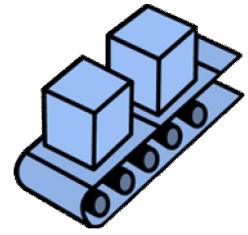




# Assembly Line



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## Lesson Focus

This lesson demonstrates the power of mass production. Students work in teams to design, construct, test, and redesign an assembly line to manufacture a product as quickly and efficiently as possible to meet the quality control criteria.

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## Lesson Synopsis

Students work individually to assemble a product and then work in teams to design, construct, test, and redesign an assembly line process whose product must meet specific quality control criteria. Students reflect and have a classroom discussion comparing the two approaches.

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## Year Levels

Year 5 – 10 Science Inquiry Skills and Science as a Human Endeavour

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## Objectives

During this lesson, students will:

- ✦ Assemble a product individually that meets the quality control criteria.
- ✦ Design an assembly line process to assemble a product as quickly and efficiently as possible meeting the quality control criteria.
- ✦ Construct an assembly line.
- ✦ Test and redesign the assembly line process.
- ✦ Compare the difference between assembling a product individually versus with an assembly line.

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## Anticipated Learner Outcomes

As a result of this lesson, students will have:

- ✦ Assembled a project by hand that meets the quality control criteria.
- ✦ Designed an assembly line process to assemble a product as quickly and efficiently as possible meeting the quality control criteria.
- ✦ Constructed an assembly line.
- ✦ Tested and redesigned the assembly line process.
- ✦ Compared the difference between assembling a product individually versus with an assembly line.

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## Lesson Activities

- ✦ Students will time themselves as they assemble a product individually that meets quality control criteria. Next, as a team they will design, construct, test and redesign an assembly line process, and finally they will compare the difference between assembling a product individually versus with an assembly line.

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## Resources/Materials

- ✦ Teacher Resource Documents (attached)
- ✦ Student Worksheets (attached)
- ✦ Student Resource Sheets (attached)

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## Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

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## Internet Connections

- ✦ Online Video: Assembly Line: Crayola Crayons (<http://videos.howstuffworks.com/discovery/4269-assembly-line-crayola-crayons-video.htm>)
- ✦ History Channel -- the Assembly Line ([www.history.com/topics/assembly-line](http://www.history.com/topics/assembly-line))
- ✦ TryEngineering ([www.tryengineering.org](http://www.tryengineering.org))
- ✦ Curriculum links ([www.acara.edu.au](http://www.acara.edu.au))

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## Recommended Reading

- ✦ Henry Ford and the Assembly Line (ISBN: 978-1584151739)
- ✦ The Assembly Line (ISBN: 978-0618484379)
- ✦ Lean Assembly: The Nuts and Bolts of Making Assembly Operations Flow (ISBN: 978-1563272639)

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## Optional Writing Activity

- ✦ Write an “explanatory essay” describing the steps of the assembly line process. Share the essays with students from another class and have them try to replicate the assembly line.

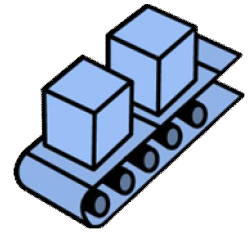
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# Assembly Line

## For Teachers: Teacher Resources (continued)



Activity 2: Design, Construct, Test, Redesign Assembly Line (per team)

- ✦ 30 brown paper bags (30 per team)
- ✦ Stack of recycled paper A4 size
- ✦ 1 full set of markers (1 full set for each team)
- ✦ 1 black marker
- ✦ 1 stop watch
- ✦ 2-4 sets of 2 cups of different sizes or other objects or that can be traced to make circles (Note: could also use a compass)
- ✦ 4 Rulers
- ✦ Copies of the Design Challenge Worksheet (1 per student)

### ◆ Time Needed

- ✦ Activity 1: Assemble One "Colour Brick" (1/2 hour)
- ✦ Activity 2: Design, Construct, Test, Redesign the Assembly Line (1-2 hours)

### ◆ Procedure

#### Activity 1: Assemble Colour Brick Alone

1. Handout the Assemble One Colour Brick worksheet
2. Introduce the design challenge scenario.
3. Share the sample Colour Brick.
4. Discuss each criterion and the tools needed to assemble the product correctly.
5. Provide each student with the materials and tools need to make one Colour Brick.
6. Once the task is clear and questions have been answered, set the timer and students can begin to assemble their Colour Brick making sure to meet the criteria while moving as quickly as possible.
7. When a student completes the colour brick they should raise her/his hand and you can write his/her name and time up on the board.
8. Have students complete the reflection questions.

