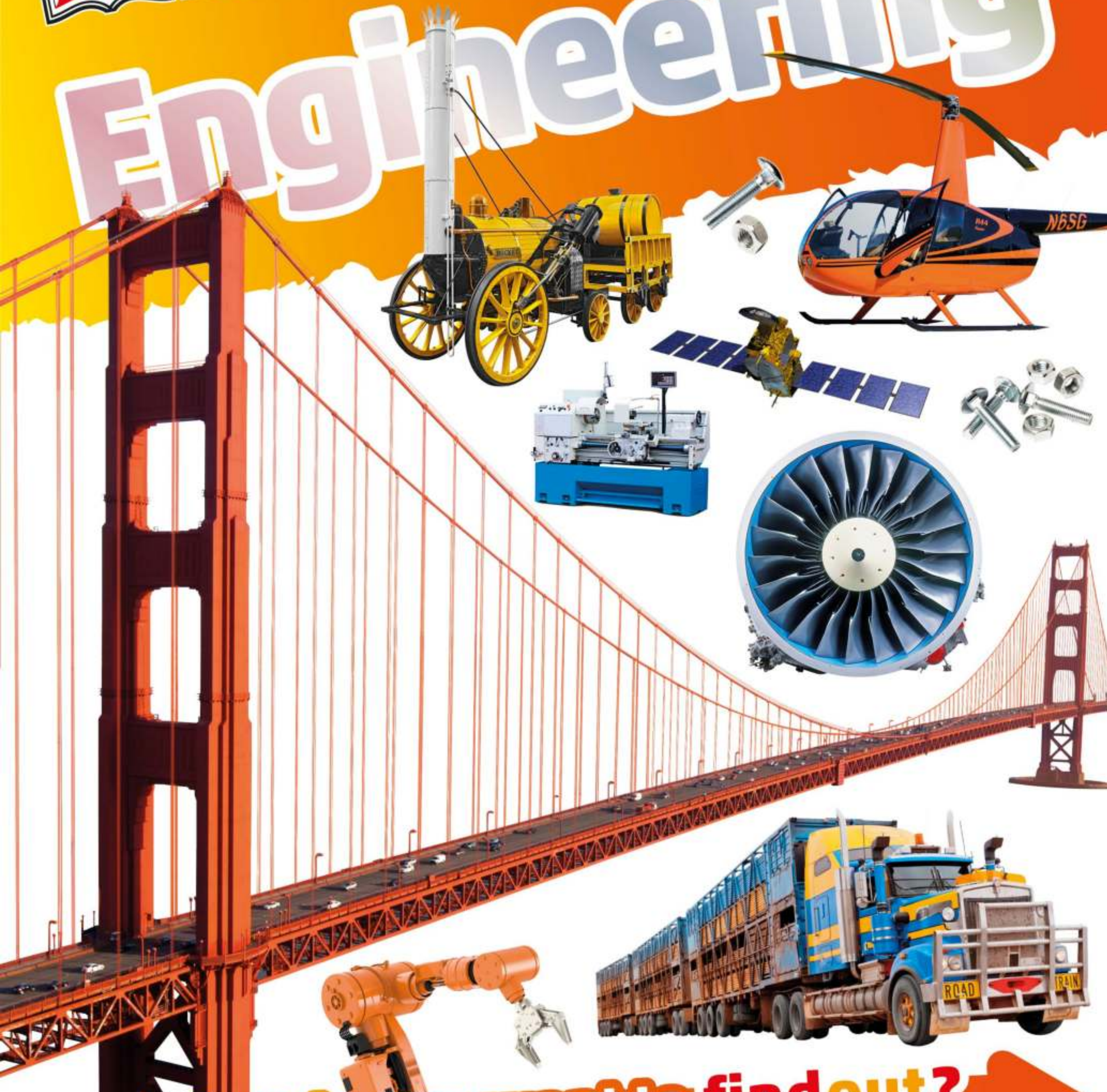
DK findout!

Engineering



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Fun Facts, Amazing Pictures, Quizzes

DK findout!

Engineering

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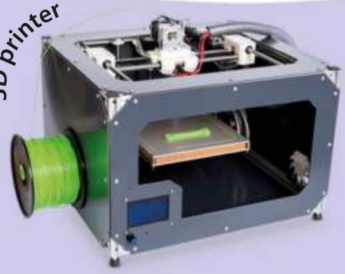

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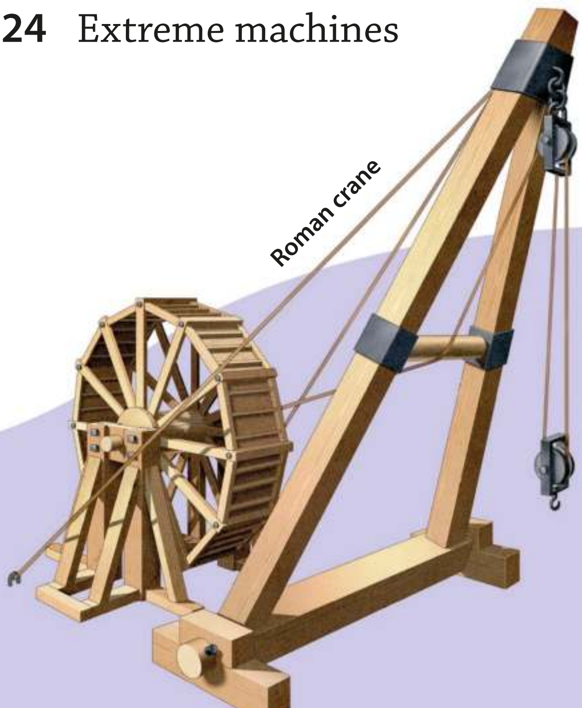
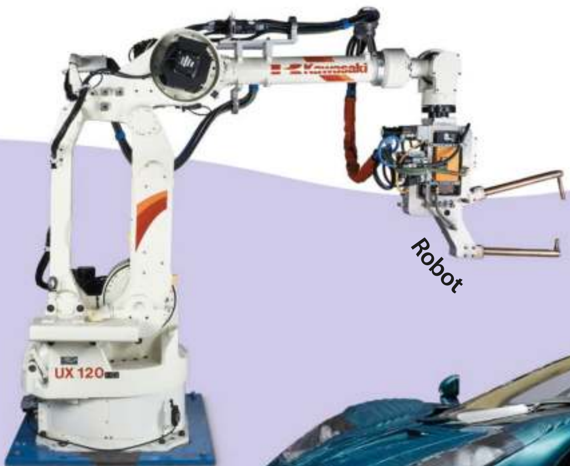


Drone

Skyscraper



Robot

Sports car

What is an engineer?

An engineer is a problem solver. Engineers use math and science to build things—from the tiniest particles to the tallest buildings. They invent new technologies, and make existing technologies even better.

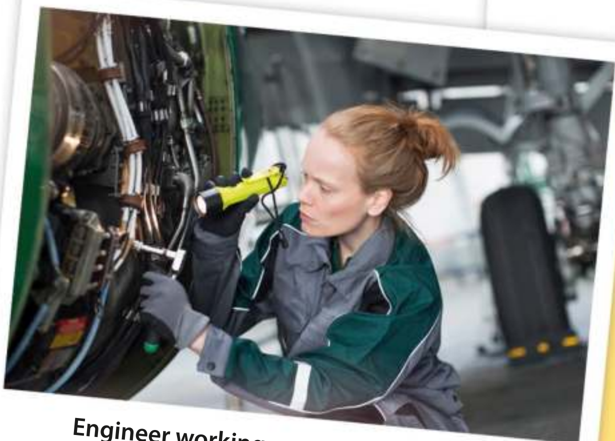
! WOW!

Engineers designed and built the **Pyramids**, the **airplane**, and the **iPad.**

New ideas

Engineers come up with ideas for new inventions, and make existing designs better. Your idea could lead to a medical device that helps cure an illness, a spacecraft that carries humans to Mars, a new clean power source, or an earthquake.

Testing the design of an Olympic bicycle in a wind tunnel



Engineer working on an airplane engine

Creative approaches

Being an engineer means coming up with solutions to difficult problems. Having studied math and science, engineers use their knowledge to design new systems and products that could change lives, from earthquake-proof buildings to cures for deadly diseases.

Engineers everywhere

Engineering is an exciting job if you love adventure. An engineer might create a new design on a computer and then get to travel to all sorts of places to help it be built and tested. Engineers work on giant jet engines, at the very top of wind turbines, under the ocean, and even in space!

An engineer at work on the International Space Station

Testing an undersea power cable on the beach in Zanzibar

Around the world

Engineers work in every country on the planet. While the building materials, landscapes, and problems that they face may be different, engineers use the same creativity and problem-solving methods wherever they work.

How do I become an engineer?

While you are at school, you'll learn a lot of the math and science you need. Later, you can go to college and study engineering. Most importantly, keep dreaming of new ways of solving problems!

First engineers

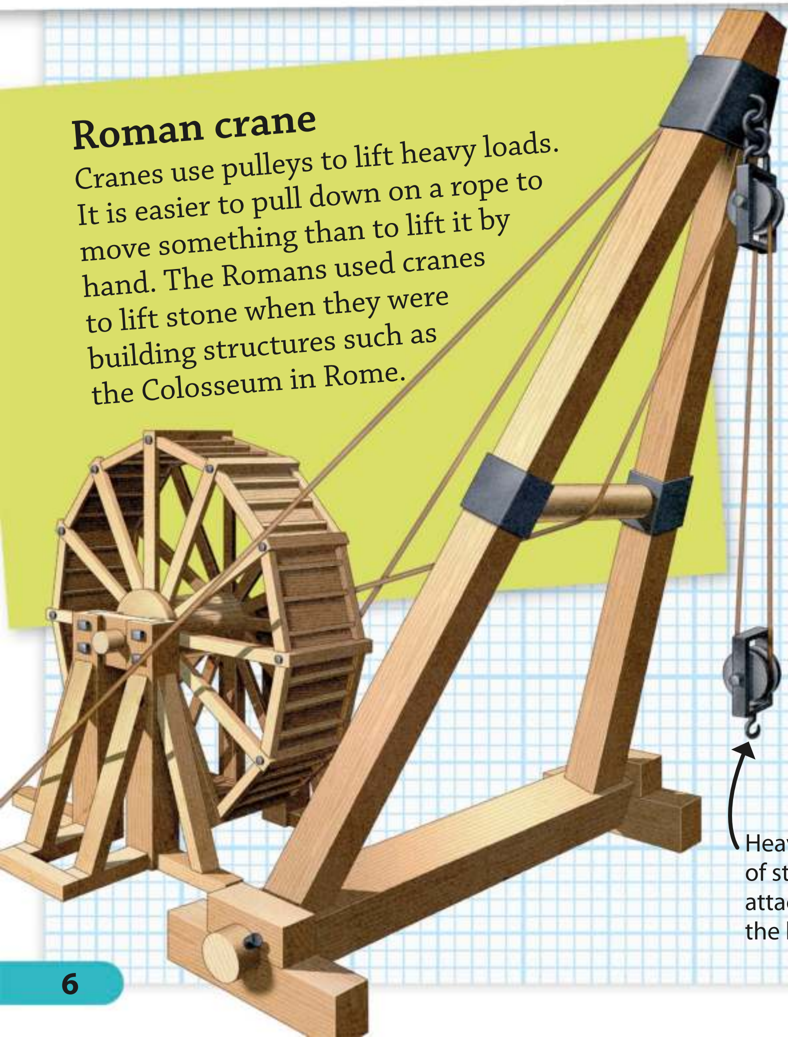
Ancient engineers had only simple tools to work with, but they built some of the world's most famous buildings, from the Pyramids in Egypt to the Parthenon in Greece. Some simple machines invented in ancient times include the lever, the crane, and the first clocks.

! WOW!

The first cities were built around 4000 BCE.

Roman crane

Cranes use pulleys to lift heavy loads. It is easier to pull down on a rope to move something than to lift it by hand. The Romans used cranes to lift stone when they were building structures such as the Colosseum in Rome.

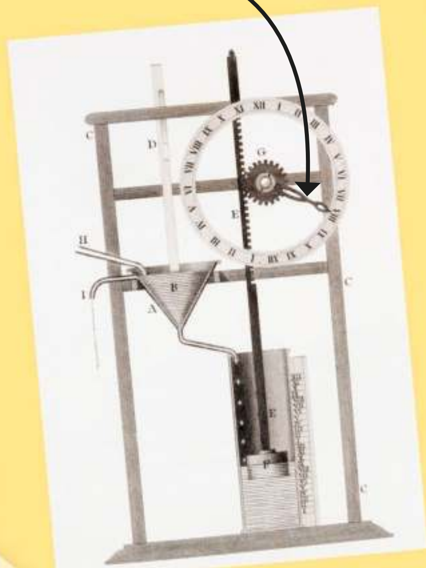


Heavy loads of stone were attached to the hook.

Ancient clock

Water clocks are one of the oldest ways of telling time. The hours could be measured because the water always took the same length of time to drip from one tank to another.

As the water rises, the hour hand turns.

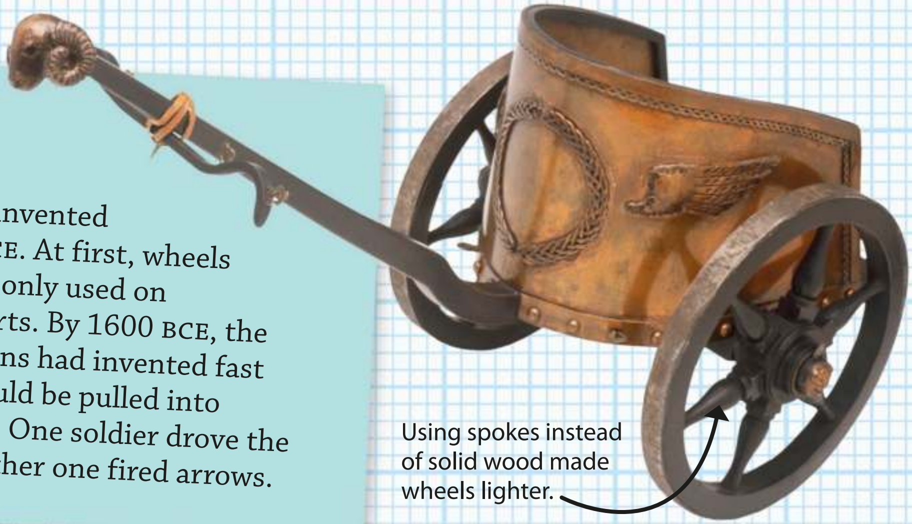


Useful levers

Levers are bars that rest on a point called a fulcrum. They make it easier to push or lift weights. The long handles of a wheelbarrow act as a lever, with the wheel as the fulcrum. Wheelbarrows were invented in China around 220 BCE.

