



Dissecting Geometry

Creative Learning
2024 Teacher Resources



Dissecting Geometry

Notes for Teachers

Dissecting Geometry is part of a series of workshops that use the site and building of the Sydney Opera House as a catalyst for learning about science, technology, engineering, arts, architecture and maths - transforming the way we understand STEM subjects and ideas through the creative and performing arts.

The workshops can be delivered alongside a tour of the House exploring First Nations perspectives, the architectural practice of Jorn Utzon and his collaborators, as well as the contemporary uses of the site as a world-class performing arts venue

The following Creative Learning Notes contain video links and suggested activities to build on an excursion to Dissecting Geometry in the Centre for Creativity.

We recommend using this resource as a starting point, to adapt content in a way that suits the learning needs of your students.

Dissecting Geometry

Workshop Overview

Students develop a series of drawings through observing the structure of the building, and work with archival photographs and objects to dissect the mathematical patterns, additive and pre-fabricated elements of the building to create new or alternative versions of the Opera House. From here, students will use installation and sculptural processes to enlarge, distort, emphasise and recreate aspects of the building from different perspectives.



Dissecting Geometry

In this workshop, students will:

- create a series of observational sketches, collaborative three-dimensional drawings and small sculptural models that replicate the geometry of the Sydney Opera House
- work with peers to distort and abstract patterns and structures of the Opera House to create new imagined versions of the Opera House and surrounding buildings
- develop an understanding of the Utzon Design Principles, in particular Utzon's use of additive architecture, counterbalance, sculpture and form
- interrogate historic and contemporary maps, photographs, drawings and models of the Sydney Opera House and consider how architects, engineers and builders collaborated and problem solved to create the building seen today



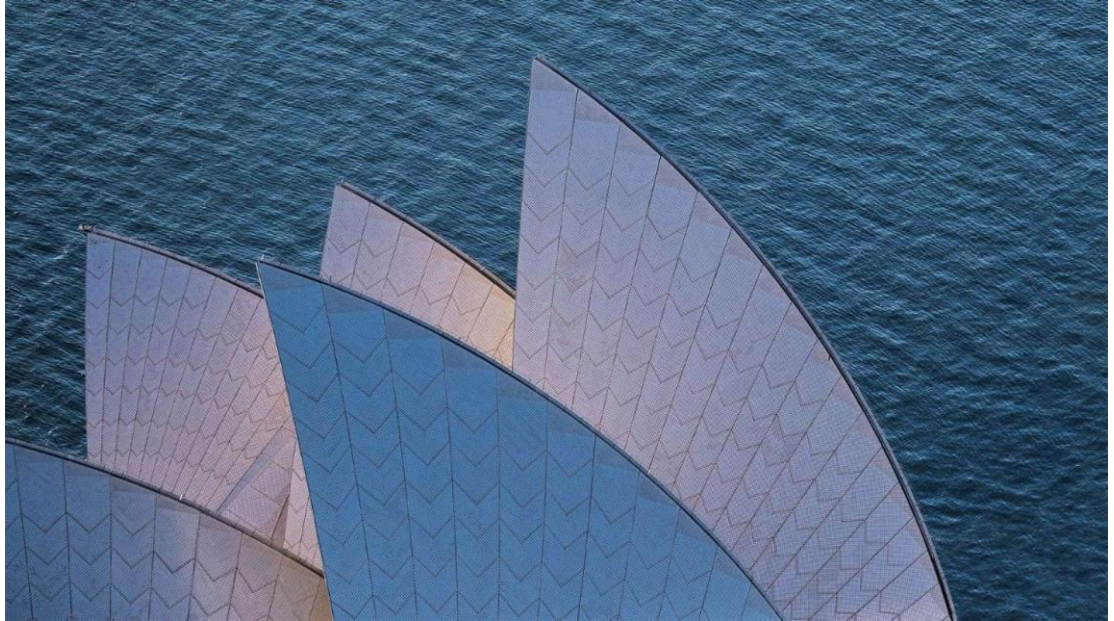
The Spherical Solution



The Sydney Opera House was designed for performing arts and cultural experiences

The Opera House is a World Heritage-listed masterpiece of 'human creative genius' that belongs to all Australians.

It is the Country's number one tourist destination and its busiest performing arts centre, welcoming more than 10.9 million visitors a year on site and hosting more than 1,800 performances attended by more than 1.4 million people.