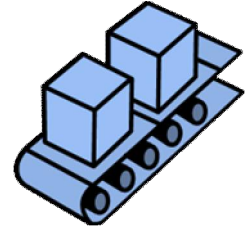
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9. Discuss reflection questions.

## Assembly Line



### For Teachers: Teacher Resources (continued)

#### Activity 2: Design, Construct, Test, Redesign Colour Brick Assembly Line

1. Separate the class into two teams of 10-12.
2. Handout the Design Challenge Worksheet and discuss.
3. Have student works in their teams to design an assembly line (Engineering Design Process steps 2 & 3: brainstorm solutions and choose best solution). To make sure all students are engaged, break the two large teams into smaller teams of 2-5 and have them design an assembly line and then share with the rest of their larger team. Each large team will need to then vote on the best design for their final assembly line.
4. Have students build their assembly line (EDP step 4). Students may need to move desks into a line, circle, etc. They need to label each station and put the materials and tools at the right stations. They need to assign each person a task and a station.
5. When each team is done with constructing their assembly line, give them some time to test and redesign if necessary (EDP steps 5 & 6).
6. Set the timer to about 10- 15 minutes (base your time on how long it took teams during testing to build one). Explain to students that you will be the Senior Quality Control Officer and will be checking to make sure their Colour Brick meets the criteria.
7. Have each team share their responses to Reflection Questions and have a class discussion. Make sure to compare and discuss individually assembling a product versus an assembly line.

#### ◆ Extensions and Variations

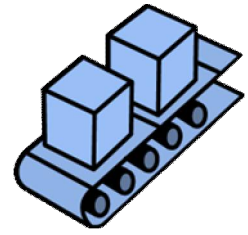
- ✦ Add more tasks, such as packaging bricks into a box to ship.
- ✦ Change the size of the brick (use large brown grocery paper bags)
- ✦ Play some fun fast music during the assembly line testing.
- ✦ Instead of giving a time and seeing how many bricks each team makes, tell students they have to make a certain amount and see how long it takes each team.
- ✦ Have students research ergonomics and consider how the various jobs on their assembly line suit each worker. Have them make any necessary modifications for their assembly line workers. (Ergonomics is a science concerned with the 'fit' between people and their work. It puts people first, taking account of their capabilities and limitations. Ergonomics aims to make sure that tasks, equipment, information and the environment suit each worker. Source: ([www.hse.gov.uk/pubns/indg90.pdf](http://www.hse.gov.uk/pubns/indg90.pdf)))
- ✦ Have students research robots used on assembly lines and consider how they would best utilize a robot in their assembly line. What specific job(s) would the robot perform and why?

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# Assembly Line



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## Student Resource: Key Vocabulary & History

### Key Vocabulary

- **Manufacturing**  
The use of people, machines and tools to turn raw goods into finished products.
- **Mass Production**  
The large scale manufacturing of a product.
- **Assembly Line**  
A manufacturing process where a product is assembled by adding parts in sequence.
- **Conveyor Belt**  
A belt moved by rollers which is used to transport objects from one place to another.

### History of the Assembly Line

The origins of the assembly line can be traced back to miners during medieval times who used bucket elevators to the shipbuilders of the fourteenth century who created moving lines of parts. By the 1900's the assembly line was used by many industries (shipbuilding, canning, milling, meat-packing, etc.), but was most successful in the automobile industry.

