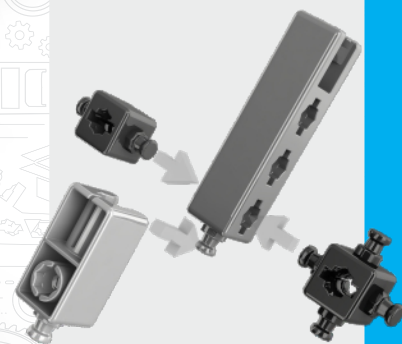
Engino®

CREATIVE™ engineering maker Master

30 IN 1 MODELS

2 models — printed instructions (included)

28 models — online 3D instructions



⊕ SNAP-FIT SYSTEM

Product code:
CE301MM-A

Online theory & activities

Theory

What we will learn

Dragons are mythical beings, usually appearing in the mythology of several cultures around the world. There is a big diversity in their size and powers, though they have common reptilian-like features. One of their weapons is that they usually blow out fire. In countries like China and Japan big celebrations for dragons are still organised. Do you want to know more about the history of dragons? Have you wondered if dragons ever lived on Earth? Which similarities did they share among different mythologies?

Dragons are famous for fire breathing abilities

This booklet of "**DRAGONS EVOLUTION**" contains a great deal of useful information and amazing facts, so that you will learn all about dragons. Follow the building instructions, contained in this booklet to build exciting models such as **a pterosaur**, **a phoenix dragon**, **an elder dragon**, **a rhaegal dragon** and **a twinheaded dragon**. Join this journey into the legendary stories of dragons!

The History of Dragons

It is not clearly known when dragons first appeared in cultures but it is estimated to be around 4000 B.C. Dragons were thought to be animals living in dark and damp caves, on mountain tops or in lakes. It is believed that the invention of such monstrous creatures with super powers is due to the early discoveries of dinosaurs' fossils or even bones from unknown animals of the past.

Stories with dragons appear in many different civilizations, all having their own significance. Dragons have appeared in a variety of sagas with gods in ancient mythologies. During the time of Christopher Colombus, when the majority of people thought the Earth was flat, dragons were believed to hide on the Earth's boundaries. This myth was busted after navigators crossed the oceans and circumnavigated the Earth finding no evidence of such creatures.

Meaning of word “Dragon”

The word dragon comes directly from the ancient Greek “Drakones” or “Draconta”, meaning to watch carefully at something. This explains why dragons were typically assigned as guards of precious treasures such as mountains of gold coins, jewels and secrets.

Did you know?

Dragons were much loved as mythological animals. They were presented as gigantic and powerful snakes or reptiles. Also, they have appeared in mythology throughout the ages and are especially popular in the culture of China. *“The phoenix”* is a dragon with wings and five claws which was used as a symbol for the emperors in China. The body of phoenix had various colours, like sunset orange and yellow.

China has a strong culture in dragons

Description of Dragons

A dragon is typically a monster of an enormous size with a reptilian nature. This is very common to almost all cultures. However, there are dragons whose size varies from small to pet-sized or even miles long. Despite their varying appearance, most dragons appeared in red or green color. Other common characteristics were their red and slanted eyes, long tails, claws and sharp teeth. Dragons are also famous for the special powers they possessed. Depending on the culture, dragons might be super powerful or very weak, friendly or aggressive, wise or dump with wings or not.

Dragon Symbolism

Dragons are often used as symbols in the cultures all over the world. Despite the fact that dragons of the Eastern countries had quite similar physical characteristics from the Western, their symbolic representations are different. This indicates the essential differences among the two continents. The most significant difference is that Europeans had illustrated dragons as evil creatures, whereas Asian cultures regard them as friendly beings.

Western and Eastern Dragons

Western Dragons

The *Western* dragons were typically huge and heavy, with sharp claws and bat-like wings. Most of the times they had reptile features, but in few cases they had fur or feathers. Sometimes the dragons were dark colored but always shiny. The ability to exhale fire was quite common to all western dragons. Most of the stories say that dragons stayed into cold and dark caves, filled with fire and water. They were mostly used as frightening and unfriendly monsters with lack of intelligence. In some sagas they had the ability to speak and communicate with humans.

Eastern Dragons

Eastern dragons were typically small in size with long bodies and horns. They used to live silently near places with large amounts of water. Also, Eastern dragons are found all over Asia, particularly in China, Korea and Japan. The dragon's body was constituted from a blend of many different animals. For example a dragon could have the body of a snake, the belly of a frog and the head of a camel. The term “Far East” dragons refers to the dragons of China, Korea and Japan. They were well respected and honored as demigods.

Chinese Dragons

Chinese mythology dates back at least 6,000 years and is very popular. The Chinese legends describe dragons as a mixture of different creatures such as horse, snake and deer. Sagas with dragons were strongly associated with rivers, water, clouds and rain. They were thought to be kind creatures for being responsible or bringing the needed rain for agriculture. In addition, they were a symbol of the empire.

Dragons from Japanese Mythology

Japanese mythology includes a creature called the "ryu" associated with water and the power of the emperor. Also, stories of snakes and centipedes are mentioned. An ancient sacred text of a Japanese religion describes an evil dragon with eight heads and eight tails, named “Yamata no Orochi”. It was so huge that when crawling it could extend to eight mountains! This dragon was slain by the god Susanoo-no-Mikoto in order to keep people safe.

Races with Dragon Boats

Boat racing ceremonies related to dragon worship dates back to more than 2000 years ago. According to Chinese custom, it was believed that such races would obtain prosperity and cultivation to the racers. The goal was to cross the river and meet the dragon. The dragon's eyes should be opened to release the good spirit and fight the evil.

Today dragon boat racing has evolved to an international sport. Beginning in Hong Kong in 1976, the race has become a tourist attraction. The boats which participate at the dragon race festival are colourful and decorated with various dragon elements. Boats feature carved dragon heads, long tails and are long enough to carry up to 20 paddlers.

Did you know?

Among the 12 different zodiac constellations of the Chinese astrology, the dragon is one of them. Each Chinese year is assigned to a single constellation and anyone who is born in that year receives the name of the annual zodiac. Thus, every twelve years newborns are called “Dragons” in China. The last year assigned to a “Dragon year” was back in 2012. People who tend to believe in superstitions, theorize that a person's characteristics are determined by their birth zodiac.

The Dragon is one of the 12 Chinese constellations

How dragons could breathe fire?

According to the legends, dragons were believed to eat other animals. The hard bones of their victims could prove to be an issue for digestion. So dragons had to grind up their prey with rocks. However, by grinding up a large amount of rocks could leave residue on a dragon’s teeth.

Thus, as the dragon releases its hydrogen and methane, the gas would mix with the oxygen in the air. Finally, this combination of rock grinding and gas storage could create the conditions for fire breathing. In the end, fire was spewed out from the dragon's mouth.

Are Dragons real?

There is no question that dragons are only mythical creatures, which appear in imaginary stories and ancient mythologies. There is no evidence to prove their existence neither in fossils nor from bones found by paleontologists. Storytellers throughout the centuries, from the ancient Greeks, Sumerians and Chinese up until today, used dragons and their supposed special powers to develop appealing stories.

The belief in dragons was mainly due to their use in mythological legends. In addition, no one knew how to deal with the fact that giant bones were discovered in deep layers from the ground. Dragons were “real” until the science of **palaeontology** appeared. Strange and uncategorized bones could be attributed to ancient mammals or dinosaurs, thus the idea of dragons being real simply vanished. However, stories with dragons are still interesting as they offer an exciting and adventurous plot!

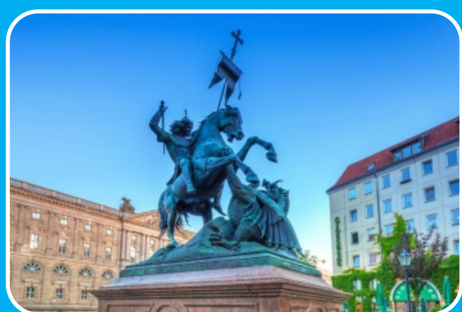
Fossils

The only direct way to learn about prehistoric creatures is by studying **fossils**. Fossils are the remains of ancient animals and plants. They have been found on every continent on Earth, maybe even near where you live!

Paleontologists estimate that only a small percentage of the dinosaurs have turned into fossils. The majority of dinosaurs lived during the Jurassic period, a time which dates more than 100 million years ago! During that period, the Earth was made only of two continents.

Did you know?

