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PREFACE

Stem Made Fun's Purpose

Our mission at STEMMadeFun is to empower individuals with learning disabilities or underprivileged to reach their full potential in the fields of science, technology, engineering, and mathematics through accessible and inclusive learning experiences that make STEM education fun and meaningful.

We have made this book to provide universal access to an educational and entertaining journey through the world of STEM. This book, is a result of countless hours of dedication from our team of passionate educators, scientists, and designers. Our goal is to inspire curiosity, ignite a love for learning, and instill confidence in every reader, regardless of their background or abilities.

We take readers on a captivating expedition, exploring various scientific concepts and phenomena in a way that is engaging, interactive, and inclusive. The book is carefully designed to cater to different learning styles, ensuring that each reader can fully participate and absorb the knowledge within.

From the first page to the last, the book is bursting with vibrant illustrations, captivating stories, and hands-on experiments that bring STEM to life. Each chapter focuses on a specific scientific discipline, such as physics, biology, chemistry, or engineering, and presents the information in a fun and accessible manner.

Throughout the book, readers will find intriguing puzzles, quizzes, and activities that reinforce the concepts they have learned. These interactive elements encourage active participation and critical thinking, making the learning process enjoyable and memorable.

ABOUT THE AUTHORS

Aashrith Bandaru
Founder

Hello, I am Aashrith Bandaru. I'm an advocate for STEM education and an entrepreneurial leader from Fremont, California. Coming from the Bay Area, a place filled with technology and innovation, I have a deep interest in the intersection of data science and business. I started my STEM journey learning programming for web development and then expanded to Python and Java. After gaining substantial knowledge, I began teaching classes with GATE and continued deepening my understanding by focusing on data science, completing numerous Udemy courses in this field. Eventually, I became the president of the Data Science Club at Irvington High School.

To enhance my business skills, I joined DECA, an organization that hosts business competitions, and I won first place in VBC at their International Career Development Conference. My entrepreneurial journey includes founding Pawfect Petcare, a pet supply startup inspired by owning a dog and a passion for business.

My dedication to community service began with becoming a Boy Scout in 8th grade. The experiences and principles I gained from scouting led me to co-found STEM Made Fun, a 501c3 nonprofit organization. This organization combines my passion for STEM with a commitment to educational accessibility and community service.

Whether I'm walking my dog, studying data science, running a business, or working to enhance my community, my goal is always to make a positive, significant impact on the world around me.

ABOUT THE AUTHORS

Krishiv Aggarwal
Founder

Hi I am Krishiv, from Fremont, California, with a strong interest in the fields of computers and engineering. Growing up in Silicon Valley with parents who hold master's degrees in STEM fields has provided me with extensive exposure to subjects relating to robotics and sciences and encouraged me to pursue knowledge in programming languages such as Python, web development (HTML, CSS, JavaScript), and C. Additionally my participation in the Aspiring Scholars Directed Research Program (ASDRP) has helped me delve deeper into the engineering aspect of these fields and solidified my interest in the subject. Currently, I am working on a project to create an automated chemical synthesizer using a UR5 robotic arm, with the aim of making drug discovery and development easier.

In addition to my academic pursuits, I am also dedicated to giving back to the community. I am the founder of STEM Made Fun (SMF), a nonprofit organization that brings STEM education to underprivileged and underrepresented communities. We host sessions in local schools where they don't have access to after-school programs and for disadvantaged girls in Noida, India. Our goal is to provide students without access to the same resources and opportunities we are fortunate to have growing up in Silicon Valley.

I am a proud Eagle Scout and have been in the Scout community since I was in fourth grade. Through Scouting, I have learned the importance of living by the principle of "doing a good turn daily" and making a positive impact on the world. Through my involvement in STEM education and community service, I aim to continue helping others to create a better future for all.

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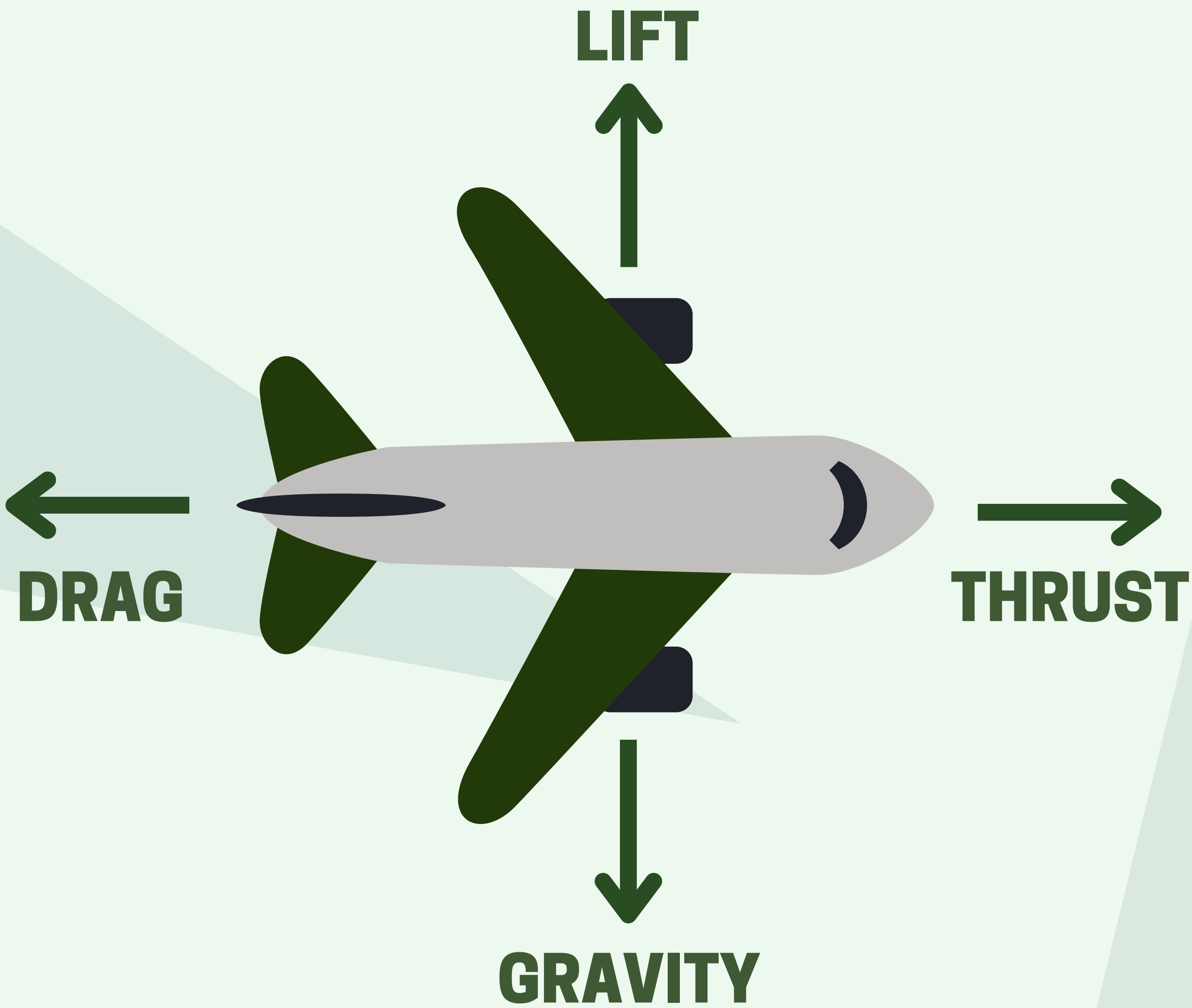
EXPERIENCE THE FORCE



CHECK OUT OUR YOUTUBE CHANNEL!

1.1 GRAVITY

What are forces and why do they matter?

Questions of the day:

Why does an apple fall down from an apple tree?

Why does a ball always come back down after being thrown up?

Why do I fall back down when I jump?

KEY WORDS

- Gravity
- Attraction
- Friction
- Weight
- Mass
- Force
- Apple
- Gravitational field

B	K	X	W	O	E	T	T	H	K	S	H	K	Q	T
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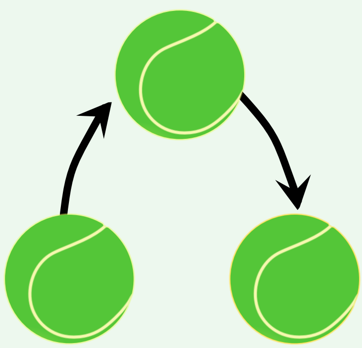
INTRO TO GRAVITY

Gravity

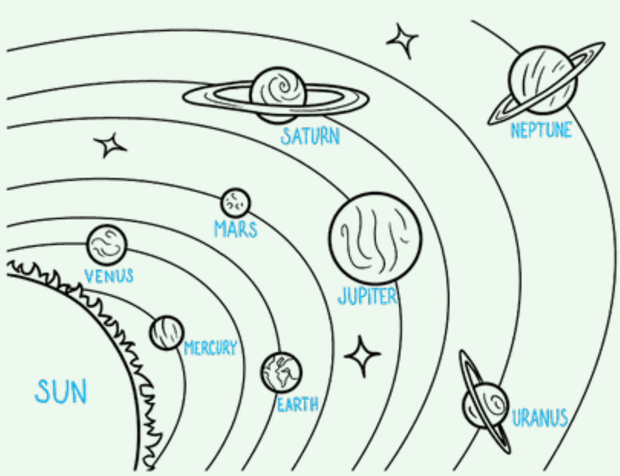


Try throwing a tennis ball up. It will always come back down due to gravity.

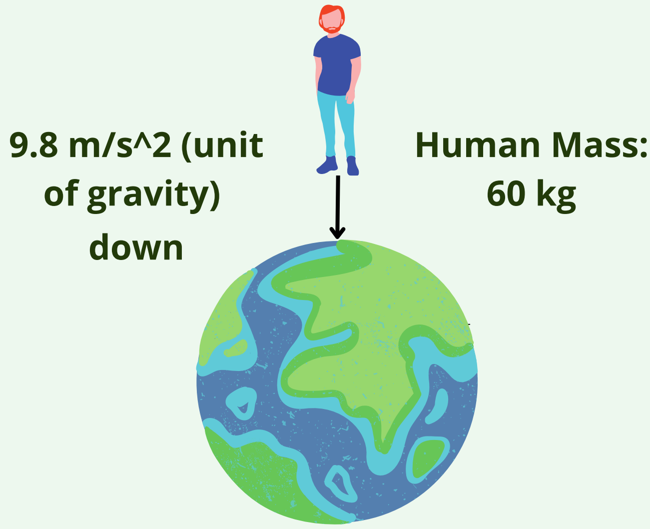
Gravity is defined as the force of attraction between two objects. All objects on Earth are attracted to Earth's center because of gravity. For example, when a ball is thrown up it comes back down because of its attraction to the earth's center. When an apple falls off a tree, it falls to the ground due to gravity.
Every object has a gravitational force, however, it is proportional to its mass. Objects with a larger mass have a more significant force of attraction.

How Does Mass Affect Gravity?

Now, you might be wondering, what is mass? Mass is the amount of matter in a physical object. Objects with large amounts of mass like the sun, have stronger gravitational fields and are able to keep planets in orbit.

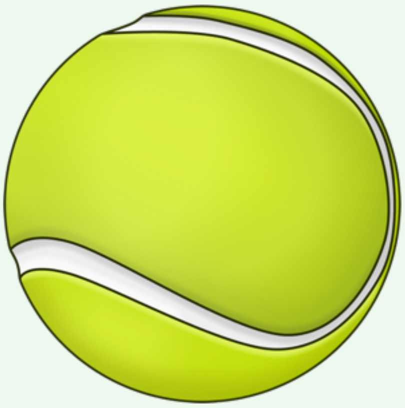


Fun Fact: The Sun's gravity has an attractive force that is so strong it keeps the entire solar system in orbit!



The Earth is very large compared to a human being with a mass of 5.972 × 10^24 kg compared to a human's average mass of 60 kg (130 pounds).

MASS AND WEIGHT



Try dropping a baseball and tennis ball at the same time. Record the time the objects hit the ground. Visually these objects are roughly the same in size but are made from different materials and therefore have different masses. Your initial assumption may be that the baseball will hit the ground first due to a larger mass.. However, the mass of an object does not affect when the ball hits the ground. The force of gravity creates constant acceleration for both objects resulting in both balls hitting the ground at the same time.

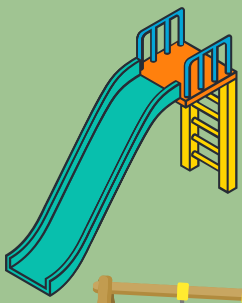
Mass VS Weight

Mass is the measure of how much matter is in an object. For example, a filled water bottle would have a greater mass than an empty water bottle because there are more particles inside of it.

Weight is the measure of gravitational force on an object. On most regions of Earth, the weight and mass of an object are the same, but for planets like Mercury with a lighter gravitational force, the weight would be much less than the mass.

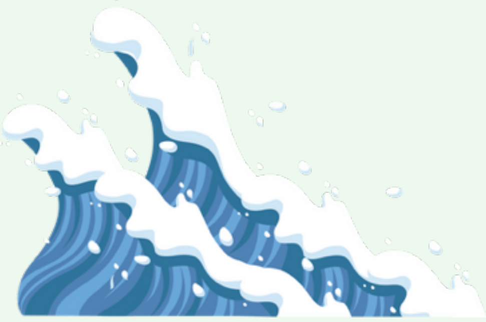
WHY DO WE CARE ABOUT "GRAVITY"

Have you ever thought of how beautiful the nature around us is? Well, then you have to thank Gravity. The only reason raindrops fall to the ground is gravity pulling them down. The only reason why plants can survive is due to the rain. The soil stays in the ground (most of it) and does not fly away when the wind comes due to gravity.



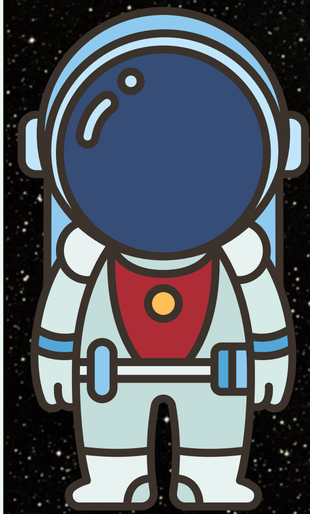
The playground is also full of gravity. Have you ever gone down a slide before? Well, how do you go down, Gravity? Whenever you throw a ball, it comes down because of, Gravity. The only reason you come down on a slide is due to gravity Gravity. When you are playing on the swings, the reason why you do not start flying is because of Gravity.

Have you ever been to a beach and seen waves crashing against the beach shore? Well believe it or not, there is a high chance those waves are caused by the gravity of the moon and the sun. As the Earth spins, some of the water is pulled by the gravity of the sun and moon and causes it to rise as a wave. Pretty cool right?



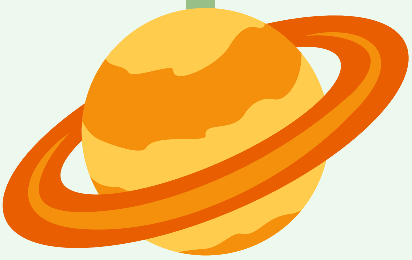
FINDING WEIGHT ON DIFFERENT PLANETS

The Astronaut's Dilemna



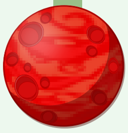
After being stranded in space our astronaut has to land on a new planet. Before landing on another planet, however, the astronaut has to figure out his weight. Without knowing his weight, his movement can be varied dependent on his weight on a planet. If the astronaut weighs 150 lbs on Earth, how much does the astronaut weigh on other planets?

1. Divide the weight of the astronaut on earth by Earth's gravity (9.8 m/s^2)
2. Multiply by acceleration of gravity of the planet
3. Obtain Value for Weight on the new Planet!



Saturn
10.4 m/s^2

Earth
9.8 m/s^2

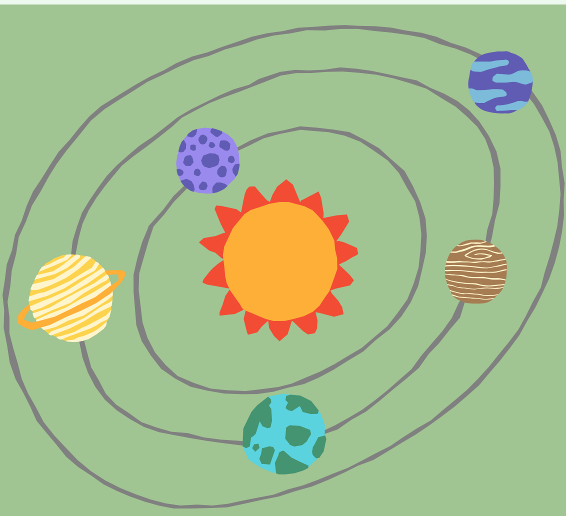


Mars
3.7 m/s^2

THOUGHT PROVOKING

What would hit the ground first?

A bullet dropped from 1 meter above the ground or a bullet shot from a gun 1 meter off the ground?



All of the planets in the solar system have gravity, so why do they not pull each other all together into a ball?

Does speed stay constant when a car is taking a turn or driving alongside a curve?

1.2 FRICTION + AIR

What is friction and why is it important?

Questions of the day

Why do different sports use different types of shoes? For example, why do soccer cleats have protruding stumps?

Why do you slip more in slippers compared to tennis shoes.

How do different shoe grips affect your movement? What about surface materials?

Key words

- Friction
- Air
- Wind
- Boat
- Coefficient
- Wood
- Plane
- Resistance
- Traction

X	P	R	X	W	O	O	D	J	S	O	B	Z	S	A
I	P	Z	K	B	C	M	K	B	X	A	I	R	N	E
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F	G	X	K	P	L	A	N	E	Y	D	F	R	H	R
D	C	P	T	U	B	R	D	N	I	W	H	I	A	N
O	U	U	T	R	E	S	I	S	T	A	N	C	E	E
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S	M	L	Y	T	J	I	K	P	W	A	I	N	R	J

WHAT IS FRICTION

By definition, friction is a force that opposes the motion of two objects that are in contact. It exists in different forms, like kinetic friction, static friction, fluid friction, and rolling friction. Since friction is a force, it is measured in Newtons (N). Friction varies based on how rough the surface is. In the real world, friction has many applications like providing traction for shoes, which is helpful for sports, preventing sliding, etc.

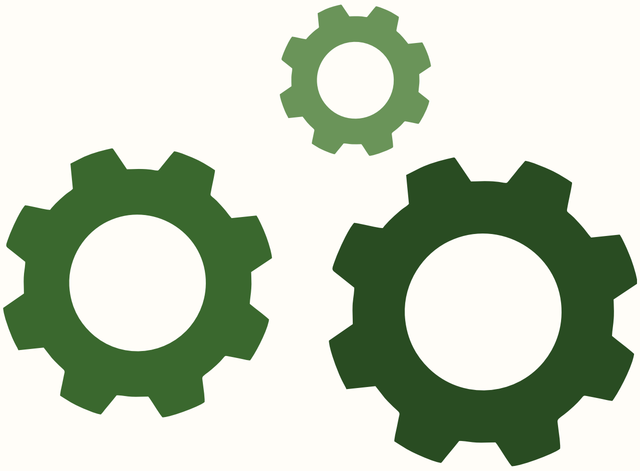
Important Definitions

- Friction: the force that opposes the motion of two objects in contact.
- Normal Force: the force that a surface exerts on an object that is on top of it.
- Friction Coefficient: a measurement of how much friction exists between two surfaces.
- Traction: the ability to stay on a surface without sliding.
- Air Resistance: the friction force between an object and the air.

Air Resistance

USES OF FRICTION

Engineering

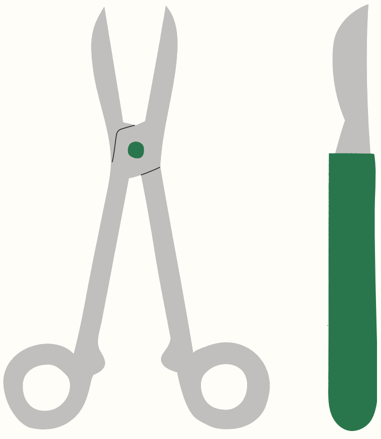


When engineers are designing machines and objects like cars and road surfaces, they rely on and account for a frictional force. For example, friction is used to help the car slow down and stop when a driver hits the brakes.

Sports Gear

Friction is also utilized in sports gear in order to increase traction and improve performance. For example, sports shoes are crafted to provide an appropriate amount of friction/grip to minimize sliding.