Henry Ford created the Model T automobile in 1908. The car was simple so owners could fix it themselves. It was also sturdy and cheap. Soon, the Ford Motor Company started receiving so many orders for Model T's that they couldn't build them quickly enough. To speed up production, Ford changed the way the Model T was built. Instead of several groups of workers each building a complete car from the ground up, workers stayed in one spot and added parts to cars as they moved past them. Parts were delivered to the employees by conveyor belts. Ford even managed to time the delivery of a part so that it would get to a worker only when it was needed. By 1913, Ford had a complete assembly line functioning. This method of production was rapidly adopted by many industries when they discovered that mass production on assembly lines sped up manufacturing time and lowered costs.

Ford used an approach for his assembly line that we call just-in-time (JIT) manufacturing today. This approach lets manufacturers purchase and receive components just before they're needed on the assembly line. As a consequence, it relieves manufacturers of the cost and burden of housing and managing idle parts. The basic elements of JIT were developed by Toyota in the 1950's and were well-established in many Japanese factories by the early 1970's. JIT began to be adopted in the U.S. in the 1980's (General Electric was an early adopter), and is now widely accepted and used.

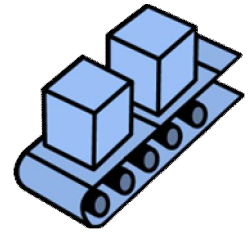
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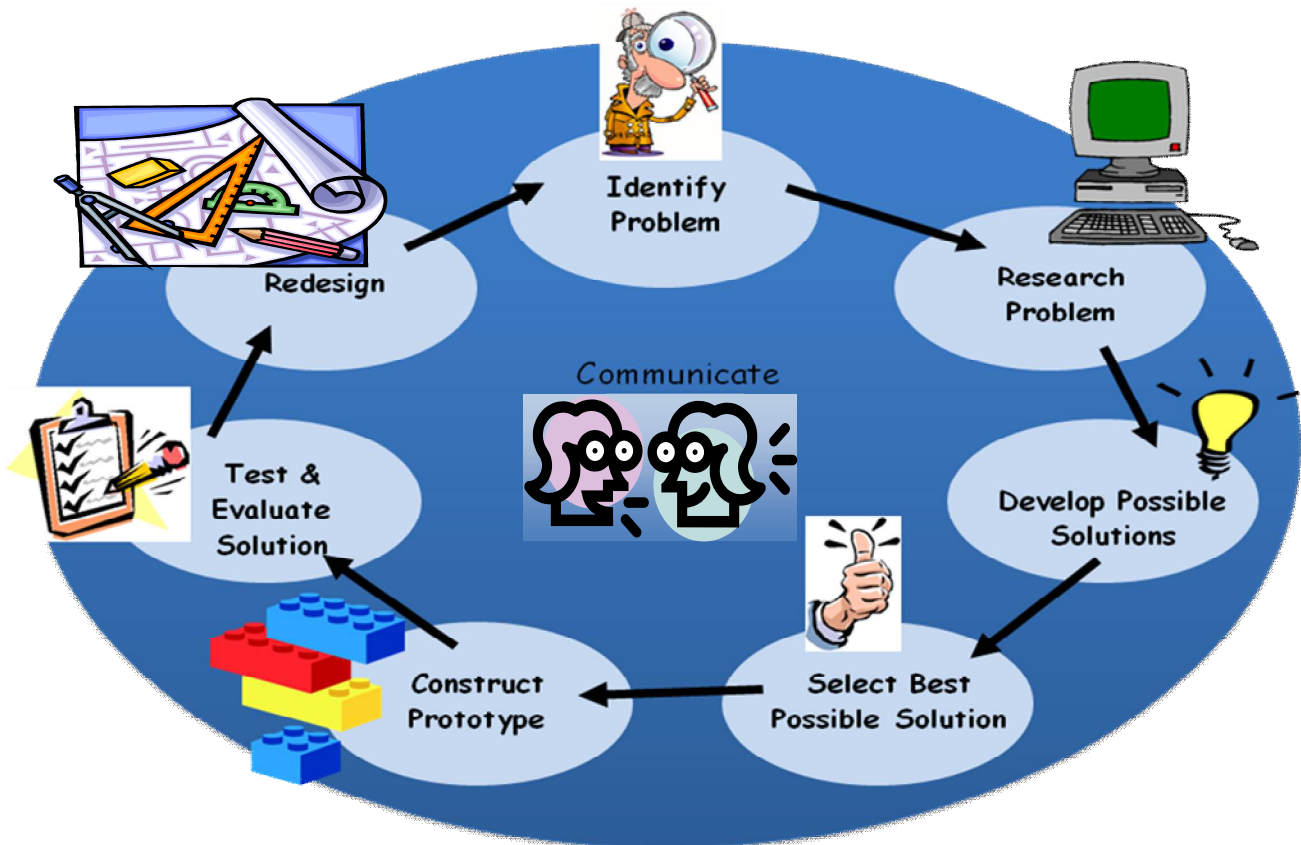
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Student Resource (continued):