A well known myth from the Middle Ages is about a knight called St. George, who rescued a young princess from being sacrificed to a dragon. When St. George passed by the city he learned about the unfair trade that the villagers had to concede in order to keep the dragon calm. He decided to take control by slaying the beast with his sword. That was the reason that the whole village turned into Christianity later.



Statue of St. George killing the dragon

Models

Pterosaur

Pterosaur's name originates from a Greek word that means "winged lizard". More than 30 different fossils of a **Pterosaur** have been found. It had wings formed by a skin and muscle membrane, while its wingspan was about 1 meter. This carnivore creature lived on small islands, in lagoons or on the coasts.

4212

The characteristics of a Pterosaur are alike to mythological winged dragons. It is believed that the stories of monestrous creatures were initiated by early discoveries of fossils from Pterosaur and other bizarre prehistoric animals.

Phoenix Dragon

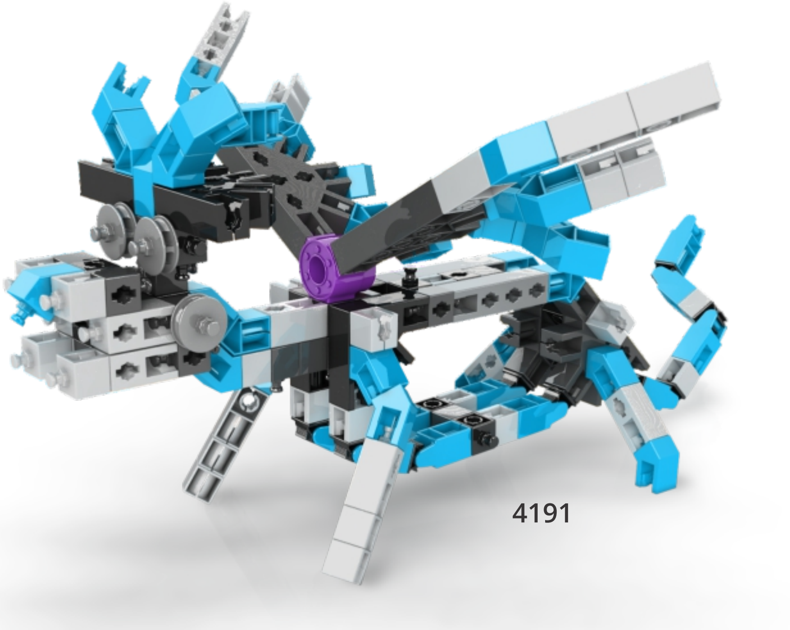
The Phoenix is a winged style dragon, with a body of fiery colors such as orange, red and yellow. Its head is decorated with several curved feathers resembling sun rays. The dragon's eyes are deep orange and its beak is tipped in brown. Unlike most winded style dragons, the Phoenix does not have arms. Its wings consist of a curved orange wing bone tipped with thorny spikes and golden wing flaps.

4196

Furthermore, the body consists of a blending of orange and yellow coloring. It's tail has three yellow feathers outlined in orange. However, the species is very curious and intelligent, their development is faster paced than other dragon species and they are capable of learning human speech.

Elder Dragon

The Elder Dragons were believed to be primarily creatures from ancient times. They had so strong powers that they were able to compete even with the gods. They have many incredibly formidable foes, since these dragons are nearly impossible to be defeated in just one battle.



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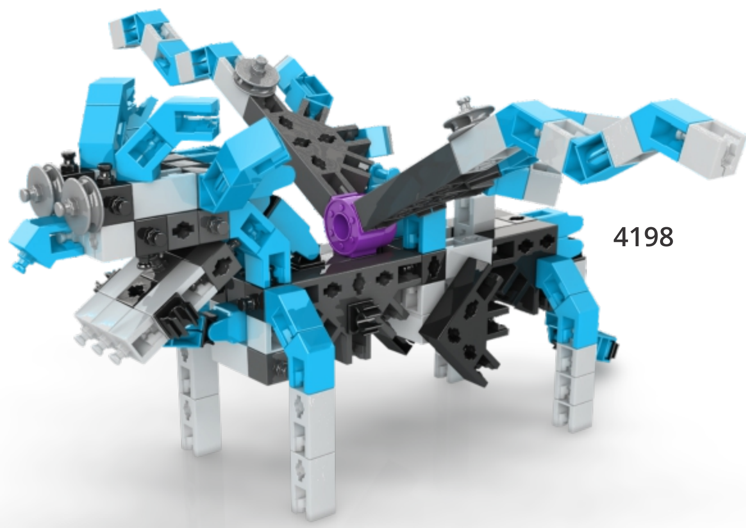
Elder Dragons are recognizable by their traditional draconic makeup: a pair of wings, plus arms and legs. This class is made up of rare, intangible monsters that have lived eternally since ancient times, and were able to bring destruction to whole ecosystems.

Rhaegal Dragon

A Rhaegal dragon is usually found in green and bronze colour, with sharp teeth and claws. He has very bright and shiny bronze eyes and belongs to the kind of flame breathing dragons. The fire he exhales is orange and yellow, shot through with veins of green.



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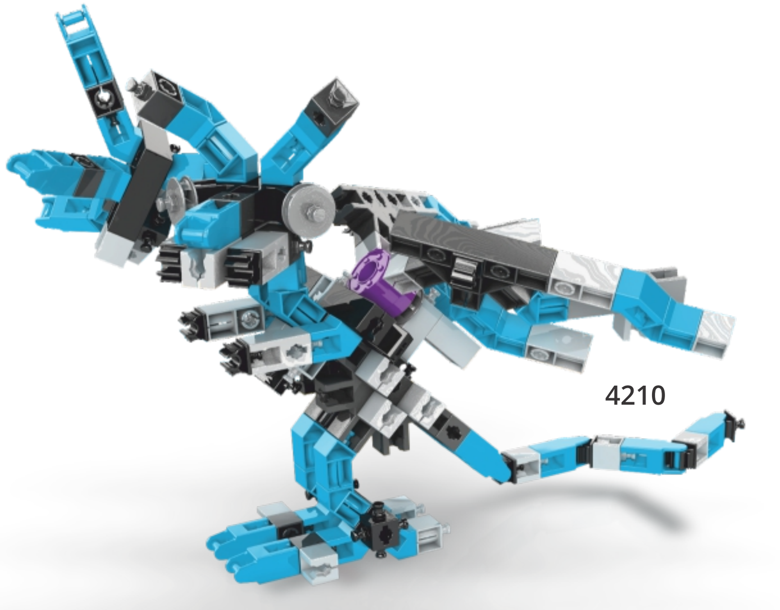
Many tales present the Rhaegal dragon to be the brother of Drogon and Viserion dragons. He is the middle of the three dragons and while not as wild as the larger Drogon, he is still quite dangerous much more than his younger brother Viserion.

Twinheaded Dragon

The two-headed dragon refers to the Chinese dragon of the rainbow Hong. These dragons have a negative meaning. Perhaps their two heads are responsible for controling two extreme phenomena like rain and clear sky.



Their two heads are sharing the same body. Such dragons are mostly found with large wings and a very long tail. It is a mystery whether these dragons should be considered as two beings that live inside the same shared body.

Did you know?

Out of all the national flags, two show a dragon figure. These two countries are Wales and the Kingdom of Bhutan. The Welsh Red Dragon is an ancient symbol dating back to Roman times. Green and white colors are representing the flag of Tudor dynasty. Tudor was victorious in a crucial battle in 1485 and placed the dragon on the flag. On the Bhutan's flag though, the white dragon symbolizes the purity of the kingdom. The two diagonal colors of the flag, represent the pneumatic and timeless force of the country.

Flag of Wales

Flag of Bhutan

National flags featuring dragons

Quiz

Can you distinguish facts from myths about dragons? Choose between **true** or **false** to the following questions.