Medical Devices

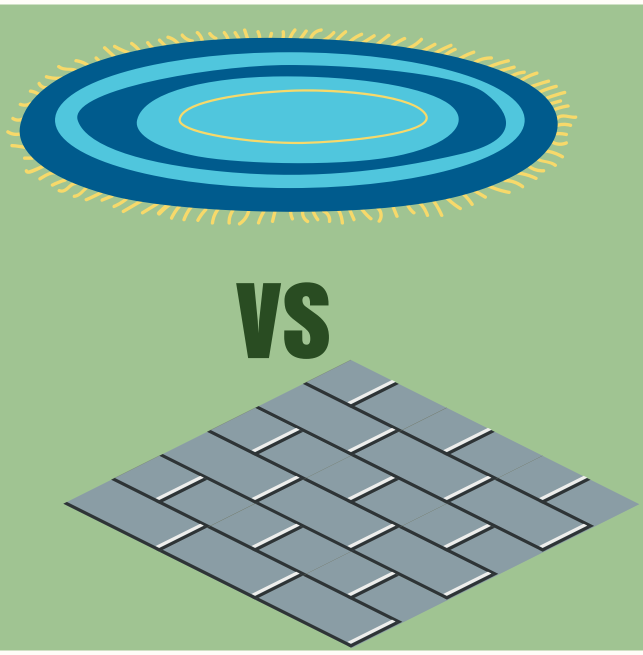


Friction is also used to improve the use of medical devices. For example, it may be used in surgical instruments to improve grip with flesh and organs in order to facilitate surgery and ensure that it is successful.

WHAT AFFECTS FRICTION

Normal Force

The normal force is the upward force that the ground exerts on a solid object and prevents the objects. The normal force also affects friction and has a direct relation to the friction force between the object and the surface. When normal force increases, the frictional force also increases.

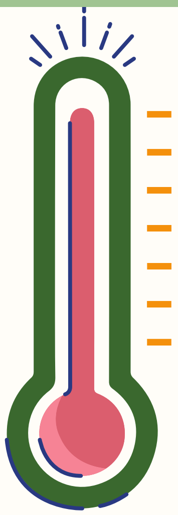


Material

The type of material that an object is made with will most likely have a large impact on its frictional force. For example, your kitchen tiles would have lower friction with the ground than carpet would as tiles are much smoother.

Temperature

Surprisingly, the weather can also have an impact on friction! Since many surfaces' properties change as the temperature changes, their frictional forces with objects may change with these properties as well.



TYPES OF FRICTION

Static

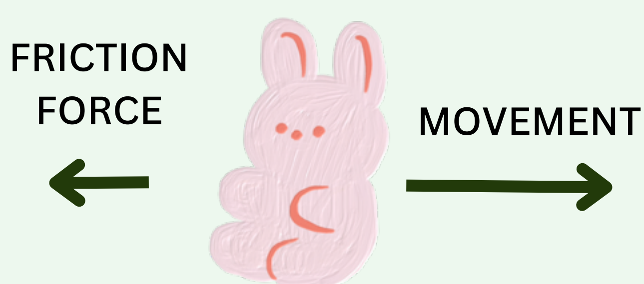
Static friction is the frictional force between an object and the ground when the object is not moving. Static friction is the force needed to move an object out of rest. To conquer static friction, you need to push the object with a force greater than the static friction force.

Object with no movement; static friction acting on the object

Outside force overcomes static friction force

Kinetic

Kinetic friction is defined as the frictional force between an object and the ground when the object is sliding. Kinetic friction depends on the roughness of the surface; the friction in the surface causes objects to slow down and stop after a certain distance (e.g. a large box that is pushed by a human).



Teddy bear moving to the right due to an external force; kinetic friction acting on it

The Teddy bear slows down and stops due to kinetic friction.

TYPES OF FRICTION

Fluid

Why is it harder to move your legs and body when you are swimming than when you are walking on a surface? The answer is fluid friction. Fluid friction is the frictional force between an object and a type of fluid like air or water and a type of fluid like air or water. Unlike other types of friction, fluid friction is affected by other factors like viscosity.

Air resistance; an example of fluid friction

Water resistance; example of fluid friction

Rolling

Similar to kinetic friction, rolling friction is the frictional force of an object when it is rolling. The force for rolling friction is usually lower than kinetic friction as it is much easier and takes less effort to roll an object than push it on a rough surface Rolling friction is also affected by other factors like velocity.

Ball rolling on ground; experiences rolling friction

Car wheels experience rolling friction with surface

APPLICATION

Experiment#1: Rolling Friction

1. Take any ball you have in your house
2. Roll it on your house floor (or any smooth floor if your house floor is rough)
3. Time how long it takes to roll a total of 1 meter
4. Repeat steps 1-3, except roll the ball on a more rough surface this time (outdoors); try to apply the same amount of force to roll the ball as you did on the smooth surface
5. Compare the time it took for the ball to roll the given distance on both surfaces

Question

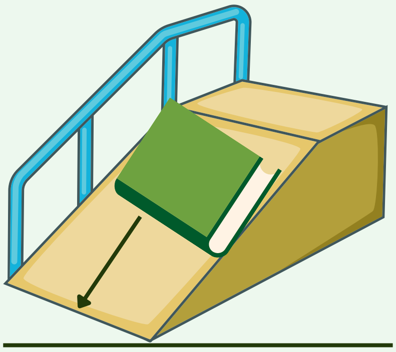
Did the ball take less, more, or the same amount of time to roll 1 meter on the rough surface than on the smoother one? Explain.

Experiment#2: Static Friction

1. Take any small box you have in your house
2. Push/slide it on your house floor (or any smooth floor if your house floor is rough; the floor needs to be fairly smooth)
3. Repeat steps 1-3, except slide the box on a much more rough surface this time (outdoors)
4. Note the difficulty in pushing the box on the smooth surface vs the difficulty in pushing on the rough surface

Question

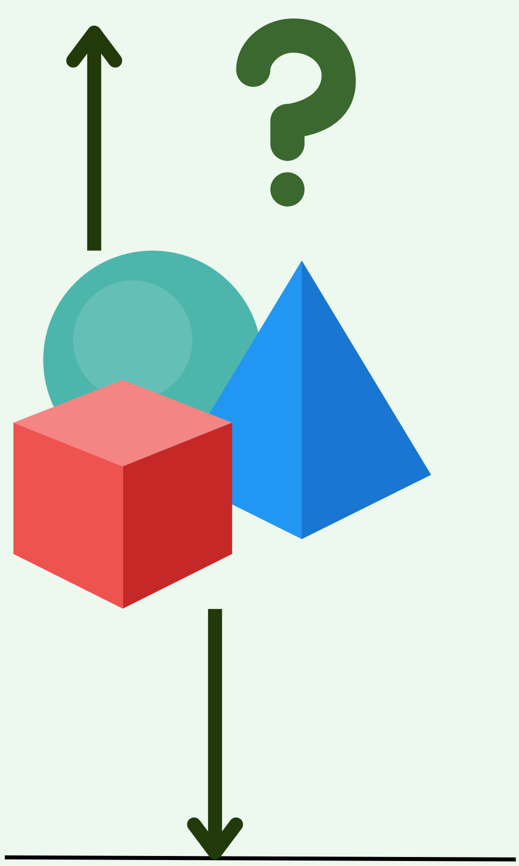
Did it take you more, less, or the same amount of effort to push the box on the smooth surface than the rough surface? Explain.



THOUGHT PROVOKING

Imagine friction suddenly disappearing off the face of the Earth. How do you think this would affect the planet and its processes?

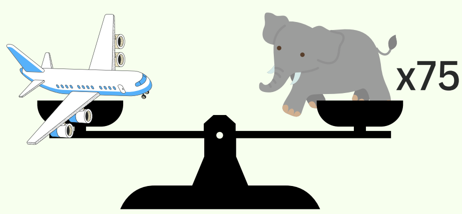
Suppose you take any mass and drop it from different heights, finding the time it takes to reach the ground. Using this, you calculate the vertical acceleration of the object. Is it possible for the ball to accelerate since there is fluid friction pushing it up? Why or why not?



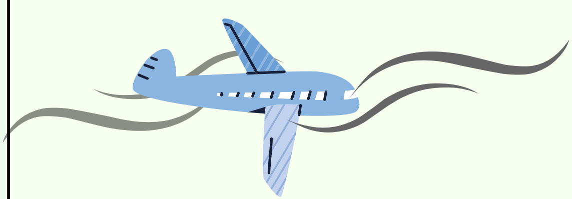
1.3 HOW AIRPLANES FLY

How do airplanes actually fly?

Questions of the day



How are planes such as the Boeing 747 able to fly despite weighing around 900,000 pounds, which is about 75 full-grown elephants?



Why do smaller planes experience more turbulence than larger planes?

Why do airplanes have propellers in the front instead of the back?

KEY WORDS

- Lift
- Drag
- Weight
- Newton
- Lightning
- Flight
- Thrust
- Engine
- Turbulence

T	H	R	U	S	T	A	H	U	U	J	S	G	V	O
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DRAG

That force you feel when putting your hand outside the window in a moving car is called drag.

Knowing how drag effects an airplane is essential for flying an airplane as safely and stable as possible.

What is drag?

When an airplane is flying, it has to move through the air, which creates resistance or drag. Drag is the force that opposes motion through a fluid, such as air or water. It is caused by friction between the object and the fluid and increases with the object's speed and surface area. In the case of airplanes, it is the force that acts against the forward motion of the aircraft. It is caused by the friction of the air flowing over the surface of the airplane, which generates turbulence and a pressure difference between the front and rear of the aircraft.

Why is drag important?

Drag is critical for airplanes to fly safely and efficiently as pilots use it to control speed and altitude during takeoff, landing, and flight. Adjusting flaps and other aerodynamic devices allows pilots to increase or decrease drag, enabling them to slow down or speed up, climb or descend, or maintain a stable flight path. Drag plays a vital role in the stability and control of an airplane, such as during a stall, when increased drag causes the nose of the aircraft to drop and restores airflow over the wings. Similarly, during maneuvers, drag on the outer wing increases, preventing the aircraft from rolling too far and maintaining a stable flight.

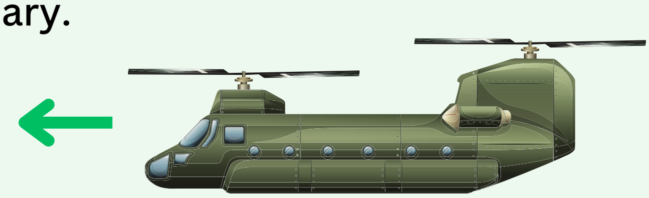
THRUST

What is thrust?

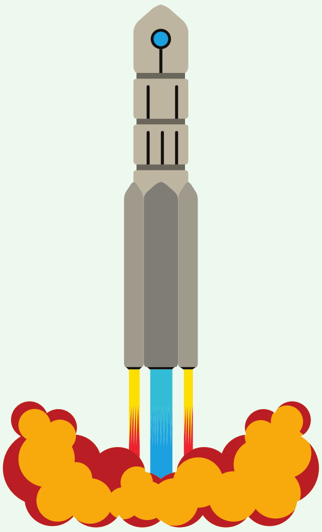
Thrust is defined as a force that pushes an object in a specific direction. In the case of airplanes, thrust is generated by the airplane's engines, which provide the necessary power to overcome the drag and lift the aircraft into the air. Thrust is one of the fundamental forces involved in flight, and it is necessary for airplanes to fly.

The engine of an airplane generates thrust by compressing air and mixing it with fuel in the combustion chamber. The ignited fuel and compressed air rapidly expand, creating a high-pressure and high-velocity stream of exhaust gases that are expelled out of the back of the engine. This expelled stream of gases provides the thrust force necessary to move the airplane forward. Thrust is used to propel the airplane forward, overcoming the force of drag that acts in the opposite direction. Drag is the resistance experienced by the airplane as it moves through the air, caused by factors such as air resistance, friction, and turbulence. Without enough thrust to overcome drag, the airplane would be unable to move forward and would remain stationary.

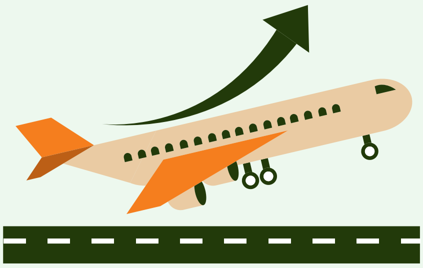
Thrust is in the direction of motion



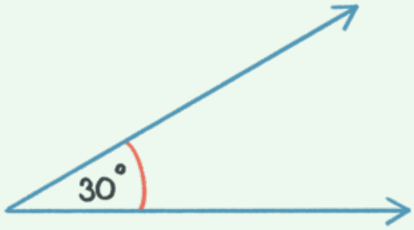
The average NASA rocket's boosters generate a combined thrust of about 5.3 million pounds or 40 million horsepower. That is equivalent to the amount of energy produced by 400,000 cars.



LIFT



Pilots control the lift of an airplane by adjusting the angle of attack and the speed of the aircraft. When the angle of attack is increased, the wing produces more lift, allowing the aircraft to climb. When the angle of attack is decreased, the lift decreases, causing the aircraft to descend.



What is lift?

Lift is an upward force that is exerted on an object when it moves through a fluid, such as air or water. In the case of airplanes, lift is used to overcome the force of gravity and keep the aircraft airborne. While drag is the force parallel and in the opposite direction of the flow force, lift is the upward force that is perpendicular to the flow force. It is what keeps objects in the air and able to gain altitude.

Why is lift important?

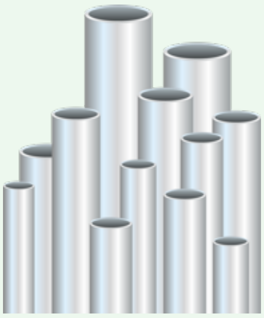
To understand how lift works, it is important to understand the basic principles of aerodynamics. The shape of an airplane's wings is designed to create a difference in air pressure above and below the wing. This difference in pressure generates lift. The curved upper surface of the wing is longer than the flat lower surface, which means that air traveling over the top of the wing has to travel a greater distance than air traveling under the wing. This causes the air to move faster over the top of the wing, creating a lower air pressure than the air underneath the wing. This difference in pressure creates an upward force that lifts the airplane off the ground. The amount of lift generated by an airplane depends on several factors, including the speed of the aircraft, the angle of attack (the angle at which the wing meets the airflow), the shape and size of the wing, and the air density. Similarly, increasing the speed of the aircraft increases the amount of lift, while decreasing the speed reduces the lift.

WEIGHT IN AERODYNAMICS

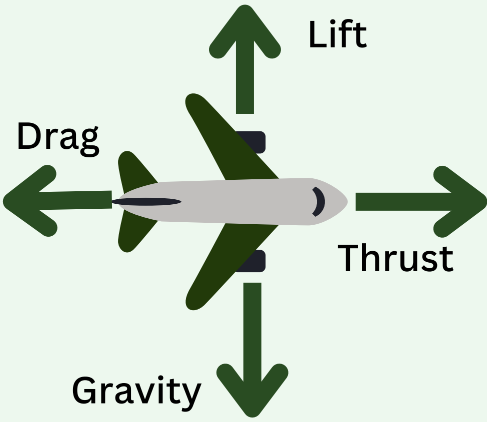
How is weight used in flight?

Weight is a critical component in the mechanics of an airplane's ability to fly. To understand how weight is used and necessary for airplanes to fly, it is essential to understand the basic principles of flight. This is where the importance of weight becomes clear. An airplane must be designed to be as lightweight as possible while still being strong enough to withstand the forces of flight.

However, weight is not only important for generating lift. It is also crucial for maintaining stability during flight. An airplane's center of gravity (CG) must be carefully balanced to ensure that the airplane remains stable in the air. The CG is the point on the airplane where all the weight is concentrated. If the CG is too far forward or too far back, the airplane will be unstable and difficult to control. To ensure that the CG is properly balanced, the weight of an airplane's passengers, cargo, and fuel must be distributed evenly throughout the airplane. This is why airlines often have strict weight restrictions for passengers and baggage. By carefully managing the weight of an airplane, pilots can ensure that it remains stable and safe during flight.



A lightweight airplane can withstand the forces of flight through the use of lightweight materials, such as aluminum and composite materials, and careful engineering.



In an airplane, the upwards force is lift, the downwards force is weight, the forward force is thrust, and the backwards force is drag.

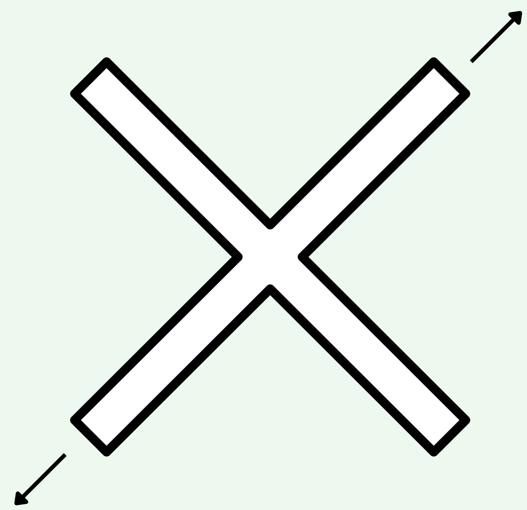
APPLICATION
HOW TO BUILD A HOMEMADE KITE!

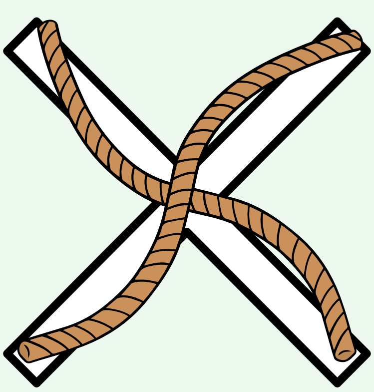
Materials:

2 thick rods or sticks (one longer than the other), some lightweight fabric (Ex. plastic bags or tissue paper), string, scissors, glue, a marker or pen

Instructions:

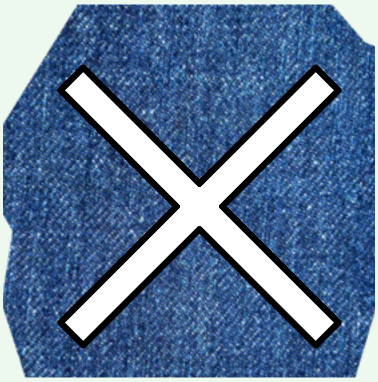
1. Start by making the frame of the kite. Take the longer rod and mark the center. Place the shorter rod perpendicular to the longer one, making a cross shape. Glue the two rods together at the center point where they meet.





2. Cut notches at the ends of both rods using the scissors. Tie a piece of string around one end of the longer rod, and knot it into the notch.

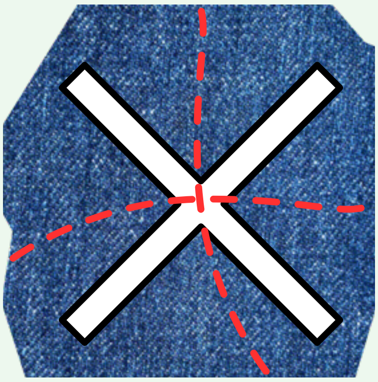
3. Stretch the fabric over the frame of the kite, leaving some excess on all sides. Use glue to attach the fabric to the rods at the edges.

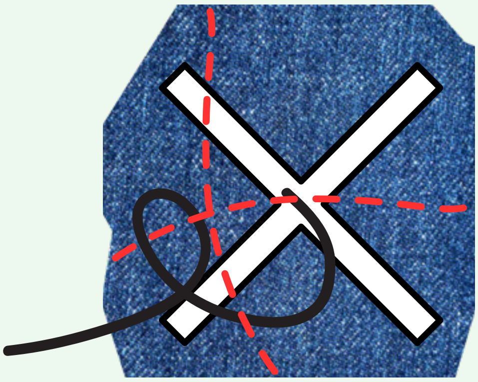


APPLICATION
HOW TO BUILD A HOMEMADE KITE!

Instructions:

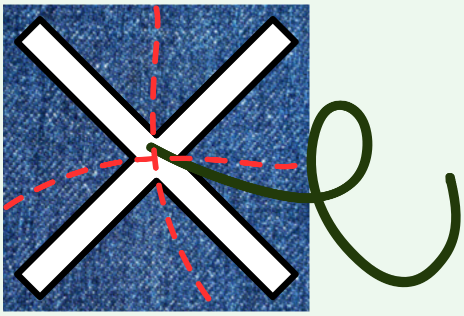
4. Cut a length of string that is about three times the length of the kite. Tie one end to the knot at the top of the kite. Run the string through the notch at the bottom of the kite, and tie it off securely.

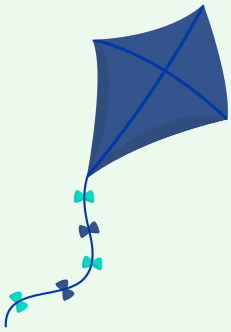




5. Attach a tail to the bottom of the kite using a long piece of string. This will help stabilize the kite and keep it from flipping over in the wind.

6. Cut off the excess fabric, leaving about an inch of overhang. Fold the overhang over the edges of the rods, and glue it down to create a neat edge.

