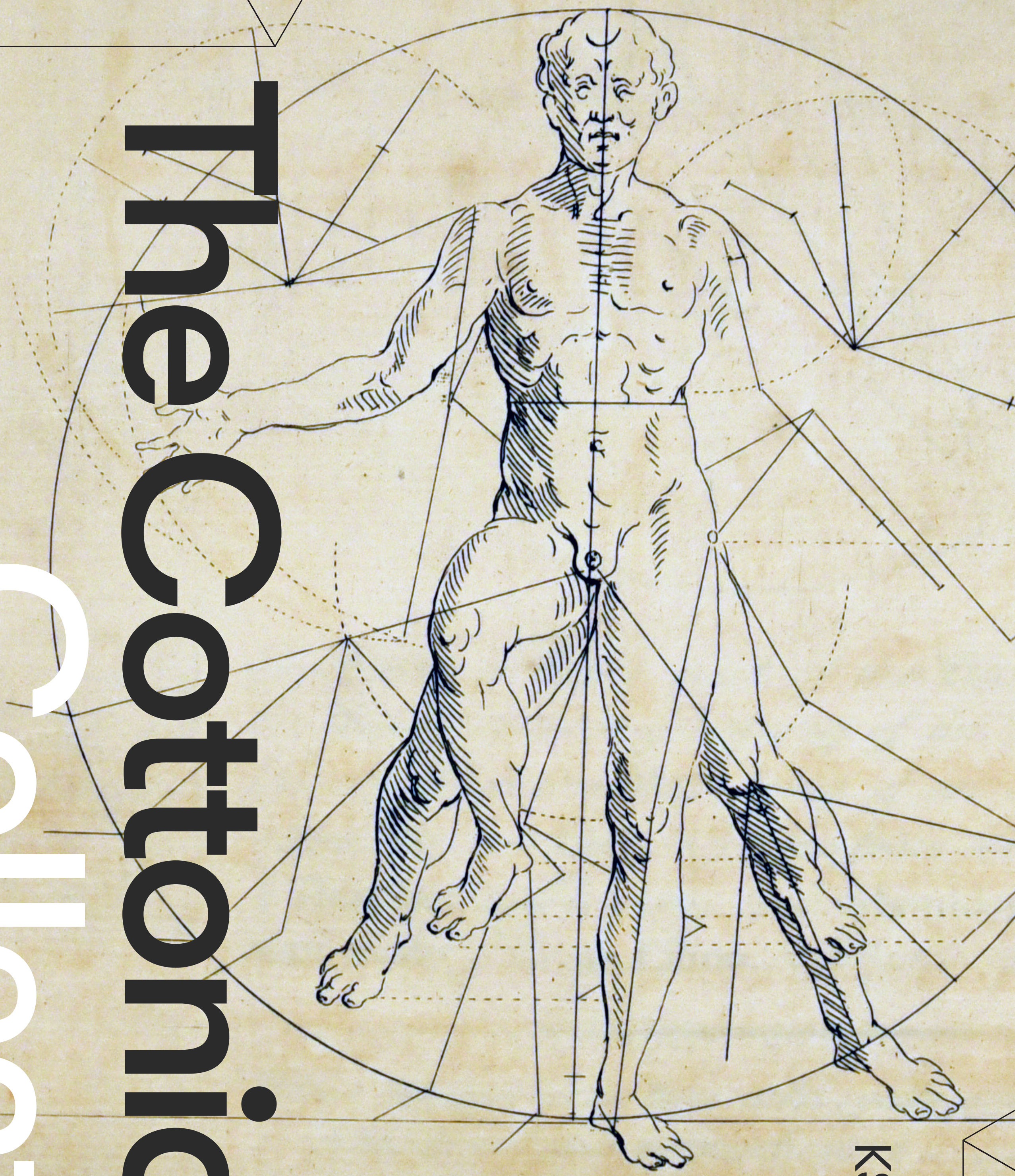
The Cottonian Collection

KS2/3 STEAM Resource



THE BOX
Museum
Gallery
Archive

The Box is Plymouth's new multi-million pound museum, gallery and archive. With brand new exhibition spaces alongside state-of-the-art facilities for research and learning, it's the perfect place to teach, inspire and engage students of all ages.

Contents

About this resource

This resource explores The Box, Plymouth's Cottonian Collection - a Designated Collection of national importance – with a particular focus on the historic book collection. It provides examples of books relating to STEAM subjects, and offers activity ideas for the classroom.

The Government believes that if we want the UK to remain a world leader in research and technology we will need a future generation that is passionate about, and skilled in, Science, Technology, Engineering and Maths (STEM).

The 2013 'Supporting the Creative Economy' report also set out that they believe in the crucial role of arts subjects in a modern education and that arts subjects should be added to STEM subjects, changing STEM to STEAM.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What is the Cottonian Collection?

The Cottonian Collection should be considered Plymouth's greatest gift. It is Plymouth's only Designated Collection, a scheme that is a mark of distinction, identifying and celebrating pre-eminent collections of national and international importance in non-national institutions.

The Cottonian Collection was formed within what is known as the 'Age of Enlightenment' - a European intellectual movement of the 17th and 18th centuries - a period which saw an explosion of public discussion with the establishment of libraries, book clubs, coffee houses and fine art and antiquarian societies.

Enlightenment thinkers in Britain, France and throughout Europe questioned traditional authority and embraced the notion that humanity could be improved through rational change. Central to Enlightenment thought were the use and celebration of reason, the power by which humans understand the universe and improve their own condition. The goals of rational humanity were considered to be knowledge, freedom, and happiness.

The collection encompasses a 2000 volume book library, several thousand prints, Old Master drawings, oil paintings, works by celebrated artist Sir Joshua Reynolds, ceramics, bronzes and plaster sculptures.

The 2000 or more volumes in the Cottonian Collection are divided approximately into a third contemporary religion and philosophy, and two thirds arts and historical books. It is also particularly rich in travel books, with a distinct focus on the ancient world and lands newly discovered in the Pacific and Americas.

In the spirit of the Enlightenment values of knowledge, freedom and happiness, the Cottonian Collection was bequeathed to Plymouth by William Cotton III in 1863 '***...for the purposes of amusement and instruction by the inhabitants of the towns of Plymouth, Stonehouse and Devonport and their vicinity...***'

The Cottonian Collectors

Robert Townson (1640 - 1707)
The Cottonian Collection owes its origins to Robert Townson. Robert was employed at the London Custom House as the 'Chief Clerk of Certificates Inwards'. Robert began collecting books and some prints in the mid-seventeenth century. A large proportion of his purchases were hymn and prayer books. However, he was also interested in the geographic, scientific and philosophical discoveries of the day and the writings of prominent Enlightenment thinkers such as John Locke and Francis Bacon, whose writings can be found in the collection.

