Sort it Out!

Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson focuses on the engineering behind industrial sorting processes. Though exploring the coin manufacturing or minting process, students explore how sorting is engineered into manufacturing and packaging systems. Working as an engineering group, students then work in teams to design and build a system to sort different sized coins for packaging.

Lesson Synopsis

The Sort it Out! lesson explores how engineers have developed sorting systems which integrate into manufacturing and packaging processes. Students explore how coins are made, then work in teams to design and build a sorting system for different coin sizes or weights. They make predictions and evaluate the strategies employed and results achieved by all student "engineering" teams.

Year Levels

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

Objectives

- Learn about engineering system.
- Learn about coin manufacturing processes.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- Manufacturing engineering and planning
- problem solving
- teamwork

Lesson Activities

Students learn how coins are manufactured and explore the sorting processes engineers have developed to speed sorting and packaging processes. Student teams develop a sorting process for coins, make predictions, execute their plan, troubleshoot, and evaluate their results and those of other teams.

Resources/Materials

- Teacher Resource Document (attached)
- Student Worksheets (attached)
- Student Resource Sheet (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Wikipedia Coins (http://en.wikipedia.org/wiki/Coins)
- US Mint Virtual Tour (www.usmint.gov/mint_tours)
- International Mints:
  - Casa de Moneda de México (www.cmm.gob.mx)
  - Royal Australian Mint (www.ramint.gov.au)
  - Royal Canadian Mint (www.mint.ca)
  - Royal Mint of the United Kingdom (www.royalmint.com)
  - Monnaie de Paris (www.monnaiedeparis.com)
  - United States Mint (www.usmint.gov)
  - India Government Mint (www.igmint.org)
- Curriculum links (www.acara.edu.au)

Recommended Reading

- The History of Money (ISBN: 0609801724)
- Manufacturing, Engineering & Technology (ISBN: 0131489658)

Optional Writing Activity

- Write an essay or a paragraph about the engineering impact when a country decides to change the appearance or material content of a piece of coin currency.
- Write an essay about how engineers incorporate anti-counterfeiting systems into the manufacture of coins.

For Teachers:
Teacher Resource

◆ Lesson Goal

Lesson focuses on the engineering behind industrial sorting processes. Though exploring the coin manufacturing or minting process, students explore how sorting is engineered into manufacturing and packaging systems. Working as an engineering group, students then work in teams to design and build a system to sort different sized coins for packaging.

◆ Lesson Objectives

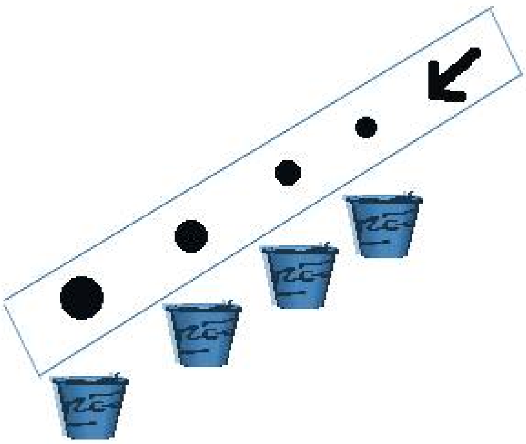
- Learn about engineering system.
- Learn about coin manufacturing processes.
- Learn about teamwork and working in groups.

◆ Materials

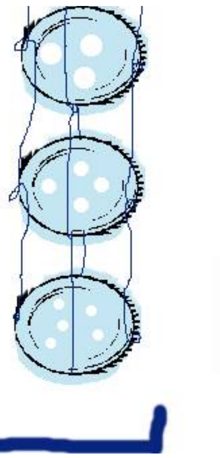
- Student Resource Sheet
- Student Worksheets
- Bag of coins of different sizes
- One set of materials for each group of students:
  - Glue, tape, paper or plastic plates, cardboard, scissors or hole punch, wood (optional), foil, paper, cardboard tubes
  - One sample of each coin to be sorted (teacher will test each system with a bag of mixed coins)
  - Collection device (paper cup, small box, plastic bag, paper bag)

◆ Tips

There are many ways to sort the coins. It's best to let the students come up with their own solutions which will also expose them to the processes of negotiation and teamwork -- all of which are part of the everyday life of an engineer.