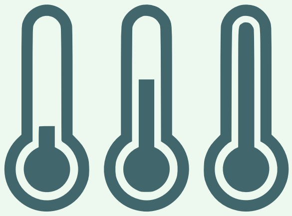


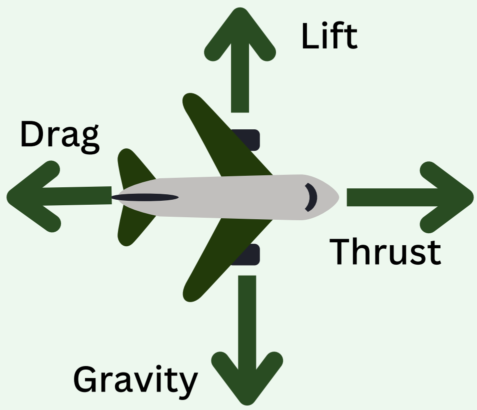


7. Your kite is now ready to test! Make sure to look for all four laws of flight in action!

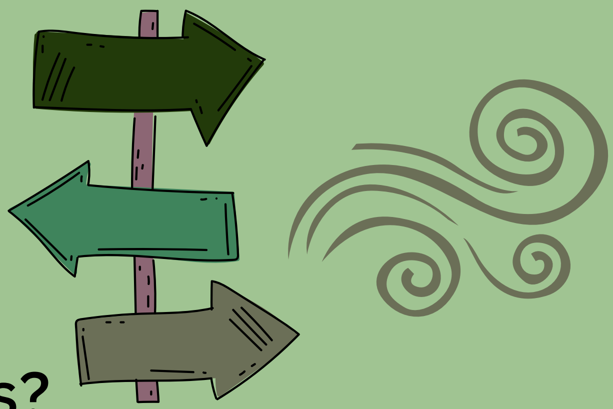
THOUGHT PROVOKING

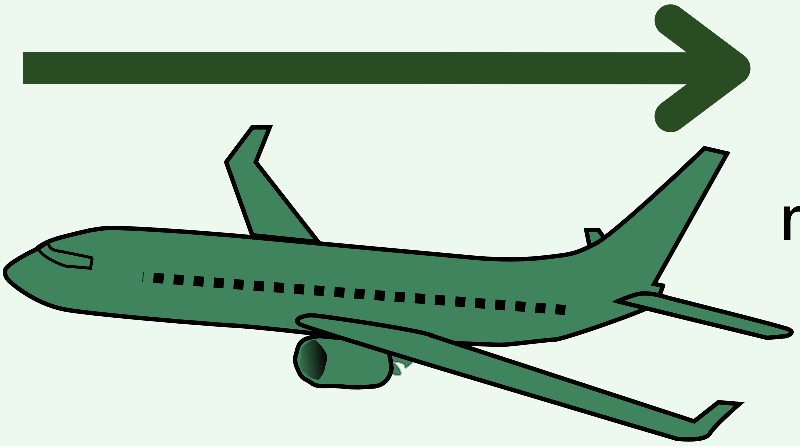
How does differences in air temperature affect the balance of a plane?





Why are wind shears extremely dangerous to landing planes?
When are planes most vulnerable to wind shears?





What is needed to make an airplane fly backwards?

1.4 AIR PRESSURE

How does air pressure play a role in planes?

Questions of the day:

How does the cabin stay warm even when you are so high up?

Why are the windows oval-shaped?

Why is there a pinhole at the bottom of every window?

KEY WORDS

- Principle
- Air
- Hypoxia
- Distribution
- Properties
- Area
- Atmosphere
- Oval
- Force
- Pressure

E	F	O	C	X	F	F	J	A	C	U	Z	J	W	S
R	V	E	R	E	H	P	S	O	M	T	A	D	A	Y
U	A	U	R	X	I	N	D	Z	U	D	F	W	J	X
S	W	I	F	L	E	L	P	I	C	N	I	R	P	F
S	R	A	R	E	A	T	I	T	L	B	Z	W	C	E
E	C	R	O	F	V	A	I	X	O	P	Y	H	T	S
R	O	N	R	U	C	Y	U	E	L	A	V	O	D	K
P	S	V	G	E	E	E	Y	U	T	F	X	P	U	O
V	U	T	P	R	O	P	E	R	T	I	E	S	J	I
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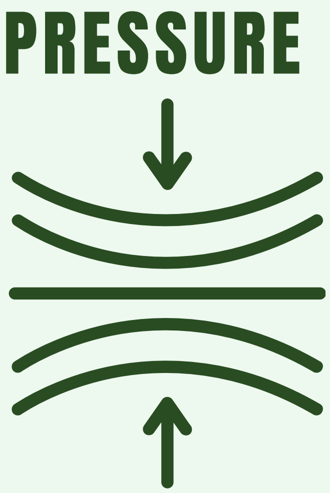
WHAT DOES PRESSURE MEAN



The general definition of pressure is the force applied perpendicular to the surface of an object per unit area over which that force is distributed. Air pressure plays a huge role inside airplanes. A proper value of air pressure inside an airplane cabin is very important. It helps the oxygen in the cabin to stay stable and allows passengers to breath. It also keeps the cabin at a stable temperature. The pressure is directly proportional to the force applied. However, pressure is inversely proportional to the surface area.

What happens when you lose cabin pressure?

When cabin air pressure is lost on a plane, it is a very dangerous scenario because the oxygen level in the cabin would reduce eventually causing hypoxia (oxygen starvation) and harming the passengers in the plane. Loss of cabin pressure is usually caused by air leaking through a hole in the plane or a cosmetic failure.

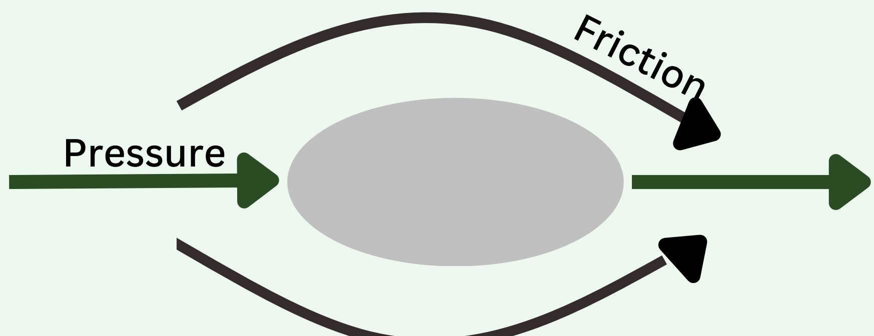
When an airplane cabin gets depressurized passengers get hypoxia as mentioned above, if a strict course of action is not taken, the passenger can go unconscious or even worse, it can lead to death. Hence when cabin pressure is lost, the priority of keeping the passengers safe is taken very seriously.

WINDOW SHAPE

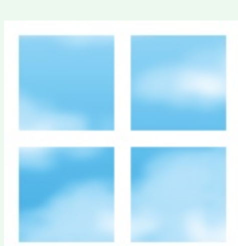
How does oval shape windows help with cabin air pressure?

Today airplanes use oval-shaped windows because they are really good when it comes to pressure distribution. Being an oval shape, it has curved edges instead of sharp or 90-degree edges. Curved edges help with the air distribution and hence keep the cabin pressurized so that the oxygen rate also stays stable and doesn't allow air to escape. It also plays a role in the airplane's performance, since the plane flies at a high speed, the curved edges help with the smooth flow of air around the edges to make the airplane fly efficiently.

CURVED EDGES



Why are the windows oval in shape instead of other shapes?



SHARPED EDGES

This is mainly done for safety purposes. Square windows have very sharp angles which usually causes the fuselage (airplane body) to expand. It isn't capable of maintaining normal cabin air pressure.

As mentioned above, the shape of the window also plays a role in the airplane's performance. Square-shaped windows are not as efficient compared to oval-shaped windows because there isn't a proper way to distribute air around sharp edges hence affecting the performance.

CALCULATING PRESSURE

Having a normal pressure reading in the cabin is extremely important to breathe properly. High air pressure or low air pressure can be very dangerous on airplanes. Significantly High or low pressure has a very high risk of catastrophic failure. The plane can explode into billion pieces mid-flight, if there the pressure is not right. When the airplane is at a cruising altitude, the cabin pressure is 12 pounds per square inch (PSI).

FORCE

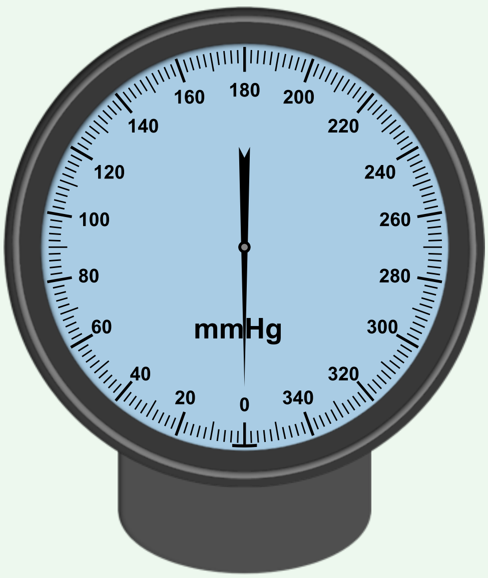
AREA

We have learned of the dangers we face with extremely low and extremely high cabin pressure and what normal cabin pressure is. Now we learn how to find the pressure with the given information (i.e force applied and area of a surface). The simplest way to calculate pressure is by dividing the forcee applied on a particular area of the surface.

As mentioned above, it is crucial to maintain cabin pressure in the normal range. In airplanes, the computers monitor the pressure 24/7 and when the pressure falls below normal, the oxygen masks get deployed.

PRESSURE VS AIR TEMPERATURE

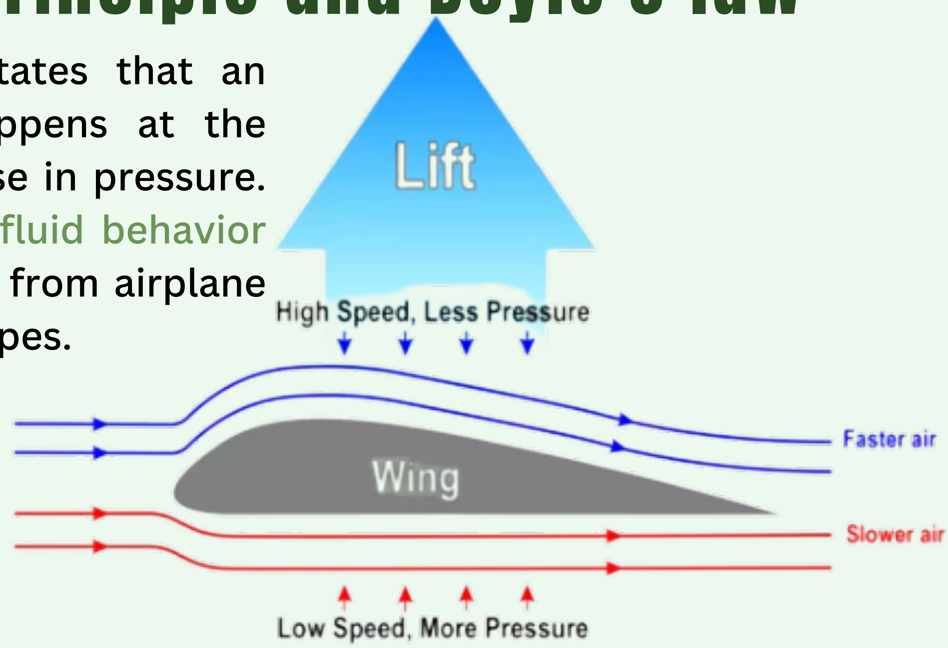
How does air temperature effect cabin pressure?

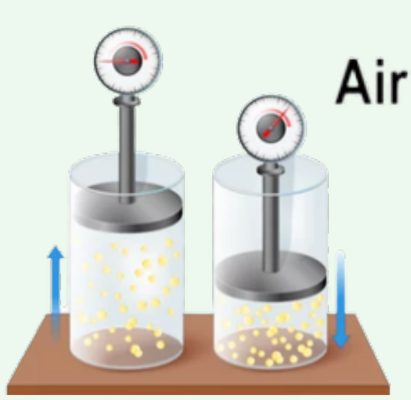


Even the temperature of the air plays a role to maintain proper air pressure. If cold air is denser than hot air, the weight would be more than warm temperatures. Air temperature also affects the performance of an Airplane. Since cold air is way denser than warm air, it creates more lift in cold air compared to hot air hence making the airplane air born easier.

Bernoulli's principle and Boyle's law

Bernoulli's principle states that an increase in speed happens at the same time as a decrease in pressure. This principle explains fluid behavior in diverse applications, from airplane flight to water flow in pipes.

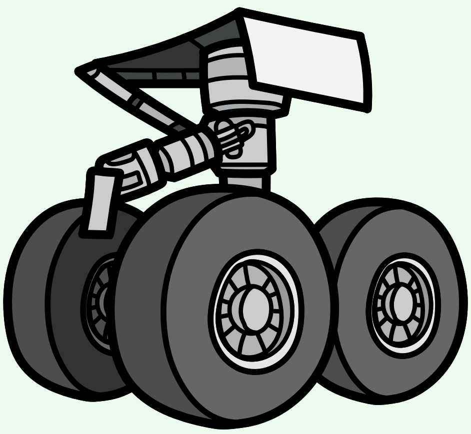




Boyle's law states that the gas pressure is inversely proportional to its volume at constant temperature.

LANDING GEAR

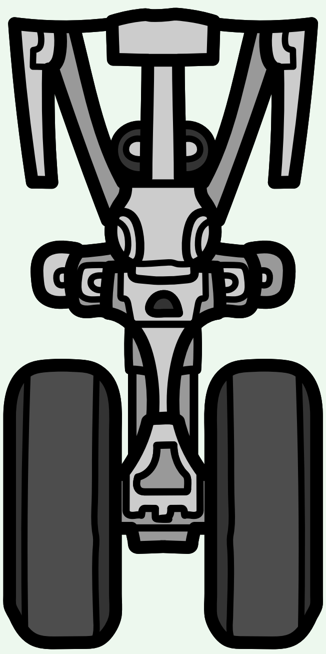
What is a landing gear on planes?



The landing gear is the wheels attached to a plane to help move from one place to another on the ground. They help with take-off and lading as well. The landing gear system on an airplane is built to handle extensive force and colossal weight. They even affect the plane's performance mid-flight. They use hydraulic pressure to retract and deploy during mid-flight.

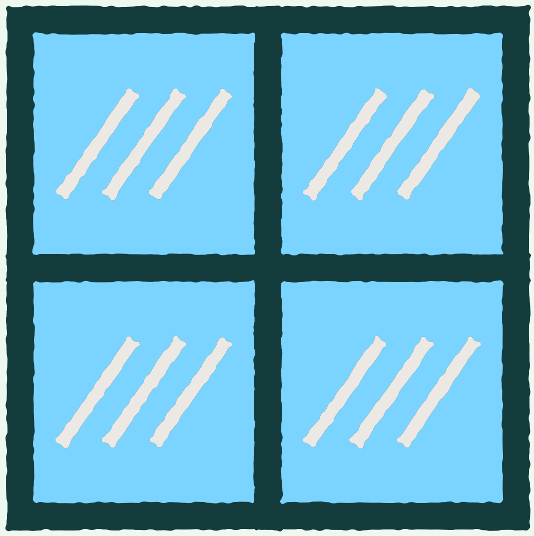
How does the Landing gear affect the airplane's performance

The landing gear on airplanes also plays a significant role in the airplane's performance. Have you ever noticed that the wheels (landing gear) retract when the plane lifts off from the ground? That is done to improve the aerodynamics of the aircraft. when the wheels are still down mid-flight, airflow will be improper and the plane won't fly efficiently. We know that it gets freezing at cruising altitude (i.e. near the earth's atmosphere), which may affect the rubber on the tires. When the wheels are retracted, it does not create any air restriction. Hence the plane can fly faster. It also helps while landing because it helps the pilots maintain a slower speed to perform a soft landing.

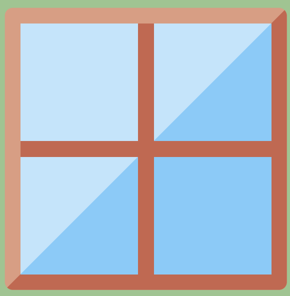


THOUGHT PROVOKING

Why is there a layer of plastic material inside the window surface?

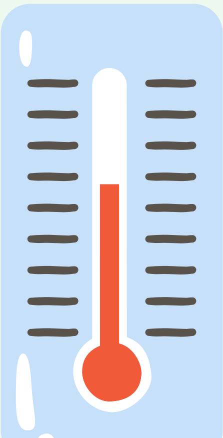


OR

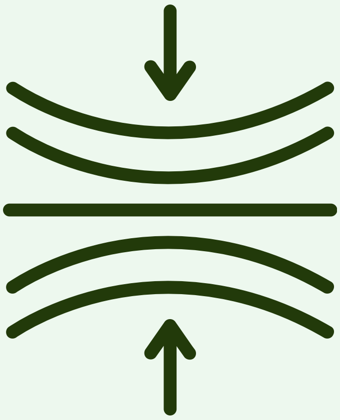


What's the difference between these 2 when it comes to air flow?

Does temperature reduce/increase/ stay the same when you reach a high altitude?



THOUGHT PROVOKING



What happens to air pressure and temperature when we move more into the atmosphere?

What is the instrument used to calculate air pressure?

Air pressure is high when it is raining (True/False)?

What is hydraulic pressure and how does it work?

1.5 SUSTAINABLE AVIATION

What are the benefits of airplanes and how are they constantly evolving?

Questions of the day:

How do airplanes help millions of people?

How could airplanes improve?

How would they help society?

KEY WORDS

- Airplane
- Design
- Technology
- Emissions
- Innovation
- Improvement
- Aerodynamic
- Engine

M	X	R	R	J	Y	N	O	S	O	N	F	Q	B	K
U	S	N	O	I	S	S	I	M	E	W	P	Q	S	G
T	N	T	S	I	M	P	R	O	V	E	M	E	N	T
D	K	A	I	R	P	L	A	N	E	S	B	E	F	A
N	L	R	C	I	M	A	N	Y	D	O	R	E	A	X
Q	D	D	E	S	I	G	N	A	V	U	W	G	Y	A
K	J	M	V	R	O	D	K	W	I	H	D	E	T	Q
B	B	Y	G	O	L	O	N	H	C	E	T	P	Q	N
S	A	E	N	I	G	N	E	O	L	R	L	I	K	H
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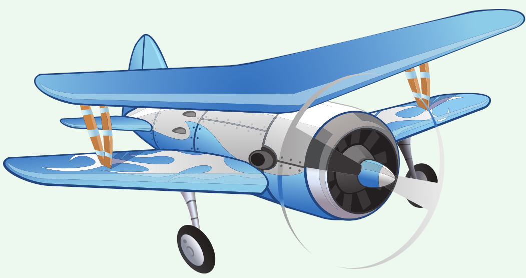
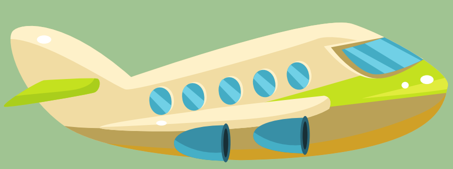
HISTORY OF AVIATION

WRIGHT FLYER

The Wright Flyer flight on December 17, 1903, is widely recognized as the first successful aircraft flight. The Wright Flyer was a biplane (pictured to the right) with a 40-foot wingspan and weighed slightly over 600 pounds. While the flight only lasted 12 seconds and the plane only traveled 120 feet, it marked the beginning of the age of aviation.



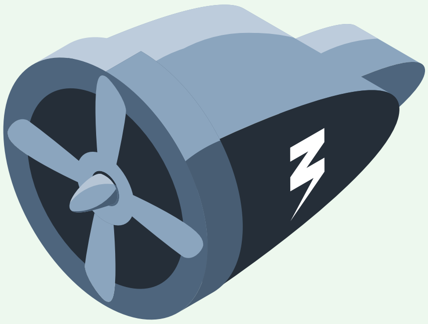
FIRST COMMERCIAL FLIGHT



The first ever commercial flight occurred on January 1, 1914, with just a singular passenger. The mayor of St. Petersburg paid $400 to fly 21 miles from St. Petersburg, Florida to Tampa, Florida. This marked the beginning of the commercial flight industry.

JET ENGINES

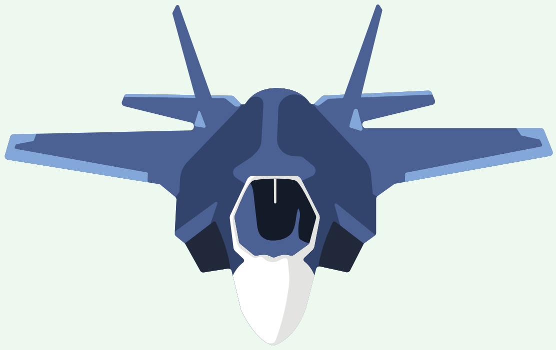
Jet engines were developed in the 1930s by German and British engineers, both working independently. Jet engines were first implemented into aircraft during World War II, and they increased the speed, efficiency, and reliability of flights.



HISTORY OF AVIATION

FIRST SUPERSONIC FLIGHT

In 1947 the United States Air Force chose Chuck Yeager to fly the Bell X-1, the world's first plane capable of breaking the sound barrier. The plane reached an altitude of 45,000 feet and a speed of Mach 1.06, which was around 700 mph. This was the start of the development of supersonic aircraft which is thought to be a large step in aircraft development.