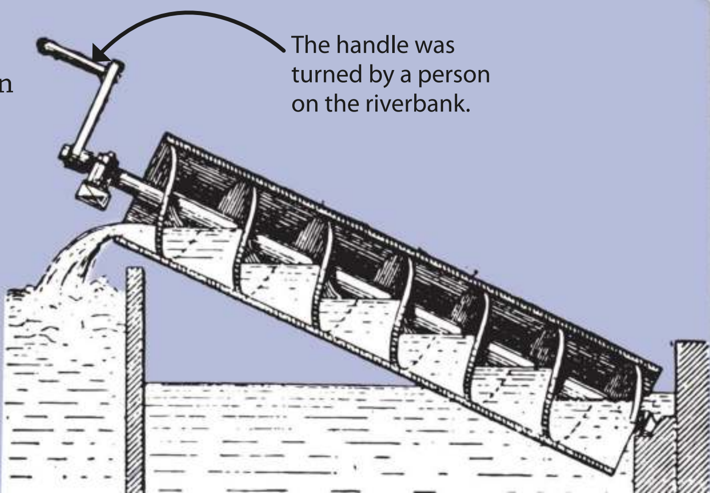
Wheeled chariot

The wheel was invented around 3500 BCE. At first, wheels were heavy and only used on slow-moving carts. By 1600 BCE, the Ancient Egyptians had invented fast chariots that could be pulled into battle by horses. One soldier drove the chariot and another one fired arrows.



Water lifter

The Archimedean screw is an Ancient Egyptian invention for lifting water. A wooden spiral is built inside a tube, with one end in the water. When the handle is turned, the water is trapped in the spiral and lifted to the top.



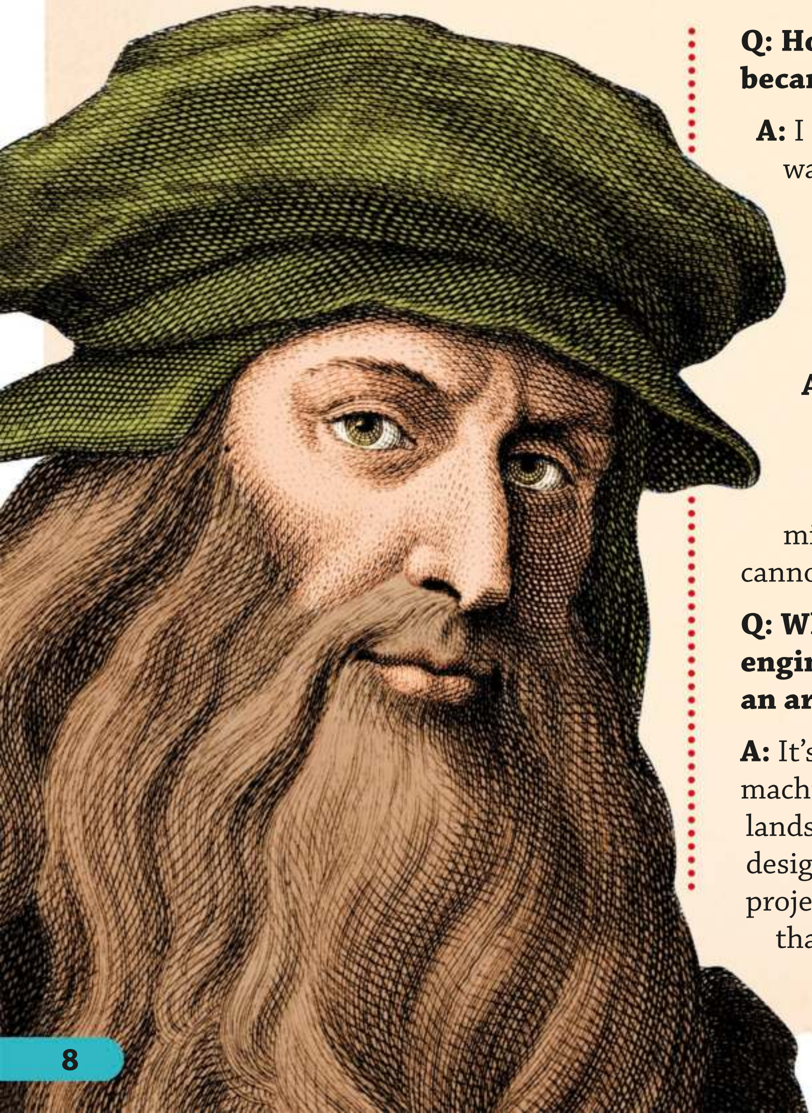
Interview with **Leonardo da Vinci**

Genius inventor

Leonardo da Vinci is best known as the artist who painted the *Mona Lisa* but he was also a self-taught engineer. He was fascinated by how everything worked—from the human body to military machines. Here, we imagine what an interview with da Vinci might have been like.

FACT FILE

- **Name:** Leonardo da Vinci
- **Dates:** 1452–1519
- **Location:** Vinci, Italy
- **Fun fact:** Da Vinci loved all animals. He bought caged birds so that he could set them free.



Q: How old were you when you became an engineer?

A: I didn't get an engineering job until I was 30 years old. After that, I worked as a military engineer for 17 years in the city of Milan, Italy.

Q: How did you get your first job as an engineer?

A: In the 1480s, the people of Milan needed help because they were at war with the city of Venice. I wrote to Duke Sforza telling him about my military inventions, such as a huge cannon. He loved my ideas!

Q: Why were you interested in engineering when you were already an artist?

A: It's as much fun to design amazing machines as it is to paint people and landscapes. I can use my drawing and designing skills to design my engineering projects. Also, engineers are paid a lot more than artists in the 15th century!

Q: What are your favorite projects?

A: I designed weapons such as tanks, catapults, submarines, and machine guns. I also worked on better levers, gears, and cranes. But my favorite inventions include machines for flying and breathing underwater.

Q: Some people say you have designed a self-moving machine. Is this true?

A: Yes! In 1495, I came up with plans for a wind-up, self-moving machine with three wheels. I didn't manage to make it work in real life, though.

Q: What is your greatest weakness as an engineer?

A: I am easily distracted by new ideas, and I often leave projects unfinished. I only managed to finish 17 paintings.

Da Vinci's design for a parachute, made from wood and cloth.

In 2000, da Vinci's parachute was finally built and floated safely down 2 miles (3 km).

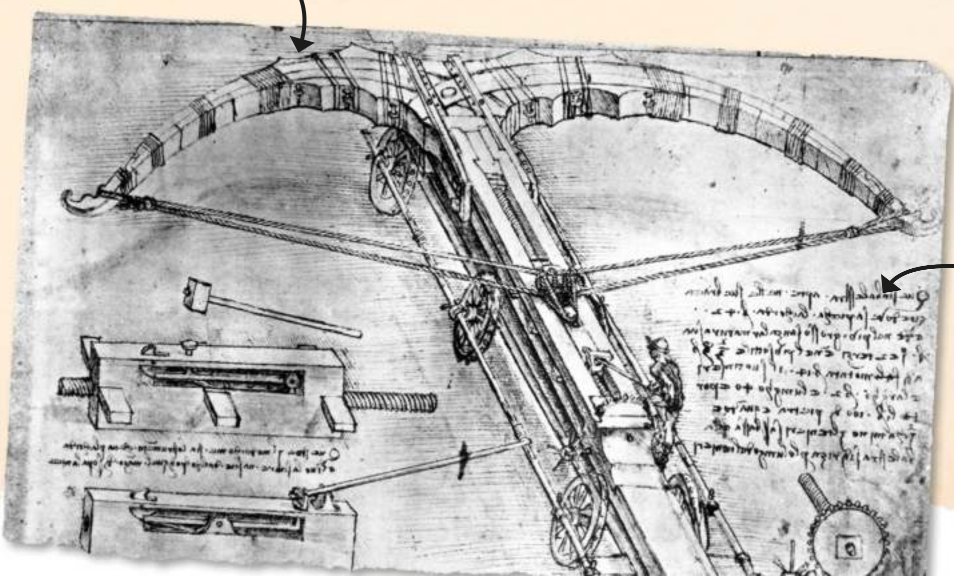
Q: What do you think is the most important skill for a good engineer?

A: Creativity and imagination! Engineers must be able to look at a project that has already been started and see how to make it even better in the future.

Q: Did any of your projects fail?

A: My design for a huge statue of a horse was ready to be built when Duke Sforza gave all the bronze away! He used it to bribe an enemy army not to attack Milan.

Da Vinci designed this catapult like a giant crossbow.



Da Vinci wrote backward to keep his thoughts secret.

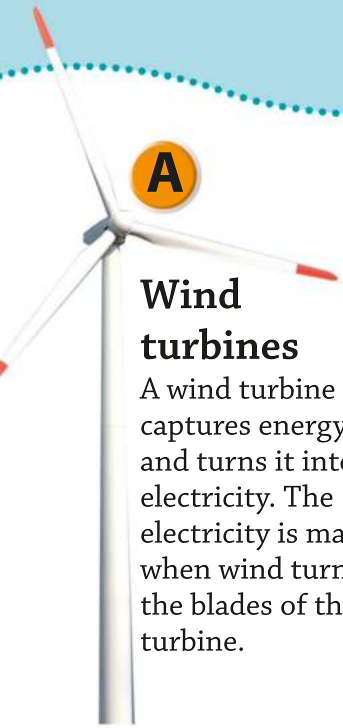
Match the problems with the solutions.

1 How did the Romans get water to their towns and cities?

2 How can food be kept cool?

3 How can we turn wind energy into electricity?

4 How can more buildings be built if there isn't any room left in a city?



A

Wind turbines

A wind turbine captures energy and turns it into electricity. The electricity is made when wind turns the blades of the turbine.

B

Satellites

A satellite sends live TV signals and telephone calls around the world. Satellites in space are linked to some on Earth, which pick up signals and turn them into pictures and sounds.

Hudson Yards

This group of new buildings is being built on top of a railroad line in New York. It will include hotels, stores, schools, houses, and parks.

F

Problem solving

Engineers look at the problems that we face in everyday life and try to make our lives more comfortable, quicker, and easier. Engineers have solved problems like keeping cool in the summer, developing energy from nature, getting food from farms to stores, flying, and exploring space. Take the quiz to match the problem with its invention.

5

How can we get people to and from the International Space Station?

6

How do the pictures get onto our television screens?

! WOW!

Engineers can remove **salt** from **seawater** so it can be used for **drinking.**

D

Soyuz craft

The *Soyuz* craft can carry three people into space. It also carries food and water.

C

Refrigerator

A refrigerator works by changing a substance called a coolant from a liquid to a gas and back again. This series of changes keeps the space cold and food fresh.

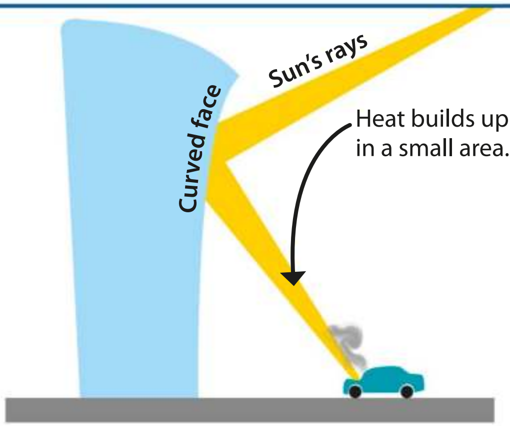
E

Aqueducts

An aqueduct is designed to carry water slowly from a hillside into a town.

Changing ideas

The "Walkie Talkie"" skyscraper in London was designed with a curved shape that reflected the Sun's rays and accidentally melted part of a car. Engineers designed a protective shade for the building to solve the problem.



The "Walkie Talkie," London

Materials

Everything around us is made from something. We call these somethings "materials." Engineers create, change, and test materials that we use every day. Our phones, cars, and even babies' diapers are all made from carefully chosen, specially engineered materials.

Plastic

Plastics are manufactured materials. They are cheap to produce and have insulating properties, which means they keep heat in or out.

Ceramics

Ceramics are materials formed at very high temperatures. Most ceramics are very hard, but brittle, which means they break easily.

Some engine parts are made from ceramics.

Fabric

Engineers can create fabrics with special abilities—for example, fabrics that block harmful rays from the Sun. Some clothing is designed to pull sweat away from the body, using tiny threads that are very close together.

Metal

Metals have a solid structure, which makes them strong. They can be bent into many different shapes—from staircases to long thin wires. Metals conduct electricity, which means an electric current can move through them.

Composite

A composite material is created when two or more materials are combined to make a new one. Engineers make composite materials that are strong but very light.

Wood

Wood is a natural material from trees. Engineers add other materials to the surface of wood to stop it from rotting. Wood is used as a building material all over the world.

Concrete

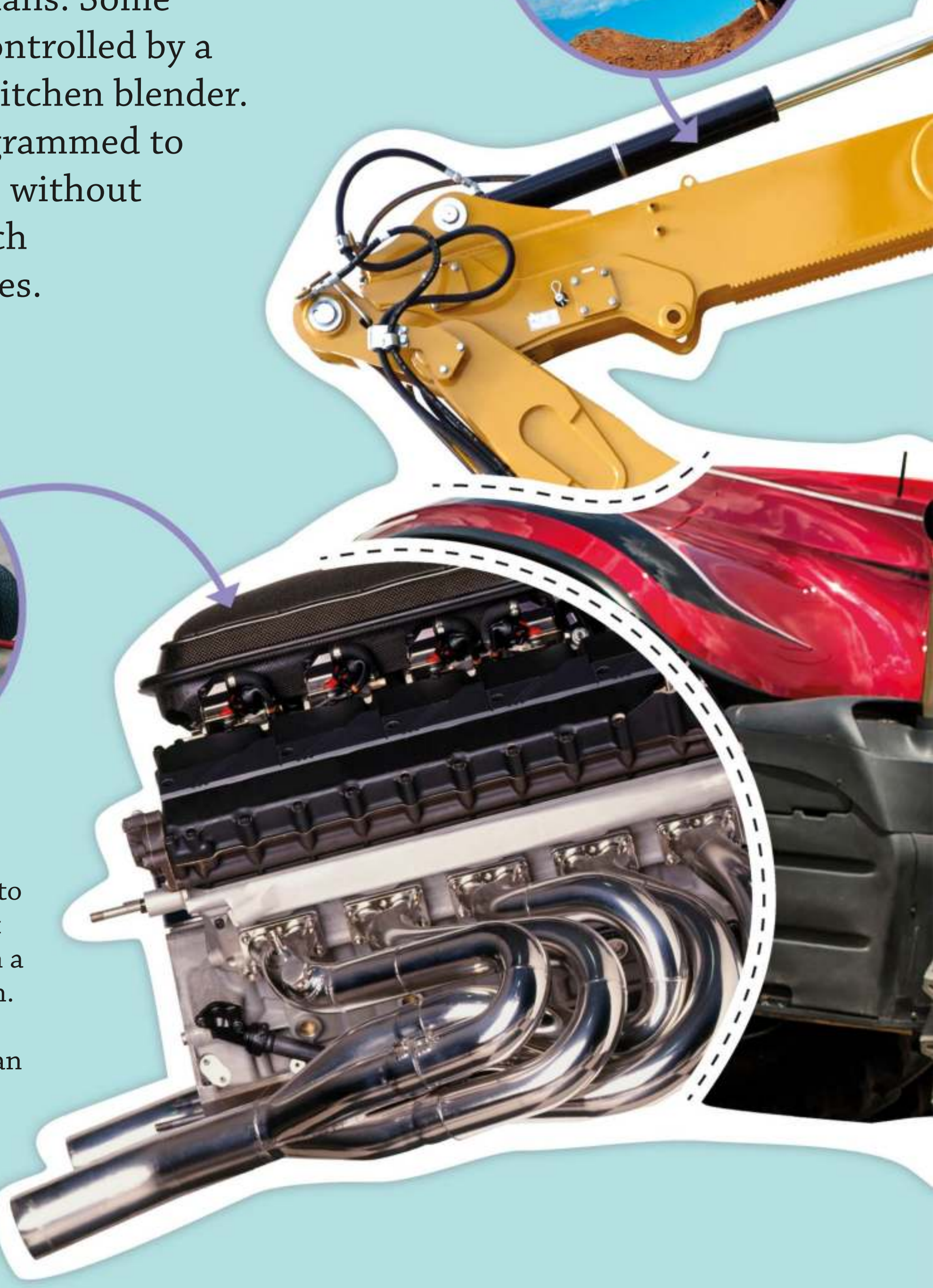
Concrete is used for many structures, such as buildings, bridges, and streets, because it can hold heavy weights without being crushed. It is made from a mixture of cement, stones, and water.