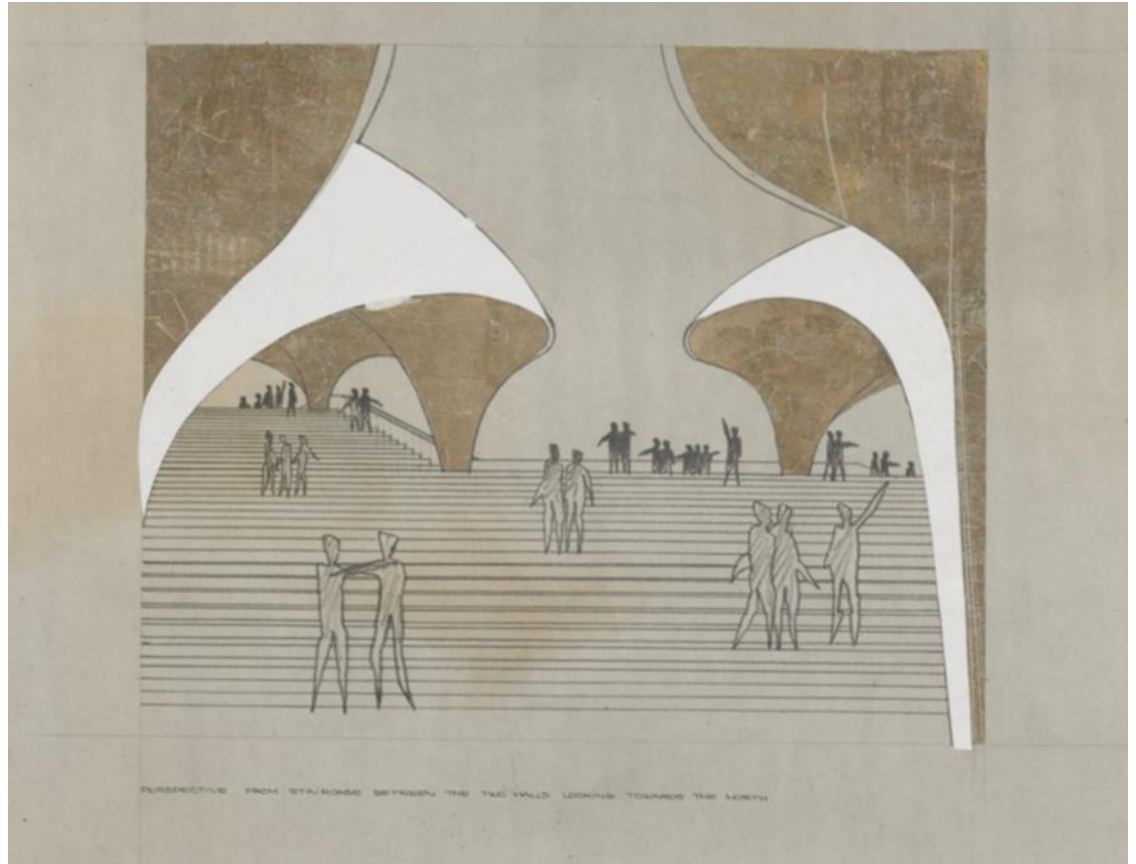


Jørn Utzon is a Danish architect who designed the Opera House

His design was received in 1957, there were 223 entries from 28 countries.

Utzon was announced the winner, receiving £5000 for his design. His drawing presented an idea in a unique and unconventional way, and used gold leaf, pencil and white paper.

The Opera House was completed and opened in October 1973.



The Spherical Solution is the name of the mathematical and engineering principle used to help build the roof of the Opera House

To work out how to build the shells, the engineers at Arup & Partners needed to express the shell shapes mathematically. Asked by the engineers in 1958 to define the curves of the roof, Utzon took a plastic ruler, bent it against a table and simply traced the curves.

A sphere has a single, constant form which can be simply and easily repeated, which are the 'sail' or 'shell' shapes of the final roof design.

This drawing by Jorn Utzon shows the thinking behind the development of how this design solution was created.