FIRST FLIGHT ACROSS ATLANTIC

The first ever non-stop flight across the Atlantic Ocean occurred in 1919 by the British pilot's John Alcock and Arthur Brown. The men flew around 1900 miles from Canada to Ireland in over 16 hours. This marked the beginning of a now-blooming tourism and travel industry.

GLOBAL SOLO FLIGHT

Wiley Post was an American pilot who completed the first-ever solo flight around the world. In approximately a week, he flew nearly 16,000 miles and demonstrated the capabilities of aircraft. This inspired generations to come to continue to develop the industry of aviation and follow in his footsteps.

EVOLUTION OF AVIATION

COMPUTER TECHNOLOGY

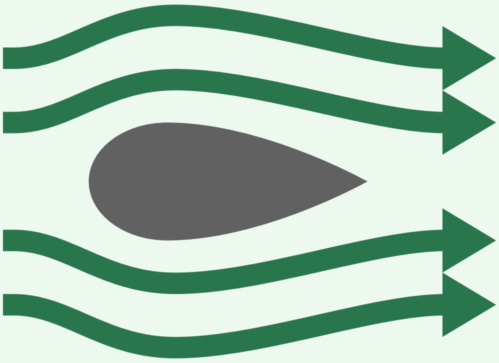
In the 1960s, computer technology began to be used in the navigation and control of aircraft. Computer technology allowed for more efficient flights through more accurate navigation with technology such as radar. This was a large milestone in the improvement of aviation and technology has continued to develop since then.

GLOBAL AIR TRAVEL

Through the gradual deregulation of global airspaces, airplanes began to be allowed to travel across countries and even continents. This was a pivotal factor that eventually led to the globalization of aviation and large-scale commercial flying.

AERODYNAMICS

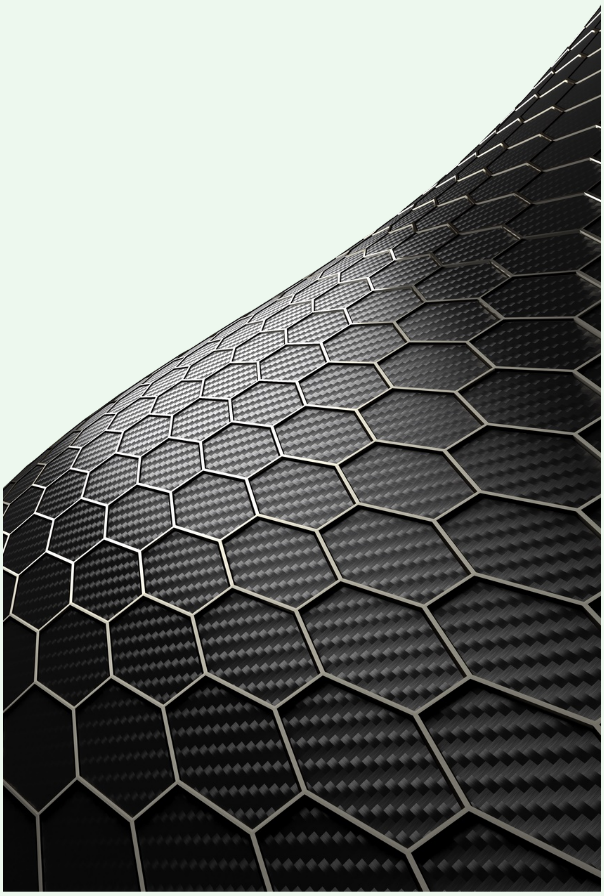
Over the years since the introduction of airplanes, especially during the 1970s, there was a focus on improving aerodynamics. Aerodynamics is the study of how air interacts with planes and affects their motion. Improvements in aerodynamics made flights take less fuel and be more efficient which allowed for the expansion of the aviation industry.



EVOLUTION OF AVIATION

CARBON FIBER

One objective of airplane design is reducing the weight of the planes. Early planes, like the Wright Flyer, were made of heavy, solid materials like oak wood, and this limited their range and efficiency. Carbon fiber was invented in the 1980s and when incorporated into aviation it made planes much lighter and easier to launch and control. Carbon fiber is a synthetic material that is extremely malleable while still being light and is a large reason airplanes are able to be so widespread today.



FUEL EFFICIENT ENGINES

Engines have continued to evolve to be increasingly fuel efficient. This has contributed to decreasing the cost of flights, and emissions. An additional benefit has been increasing the range planes can fly by decreasing the amount of weight they must carry. The largest developments in efficient engines were during the 1990s when multiple breakthroughs were made.

AVIATION IN SOCIETY

BENEFITS OF MODERN AVIATION

Over 1 billion passengers a year
Safety and efficiency optimized through GPS and navigation
Increases global connectivity through travel
Allows for cultural exchange
Tourism boosts the economy
Global Trade
New Economical Sectors
Aerospace manufacturing + engineering

CONCERNS

While aviation has many benefits for society there are many concerns surrounding it, primarily environmental. Global warming is a prevalent issue currently and airplanes consume large amounts of fuel and have a lot of emissions. In order to combat global warming, one important factor is decreasing the natural gas emissions associated with aircraft.

POSSIBLE SOLUTIONS

- Fuel efficiency
  - Efficient engines
  - Lighter construction
  - More aerodynamic designs
  - Alternative fuel sources
- Pilotless flights
  - Increase safety
- Increased speed
  - Supersonic
- Use of 3d printing in manufacturing
  - Possible to decrease costs
  - Lightweight part

APPLICATION

PARACHUTE EXPERIMENT

Create a small parachute using materials such as plastic bags or tissue paper. Attach a weight, such as a small toy, to the parachute and drop it from a height. Experiment with different parachute sizes and shapes to see how they affect the speed and efficiency of the descent.

MATERIALS

- Light plastic bag or thin paper
- Toy or other small items
- String
- Tape

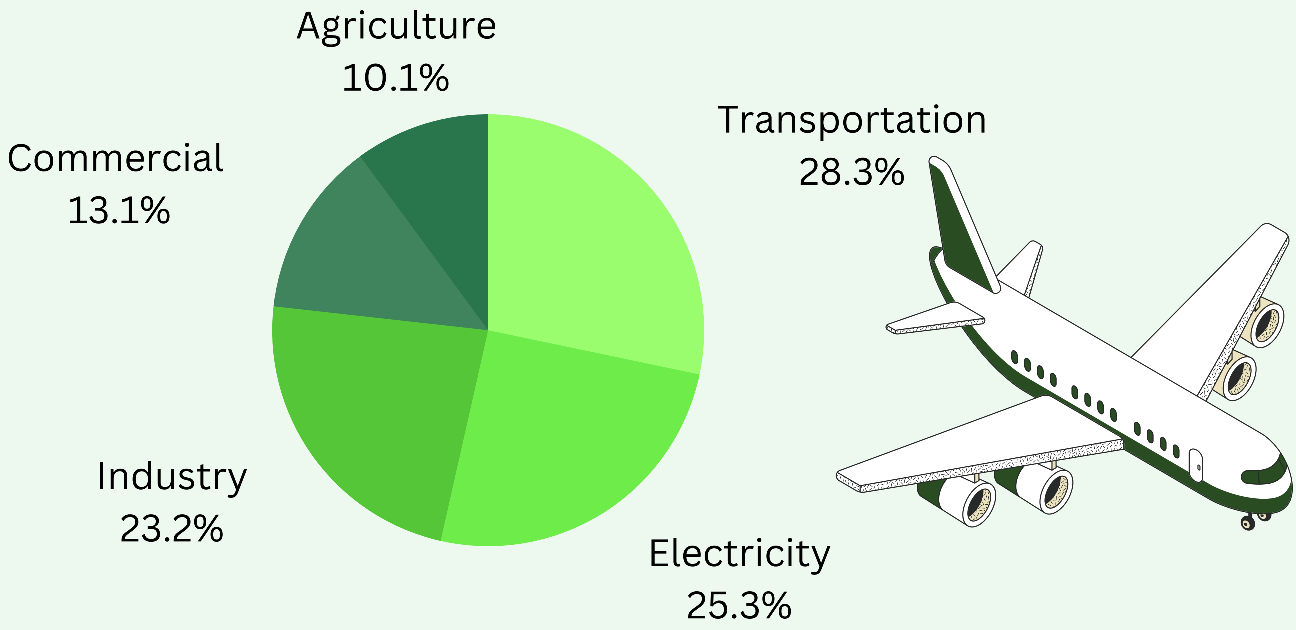
STEPS

1. Gather your materials (see above)
2. Attach the string to the bag or paper using tape
3. Attach the lightweight object to the string by tying the string around it or with the tape
4. Drop from various heights and try different materials and weights, observe the changes made in the speed of falling.

THOUGHT PROVOKING

WHY IS IT IMPORTANT FOR AIRPLANES TO BE FUEL EFFICIENT?

Think about what would happen if airplanes consumed much more fuel every trip. What would change about the world? Analyze impacts on the environment, economy, and access to flights.



Carbon Emissions

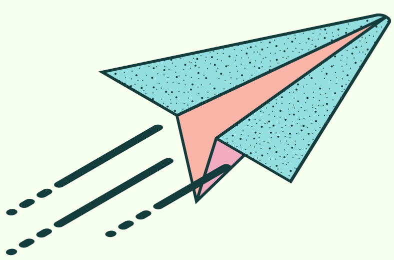
WHY AREN'T PRIVATE PLANES READILY AVAILABLE?

In the status quo, only the wealthy use private planes often. Why is this? Think about how the world would change if every person was able to use private planes when needed. What factors stop this from being possible?

1.6 APPLYING TO AIRPLANES

WHAT ARE FORCES AND WHY DO THEY MATTER?

QUESTIONS OF THE DAY



How does the design of a paper airplane affect its flight performance?
Can the paper airplane's flight be controlled and manipulated, and if so, how?
What role does aerodynamics play in the flight of a paper airplane?
How does the weight distribution of a paper airplane affect its flight?

KEY WORDS

- Pressure
- Weight
- Wing
- Drag
- Mass
- Angle
- Thrust
- Lift
- Airflow

E	Y	D	Y	M	T	Y	J	G	A	R	D	L	Z	S
T	A	S	V	H	H	Q	V	J	O	H	Z	K	M	I
F	H	P	G	S	Z	J	S	W	T	M	K	H	E	P
N	B	R	Q	E	Y	Y	W	T	E	I	V	W	U	R
E	M	V	U	J	E	I	O	H	I	N	U	R	A	E
O	G	Z	A	S	N	Q	L	G	G	P	L	A	N	S
U	Z	X	T	G	T	Q	F	I	X	K	I	L	T	S
Z	V	A	P	M	U	M	R	E	F	T	F	R	P	U
D	O	O	M	A	S	S	I	W	E	B	T	R	I	R
I	J	H	T	Z	A	Z	A	N	G	L	E	L	I	E

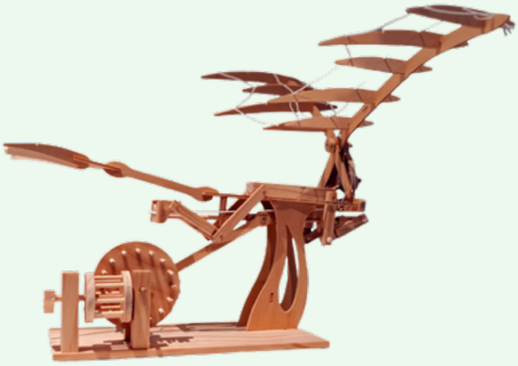
IMPORTANCE OF PAPER AIRPLANES

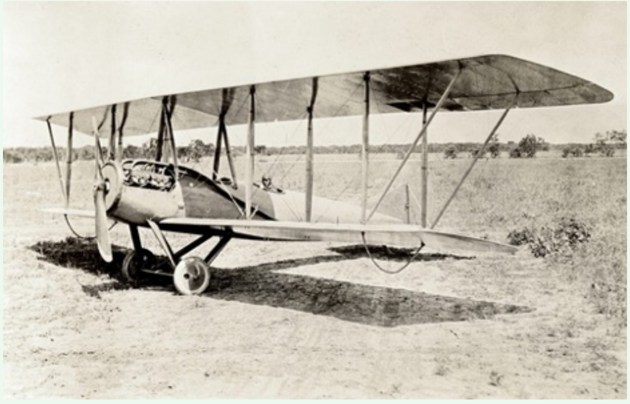
WHAT ARE THEY FOR?

Airplanes are vital for global connectivity, trade, and tourism, enabling fast travel and cultural exploration. They also aid in emergencies, delivering aid and saving lives. The aviation industry creates jobs and boosts the economy. Advancements in technology have made planes safer and more fuel-efficient and contributed to progress.

HISTORY OF THE PAPER AIRPLANE

Early in the 20th century, Leonardo da Vinci began experimenting with paper folding to make basic flying toys. This is when the history of paper aircraft can be found. These early paper crafts over time developed into more complex designs and gained popularity all across the world. Paper airplanes were a common type of entertainment soldiers used to pass the time during World War II. In the years that followed, making paper airplanes became a well-liked activity for both kids and adults, sparking the creation of several books, periodicals, and websites that provide instructions on how to create various designs. People still enjoy making paper airplanes nowadays because they can use their imagination and ingenuity to build one-of-a-kind flying creations that soar through the air.





FACTORS AFFECTING PAPER AIRPLANES

Wingspan

The wingspan of paper airplanes affects their flight performance in several ways. A wider wingspan provides more surface area, generating lift and extending flight time. Additionally, an even wingspan is crucial for the stability of the airplane during flight, as an uneven wingspan can cause the plane to topple over and crash.

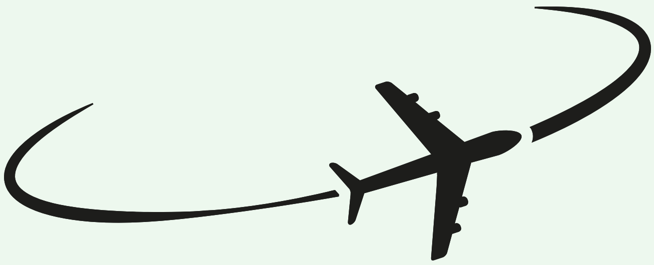
Flat Tip

Flat-tipped paper airplanes offer many benefits in order to enhance their abilities. Firstly, they increase airflow over the plane's surface, reducing drag and improving efficiency. Secondly, these planes enhance stability and accuracy, helping to minimize turbulence during flight. This results in smoother and more effective flights. Additionally, flat tips are known to enhance a paper airplane's speed and distance-traveling abilities.

Pointed Tip

A pointed tip on a paper airplane offers multiple advantages. Firstly, it reduces drag, allowing the plane to fly more efficiently and cover greater distances. Secondly, it improves aerodynamics by smoothly guiding airflow across the wing's surface. This leads to a stable and predictable flight path for the paper airplane.

FACTORS AFFECTING PAPER AIRPLANES

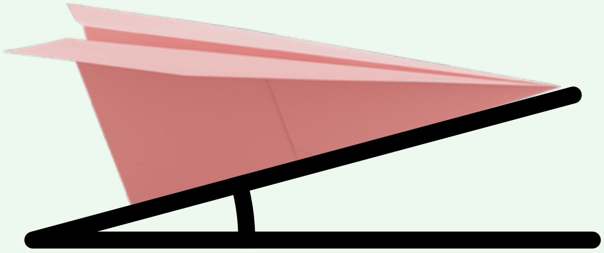


Weight

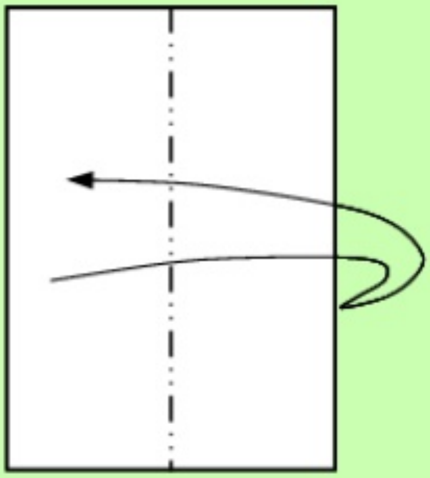
The weight of a paper airplane has various effects on its flight performance. Heavier planes pose challenges in launching and control but offer slower and more stable flights due to increased gravitational force. Conversely, lighter planes fly faster and are more agile but may stall or lose altitude quickly due to reduced wing lift. Lighter paper airplanes require less force to launch and offer increased maneuverability, allowing for quick and agile flights, but they are more susceptible to wind disturbances and may struggle to maintain a steady course.

Launching Angle

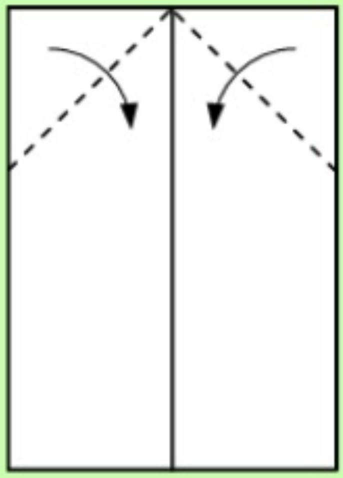
The launching angle is crucial for paper airplanes as it determines the initial trajectory of the flight. It greatly affects speed, height, and stability. A steep launch angle can lead to excessive speedd and quick altitude loss, making the plane difficult to control and prone to crashing. Conversely, a shallow angle results in slow and unsteady flight, reducing the distance covered. Optimal launch angles ensure a balanced flight with good speed, altitude, stability, and control.



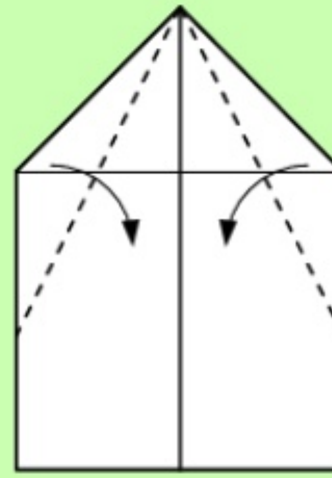
FORMER RECORD AIRPLANE DISTANCE



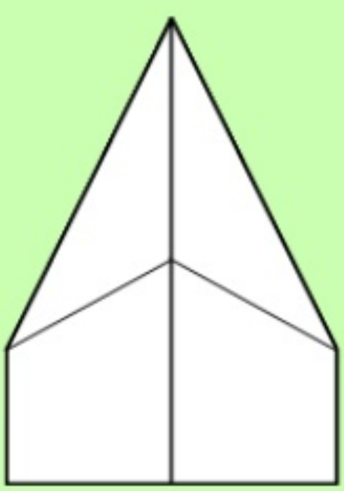
Fold the paper in half lengthwise: Fold the paper in half lengthwise, creating a crease down the center of the paper.



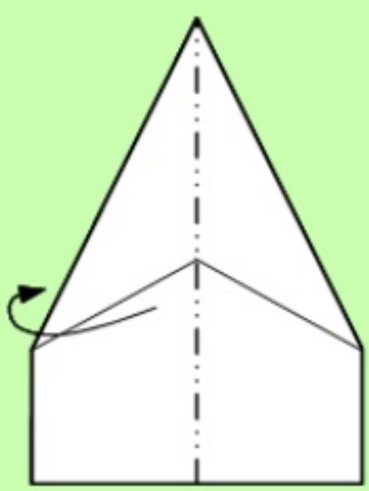
Fold the corners of each side to the crease on the center of the paper



Fold the new corners of each side to the crease on the center of the paper



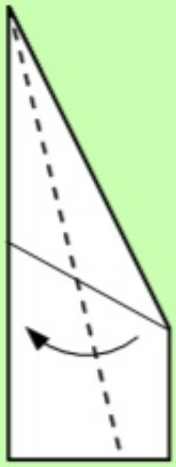
Make sure to flatten all the creases properly or else you might not get desired results.

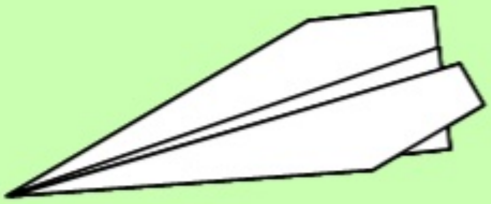


Flip the folded paper back side up

Fold the plane backwards in half so that each side is on top of the other

FORMER RECORD AIRPLANE DISTANCE





Make a vertical fold on each side to the base of the plane to make the wings

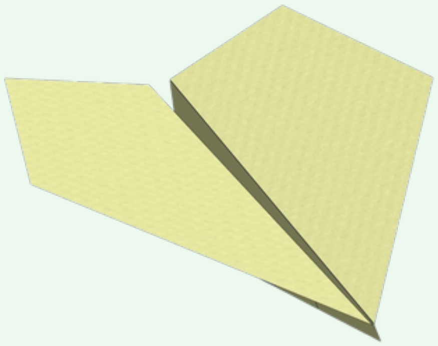
Crease the fold and make sure it is flush

Lift the wings and make sure both wings are at the same angle to keep it balanced

Please follow the instructions carefully to ensure the best possible results. To avoid injury, refrain from throwing paper airplanes near anyone's face or eyes. Also, be mindful of your surroundings and avoid flying paper airplanes in areas with low ceilings or near fragile objects. Never throw paper airplanes out of windows or balconies. Always handle paper airplanes with caution and supervise children when making and flying them. Keep in mind that safety should always come first when enjoying this fun and entertaining activity.