Machines

Machines can do tasks that are too tiny, huge, boring, or dangerous for humans. Some machines can be controlled by a human, such as a kitchen blender. Others can be programmed to follow instructions without human control, such as driverless vehicles.

Digger with crane arm

Formula 1 car



Engine

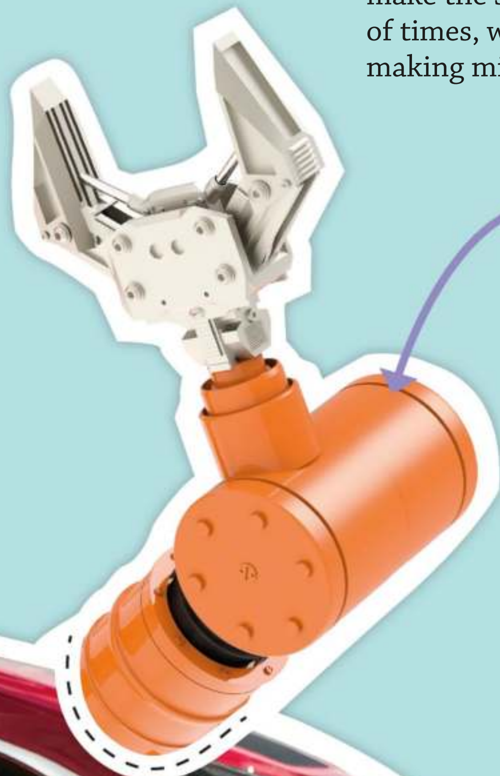
A car's engine burns fuel to spin its wheels, moving it forward much faster than a human could possibly run. Formula 1 racing cars use very powerful fuel, and can travel at up to 231 mph (372 kph).

Crane arm

By using levers and hydraulic power (water pressure), crane arms are able to lift much more weight than humans could ever manage.

Robotic arm

Robot arms can precisely grip and lift small parts, so they are useful for making goods such as cars. Robots can make the same movements hundreds of times, without getting tired or making mistakes.



Sending out packages

Driverless tractor

Driverless technology allows farmers to mow and plant their fields from home! They put instructions into a computer, and then the tractor does all the work.

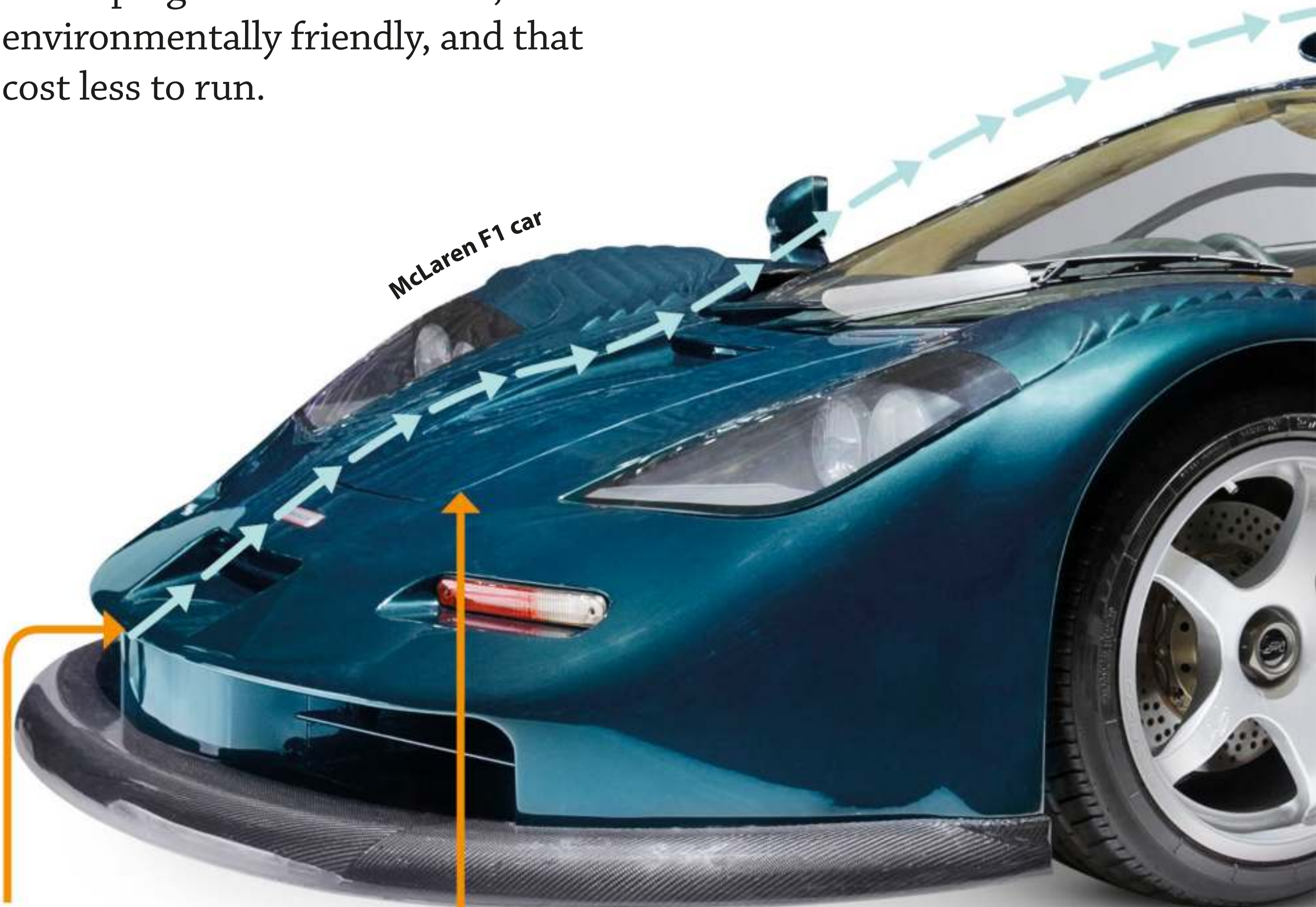
Self-driving tractor

Cars

The first car was made over 120 years ago. It was called the Benz Motorwagen, had three wheels, and could only go as fast as 6 mph (10 kph). Modern cars have four wheels and can reach speeds of up to 273 mph (439 kph). Engineers are always developing cars that are safer, more environmentally friendly, and that cost less to run.

Fit for purpose

Cars are used for lots of different tasks. Some need to be able to go very fast, carry a lot of people, or move heavy materials a long way. Engineers keep these specific needs in mind when they design a car.



Smooth shape

The car has a smooth shape so that air can pass easily over the body. This lets the car travel faster.

Hood

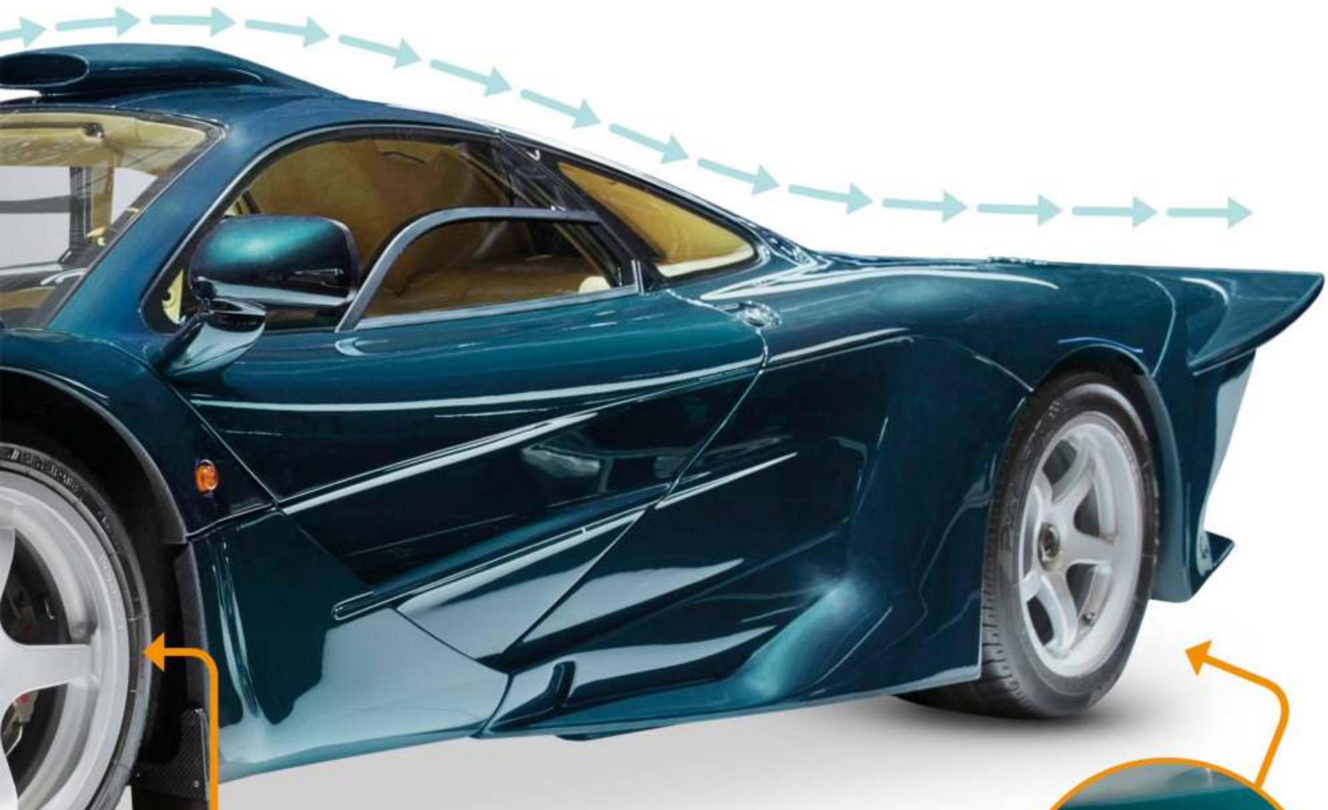
In most cars the engine is under a lid, called the hood. In the McLaren F1, the hood has a gold layer inside, which protects the car from the heat of the engine.

Electric car

Battery powered
Engineers have created cars that run off big rechargeable batteries. These batteries are charged by electricity. They are better for the environment because they do not release any gas.

Off-road driving on sand dunes.

Tricky terrain
For tough, bumpy surfaces cars need to have a special design and shape. They have big tires so they are higher off the ground. This keeps them more stable and makes sure they don't trip over any obstacles.



Tires

A tire's tread is the pattern of grooves that you see on the outside. They let water pass underneath and help the car grip the road.

Exhaust

The exhaust lets the hot gases produced by the engine escape. The pipes of the exhaust remove the gases as quickly as possible.

Power

We need electricity to run most machines—from ovens to space rockets. Engineers design and build the different structures that create electricity. Most electricity is made in large power plants from burning fossil fuels, or using renewable sources such as wind or water power. Steam is created that then turns a turbine, a machine with blades that spins so quickly it can create electricity.

Power networks

Electricity is transported from power plants to homes and offices through aluminum cables. They are held above the ground by metal towers called electricity pylons.

Electricity pylons

Fossil fuels

Coal, gas, and oil are all fossil fuels. These are made up of the squashed remains of plants and animals. When they are burned, they heat up water to create steam, which then turns a turbine.

Water power

Water flowing downhill can turn a turbine to create power. Engineers make use of this by building dams with turbines in them. Ocean waves and currents can also be used.

Wind power

The arms of wind turbines turn when the wind blows, which creates electricity. Large turbines create a lot more power. Modern turbines can be more than 328 ft (100 m) tall!

Solar power

Solar panels are made up of cells that absorb sunlight. The light is then turned into electricity. Solar panels work best where there is lots of sunlight and hardly any clouds.

Geothermal power

Geothermal power uses the natural heat of the Earth. One way to create power is to pump cold water deep under the Earth's surface, where it is so hot it turns into the steam needed to turn a turbine.

Nuclear power

Nuclear power uses a process called fission, where atoms are split apart. The heat this creates boils water to make steam, which then turns turbines to produce electricity.

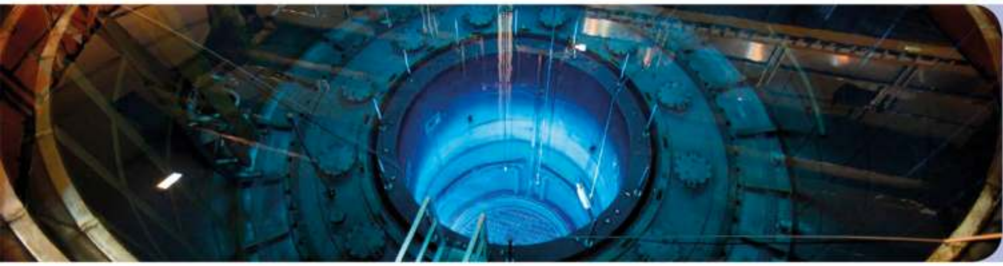
Coal power plan
The white smoke rising from the towers of coal power stations is steam from the boiling water used to turn the turbines that make electricity.

Hydroelectric dam
Dams turn rivers into lakes, which create higher pressure. The weight of the water rotates turbines inside the dam.

Wind farm
Groups of wind turbines are called wind farms. They are built where there are few people and strong winds. Some are even built out at sea.

Solar farm
The energy produced from a single solar panel is very small. Solar farms have large groups of solar panels, called arrays.