1. Dragons lived on Earth a long time ago, even before dinosaurs.

☐ True ☐ False

2. Dragons appeared in many cultures all over the world and were used as symbols to represent qualities and ideas.

☐ True ☐ False

3. The majority of legends in western cultures present dragons as unfriendly creatures with little intelligence.

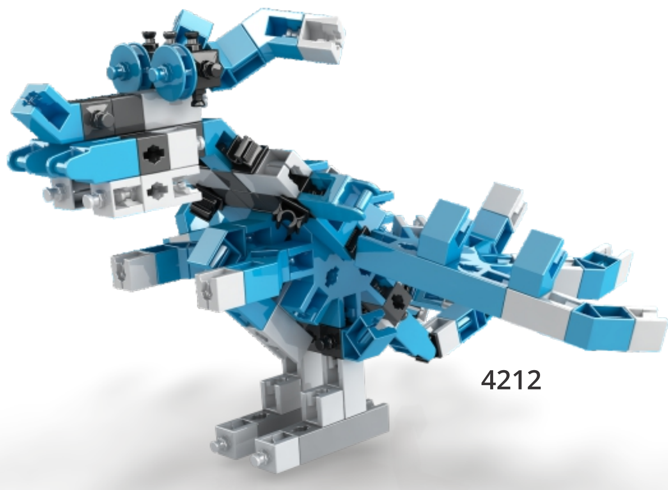
☐ True ☐ False

4. The next "year of Dragon" in China will be the year 2021.

☐ True ☐ False

Experiment with the dragon's bone

As you have already read some kinds of Dragons had wings that were used to fly! Despite their enormous size and huge mass they obtained flights! To achieve this, they used their giant wings which were much bigger than their size.



In order to achieve a flight a dragon must generate a force in an upward direction that surpasses its gravity (the force that the Earth applies to pull any object towards its center). For that reason, they used their strong wing muscles to flap their wings. This way an upward force was created and enabled them to fly.

The shape of the dragons' wings made the flight possible. In addition, it determined how well the air flows over the wings. Moreover, it enabled them to fly through air with minimum air resistance, thus less effort and energy were required.

- How was it achievable for a dragon to fly despite its huge mass and size?
- Is it possible for a human to fly if he/she wears a pair of wings?
- Why can same animals fly while others, even if they have wings, cannot?

Let's perform the next page's experiment to get answers for all these questions!
Get ready to discover what density is and how it determines if an animal can fly or not.
Find out which factors and how these factors affect density.

Learning about: **Density**

Dragon's bone

Imagine that you have two bones of the same size, of which the one is hollow and the other one is solid. How can you recognise which one is the Dragon's bone? Perform the following experiment to find out!

Discover:
- How can you calculate the volume of a cuboid?
- How can you identify a hollow structure?

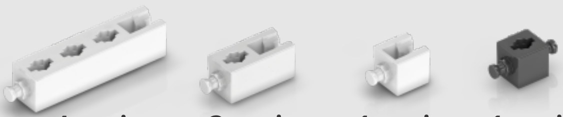
Level Of Difficulty ★★★☆☆

Materials Needed:
- Engino® (ce301mm-a).
- A4 paper, Scissors, Adhesive tape, Calculator

Procedure:

1. Find the instructions and build the **Dragon's bone** model.

2. Obviously the two shapes have the same size. Calculate the dimensions of one of them. Measure the dimension of the length, width and height using **Engino units** (see below). Write your findings in **exercise 1**. Then multiply the three dimensions to determine the volume of the shape.



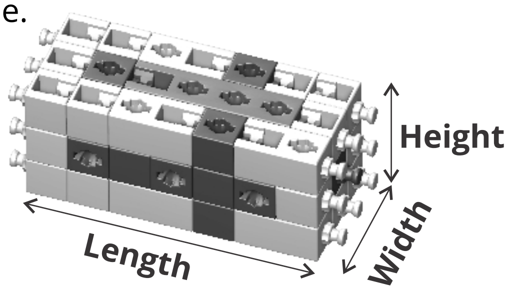
4 units 2 units 1 unit 1 unit

3. Follow the next page's instructions to **print** the side surfaces of the bones and **wrap** the 'bones' using these surfaces as it is explained.

4. Hold the 'bones', one in each hand and estimate which one has greater mass. Write your observations on **exercise 2**.

5. Calculate the ratio of the bone's mass to its volume for each one in **exercise 3.** The ratio of the object's mass to its volume is called **density**. Then compare your findings in **exercise 4**.

1. Write the size of the length, width and height of the bone. Use the given formula to calculate the volume of the shape.



Length = ...cm

Width = ...cm

Height = ...cm

Volume = length x width x height

Volume = $\boxed{\quad}$ x $\boxed{\quad}$ x $\boxed{\quad}$

Volume = $\boxed{\quad}$ cm^3

2. One of the two shapes has greater mass. Which one is it? Explain your answer.

....

....

....

3. Use your calculator to calculate the ratio of the mass of the object to its volume. It is given that **bone 1** has a mass of 31.5g while **bone 2** has a mass of 63g.

Bone 1: $\frac{\text{mass}}{\text{volume}} = \frac{\ldots\ldots}{\ldots\ldots} = \ldots\ldots$

Bone 2: $\frac{\text{mass}}{\text{volume}} = \frac{\ldots\ldots}{\ldots\ldots} = \ldots\ldots$

4. Which one has less density? Which one is the dragon's bone? Which factors affect the density of an object?

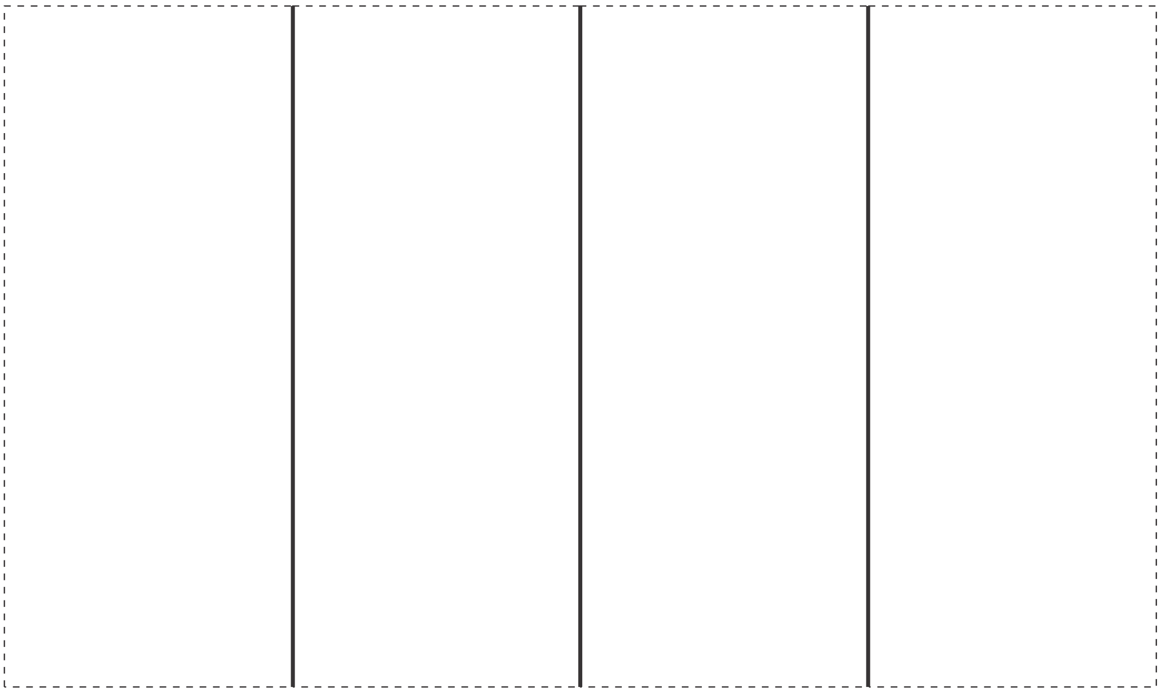
....