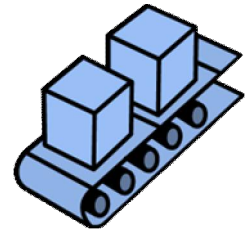
## The Engineering Design Process





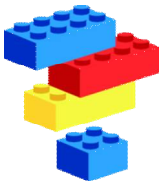
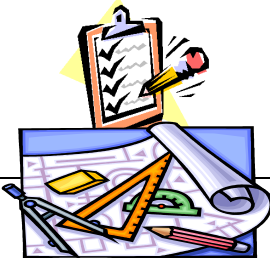


	<p><b>Identify the Problem</b> What is the problem you want to solve?</p>
	<p><b>Research Problem</b> What do you know about the problem? Find out as much about the problem as you can. What are the criteria (conditions that the design must satisfy—its overall size or weight, etc.) and constraints (limitations with material, time, size of team, etc.) of this problem?</p>



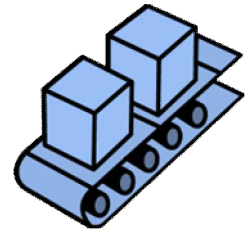
# Assembly Line



Student Resource (continued):

	<p><b>Develop Possible Solutions</b> Brainstorm as many solutions as possible.</p>
	<p><b>Select Best Possible Solution</b> Which of your designs do you think is the best possible solution?</p>
	<p><b>Construct Prototype</b> Using the materials given, build a prototype (a working model) of your design. Don't forget about the criteria (conditions that the design must satisfy) and constraints (limitations that need to be designed around).</p>
	<p><b>Test &amp; Evaluate Solution</b> Test and evaluate your design. Did you satisfy the criteria and constraints?</p>
	<p><b>Redesign</b> Did your design solve the problem? If not, brainstorm a new design, build and test it until you have successfully solved the problem.</p>
	<p><b>Communicate</b> At each step in the process you must communicate with your team members. You need to also communicate with others outside of your team to get feedback on your design. You need to communicate verbally as well as by describing your design thorough writing and drawings. Communication is at the core of the engineering design process.</p>

# Assembly Line



## Student Worksheet: Assemble One Colour Brick

### ◆ Scenario

A local toy company is calling on engineering teams to implement time saving methods to help them meet the demands of manufacturing their most popular product— “colour bricks.” This toddler toy is made out of recycled brown bags and has been hugely popular. They are constantly selling out! The toy company needs to place an order for one million colour bricks in just 3 days!

### ◆ Assemble One Colour Brick

See how fast you can assemble one colour brick and still meet the criteria.

### ◆ Criteria

- ✦ The brick must be made up of 2 brown bags.
- ✦ The brick must be filled with 4 pieces of recycled paper (lightly crunched up and stuffed into one bag. The other bag will cover this bag and the crunched up paper.)
- ✦ The largest sides of the brick must be filled with dots. (3 large 3cm diameter & 3 medium 1cm circles scattered per side). One side must have 3 blue and 3 green circles. The other side must have 3 red and 3 orange circles.
- ✦ The top and bottom of the brick must have 4 vertical 1cm purple stripes with 1cm in between each stripe.
- ✦ Both sides of the brick must have **Colour Bricks** written in black marker. Letters must be centered on the sides and 2cm in height and 12cm long.