Geothermal power
Places like Iceland and Japan have hot areas under the Earth's surface. This makes it easier to heat up water to create geothermal power.



Nuclear reactor
Just 1/3 oz (6 g) of nuclear fuel can make as much energy as 1.1 ton (1 metric ton) of coal. However, the uranium used to make nuclear fuel is rare.

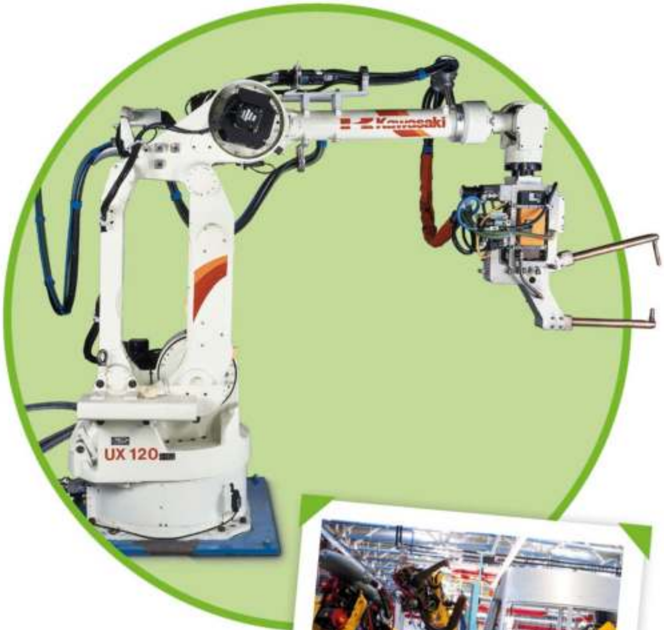
Humanoids

Humanoid robots look and move like humans. They can work with tools and let engineers learn more about how the human body works and moves. A humanoid with a human face is called an android.

Robot workers

Robots can be used to do jobs that need care and speed. They are used to build cars, carry out surgery, and harvest food on farms. Some of these robots are controlled by humans, while others are programmed to work on their own.

Asimo is the most advanced robot in the world. It can move like a person and can recognize humans.



Some robots work together on factory production lines to make cars. Each robot does the same job over and over again.

Robots

Robots are machines that are built by engineers to do jobs and perform actions that would otherwise be done by a human. Robots do the things that people do, but with more force and speed, and more precisely. There are more than a million robots in the world—they are all around us!

Robot body parts

Engineers have created robotic body parts that can be attached to humans. These robotic body parts are called prosthetics. They are controlled by the brain of the person wearing them.

Hard to reach

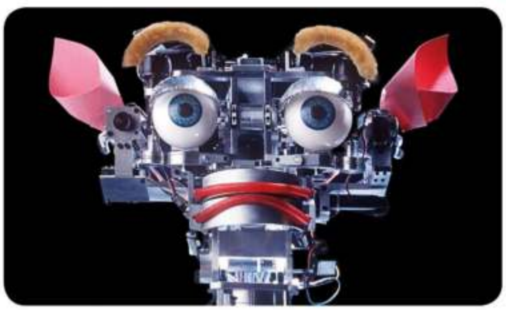
Robots can reach places that humans can't. They are used underwater, in space, and underground, because these places can be dangerous for humans. They find objects, collect data, and take pictures.

Robot arms move in the same way that real arms move. They are powered by batteries.

Kurt I is a robot that works in the sewers. It makes sure everything is working properly and fixes things that aren't.

Robots with feelings

The big difference between robots and humans is that humans have emotions. Engineers have made robots that respond to a human's feelings. One of these robots, Kismet, responds to the feelings of the person it is communicating with by moving its face and changing the tone of its voice.



Kismet

Incredible engineers

Everything around us started out as an idea. Great thinkers have dreamed up new inventions to improve our daily lives—and they continue to do so. From early machines and basic technologies to soaring skyscrapers and futuristic robots, the engineering industry continues to shape our world.

George Stephenson

Known as the "Father of Railroads," George Stephenson (1781–1848) designed and built the first commercial locomotive. The *Rocket* was the first vehicle to go faster than a horse, at 29 mph (47 kph).

A working replica of Stephenson's *Rocket*

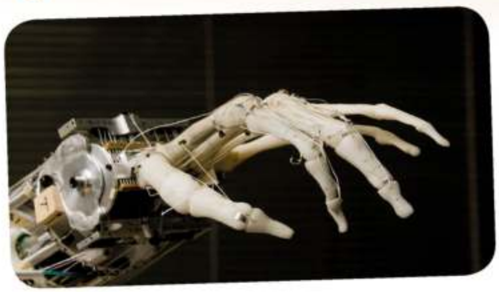
Lillian Moller Gilbreth

Engineer Gilbreth (1878–1972) improved the layout of kitchens in America and the efficiency of household items. She was the first woman elected into the National Academy of Engineering.

Gilbreth calculated the best height for ovens

Yoky Matsuoka

Computer scientist Yoky Matsuoka (1972–) is using robotic technology to help disabled people become more mobile. Her model of a robot hand is the first step in creating a prosthetic hand controlled by the brain.



Matsuoka's ground-breaking robotic hand

Isambard Kingdom Brunel

Engineer Brunel (1806–1859) designed and built ships, bridges, and railroads. His *SS Great Britain* was the first iron steamship with a propeler to cross the Atlantic. He also worked on the first tunnel to be built underwater.

SS Great Britain

Alexander Graham Bell

After working as a speech therapist for deaf people, scientist Alexander Graham Bell (1847–1922) invented the telephone. Speech could be sent along wires for the first time, changing the way we communicate.

A man uses one of Bell's first telephones

Dr. Maggie Aderin-Pocock

Space engineer Dr. Maggie Aderin-Pocock (1968–) works on satellites that gather information on climate change. She also invented a tool for the huge Gemini Telescope, which is 26.6 ft (8.1 m) wide.

The Gemini Telescope in Chile

! WOW!

Bell's first telephone message was to his assistant: "Mr. Watson, come here! I want to see you!"

Extreme machines

These amazing machines are all extremely big, heavy, or powerful. This means they are perfectly suited to doing certain jobs, such as lifting, carrying, or drilling.

GIANT DRILL

Tunnel boring machines are used to dig giant tunnels underground for roads and railroads. The largest one in the world is named Bertha. It can drill or bore a hole as tall as a five-story building.

Road train

Some Australian outback trucks can pull three long trailers. These megatrucks, called road trains, can be as long as two basketball courts and carry the equivalent weight of 40 elephants!

NUCLEAR SUBMARINE

The Russian Typhoon Class are the world's biggest submarines. They are 574 ft (175 m) in length—longer than five blue whales. They can stay underwater for four months at a time, are nuclear-powered, and carry weapons like missiles.

Super Guppy

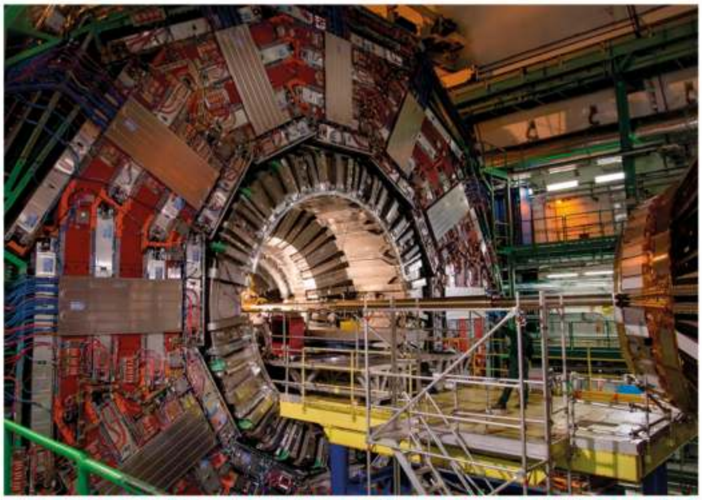
This enormous but strange-looking plane was built by NASA to transport large cargo, such as satellites, rockets, and smaller planes. It opens in the middle, allowing the cargo on and off.

GANTRY CRANE

The largest crane in the world is the Taisun gantry crane, currently in Sandong Province, China. It can lift 22,000 tons (19,600 metric tons), and is used to move large materials around and build boats in shipyards.

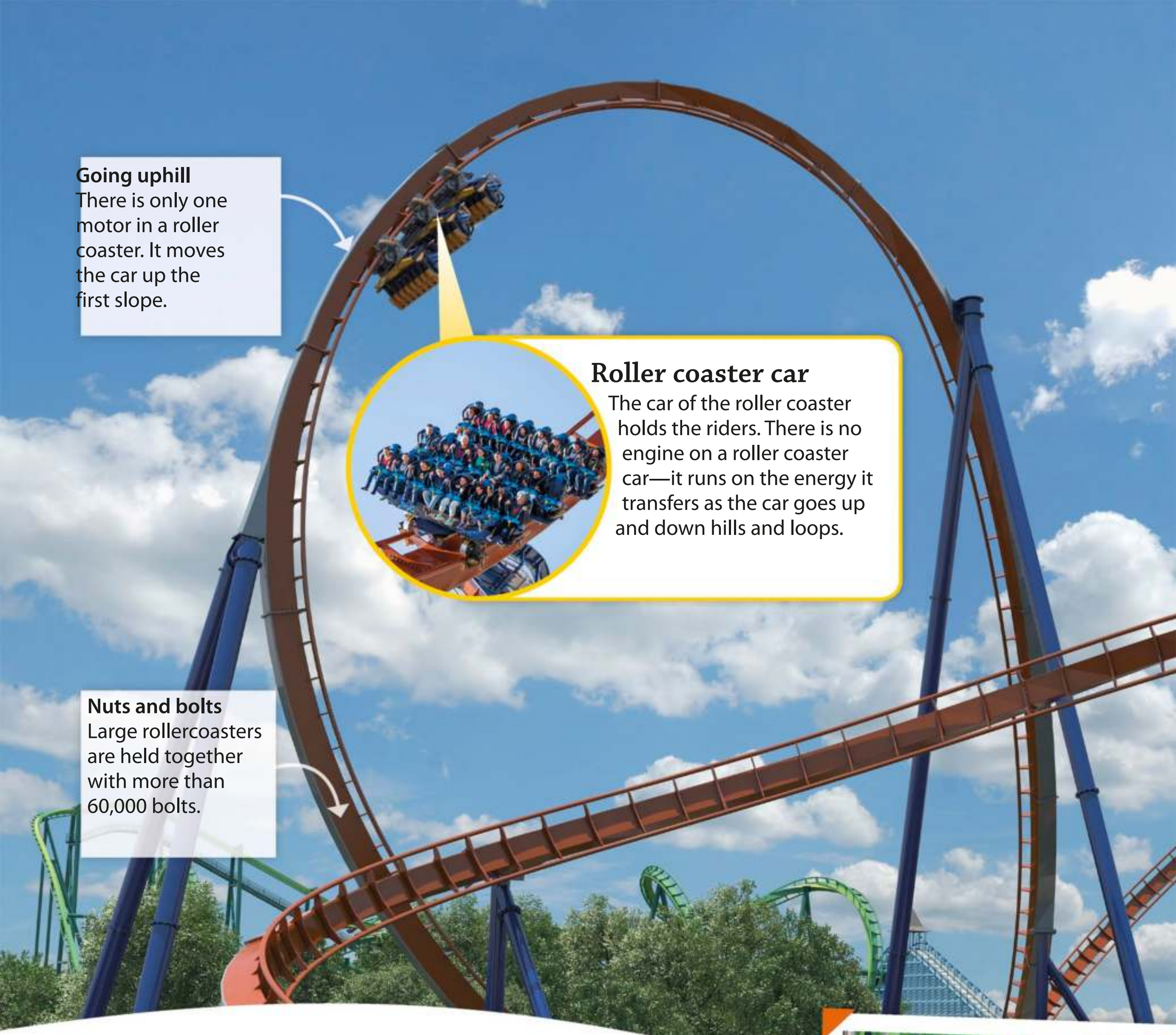
HADRON COLLIDER

This particle accelerator is used for physics experiments that try to understand how the world began and what it is made out of. It uses magnets to “shoot” particles extremely fast, and is the world’s biggest machine. It is in Switzerland and is almost entirely underground.



Supercarrier

The American Nimitz Class are the world’s largest aircraft carriers. Carrying over 6,000 people, they can go 20 years without refueling. The flight deck holds more than 60 aircraft!



Roller coasters

Engineers create complicated and careful designs to make roller coasters safe and fun. Mechanical, electrical, and structural engineers all work together to imagine, design, and build these exciting machines.


Upside down

WOW!

The **Kingda Ka** in the **US** is the tallest roller coaster in the world. Its tallest point is **456 ft (139 m)** from the ground!

Wheels
Wheels prevent the car from wobbling and falling off the track.

Brakes
Roller coasters have magnetic, automatic breaks so that the cars can be stopped.

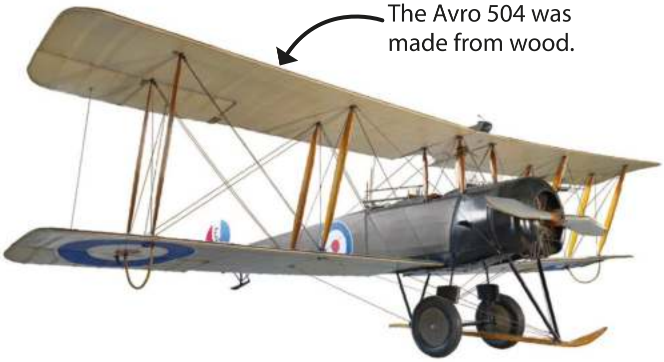
Thrill ride
When you are upside down on a roller coaster, you are being pushed and pulled around by different forces. Gravity is trying to pull you out of your seat, but acceleration pushes you into your seat. This is why you end up feeling weightless.

Early roller coaster

Wooden coasters
The first roller coasters were called switchback railroads. They were made of wood, didn't have loops, and were much slower and shorter than modern roller coasters.

Flying machines

Flying machines are usually known as aircraft. They include planes, helicopters, gliders, and drones. Aircraft have come a long way since the Wright brothers made their first flight in 1903—they can now fly all the way around the world.



Avro 504

The Avro 504 was used for bombing and spying by the British in World War I. It was a biplane, which means an aircraft with two wings stacked one above the other.

FACT FILE

- » **Year:** 1913
- » **Speed:** 90 mph (145 kph)
- » **Fun fact:** Avro 504 was the most widely used plane for training pilots for the British Royal Flying Corps.

FACT FILE

- » **Year:** 1937
- » **Speed:** 143 mph (230 kph)
- » **Fun fact:** The Indian Air Force used this plane to fly around the world.

Flight design CTSW

This aircraft is built from light, strong materials called composites. It has a very large fuel tank.

Hawker Harrier

The Hawker jet aircraft can take off straight up into the air! It is also called the Jump Jet.