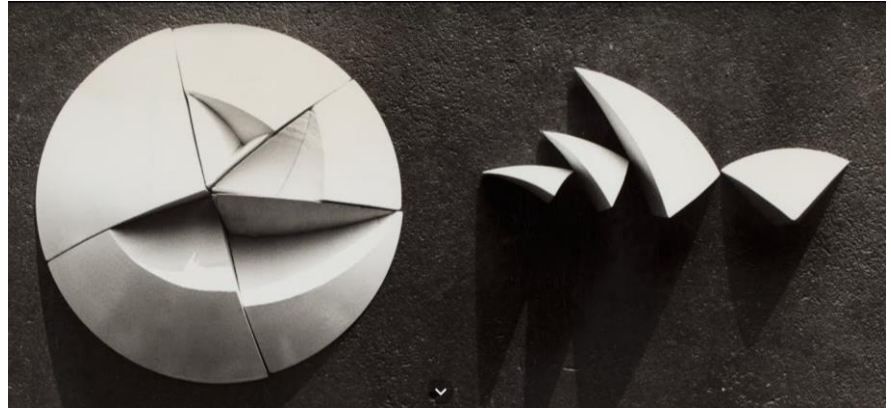


The Spherical Solution as a three-dimensional model

This is where the popular myths comes from – that Utzon was inspired to use a sphere when he had a eureka moment while peeling an orange – it perfectly described the thin shell structure of the roof.

By finding the parts of a sphere that best suited the existing shapes of the shells, each new form could be extracted.

Learn more about the [types of physical and digital models created for the Sydney Opera House](#) here.



The tiles of the Sydney Opera House

Utzon wanted the shells to contrast with the deep blue of Sydney Harbour and the clear blue of the Australian sky. The tiles needed to be gloss but not be so mirror-like to cause glare. Utzon was inspired by Japanese ceramic bowls which were slightly coarse and had a granular texture in the clay.

Three years of work by Höganäs of Sweden produced the effect Utzon wanted – 120mm square, made from clay and crushed stone.

Tiles were placed face down in one of 26 chevron shaped beds each with a base shaped to match the curve of the roof. In total, there are 1,056,006 tiles on the roof.