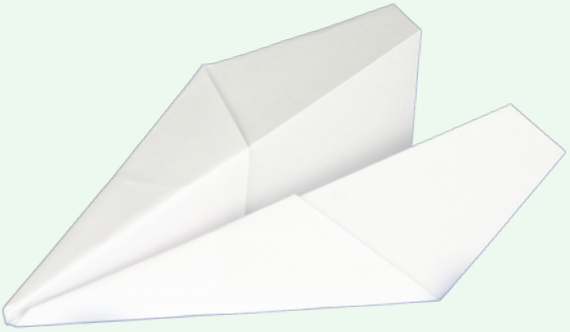
FORMER RECORD AIRPLANE DISTANCE EXPLANATION

The primary design, weight distribution, and throwing prowess of the notable paper airplane are just a few of the contributing aspects that allow it to fly as far as it does.



A well-made paper airplane with a balanced weight distribution, along with a symmetrical shape will fly farther and steadier. The throw's technique and speed will also have a big impact on how far the plane travels. The total distance a paper airplane will travel can also be influenced by variables like wind speed and direction.

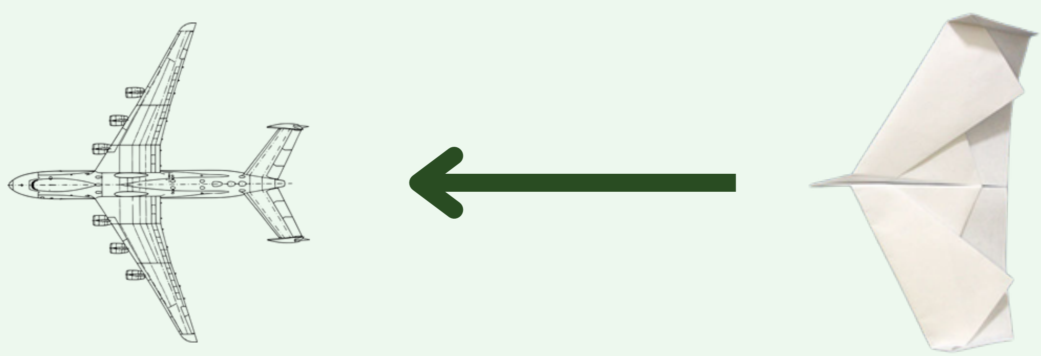
John Collins' World Record Paper Aircraft is a remarkable illustration of how design and balance may impact a paper airplane's flying. The aircraft's expertly balanced design that balances the four forces of flight—lift, weight, push, and drag—has helped it set the world record for the longest flight. The 155-degree dihedral angle of the aircraft is one of the primary design features that contribute to its remarkable flight.



By ensuring the best possible airflow over the wings, this angle aids in maintaining the balance of the aircraft while it is in flight. The plane's pointed front also aids in reducing drag, which slows it down. The plane's slope allows more air to flow by.

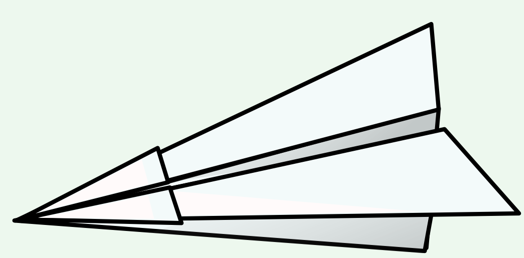
THOUGHT PROVOKING

Can the principles of paper airplane design be applied to real aircraft design?

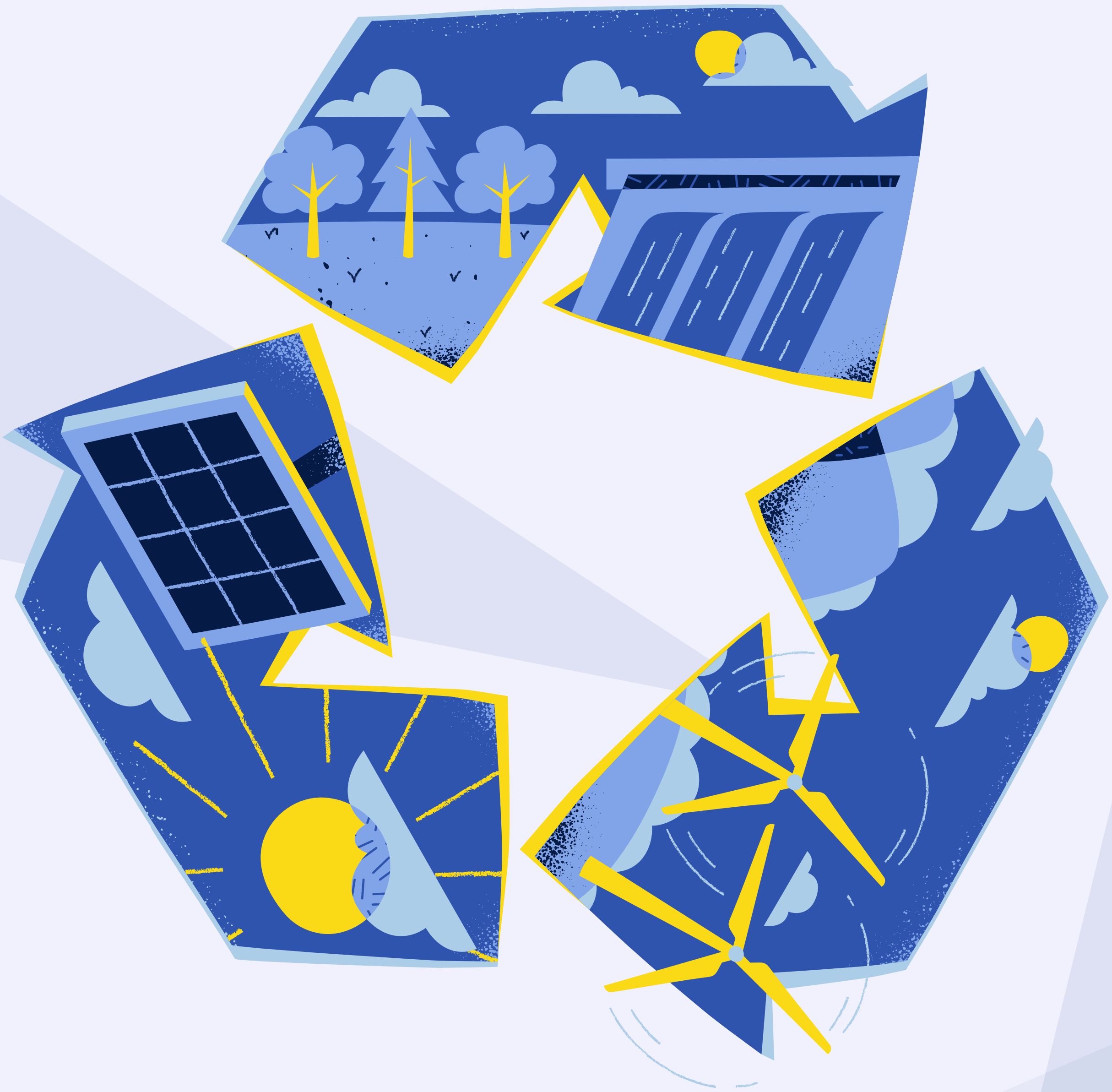


Can a paper airplane be used for scientific research, such as studying airflow or turbulence?

How can the design of a paper airplane be optimized for distance, speed, or accuracy?



FLOW OF ELECTRICITY



CHECK OUT OUR YOUTUBE CHANNEL!

SMF

2.1 ELECTRICITY

What is electricity and how is it used?

Questions of the day:

How is electricity made, and what are some of its benefits and disadvantages?

Where does lightning come from?

Keywords

- Neutron
- Electric
- Proton
- Electron
- Static
- Charged
- Energy
- Circuit
- Current

J	D	S	T	A	T	I	C	U	X	Z	P	T	U	U
A	M	P	M	F	K	L	I	B	V	R	W	E	O	S
E	L	E	C	T	R	O	N	X	O	H	L	Y	R	C
W	S	J	A	A	N	O	R	T	U	E	N	G	I	B
Y	N	B	M	O	M	X	O	N	C	I	X	R	V	X
S	O	D	P	G	B	N	P	T	S	J	C	E	P	J
W	W	J	T	N	E	R	R	U	C	U	J	N	V	Q
B	I	T	W	V	T	I	L	O	I	E	U	E	W	N
D	W	Q	P	P	C	R	O	T	N	W	Z	O	F	Y
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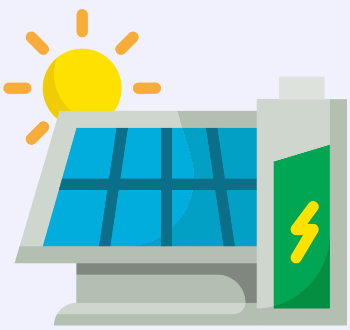
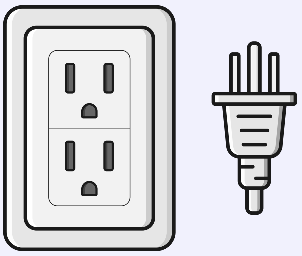
FLOW OF ELECTRICITY



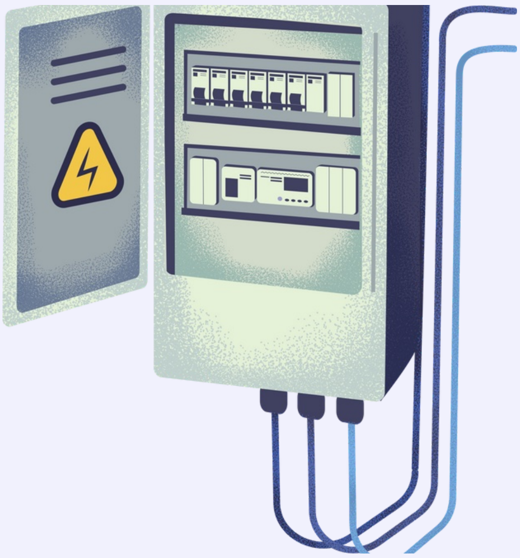
What is the flow of electricity?

Similarly to how water flows in pipes, electricity flows through its own type of pipes. Wires, conductors, and other electrically conductive materials provide a path that electricity needs to flow, also known as an electrical current. This current travels through the wires from a power source, such as a battery or a power plant, to the appliance you want to use, such as a TV. Electricity has become a daily part of our lives. From a lightbulb to a charger to the massive satellites in orbit, which all require electricity, our society now depends upon electricity.

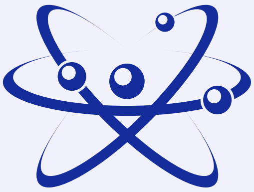
What does the flow look like?



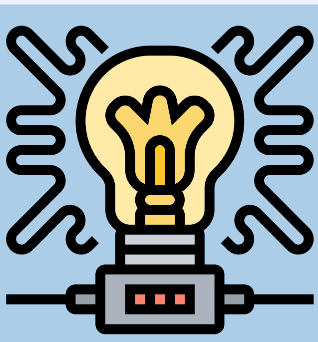
Electricity is a type of energy that flows through wires to power devices, but it's not something we can see with our eyes. If we could, it might look like a bright and fast-moving spark, but in reality, we must use other ways to know when electricity is flowing. For example, we can tell when electricity is flowing by the devices that turn on, like a light bulb or a fan, as the functioning of the utility shows the flow. Even though we can't see the flow of electricity literally, we can still tell when it's flowing as it powers devices and makes them work.



PROTONS, ELECTRONS, AND NEUTRONS

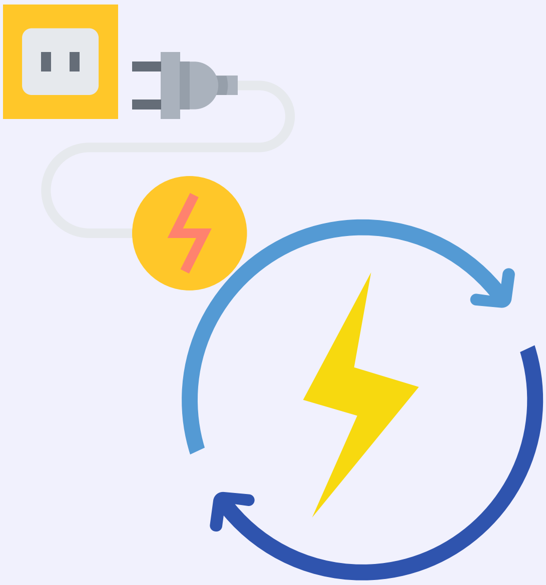


The flow of electrons in the flow of electricity is called electric current. Electric current is measured in units of amperes (often shortened to "amps"), which is the rate at which electric charge flows through a material. When a large number of electrons are moving through a material, the electric current is strong, and when fewer electrons are moving, the electric current is weaker.



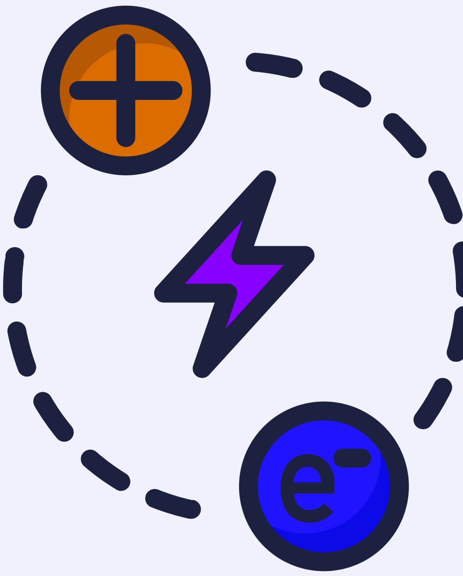
Electrons, protons, and neutrons play a crucial role in the flow of electricity. Electricity is the movement of electric charge, and the electric charge is carried by electrons. In an atom, electrons are negatively charged particles that orbit around the positively charged nuclei, which are made up of protons and neutrons.

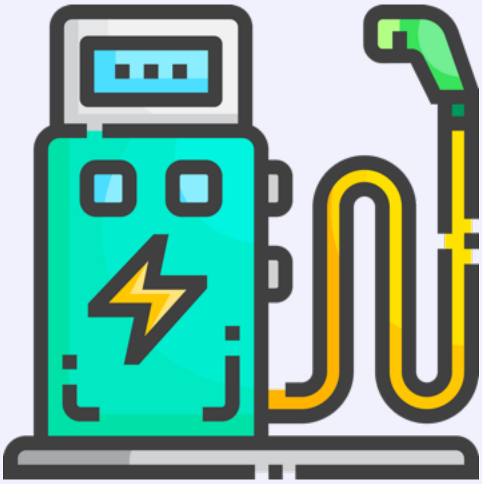
The flow of electricity is directly related to the movement of electrons. When an electric field is applied to a material, it causes the electrons to move, creating an electric current. The number of electrons and protons in an atom affects its electrical properties, as materials with an excess of electrons are said to be negatively charged, while materials with fewer electrons are said to be positively charged.

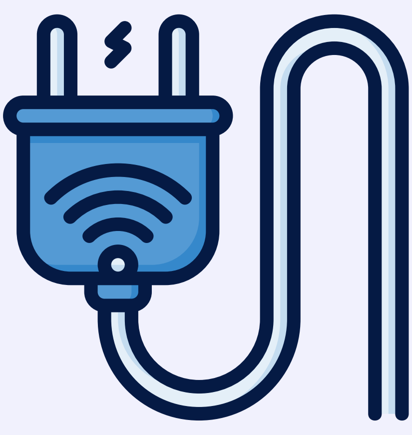


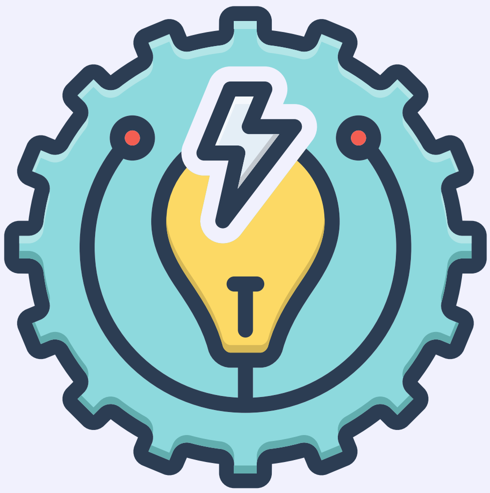
PROTONS, ELECTRONS, AND NEUTRONS

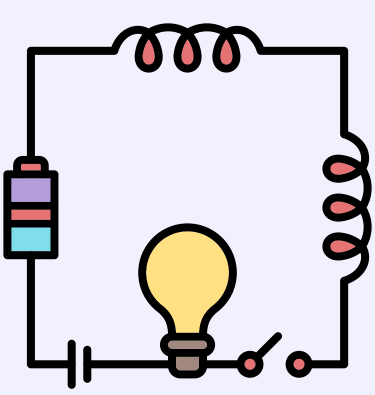
This relationship between electrons, protons, and the flow of electricity can be understood through the concept of electric charge. Electric charge is a fundamental property of matter and is determined by the number of electrons and protons in an atom. When there are more electrons than protons in an atom, it is negatively charged; when there are more protons than electrons, it is positively charged.









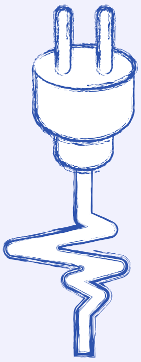


In conclusion, electrons, protons, and neutrons all play a role in the flow of electricity. Electrons carry the electric charge and determine the electrical properties of a material, and the movement of electrons creates the electric current. The number of electrons and protons in an atom also affects its electrical properties and the flow of electricity.

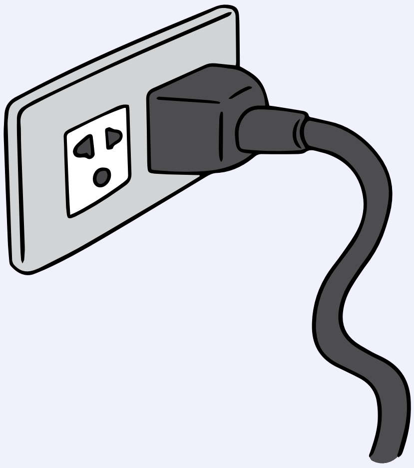
CONDUCTORS AND INSULATORS

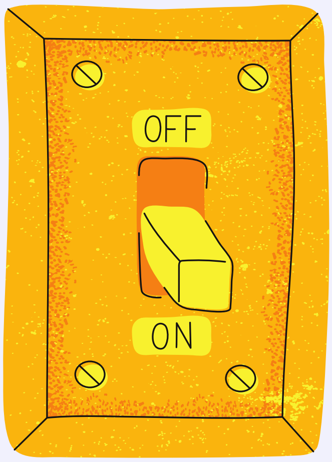
Conductors	Insulators
Copper Aluminum Silver Humans	Rubber Glass Pure water Oil

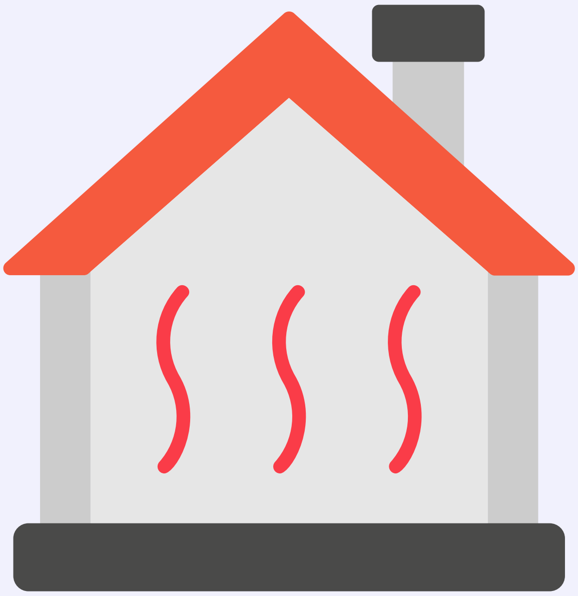
The flow of electricity is affected by the type of material the current passing through. Conductors have a high number of free electrons, which are electrons that are not tightly bound to a particular atom. These loose electrons can move freely through various materials, allowing electric current to flow easily. Examples of conductors include copper, aluminum, and silver.



Insulators, on the other hand, have few free electrons, so electric currents cannot flow easily through these materials Examples of insulators include rubber, wood, glass, and air. Insulators are usually found in electrical systems to protect people and equipment from electric shock and to prevent electrical fires.







LIGHTNING

Why does Lightning Occur?

Lightning occurs when there is a buildup of electrical charge in the atmosphere, usually in the form of thunderstorms. Air acts as an insulator between the positive and negative charges in the cloud and between the cloud and the ground. When the opposite charges build up enough, this insulating capacity of the air breaks down, and there is a rapid discharge of electricity that we know as lightning.

The Discovery of Electricity?