William Townson (1682 – 1740)
William Townson inherited the collection and position as 'Chief Clerk of Certificates Inwards' from his father. William was a keen collector and he began to build up the prints and drawings that can be found in the collection, although it is not known precisely which works can be attributed to him. Whilst visiting the auction rooms of London, it is believed that he met and befriended a young man called Charles Rogers. Rogers and Townson became good friends and it is likely that Townson helped Rogers to hone his connoisseurship skills.

Charles Rogers (1711 – 1784)
Rogers inherited the collection from his friend in 1741. Under his direction, the collection grew to an impressive size and by the time of his death in 1784 it contained over 8000 prints, nearly 5000 books and over 2000 drawings. Rogers was well-known in the London art world for his connoisseurship and his knowledge of the Italian Old Masters. Indeed, the Cottonian under Rogers contained drawings and prints by Michelangelo, Leonardo Da Vinci and Raphael.

Rogers was also a keen book collector and amassed books on everything from Ancient Roman and Greek antiquities, the fine arts, Latin and Greek Classics, Geography and titles by English authors such as William Shakespeare, Edmund Spenser and John Milton.

Although predominantly interested in the fine arts, Rogers' purchases reveal him to have been an intelligent, well-educated and well-read gentleman.

William Cotton I (1731 – 1791)
Rogers left the collection to his brother-in-law, William Cotton I. It is believed that Cotton I made few, if any, alterations to the collection. It is likely that when Cotton II inherited the collection in 1791, it was exactly as Rogers had left it on his death some thirteen years earlier.

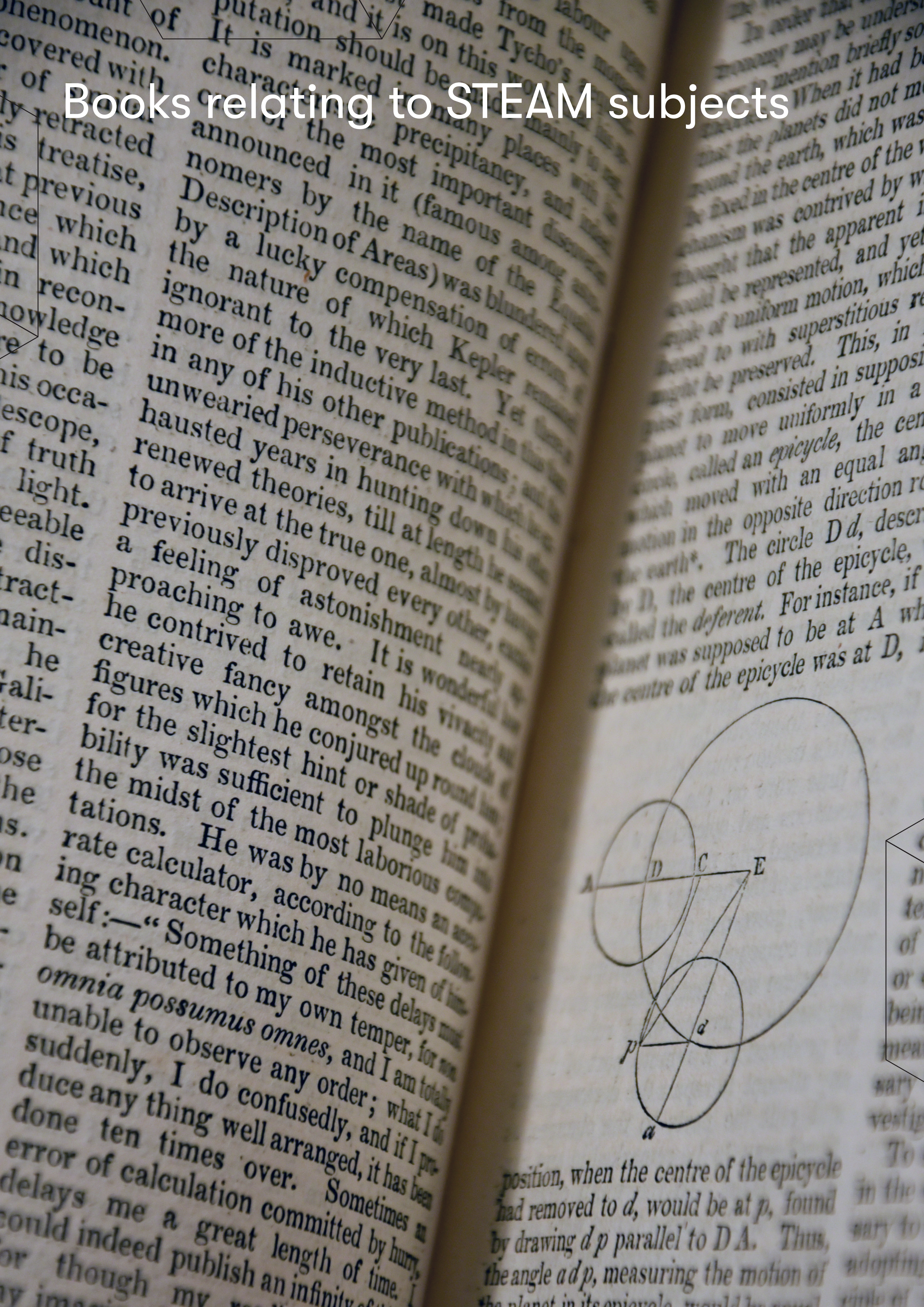
William Cotton II (1759 - 1816)
William Cotton II inherited the collection in 1791. He relocated the collection from Rogers' central London home to Clapham Common.

Despite selling two-thirds of the collection by auction in 1799 and 1801, he continued to collect books. He had a special interest in the world beyond Britain's shores and some of his purchases included Captain Cook's ***Voyages of Discovery*** and George Vancouver's ***A Voyage of Discovery to the north Pacific Ocean, and round the world.***

William Cotton III (1794 – 1863)
After inheriting the collection from his father in 1791, William Cotton III moved to Leatherhead, Surrey, before finally settling in Ivybridge, Devon in the 1830s. Unlike his predecessors, Cotton III was wealthy enough to live a leisured life as a gentleman, and he was free to spend his time studying the books and artwork contained in the collection. In particular, he was interested in the study of the ancient Britons and 'domestic antiquities', and published his own works on the Celtic cromlechs and barrows of Devon and Cornwall.