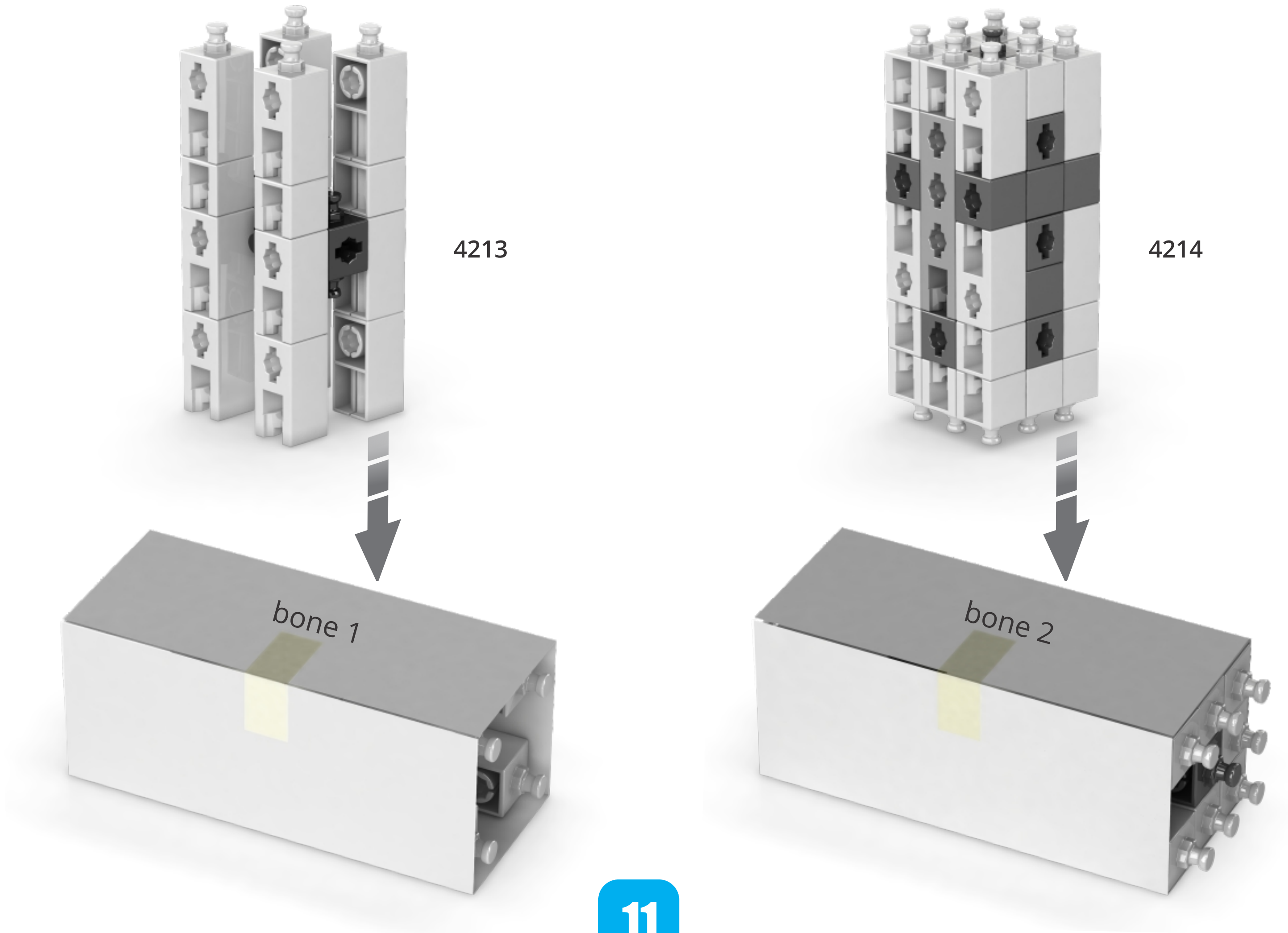
....

....

a) **Print** the last page on an A4 paper twice.
b) Use the scissors to cut along the **dotted** line.
c) Bend the paper along the **continuous** lines.
d) **Wrap** the two bones using the two side surfaces.
e) **Strap** the edges of the paper using the **Adhesive tape**.
f) **Note bone 1** and **bone 2** on the paper as it is shown below.

Side surface for the Bones

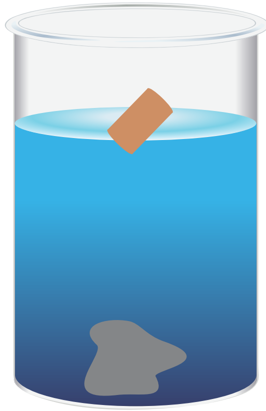




Theory

Density

Density is a measurement that compares the amount of matter an object has to its volume. Every pure substance has a unique density value, thus density identifies a substance. To calculate the density (usually represented by the Greek letter “ρ”) of an object divide the mass (m) of the object by its volume (V). An object with much matter in a certain volume has high density, while an object with little matter in the same amount of volume has low density. Objects with smaller densities float in liquids with greater densities. For instance, a cork floats if placed in a cup of water.



Advanced information:

From the formula it is obvious that density, mass and volume are interrelated! As a matter of fact, density is directly proportional to mass and inversely proportional to volume. In other words, the bigger the mass of an object the bigger the density. While, the greater the volume it has the smaller the density.

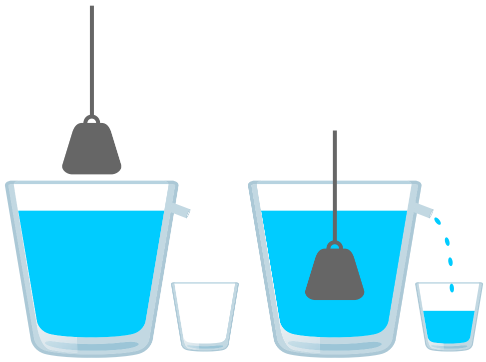
$$\boxed{\rho = m / V}$$

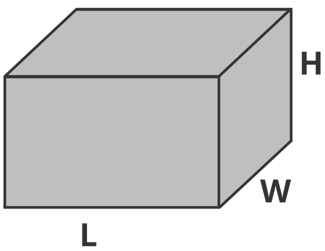
ρ = density
m = mass
V = volume

Formula for calculating Density

Volume

Volume is the amount of space occupied by an object. The SI (international system of units) unit for volume is the cubic meter (m^3). More units, such as cm^3 (cubic centimeters), L (Liters), mL (milliliters), etc are also used to quantify numerically the volume. Different ways are used to find the volume of different shapes, this is regarding the shape and the state of the object.

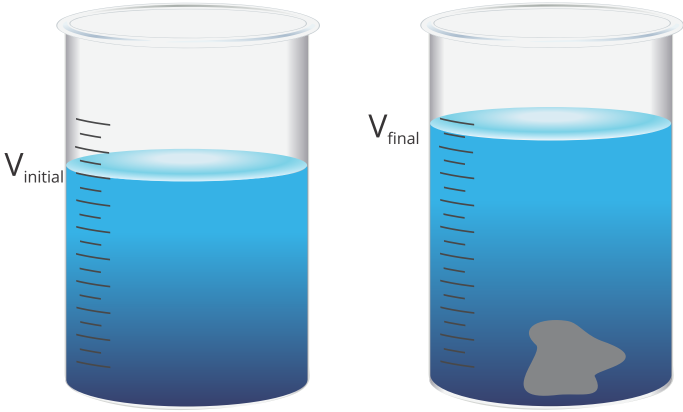




- For a **regular-shaped** object the volume can be determined using specific formulas that multiply the three dimensions of the object. For example, the formula V= length x width x height is used to calculate the volume of a cube or a cuboid.

- Moreover, the volume of a **liquid** in a graduated cylinder can be qualified by the reading of the cylinder.

- Archimedes principle is used if the object has an **irregular shape**. An amount of water in a graduated cylinder determines the initial volume. When the object is placed into the cylinder the new reading defines the final volume. The difference between the two volumes equals to the volume of the irregular shape.



Mass

Mass is the quantity of matter in an object. It is measured in kilograms in the International System of units (SI). In addition, different units such as grams are used for small objects (such as an apple) and tones for huge ones (such as a big ship). The instrument used to measure the mass of an object is a balance. The mass of a body is considered to be constant. For instance, if an object has a mass of 2kg on Earth, it would have a mass of 2kg on the Moon.

How could dragons fly?

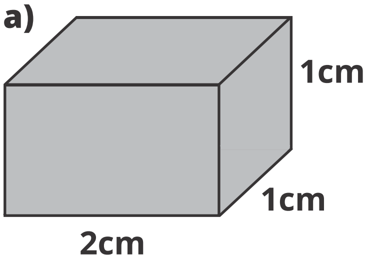
The answer is simple! Dragons, like all birds, have hollow bones that enable them to fly. Hollow bones look like other bones, with the usual hard exterior. However, instead of being filled, hollow bones have air cavities inside. In other words, dragon bones have air sacs in them. Flying animals need so much oxygen to fly, for that reason their lungs are extended into their bones. Many people think that their bones are lighter from other similar-sized mammals because they are hollow. However, this is not actually true. In fact, birds', and specifically dragons', skeletons weigh about the same as other animals of the same size. The fact that dragons have hollow bones and weigh the same as other similar-sized animals is strange but true. That is because their skeleton occupies a larger volume.

