# Packaging Designer
## Lesson 2: Designing the Packaging

### Australian Curriculum: Mathematics (Years 8 -10)

ACMMG195: Choose appropriate units of measurement for area and volume and convert from one unit to another. (Year 8)
ACMMG197: Investigate the relationship between features of circles such as circumference, area, radius and diameter. Use formulas to solve problems involving circumference and area. (Year 8)
ACMMG217: Calculate the surface area and volume of cylinders and solve related problems. (Year 9)
ACMMG222: Investigate Pythagoras' Theorem and its application to solving simple problems involving right angled triangles. (Year 9)
ACMMG224: Apply trigonometry to solve right-angled triangle problems. (Year 9)
ACMNA234: Substitute values into formulas to determine an unknown. (Year 10)

### Lesson abstract

Students develop their packaging design. They consider how mathematics is useful in this task, and see the role of mathematical modelling in designing. They begin to prepare a report in which they communicate their work clearly. They reflect on the modelling and design cycles and consider how mathematics can affect design work.

### Mathematical purpose (for students)

Mathematical modelling is often an important part of designing.

### Mathematical purpose (for teachers)

Students gain practical experience of working on a design problem that has mathematical constraints and requires making assumptions and simplifications. They see the role of mathematics in planning and describing a design (e.g. the dimensions), in quantifying real world criteria (e.g. efficiency) and in testing out ideas. They reflect on how each phase of the mathematical modelling cycle has been involved, from formulating (e.g. treating curvy bottles as cylinders) to evaluating (e.g. comparing efficiencies of different designs). They appreciate that decisions made during design and mathematical modelling processes may need to be refined as they work on the problem.

Lesson Length 50 minutes approximately

Vocabulary Encountered

Lesson Materials

- Slide show: ST7_Packaging_2a.pptx
- Student Sheet 1 - The Design Report (one per student)

We value your feedback after these lessons via https://www.surveymonkey.com/r/J8GPD7Z

***Mathematics by Inquiry*** is an initiative of, and funded by, the Australian Government Department of Education and Training

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## Lesson structure

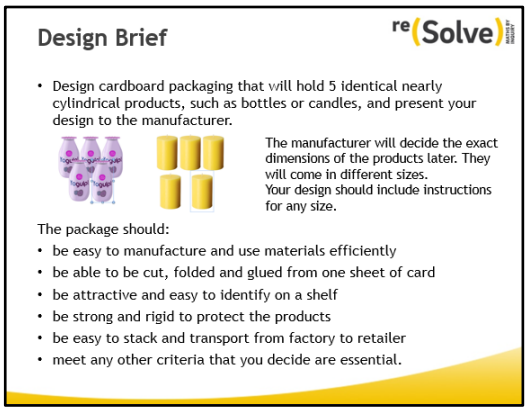
- Whole-class discussion: Introduction (about 5 minutes)
- Collaborative small-group work: Developing the design (about 20 minutes)
- Collaborative small-group work: Drafting the report (about 15 minutes)
- Whole class discussion: Design issues and reflection (10 minutes)

# Review Design Brief and Report

Provide each pair of students with a copy of Student Sheet 1 - The Design Report, which gives the design brief and detailed information about the report.

Show slides Design brief and Design Report, and look at the handout with students, so that they are clear on what to do. The handout has more details than the slides.

Suggest that to help with writing the report students should make a note of their thinking as they go along.

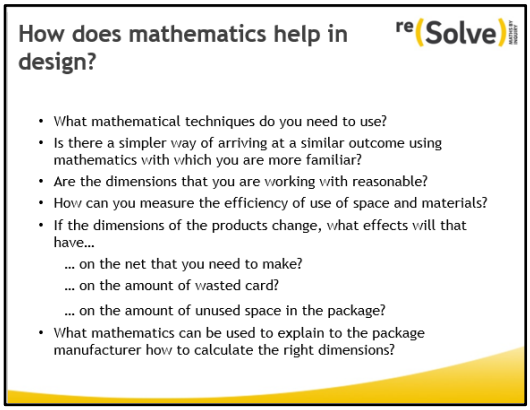


# Developing Your Design

Students now spend time developing their designs, working in the same pairs as in the previous lesson. Monitor students as they work.

Enabling prompts

- Provide students with five identical cylindrical products to test ideas (circular objects such as coins may be sufficient).
- Suggest they think about a design that they can adapt.
- Work with specific dimensions, and later adapt the design to general dimensions.




### Highlighting mathematics

At a convenient point, bring the class together and show the slide How does mathematics help in design which gives some ideas about what mathematics students should think about whilst working.

There are opportunities for students to use a lot of mathematical knowledge here, if they are able. However, the important aspect is that mathematics has to be used in the service of the real world problem, taking real world constraints seriously

As well as using mathematics to give instructions for making packages of different sizes, students can also think about good mathematical measures that can help them to quantify and compare efficiencies. For example, they might use the percentage of area of card that it wasted to decide between designs through a measure of

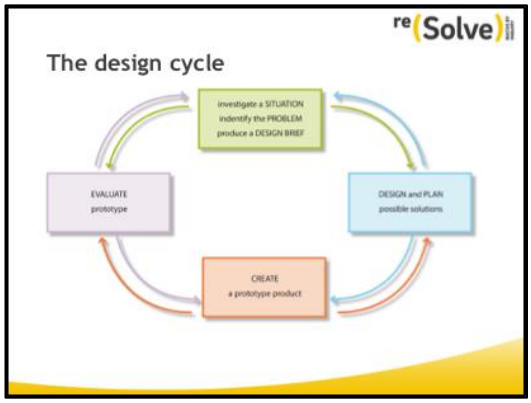
efficiency, or the volume of unused space within the package, or unused space in cartons used for transportation. Designing ways to quantify real world criteria is an important part of mathematical modelling.

