

Additional Material for Projects and Technical Applications.

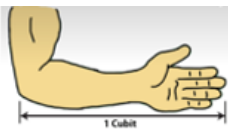
What is Physics

Project proposal: Historical Units of Measurements

Objective: Use one of the historical units of measurement for length to measure the width of the class.

Procedure:

- Use one of the historical units of measurement for length to measure the width of the class.
- Ask your classmates and teacher to do the same.
- Compare the results.
- What were the problems with using such unit?



A cubit is the length from the elbow to the fingertips. It was used in ancient Egypt.



Yard is the distance between the end of the outstretched arm and one's chin.



Foot is the measure of one's foot.



Hand -span is the maximum distance between the tips of the thumb and little finger.

Fig.1 Examples of historical units

- Find out traditional measurement units of your country and do some measurement with it.

Project proposal: Make your Own Clock

Objective: We want to boil eggs exactly 3 minutes. What can be used to measure this time?

- a) Minute - glass.

Material needed: clear plastic cup, paper cone with the size of its top a little bigger than the top of plastic cup.

Procedure:

- make a small hole at the bottom and place it in the cup,
- find the amount of sugar or salt that will go through the cone in just 3 minutes.

b) Water clock.

Material needed: plastic bottle, scissors, paper and adhesive tape to make the scale, a pin to make a hole in the lid of the bottle, a container into which water can drip.

Procedure:

- Cut off the bottom of the bottle, ask an adult to do it and also to make a hole in the lid (e.g. with a nail warmed above the candle).
- Stick a narrow paper strip on the bottle. Write the elapsed time on it ; this will create a scale.
- Pour water into the bottle, start the stopwatch and mark the current water level, after each minute. Continue measuring the time until the bottle is empty.

Project proposal: Trundle Wheel

The picture bellow illustrates professionally made trundle wheel.



Fig.2 Trundle wheel

Materials needed: 1 paper plate or cardboard, a metal paper fastener, a long object for the handle, an index card, tape, a measuring device, scissors, and a pencil.

Procedure:

- Begin by conducting research on the internet.
- Create a visual representation or drawing of how your trundle wheel will look.
- Ensure that the trundle wheel has a circumference of one meter.

- To create a precise circle, use a string with a radius of 16 cm.
Use the formula $C = 2\pi r$, where $r = C/2\pi = 100 \text{ cm} / 2\pi \approx 15.9 \text{ cm}$.
Pin one end of the string to the cardboard and insert a pencil into the loose end. Use this setup to draw a circle.
- Cut out the circle shape from the cardboard.
- Divide the circle into quarters and then further divide each quarter into halves.
This will create smaller equal parts on your circumference, allowing you to measure distances smaller than one meter.
- Attach the handle to the wheel, ensuring it can rotate freely.
- Conduct various measurements using your trundle wheel.
- Ask someone to record a video so that you can present your device.
- Document your ideas on how to improve your device.

Technical applications

The International Space Station (ISS)

ISS – is the biggest object ever flown in space. ISS is both an example of what humas achieved and at the same time a place where new experiments are performed to advance further our knowledge of our world and of the universe.

It travels around the Earth at an average speed of 27,700 km/h, completing 16 orbits per day. (16 sunrise and sunsets in one day). At night it can easily be seen from Earth, as it flies more than 300 kilometers above us. 16 countries, including the USA, Russia, Japan, Canada and many ESA (European Space Agency) member states worked together to build the Station.

Building the International Space Station, putting it into the orbit, creating the conditions for human to live and work there at more than 300 km above the Earth, was possible by well knowing the laws from different areas of physics (mechanics, kinematics, mechanics of fluids, thermodynamics, electricity, optics, physics of particles etc.).

The largest part of the ISS is a central truss to which 16 huge solar panels are attached. The modules where the astronauts live and work are attached to the centre of the truss. Europe's biggest ISS project is the Columbus science laboratory, where astronauts can carry out scientific experiments in weightless conditions. Many different types of experiments can take place both inside and outside this space laboratory.

ESA also makes the Automated Transfer Vehicle (ATV), a series of uncrewed spacecraft designed to take supplies to the ISS. The cargo craft delivers food, fuel, equipment and other supplies

International Space Station in Numbers

- Launch date: November 20, 1998.
- Cost: Approximately 140 billion euros.
- Construction time: Over 10 years.

- Distance from Earth: Varies between 330 and 435 kilometers above the Earth's surface.
- Weight: Approximately 419,725 kg.
- Length: 109 meters.
- Width: 73 meters.
- Height: 20 meters.
- Pressurized volume: 931 cubic meters.
- Power generation: 8 solar arrays with a total of 262 400 solar cells, generating up to 120 kilowatts of electricity.
- Number of modules: 16 pressurized modules, including living quarters, science laboratories, and docking ports.
- Number of countries involved: 15, including United States, Russia, Canada, Japan, and 11 European countries (Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom).
- Number of spacewalks: Over 230 spacewalks have been conducted on the ISS for maintenance, upgrades, and experiments.
- Length of orbit: The ISS orbits the Earth once every 90 minutes, traveling at a speed of approximately 28 000 kilometers.

How it was built – there are many amazing videos on youtube how this flying laboratory was built piece to piece up to the size of a football pitch.

You can also see the Earth as seen from ISS from youtube.

https://www.youtube.com/watch?v=4_OT4xFrimM

To find when the ISS is visible from where you live, visit <https://www.astroviewer.net/iss/en/observation.php> and fill the name of your town.

You can also go by searching on Google for “spot the station” that will go to the NASA webpage spotthestation.nasa.gov where you can register to receive an email or an SMS when the station flies above your city.

The email will look like this:

Time: Thu May 04 3:56 AM, Visible: 5 min, Max Height: 42°, Appears: 20° above WNW, Disappears: 10° above ENE

ISS can be seen from Earth during cloudless nights. In such a night, try to find ISS moving in the sky, make a photograph of the sky and put it into your project.

You can find some videos on You Tube channel, where the life on ISS is nicely documented. As for example the following one:

<https://www.youtube.com/watch?v=SGP6Y0Pnhe4>

The experiments carried out to develop space exploration have result in many discoveries that are finally applied in the everyday life.

Ten most important results of space exploration research that are used in daily life are the following:

1. Global Positioning System (GPS) - The GPS is a satellite-based navigation system that is widely used for navigation, tracking, and location-based services. It was developed by the US Department of Defense for military use, but is now commonly used in cars, phones, and other devices.
2. Memory Foam - Memory foam was developed by NASA in the 1960s for use in aircraft seats to provide better cushioning and protection for passengers during accidents. Today, it is used in a wide range of consumer products, including mattresses, pillows, and footwear.
3. Scratch-resistant lenses - The material used to make scratch-resistant lenses was originally developed for NASA's space helmet visors. Today, it is used in a variety of eyeglasses, sunglasses, and safety glasses.
4. Water filtration systems - NASA developed water filtration systems that were used on the International Space Station to recycle water for drinking and other uses. Today, these systems are used in many parts of the world to provide clean drinking water.
5. Artificial limbs - NASA developed robotic arms for use in space, which led to the development of artificial limbs for amputees. These artificial limbs are now widely used and have greatly improved the lives of those who use them.
6. Satellite television - The technology used to transmit television signals from satellites was originally developed for NASA's space program. Today, it is used to provide television programmes to millions of households around the world.
7. Cordless power tools - The first cordless power tool was developed by NASA for use by astronauts during space missions. Today, cordless power tools are used in many industries and are a common tool in many households.
8. Infrared ear thermometers - Infrared ear thermometers were originally developed for use in space to measure the temperature of stars and planets. Today, they are commonly used in homes and medical facilities to measure human body temperature.
9. Dustbusters - The technology used in handheld vacuum cleaners was originally developed for NASA to collect samples of moon rocks. Today, handheld vacuum cleaners are commonly used in homes and businesses.
10. Solar panels - The use of solar panels to generate electricity was originally developed for use in space. Today, solar panels are commonly used to provide electricity in homes, businesses, and other locations around the world.

Mark in the table the research results you know of and which of them you or your family member are using in their daily life. See the example in the first line.

Research	I know	Me or my family uses	Example
Geo Positioning Systems (GPS)	Yes	Me, my family	I use GPS of my phone with Google maps to find a location in my town. My father's car also has GPS which helps him always know where he is.
Memory Foam			
Scratch-resistant lenses			
Water filtration systems			
Artificial limbs			
Satellite television			
Cordless power tools			
Infrared ear thermometers			
Dustbusters			
Solar panels			

What are the applications of ISS?

The ISS is used for the trials of spaceship equipment and systems that are needed for Mars and Moon missions. NASA predominantly uses the station to understand the effects of working and living in space. Such invaluable information will further demystify the conditions necessary for humans to survive on other planets.

The top 5 most important projects that are actually run on ISS are:

1. Microgravity research - Scientists conduct experiments on the ISS to better understand how microgravity affects human health, plant growth, combustion, and other phenomena.
2. Space manufacturing - Experiments on the ISS are being conducted to investigate new materials, such as metal alloys and carbon nanotubes, that could have important applications in a wide range of industries.
3. Earth observation - Data collected from the ISS is used to better understand climate change, natural disasters, and other environmental challenges.
4. Human spaceflight research – Scientists are studying the effects of long-term spaceflight on the human body, including changes in bone density, muscle mass, and cardiovascular function. This research is important for preparing astronauts for future missions to the moon, Mars, and other destinations.

5. Technology demonstration – In ISS labs are studied new propulsion systems, robotics, and communications technologies that could make space missions safer, more efficient, and more productive.

Project proposal: Robotic Arm (Adapted from ESA resources)

Objective: Find out facts about Robotic Arm and make your own model.

The European Robotic Arm (ERA) plays a crucial role in the International Space Station (ISS). Let's explore some interesting facts about this remarkable robotic arm.

About the European Robotic Arm: ESA astronaut Thomas Pesquet captured a photo of the robotic arm from the ISS. He described it as one of the most essential parts of the Space Station, used for capturing and docking supply spacecraft.



Fig.3 ISS

The ERA is the first robot capable of "walking" around the Russian section of the ISS. It measures over 11 meters in length and can anchor itself to multiple locations on the Station. This allows it to move back and forth with a wide range of motion. Its primary location is the Multipurpose Laboratory Module, also known as "Nauka."

The ERA can move small payloads from inside to outside the ISS and even assist astronauts in working outside the Space Station.