As he had no children of his own, Cotton III decided to leave the collection to the people of Plymouth for their '***amusement and instruction***'. In 1853 the collection was moved to Plymouth Propriety Library, before being transferred to Plymouth City Museum and Art Gallery in 1915, now The Box.

Books relating to STEAM subjects



Science:
The Life of Galileo Galilei and *The Life of Kepler*

Author: John Elliot Drinkwater
Published: London, 1830

This book, published in 1830, includes sections on Italian astronomer, physicist, engineer, philosopher, and mathematician Galileo Galilei (1564 - 1642) and his contemporary from Germany, the mathematician and astronomer Johannes Kepler (1571 - 1630).

Both Galileo and Kepler played pivotal roles in the development of scientific reasoning, through meticulous testing of theories and publication of their results and theories. One long standing theory that both men were involved with was Heliocentrism, the astronomical model in which the Earth and planets revolve around the Sun at the centre of the Solar System. Prior to this Geocentrism - where the Earth was considered to be at the centre of all the celestial bodies - was the accepted theory.

The first geometric mathematical model of Heliocentrism was presented by Nicolaus Copernicus in 1543. This model drew heavily on Latin translations of Islamic scientific texts, particularly those of Nasir al-Din Tusi (1201 -1274). Tusi's book ***Zij-i ilkhami*** (Ilkanic Tables) contains astronomical tables for calculating the positions of the planets and the names of the stars.


M. Gauci Lit

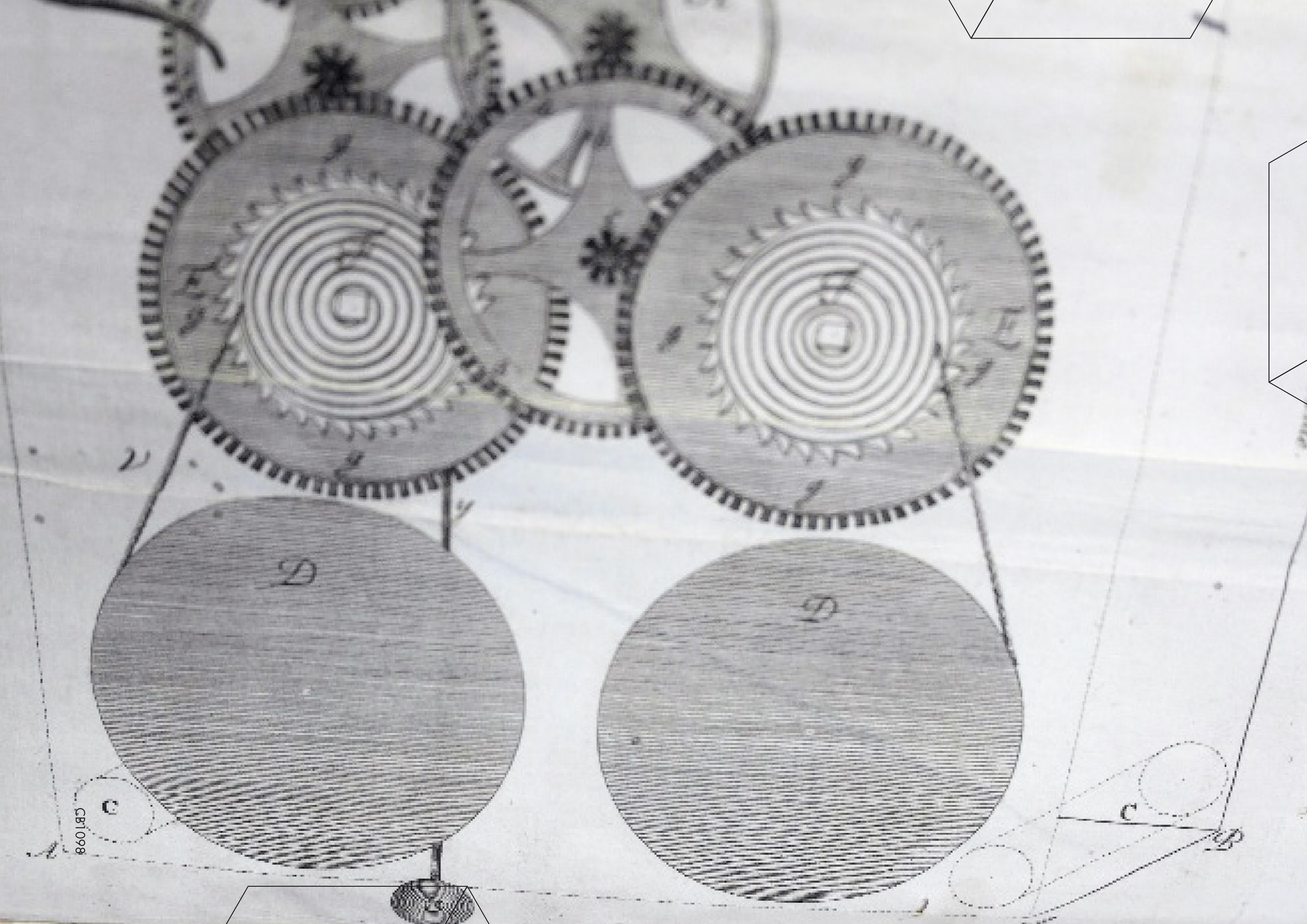
Technology:
The Artificial Clock-maker. A Treatise of Watch and Clock-work

Author: William Derham
Published: London, 1714

The relationship between the accurate measuring of time and major scientific discoveries should not be underestimated. In this book, the natural theologian and natural philosopher William Derham references two very early pendulum clocks. Also mentioned in this book is a watch made for King Charles II and signed '***Robert Hooke invent. 1658. T. Tompion fecit, 1675***'. Under the instruction of scientist Robert Hooke, clockmaker Thomas Tompion made some of the first watches with balance springs, which had the potential to be much more accurate than earlier watches. Hooke is today best remembered for Hooke's Law.

In 1709 William Derham, also the Rector of Upminster, published the most accurate measure of the speed of sound to date, at 1,072 Parisian feet per second. Derham used a telescope from the tower of the church of St Laurence, Upminster to observe the flash of a distant shotgun being fired, and then measured the time until he heard the gunshot with a half second pendulum. Measurements were made of gunshots from a number of local landmarks.