### Preparing the report

Once students have settled on a design, ask them to begin drafting their reports. Remind students they will have other lessons to work on their reports, so they need not rush to finish them now.

# Design Cycle and Mathematical Modelling

The purpose of this whole class discussion is to draw out the role of mathematics in design processes. Students might also comment on the similarities and differences between the processes of design and modelling, both of which the students have been involved with in this unit.




## Design Cycle

Show slide The design cycle.

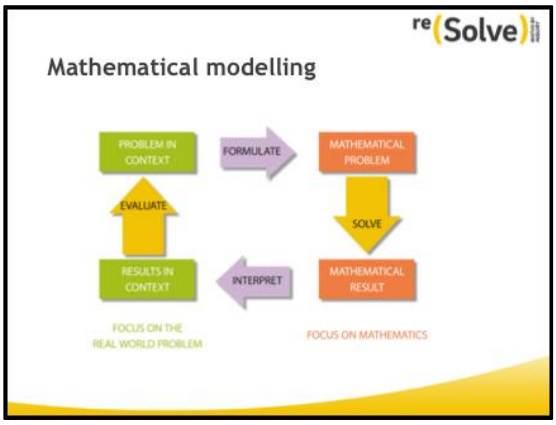
Review some of your previous discussion about the design cycle

Ask students

- Where do you think we are now?
- Which parts of the cycle do we still need to do?
- Will we leave out any parts of the cycle?

This sort of meta-level thinking will help students find the language they need when they discuss what they have done and the choices they have made.

## Mathematical Modelling




Ask students to describe how they are using mathematics in their design work. It is likely that they will suggest:

- Working out the dimensions to cut the card for particular dimensions of a product,
- Working out the dimensions to cut the card for any size of product,
- Writing a formula for sizes to give to manufacturer,
- Checking how efficient a design is, and possibly comparing.

Summarise this discussion by pointing out that mathematics is useful especially in the 'design and plan' phase of the design cycle:

- to make detailed plans, with accurate dimensions, angles etc
- to test ideas (e.g. to see if shapes will fit together)
- to measure efficiency etc.

Show slide Mathematical modelling.

Remind students of the four main phases of mathematical modelling. Brainstorm with the class the mathematical modelling actions that have been undertaken at each stage. Each group will have been working on a somewhat different problem.

### Expected Student Responses

- Formulation:
  - Treating a candle or a bottle as a cylinder, so ignoring variation in radius along the height.
  - Specifying a suitable geometric shape for the container.

    - Deciding how to measure amount of card wasted (e.g. as a percentage of the area), or the amount of unused space in the container or in carton for transportation.
- Solving:
    - A variety of methods will have been used from simple (e.g. drawing around circular objects and measuring) to complex (using trigonometry, algebra.)
- Interpreting
    - Writing clear instructions of how to scale measurements up or down for different dimensions.
- Evaluating –
    - Comparing efficiencies of various designs
    - Thinking about the practical aspects of the mathematical solution – is it sufficiently attractive, convenient, secure, efficient, etc.

## Design and Mathematical Modelling

Ask students, "In which ways are the processes of mathematical modelling similar and different to those we engage in when we design?" Some points that students may make include:

- In both there is a cycle of developing ideas, then trying to improve them.
- Just as in the design cycle, in modelling you must work towards a solution by thinking about what is feasible and what can be varied to reach a satisfactory outcome.
- For both, there is often a back-and-forth nature between phases in the cycle.
- Both take the real world considerations seriously.
- Both involve making assumptions, especially at the start.
- Mathematical modelling can be an important part of a design process.
- Mathematics is a good language to describe general features of designs.

# The Design Report

Name: _____

## Design brief

You need to create a design for a package to hold five identical (nearly) cylindrical products, such as bottles or candles. You can choose your own product and design a good package for that type of product.

The manufacturer is not yet sure about the exact size of the products. Your design must include instructions so the manufacturer can make the right package for any size in the product range.

The package should:

- be easy to manufacture and use materials efficiently
- be able to be cut, folded and glued from one sheet of card
- be attractive and easy to identify on a shelf
- be convenient for the customer
- be strong and rigid to protect the products
- be easy to stack on shelves, and easy to transport from factory to retailer
- meet any other criteria that you decide are essential.

## Design report

Your report should:

- Describe the products being packaged (e.g. ripple sided candles for a meditation retreat).
- Give a clear description of the container.
  - Show what the package will look like for products of different shapes in your product range (e.g. short fat or tall thin bottles).
- Show clearly how your design meets the brief. Highlight its good features.
- Explain how to make the container (instructions and drawings).
  - Show how the container is cut and folded from a single sheet of card.
  - Explain how to calculate the dimensions of the container once the size of the product is known.
- Explain how the containers will stack for transportation and go on shelves.
- Discuss the efficiency of the design e.g. show how much card is wasted, and how much space is wasted when many containers are packed in large cartons for shipping.

In writing the report, be sure to explain and justify the design choices you made. Show how you arrived at your decisions, perhaps explaining why you rejected other possibilities.

## Assessment Criteria

- Does the packaging meet the design brief?
- Are there good instructions for making the packages for products of various sizes?
- Does the report explain how and why design decisions were made?
- Have aspects such as ease of transport and reducing wastage been considered and quantified?

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