### ◆ Constraint

- ✦ Use only the materials provided.

### ◆ Reflect

1. How long did it take you to make 1 colour brick?
2. What was the easiest task and why?
2. What was the most challenging task and why?
4. Is there an easier and/or faster way to make the brick? If yes, describe

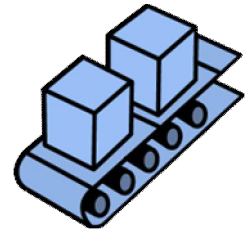
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# Assembly Line



## Student Worksheet: Design Challenge

### ◆ Scenario

A local toy company is calling on engineering teams to implement time saving methods to help them meet the demands of manufacturing their most popular product— “colour bricks.” This toddler toy is made out of recycled brown bags and has been hugely popular. They are constantly selling out! The toy company needs to place an order for one million colour bricks in just 3 days! They will award the contract to the engineering team that can make the bricks the fastest while meeting the quality control constraints.

### ◆ Design Challenge

Each team (approximately 8-10 per team) will design an assembly line process that will make as many “colour bricks” in 10 minutes as possible and still meet all of the quality control constraints.

### ◆ Criteria

- ✦ Each brick must be made up of 2 brown bags.
- ✦ Each brick must be filled with 4 pieces of recycled paper (crunched up and stuffed into one bag. The other bag will cover this bag and the crunched up paper.)
- ✦ The largest sides of the brick must be filled with polka dots. (3 large 3cm diameter & 3 medium 1cm circles scattered per side). One side must have 3 blue and 3 green circles. The other side must have 3 red and 3 orange circles.
- ✦ The top and bottom of the brick must have 4 vertical 1cm purple stripes with 1cm in between each stripe.
- ✦ Both sides of the brick must have **Colour Bricks** written in black marker. Letters must be centered on the sides and 2cm in height and 12cm long.

### ◆ Criteria

- ✦ You must only use the materials provided.

### ◆ Planning Stage

Meet as a team and discuss the problem you need to solve. Then develop and agree on a process for solving the challenge. You'll need to determine what materials you want to use.

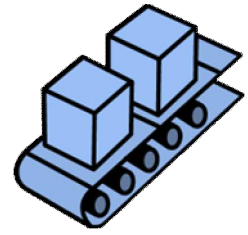
Draw your design below, and be sure to indicate the description and number of parts you plan to use.

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## Student Worksheet: Design Challenge

Brainstorm designs for your assembly line:

Team Chosen Assembly Line Design:

### ◆ Construction Phase

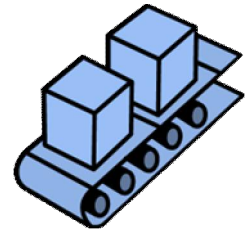
Build your assembly line. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

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## Student Worksheet (continued):

### ◆ Testing Phase

Each team will test their assembly line. If your design and process were unsuccessful, redesign and test again. Continue until you are happy with your solution. Be sure to watch the tests of the other teams and observe how their different designs worked.

### Sketch your Final Design

### ◆ Evaluation Phase

Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

1. Was the order of your assembly line tasks successful? If not, why?

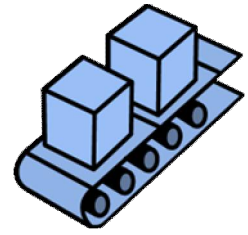
2. Did you have enough people in your assembly line to have experts in one task? If not, how would it have changed your assembly line if you had more people?

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## Student Worksheet (continued):

3. Did your group meet the quality control criteria? If not, why?

4. If you had more time or different supplies what would you add, change, or do differently?

5. Was it hard to go fast and still meet the quality control criteria? What would it take to improve?

6. Did your team work together harmoniously and efficiently?

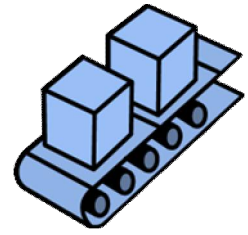
7. What are the benefits of the assembly-line method when compared to assembling a product individually?