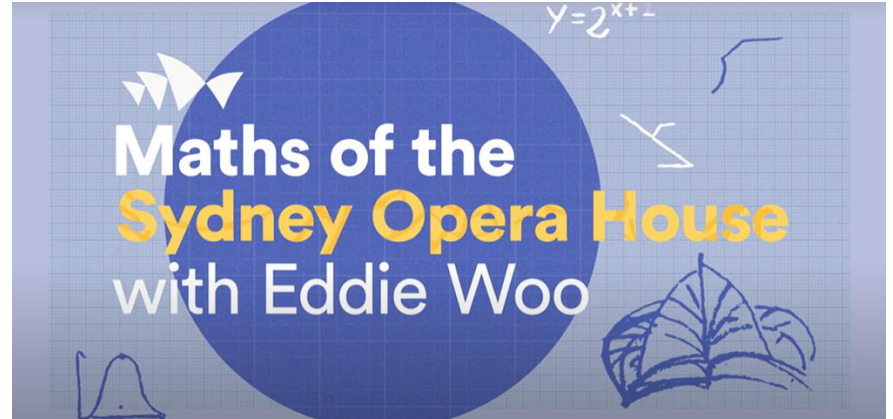


The Purity of Geometry

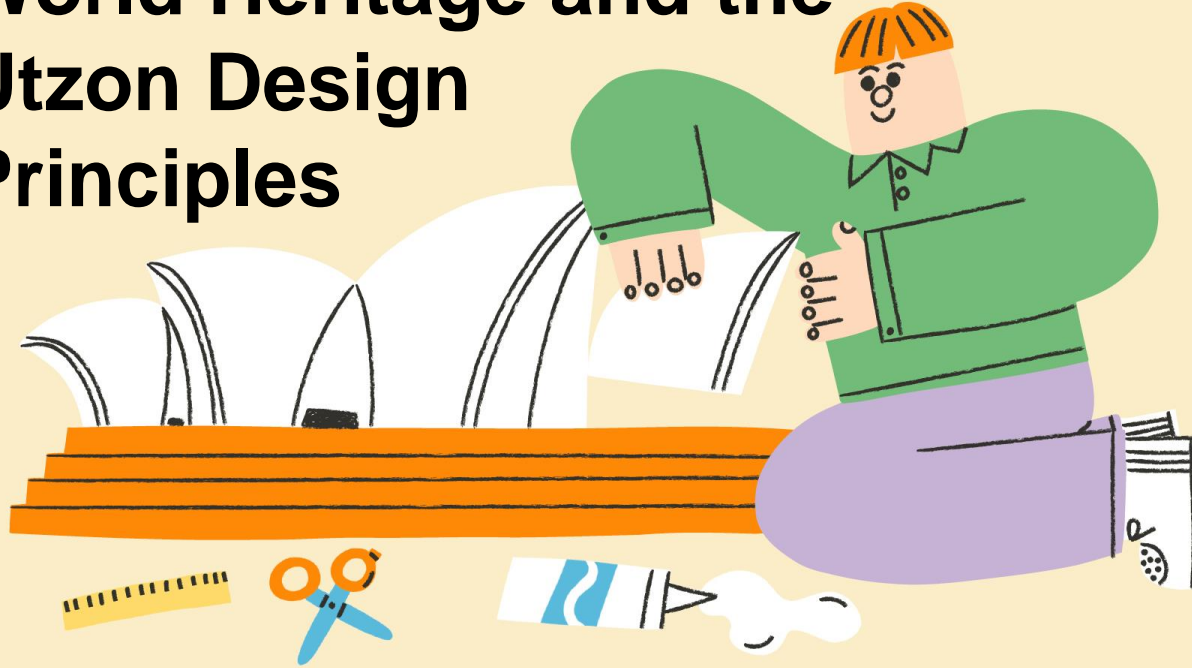
There are many mathematical concepts behind the construction and design solutions of building the Sydney Opera House, such as algebra, geometry and infinite numbers.

In the classroom

[Watch this video](#) with Maths teacher Eddie Woo to find out how geometry and Utzon's 'Spherical Solution' resolved the construction dilemma that the unique design of the arched sails caused with Eddie Woo and Peter Mould, former NSW Government Architect.



World Heritage and the Utzon Design Principles

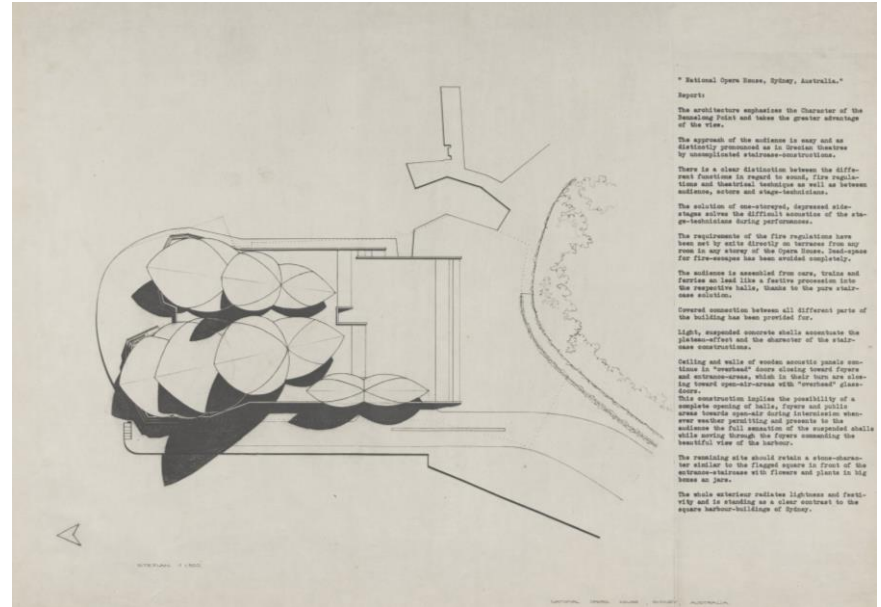


The Utzon Design Principles

Overview

It had a fantastic site, with a beautiful and demanding position on Bennelong Point...I was convinced that a new building in such a position as to be seen from all sides, had to be a large sculptural building. (Jorn Utzon)

The *Utzon Design Principles* form a document prepared by architects Jørn Utzon and Richard Johnson outlining Utzon's vision for the Sydney Opera House, its setting and his comments on its future. It is the first critical step in the process of establishing a reference point for the conservation of the building.