The distance was known by using triangulation, and therefore the speed that the sound had travelled could be calculated.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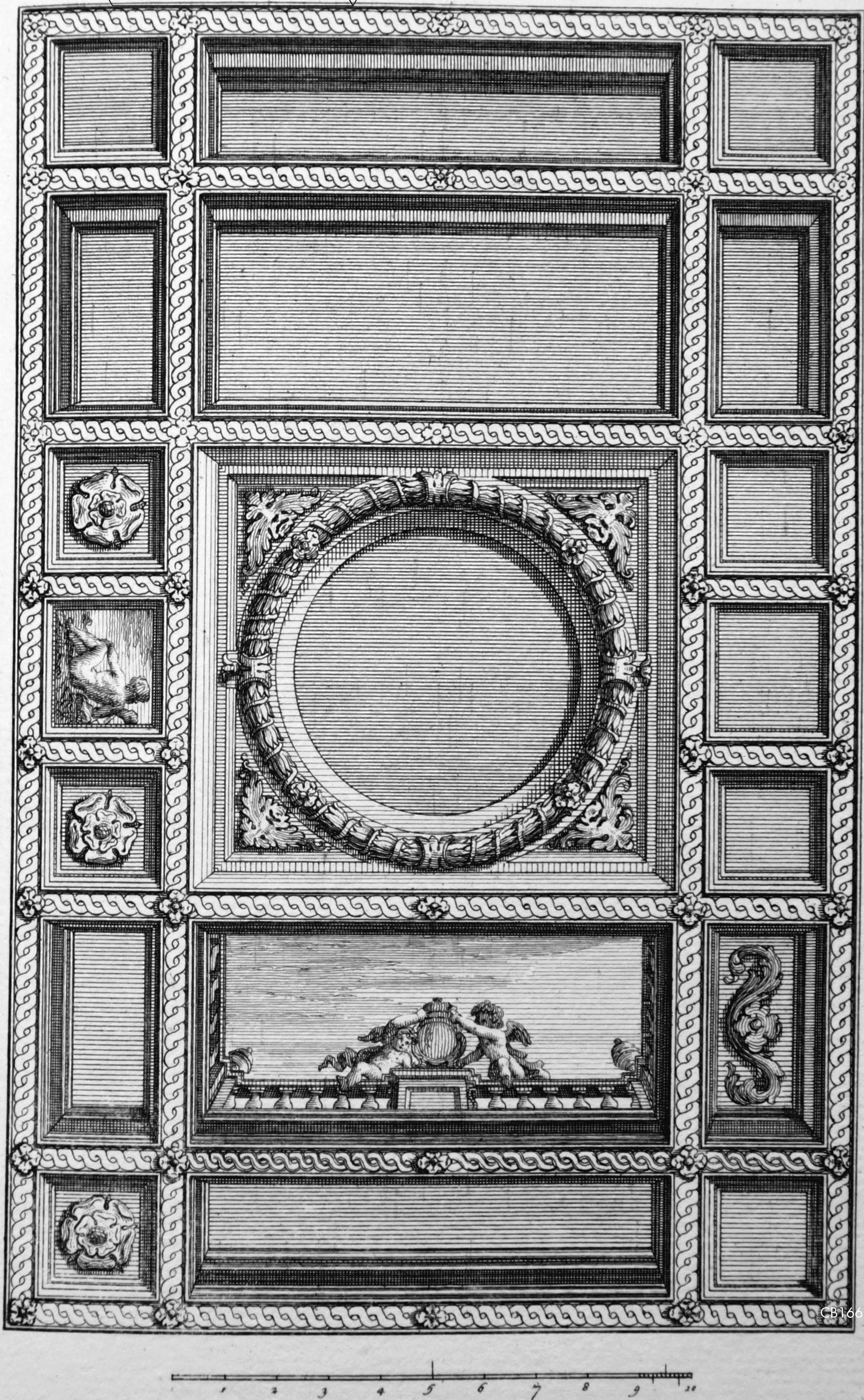
Engineering: *The Designs of Inigo Jones*

Author: Isaac Ware
Published: London, c1731

Inigo Jones (1573-1652) has been described as 'the first English classical architect'. Jones, a follower of Andrea Palladio, has been described as the father of English Palladianism. He is best known for his revolutionary buildings in London, most notably the Queen's House, Greenwich and the Banqueting House, Whitehall.

An architect of immense creativity, one of his greatest influences was Andrea Palladio. He examined Palladio's buildings in detail, as well as his books and drawings. However, he also drew on the ideas of architects such as Bramante, Serlio, Scamozzi (whom he met in Venice, 1614), Vitruvius and the French designer Jean Barbet. Travel was key to Jones's meteoric rise. On two separate occasions he travelled to Italy, undertaking an early version of the Grand Tour. Jones' trips to Europe taught him not just architectural ideas but also an important new way of engineering roofs.

Proportion is a central principle of architectural theory and an important connection between mathematics and art. It is the visual effect of the relationships of the various objects and spaces that make up a structure to one another and to the whole. This ceiling design by Jones is complex – both split into thirds and utilising double squares.