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## For Teachers: Alignment to Curriculum Frameworks

### Science Inquiry Skills

#### Year 5

With guidance, select appropriate investigation methods to answer questions or solve problems (**ACSI S086**)

Use equipment and materials safely, identifying potential risks (**ACSI S088**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSI S091**)

#### Year 6

With guidance, select appropriate investigation methods to answer questions or solve problems. (**ACSI S103**)

Use equipment and materials safely, identifying potential risks (**ACSI S105**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSI S108**)

#### Year 7

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSI S125**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task (**ACSI S126**)

Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method (**ACSI S131**)

#### Year 8

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSI S140**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task (**ACSI S141**)

Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method (**ACSI S146**)

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## Year 9

Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSI S165)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSI S166)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSI S171)**

## Year 10

Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSI S199)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSI S200)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSI S205)**

## Science as a Human Endeavour

### Year 5

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena **(ACSHE081)**

Scientific understandings, discoveries and inventions are used to solve problems and directly affect people's lives **(ACSHE083)**

### Year 6

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena **(ACSHE098)**

Scientific understandings, discoveries and inventions are used to solve problems and directly affect people's lives **(ACSHE100)**

### Year 7

Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **(ACSHE223)**

People use understanding and skills from across the disciplines of science in their occupations **(ACSHE224)**

### Year 8

Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **(ACSHE226)**

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People use understanding and skills from across the disciplines of science in their occupations **(ACSHE227)**

### Year 9

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE158)**

Advances in science and emerging sciences and technologies can significantly affect people’s lives, including generating new career opportunities **(ACSHE161)**

### Year 10

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE192)**

Advances in science and emerging sciences and technologies can significantly affect people’s lives, including generating new career opportunities **(ACSHE195)**

Mathematics Links with Science Curriculum (Skills used in this activity)	General Capabilities	Cross-Curriculum Priorities
<ul style="list-style-type: none"> <li>Process data using simple tables</li> <li>Data analysis skills (graphs)</li> <li>Analysis of patterns and trends</li> <li>Use of metric units</li> </ul>	<ul style="list-style-type: none"> <li>Literacy</li> <li>Numeracy</li> <li>Critical and creative thinking</li> <li>Personal and social capacity</li> <li>ICT capability</li> </ul>	<ul style="list-style-type: none"> <li>Sustainability</li> </ul>

## Science Achievement Standards

### Year 5

By the end of Year 5, students classify substances according to their observable properties and behaviours. They explain everyday phenomena associated with the transfer of light. They describe the key features of our solar system. They analyse how the form of living things enables them to function in their environments. Students discuss how scientific developments have affected people’s lives and how science knowledge develops from many people’s contributions.

***Students follow instructions to pose questions for investigation, predict what might happen when variables are changed, and plan investigation methods. They use equipment in ways that are safe and improve the accuracy of their observations.*** Students construct tables and graphs to organise and identify patterns. They use patterns in their data to suggest explanations and refer to data when they report their findings. They describe ways to improve the fairness of their methods and communicate their ideas, methods and findings using a range of texts.

## Year 6

By the end of Year 6, students compare and classify different types of observable changes in materials. They analyse requirements for the transfer of electricity and describe how energy can be transformed from one form to another to generate electricity. They explain how natural events cause rapid changes to the Earth's surface. They decide and predict the effect of environmental changes on individual living things. Students explain how scientific knowledge is used in decision making and identify contributions to the development of science by people from a range of cultures.

***Students follow procedures to develop investigable questions and design investigations into simple cause-and-effect relationships. They identify variables to be changed and measured and describe potential safety risks when planning methods. They collect, organise and interpret their data, identifying where improvements to their methods or research could improve the data.*** They describe and analyse relationships in data using graphic representations and construct multi-modal texts to communicate ideas, methods and findings.

## Year 7

By the end of Year 7, students describe techniques to separate pure substances from mixtures. They represent and predict the effects of unbalanced forces, including Earth's gravity, on motion. They explain how the relative positions of the Earth, sun and moon affect phenomena on Earth. They analyse how the sustainable use of resources depends on the way they are formed and cycled through Earth systems. They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. Students describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem. They explain how the solution was viewed by, and impacted on, different groups in society.