In 1752, Benjamin Franklin flew a kite with a metal key attached to it during a thunderstorm. He observed that the silk ribbon attached to the key became charged with electricity, and when he touched the key, he felt a shock, demonstrating that lightning was indeed a form of electricity. This experiment was a significant step in understanding the true nature of electricity and its relationship with lightning, leading to the development of lightning rods to protect people and buildings from lightning strikes.

Revolutionization of Electricity

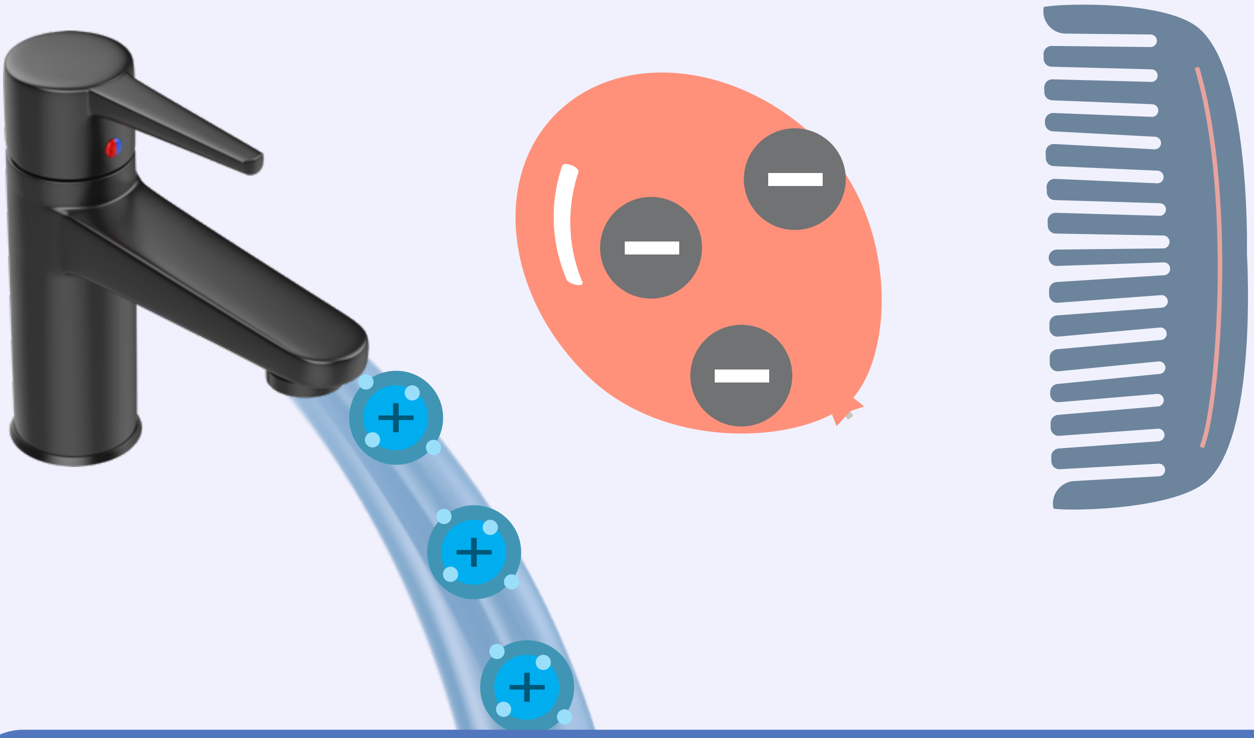
Electricity has transformed the world by powering homes, cars, and factories, connecting people through technology. It led to the invention of the telegraph, cars, the telephone, and eventually even the internet. This changed how we communicated. Electricity has also enabled new technologies, such as motors and generators, which are transforming the way we live and work. Today, it remains a vital part of modern society and continues to shape the future.

APPLICATION

Steps needed:

Supplies needed:
A sink and a comb or a balloon

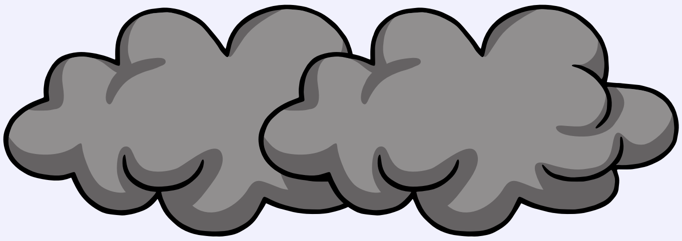
1. Turn on the faucet with a small stream of water
2. Charge the comb or balloon by rubbing it in your hair
3. Hold the comb or balloon close to the stream of water without touching it
4. Observe the water bending
5. Why do you think this happened?

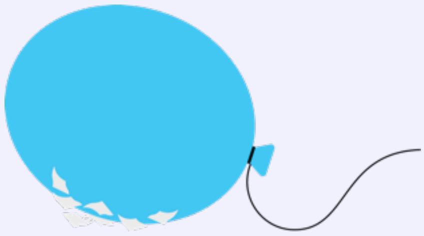


APPLICATION

Why this works?

Atoms are made up of protons with a positive charge, neutrons with no charge, and electrons with a negative charge. Typically, the positive and negative charges in an atom balance each other out, making the atom and the object it composes neutral in charge. However, when two objects are rubbed together, some electrons may transfer, causing one object to become positively charged and the other negatively charged. This leads to their attraction due to their opposite charges. Static electricity is less likely to build up on humid days because the charged particles attach to the water molecules in the air.



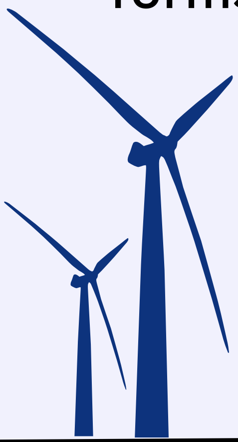


The buildup of static electricity can be a useful phenomenon, but it can also be problematic in certain situations. For example:

- Static electricity can pose a risk of fire or explosions in environments with flammable materials, such as gas stations, chemical plants, or grain silos.
- Static electricity buildup can cause discomfort or pain when it discharges through our bodies, such as when we get a shock from a doorknob or a car door.
- Static electricity can interfere with sensitive electronic equipment, such as in manufacturing plants or hospitals, where it can cause malfunctions or damage to equipment.
- Static electricity can attract dust and other particles, leading to cleanliness issues in certain environments, such as laboratories or clean rooms.

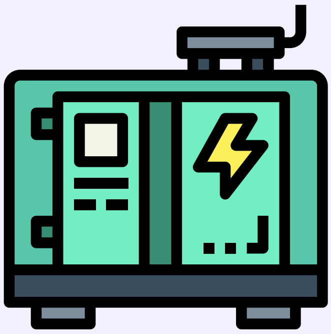
THOUGHT PROVOKING

Can the flow of electricity be used to create new forms of art, music, and expression?



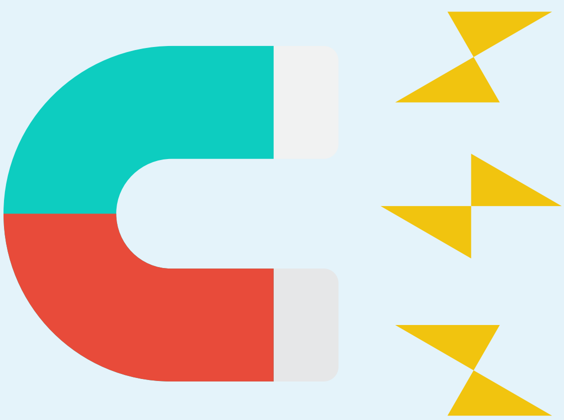
Electricity is currently made mainly through non-renewable sources, what are the ways we can make it renewable?

What are different ways to produce energy? Which are friendly to the environment and which are not?



2.2 MAGNET

Questions of the day



How can you magnetize a material that is not naturally magnetic?

How are magnets used in transportation, such as trains and levitating vehicles?

Are magnets able to lose their magnetism over time? If so, why and how can they be re-magnetized?

Keywords

- Attraction
- Field
- Flux
- Force
- Levitate
- Magnetism
- Pole
- Repulsion

A	M	R	R	R	M	F	H	A	A	I	P	X	M	F
F	O	R	C	E	L	P	S	M	T	E	U	K	I	K
A	M	A	O	P	J	R	E	A	T	W	R	O	G	C
W	H	G	X	U	L	F	T	G	R	X	C	L	U	M
K	O	X	A	L	Q	I	A	N	A	A	I	C	U	P
Z	Z	N	E	S	T	E	T	E	C	E	F	X	C	D
N	N	W	L	I	E	P	I	T	T	Y	T	Y	L	R
N	A	N	O	O	I	D	V	I	I	E	L	E	D	L
V	P	V	P	N	F	I	E	S	O	O	I	G	N	H
V	B	K	K	F	U	I	L	M	N	F	E	S	M	A

HISTORY BEHIND MAGNETS

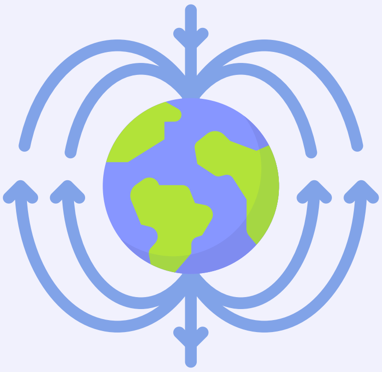
It was discovered that certain stones, known as lodestones, could attract iron at the beginning of magnetism's history. In 200 BC, the Chinese were the first to record the usage of lodestones for navigation. William Gilbert, an English physician, studied magnetism through experiments in the 16th century and produced "De Magnete," which is regarded as the first comprehensive analysis of magnetism. He found that the Earth had a north and south magnetic pole and functioned as a gigantic magnet.

Electric currents produce magnetic fields, as Hans Christian Oersted of Denmark discovered in the 19th century. Electromagnets, which are utilized in many modern technologies, including motors and generators, were developed in effect. The development of permanent magnets(ex. fridges) and magnetic storage technologies like hard drives and credit cards were made possible by the discovery of magnetic materials like iron, nickel, and cobalt.

Nowadays, magnetism is employed for various purposes, from renewable energy sources like wind turbines to diagnostic imaging. With ongoing investigations into novel materials and future uses, it is still a crucial area for study and innovation.

HOW DO MAGNETIC FIELDS BEHAVE

What is a magnetic field?



Magnetic fields are invisible force fields that surround magnets or moving electric charges. They're created by the movement of electric charges, such as electrons, which generate electric currents. These currents generate magnetic fields. Even though they can't be seen, they can be detected with instruments like compasses or magnetometers. The behavior of magnetic fields is determined by the size and direction of the electric currents and magnetic materials involved, making them constantly changing and a bit unpredictable.

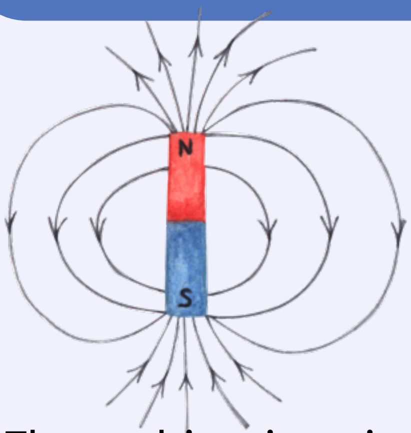
Nature of a magnet

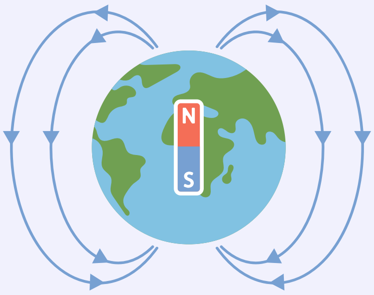
Magnetic fields have a dipolar nature, meaning they have a north and south pole. This dipolar nature arises from the orientation of the electrons within the magnetic material. The same poles repel each other, while opposite poles attract. The strength of the magnetic field is strongest at the poles and weaker further away. Magnetic fields can also pass through non-magnetic materials, such as air, water, and plastic, making them ideal for various applications.

Applications

Magnets and electric charges generate magnetic fields that surround us. These fields power electronic devices such as generators, motors, transformers, and even hard drives. Magnetic fields are essential for medical imaging, particularly MRI scans, which capture detailed images of our organs and tissues. Magnetic fields are also behind credit card production, security systems, and the levitation of high-speed trains. These unique properties make magnetic fields ideal for use in transportation, medicine, and telecommunications.

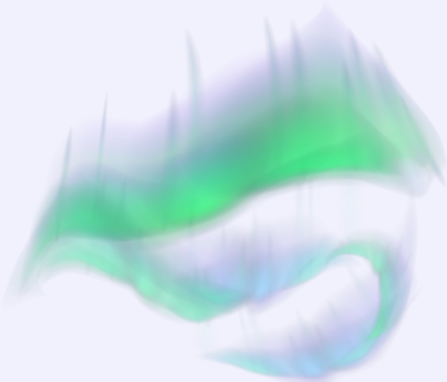
MAGNETISM AND THE EARTH



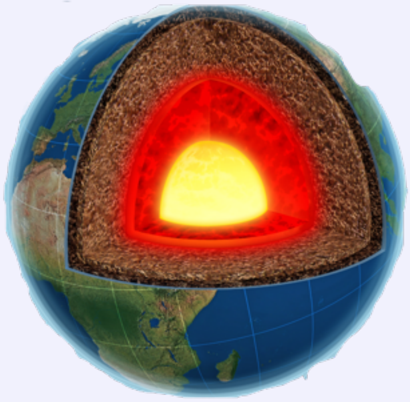


The melting iron in the Earth's core is in constant motion and generates electric currents, producing a magnetic field. This magnetic field has North and South Poles, similar to a bar magnet. The Earth's magnetic field is created by the motion of this molten iron, which is heated by the planet's internal processes.

Effect on Earth



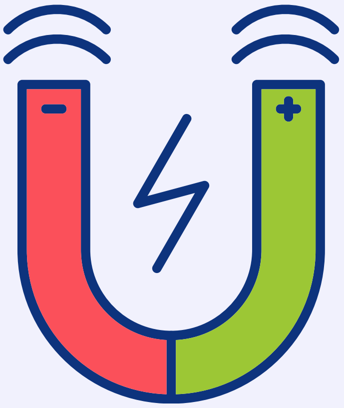
Earth's magnetic field is generated by the motion of molten iron in its core, creating a magnetic field with North and South Poles. These poles are close to the geographic North and South Poles. The Earth's magnetic field protects the planet from harmful cosmic radiation and charged particles from the Sun and causes beautiful phenomena such as the aurora borealis and aurora australis.

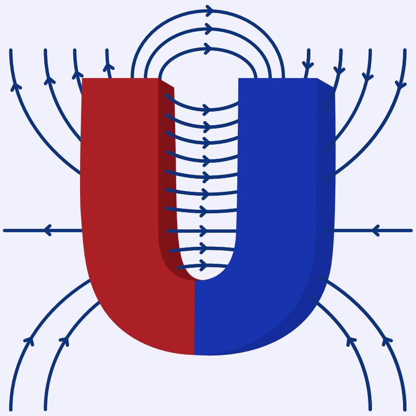


The Earth's magnetic field is a vital force that protects life on our planet by deflecting harmful cosmic radiation and charged particles from the Sun. This shield is critical for preventing harm to living organisms.

WHAT MATERIALS ARE MAGNETIC

Some basic materials are magnetic. Examples include iron, nickel, and cobalt. These metals can produce magnetic moments because each of them has an outer electron shell that is partially filled. The electrons part of this outer shell makes it so that it attracts the protons. These magnetic moments are the product of the electrons' orbital motion and spin, which produce a magnetic field.

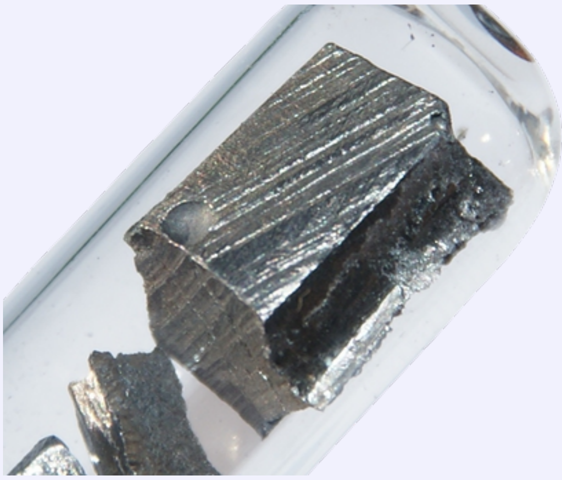


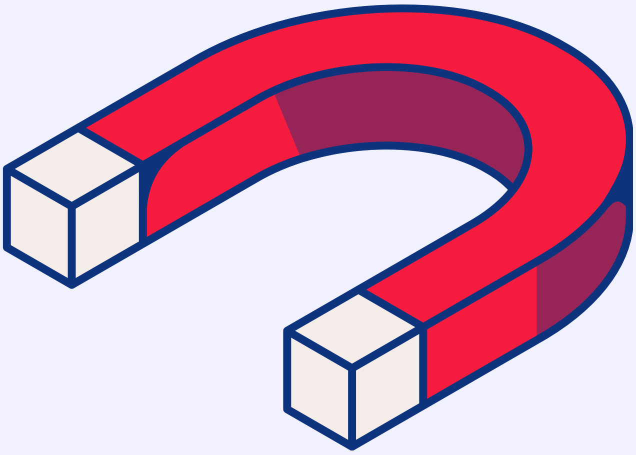


Individual atoms' magnetic moments line up with one another in ferromagnetic materials like iron, nickel, and cobalt to produce a potent net magnetic field. An external magnetic field can induce this alignment, producing a magnet that keeps its magnetization even when the external field is removed.

TYPES OF MAGNETS

The strongest permanent magnets now on Earth are neodymium iron boron (NdFeB) magnets. They are created by adding neodymium, iron, and boron in a precise ratio, followed by the application of a powerful magnetic field. As the generated magnet has a high energy density, it can be applied to many different things, such as electric motors and generators. Because the electron arrangement of materials like paper, glass, and rubber prevents the formation of magnetic moments, these substances are not magnetic. These materials' shifting electron velocities cancel out any magnetic fields that individual atoms might have produced.





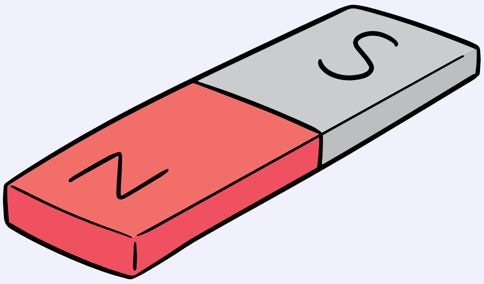
In conclusion, the behavior of a material's electrons determines whether it has magnetic properties. Metals with partially full outer electron shells, like iron, nickel, and cobalt, can produce magnetic moments and a net magnetic field. The strongest permanent magnets now on the market are neodymium magnets (made with iron boron (NdFeB)). Due to their electron arrangement, other materials, including paper, glass, and rubber, do not possess magnetic characteristics.

APPLICATION

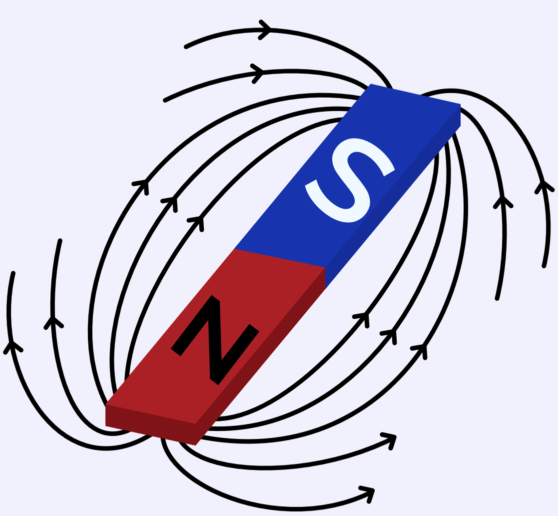
Magnetic Fields Experiment:

1. You will need a bar magnet and iron filings
2. Place the magnet on a flat surface and sprinkle iron filings on top
3. The filings will align themselves along the magnetic field lines, showing the shape of the field
4. You can use a plastic bag or a clear container to keep the filings contained
5. Test with different fillings and metals to see what difference they make, and if they have the same magnetic field
6. Record your experiment

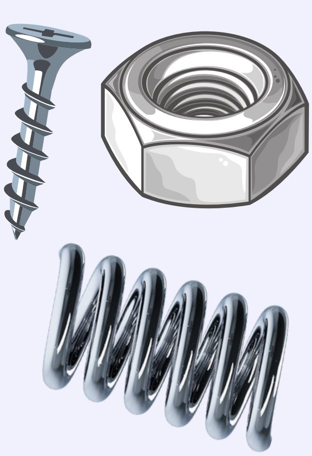
BAR MAGNET



IRON FILINGS

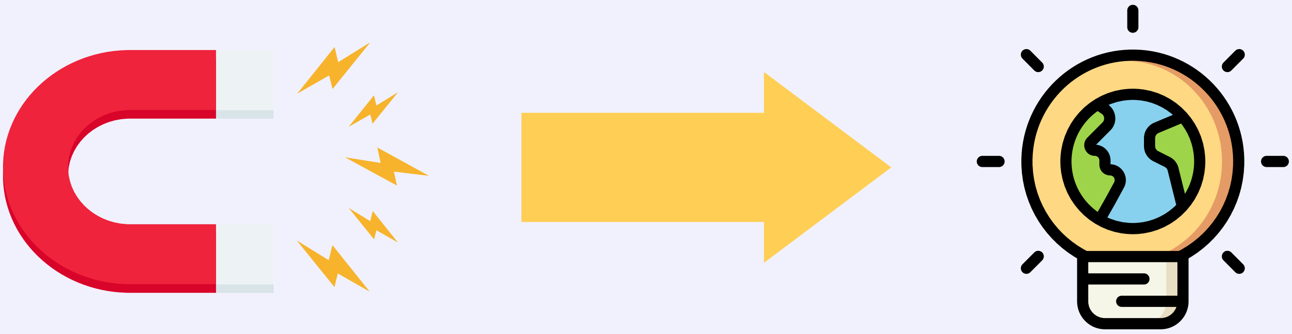


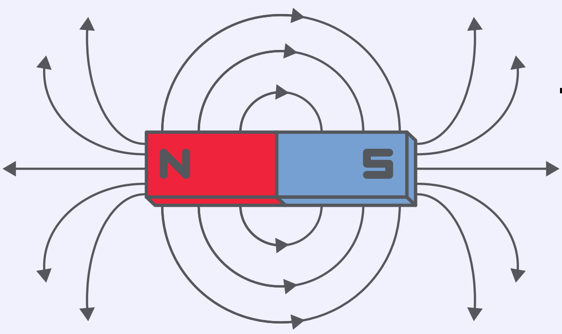
ASSORTMENT OF METALS



THOUGHT PROVOKING

Can magnets be used to create sustainable energy sources?