1 2 3 4 5 6 7 8 9 10

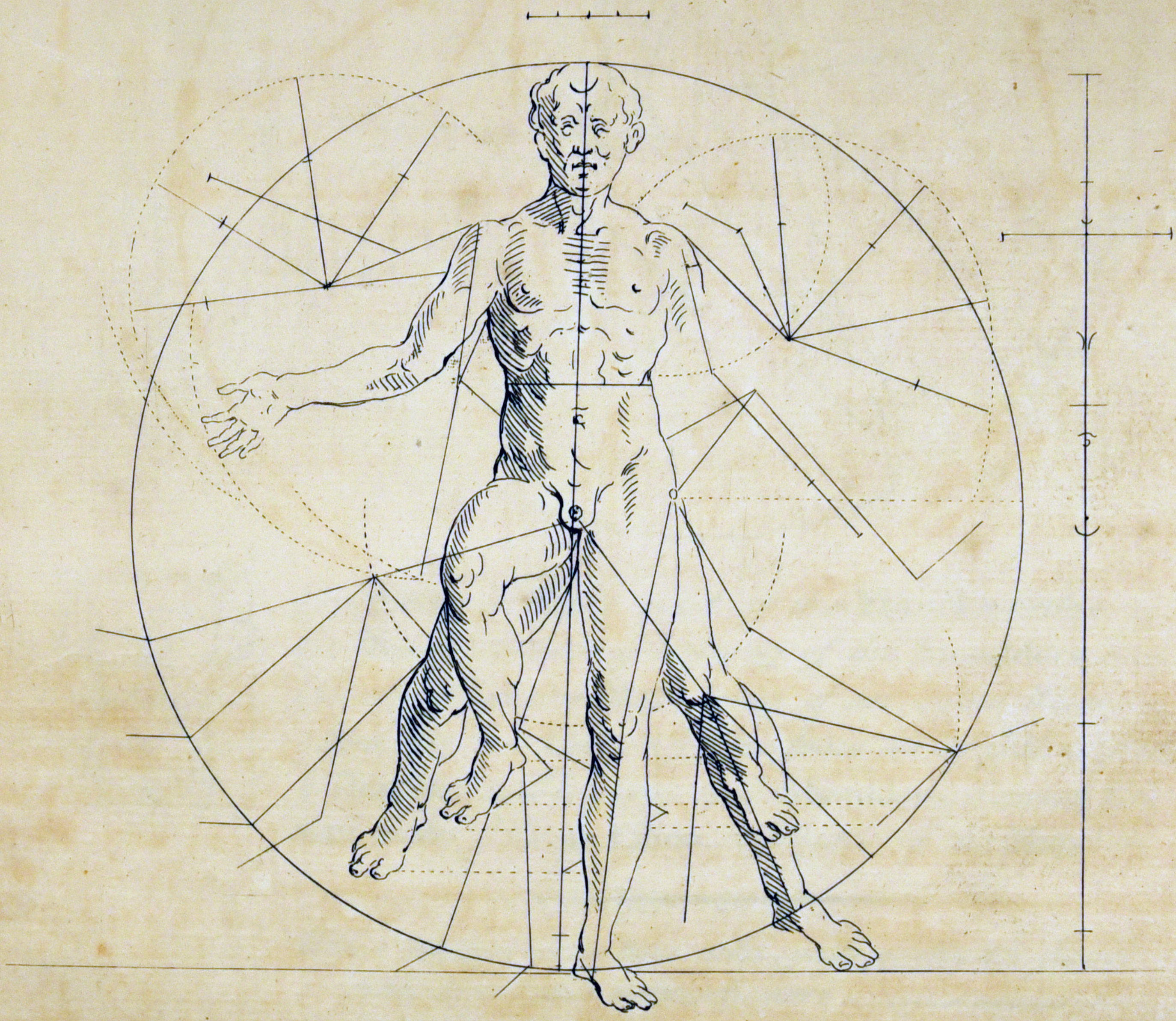
Art:
General Instructions for Drawing

Author: Edward Cooper
Published: London, c1720

Edward Cooper was the most distinguished print publisher of his generation and a leading figure in the art world. He was recognised as an authority on the fine arts, and sold paintings and art materials. His colours were mentioned c.1699-1700, '***Most of the Collours a foresaid you may Buy in Little Bladders and the rest in powders with oyles, [shells] and varnish att Mr Coopers at the sign of the three pidjohns in Bradford (sic) Street, a print shop***'.

This book collects 8 printed plates after works by Leonardo da Vinci, the Italian polymath whose areas of interest included invention, sculpture, architecture, science, music, mathematics, engineering, literature, anatomy, geology, astronomy, botany, writing, history, and cartography – though he is most well known as one of the greatest painters of all time. One of Leonardo's most celebrated images is that of the Vitruvian Man – a drawing based on correlations of ideal human proportions with geometry described by the ancient Roman architect Vitruvius in Book III of his treatise ***De Architectura.***

This book is a fragment of a larger collection put together by Cooper on the mechanics of the human body, based on knowledge of the drawings of Leonardo. They look specifically at the human figure in motion, and how to accurately depict this with the correct proportions.



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Mathematics:
Mathematicall Magick

Author: John Wilkins
Published: London, 1691

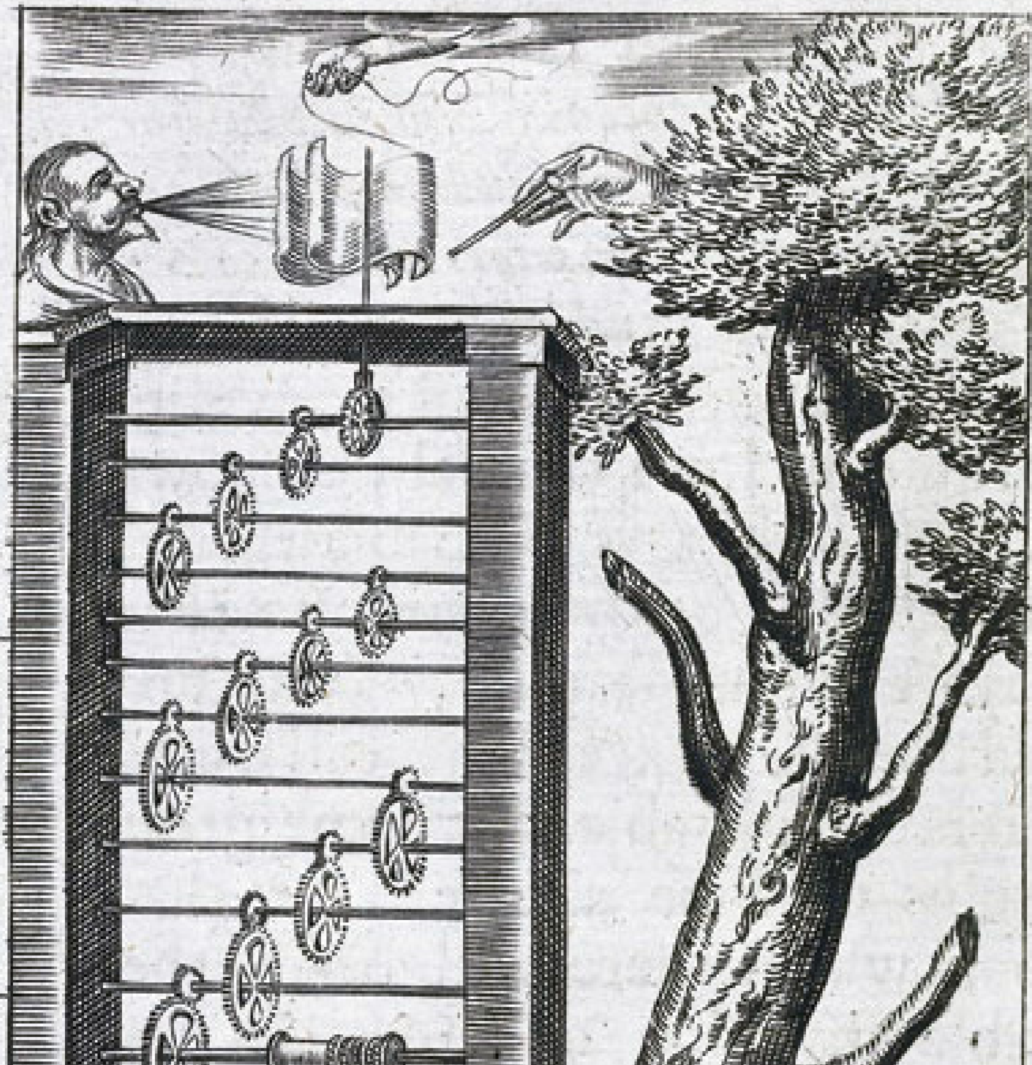
John Wilkins FRS (1614 – 1672) was an Anglican clergyman, natural philosopher and author. He was one of the founders of the Royal Society, the world's oldest independent scientific academy.