Vision, design and conservation

Sydney Opera House Utzon design principles

Utzon was inspired by organic shapes, nature's colours especially at sunrise and sunset, naval charts and headlands, reflection of sunlight, clouds and birds wings.

Utzon was also interested in how inspiration from nature connected with an experience of the building for the people who visit. Things like bringing joy, feeling like you're in another world, being in a festive mood, feeling detached from the city and how to also create moments of rest.



2



3



4

- In small groups, research one of the Utzon Design Principles and present your findings to the class.
- Identify in images and on maps of the Opera House where you might find these Design Principles expressed on the building itself
- Analyse a building in your local area. In what ways does that building relate to Utzon's key design ideas?

The Utzon Design Principles

Prototypes and prefabrication

Building the Opera House was incredibly difficult. Using expertise from design, engineering and computer science, Utzon's plans were able to come to life. Following a long process of trial and error, Utzon and his team problem-solved the design with many sketches, models and prototypes.

The Opera House even commenced building when the working drawings had not yet been completed or finalised. Once builders and engineers were happy with the prototype, a mould or blueprint of the final sections could be made replicated. From this, all the required pieces could be produced and pre-made (or prefabricated) quickly and easily.



World Heritage

Valuing an icon

Sydney Opera House stands by itself as one of the indisputable masterpieces of human creativity, not only in the 20th century but in the history of humankind (International Council Report on Monuments and Sites to the World Heritage Committee).

On 28 June 2007 the Sydney Opera House was included on the UNESCO World Heritage List under the World Heritage Convention, placing it alongside the Taj Mahal, the ancient Pyramids of Egypt and the Great Wall of China as one of the most outstanding places on Earth.

According to UNESCO, the Sydney Opera House is a great architectural work of the 20th century that brings together multiple strands of creativity and innovation in both architectural form and structural design. “Its significance is based on its unparalleled design and construction,” UNESCO stated. “It is a daring and visionary experiment that has had an enduring influence on the emergent architecture of the late 20th century

The design represents an extraordinary interpretation and response to the setting in Sydney Harbour. The Sydney Opera House is also of outstanding universal value for its achievements in structural engineering and building technology. The building is a great artistic monument and an icon, accessible to society at large.”

Curriculum connections and further research



Curriculum Links

Connecting with the classroom

Mathematics

- MA4-3WM recognises and explains mathematical relationships using reasoning
- MA4-1WM communicates and connects mathematical ideas using appropriate terminology, diagrams and symbols
- MA5.1-1WM uses appropriate terminology, diagrams and symbols in mathematical contexts
- MA4-7NA operates with ratios and rates, and explores their graphical representation
- MA4-11NA creates and displays number patterns; graphs and analyses linear relationships; and performs transformations on the Cartesian plane
- MA5.1-7NA graphs simple non-linear relationships
- MA4-12MG calculates the perimeters of plane shapes and the circumferences of circles
- MA5.1-8MG calculates the areas of composite shapes, and the surface areas of rectangular and triangular prisms

English

- EN4-9E uses, reflects on and assesses their individual and collaborative skills for learning

Design and Technology

- DT4.4 describes the work and responsibilities of designers and the factors affecting their work

Curriculum Links

Connecting with the classroom

Visual Arts

- VAES3.1 Investigates subject matter in an attempt to represent likenesses of things in the world
- VAES3.4 Communicates about the ways in which subject matter is represented in artworks
- 4.6 selects different materials and techniques to make artworks
- 4.9 begins to acknowledge that art can be interpreted from different points of view
- 5.4 investigates the world as a source of ideas, concepts and subject matter in the visual arts

Resources

More about the Sydney Opera House

Sydney Opera House: Our Story

- <https://www.sydneyoperahouse.com/our-story>

How we work – strategic plans and programs

- <https://www.sydneyoperahouse.com/about-us/how-we-work>

Community projects

- <https://www.sydneyoperahouse.com/about-us/in-the-community>

Careers and opportunities

- <https://www.sydneyoperahouse.com/about-us/careers-and-other-opportunities>

Creative Learning resources

- <https://www.sydneyoperahouse.com/learn/teachers-and-students/classroom-resources>

50th Anniversary Celebrations

- <https://www.sydneyoperahouse.com/50>

Get in touch

Got questions? Contact us with any enquiries about our education programs for schools via phone or email.

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