A ramp may be used with holes just a big larger than each coin cut into a cardboard or wood base -- the smaller holes are at the top so that the smaller coins are sorted out first. In this method, the angle of the ramp will determine if the coins move down at a slow enough speed to be caught in the holes (too close to vertical will cause the coins to move too fast to be caught in the holes; too horizontal a slope will cause the coins to get caught and not move down).



◆ Tips (continued)

Another method is using gravity by setting up a series of hanging plastic or paper plates, precut with holes for coins to fall through. In this system the larger coin holes will be in the top plates, with the smallest at the bottom. By shaking gently, or angling the plates so the coins fall from one to the next, the coins will sort themselves through.

◆ Procedure

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework. If possible, provide students time to visit the websites of various mints worldwide.
2. Divide students into groups of 2-3 student "engineers," providing a set of materials per group.
3. Explain that students must develop a system for sorting coins, just as engineers develop sorting systems for manufacturing and packaging facilities.
4. Students meet, review provided materials and coin samples, and develop a plan for their system. They agree on materials they will need, write or draw their plan, and then present their plan to the class.
5. Student groups next execute their plans. They may need to rethink their plan, add materials, or start over.
6. The teacher or "engineering manager" will move from system to system and test the sorting "machine" using a bag with 10 of each coin.
7. Teams record how many coins are correctly sorted into separate containers (boxes, bags, cups).
8. Each student group evaluates the results, completes an evaluation/reflection worksheet, and presents their findings to the class.

◆ Time Needed
Two to three 45 minute sessions

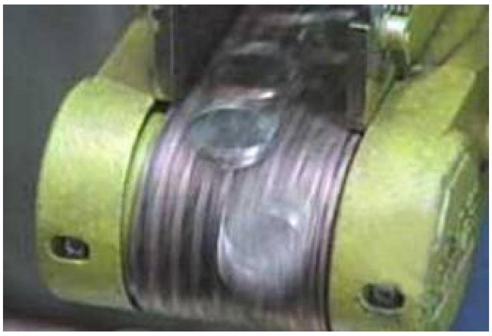
Sort it Out!

Student Resource:
Minting and Sorting Processes

◆ Separate and Sort

Various sorting tasks are essential in industrial processes. For example, during the extraction of gold from ore, a device called a shaker table uses gravity, vibration, and flow to separate gold from lighter materials in the ore (sorting by size and weight).

◆ Minting



A mint is a facility which manufactures coins for currency. In the beginning, hammered coinage or cast coinage were the only choices. In more modern mints, coin dies are manufactured in large numbers and planchets are made into coins by the billions.

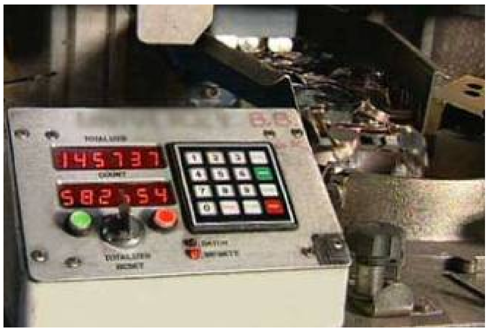
Each city-state in ancient Greece had its own mint. Roman mints were spread far and wide across the empire, and used extensively for propaganda purposes. One way people knew there was a new emperor was when he minted coins with his (or her) portrait on it. Many of the emperors that ruled only for a very short time made sure that they got their portrait on some coins. Quietus, for example, ruled only part of the empire from 260–261 AD, yet he issued several coins bearing his image.

◆ Did you Know?

- In a given year, the United States Mint produces between 14 and 28 billion circulating coins. As of 2004, 65 to 80 million coins are minted each day.
- Since opening in 1965 the Australian Mint has produced over eleven billion circulating coins and has the capacity to produce over two million coins per day, or over six hundred million coins per year.
- In the United Kingdom, the Royal Mint's latest presses can each strike more than 700 coins per minute, making it impossible for the human eye to separate the individual pieces as they pass through the press.
- The Winnipeg Mint is the powerhouse of Canada's high-volume coin production. Here, technologically advanced processes and equipment produce up to 15 million plated coins each day for Canadian and foreign circulation.