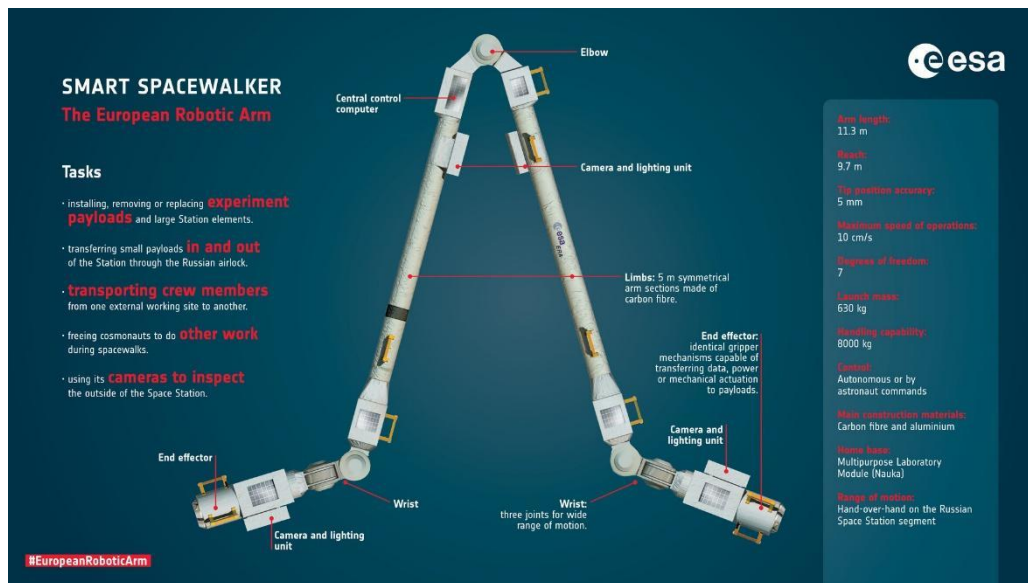


Fig.4 The European Robotic Arm

100% made-in-Europe, this intelligent robotic arm consists of two end effectors, two wrists, two limbs and one elbow joint together with electronics and cameras. Both ends act as either a 'hand' or a 'shoulder' for the robot.

Building a Robotic Arm Model

Materials needed: popsicle sticks of various sizes, hole puncher, cardboard, hot glue gun, small objects (e.g., bottle caps, pencils, wine corks), split pin paper fasteners, scissors.

Procedure:

1. Ask your teacher or parent to prepare popsicle sticks with three holes, two of them located 1 cm from the edges and the third in the middle between them. Ensure that all sticks are aligned and positioned uniformly. Alternatively, you can find popsicle sticks with pre-drilled holes in craft stores, which makes the process easier.

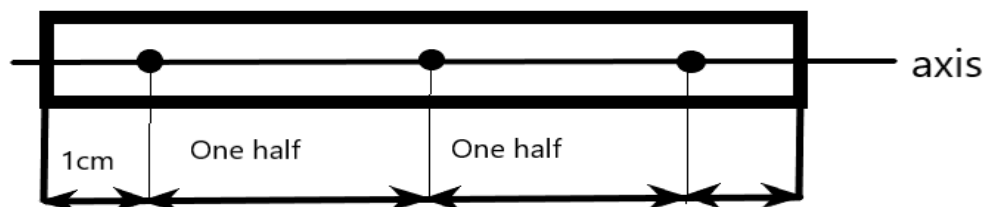


Fig. 5 Popsicle sticks -holes

Use popsicle sticks of different sizes.

Prepare pairs of popsicle sticks attached in the center with pin paper fasteners, as shown in the picture.

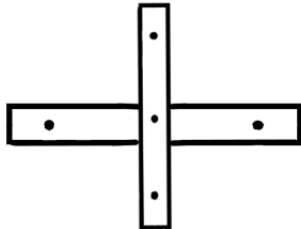


Fig.6 Popsicle sticks - connecting

Building the Robotic Arm Model:

Distribute different numbers of popsicle sticks, providing pairs of the same size to each group.

Provide each group with two strong cardboard rectangles to be used as jaws. Alternatively, you can use round sticks with a diameter of 5mm and varying lengths as jaws and handles.



Fig. 7 Robotic arm from popsicle sticks

Pupils' Task:

- Assemble a chain by connecting the cross-shaped popsicle sticks using pin paper fasteners, as shown in the picture.
- Ask the teacher to attach handles to both ends using hot glue.
- Now it's time to experiment with your robotic arm model.
- Activity Questions (Communicate with other groups):
 1. Try to pick up different items.
 2. What is the heaviest item you were able to lift?

3. How did the manipulation differ with the size of the object?
4. How did the manipulation differ with the material of the object? (Which object slid the most?)
5. How did the length of the handles and jaws affect the manipulation?
6. Compare your experiences with other groups using longer or shorter arms.
7. How do you think the experience would change if you used the robotic arm on the Moon or another planet?
8. Do you have any ideas on how to improve the functioning of the arm?

Kinematics

Project proposal: Measuring the Reaction Time.

Objective: Use the knowledge about the motion with constant acceleration to measure the reaction time.

Materials needed:

50 cm ruler.

Procedure:

- Insert the end of the ruler between the thumb and the other fingers of the classmate's hand.
- When you let the ruler fall vertically down, your classmate will try to catch it as soon as possible
- Measure his reaction time several times and calculate the average value. (If you have trouble to imagine it, you can find videos on the Internet for reference.)
- Now that you know the distance, let us focus on the question of time. What kind of movement did the ruler exhibit?? It was moving down with some acceleration, in the next chapter we will talk about it more, but for now just use the value of acceleration $10 \frac{m}{s^2}$. This value represents the acceleration due to gravity for objects falling towards Earth.
- For movement with constant acceleration we derived the equation $d = \frac{at}{2} = \frac{at^2}{2}$. Since we are interested in time, we can rearrange the equation to solve for time:

$$t = \sqrt{\frac{2d}{a}}.$$

Project proposal: Make your own story of somebody's day.

How much time he went to school, by car or tram, with what speed, when did he go home and so on.

Then make the plots speed - time and distance - time.

Project proposal: Find some application for your mobile phone that tracks the number of steps taken in a given time, the total distance traveled, calories burned and the average speed for a given time. Use it for a day and then answer the following questions

- How many steps did you take throughout the day?
- Find out how to calculate the average length of your step.
- How far did you walk during the entire day?
- What was the distance you covered between 7.30 a.m. and 9.a.m.
- What was your average speed for the entire day?
- Make plot distance – time for the chosen time interval.
- Prepare a task for your classmates to calculate based on the data from application.

Project proposal: Doppler Effect.

Objective: Have you ever stood alongside a road while a car passed by with its horn blowing? If so, you probably noticed that the pitch of the sound was higher when the car was approaching than after it passed. This phenomenon is called the Doppler effect.

With a simple model we can visualize the shortening of the wavelength when the wave source moves towards the observer.

Material: hard paper (A4), pencil, ruler, scissors, black marker

Procedure:



Fig. 8 Tool to visualize Doppler effect

- Cut a strip about 6 cm wide along the longer side of the paper and draw 1 cm wide strips 1 cm apart, on it using a marker.
- From the rest of the paper, cut an 8 x 18 cm rectangle and fold it in half to create an 8 cm wide sleeve through which the strip of paper can pass freely.
- Cut out a 3 x 3 cm window in the case.
- Draw two black stripes above and below the window, similar to the previous one.
- Insert the paper with strips into the case and quickly move it back and forth.

- In the window, you will observe the passing stripes, which seem narrower compared to the stripes on the case.

Explanation:

Due to the limitations of human vision, we perceive more than three strips when the paper moves rapidly in the window. As a result, the observed stripes appear narrower than ones surrounding the window.

(The source was not found)

Technical applications

The Doppler effect

Doppler effect is a phenomenon that occurs when there is relative motion between a source of waves and an observer. It results in a change in the frequency and wavelength of the waves perceived by the observer, depending on the direction and velocity of the relative motion (Think of the different sound of the ambulance when it is approaching – higher pitch - compared to when it is moving away – lower pitch).

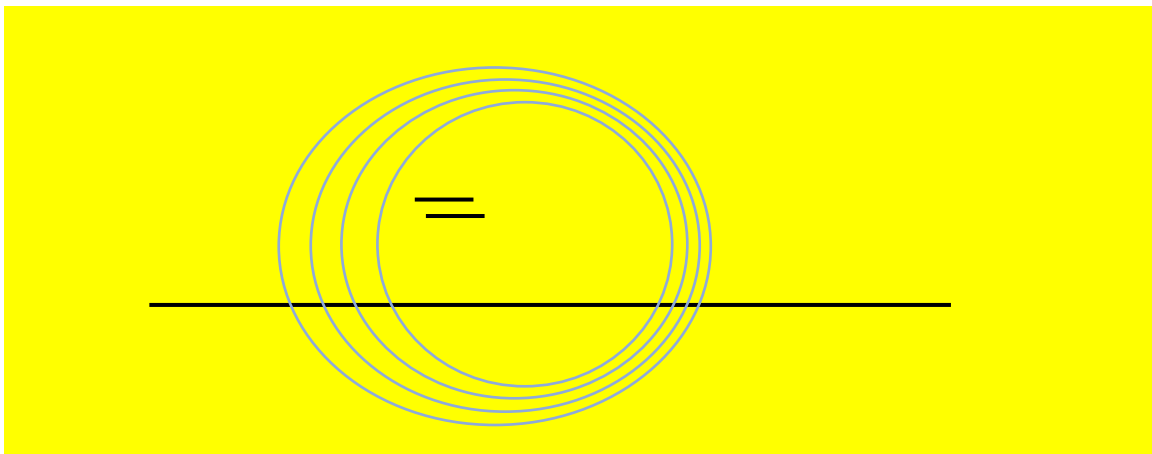


Fig. 9 Doppler effect

Application of Doppler effect

RADAR: Radar (Radio Detection and Ranging) systems use the Doppler effect to detect the velocity of objects, such as cars, airplanes and ships. A radar system transmits radio waves that bounce off the object and return to the radar receiver.

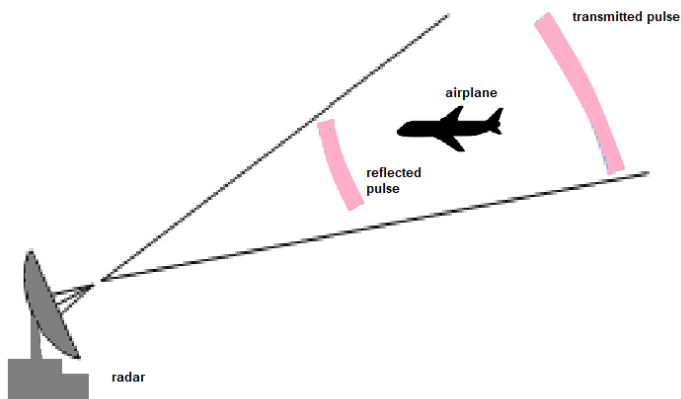


Fig. 10 Radar

Ultrasonic flow meters: These devices use the Doppler effect to measure the velocity of fluids, such as water or oil, flowing through a pipe.