FACT FILE

- » **Year:** 1989
- » **Speed:** 730 mph (1,175 kph)
- » **Fun fact:** The Harrier can hover like a helicopter, fly backward, and even stop and turn in midair.

Robinson R44

Helicopters can fly up and down, as well as forward. They can be used for rescuing people or carrying heavy loads. R44 helicopters have a fuel container designed to survive a crash.

WOW!

Helicopter blades spin **500 times** a minute.

FACT FILE

- » **Year:** 1993
- » **Speed:** 149 mph (240 kph)
- » **Fun fact:** The Robinson R44 is the world's bestselling private helicopter.

V-22 Osprey

This aircraft is a tiltrotor aircraft. That means it has rotors that can face upward to fly like a helicopter, or forward to fly like a plane.

FACT FILE

- » **Year:** 2007
- » **Speed:** 351 mph (565 kph)
- » **Fun fact:** The V-22 Osprey can be folded so it can be stored on ships.

The Osprey can carry 32 passengers.

DJI Phantom 3

A drone is an aircraft that is flown remotely by a pilot. Engineers have created drones to travel into dangerous areas, such as erupting volcanoes.

Drones can have cameras mounted underneath.

FACT FILE

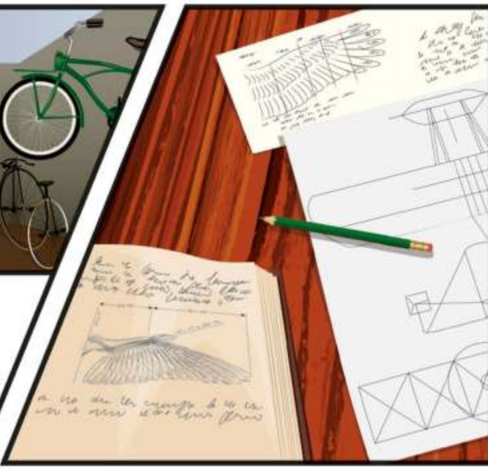
- » **Year:** 2015
- » **Speed:** 35 mph (57 kph)
- » **Fun fact:** Farmers can use drones to find out if their crops have enough water.

The Wright brothers

Orville and Wilbur Wright invented the world's first airplane. In 1903, the Wright Flyer made its first flight and changed the way that people traveled. The brothers tested and invented every part of their flying machines so well that many of their ideas are still used today.

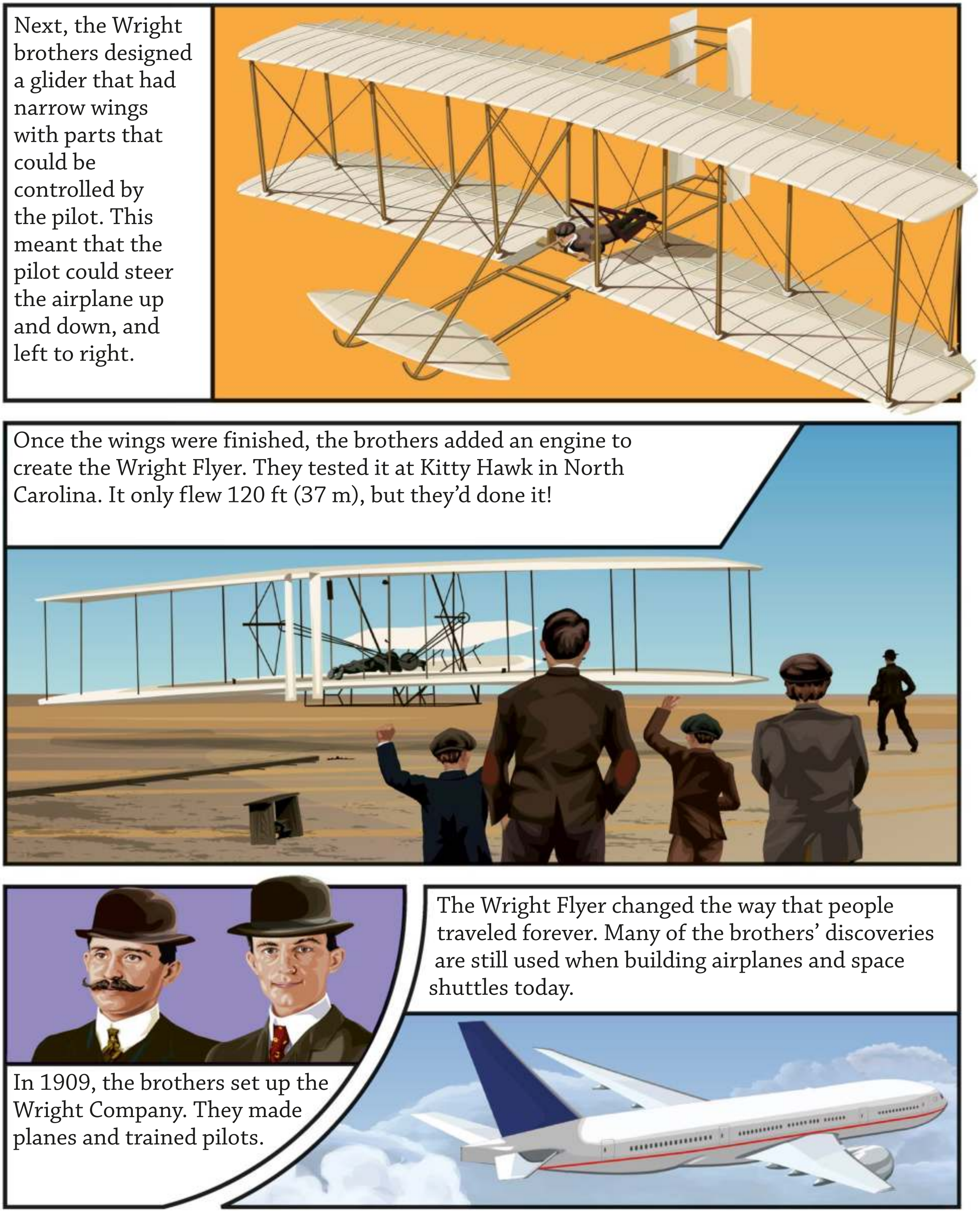
Orville and Wilbur became interested in engineering when they were children and their father bought them a flying toy.

In 1892, the Wrights started their first engineering business, making and selling bicycles. They soon decided to aim for the sky.



The pair wanted to build a flying machine. They studied birds and learned how their wings worked. They noticed that the wings moved in different parts.

To test their ideas, the brothers built a wind tunnel. These tests meant that they could study how wings would work in the air.


Next, the Wright brothers designed a glider that had narrow wings with parts that could be controlled by the pilot. This meant that the pilot could steer the airplane up and down, and left to right.
Once the wings were finished, the brothers added an engine to create the Wright Flyer. They tested it at Kitty Hawk in North Carolina. It only flew 120 ft (37 m), but they'd done it!
In 1909, the brothers set up the Wright Company. They made planes and trained pilots.
The Wright Flyer changed the way that people traveled forever. Many of the brothers' discoveries are still used when building airplanes and space shuttles today.

Jet engines

Planes fly using thrust and lift. Thrust is created in the engines by pushing air and hot gases out of the back at high speeds. This pushes the plane forward. Lift keeps the aircraft in the air and is created by air rushing over the wing that pulls the plane up.

Jumbo jet engines

Jumbo jets get their name from their huge size, which means they need large engines, too. A passenger liner carries up to 54,000 gallons (200,000 liters) of fuel on long flights.

This fan is 10 ft (3 m) wide

Fan blades

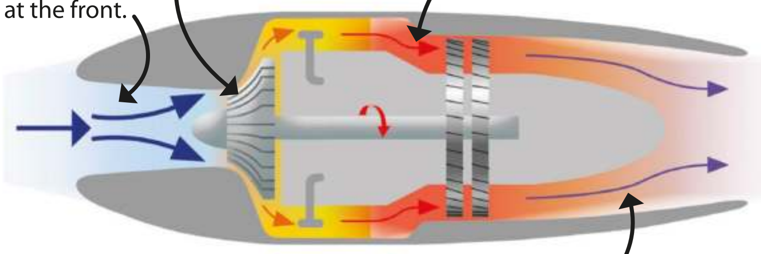
Jumbo jet engines have huge fans that suck in cold air. The fan blades are made from a strong metal called titanium.

WOW!

The world's **largest jumbo jet** can carry **853 passengers.**

How does a jet engine work?

The jet engine is a type of engine that uses air mixed with fuel. It is also known as a turbofan. The engine takes in air, mixes it with fuel, and burns the mixture to create thrust.

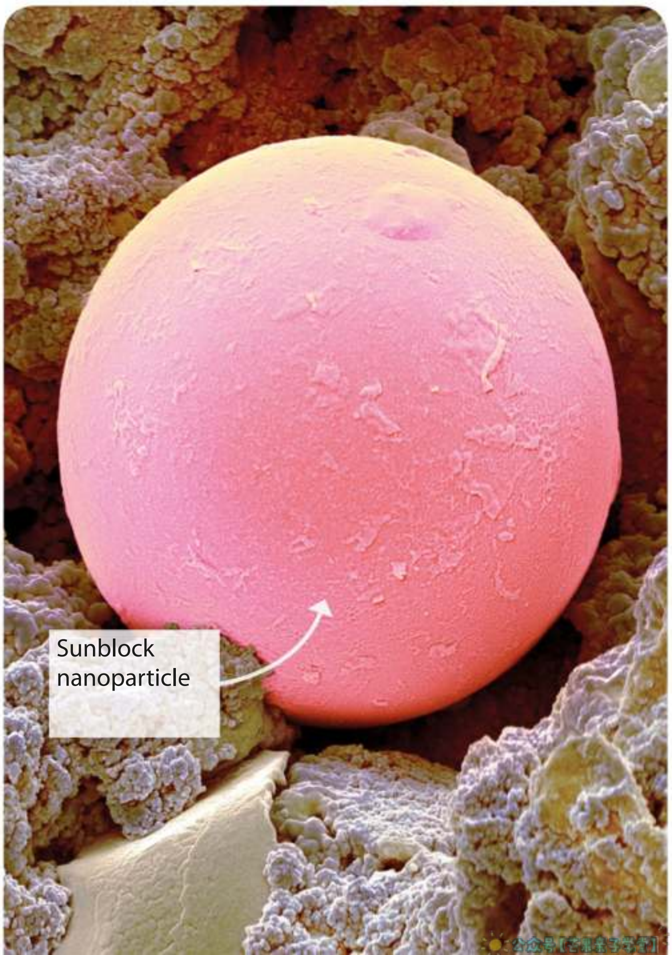


Nanotechnology

Nanotechnology is engineering on a scale so tiny it can't even be seen with a normal microscope. Engineers work at this scale to tackle very small problems like bacteria in the body or rain getting your clothes wet. Eventually, they hope to create machines so small they can travel inside your body to release medicine exactly where it is needed.

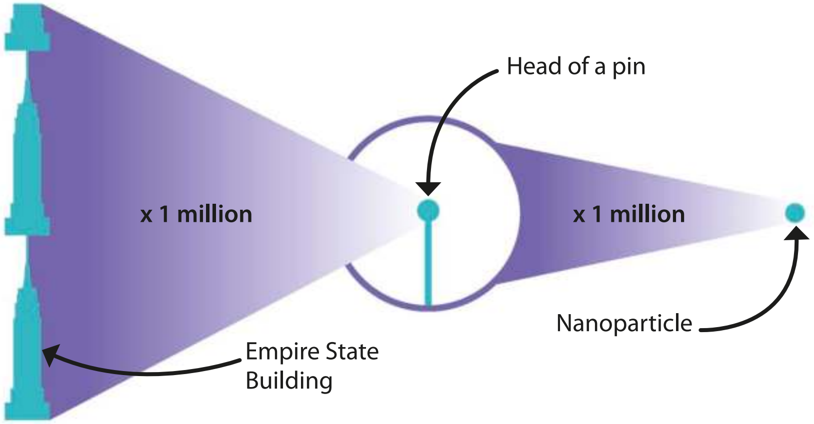
Antibacterial bandages
Silver nanoparticles kill bacteria. Doctors and nurses use liquid silver as a treatment to stop wounds from getting infected. Engineers can now make bandages with silver nanoparticles in them, which are easier to use.

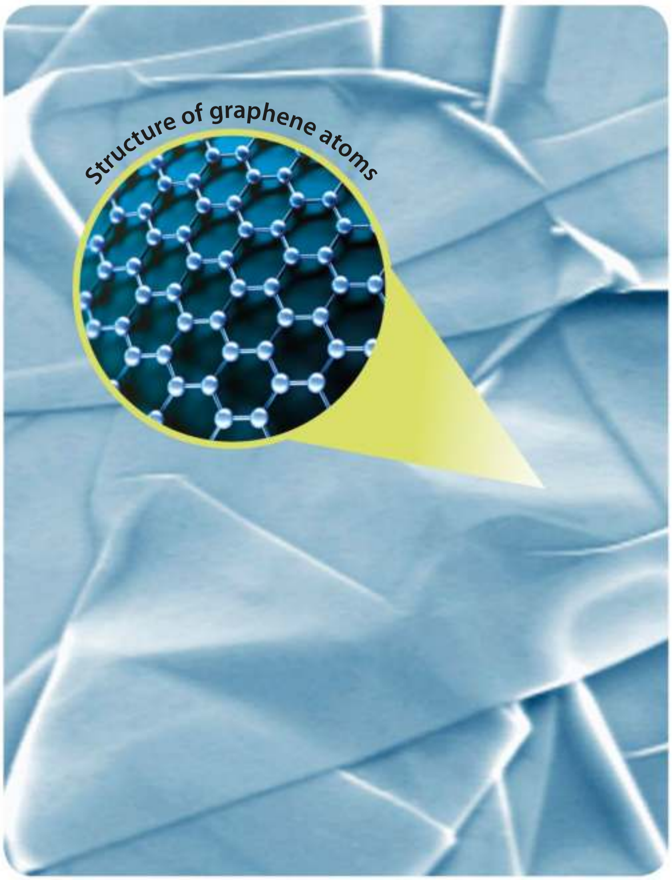
Sun protection
Sunblock cream can be made from nanoparticles of special chemicals that absorb harmful UV light from the Sun. Their tiny size means they are transparent and make the cream feel very light on your skin.



How small is a nanoparticle?