◆ Manufacturing Steps

- Most coin production starts with the arrival of coils -- rolled-up strips of flat metal. Coils are about a foot wide, 450 metres long, and about as thick as the final coin thickness. Each coil weighs close to 2700 kg.
- After cutting a batch of blanks, the remaining metal (webbing), is chopped off and collected in a bin. By recycling the webbing to make new coinage strip, we ensure material is not wasted.
- Each row of stamping presses usually run the same coin denomination with the press force adjusted to the strength of the metal. Sensors are able to screen and detect flawed coins. The planchet's size, hardness, design intricacy, and relief determine the force needed to strike. In the U.S. system, Golden Dollar coins require the greatest force, and pennies require the least force.
- If an error in weight or design is identified by engineered quality control system, they are sorted from the good coins and sent to coin destruction machines called wafflers. These machines use two high-pressure rollers to impress a ridged pattern into the metal. Distorted and mutilated, the metal loses denomination value. However, it is recycled for future use.
- If the coins pass inspection, the operator pulls the trap’s lever. This discharges the coins onto a conveyor belt that transports them to the counting and bagging area.
- An automatic counting machine, fitted with a sensor that detects correct products, counts the coins and drops them into large bags. The filled coin bags are weighed on a scale to make sure the contents are properly packed.
- The bags are sealed shut, loaded onto pallets, and taken by forklifts to the vaults for storage, where they remain in inventory until needed in circulation.



Sort it Out!

Student Worksheet: You Are the Engineer!

You are a team of engineers working in a mint who have been given the challenge of developing a sorting system for different coins manufactured at your facility.

◆ Research/Preparation Phase

1. Review the various Student Reference Sheets, and if possible visit the websites of various mints.

◆ Planning as a Team

2. Your team has been provided with some "building materials" by your teacher. You have glue, tape, paper or plastic plates, cardboard, scissors or hole punch, foil, paper, cardboard tubes, one sample of each coin to be sorted, and a collection device (paper cup, small box, plastic bag, paper bag).

3. Start by meeting with your team and devising a plan to build your structure. You'll need to figure out which materials you want to use (you don't need them all!)

4. Draw your sorting mechanism plan in the box below:

Predict the % of coins you think will be sorted properly based on your design: ___ %

Sort it Out!

Student Worksheet: Evaluation

◆ Construction Phase

5. Build your sorting mechanism, and test using the sample coins you were provided.

◆ Testing Phase

6. Your teacher will test your system using a bag of coins. Your job is to explain how the system works so that your teacher is clear about how and where to put the mixed coins.

◆ Evaluation Phase

7. Evaluate your teams' results, complete the questions below, and present your findings to the class.

Did you succeed in creating a system that successfully sorted some coins? If not, why did it fail?

What percentage of the test coins were properly sorted? How did this compare with your prediction? What do you think caused any difference?

What percentage of error do you think is acceptable for real coin minting facilities?

What percentage of error do you think is acceptable for medicine manufacturing firms? What are the safety issues to consider here?

What percentage of error do you think is acceptable for nail manufacturers?

Did you need to redesign your system in the construction phase? What was missing from your original drawn design?

If you had to do it all over again, how would your planned system change? Why?

Do you think that engineers have to adapt their original plans during the manufacturing process? Why might they?

What designs or methods did you see other teams try that you thought worked well?

Did you find that there were many designs in your classroom that met the project goal? What does this tell you about engineering systems in the real world?

Do you think you would have been able to complete this project easier if you were working alone? Explain…

Sort it Out!

For Teachers:
Alignment to Curriculum Frameworks

Science Inquiry Skills
Year 5

With guidance, select appropriate investigation methods to answer questions or solve problems (**ACSIS086**)

Use equipment and materials safely, identifying potential risks (**ACSIS088**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSIS091**)

Year 6

With guidance, select appropriate investigation methods to answer questions or solve problems. (**ACSIS103**)

Use equipment and materials safely, identifying potential risks (**ACSIS105**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSIS108**)

Year 7

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSIS125**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSIS126)**

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 **(ACSIS131)**

Year 8

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSIS140**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSIS141)**

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 **(ACSIS146)**

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 **(ACSIS165)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS166)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS171)**

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 **(ACSIS199)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS200)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS205)**

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)**

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
• Process data using simple tables • Data analysis skills (graphs) • Analysis of patterns and trends • Use of metric units	• Literacy • Numeracy • Critical and creative thinking • Personal and social capacity • ICT capability	• Sustainability

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.

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 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.