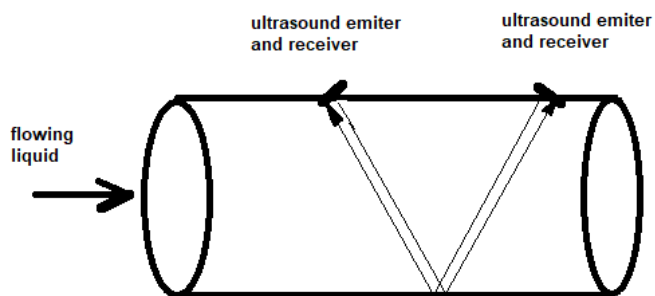


Fig. 11 Ultrasonic flow meter

Medical imaging: Doppler ultrasound is a non-invasive medical imaging technique that uses the Doppler effect to measure blood flow in the body.

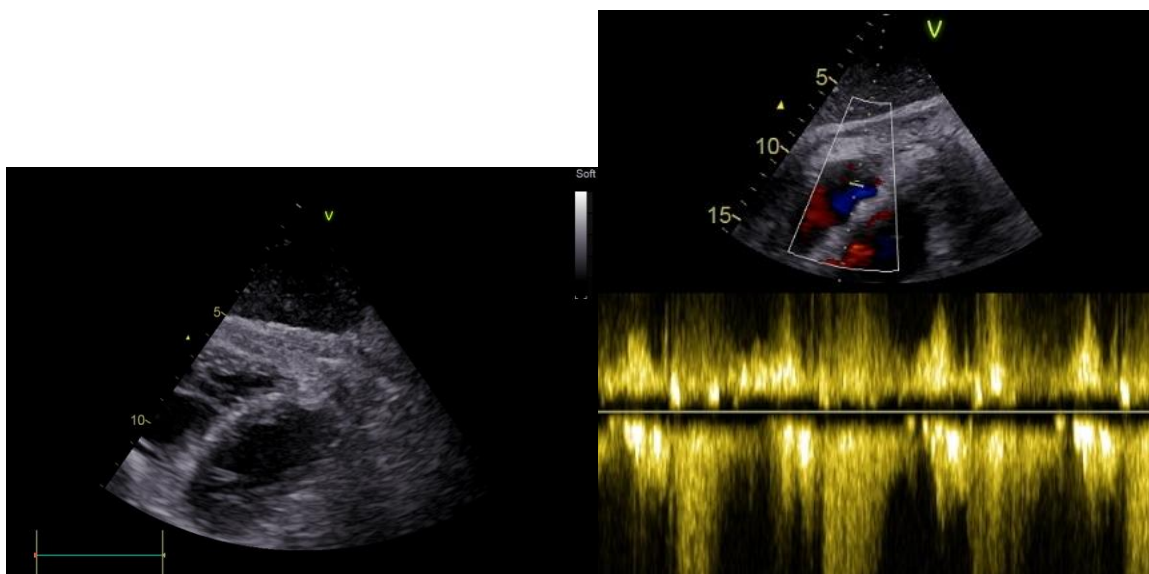


Fig.12 Ultrasound medical imaging

Astronomical observations: The Doppler effect is used in astronomy to measure the velocity and distance of celestial objects related to the Earth.

Dynamics

Project proposal: Write your Own Experiment Using Newton's First Law.

Objective: Test the Newton's First Law.

- Conduct research in books or on the Internet to select an experiment.
Remember to note down the source.
- Make a list of the materials you will need.
- Document the procedure for the experiment.
- Perform the experiment.
- Present the experiment to your classmates or conduct it at home and have your parents make a video of it.
- Reflect on the trickiest part of the experiment and share what you have learned.

Project proposal: Hair Dryer on a Wheel Cart.

Objective: Test the Newton's Third Law.

Materials needed:

Hair dryer, skateboard and something to attach the hair dryer to the skateboard, extension cord.

Procedure:

- Attach the hair dryer to the skateboard in a way that directs the airflow towards the imaginary axis between the skateboard wheels. Ensure that it is securely attached.
- Take precautions and make sure the hair dryer is only able to move within the length of the extension cord.
- Ask your classmate to record the experiment.

Project proposal: Two People on Two Skateboards

Objective: Test the Newton's Third Law.

Materials needed: two identical skateboards, two volunteers of the same weight, elbow and knee pads for safety, helmets

Procedure:

- Ensure the volunteers wear elbow and knee pads along with their helmets for safety.
- Have both volunteers stand on their respective skateboards, close to each other and facing each other.
- If one volunteer pushes, both individuals will move with the same velocity but in opposite directions.
- Ask your classmate to record the experiment.

Project proposal: Balloon Rocket

Objective: Demonstrate Newton's Third Law.

Materials needed: 1 balloon, 5 meters of string, 1 drinking straw, cellotape

Procedure:

- Thread the string through the straw.
- Tie the ends of the string to two chairs, ensuring the string is tightly stretched.
- Inflate the balloon and then hold its mouth tightly to prevent air from escaping.
- Ask a classmate to tape the balloon to the straw.
- Release the mouth of the balloon and observe the rocket sliding along the string.
- As the air blows out in one direction, the rocket moves in the opposite direction.

Project proposal: Spring Balance

Objective: Make and test your design of spring balance.

Research: Look for projects on the Internet and take pictures of the one you decide to create.

Strategy and modelling:

- Decide on the type of spring balance you want to make.
- Gather the necessary material.
- Most probably you will need: cardboard paper for making a scale, a marker, scissors, a ruler, a spring, or a hard rubber, a cylinder for housing the spring or rubber (can be made from a smaller, regular-shaped bottle), a cover to secure the rubber or spring, and a hook that you can fashion from a wire clothes hanger from the dry cleaners.
- Construct the spring balance.
- Test it by using known weights and use the results to calibrate your scale.

- The provided picture shows a professionally made spring balance, which you may have at school. It can serve as a reference for designing your own.



Fig.13 Spring balance

Project proposal: Make your Own Toy- Butterfly.

Objective: Make a toy using the knowledge of center of mass.

Materials needed: a piece of sturdy paper, matches, glue, 2 one- cent coins and scissors.

Procedure:

- Find or draw a picture of a butterfly. If drawing, ensure it has axial symmetry, meaning the left and right sides are identical. You can use a trick to achieve this: Draw one side, cut it out, fold the paper along the axis of the butterfly, and trace the cut half onto the uncut portion. Alternatively, you can choose to draw any other animal you're comfortable with, just remember to maintain axial symmetry.

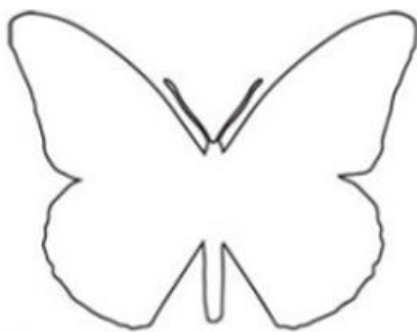


Fig.14 Balancing butterfly

- Glue a part of the wooden skewer in the center of butterfly

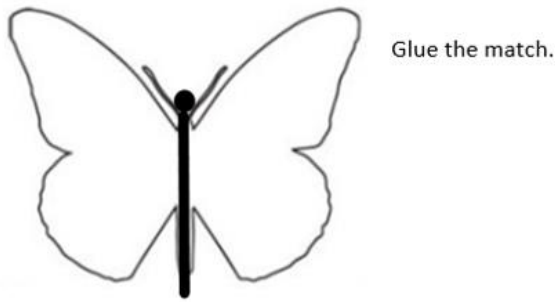


Fig.15 Balancing butterfly

- Glue the cent coins on the top of the wings.



Fig.16 Balancing butterfly

- Experiment to find the balance point where it can remain on your fingertip.

Technical applications

How does a truck behave on a tilt road?



Fig.17 3D models of trucks

To gain a deeper understanding of what occurs when a truck travels on an inclined (tilt) road, utilize a 3D model. In this AR you have access to a 3D truck model navigating a road that can be tilt at various angles, and its cargo load can be adjusted. You can observe how the truck's stability changes in response to alterations in both the load and the road's tilt.

The truck remains stable as long as the resulting force remains below the rollover threshold. When the resulting force exceeds this limit, the truck rolls over.

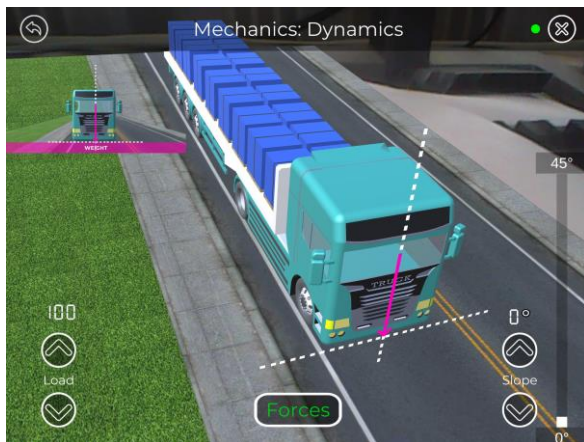


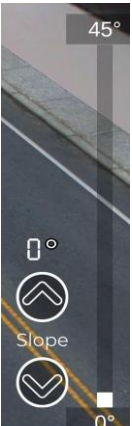



Fig. 18 The 3D AR model user interface of the truck driving a tilt road experiment

To comprehend these dynamics in the AR 3D simulation, you interact with the 3D model through the following user interface elements:

	<p>Increase and Decrease Load Buttons: located in the left-hand side of the screen, the 'Up' button increases the truck's load, while the 'Down' button decreases it in three stages: unloaded, half-loaded and full-loaded.</p>
	<p>Forces button: Positioned at the bottom of the screen, this button toggles the display of the forces acting on the truck. These forces determine whether the truck remains on the road or experiences a rollover, depending on the road's tilt and the truck's load.</p>
	<p>Increase and Decrease Tilt Buttons and Slider: Found on the right-hand side of the screen, the Up and Down Tilt buttons allows you to adjust the road's tilt angle from 0 to 45 degrees while the tilt slider allows the visualization of the amount of tilt.</p>

	<p>Detail view: Positioned in the upper left hand side, it gives user an image taken always from the front of the truck and from a frame of reference solidary with the truck. This view allows user to better view the road tilt and also the forces involved, regardless of the point of view from which the user looks at the truck.</p>
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For a more comprehensive understanding of the simulation and to visualize the forces at play, consider exploring the 3D model from various perspectives: from above, from the sides, from the front or from the rear. For this, after activating the AR 3D model with the trigger, you might have to either move around the page containing the corresponding trigger or rotate the page, trying always to keep the triggered simulation active.



Fig. 19. Trigger of the truck driving a tilt road experiment.

How do cars keep on the road or not at great speed in a curve.

To gain a deeper understanding of what occurs when a truck maneuvers on a curved road with varying speed and load, a 3D model can provide valuable insights. Within this AR environment, you'll have access to a 3D truck model navigating a curved road, with the ability to adjust its speed and load. You can observe how the truck's stability changes in response to alterations in speed and load.

The truck maintains its stability as long as the resultant force remains below the rollover threshold. When the resultant force exceeds this limit, the truck rolls over.