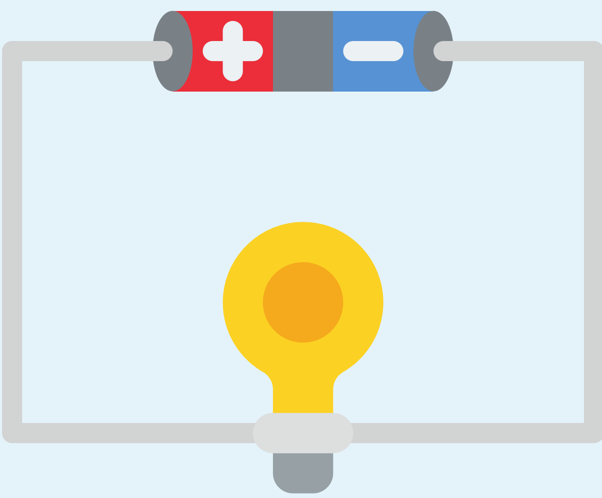
What factors influence the strength and direction of the magnetic field generated by a magnet?

How do magnetic fields affect living organisms, and what implications does this have for the environment?

2.3 HOW DO CIRCUITS WORK

How does a electric circuit work and where are they found?

Questions of the day



Describe circuits in your own words.
How do you think circuits play a role in the world of electricity?
Think of some examples of circuits which is used in our daily lives.

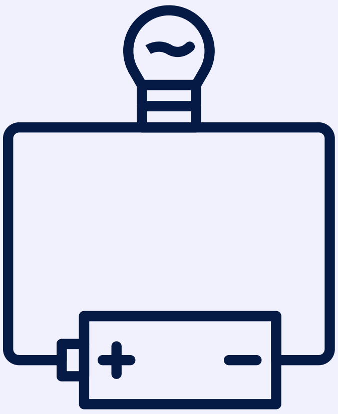
KEY WORDS

- Battery
- Light
- Switch
- Parallel
- Series
- Electric
- Circuit
- Light Bulb

Z	X	Q	I	A	P	S	W	I	T	C	H	E	I	Z
A	N	Z	C	S	E	A	E	P	A	A	N	D	L	E
T	P	S	O	R	Y	Y	R	Z	S	A	R	J	O	H
G	P	Z	I	R	T	T	L	A	L	S	X	N	Y	X
Z	Z	E	B	F	W	H	I	O	L	V	O	M	R	L
X	S	L	V	M	K	E	G	U	B	L	U	B	E	N
D	C	B	S	T	X	Q	H	I	C	F	E	L	T	S
R	Z	Q	R	C	A	O	T	X	L	R	B	L	T	S
W	U	V	G	D	O	D	N	U	H	X	I	D	A	R
C	I	R	T	C	E	L	E	J	K	S	X	C	B	N

CIRCUITS: THE FLOW OF ELECTRICITY

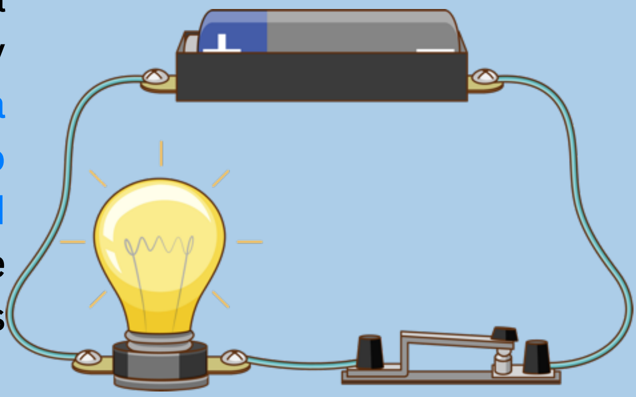
What is a circuit?

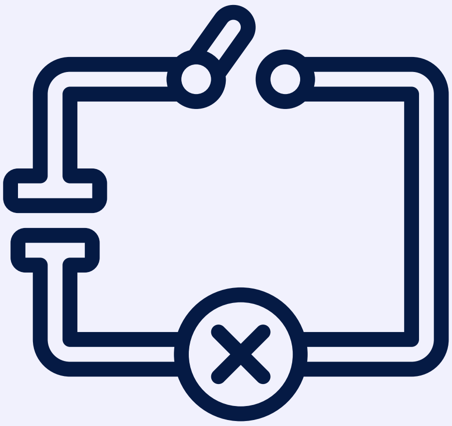


An electric circuit is a closed loop that electricity passes through. It can be oriented in almost any shape and size. The circuit is made from individual components—for example, battery, light bulb, wires, etc. When all these components are put together in a certain shape, it creates a path for electricity can flow continuously. When a switch is installed on the circuit, you can manually control the flow of electricity in the circuit.

What is a closed and open circuit?

As mentioned above, a circuit is a closed path that helps flow electricity effortlessly. A circuit is called a "closed circuit" when there is no disturbance in the connection and the shape is complete. When there are no gaps, the electricity passes through quickly.

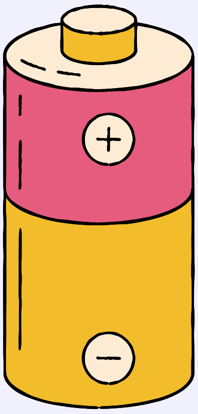




Now we all know what a closed circuit is. On the other hand, an open circuit is the opposite of a closed circuit. When the connection is broken, electricity stops flowing, causing the bulb not to work. This is caused by a bad connection on the battery, a light switch in the off position, and more. An open circuit would mean that electrons would be lost from the system.

COMPONENTS OF CIRCUIT

Battery



The battery is the primary power source for the electric circuit. It provides a source of energy for the light bulb to turn on. However, using only one battery for an electric circuit is not necessary. You can run dual batteries if the bulb consumes more power. On a regular battery, there are two components, i.e one at the top and one at the bottom. Those components are called terminal ends, and they are represented as "+" and "-" as shown in the diagram given. The "+" symbol at the top represents the positive terminal. On the other hand, the "-" represents the negative terminal.

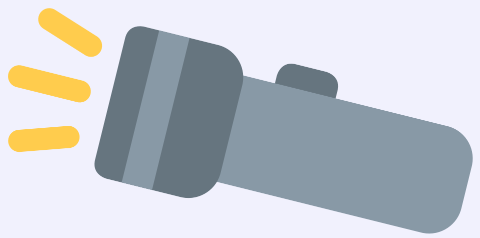
Wires

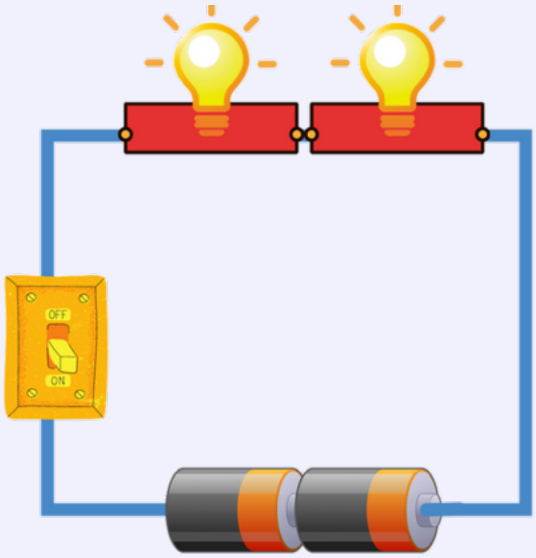
The wires in an electric circuit help with the flow of electricity from the battery to the light bulb so that it can turn on. The wires are connected directly from the terminal ends of the battery to the connection points on the light bulb. In some circuits, the wires are connected to a light switch. If the wires are damaged or split anywhere, the flow of the electricity can get disturbed, and the circuit becomes open.

Loads

The light bulb is the most common load also one of the most critical components in the electric circuit because it lets us know if the electricity in the circuit is flowing or not. If the bulb does not light up, the battery could be dead, or there is a problem with a circuit, such as a broken wire, causing it to become an open circuit.

CIRCUIT TYPES

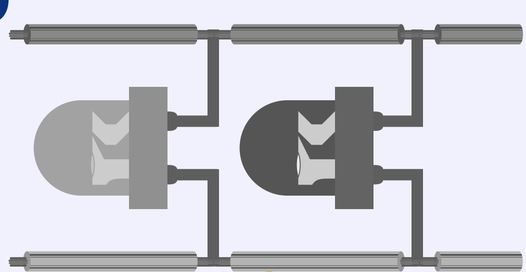




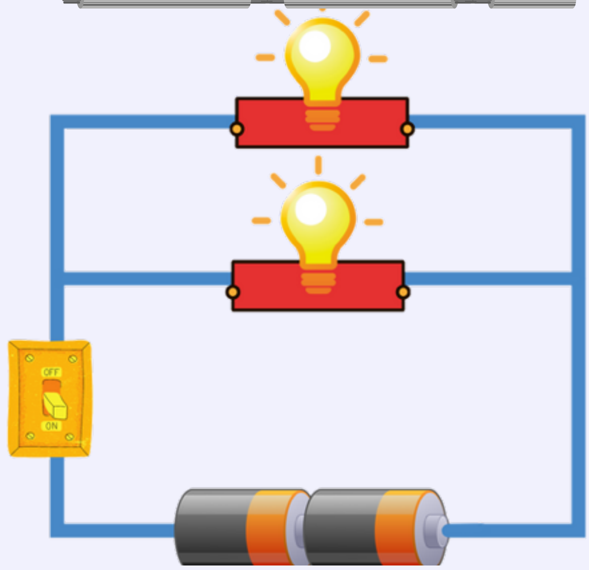
What is a Series Circuit?

The series-type circuit lives up to its name. The light bulbs are connected in one path, and they are controlled by one light switch. With series circuits, you do have a few advantages and disadvantages. One of the advantages is that you can power everything with one switch. In a series circuit, the electricity flows clockwise and completes one loop. But on the other hand, it does have its disadvantages. One of them is that the whole system will shut down if the connection becomes open.

What is a Parallel Circuit?



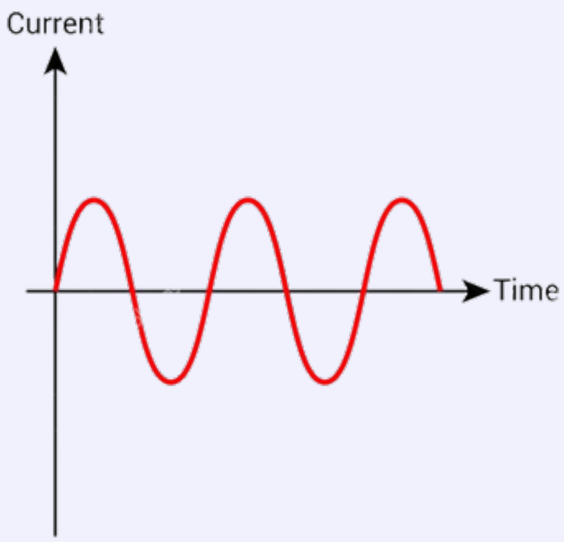
The parallel type circuit is the opposite of a series circuit. The difference between the two circuits is that both light bulbs are oriented parallelly. It is also connected separately from the series circuit, where the bulbs are connected on one path. A parallel circuit also has its own advantages and disadvantages. One advantage is that if one wire is broken or disconnected, the whole system won't shut off; the other bulb will stay on. The disadvantage is that both bulbs use the same battery, which stresses the battery.



ALTERNATING AND DIRECT CURRENT

What is Alternating Current?

Alternating Current

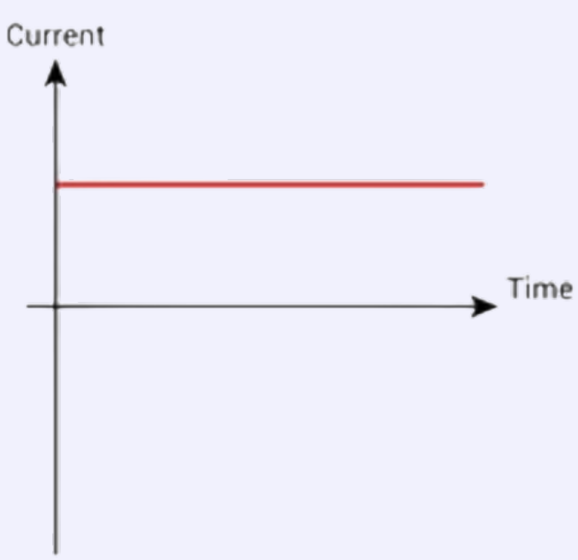


An alternating current is where the electricity in the circuit reverses at a specific time, which happens periodically. Alternating current has its own advantages and disadvantages. One of the advantages of AC (Alternating Current) is that it is less expensive to generate than DC (Direct Current). AC current is capable of traveling long distances. One of the disadvantages of AC current is that high voltage is used. High voltage can be very dangerous to work with because there is an increased risk of electric shock. AC current is regularly used for electricity.

What is Direct Current?

Direct Current is the current that flows straight in one path. Direct Current or DC does not reverse periodically. DC current also has its own advantages and disadvantages. One advantage is DC current is that you can regulate the current flow in the circuit, for example regulating the speed of a regular DC motor. One disadvantage of DC current is that the maintenance cost is very high compared to an Alternating Current. DC current is regularly used for electronics.

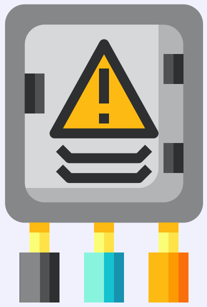
Direct Current

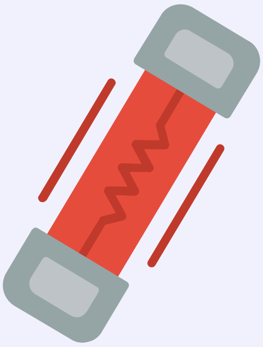


SAFETY COMPONENTS

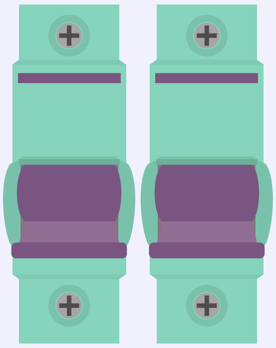
What is a Electric Fuse?

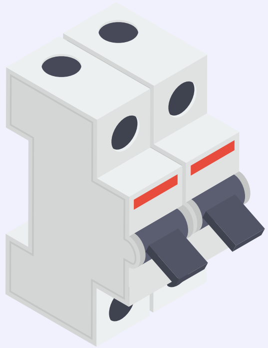
Unlike light switches, fuses are safety components of every major circuit. It prevents damage to electrical components. The fuse is rated at a specific current rating until it blows and creates an open course. An electric fuse has a thin metal coil inside where the current flows. If there is too much electricity flowing, for example, 30 volts flowing through a fuse rated at 20 volts, it overheats the coil, and the metal separates, causing the connection to split. If something like that happens, the solution is to swap it out with another 20 volts fuse. A fuse with a higher rating should not be replaced with it. For example, if a 20-volt electrical appliance is connected to the circuit and you install a 30-volt fuse, the electricity flow might be excess. If that happens, the appliance will get ruined.





What is a Miniature Circuit Breaker?

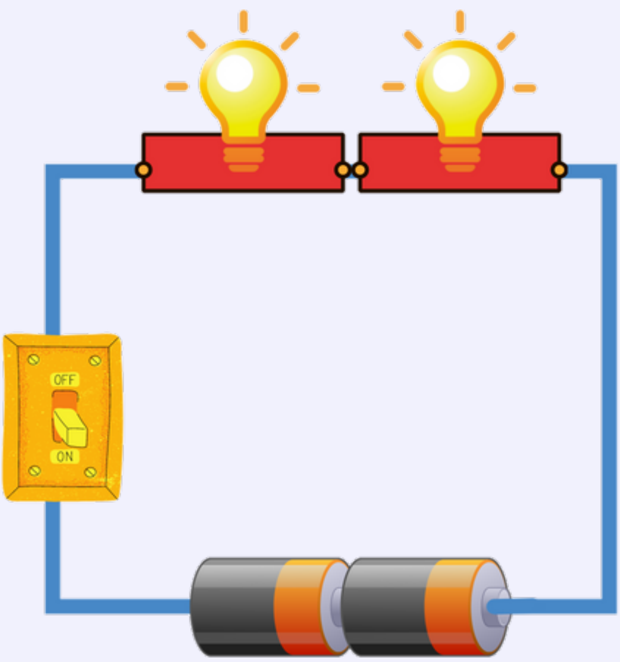




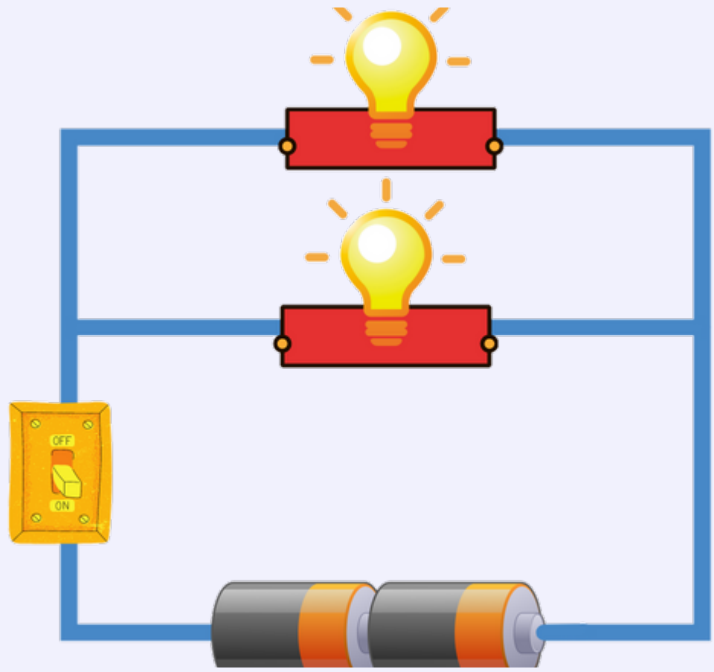
Miniature circuit breakers, or MCBs, are another safety component in an electric circuit. This works the same way how a fuse works. It has a limitation on the flow of electricity. MCBs can also work like a light switch in the circuit. The only difference is that a light switch won't do anything in case of a current increase. Whenever the current flowing in the MCB is unusually high, it immediately trips the switch causing the connection to cut off. If that happens, we can instantly flip the switch back to the on position and not spend any money on a fuse. It is also very helpful when it comes to doing electrical work. You can instantly cut the power by flipping a light switch without removing any fuses.

APPLICATION

Using just batteries, wires, an LED, and a switch, build both a parallel and series circuit using what you learned.



Series

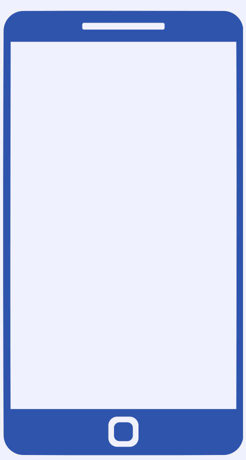


Parallel

Explain how you build each circuit and how it works. Which circuit seems to be more reliable? Which circuit was easier to build? Which type of circuit seems more likely to be used in real-life settings?