Wilkins is one of the few persons to have been head of a college at both the University of Oxford and the University of Cambridge.

Whilst at Oxford he drew together a significant group interested in experimental science known as the Oxford Philosophical Club. Members included architect Christopher Wren and Robert Hooke.

Mathematicall Magick is divided into two books. The first explores traditional mechanical devices such as balances, levers, wheels or pulleys, wedges and screws. It offers proposed solutions to problems – such as how you might lift an entire oak tree from the ground with a single human hair using pulleys and wheels.

The second book explores devices which move independently of human interference like clocks and watches, water mills and wind mills. Excitingly in the second book, Wilkins suggests that with enough practise, humans should be able to fly. He believes this would be best achieved with a 'flying chariot', which would either be equipped with an engine, or be large enough for many people to work together with mechanical componants.



Ideas for Activities

Science

One of Kepler's most important discoveries was made after working with data collected by Tycho Brahe – the Laws of Planetary Motion.

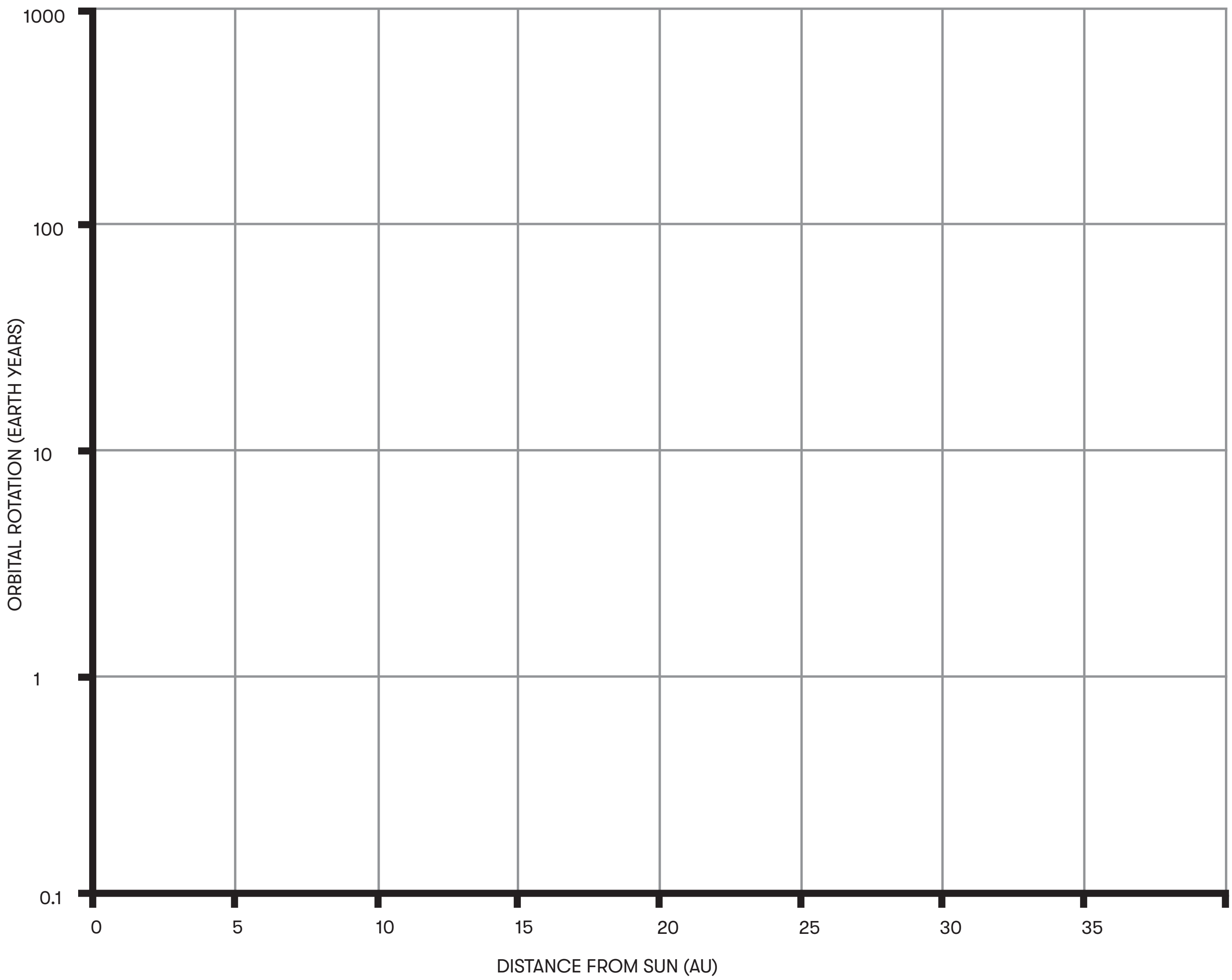
His three Laws describe the motion of planets around the Sun:

1. The Law of the Ellipses
The path of the planets about the Sun is elliptical in shape, with the centre of the sun being located at one focus.
2. The Law of Equal Areas
An imaginary line drawn from the centre of the Sun to the centre of the planet will sweep out equal areas in equal intervals of time.
3. The Law of Harmonies
The ratio of the squares of the periods of any two planets is equal to the ratio of the cubes of their average distances from the Sun

There is a relationship between a planet's distance from the Sun and its period of revolution. We'll simplify the Third Law by saying that a planet's 'year' is determined only by its average distance from the Sun. The further away from the Sun it is, the slower the planet's orbital speed and the longer its path. Both of these factors result in taking longer to make one complete orbit and a planet having a longer year.

Using the data below, ask your pupils to plot a graph showing the orbital rotation periods of the planets against the distance of the planets from the Sun. The unit of length used is the Astronomical Unit, roughly the distance from the Earth to the Sun.

