time of completion next to "Individual Assembly" on their data sheet.
9. Allow time for families to discuss some of the challenges of having each member of the team re-assemble a pen on his or her own.
10. Announce to the group that their next challenge will be to see if they can improve their family's combined assembly time by working together in an organized assembly line. Allow about 10 minutes for each family to discuss and design their assembly line process. Remind them that the goal is still to re-assemble all of their pens, but this time each team member will engage in a specific assembly task.

DESIGNING A BETTER PROCESS



Model T assembly line.

American car manufacturer Henry Ford (1863-1947) developed the assembly line technique for large-scale production. His business was successful, in part, through the continuous improvement of his assembly line processes. Ford and his workers installed the first conveyor belt-based assembly line in his car factory around 1913-1914. The assembly line reduced the production costs for automobiles significantly by reducing the time it took to make a car. Using his engineered assembly line, Ford's famous Model T automobile was eventually assembled in ninety-three minutes. As a result, the automobile became more affordable to the average American.

11. Once all the members on a team know their roles, ask everyone to disassemble their pens again. They may organize the individual parts in whatever way they choose for their particular assembly line process. As before, start the assembly process by saying "GO!" and start timing the process. Keep announcing the time until all families have completed assembly. Have each recorder note their "Assembly Line Trial #1" completion time on the data sheet.
12. Take a moment to find out from the various families if this assembly line process was slower or faster than their earlier individual assembly time. Ask the families to discuss as a team what they observed and experienced with the first trial of their assembly line. Did every step in the process work the way they had imagined? What could they do to improve their process, resulting in even faster assembly? Explain to the group that working to improve their assembly line process is a form of **optimization**—making adjustments to a process to increase its efficiency or outcome.
13. Give the families 5 minutes to improve their process, if they wish, before disassembling their pens again for a second trial. Start the assembly process with another "Go!" and announce times as before. When all families have recorded their "Assembly Line Trial #2" time, ask if their times improved with the second trial. As time allows, have a few families share with the whole group the various approaches they used to optimize their assembly lines.
14. Explain to the group that engineers don't just design *things*—they also design systems and processes, such as creating the most efficient method for assembling a ballpoint pen.

Extensions

- Challenge families to try designing and optimizing an assembly line at home that accomplishes a routine and repeatable task such as making multiple sandwiches for lunch, folding and storing laundry, or setting the table for dinner.



ENGINEERING CONNECTION

Industrial engineers work to design the best possible way of doing or making something safely, quickly, accurately, and for the lowest cost. Reverse engineering, taking something apart to analyze how it was made or operates, is an important technique used to improve a product or to troubleshoot a problem in a piece of machinery. Reverse engineering can also be used to analyze a process or system to find ways of making it better. An assembly line is a process used to make a product faster and more efficiently by using uniform parts and following the same steps each time. Industrial engineers are often tasked with designing new assembly line processes, as well as analyzing and optimizing existing processes.

ASSEMBLY LINE

Data Sheet

	Completion Time
Individual Assembly	
Assembly Line Trial #1	
Assembly Line Trial #2	

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ASSEMBLY LINE

Data Sheet

	Completion Time
Individual Assembly	
Assembly Line Trial #1	
Assembly Line Trial #2	

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