Quiz

Exercise 1

Calculate the volume in each case.

a)



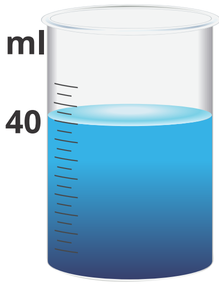
Volume of a cuboid

Volume = length x width x height

Volume = ___ x ___ x ___

Volume = ___ cm^3

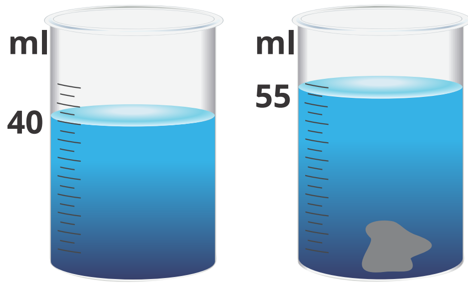
b)



Volume of water

Volume= ___ ml

c)



Volume of a pebble

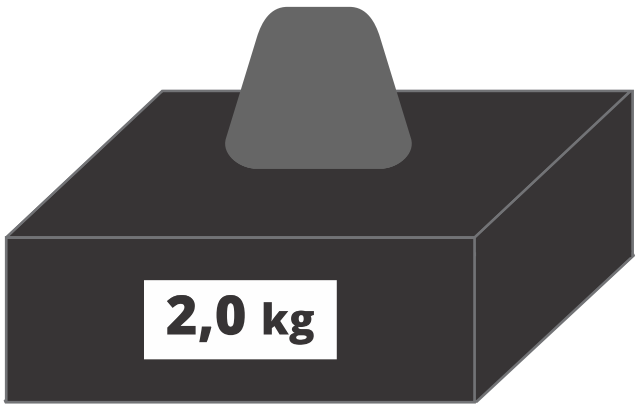
Volume = V_{fianl} - $V_{initial}$

Volume = ___ - ___

Volume = ___ ml

Exercise 2

The object on the right has a **volume** of **0,5m^3**.
a) Use the figure on the right to find the mass of the object and
b) Use a calculator to calculate its density.



a) Mass = ___ kg

b) Density = mass / volume

Density = ___ / ___

Density = ___ kg/m^3

Knowledge check: check what you have learned.

- [ ] What is **density**?
- [ ] Which **factors** affect **density**?
- [ ] How can we calculate the **volume** of a shape?
- [ ] What is **mass**?
- [ ] How could **dragons fly**?

Theory

What we will learn

Space exploration is probably the greatest achievement of the human history. From the first launch of a satellite in 1957 until today, many mysteries of our solar system have been unravelled. Orbiting satellites, landing probes and even manned missions are some of the highlights in this short lived era of space exploration. Have you ever questioned how to launch a satellite? Ever wondered about the threats and dangers astronauts have to overcome when living in space?

An astronaut floating in space

This booklet of **SPACE EXPLORATION** contains a great deal of useful information and amazing facts, so that you will learn all about space exploration and space science. Follow the **building instructions**, contained in this booklet and also online, to build exciting models such as **a space shuttle, a moon rover, a landing pod, a space rocket and a future space transportation bus**. Get on board in this journey to space and deploy your newly acquired knowledge.

The History of Exploration

Since the dawn of history humans were attracted by the stars of the night sky. Many civilizations believed that the celestial sphere was the perfect place for gods and superheroes to live. Many story tellers and mythological sagas were inspired by the deep desire of exploring the heavens.

The story of Icarus is one of the most known sagas of people flying in space. The young man was captured along with his father by the Minoan King inside the castle. They broke out by making wings from wax and managed to escape. Despite his father’s advise, Icarus attempted to fly close to the Sun but due to the heat, his wings began to melt, he fell into the sea and eventually died. The Icarian Sea in Greece was named after this legend.

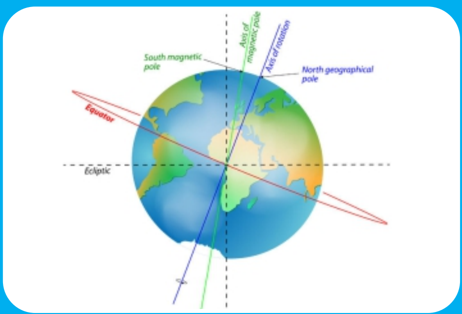
Space exploration became viable thanks to **Sir Isaac Newton**. He was the first man who understood that the same force which is responsible for objects dropping on Earth is also dictating the motion of planets in space. This force is caused by **gravity**. Newton could calculate the minimum velocity needed to escape the Earth’s gravitational pull. This is called the **“escape velocity”** of Earth and it is about 40000 km per hour! Escape velocity depends on the mass and size of an object. Hence, for the Moon this is much less, whereas for planet Jupiter it is larger.

Principles of rocket science

Space scientists had to invent special propulsion methods that would achieve these extremely high speeds. A Russian schoolteacher, **Konstantin Tsiolkovsky** (1857–1935), delivered a mathematical equation that could take into account many complicated factors during and after a rocket launch. Tsiolkovsky's equation became a fundamental concept of rocket science and it is still taught today! He is considered to be the father of astronautics.

Did you know?

We know that the Earth is rotating around its axis every 24 hours. Due to Earth's spherical shape, the equator is spinning faster compared to a place near the poles. In fact, the rotation speed on the equator is 1670 kilometres per hour. Therefore, launching a rocket from the equator demands less energy and less cost as it takes advantage of this initial speed! That's why the majority of space rockets are launched from locations near the equator.

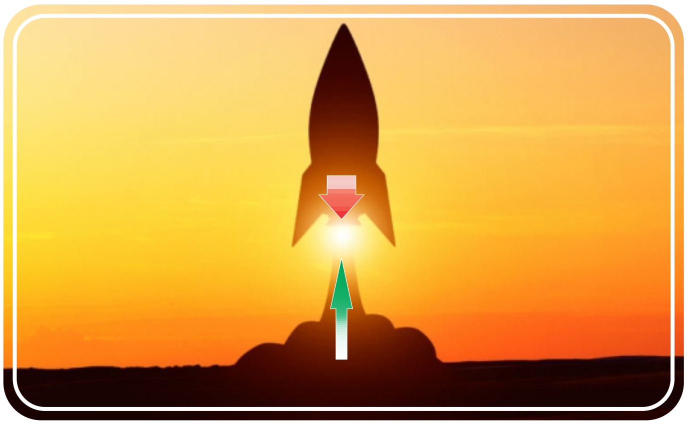


Earth spins faster in equator

Principles of rocket science

Rocket science was initially developed to create weapons that can cause damage from long distance. Rockets use liquid fuel which releases extremely high energetic gases that push the ground with a huge force.

According to Newton's third law, the ground pushes the rocket back with an equally huge force resulting in moving the rocket upwards in a very high velocity. This upward force is called **thrust.**



To achieve escape velocity, thrust should be sufficient to overcome the force of **gravity** which pulls down the rocket. There are two main forces acting on the rocket:

Thrust	The amount of **take off power** caused by the rocket's engine
Gravity & Drag	The **weight** of a rocket is pulled down to Earth due to gravity. Also, **air** resistance slows down a rocket.

Milestones of space era

1957

Space exploration began with the launch of *"Sputnik 1"*, the first satellite which was sent into orbit around the Earth. It had a diameter of 58 cm and carried 4 radio antennas for communication. Such an achievement triggered the race of conquering space!

1961

The first man who was sent to space was the Russian cosmonaut Yuri Gagarin. His journey lasted for 90 minutes, in which he completed one orbit of the Earth, travelling at 27,400 kilometres per hour.

1962

The first successful approach on another planet was achieved by *"Mariner-5"*. The probe approached planet Venus and sent back valuable information. We learned that Venus has a temperature near 500 degrees Celsius.

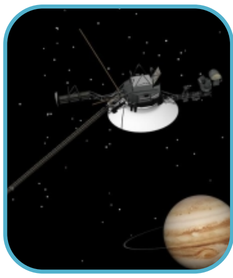
1969

The greatest time in space exploration was probably the first manned mission to the Moon. Neil Armstrong was the first man to walk on a body outside of Earth! After a three day journey, the mission of *"Apollo 11"* reached the Moon. This historic moment was televised to the entire world.

1970

The first robotic probe that collected sample from another body was *"Luna 16"*. It took about 100 grams of rock from the Moon, which was sent back to Earth. Robotics were proved to be less expensive for space missions.

1977



The Voyager 1 and *Voyager 2* spacecrafts were launched. They were the first objects which obtained escape velocity of the solar system. Today, both spacecrafts are about 17.3 billion kilometres away from Earth, located at the boundaries between our solar system and interstellar space.