Planets	Orbital Rotations (Earth Years)	Distance from the Sun (AU)
Mercury	0.24	0.38
Venus	0.61	0.72
Earth	1	1
Mars	1.9	1.52
Jupiter	11.8	5.2
Saturn	29	9.5
Uranus	84	19.2
Neptune	165	30



Technology

Many attempts at measuring the speed of sound were attempted - first by Sir Isaac Newton, who published a speed around 15% too low.

Measuring the time taken for a sound wave to move from one point to another is difficult. Speed can be calculated with the simple formula:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

The accepted speed of sound at sea level is 340.29 m/s. Derham made his accurate discovery by using triangulation - by knowing the distance between himself and his shotgun-wielding assistants and measuring the length of time it took for the sound to reach him, he was able to determine the speed at which the sound had travelled.

Let's use an example of something we've all experienced - seeing a lightning strike and hearing the thunder. We'll assume the speed of light is 299,792,458 m/s (we won't question that one), so the lightning is seen almost instantly. The thunder is heard 3 seconds later.

Speed = 340 m/s (rounded down)
Time = 3 seconds

$$340 = \frac{\text{Distance}}{3}$$

Distance = 340 x 3 (**Distance = 1020)**
The lightning is 1020m away.

Let’s test this outside on your school fields, or wherever is suitable. Devise a ‘firing’ system (avoid shotguns) so that your pupils know when to make the noise - perhaps wave a flag. Send pairs - one with a camera and one with a drum - to different points on the field.

Once all are sited, they should all be turned to look directly at the pupil with the stopwatch - perhaps situated on a bank or somewhere slightly higher. When you signal, both pupils should count to three, then bang the drum once and simultaneously take a picture so the flash goes off. The pupil with the stopwatch should time the difference between the flash of light and when they hear the sound.

You’ll need:
• Trundle wheel
• Stopwatch
• Camera with flash
• Hand drums
• Flag

Measure the distance between the stopwatch and the drum between tests and record the times taken for each point.

Once back in the classroom these measurements can be tested by using the formula:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Engineering

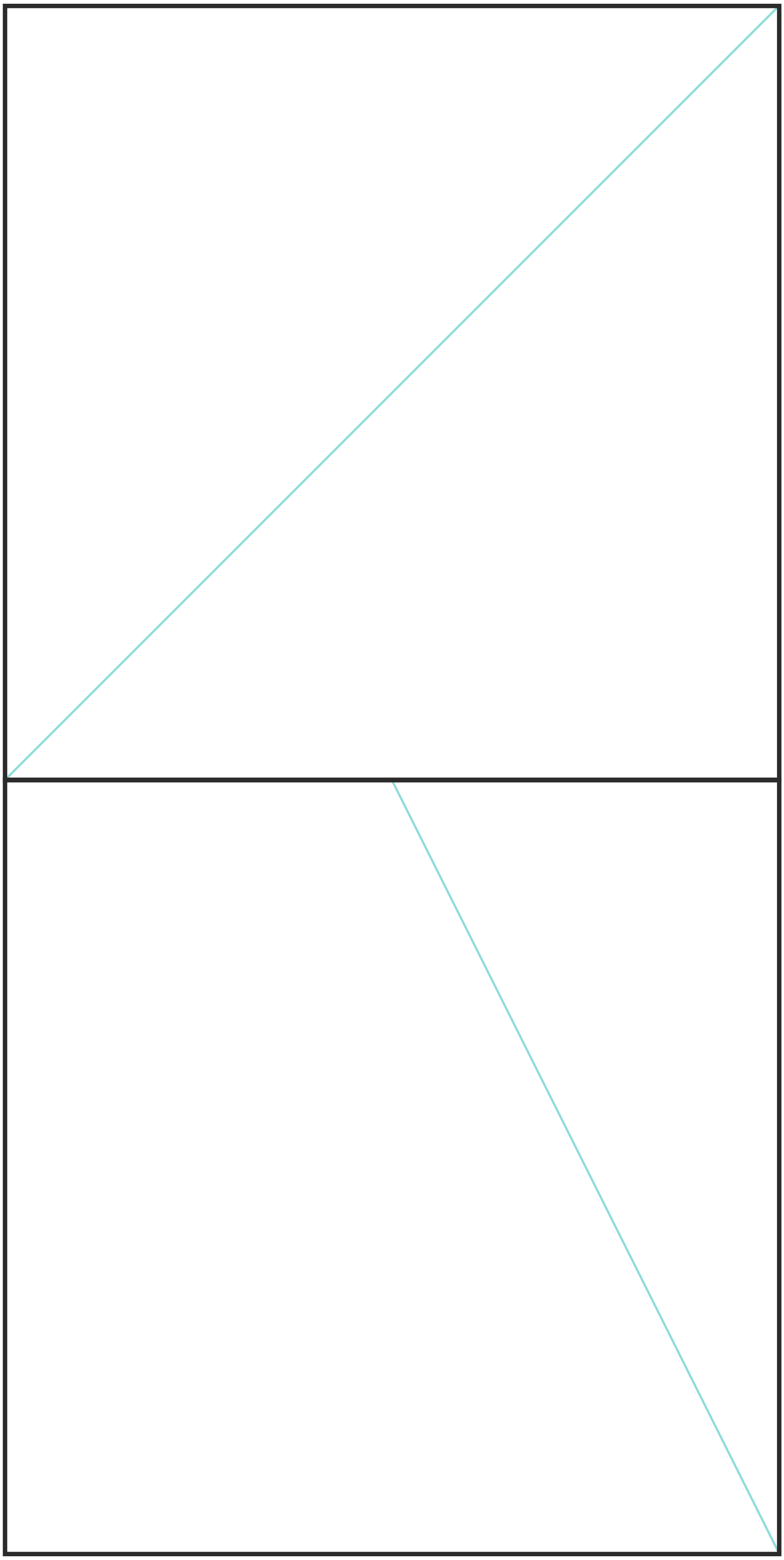
Proportion is the visual effect of relationships of the various objects and spaces that make up a structure to one another and to the whole.

Inigo Jones was hugely influenced by both Vitruvian and Palladian proportions when designing his buildings. Underpinning their approach to designing buildings and structures was geometry - points, lines, planes, surfaces, angles and curves. Symmetry was also very important.

On the next page we have a simple double square rectangle.

Use this unmeasured rectangle as a starting point for your pupils to explore basic geometry, measure angles, segment lines (including creating a scale for the drawing), bisect lines (including with a compass) and uncover reflective and rotationally symmetric shapes.

Your pupils can also label and measure the triangles uncovered and use trigonometry to determine their area. We have started you off with a couple of lines already on the next page.