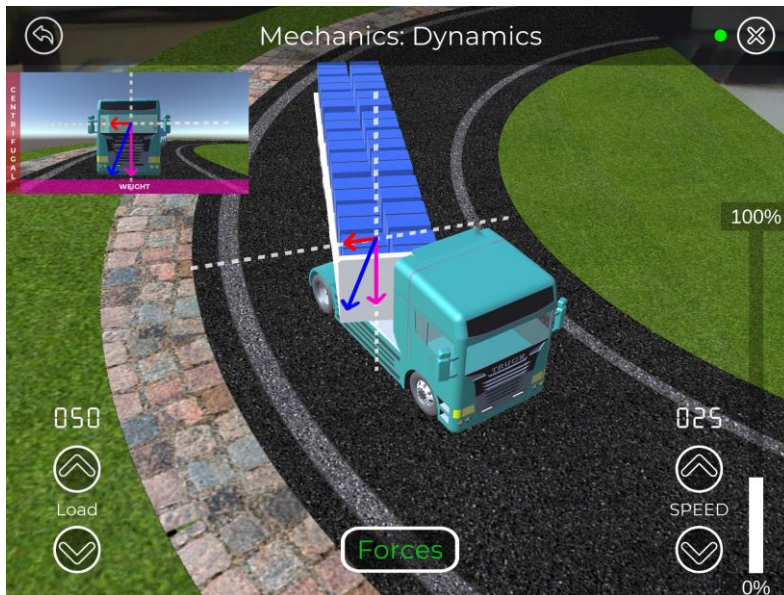



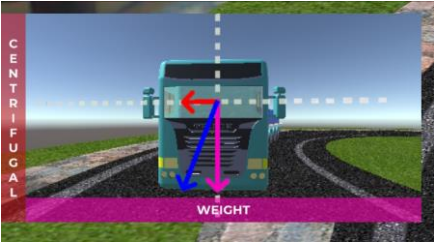


Fig. 20 The 3D AR model user interface of the truck driving through a curve experiment.

To comprehend these dynamics in the AR 3D simulation, you can interact with the 3D model through the following user interface elements:

	<p>Increase and Decrease Load Buttons: located in the left-hand side of the screen, the 'Up' button increases the truck's load, while the 'Down' button decreases it in three stages: unloaded, half-loaded and full-loaded.</p>
	<p>Forces button: Positioned at the bottom of the screen, this button toggles the display of the forces acting on the truck. These forces determine whether the truck remains on the road or experiences a rollover, depending on the road's tilt and the truck's load.</p>

	<p>Increase and Decrease Speed Buttons and Slider: Found on the right-hand side of the screen, the Up and Down Speed buttons allows you to adjust the truck speed from 0% to 100% of its maximum speed while the speed slider allows the visualization of the amount of speed.</p>
	<p>Detail view: Positioned in the upper left hand side, it gives user an image taken always from the front of the truck and from a frame of reference solidary with the truck. This view allows user to better view the forces involved, regardless of the point of view the user looks at the truck.</p>

For a more comprehensive understanding of the simulation and to visualize the forces at play, consider exploring the 3D model from various perspectives: from above, from the sides, from the front or from the rear. For this, after activating the AR 3D model with the trigger, you might have to either move around the page containing the corresponding trigger or rotate the page, trying always to keep the triggered simulation active.



Fig. 21. Trigger of the truck driving through a curve experiment.

Mechanics of Fluids

Project proposal: Save the Egg.

Objective: Find a way for an egg to fall from the 1st floor without breaking, without just wrapping the egg in any wrapping or packaging material.

Materials needed: paper, twine, balloons, cardboard, plastic bags, paper boxes, polystyren, springs, aluminum foil, scissors, sellotape and other readily available items.

Strategy and modelling:

- Create several sketches of potential solutions for saving the egg when it falls from an agreed-upon height (at least from the first floor).
- Discuss the sketches with your classmates, teacher, parents. Make a table and put in the comments and then think about improvement if possible.

Proposed way of saving an egg.	Pluses	Minuses	Possible improvement

- Select the best solution based on the discussions and evaluations.
- Create a list of the necessary materials for implementing the chosen design.
- Build your chosen design based on the selected solution.
- Perform a test drop of the egg using the designed apparatus. Request someone to record the experiment.
- Watch the recorded video and analyze the results. Identify areas for improvement, if necessary.
- Make any necessary improvements to the design based on the analysis.
- Conduct a final test using the improved design. Once again, ask someone to record the experiment.

Project proposal: Cardboard Ship Design

Objective: Create a cardboard ship that can bear a 2kg load and float in a sink using cardboard, aluminum foil, scissors, and sellotape.

Strategy and Modeling:

- Create several sketches of different boat designs.

- Discuss the sketches with your classmates, teacher, and parents. Use a table to collect comments and suggestions for possible improvements.

Boat design	Pluses	Minuses	Possible improvement

- Select the best solution based on the discussions and evaluations.
- Make a list of the necessary materials required for constructing the chosen design.
- Construct the cardboard ship based on the selected design.
- Perform a test by placing a 2kg load on the ship and placing it in a sink. Request someone to record the test.
- Watch the recorded video and analyze the results. Identify areas for improvement, if necessary.
- Make any necessary improvements to the design based on the analysis.
- Conduct a final test using the improved design. Once again, ask someone to record the test.

Project proposal: Homemade Powered Boat

Objective: Create a boat powered by materials found at home.

Materials needed: plastic bottles, cans, and other readily available items.

Strategy and modelling:

- Search the Internet for ideas and inspiration. Note down the webpage or source that inspired you.
- Create a sketch of the chosen boat design.
- Discuss the sketch with your classmates, teacher, and parents.
- Use a table to collect comments and suggestions for possible improvements.

Boat design	Pluses	Minuses	Possible improvement

- Select the best solution base on the discussions and evaluations.

- Make a list of the necessary materials required for constructing the chosen design.
- Built your boat design using the selected materials.
- Test the boat by powering it using the chosen materials. Request someone to record the test.
- Watch the recorded video and analyze the results. Identify areas for improvement, if necessary.
- Make any necessary improvements to the design based on the analysis.
- Conduct a final test using the improved design. Once again ask someone to record the video.

Project proposal: Hoover with Flexible Corrugated Pipe Sleeve

Objective: Using the Bernoulli Principle make a hoover.

Materials needed: flexible corrugated pipe sleeve, small paper waste.

Strategy and modelling:

- Look on the Internet for some ideas. Put down the page you were inspired.
- Make a list of the necessary material.
- Prepare the experiment.
- Test it. Ask someone to record it.
- Try testing Flexible Corrugated Pipe Sleeves with different diameters.
- Put down the observation and discuss it with classmates and a teacher.
- Make a competition: What is the maximum weight you were able to suck in? What does it depend on?

Technical applications

Why airplanes fly?

The basics of how things fly are actually quite simple, but if you want to become an aeronautical engineer, it takes a lot of studying and learning. Let's start with the easy part. The physics of flying is based on Newton's laws.

One of Newton's laws says that if something wants to move forward, something else has to move backward. This rule applies to flying too. When things fly, they have to overcome the force of gravity pulling them down. There are four forces that come into play when flying: forward, backward, downward, and upward. When something moves forward, it has to overcome the force of air pushing against it. And when something goes up, it has to overcome the force of gravity pulling it down.

Now, let's try a fun experiment to understand flying better. Have you ever stuck your hand out of a car window? If you have, you might have noticed that as the car goes faster, it becomes hard to keep your hand straight and level. But never, ever try it on

the highway and always inform the driver what you want to do! By changing the angle of your hand, you can feel the force pushing it backward or lifting it up.

Another example of flying is flying a kite. I'm sure you've flown a kite before, or at least seen others do it. When we fly a kite, we first run as fast as we can to get it up in the air. Then we adjust the kite so that the wind keeps it flying. If we do it right, the wind pushes the kite and keeps it in the air. The shape of the kite makes the air move in a way that pushes the kite up. Our job is to hold onto the kite and make sure it doesn't fly away.

Now, let's talk about the Wright brothers, who were the first to build an actual airplane. Before they built the airplane, they tested and experimented with different ideas using unpowered aircraft. These aircraft were like big kites or gliders that the Wright brothers could fly. They did this to learn about how to control the aircraft and how things worked in the air.

Below is a picture of 1900 aircraft flown as a kite at Kitty Hawk.

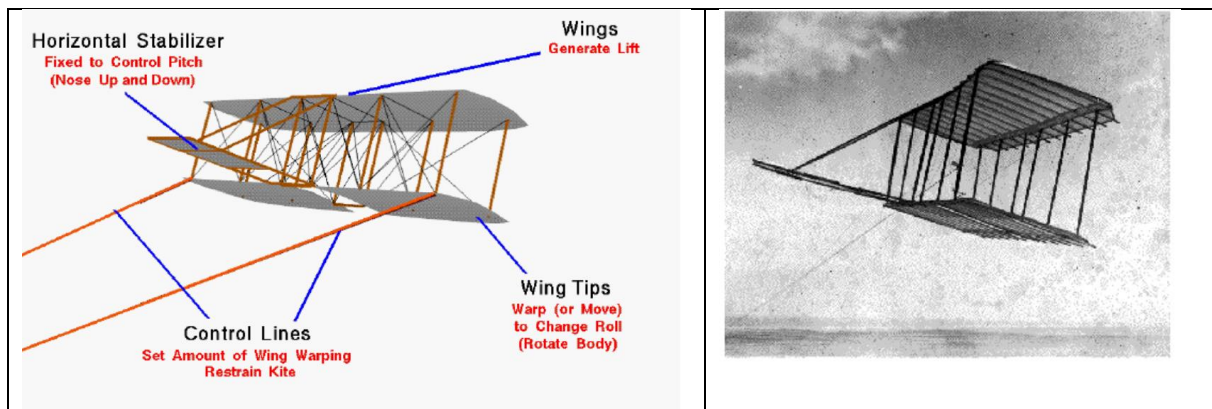


Fig. 22 [Wright Unpowered Aircraft - Flown as a Kite](#) taken from NASA

With kites, we're fine with physics, but an airplane is a different colossus. Airplanes can weigh hundreds of tons and have wings with a very large surface area, sometimes over 100 square meters, depending on the type of airplane.

The wing area of an airplane is important because it helps create lift, which is what allows the plane to stay up in the air. Let's try to understand it better using swimming as an example. Have you ever noticed that animals like ducks or frogs have membranes between their fingers or toes? This is similar to how wings work on an airplane. By having a larger surface area, they can generate more lift and stay afloat or glide through the water more efficiently. It's similar to using fins when swimming to increase speed. Nobody would try to paddle through the water using just a handle, right?

Now, let's think about airplanes flying in the air. The air around us has such a low density that we don't feel it when we walk. However, airplanes fly at very high

speeds, sometimes up to 900 kilometers per hour! When an airplane is in motion, the way it generates lift is through a combination of factors, including the speed at which it moves through the air.