1996

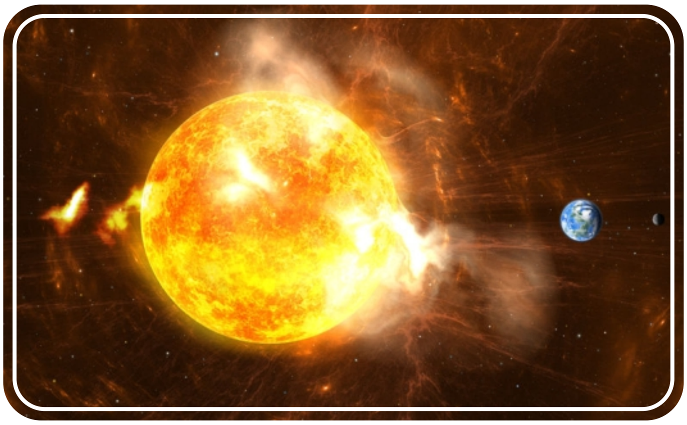
The first mission that successfully landed on Mars was the *"Pathfinder"*. The rover was 65 cm long and carried aboard 3 cameras which took the first pictures from the planet's surface.

1999

The assembly of International Space Station (ISS) got started. The station is in orbit at 400 km over the Earth surface and fully constructed after multiple missions. Today, the facility can accommodate up to six astronauts, and orbits the Earth in every 90 minutes!

2004

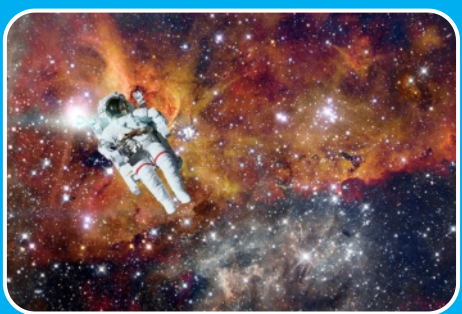
The *"Rosetta"* mission was the first probe to orbit and land on a comet. It took 10 years to reach the selected target. Finally, in November 2014, a robotic machine landed on the comet's surface.



The Earth’s magnetosphere has a more important application apart from pointing the needle of a compass to the north pole. It is providing a shield against solar wind to keep us safe! When a spacecraft leaves the Earth magnetosphere it is exposed to this radiation. Electronic devices can sustain this strong radiation. However, shielding astronauts during a long interplanetary travel remains a hard puzzle to be solved.

Did you know?

The word “Astronaut” comes from the combination of two Greek words. The word *Άστρον* (astron) means a star, while the world *Ναύτης* (nautes) means sailor. So, an astronaut is someone who sails among the stars. Russians use the word “Cosmonaut” instead, which has a very similar meaning. *Κόσμος* (cosmos) is also a Greek word which means Universe. Thus, spacemen can be called sailors among stars or around the Universe.

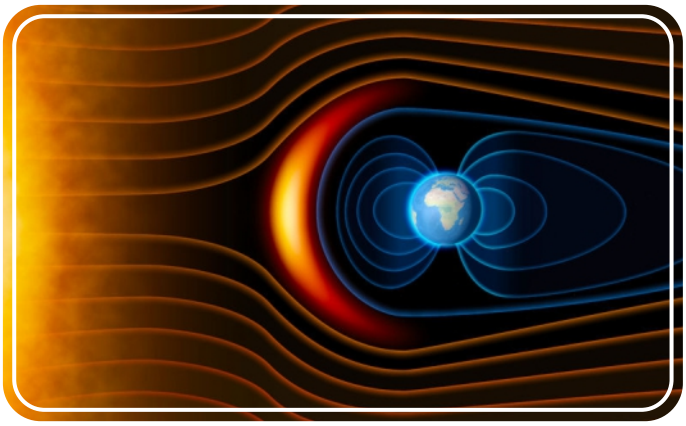


A spaceman “sailing” in space

Hazards in Space

Solar Wind and Radiation

Life on Earth is powered by the Sun. It provides heat to keep our planet warm, and radiation for vital biological activities, such as photosynthesis. However, the Sun is an extremely active star. In fact, high energetic particles leave the Sun with a speed of 400 km per second! This flow of material from the Sun is called **Solar Wind.**



Cruel conditions

Conditions on Earth are somehow unique throughout the Solar System. No other planet nor any celestial body is found to have conditions so friendly for life. For example, the Moon does not possess an atmosphere and astronauts who walked there had to wear special suits to keep them warm. Furthermore, they had to carry oxygen tanks for breathing. Space is an extremely cold place since the average temperature is near 150 degrees minus zero!

Lack of Gravity

Human bodies are used to operate under the experience of the Earth's gravitational force. The absence of gravity in space can affect the health of astronauts. Research has shown that living in zero gravity conditions can lead to serious effects on bone and muscle physiology. For instance, maintaining the appropriate blood pressure and blood flow to the brain is problematic. The International Space Station is equipped with specialized fitness machines, to keep astronauts strong and healthy.

Living In the International Space Station (ISS)

Eating in ISS

Since there are no shops in space, astronauts obtain their food by delivery service! Food supplies are sent from Earth in scheduled missions, to assure a proper nutrition of the crew. In the early days, their food was mainly in the form of cold paste in aluminium tubes and cube-shaped bites. Fortunately today, eating in space has improved a lot. The menu on the International Space Station includes more than 100 items. This includes frozen vegetables, fresh fruit, pre-packed meals, desserts, refrigerated food and dairy products.

Sleeping in ISS

The lack of gravity makes sleeping in space quite different. Astronauts have to sleep inside a sleeping bag which should be attached on a wall. They also tie themselves to assure that they will not float around. In addition, since the ISS is orbiting the Earth in every 90 minutes, there are 16 sunsets and sunrises every 24 hours! Thus, astronauts have a hard time knowing the right time for a sleep.

Spacewalks

Astronauts have to leave the station to install new equipment, perform experiments and do repairs. Depended on the operation, a spacewalk can last from a few minutes to many hours. For example, the construction of the ISS, which began in 1998, demanded over 1,000 hours in spacewalks. Astronauts are connected to the station with safety tether so they won't come adrift and get lost in space.

Did you know?

Reaserch in astronomy was boosted by the advent of space era, since telescopes in space can perform better. Launched in 1990, the Hubble Space Telescope is a legendary observatory which transformed the view we had about the Universe. With a mirror size of 2.4 metres and sophisticated scientific instruments astronomers unravelled deep mysteries about stars and galaxies.

The Hubble Space Telescope

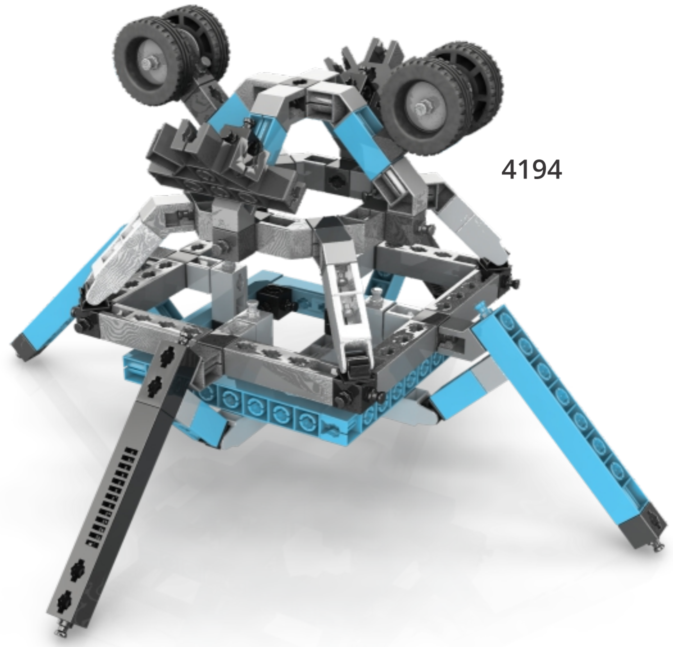
Models

Space Rocket

The *Saturn V* rocket is a legendary rocket of space exploration. It was developed to support the Apollo program, which was dedicated to manned missions to the Moon. Designed in 1962, this monstrous rocket was 110 metres tall, and 10 metres wide. Its total mass was about 3 thousand tons!

4199

All of the 9 *Apollo* missions to the moon were launched by this rocket. A total number of 24 astronauts travelled to the moon, but only 12 walked on its surface!