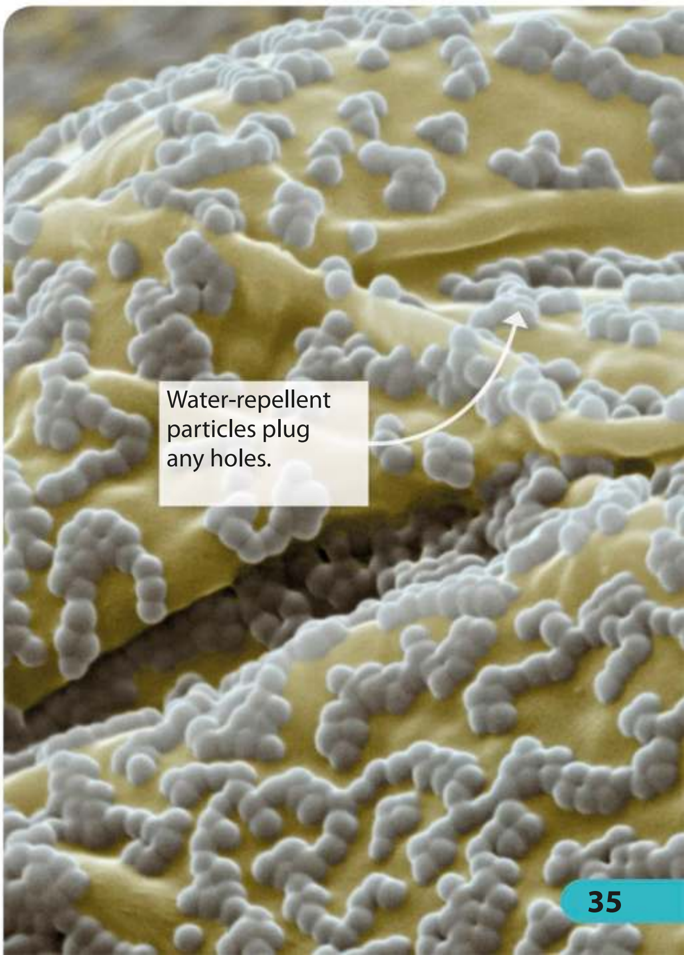
A nanometer is one-millionth of a millimeter. Objects on the nanoscale are less than 100 nm (nanometers) in length. They can only be seen through very powerful microscopes.





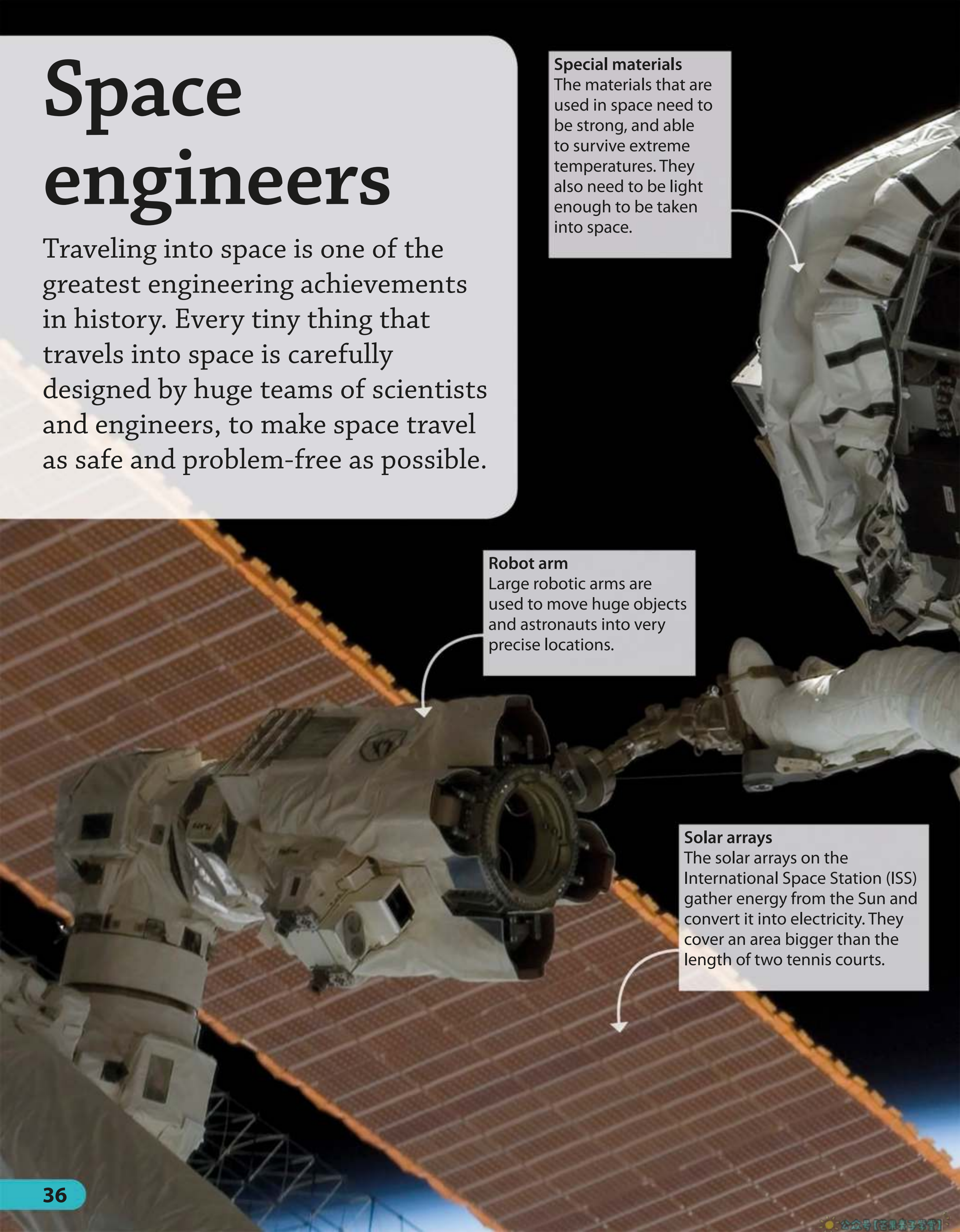
Super-strong material
The strongest, thinnest, lightest material that engineers have created so far is called graphene. It is 200 times stronger than steel and is made from a single layer of pure carbon atoms (tiny particles that make up all materials), arranged in a honeycomb pattern.

Water-repellent fabric
Nanoparticles of silicone can be added to fabrics to make them completely waterproof. Because nanoparticles are so tiny, they can completely cover any holes in the fabric's surface and block water from being absorbed.



Space engineers

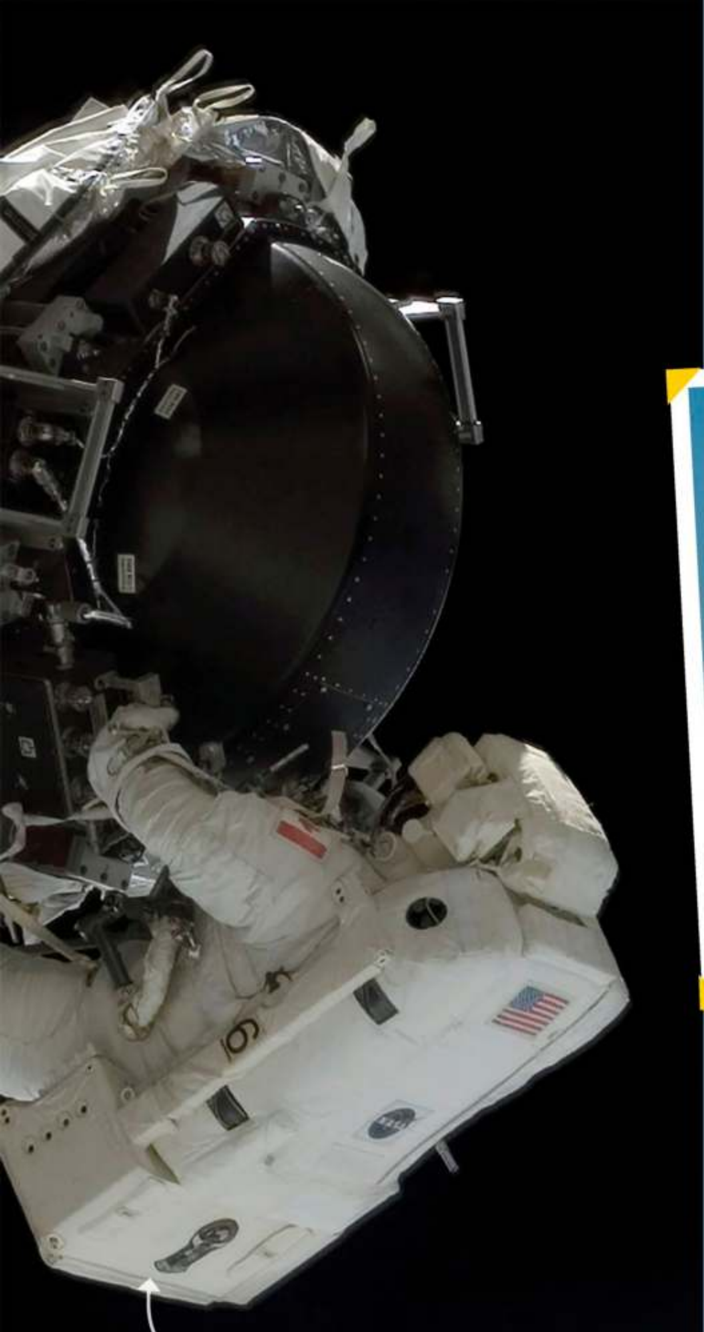
Traveling into space is one of the greatest engineering achievements in history. Every tiny thing that travels into space is carefully designed by huge teams of scientists and engineers, to make space travel as safe and problem-free as possible.



Special materials
The materials that are used in space need to be strong, and able to survive extreme temperatures. They also need to be light enough to be taken into space.

Robot arm
Large robotic arms are used to move huge objects and astronauts into very precise locations.

Solar arrays
The solar arrays on the International Space Station (ISS) gather energy from the Sun and convert it into electricity. They cover an area bigger than the length of two tennis courts.



Spacesuit
An astronaut's spacesuit protects the astronaut in space. Objects fly very fast in space, so even small bits of dust could injure an unprotected astronaut. Spacesuits also provide astronauts with oxygen, water, and protection from the Sun.

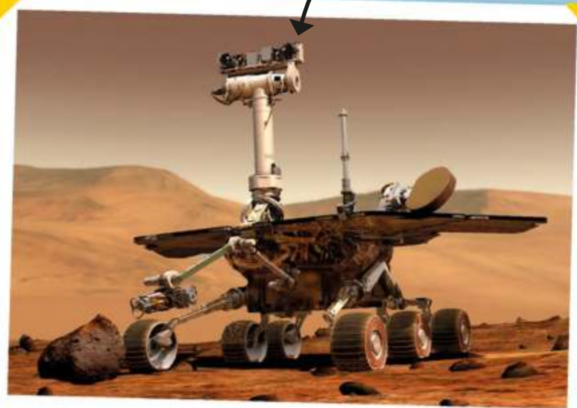
Exploring space

Clever engineering lets us visit and explore space. We even send machines to planets that humans cannot land on yet.

US space shuttle

Back and forth
Space shuttles were used to carry astronauts and equipment into space. US space shuttles have carried out 135 missions into space, with each shuttle takeoff generating as much power as 15,000 train engines.

Curiosity's mast holds seven cameras.



Curiosity rover

Life on Mars
A rover is a large robot that drives around a planet taking pictures and collecting data for scientists to study. There are currently four active rovers on the surface of Mars.

Mix it up!

Chemical engineers use chemicals to make new products, and to make existing products better. Natural chemicals come from plants and animals, while synthetic chemicals are created in laboratories. When chemicals are mixed together, they react and change. Everyday things, such as medicines, toilet paper, and plastic, are all created by chemical engineering.

Medicine

Chemical engineers use natural and synthetic chemicals to make medicines. They experiment to find out which chemicals make people better, and what treatments work best, so that people can live longer and healthier lives.

Environment

Chemical engineers help keep the environment clean. They work to improve recycling, clean up oil spills, and build systems to reduce harmful gas formation.

Food and drink

Some food products are engineered. Preservatives, flavoring, dyes, and vitamins are added to food. They can make it last longer, and taste and look nicer.

Materials

Engineers develop materials that work in different ways. Plastic can be changed into many forms. For example, it can be used for packaging, fabrics, and building.

Clothes

Clothes are designed for exact uses, such as to be waterproof or warm. The special materials used in waterproof clothing are designed so that water slides off them. They are created using synthetic chemicals.

Energy

Engineers have developed ways to get energy from different sources, such as coal, gas, the Sun, and wind. They are now trying to work out how to get energy from plants.

Building our world

Have you ever walked over a bridge, drunk water from a faucet, or taken a train? These are all things that civil engineers make happen. They help design and construct things that make the everyday life of the whole world go smoothly.

Tunnels

Instead of building a road over an obstacle, it may be safer or cheaper to build a tunnel through or under it. Civil engineers also keep people safe while they are in the tunnel, by building in lights and a good flow of air.

» **Name:** Gotthard Base Tunnel, Switzerland

Roads

Roads play an important role in every country. In the US, there are over 4 million miles (6.5 million km) of road. Engineers decide what materials to build roads from so that they will last a long time.

» **Name:** Pan-American Highway, US

Canals

Networks of canals allow boats to travel between different bodies of water. They can be as simple as a ditch between two lakes, or as complex as a channel between two oceans.

» **Name:** Beijing-Hangzhou Grand Canal, China

Railroads

Trains are a very useful way of transporting people and goods across land. On average, a train car uses one-quarter of the fuel a truck uses. Railroads also help lower car traffic.

» **Name:** Trans-Siberian Railroad, Russia

» **Name:** Tate Modern, London, UK

Buildings

Buildings protect people and their possessions from the cold, wind, and rain. Civil engineers are in charge of the structure of a building, which allows it to support weight and stand up against weather.

Bridges

Engineers design bridges to support the weight of cars, trucks, trains, and people as they cross rivers, bays, and canyons. Civil engineers decide what type of bridge is best for the kind of traffic it will carry.