The relationship between speed and lift is quite interesting. Lift actually increases with the square of the speed. So if you double the speed, you get four times the lift, and if you increase the speed by ten times, you get a hundred times the lift! This is why airplanes need to move at high speeds to generate enough lift to stay airborne.

Additionally, the design of the aircraft plays a crucial role. This is where we can bring in Bernoulli's equation. Bernoulli's principle helps explain how differences in air pressure create lift. The shape of the wing and the way air flows over and under it create a pressure difference, resulting in lift.

Understanding these principles of physics and aerodynamics is essential for designing and operating airplanes. It's fascinating how different scientific concepts come together to make flight possible!

Following picture will help our understanding.

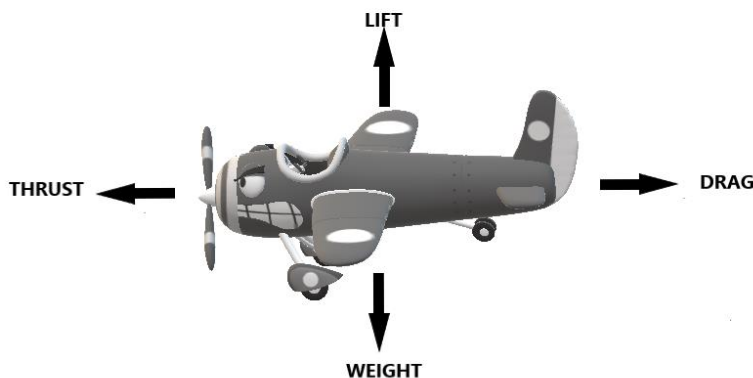


Fig. 23 Forces acting on the airplane

And now the wing design:

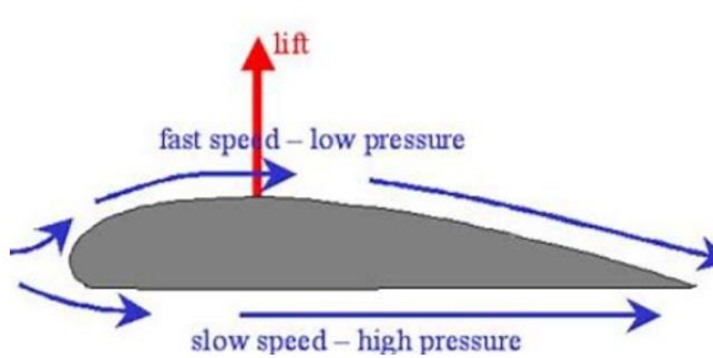


Fig. 24 Airplane wing

Wings are shaped so that the air that wraps around the wing from above goes through a longer path compared to the air under the wing. This results in the air above the wing of the airplane having a higher speed than the air below it. According to Bernoulli's equation, the air pressure above the wing is then lower than below it, and the aerodynamic force called lift acts upwards on the wing

You will understand more with 3D model of the airplane.

In this AR environment, you'll find a 3D model of an airplane soaring into the sky. You can observe how it ascends or descends when the flaps are adjusted and how its speed changes when the propeller's speed is altered.

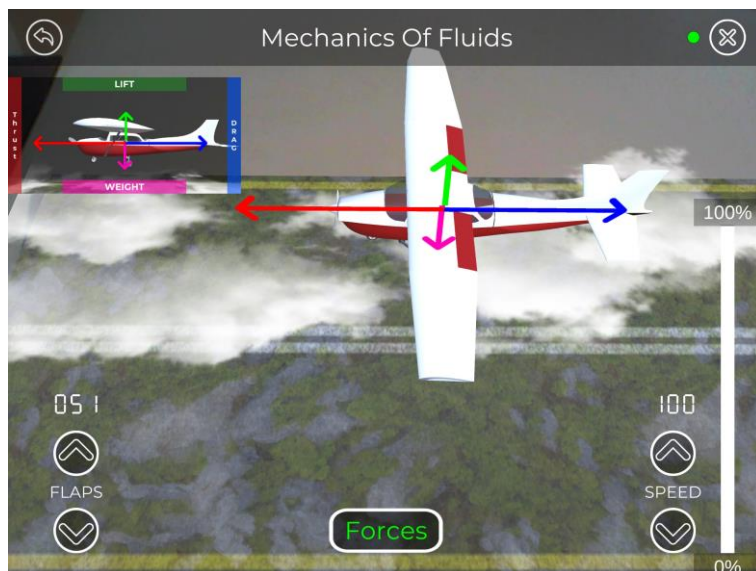



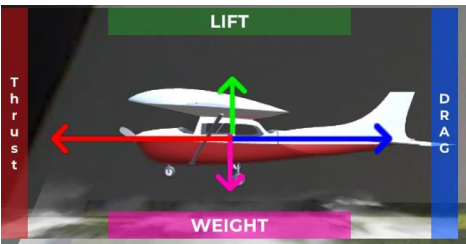


Fig. 25 The 3D AR model user interface of an airplane.

To how the airplane operates, within the AR 3D simulation, you have access to the following user interface elements:

 <p>The image shows two circular buttons with white outlines. The top button contains an upward-pointing chevron, and the bottom button contains a downward-pointing chevron. The word 'FLAPS' is written in white capital letters between the two buttons.</p>	<p>Up and Down Flaps Buttons: Located on the left-hand side of the screen, the 'Up' button lowers the flaps, causing the airplane to ascend, while the 'Down' button raises the flaps, causing it to descend.</p>
 <p>The image shows a rectangular button with a black border and rounded corners. The word 'Forces' is written in green capital letters inside the button.</p>	<p>Forces button: Positioned at the bottom of the screen, this button toggles the display of the forces acting on the airplane.</p>
 <p>The image shows a vertical speed slider. At the top, there is a grey bar with '100%' written in white. Below it is a white vertical bar representing the speed range. At the bottom, there is a grey bar with '0%' written in white. To the left of the slider, the word 'SPEED' is written in white capital letters. Above 'SPEED' is a digital display showing '100'. Below 'SPEED' are two circular buttons with white outlines: the top one has an upward-pointing chevron and the bottom one has a downward-pointing chevron.</p>	<p>Increase and Decrease Speed Buttons and Slider: Found on the right-hand side of the screen, the 'Increase' and 'Decrease' Speed buttons allows user to adjust the airplane speed from 0% to 100% of its maximum speed while the speed slider allows the visualization of the amount of speed.</p>
 <p>The image shows a 3D model of a red and white airplane. Four force vectors are shown: a red arrow pointing left labeled 'Thrust', a green arrow pointing up labeled 'LIFT', a blue arrow pointing right labeled 'DRAG', and a pink arrow pointing down labeled 'WEIGHT'.</p>	<p>Detail view: Positioned in the upper left hand side, it gives user an image taken always from the side of the airplane and from a frame of reference solidary with the airplane. This view allows user to better view the forces involved, regardless of the point of view from which the user looks at the airplane.</p>

For a more comprehensive understanding of the simulation and to visualize the forces at play, consider exploring the 3D model from various perspectives: from above, from the sides, from the front or from the rear. For this, after activating the AR 3D model with the trigger, you might have to either move around the page containing the corresponding trigger or rotate the page, trying always to keep the triggered simulation active.



Fig. 26. Trigger of the 3D AR airplane model.

What about the birds?

Birds fly in a way that's a bit like swimming and a bit like flying in airplanes. Unlike airplanes, birds don't have fixed wings. Instead, they flap their wings to move through the air. But it's not just about flapping backwards, because they also have to overcome the force of gravity. Birds direct the air diagonally with their wing movements, which helps them overcome both air resistance and their own weight.

Birds are specially adapted for flying. Their bones are hollow, making them lighter than humans. This is why birds can float on the water without diving too deep. Our bodies are denser than water, so we sink. Sometimes you might see large birds, like vultures, soaring in the sky without flapping their wings. They glide like gliders, using air currents to stay up in the air. Amazingly, the Great Condor can fly for long distances without flapping its wings at all! Scientists studied these birds and found that they spent only a small percentage of their flight time flapping their wings. Condors have big wings and use air currents to help them glide effortlessly.

When birds fly in a V-formation, there's an interesting physics concept at play. As birds flap their wings, the air that rolls off their wingtips creates rotating vortexes. This means that the air immediately behind a bird is pushed downwards, while the air behind and on the sides is pushed upwards. When birds fly in a V-formation, they benefit from this air movement and get a free lift. It helps them conserve energy during long flights. This is similar to why fighter jets in the air force also adopt a V-formation.

Winglets on airplanes also serve a purpose. They help reduce something called wingtip vortices. As air flows around the wing, it creates pressure differences that result in air streams curling upward around the wingtips. These air vortices represent energy loss. Winglets are designed to minimize these vortices and improve the efficiency of the airplane.

How submarines work?

People have always been curious about exploring new frontiers, whether it's flying in the sky or diving underwater.

Did you know that diving devices have been around for a long time? Way back in 332 BCE, during the time of Alexander the Great, divers were used during the siege of Tyre. They used something called a diving bell, which helped them stay underwater for a short time.



Fig. 27 Diving bell

The first prototype submarine was built in 1578 by an Englishman named William Bourne. It was a closed boat that could be submerged beneath the water's surface. To control the depth, they used a hand-operated wooden screw and leather bags filled with water.

But the first practical submarine that could actually be used for real purposes was built in 1620 by a Dutch engineer named Cornelis Jacobszoon Drebbel. His submarine could carry up to 16 people and had oars for propulsion. It was covered in greased leather, had a watertight hatch, and used large pigskin bladders to control buoyancy. Find the picture on the Internet and think about what needed to be improved.

Submarines became more advanced over time. In 1720, a carpenter named Yefim Nikonov built the first military submarine for Tsar Peter the Great of Russia. The

United States also had its own submarine called the Turtle in 1776. It was shaped like an egg and operated using hand-powered screws.

During the American Civil War, both the Union and the Confederate States of America used submarines. The Union's submarine called the Alligator had advanced features like compressed air supply and an air filtration system. The Confederate submarine named CSS H.L. Hunley successfully sank a ship but unfortunately sank itself shortly after.

Designing submarines was a challenging task for engineers. They had to solve problems like supplying air to the crew, making the submarine strong enough to handle the pressure underwater, and finding ways to control the buoyancy. They also developed special devices inspired by dolphins, like sonars, to help navigate underwater.

Submarines have come a long way since then. Today, they can go as deep as 240 meters underwater! It's fascinating to see how science and engineering have allowed us to explore and understand the depths of the ocean.

Remember, exploration is all about curiosity and pushing the boundaries of what we know. Who knows what amazing discoveries lie beneath the sea?

[How Does a Submarine Sink and Rise? Soda Bottle Diver | Cartesian Diver Physics Experiment - YouTube](#)

You will understand more with 3D model of the submarine.