4194

It could lift off the ground and return with the crew back thanks to a small rocket . Similar landing pods are designed when missions are planned to land on other planets or comets. However, instead of astronauts they carry robotic rovers to be deployed and explore the territory.

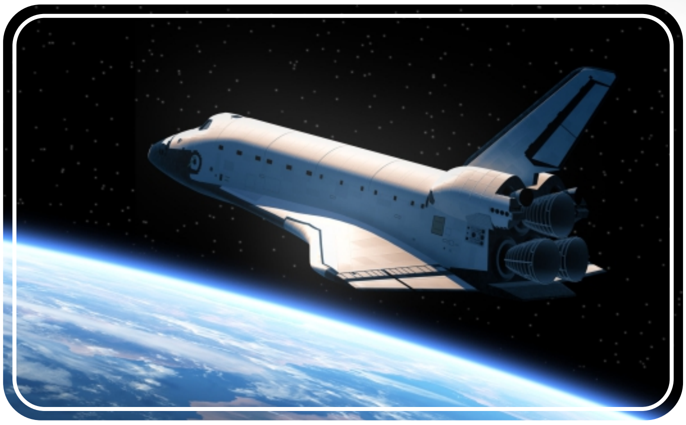
Landing Pod

A total of 6 missions of the Apollo program managed to transport astronauts on the Moon. Landing was a challenging task since there are no airports and the terrain on the Moon is rough. To solve this problem, the *Apollo Lunar Module* was designed. It was a specialized pod which could detach from the main spacecraft and slowly land on the Moon.

Space Shuttle

The American *"Space Shuttle"* program delivered an iconic symbol in space exploration. The program was designed so that the spacecraft can be attached to a rocket and sent to space, while it could be able to return back to Earth and land as an aeroplane.

4204



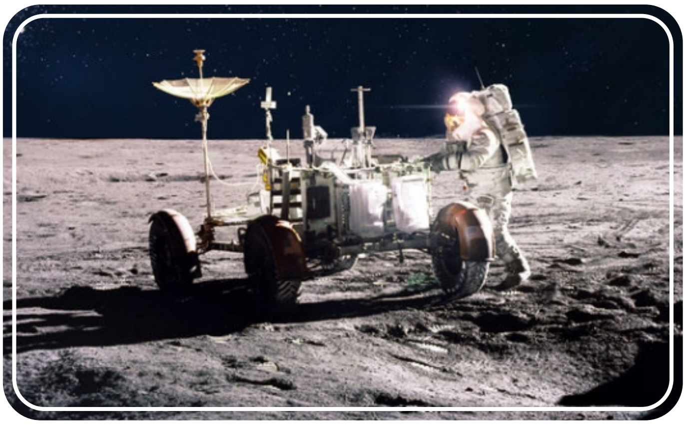
Its primary mission was to carry astronauts and equipment for the construction of the International Space Station. It also delivered several space telescopes and interplanetary missions. The Shuttle is the only winged manned spacecraft that has achieved orbit and landing. In addition, it is the only reusable manned space vehicle that has ever made multiple flights into orbit.

4203

Lunar Rover

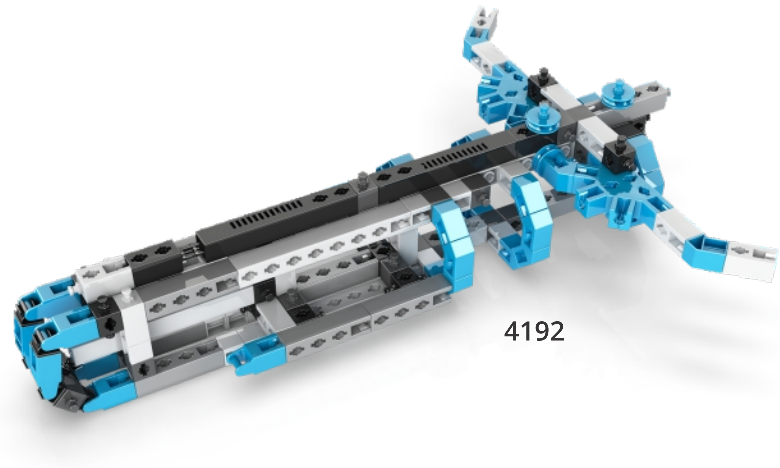
Astronauts of the 3 last Apollo missions had the opportunity to drive a rover on the surface of the Moon. Their car was named *Lunar Rover Vehicle* and allowed the astronauts to visit sites almost 8 kilometres away from their landing place. It was an electric vehicle which had a top speed of 13 kilometers per hour.

The rover was hinged inside the landing pod and occupied a volume not much bigger than a washing machine! All 3 rovers were left on the Moon, since folding them back to the pod was impractical.



Future Space Transportation

Travelling among distant stars and galaxies is unfeasible with the existing technology. Nonetheless, the research is very active on improving the efficiency of space travelling and bringing novel ideas into action.

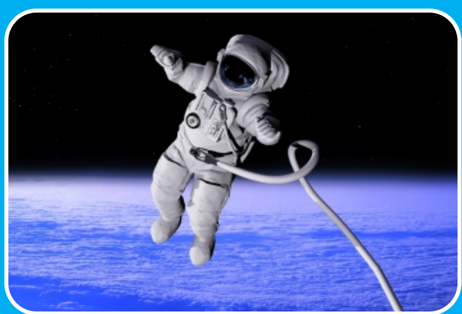


4192

An interesting prospect is space tourism, which includes adventures and entertainment in space for private personnel. Also, by improving space technology it could be possible to deliver packages worldwide in just 2 hours!

Did you know?

All objects (stars, planets, galaxies) attract each other because of gravity, which depends on the mass of the objects. Small objects (people, furniture etc) also attract each other, but the force is so weak due to the small amount of mass, that has no effect. In space, astronauts feel weightless because of the lack of gravity, while in larger planets they would weigh much more than in earth.



An astronaut weightless in space

Quiz

Do you know the answer of these questions? Write a ✓ into the correct box.

1. On which of the following objects the force of gravity is stronger on the surface?

☐ Earth ☐ Jupiter ☐ Moon

2. In which year the first man walked on the moon?

☐ 1969 ☐ 1961 ☐ 1970

3. Throughout all the Apollo missions, how many people have walked on the moon?

☐ 1 ☐ 24 ☐ 12

4. How long does it take for the international space station to make one orbit around the Earth?

☐ 24 hours ☐ 90 minutes ☐ 7 days

Experiment with the rocket launcher

As you have already learnt rockets use liquid fuels in order to escape from the Earth's gravity. Space exploration is made possible thanks to Newton's third law which states that for every action there is a reaction. Gravity pulls back anything that tries to escape from Earth. This force is so strong that the velocity needed to escape the Earth's gravitational pull is about 40000 km/h! Therefore, space scientists had to invent powerful propulsion methods that would achieve these speeds.


4192

The rocket uses liquid fuel that releases extremely high energetic gases that push the ground with a huge force. According to the third law, the ground pushes the rocket back with equally huge but in opposite direction force resulting in moving the rocket upwards in a very high velocity. The velocity that a rocket is required to gain in order to escape from the Earth's gravitational field is called escape velocity.

- How is the rocket velocity related with the offered energy?
- Which forms of energy does a rocket have when escaping from Earth?
- Is it easier or more difficult to launch a heavier rocket?

Are you ready to find out how spaceships can escape from the Earth's gravitational pull? Let's preform the next page's experiment to find out how a rocket achieves escape velocity!
Get ready to learn about energy and how it can be converted from one form to another.

Learning about: **Energy and Newton's 2nd Law**

Rocket Launcher

The first object to attain escape velocity of the Earth was the spacecraft "*Luna 1*" in 1959. Escape velocity is the minimum speed that an object should obtain to surpass the Earth's gravitational influence.

Discover:

- The energy conservation.
- Newton's 2nd Law.

Materials Needed:

- Engino® (ce301mm-a).
- Measure tape.