» **Name:** Danyang-Kunshan Great Bridge, China

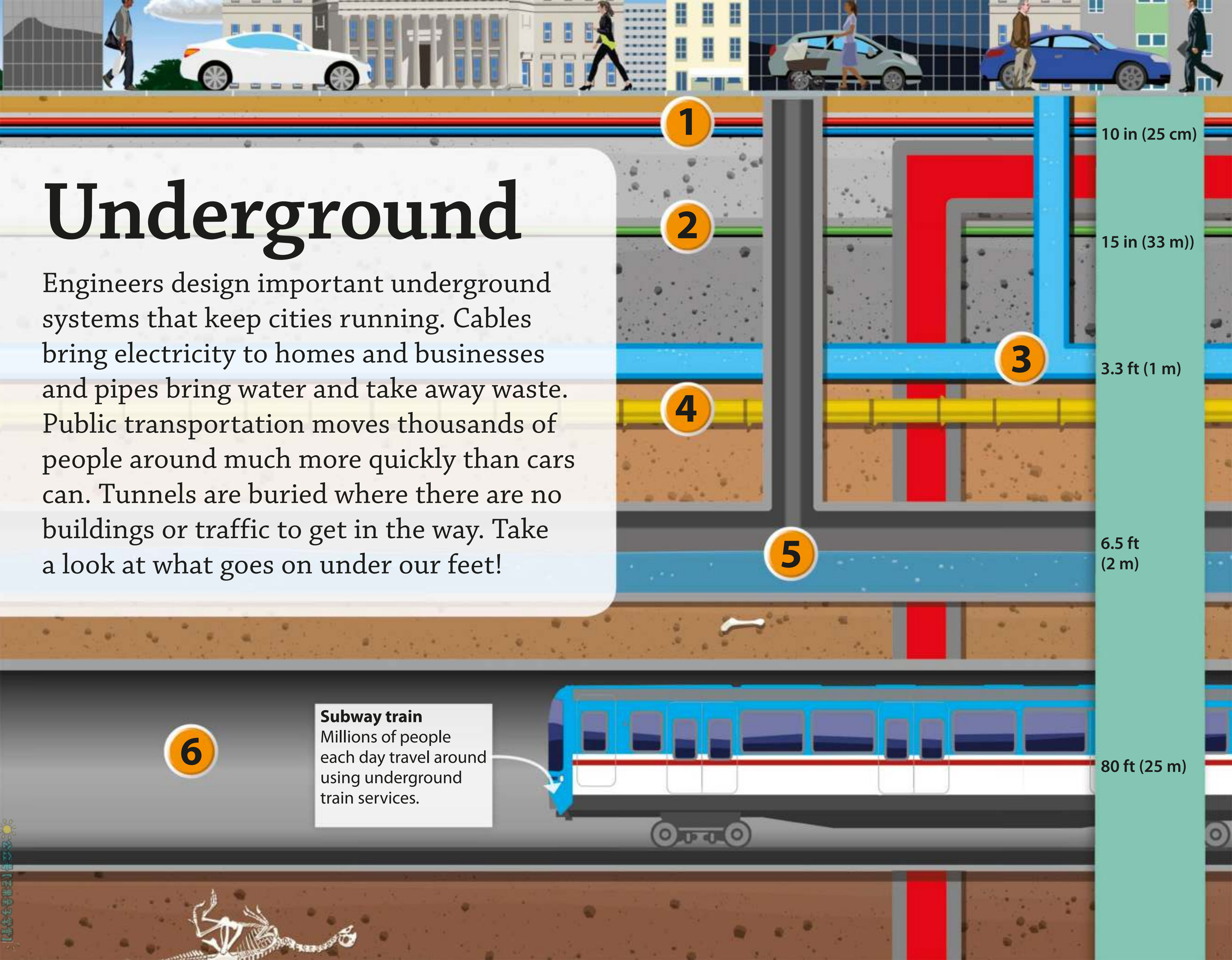
» **Name:** Three Gorges Dam, China

Dams

Dams block the flow of a river, letting water build up behind them to form a lake. The flow of water through the dam can then be used to make electricity.

Underground

Engineers design important underground systems that keep cities running. Cables bring electricity to homes and businesses and pipes bring water and take away waste. Public transportation moves thousands of people around much more quickly than cars can. Tunnels are buried where there are no buildings or traffic to get in the way. Take a look at what goes on under our feet!



Key

» **1. Telephone and electricity cables:** Electricity travels through miles of buried cable from power stations to houses, stores, and offices.

» **2. Fiberoptic cable:** These cables use light to move information and energy around the city. Services like the Internet and television are connected using fiberoptic cables.

» **3. Water mains:** Water mains are pipes that bring clean water to buildings such as houses. The water in the pipe is put under pressure to keep it moving fast around the network.

» **4. Gas pipes:** Natural gas is used for cooking and heating. It is transported underground using metal pipes specially engineered for safety.

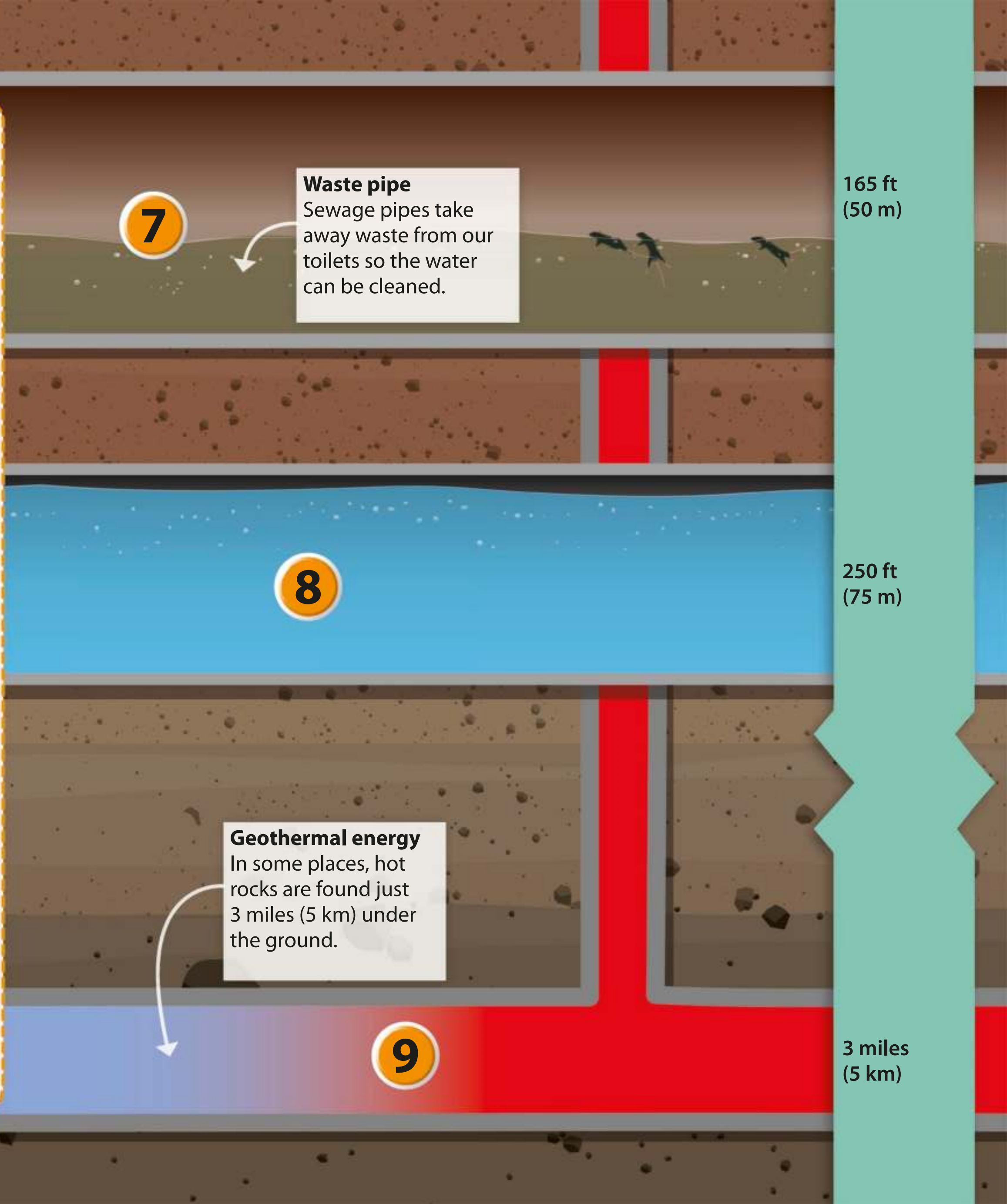
» **5. Water drain:** Drainage systems are designed by engineers to prevent flooding as well as to circulate water from our toilets and sinks.

» **6. Underground transportation:** It is much faster to take a subway than to drive! Underground train systems use deep tunnels under cities to transport millions of people without getting stuck in traffic.

» **7. Sewer system:** Do you ever wonder where your waste goes when you flush the toilet? Gravity makes the water flow downward to a treatment facility, where it can be cleaned and reused.

» **8. Deep water mains:** A city's water supply often comes from underground rocks filled with water, called an aquifer. This is connected to the deep water mains then sent to smaller, local water pipes.

» **9. Geothermal heating:** In some places with hot rocks near the surface, such as Iceland, engineers can pump water down into the Earth's crust to heat it up. The water turns into steam, which is then used in power plants to create electricity.



Eiffel Tower

Standing over Paris, the Eiffel Tower is one of the world's greatest engineering achievements. Built in 1889, it was the tallest structure in the world for four decades. More than 250 million people have visited the tower.

Viewing platform

A staggering 906 ft (276 m) above the ground is a viewing platform. From here, visitors can enjoy breathtaking views of Paris and its other landmarks, such as the Arc de Triomphe.

Elevators

The top level is accessed by two elevators. The distance covered by the elevators going up and down every year is the same as traveling around the world twice!

Ironwork

This wrought-iron structure in a lattice design weighs about 11,000 tons (10,000 metric tons). Every seven years the ironwork is coated in 55 tons (50 metric tons) of paint to prevent rust.

FACT FILE

- **Name:** Eiffel Tower
- **Country:** France
- **Height:** 1,052 ft (321 m)
- **Weight:** 11,000 tons (10,000 metric tons)

WOW!

The Eiffel Tower **grows 6 in (15 cm) taller** in hot weather!

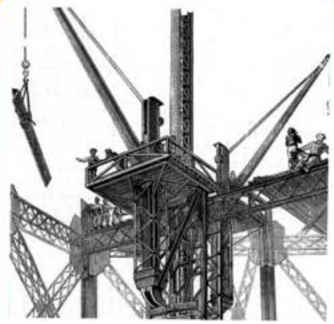
Construction

The Eiffel Tower was designed to be a temporary entrance for the World's Fair in 1889, but it soon became permanent. Deep concrete and limestone foundations were laid first before the structure got underway.

Gustave Eiffel

Creator
The tower is named after engineer Gustave Eiffel whose company ran the project. Eiffel also helped design the Statue of Liberty in New York.

Building up
More than 300 builders worked for over two years on the project. A major part was to make the rivets that hold the pieces together.



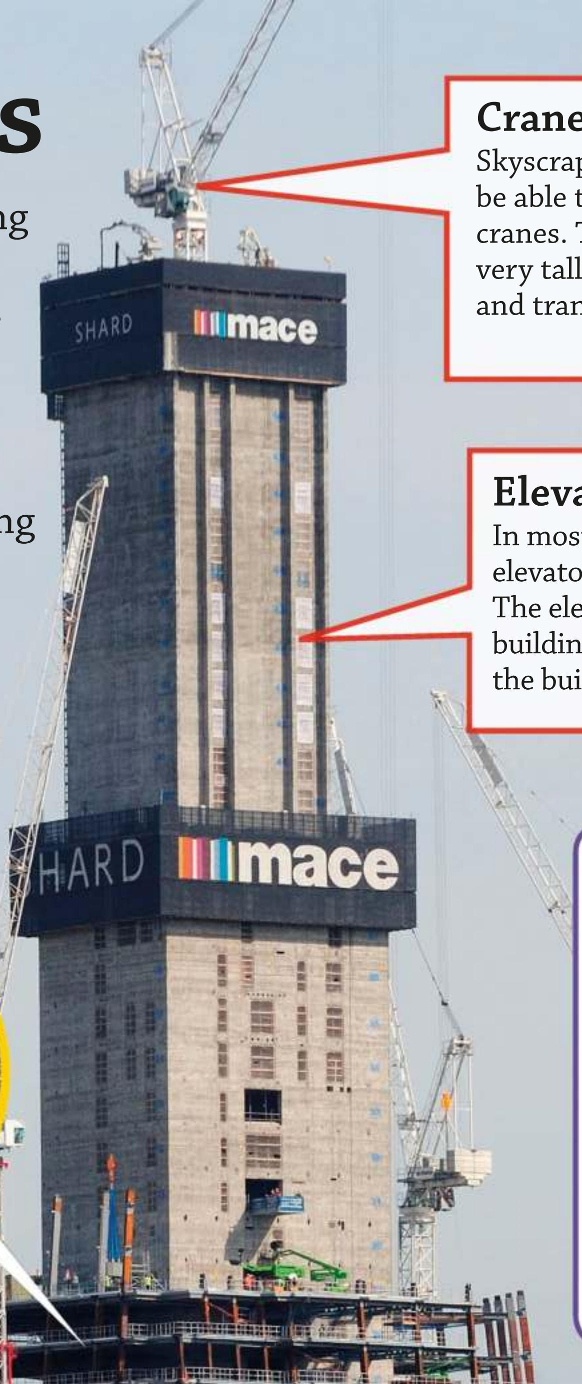
Working on-site

At the halfway stage

Tower of strength
Guards, screens, and moving creeper cranes helped support the structure and keep it safe for workers.

Skyscrapers

A skyscraper is a very tall building with lots of floors. Skyscrapers are so big that they have become landmarks all over the world. These magnificent engineering structures take a long time to build, and a lot of careful planning to make sure everything is safe.



Cranes

Skyscrapers would not be able to be built without cranes. These machines are very tall and are used to lift and transport materials.

Elevator shaft

In most skyscrapers, the elevator shaft is built first. The elevator shaft is the building's core. It helps keep the building stable and safe.

Super structure

Skyscrapers are built in a giant 3D grid. This is called a super structure. It is like the building's skeleton.

Beautiful building

Many skyscrapers are designed with curves, twists, and patterns to make them stand out from the rest. The Shard, in London, was designed to look like lots of shards of glass poking into the sky.

The completed building

Steel
Skyscrapers are made of steel. Steel is strong and light, which makes it perfect for tall buildings. If the metal was too heavy, the building wouldn't be able to support itself.

Curtain wall
The curtain wall covers the outside of the building. It is connected to the steel grid inside.

Foundations

A foundation keeps the building stable, and protects it against wind and earthquakes. Skyscrapers have foundations made from concrete that go deep into the ground.

Under the Shard

A long way down
The Shard sits on top of many huge layers of concrete. These layers support the skyscraper's weight, and go down 174 ft (53 m).

Building bridges

A bridge is a structure that lets people cross water, canyons, roads, or railroads. Bridges often support heavy weights. They can be very long, and have to face challenges including wind, rain, and heavy traffic. When engineers design a bridge, they must make sure all the pieces fit together and balance properly.

BASCULE

A bascule bridge has a section that can be raised or lowered to allow ships to pass through it. Bascule bridges have been used since ancient times—for example, as castle drawbridges.

Arch

Arch bridges were first engineered by the Ancient Romans. The arch of the bridge runs between two towers. The towers are where most of the weight is supported. Many arch bridges are used to carry railroad lines.

TRUSS

A truss bridge is created by fitting pieces of steel or wood together into triangle shapes called trusses. These carry the weight of the bridge. Trusses are very strong because each point of each triangle supports weight.

Beam

A beam bridge is the simplest kind of bridge. It is a strong, metal plank with legs that go deep into the water or ground. A beam bridge is stiff, and does not bend or twist when a heavy vehicle crosses it.

Cable-stayed

A cable-stayed bridge has one or more towers. From this tower, lots of support cables stretch to the bridge below. The cables fan out from the top of the tower to balance the weight of the bridge.