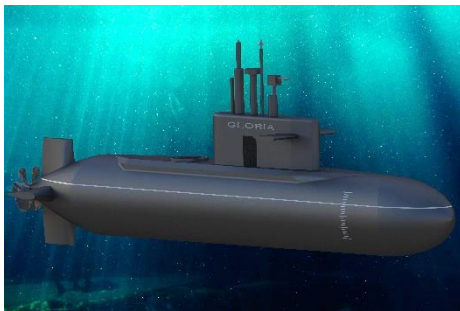


Fig. 28 3D Model of a submarine

In this AR environment, you will find a 3D model of a submarine that moves into the water. You can observe how it can descend or ascend when the water is pumped into or out of the ballast tanks.

To understand how the submarine operates, within the AR 3D simulation, you have access to two user interface elements:

To understand the submarine operation, in the AR 3D simulation you have the possibility to interact with the 3D model using the following user interface elements:

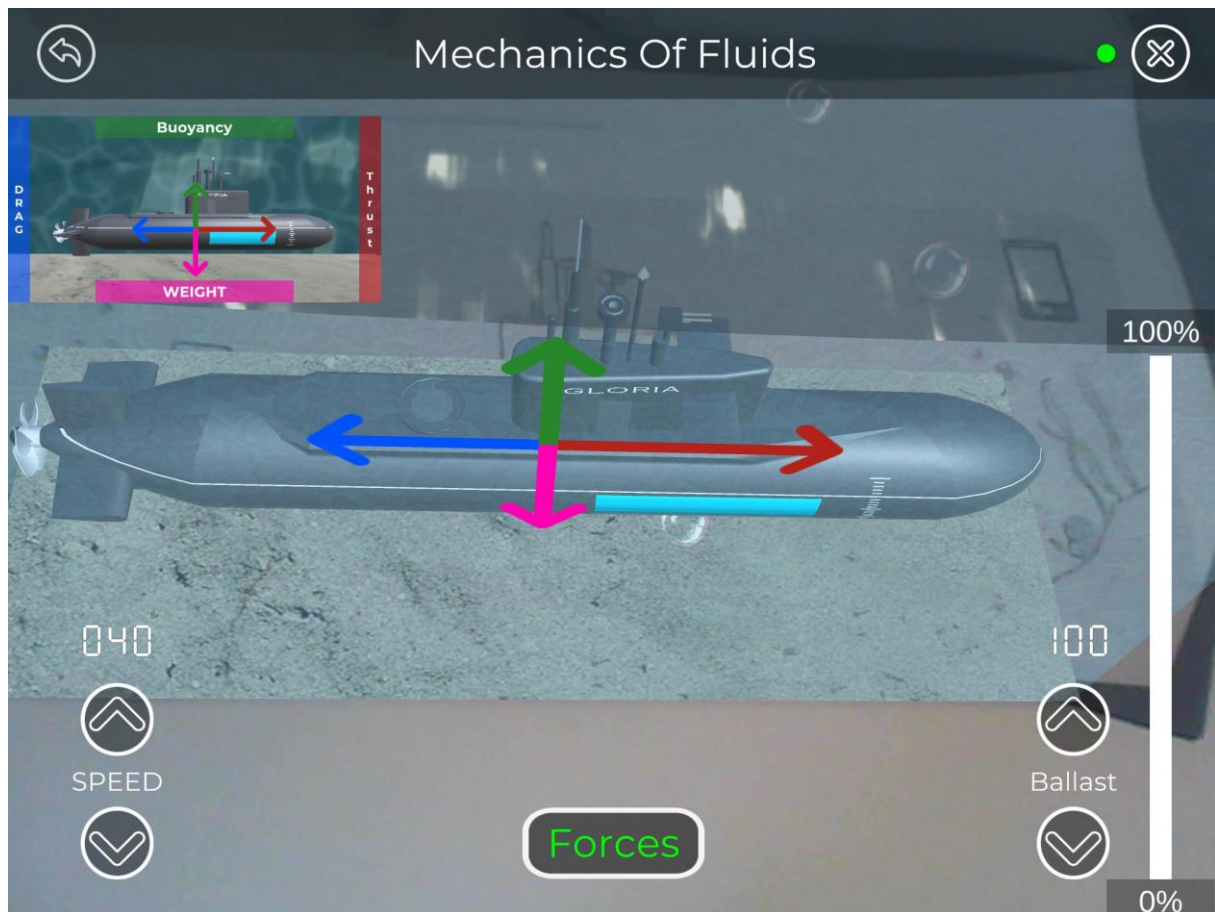
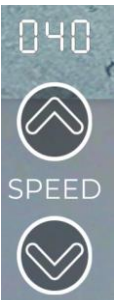


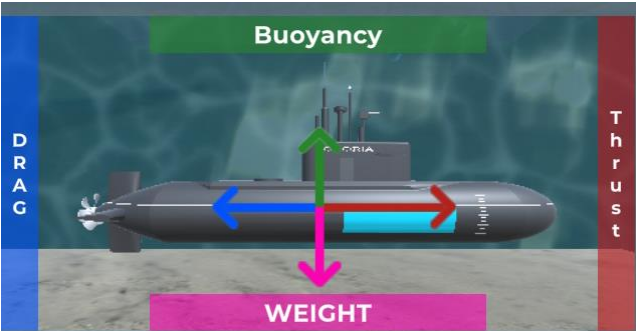


Fig. 29 The 3D AR model user interface of a submarine.

	<p>Increase and Decrease Speed Buttons: Located on the left-hand side of the screen, the 'Increase' button increases submarine speed, while the 'Decrease' button lowers the submarine speed.</p>
	<p>Forces button: Positioned at the bottom of the screen, this button toggles the display of the forces acting on the submarine.</p>

	<p>Increase and Decrease Balast Buttons and Slider: Found on the right-hand side of the screen, the 'Increase' and 'Decrease' Balast buttons allows user to adjust the ballast size (quantity of water pumped into the ballast tanks) of the submarine making it to descend or ascend respectively.</p>
	<p>Detail View: Positioned in the upper left-hand side, it gives user an image taken always from the side of the submarine and from a frame of reference solidary with the submarine. This view allows user to better view the forces involved, regardless of the point of view the user looks at the submarine.</p>

For a more comprehensive understanding of the simulation and to better visualize the forces at play, consider exploring the 3D model from various perspectives: from above, from the port and starboard sides, from the bow or from the stern. For this, after activating the AR 3D model with the trigger, you might have to either move around the page containing the corresponding trigger or rotate the page, trying always to keep the triggered simulation active.

Though in real submarines the filling of the ballast tanks cannot be visualized from outside, in the AR 3D simulation this was made visible on the starboard side of the submarine and in the Detail View. The ballast level is not visible on the port side of the submarine.



Fig. 30. Trigger of the 3D AR submarine model.

How water locks work?

A water lock, also known as a canal lock, is a clever device used in canals and rivers to help boats move through different water levels. It's like an elevator for boats!

A water lock is made up of several chambers with gates at each end that can be sealed tightly. These gates keep the water in the lock chamber from flowing out.

Here's how it works:

Let's say a boat wants to go downstream. The lock chamber is filled with water at the same level as the upstream part of the canal. The gate at the upstream end is opened, and the boat enters the lock chamber. Once the boat is inside, the upstream gate is closed. Then, the water in the lock chamber is slowly drained out downstream. This makes the water level in the lock chamber the same as the downstream part of the canal. Finally, the gate at the downstream end is opened, and the boat can exit the lock chamber and continue its journey downstream.

Now, let's imagine a boat wants to go upstream. The lock chamber is filled with water at the same level as the downstream part of the canal. The gate at the downstream end is opened, and the boat enters the lock chamber. Once the boat is inside, the downstream gate is closed. Now, here comes the interesting part. The lock chamber is slowly filled with water from upstream. This is possible because of the principle of communicating vessels, which means that the water levels in connected vessels will eventually become equal. As the water level rises in the lock chamber, it matches the water level in the upstream part of the canal. When the levels are the same, the gate at the upstream end is opened, and the boat can exit the lock chamber and continue its journey upstream.

By using a water lock, boats can smoothly move between different water levels in a canal. It's a smart way to overcome changes in elevation and make sure boats can navigate both upstream and downstream. Water locks are a great example of how engineering and clever design can make our lives easier and help us travel by water in a controlled and efficient way!

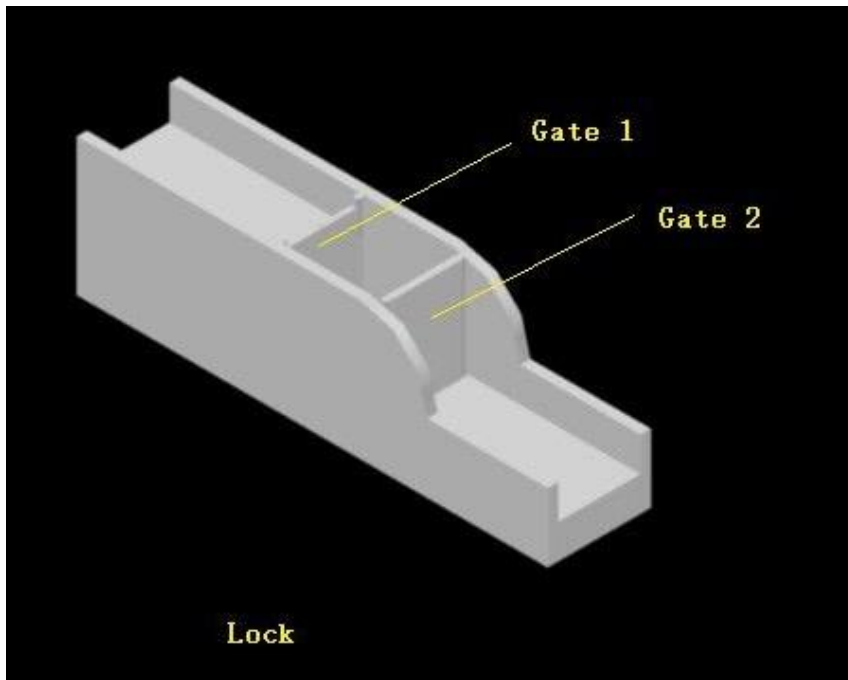


Fig. 31 Water lock 3D model.

You can watch boats passing Gatun lock of the Canal of Panama on the web cam at:
<https://multimedia.panama-canal.com/Webcams/gatun.html>

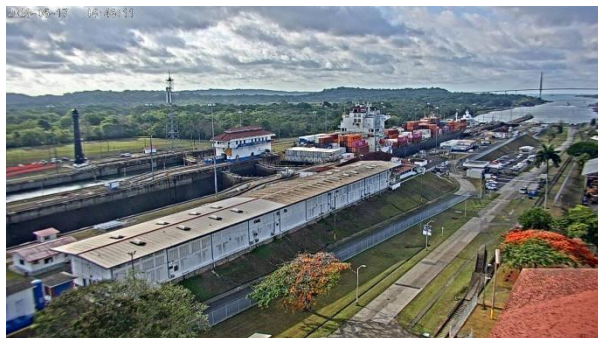




Fig. 32 Successive screen shots taken from the web cam depicting two boats passing the Gatun lock.