Art

Vitruvius discovered a formula to model what he thought were ideal proportions for a man. Da Vinci used this ideal model when he was drawing the Vitruvian Man in 1490.

The drawing shows a man standing in a square, which is inside a circle. The man has two pairs of outstretched arms and two pair of outstretched legs. Google Vitruvian Man to find this image - there are plenty of different versions available to view, but Da Vinci's original can be found online.

These proportions are described in this extract from Da Vinci's accompanying text below the drawing, written in his coded 'mirror writing':

- A palm is the width of four fingers
- A foot is the width of four palms (i.e. 12 Inches)
- A cubit is the width of six palms
- A pace is four cubits
- A man's height is four cubits (and thus 24 palms)
- The length of a man's outspread arms is equal to his height
- The distance from the hairline to the bottom of the chin is one-tenth of a man's height
- The distance from the top of the head to the bottom of the chin is one-eighth of a man's height
- The distance from the bottom of the neck to the hairline is one-sixth of a man's height

The entire text can be found online.

Use these to test the 'ideal' proportions proposed by Vitruvius and Da Vinci - do these still fit a 21st Century person? Are there any pupils in the class that have 'ideal' proportions? Use a simple table to record data from individuals and compile this with data across the class - you can easily make graphs from the data, or show how the measurements taken can be expressed as ratios.

A more visual way of exploring the measurements you have taken could be through geometry. Using large pieces of paper (lining paper is a cheap option), use the measurements taken to create a geometric version of a human body. Individual 'units' (building on the work in the previous 'Engineering' section) can be cut out from the paper and painted. These can be reassembled into a 'body' in a number of ways.

Your pupils could systematically replicate the proportions of each part of the body in their corresponding locations on the paper, or reconfigure these shapes into a sequence from small to large, or attempt to fit as many of the shapes into a 'height x outspread arms' square - can you think of any other ways to reconfigure the body?

Ask your pupils to consider the work of the artist Robert Mangold, whose work explores shape, colour, symmetry and asymmetry.
In particular, ask them to look at *Three Squares Within a Triangle* (1975) and his other works from the same period, as examples of how geometric shapes can be presented as a work of art.

What variations on this theme might your class create?

Mathematics

Mathematicall Magick explores the use of traditional mechanical devices such as balances, levers, wheels or pulleys, wedges and screws.

The book offers theoretical solutions to a given problem – in this case how you might lift an entire oak tree from the ground with a single human hair or human breath using pulleys and wheels.

Wilkins suggests that '***forcing up the Oak by the roots will be equilvalent to the lifting up of 4000000000 pound weight***'. The 'engine' uses two double pulleys and twelve wheels. He suggests '***that the same strength of… hair…would be able to move the world***'.

He imagines the world weighs 2400000000000000000000000 (2.4 septillion) pounds. He then simplifies the maths by proposing we start from a number of 1000000000000000000000000 (1 septillion).

Below are the figures he uses to demonstrate his findings. They show that by using his pulleys and wheels, the force required reduces by a factor of ten when multiple pulleys and wheels are used.

He even states himself it is '***so obvious, that every ordinary Artificer (a skilled craftsman or inventor) doth sufficiently understand it***'.

The forces on his wheels with this starting point are as follows:

To the first wheel will be put as:	10000000000000000000000
To the second as	100000000000000000000
To the third as	1000000000000000000
To the forth as	10000000000000000
To the fifth	100000000000000
To the sixth	1000000000000
To the seventh	10000000000
To the eighth	100000000
To the ninth	1000000
To the tenth	10000
To the eleventh	100
To the twelfth	1
To the sails (hair) as	1/109

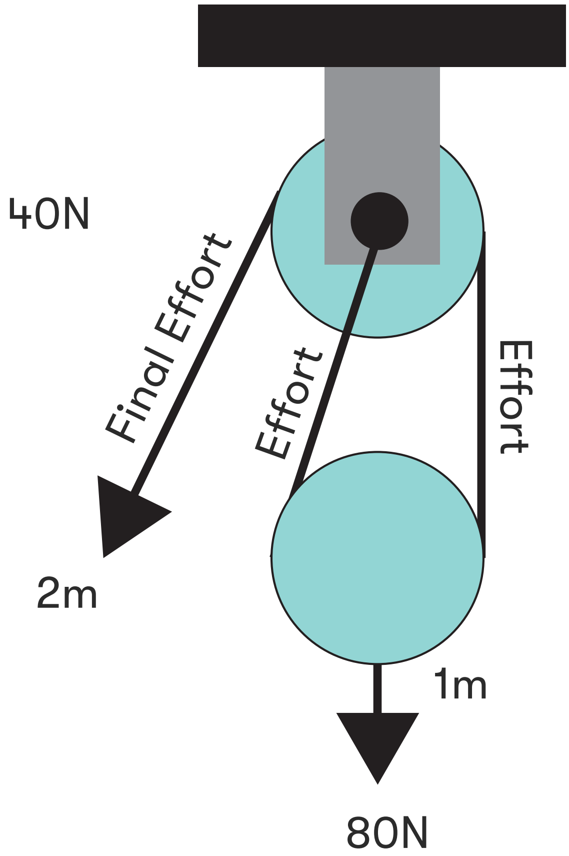
Let’s explore pulleys further. A simple equation can be used to work out the Mechanical Advantage of using a pulley to lift any weight. Single pulleys make it safer to lift weights, but double pulley systems - with one fixed and one moving - allow the effort to be applied downward towards the person pulling the rope.

Ask your pupils to test a range of efforts and loads using the equations on the next page. Once they have mastered this, try adding further pulleys to the system to make the equations
more complex:

• Can they design a system where the load would be 150N with an effort of just 25N?

• How many pulleys would be required with these parameters?

1. This diagram shows a simple pulley system. Lets assume a 40N effort is used to move 80N load. The effort moves 2 metres, and at the same time the load moves 1 metre.



$$\text{Mechanical Advantage} = \frac{\text{Load}}{\text{Effort}} = \frac{2}{1} = 2$$

$$\text{Velocity Ratio} = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}} = \frac{2}{1} = 2$$

2. To work out the efficiency of the pulley system, another use:

$$\text{Efficiency} = \frac{\text{Mechanical Advantage}}{\text{Velocity Ratio}} \times 100 = \frac{2}{2} \times 100\% = 100\%$$

3. No pulley system can be 100% efficient, due to loss of energy through friction - it would break the first and second laws of thermodynamics (so try not to do that if you can?).

Visit our website for the latest offers, news and projects for schools, and to book your experience with us:

theboxplymouth.com

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LOTTERY FUNDED