Students identify questions that can be investigated scientifically. ***They plan fair experimental methods, identify variables to be changed and measured. They select equipment that improves fairness and accuracy and describe how they considered safety. Students draw on evidence to support their conclusions.*** They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. They communicate their ideas, methods and findings using scientific language and appropriate representations.

## Year 8

By the end of Year 8, students compare physical and chemical changes and use the particle model to explain and predict the properties and behaviours of substances. They identify different forms of energy and describe how energy transfers and transformations cause change in simple systems. They compare processes of rock formation, including the time scales involved. They analyse the relationship between structure and function at cell, organ and body system levels. Students examine the different science knowledge used in occupations. They explain how evidence has led to an improved understanding of a scientific idea and describe situations in which scientists collaborate to generate solutions to contemporary problems.

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Students identify and construct questions and problems that they can investigate scientifically. ***They consider safety and ethics when planning investigations, including designing field or experimental methods. They identify variables to be changed, measured and controlled.*** Students construct representations of their data to reveal and analyse patterns and trends, and use these when justifying their conclusions. ***They explain how modifications to methods could improve the quality of their data and apply their own scientific knowledge and investigation findings to evaluate claims made by others.*** They use appropriate language and representations to communicate science ideas, methods and findings in a range of texts types.

## Year 9

By the end of Year 9, students explain chemical processes and natural radioactivity in terms of atoms and energy transfers and describe examples of important chemical reactions. They describe models of energy transfer and apply these to explain phenomena. They explain global features and events in terms of geological processes and timescales. They analyse how biological systems function and respond to external changes with reference to interdependencies, energy transfers and flows of matter. They describe social and technological factors that have influenced scientific developments and predict how future applications of science and technology may affect people's lives.

Students design questions that can be investigated using a range of inquiry skills. ***They design methods that include the control and accurate measurement of variables and systematic collection of data and describe how they considered ethics and safety. They analyse trend in data, identify relationships between variables and reveal inconsistencies in results. They analyse their methods and the quality of their data, and explain specific actions to improve the quality of their evidence.*** They evaluate others' methods and explanations from a scientific perspective and use appropriate language and representations when communicating their findings and ideas to specific audiences.

## Year 10

By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. They explain how chemical reactions are used to produce particular products and how different factors influence the rate of reactions. They explain the concept of energy conservation and represent energy transfer and transformation within systems. They apply relationships between force, mass and acceleration to predict changes in the motions of objects. Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their view.

***Students develop questions and hypotheses and independently design and improve appropriate methods of investigation, including field work and laboratory experimentation. They explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of their data.*** When analysing

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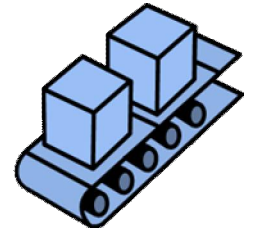
data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty. Students evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views, the quality of methodology and the evidence cited. They construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes.

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# Assembly Line



## For Teachers: Teacher Resources

### ◆ Lesson Goal

The goal of this lesson is for students to design, construct, test and redesign an assembly line process, and finally they will compare the difference between assembling a product individually versus with an assembly line.

### ◆ Lesson Objectives

During this lesson, students will:

- ✦ Assemble a product individually that meets the quality control criteria.
- ✦ Design an assembly line process to assemble a product as quickly and efficiently as possible meeting the quality control criteria.
- ✦ Construct an assembly line.
- ✦ Test and redesign the assembly line process.
- ✦ Compare the difference between assembling a product individually versus with an assembly line.

### ◆ Materials

Activity 1: Assemble one Colour Brick (per student)

- ✦ 2 brown paper bags
- ✦ 5 pieces of recycled paper (A4 size)
- ✦ 1 set of markers
- ✦ 1 black marker
- ✦ 2 cups of different sizes or other objects that can be traced to make circles (Note: could also use a compass)
- ✦ 1 ruler
- ✦ 1 copy of the Assemble One Colour Brick Worksheet
- ✦ Sample Colour Brick (only need one to show class)



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