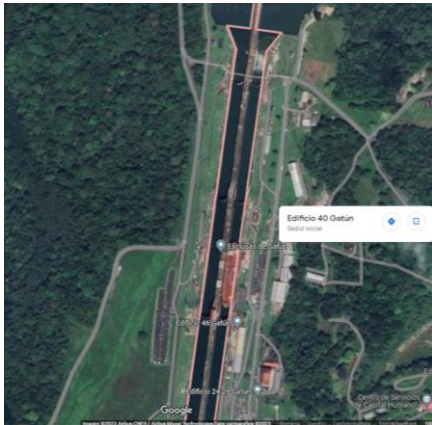


Fig. 33 Aerial view of Gatun lock taken using Google Maps.

Work, Power, Energy

Project proposal: Efficiency of Different Devices

Objective: To compare the efficiency of various devices used for boiling 0.5 liters of water.

Materials needed: Tap water, electric kettle (use different ones, or compare the results with your classmates), stopwatch, thermometer.

Strategy: To perform this task, it is essential to calculate the amount of energy required to boil the water.

- The amount of heat needed to bring water to a boil can be determined using the formula: $Q = mc\Delta t$,

where: Q = amount of heat energy in Joules (J), m = mass of water in kg, c = specific heat capacity in $J/(kg\ K)$, Δt = change in temperature (boiling temperature of water - initial temperature of water).

Given that water boils at 100°C under normal atmospheric pressure and has a specific heat capacity of 4180 J/(kg K), assuming the initial temperature of cold tap water as 15°C (use the actual temperature of the water you will be heating), we can calculate the energy required to start boiling the water.

- Sample calculation example:

mass of heated water: 0.5 kg, water temperature before the start of heating: 15°C, boiling temperature of water: 100°C.

The energy required for the water to start boiling: $Q = 0.5 \text{ kg} * 4180 \text{ J/(kg K)} * (100^\circ\text{C} - 15^\circ\text{C}) = 177\,650 \text{ J}$

- To measure the efficiency, follow these steps:

Measure the time necessary to bring the water to a boil.

Calculate the power of the kettle needed for the water to start boiling:

Power (in watts, W) = 177,650 J / time necessary to bring water to boil (in seconds).

Efficiency = The performance indicated on the appliance (refer to the picture - 1500 W) / power of the kettle needed for the water to start boiling.

The data indicating the power input of the device can be found at the bottom or on the backside of the device.



Fig. 34 Data on the device.



Fig. 35 Data on the device.

- By conducting this experiment and comparing the efficiency of different devices, we can gain insights into their performance and make informed decisions regarding their usage.

Project proposal: Energy Savings with Different Light Sources

Objective: To investigate the energy-saving potential of different light sources, with the aim of reducing monthly electricity payments, which constitute a significant portion of the family budget.

Strategy:

- To do this investigation, we need some important information that we can get from something called an electric meter or energy meter. This special device measures how much electricity is used over a certain period of time. Electric companies use these meters to keep track of how much electricity you use and to calculate how much to charge you. They usually measure electricity in units called kilowatt-hours (kWh). This helps us know how much electricity your family uses in your house.
- The table illustrates the usage patterns, energy consumption, and estimated costs for various light sources. The input power represents the wattage of each respective light source. By calculating the energy consumption in Wh and converting it to kWh, we can evaluate the potential cost savings based on the price per kWh applicable in your country.

Appliance /device	Used in hours/week	Used in hours/year	Input power in W	Energy consumption in a year in Wh	Energy consumption in a year in kWh	The price for kWh Different for each country
Led bulb	$5 \times 7 = 35$	$35 \times 52 = 1820$	22	$22 \times 1820 = 40040$	40	
Classic light bulb	$5 \times 7 = 35$	$35 \times 52 = 1820$				
Halogen bulb	$5 \times 7 = 35$	$35 \times 52 = 1820$				
Neon tube	$5 \times 7 = 35$	$35 \times 52 = 1820$				

- Your task is to fill the missing parts.
- Through this investigation, we aim to identify the light source that offers the highest energy efficiency and potential savings in electricity costs. The findings will provide valuable insights for making informed decisions on lighting choices and contribute to overall energy conservation.

Project proposal: Compare in Similar Way Different Appliances at Home.

Project proposal: Create Your Own Solar Oven and Refrigerator

Solar Oven

Materials needed: large cardboard boxes, aluminum foil or a mirror, non-toxic black paint or black paper, a wooden board, scissors, adhesive tape, a cooking pot (preferably black or painted with non-toxic color), and something to cook, like an egg.

Procedure:

Take a big cardboard box and cover the inside with aluminum foil or a mirror. This will help reflect the sunlight inside.

Paint the cooking pot black or wrap it with black paper. Black absorbs more heat from the Sun.

Cut a hole in the top of the box and place the pot inside, making sure it sits securely.

Seal any gaps or openings with adhesive tape to keep the heat trapped inside.

Find a sunny spot outside and position the solar oven so that it faces the sun directly. The reflected sunlight will heat up the pot, allowing you to cook your food, like an egg.

Refrigerator

- Materials needed: two containers: an outer one made of porous material (such as clay) and an inner one that is waterproof to protect your food. The space

between the containers will be filled with wet sand. You will also need a cover for the top, where you can put more wet sand.

- Place the smaller, waterproof container inside the larger, porous container.
- Fill the space between the containers with wet sand. This will help keep the inner container cool.
- Place a cover on top of the larger container, making sure to leave a space to add more wet sand. This cover will provide shade and insulation.
- If you need any additional information or another ideas, you can find them online.

Extra tasks: If you ask your parents or even your grandparents, they might have some interesting knowledge and stories about how they kept the food fresh in warm weather. Their experiences can give you more ideas and insights for your project.

Technical applications

1. What are energy transformations we meet daily in our lives?
2. Where do we find energy to transform into other forms?

Energy transformation.

We already know that energy is the ability to do work. Energy changes form whenever it is used to do work. When energy changes form it is called energy transformation. Energy transformations occur everywhere in the universe. It happens all the time, that is because energy cannot be created or destroyed. Energy can neither appear out of nowhere nor vanish into nowhere.

The biggest source of energy on Earth is the Sun. The nuclear energy of the Sun is constantly being changed into so called electromagnetic energy, part of which is light energy. This energy travels in waves through space. On Earth light energy from the Sun is used by plants to make their own food. During a process called photosynthesis it is transformed into the chemical energy found in plants. Then we and animals eat the plants and get energy from them. A lot of people also eat animals and use the energy these animals took from the plants when they ate them.

The chemical energy of the food transforms into heat and mechanical energy. We need energy to maintain the body's temperature. What do we do if we are cold? We rub our hands together, jump up and down and it helps get us warmer. We can also transform our body energy into sound energy, we talk, yell, whisper, or sing. In that way we are one of the transformers of energy from the Sun.

There is one form of energy without which we can not imagine our life – electricity. Electricity is a kind of energy that can flow from one place to another. We use a lot of electricity in our homes, we turn on lights, use computers, watch television, and cook food. Where does it come from? What energy transformations have to happen to bring it to us?

Most of it is made using fossil fuels. These are remains of ancient trees and plants that grew hundreds of millions of years ago. Over time they turned into coal, oil, and gas. Fossil fuels produce heat energy when we burn them. That makes hot water turn into steam. The heat energy of steam turns into motion energy. The motion energy transforms into electricity which then comes into our homes through wires. Then we can change it again to our use. Electrical energy that reaches a light bulb changes to light and heat energy. In this case, the heat energy is considered to be “wasted” energy. Waste energy in the form of heat is heat that is produced by a machine, or other process that uses energy, as a byproduct of doing work. As a fundamental result of the laws of thermodynamics we can not transform all energy into work. So far it is enough if you remember that heat can be transferred only from the place with higher temperature into the place with lower temperature. (It means for example that you can not transfer heat from cold tea into the warm one). So, in the case of a light bulb, the task for engineers is to improve how well light bulbs convert electrical energy into light energy.

Efficiency of energy conversion refers to the percentage of energy that is converted from one form to another without being lost in the process. In other words, it is a measure of how effectively a system or device converts input energy into useful output energy.

Efficiency is typically expressed as a percentage, calculated by dividing the useful output energy by the total input energy and multiplying by 100. For example, if a system converts 75% of the input energy into useful output energy, then its efficiency is 75%.

The table below shows examples of conversion of energy between the most common types that we can encounter in our daily life.




Find your own examples that correspond to the conversion of energy from one type to another and write them in the empty cells of the table. Ask your parents or classmates to help or use Internet to search for examples.

Fill in the blue boxes your examples of energy conversions.




From -> To	Mechanical energy	Thermal energy	Electrical energy	Chemical energy	Radiant energy
Mechanical Energy	Lever	Breake	Electrical generator	Churners	Matches
Thermal energy	Steam engine	Heat exchange system	Termocouple	Furnace	Electric bulb
Electrical energy	Electric motor	Electric heater	Electric transformer	Batery charger	LED
Chemical energy	Muscle	Stove	Battery	Chemical reactor	Firefly
Radiant energy	Solar sail	Solar panel	Photovoltaic panel	Plants	Prism

Energy transformations explained

Photosynthesis is the process by which green plants, algae, and some bacteria convert light energy from the Sun into chemical energy in the form of glucose or other organic compounds (like cellulose and lignin which the main part wood is made of).



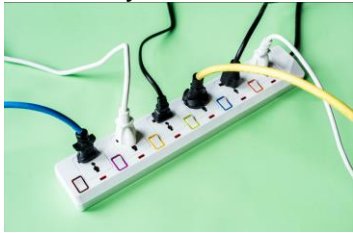
Kind of energy in	Device	Kind of energy out	Your comments and observation
Energy from the Sun 	Plant (ex. tree) 	Chemical energy in the tree wood 	

Chemical energy is released by burning the wood. This chemical reaction is called combustion. Byproduct of this process are carbon-dioxide, water vapor, and ash in the presence of heat and oxygen. On average, woods have an energy content of around 17-20 MJ per 1 kg. On average, traditional wood stoves have an efficiency of around 60% to 70%.



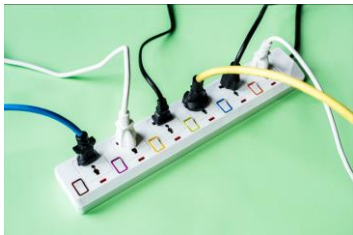
Kind of energy in	Device	Kind of energy out	Your comments and observation
Chemical energy in the wood 	Campfire 	Heat, light 	

Photovoltaic devices convert solar energy into electricity using a process called the photovoltaic effect. When sunlight hits the PV panel a flow of electrons in the form of a direct current (DC) is created, which can be captured and used as electricity. As of 2021, the efficiency of commercial solar panels typically ranges from around 15% to 22%. However, there are some experimental and research-grade panels that have achieved efficiencies of over 40%.