Suspension

The road part of a suspension bridge hangs from two tall towers. The tall towers are secured deep under the water or ground below, which keeps them strong. Long steel cables connect the towers and the bridge.

! WOW!

The Golden Gate Bridge in San Francisco, CA, weighs 887,000 tons (804,673 metric tons).

Cantilever

A cantilever is a structure that is only supported at one end. A cantilever bridge is lots of these structures put together to make a crossing. They are easier to build than other bridges because they don't need to be supported when they are being put together.

Meet the expert

We put some questions to Dr. Lucy Rogers, a Chartered Engineer, writer, and maker from the UK. Dr. Rogers writes, experiments, makes engineering videos, and appears on engineering television shows.

Q: We know it is something to do with engineering, but what is your actual job?

A: I solve problems. Sometimes I calculate the probability of spacecraft being hit by space debris. Sometimes I make robot dinosaurs at a theme park react to visitors. I write articles for the European Space Agency, national newspapers, and magazines. I work with engineering companies and make how-to videos. I am also a judge on BBC Robot Wars.

Dr. Rogers enjoys working on experiments

Q: What made you decide to become an engineer?

A: At school I really enjoyed making things. We had a “Great Egg Race” club, where we would have to solve problems. I also liked math and physics, so engineering was ideal.

Q: Do you have a favorite thing that you have built?

A: My latest project is often my favorite—currently my light-up gold boots. Anyone can change the color of the lights by tweeting “#Cheerlights” and their favorite color of the rainbow.

Dr. Rogers’ latest project—light-up gold boots

Q: Do you use any special equipment?

A: My hands and imagination are the tools I value most. To make things, I use tools such as a lathe for shaping wood or metal, a welder for sticking metal together, and a 3D printer for making small plastic items. I also use a computer. This helps me draw things, calculate things, write stuff, and also ask the Internet for help. The Maker Community (people all around the world who make things) are also always willing to help and share ideas.

Lathe
Shapes metal and wood by spinning the material fast, and using a cutting tool over the surface in a regular pattern.

Q: What do you love most about engineering?

A: The buzz I get when I solve a problem for someone or something. Although most of my projects are fun, they demonstrate useful ideas. These ideas can be used in industry or in the home. For example, my gold boots could be 100 machines in a factory that need to be controlled or checked all at once. This could be done not just from the factory, but even from another country.

Q: What is a usual work day for you?

A: I don't have a "usual" day—especially if I am on site, visiting factories, filming, or at a conference. Other times, I work from home—I don't have to be in an office. I like to get up early and do some writing before breakfast. This could be preparing a speech, writing a report, or writing part of a book. After lunch I usually go into my workshop and make things. I spend a lot of the day keeping my eye on Twitter and my emails, too—this is how I talk to potential, current, and past colleagues and clients.

Q: What are the best and worst things about your job?

A: The best thing is learning new stuff every day. I use my skills to make things and solve problems. The worst thing is being a beginner at new stuff every day—I want to skip the "learning" bit and immediately become an expert. Sadly, I have found no short cuts.

Bioengineering

Bioengineers work on changes to the natural world. They research how our bodies work to create new medicines, and design inventions called prosthetics to replace missing body parts. Some bioengineers investigate farming and food technology.

WOW!

The **Ancient Egyptians** made the first prosthetic—a **wooden toe.**

Lab-grown meat

In 2013, the world's first lab-grown burger was created. Engineers are working on ways to make it in larger batches and more cheaply—the burger cost $330,000 (£267,500) to create! The meat has the right texture but doesn't taste very good yet.

This meat was made from stem cells from a cow's shoulder.

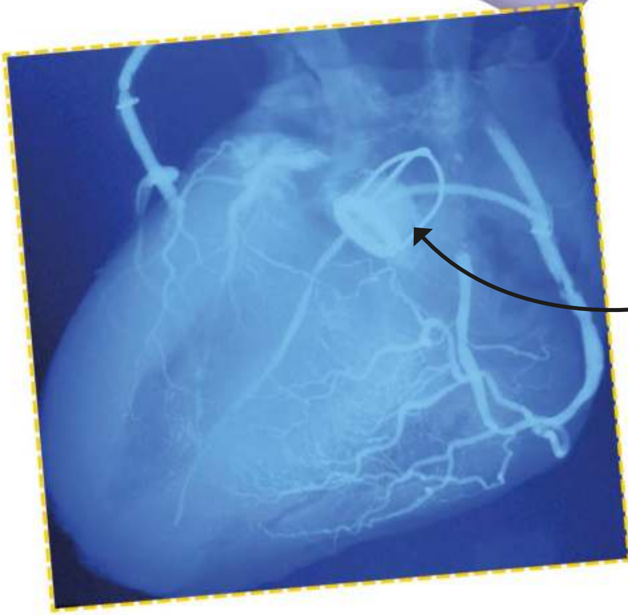
Mechanical hand

Biomechanics is the science of how our bodies perform. Engineers can create mechanical body parts that are able to move and hold objects. They have also built running blades for athletes with missing feet or legs.

Mechanical parts can replace hands lost in accidents.

Artificial heart

Bioengineers are working to create an entire artificial heart that can beat like a real one. This is a huge challenge—the human heart beats around 35 million times a year so a replacement heart must be very strong and reliable.



Some parts of the heart can already be replaced by surgeons.

This calf was born to cloned parents.

Cloned cows

Researchers from Texas have cloned cows that make more, better-quality meat than average cows. Clones are identical copies of animals.

Food technology

Genetic engineers are creating animals and plants that are more nutritious to eat and can fight back against disease and pests. Helping farmers grow more food on the same amount of land could help end hunger around the world.

Going green

Engineers come up with ideas that will help the planet and our natural environment. They find new and creative ways to get rid of waste and save energy. Engineers also work on making new products that do not damage the world around us.

Fresh Kills landfill site, Staten Island, New York

Landfill repair
This site was once where all of the garbage from New York was dumped. It has now been cleaned up and specially engineered into a big park. Trees have been planted and lakes created to make the area more attractive, healthier, and safer.

The LifeStraw lets you drink dirty water safely.

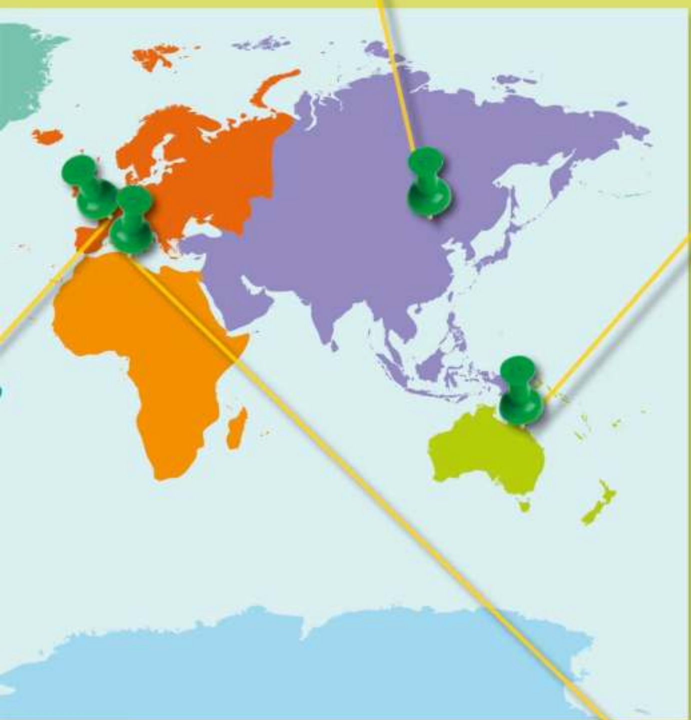
Water straws
A company in Switzerland has made a drinking straw that makes dirty water clean enough to drink. The straw has tiny fibers inside, which trap dirt, letting only clean water through. The straw is used by people who live in or explore areas without clean water.

New forest in China

Planting trees
In China, engineers have created a natural barrier against damaging dust storms. This "Great Wall" of trees is being planted on land that was once used to grow crops.

Wind farm in Australia

Powerful wind turbines
Each wind turbine can power around 750 homes. Wind power is a form of renewable energy, or energy that can be used again, which doesn't harm the environment.



Food cooking in a solar oven

Solar ovens
The heat of the Sun is so powerful it can be used to cook food. Silver-colored reflectors can be used to focus the Sun's rays on a particular spot. It takes a long time to cook anything using this method, but it's better for the environment than using gas or electricity.

Future engineering

Engineers are always looking for new ways to create things that will help people. These are some new and exciting ideas that may soon become everyday sights.

Robot suits

These suits help injured people walk again. The suit has several "walk modes" so patients can gradually recover from their injuries.

Robot suit

Bug snacks

Insects are high in protein and easy to farm because they don't take up much space. Bugs are a food of the future!

Insect protein bars

Edible insects

Self-driving cars

These cars are designed to drive themselves. They have computer sensors that monitor all sides so that they can drive safely without being controlled by anyone.

There are no driving controls inside the car

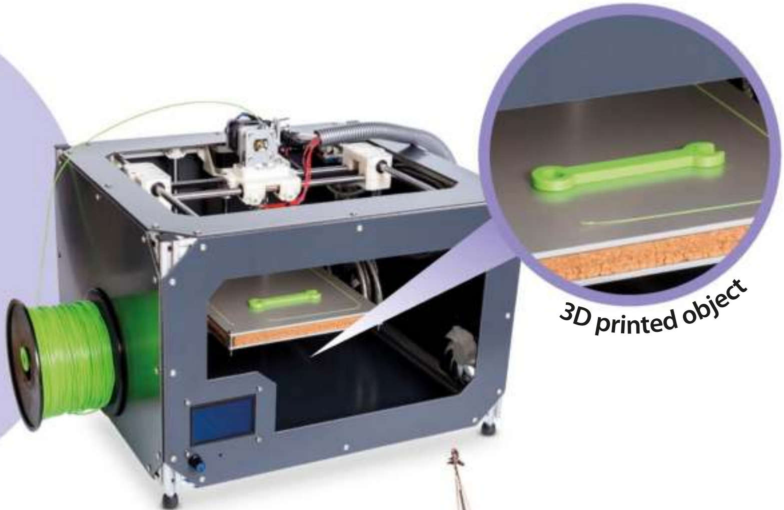
Solar roadways

This road surface works like a solar panel. It collects energy from the Sun that can be turned into electricity without harming the environment.

Solar roadway

3D printing

This process takes a computer design and turns it into a 3D object. The object is made by printing lots of layers on top of each other, using materials like plastic.



3D printed object

Space houses

Space engineers have created designs for houses that could one day allow people to live on Mars. These designs are still being tested.

Design for homes on Mars

Engineering facts and figures

The world of engineering is full of amazing things. Here are some weird and wonderful facts and figures that you may not know.

The Pan-American Highway is the longest road in the world. It is **30,000 miles (48,000 km)** long and connects North and South America.

LONGEST ROAD!

HUNDREDS OF PEOPLE pushed blocks of stone uphill to build the city of **Machu Picchu** in Peru, South America, around the year 1450.

THE WORLD'S **TALLEST WIND TURBINE** IS OVER **722 FT (200 M)** HIGH.

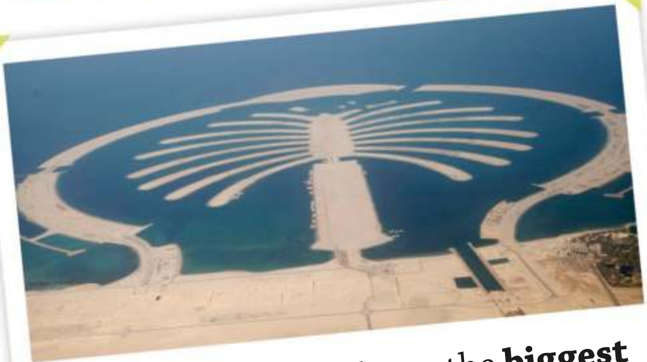
25,572 strands of wire make up the cables of San Francisco's Golden Gate Bridge.

220 mph (350 kph) is the top speed of trains in China.

The world's **highest outdoor elevator** is **Bailong** in China, **1,070 ft (326 m) tall.**

20 years of **scientific research** and **engineering** led to the creation of the **Hubble Telescope**.

15 billion
cans of **aerosol** are produced worldwide **every year**.



Dubai's Palm Islands are the **biggest man-made islands** in the world.

1863

was the year the first underground railroad opened, in London. It was called the Metropolitan Railroad.

3.9°

is the angle of the Leaning Tower of Pisa. Its foundations were laid in soft soil that could not support its weight, so it tipped to one side.

Glossary

Here are the meanings of some words that are useful for you to know when learning all about engineering, from bridges to spaceships.

accelerate To speed up

aerospace engineering Projects to do with aircraft and spacecraft

android Robot with a human face

astronaut Someone who is trained to travel and work in a spacecraft

atom Smallest part of something that can take part in a chemical reaction

Civil engineering includes roads

automatic Something that works on its own without human help

bioengineering Technology that is used to help the human body

cantilever Structure that is only supported at one end

chemical Substance made by a reaction between particles such as atoms

chemical engineering Science that uses chemicals to make new products

civil engineering Designing man-made projects such as bridges and roads

combustion Process of burning

composites Something made from several parts or materials

coolant Liquid or gas that cools things down

debris Bits of broken up and loose material

design To plan and work out how something will work and what it will look like

drone Flying machine with no pilot

eco To do with not harming the natural environment

energy Source of power such as electrical energy or heat energy

environment Area that someone lives in, or a machine works in

environmental engineering Projects to do with the world around us

fiberoptic Cables that are used to move light signals

fossil fuels Fuels made from animals and plants that died millions of years ago, for example coal

geothermal Heat that comes from inside the Earth

humanoid Robot that is looks and moves like a human

hydraulic power When something is moved by water or another liquid

International Space Station (ISS) Large space station and laboratory that orbits the Earth

machine Something that is powered by energy and is used to carry out a task

manufactured Made by humans rather than grown naturally

material Substance that is used to make or build things

mechanical Something that is controlled by a machine

mechanical engineering Engineering that makes and designs machines

nanotechnology Science that deals with making technology very small

nuclear-powered Action that is powered by nuclear energy

particle Something that is very small, such as a proton or electron

power source Energy that is used to make a machine work, such as electricity

A humanoid robot.

prosthetic Artificial body part to replace one that is missing

renewable Type of energy that can be produced without polluting the air or water, such as solar power

robot Machine that is programmed by a computer to do different tasks

satellite Any object that goes around the Earth, but often a man-made machine that collects scientific information

software Programs and instructions that are used by a computer

structure Building that is made up of several parts

sustainable Energy or materials that can keep going for a long time

synthetic Something that is man-made

technology Using scientific knowledge to create machinery and devices, such as computers

thrust Forward motion

transfer When energy is moved from one object to another, or an object moves from one place to another

transform When something turns into something else, for example changing shape

turbine Wheel or rotor that is turned to make power

wind tunnel Tunnel that lets engineers see the effect of wind on objects such as cars or bikes

Index

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