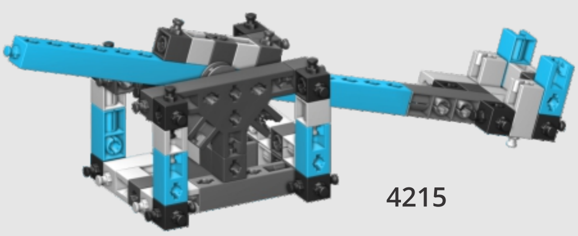
Procedure:

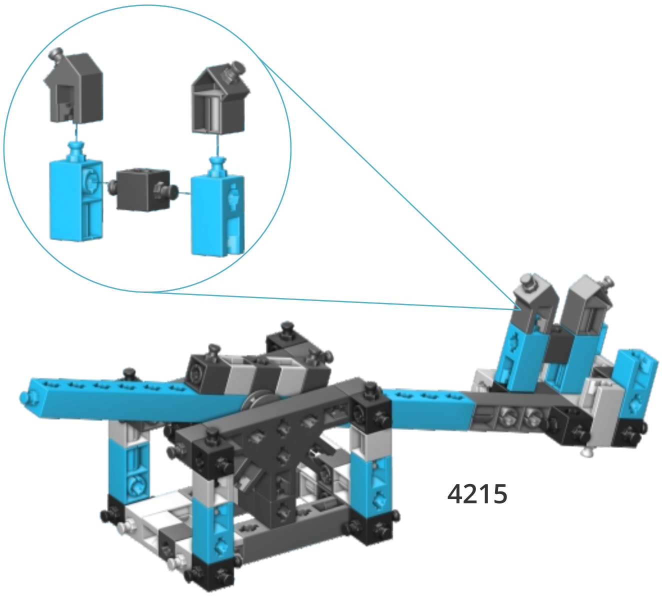
1. Find the instructions and build the **Rocket Launcher** model.

2. For safety reasons, it is better to conduct the experiment at a spacious place and make sure that no one is standing to the direction of the projectiles.

3. Place the rocket sample on the model as it is shown on the right. Hold the base of the model with one hand to keep it stable and apply a force on the edge of the rod with the other one. Observe what is happening and do **exercise 1**.

4. Place the rocket back to the model. Repeat a launch but in this case apply a **weak** force. Observe the distance the rocket travelled. Then, execute a second launch by applying a **greater** force to the rod. Observe the travelled distance and answer **exercise 2**.





1. Complete the sentences using the words from the box.

body, force, escaping, launched, velocity

As soon as you applied a .... to the rod, the rocket gained .... This is called conservation of energy. The energy from our ...., called chemical, was converted into another form of energy, called kinetic, and thus the rocket was .... A similar conversation of energy takes place when a rocket is .... to Space.

2. In which of the two cases (weak / greater force) did the rocket travel further? What is the relationship between the applied force and travelled distance?

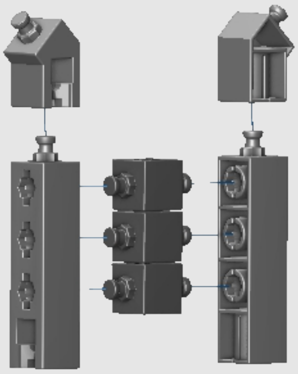
....

....

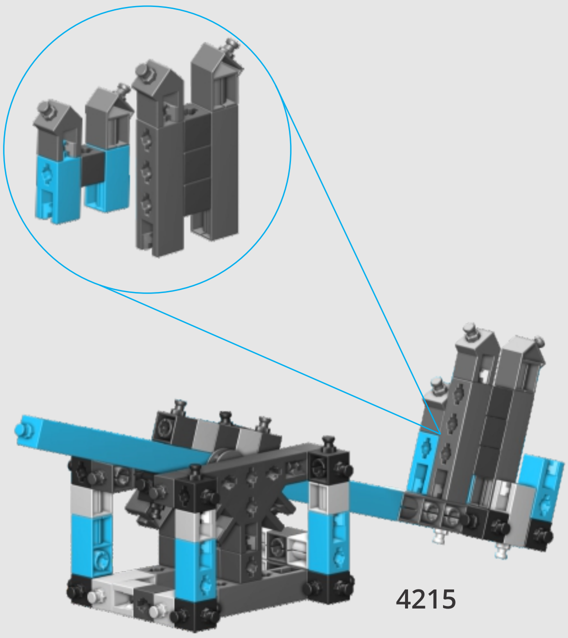
....

Procedure:

5. Build a second rocket sample as it is shown below.

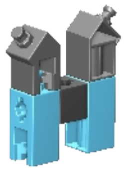
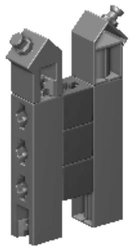


6. Load both rockets on your model. For this case you will be launching the two rockets **simultaneously**. Apply a great force on the edge of the rod and be careful **not to break the model**. A second person can be helpful to see the exact points where the projectiles hit the ground. Complete the table on **exercise 3** for the **1st trial**. Repeat the procedure two more times to complete the table.



7. Do **exercise 4** and **5**.

3. Put a tick ✔ to indicate which rocket launched further.

Rocket	1st Trial	2nd Trial	3rd Trial
1 			
2 			

4. Recall that the applied force is the same for the two cases. What is the difference between the two rockets? How does this factor affect the travelled distance you observed?

....

....

....

....

....

5. Which of the following statements are true and which are false? Put a √ to the correct box.

a) Launching a heavier rocket to space would demand more energy and more cost.

☐ True ☐ False

b) Energy conservation is not valid for rockets and spaceships.

☐ True ☐ False

Theory

Velocity and acceleration

In order to figure out the concept of Newton's 2nd law we need to understand the notion of velocity and acceleration first.

Any moving object has velocity. Velocity is the change in distance over time. In simple terms, if you are able to cover more distance in less time then you have a higher velocity.

Acceleration is the change in velocity of an object, from slow to fast or from fast to slow. Acceleration and travelled distance are interrelated.

Forces and Newton's 2nd law

We cannot see forces, but we can understand their effects when they are applied. In order to change the shape of an object, temporarily or permanently, a force must be applied on it. Forces also cause objects to change their motion. For instance we apply a force to make an object move, stop or change the direction of movement.

Newton's Second Law states that **the sum of forces acting on an object is equal to the mass of the object multiplied by the acceleration of the object.** Newton used the word "mass" as a way to say "quantity of matter" or "how much there is of something".

Advanced information:

From the formula it is obvious that force, mass and acceleration are interrelated! As a matter of fact, force is directly proportional to mass and acceleration. Therefore, for the same mass, the bigger the force the bigger the acceleration. Whereas to achieve the same acceleration, the bigger the mass the more force is needed.

$$\boxed{F = m \times a}$$

F = force
m = mass
a = acceleration

Formula for Newton's second law

Conservation of energy

Energy comes in many forms; we can see or feel energy in nature such as in winds, waves and sunlight or we can chemically produce it using for example fuels and batteries. A fundamental principal in physics is the law of **conservation of energy.** It states that in an isolated system the total amount of energy remains constant over time. Energy can only be converted from one form to another. When a spaceship escapes from Earth it converts the chemical energy (liquid fuels) into mechanical. Mechanical energy consists of two different forms, the kinetic and the potential energy which are explained below.

During any kind of energy conversion, some energy is lost to the surroundings. "Lost" does not mean 'disappeared', just that some of the energy has been wasted unintentionally to something else. In addition to the spaceship's example above the mechanical energy is less than expected due to the fact that some energy is converted into two other forms, sound and thermal energy.

Forms of Mechanical Energy

One of the most common forms of Energy is the **kinetic energy** which is the energy of any object in motion. The bigger the mass of a moving object and the higher its velocity, the more kinetic energy it will have.

An object that is not moving may still have the potential to do something! This "stored" energy is known as **potential energy**. There are various forms of potential energy, the most obvious one is the one caused by the Earth's gravitational pull. The bigger the mass of an object and the higher it is positioned the more potential energy it has!

For instance, if you hold up some books and then let them go, the potential energy will be converted into kinetic energy.

Quiz

Exercise 1

In the pictures below you can observe various forms of energy. Choose the correct one from the box, the **main form of energy depicted** in each picture and write it in the space provided.

kinetic, potential, thermal

.... energy .... energy .... energy

Exercise 2

A **force** of **20N** is applied to the golf ball which has a **mass** of **0.05kg**. Using the formula: **acceleration = force ÷ mass** calculate its acceleration.

acceleration = force ÷ mass

acceleration = ☐ ÷ ☐

acceleration = ☐ m/s^2

Knowledge check: check what you have learned.

- ☐ What is **velocity** and **acceleration**?
- ☐ What does **Newton's 2nd law** state?
- ☐ Which **factors** affect the **acceleration** of an object?
- ☐ What is **conservation of energy**?
- ☐ Which are the two forms of **mechanical energy**?