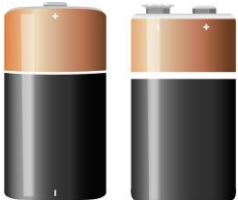


Kind of energy in	Device	Kind of energy out	Your comments and observation
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Energy from the Sun 	Photovoltaic device (solar panels) 	Electricity 	
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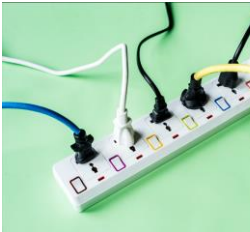


The energy of the wind turns the blades of wind turbine that turn the rotor of an electric generator thus converting the mechanical energy into electricity. On average, modern wind turbines have a conversion efficiency of around 40% to 50%.

Kind of energy in	Device	Kind of energy out	Your comments and observation
Energy of the wind 	Wind turbine 	Electricity 	

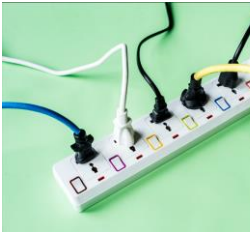


When the battery is connected to a circuit, a chemical reaction occurs between the electrodes and the electrolyte, generating an electrical current. In the flashlight, the current generated by the battery passes through the bulb filament, creating both light and heat.

Kind of energy in	Device	Kind of energy out	Your comments and observation
Chemical energy of the battery 	Flashlight 	Light, heat 	

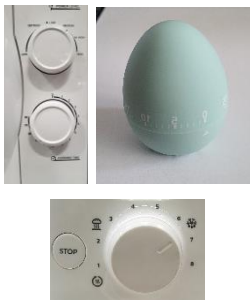
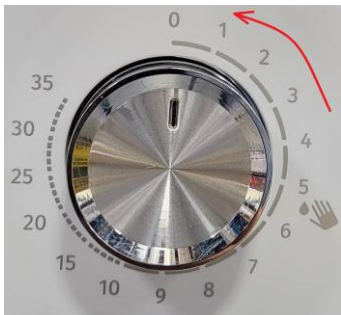
The electricity is converted into light and heat in the lamp bulb. In this case, the heat is an unwanted byproduct. Therefore, scientists have developed new lighting devices (e.g., LEDs) to increase the amount of light and reduce heat. The efficiency of incandescent bulbs is typically around 2-13%. In contrast, LED bulbs are capable of converting roughly 70% of their energy into light.






Kind of energy in	Device	Kind of energy out	Your comments and observation
Electricity from the mains electricity 	Lamp 	Light, heat 	

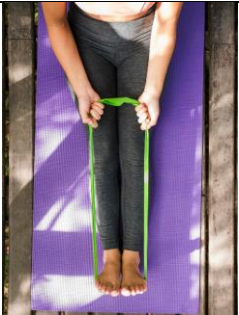
We enjoy the light and sound from a TV set, the heat is an unwanted byproduct.

Kind of energy in	Device	Kind of energy out	Your comments and observation
Electricity from the mains electricity 	TV 	Light, heat, sound 	




When the mainspring is released, its elastic energy is transformed into kinetic energy, which ensures a constant rotation speed of the timer knob.

Kind of energy in	Device	Kind of energy out	Your comments and observation
Elastic energy of the mainspring	Timers used in households appliances 	Kinetic energy of the knob 	

			
<p>The elastic energy of the bow is transformed into kinetic energy of the bowstring, which then transfers its kinetic energy to the arrow, propelling it at high speed.</p>			
Kind of energy in	Device	Kind of energy out	Your comments and observation
<p>Elastic energy of the bowstring</p> 	<p>Bow and arrow</p> 	<p>Kinetic energy of the arrow</p> 	
<p>We use the strength of our muscles to wind the paddle wheel. By winding the wheel, the attached rubber band also winds and by releasing the rubber band it unwinds making the wheel to rotate and thus propelling the boat moves.</p>			
Kind of energy in	Device	Kind of energy out	Your comments and observation
<p>Elastic energy of the rubber band</p>	<p>Paddle boat</p> 	<p>Kinetic energy of the wheel (image: rotating wheel)</p>	

			
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Gasoline is transformed into motion in a car through a process called internal combustion. The process takes place in the car engine pushing the pistons up and down, rotating the crankshaft which turns the wheels of the car. For 1 kilogram of gasoline burned in engine, approximately 44.4 MJ of energy can be released and used to perform mechanical work, turning the cars' wheels. The efficiency of the conversion process can vary depending on factors such as the design of the engine and the driving conditions, and can range from around 20% to 50%.

Kind of energy in	Device	Kind of energy out	Your comments and observation
Chemical energy of gasoline 	Car 	Kinetic energy of the car 	

Food is processed in our bodies, and during this process, energy is released through chemical reactions. Different types of food, like proteins, carbohydrates, and fats, are broken down into smaller substances. These substances combine with oxygen from the air we breathe, releasing energy in a process called aerobic combustion. However, 55% of this energy is lost as heat.

When we need a lot of energy quickly, like during intense exercise, our body switches to a different process called anaerobic combustion. This process doesn't use oxygen and converts glucose into lactic acid. It is a very inefficient process because we only get 800 kJ from 1 kg of glucose!

Kind of energy in	Device	Kind of energy out	Your comments and observation
Chemical energy of food	Cells	Energy needed for human body Even if we do nothing, we need energy - for example, breathing, heartbeat, maintaining	

		<p>body temperature - the so-called basal metabolism.</p> <p>Defined under the following conditions:</p> <p>fasting (16 hours without food intake, 36 hours without protein intake, which have a significant specific dynamic effect)</p> <p>indifferent temperature (20-22 degrees clothed, 30 degrees unclothed)</p> <p>with physical and mental peace</p>	
<p>Many athletes, like runners, lose a significant amount of energy during intense performances, particularly through breathing. To prevent their body temperature from dropping rapidly, they often use reflective blankets. These blankets reflect the heat radiation coming from the body, helping to retain warmth.</p> <p>We can do a similar thing at home by placing aluminum foils behind radiators. This prevents heat from being lost through the walls and instead directs it into the room, keeping it warmer.</p>			
Kind of energy in	Device	Kind of energy out	Your comments and observation
<p>Chemical energy of sugar</p> 	<p>Muscle cells</p> 	<p>Kinetic energy of the runner</p> 	

Figures acknowledgements

Fig.1 Example of historical units

<https://www.toppr.com/ask/content/story/amp/standard-units-of-measurement-120518/>

Fig.3 ISS

[Image by vecstock](https://www.freepik.com/free-photo/spacecraft-orbiting-planet-earth-global-communications-generated-by-ai_41438906.htm#query=ISS%20space%20station&position=9&from_view=search&track=ais) on Freepik

Some figures in the part: Energy transformations explained.

Tree

[Image by brgfx](https://www.freepik.com/free-vector/isolated-tree-white-background_4382376.htm#query=tree%20drawing&position=3&from_view=keyword&track=ais) on Freepik

Chemical energy in the tree wood

[Wood Log Vectors by Vecteezy](https://www.vecteezy.com/free-vector/wood-log)

Campfire

[Image by rawpixel.com](https://www.freepik.com/free-photo/campfire_10012828.htm#query=campfire&position=2&from_view=search&track=sph) on Freepik

Light, heat

[Image by rawpixel.com](https://www.freepik.com/free-vector/handheld-luminous-flashlights-different-modifications-realistic-set-grey-background-isolated-vector-illustration_38753969.htm#query=flashlight&position=3&from_view=keyword&track=sph) on Freepik

Heat, light

[Image by rawpixel.com](https://www.freepik.com/free-photo/high-angle-woman-warming-bonfire_7662794.htm#page=4&query=campfire&position=47&from_view=search&track=sph) on Freepik

Solar panels:

[Image by rawpixel.com](https://www.freepik.com/free-photo/beautiful-alternative-energy-plant-with-solar-panels_20735352.htm#query=solar%20panels&position=1&from_view=search&track=ais) on Freepik

Power plug and outlet:

[Image by rawpixel.com](https://www.freepik.com/free-photo/electricity-power-supply-plug-outlet_2971586.htm#query=socket%20with%20a%20plug&position=31&from_view=search&track=ais) on Freepik

Energy of the wind (tree)

[Download - Tree In Wind Png @pngkey.com](https://www.pngkey.com/detail/u2q8a9o0y3w7o0a9_download-tree-in-wind-png/)

Wind turbine:

[https://www.freepik.com/free-photo/beautiful-view-wind-turbines-grass-covered-field-captured-holland_8766603:htm#query=wind%20turbine&position=0&from_view=search&track=ais](https://www.freepik.com/free-photo/beautiful-view-wind-turbines-grass-covered-field-captured-holland_8766603.htm#query=wind%20turbine&position=0&from_view=search&track=ais)

Chemical energy of gasoline

https://www.freepik.com/free-photo/close-up-hand-holding-gas-pump_21252887.htm#page=2&query=chemical%20energy%20of%20gasoline&position=21&from_view=search&track=ais>Freepik

Car

https://www.freepik.com/free-photo/3d-racing-car_1050091.htm#query=formula%201%20car&position=1&from_view=keyword&track=ais

Chemical energy of food

https://www.freepik.com/free-photo/top-view-delicious-gourmet-dishes-with-different-vegetables-meat_18348474.htm#page=5&query=food&position=16&from_view=search&track=sph>Image by wirestock on Freepik

Cells

Internal structure of a cell. Digital illustration. Image Credit: Andrea Danti / Shutterstock, in <https://www.news-medical.net/news/20180926/Mapping-the-trillions-cells-in-the-human-body.aspx>

Elastic energy of the bowstring

https://www.freepik.com/free-photo/businessman-aiming-target-with-bow-arrow-isolated-gray-studio-background-business-goal-challenge-competition-achievement-concept_13343341.htm#query=figure%20with%20a%20bow&position=31&from_view=search&track=ais>Image by master1305 on Freepik

Bow and arrow

https://www.freepik.com/free-vector/collection-indian-artifacts-flat-design_948038.htm#page=8&query=bow%20and%20arrow&position=49&from_view=search&track=ais>Freepik

Kinetic energy of the arrow

<http://www.clker.com/cliparts/1/0/9/f/15164999941967990656free-archery-clipart-images.med.png>

Elastic energy of the rubber band

https://www.freepik.com/free-photo/woman-doing-yoga-outdoors_4158280.htm#query=training%20with%20rubber&position=45&from_view=search&track=ais>Freepik

Chemical energy of sugar

https://www.freepik.com/free-photo/sugar-cubes-tall-glass_7903063.htm#query=sugar&position=43&from_view=search&track=sph

Muscle cells

https://www.freepik.com/free-photo/3d-medical-figure-showing-elbow-pronation_3142016.htm#page=3&query=muscle%20cells&position=17&from_view=search&track=ais>Image by kjpargeter on Freepik

Kinetic energy of the runner

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