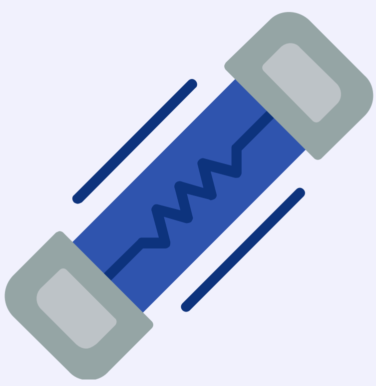
THOUGHT PROVOKING

In the given pictures below, which object is most likely to use alternating current?



What would happen if the electrical current constantly reverses during a circuit?

Why is a plastic material used commonly in electronics? Especially for exteriors?

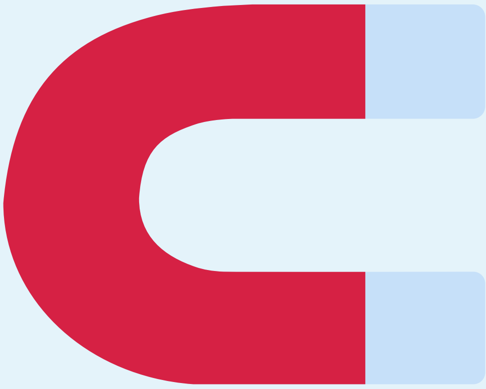


In what cases would people pick alternating current over direct current or direct current over alternating current?

2.4 CIRCUITS

How do electricity and magnets play a role in our lives?

Questions of the day



Does a magnetic field expire and lose its field?

What do you think happens when an electric field overlaps a magnetic field?

Is it possible to remove an object's magnetic field?

KEY WORDS

- Magnetic
- Electric
- Field
- Circuit
- Attraction
- Transform
- Positive
- Negative

B	N	E	G	A	T	I	V	E	J	F	S	B	C	O
L	T	Y	S	I	I	T	P	E	R	I	I	U	P	M
C	T	D	M	R	O	F	S	N	A	R	T	E	A	N
I	K	K	L	E	G	D	K	H	K	M	K	G	L	O
R	N	O	I	T	C	A	R	T	T	A	N	A	N	D
T	N	G	Y	A	P	E	L	N	Z	E	P	L	W	V
C	N	E	W	D	C	H	H	U	T	T	N	Y	B	T
E	Z	M	P	P	M	E	C	I	R	C	U	I	T	D
L	E	E	Y	K	B	Z	C	B	I	V	B	Y	L	T
E	V	M	Q	D	E	E	V	I	T	I	S	O	P	U

APPLICATIONS OF CIRCUITS

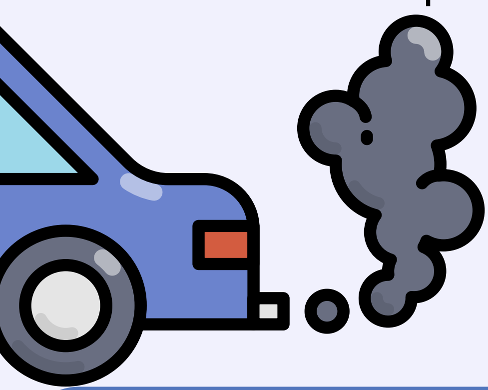
Circuits in our Daily Lives

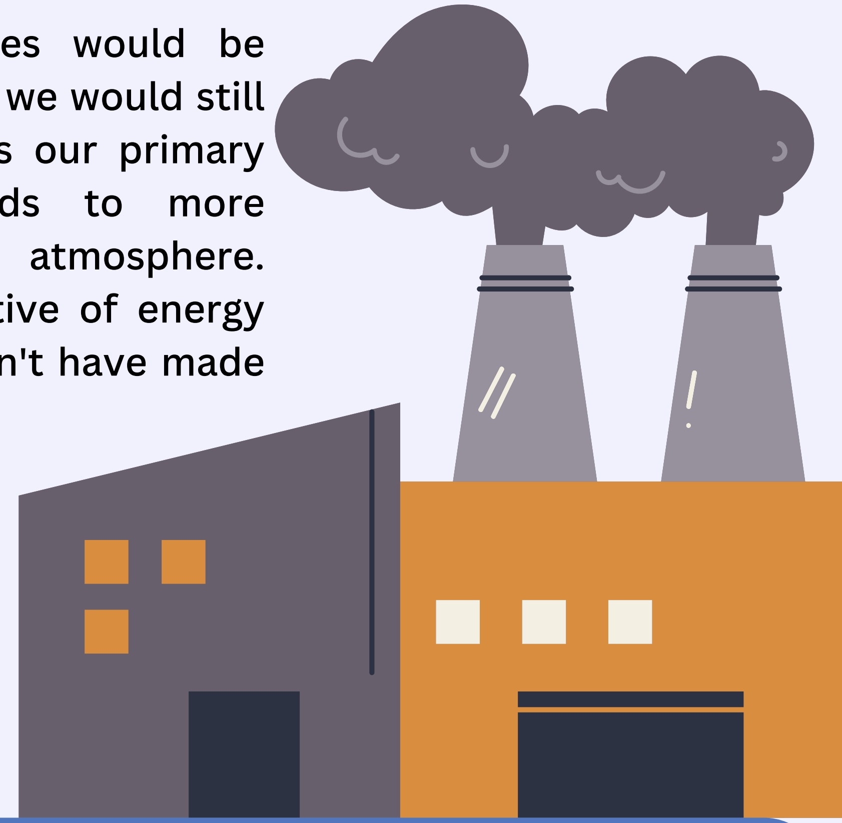
Now, you might be wondering, how does a circuit affect us?

Circuits provide every utility that is around you. For the simple day-to-day activities that you or your parents use, they all use circuits to guide and provide electricity. Everything is run by a circuit, from refrigerators to toasters, to microwaves, to the lights lighting up our streets at night.

Everywhere . . .

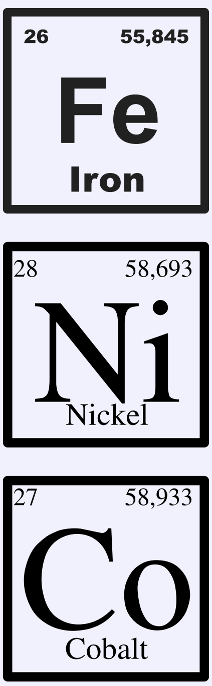
Without electricity, our lives would be much different. For example, we would still be relying on gas and oil as our primary power source, which leads to more pollution within Earth's atmosphere. Without the cleaner alternative of energy through electricity, we couldn't have made it this far in the first place!



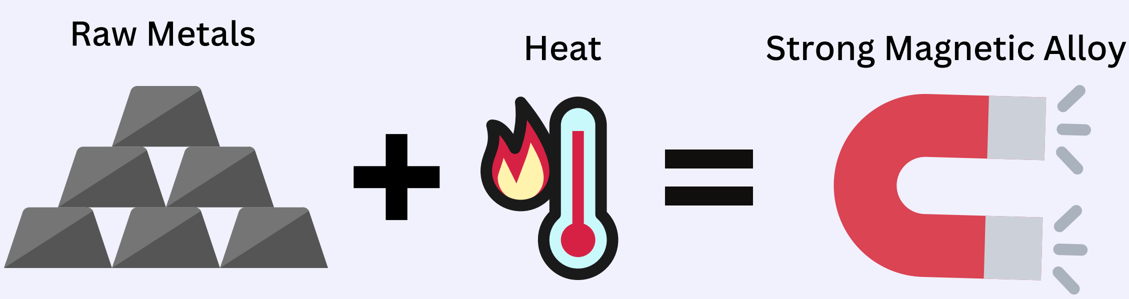


APPLICATIONS OF CIRCUITS

Magnets in Nature & their Applications

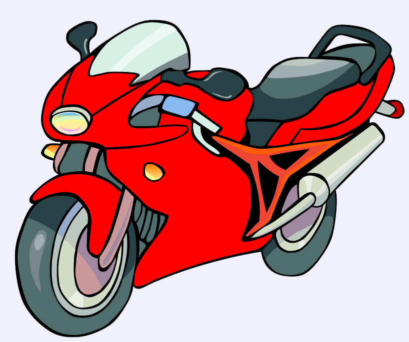


There are only a few natural magnets in nature. Although they may not seem important, they are responsible for many of the magnetic properties found in magnets today. Many magnets are usually made as an alloy (a combination of raw metals and heat) of these metals, resulting in a powerful magnet.



Magnets in our Daily Lives

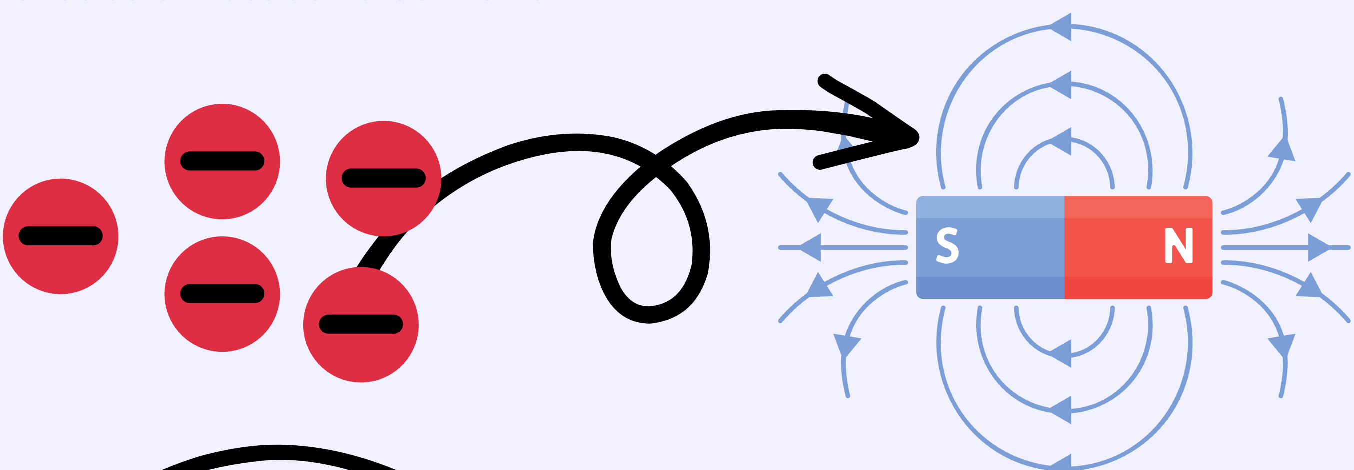
Like circuits, magnets play a big role in our lives. Much of modern transportation relies on magnets as motors, which power the wheels on cars and motorcycles, are made by their properties. Additionally, the faster train on Earth right now is the Magent-based bullet train in Japan. Have you ever experienced going to the dentist? Well, then you have experienced the force of a magnet! X-rays that doctors take of your teeth use magnets to see, well, your teeth! Much of modern medicine also contains magnets.

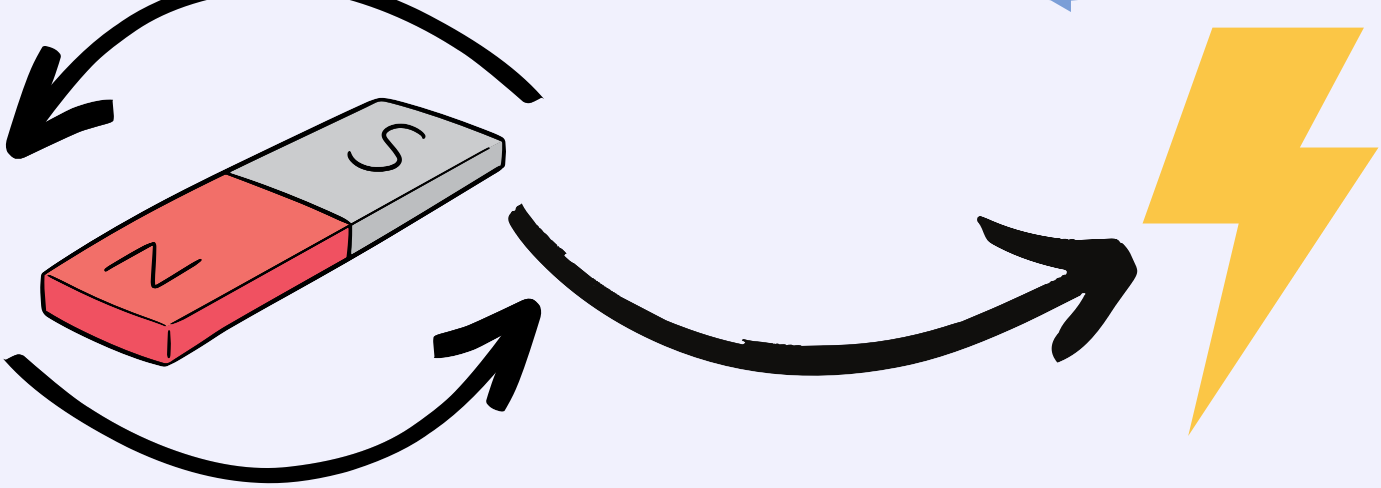


CIRCUITS & MAGNETS: RELATIONSHIPS

Their Mutual Connection

Electricity and Magnetism are closely related. They have an inverse relationship, in which flowing electrons from an electric field will produce a magnetic field, and spinning magnets can create an electric current.





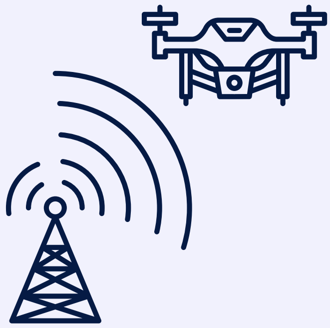
Many applications of circuits and magnets use a combination of both electricity and magnets. For example, a motor uses electricity (powered by gas or some equivalent) to start itself and spins magnets really fast to generate electricity for the car to run on.

ELECTROMAGNETISM

The Combination

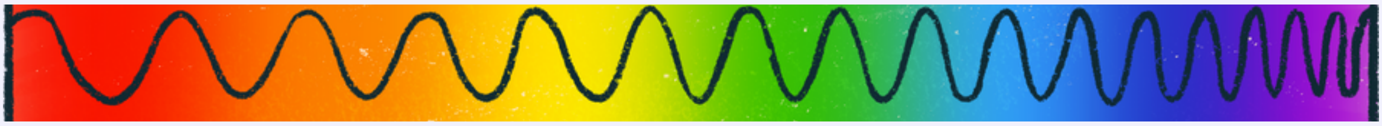
What happens when a magnetic field and an electric field combine? Well, you get something called electromagnetism. This force is one of the four fundamental forces of nature, as creates a new sort of field, titled: the electromagnetic field. The electromagnet force is what binds atoms together and allows magnets to work. The concept of electromagnetism was proved by Albert Einstein, as he showed the relationship between both electric and magnetic forces.

Electromagnetic Spectrum



Electromagnetism also describes the various kinds of waves in our everyday science. Thanks to a specific spectrum of electromagnetic waves, we can do multiple different tasks in our daily lives. These waves are radio waves and microwaves to X-rays and gamma rays.

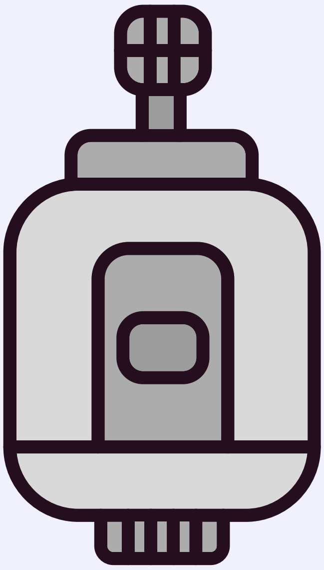
The visible light spectrum is just a tiny part of the electromagnetic spectrum, and it contains the wavelengths for all the colors visible to the human eye. The spectrum works by sorting the different waves by frequency, or number of wave cycles per second, with radio waves having the lowest frequency, the longest wave length, and gamma rays having the highest frequency, the shortest wavelength. This is why a sunset is red and orange, as those colors can disperse in the sky easier due to their longer wavelengths, which allow them to travel longer distances.



Electromagnetism plays a crucial role in technology. It creates many different fields of jobs, including electrical engineering, production, electronic communication, and light/heat/sound distribution. Electromagnetism is used in radio communication, electronics, the internet, speakers, and so much more!

APPLICATION

Explain how magnetic force plays a major role in electric motors.



How did old Fashion Compasses work to get sailors to their destinations in the olden days?

THOUGHT PROVOKING

Which is stronger?

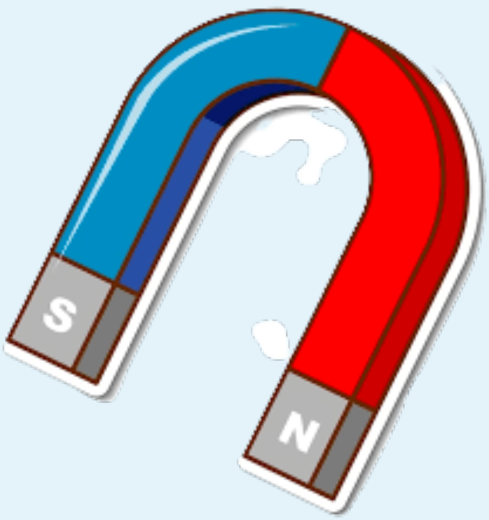
A naturally found magnet or a magnet created through artificial means?

Is an electromagnet or a magnet stronger?

2.5 ELECTROMAGNETS

What are electromagnets and how are they made?

Questions of the day



How do magnets work?

What metals have magnetic properties?

What uses of magnets can be seen in our everyday lives?

Magnets have two sides. One is North. What is the other called?

KEY WORDS

- Magnet
- Electric
- Compass
- Iron
- Electromagnet
- Nickel
- Copper
- Wire
- Field

B	N	E	G	A	T	I	V	E	J	F	S	B	C	O
L	T	Y	S	I	I	T	P	E	R	I	I	U	P	M
C	T	D	M	R	O	F	S	N	A	R	T	E	A	N
I	K	K	L	E	G	D	K	H	K	M	K	G	L	O
R	N	O	I	T	C	A	R	T	T	A	N	A	N	D
T	N	G	Y	A	P	E	L	N	Z	E	P	L	W	V
C	N	E	W	D	C	H	H	U	T	T	N	Y	B	T
E	Z	M	P	P	M	E	C	I	R	C	U	I	T	D
L	E	E	Y	K	B	Z	C	B	I	V	B	Y	L	T
E	V	M	Q	D	E	E	V	I	T	I	S	O	P	U

HISTORY OF THE COMPASS

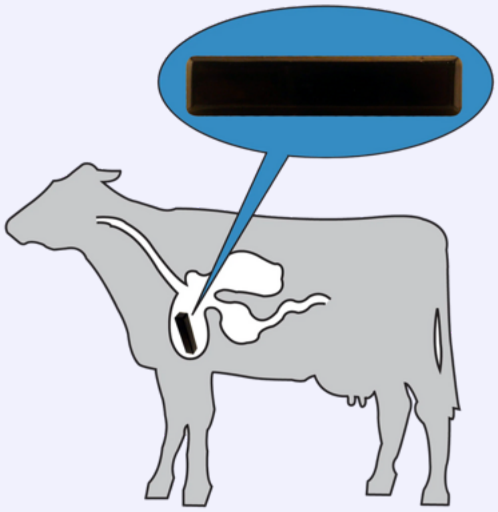
Compass

A compass always points north

By definition, a compass is a magnet that always points north. Compasses are used to help people figure out which direction is north which helps them navigate. Sailors and hikers commonly use compasses. Compasses were said invented in Ancient China around 1000 years ago, but the Vikings used a very old type of compass almost 3000 years ago!

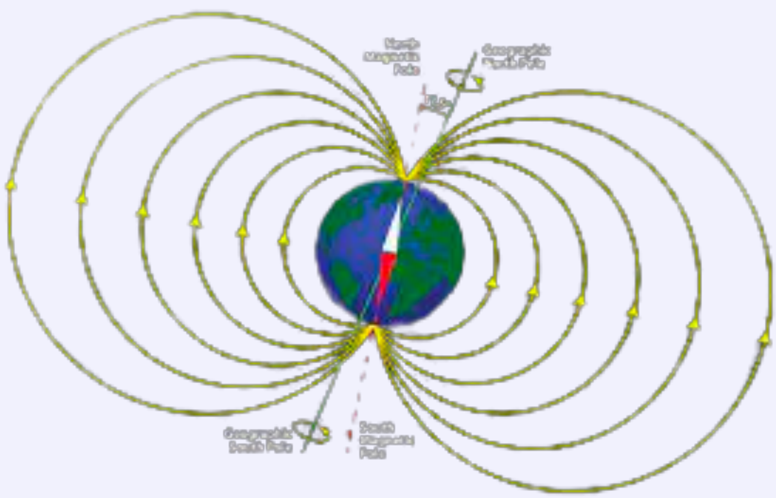
Other early tech with magnets

You've learned about the compass, one of the earliest techs that used magnets. Another example of early magnetic tech is the cow magnet. A cow magnet was used to stop metal that a cow could accidentally eat from traveling farther inside the cow, which caused more damage.



Fun Fact: A cow magnet actually goes inside the cow! It stops metals from traveling farther inside the cow by using its magnetic forces, which attract the metal to the magnet.

HOW COMPASS WORKS



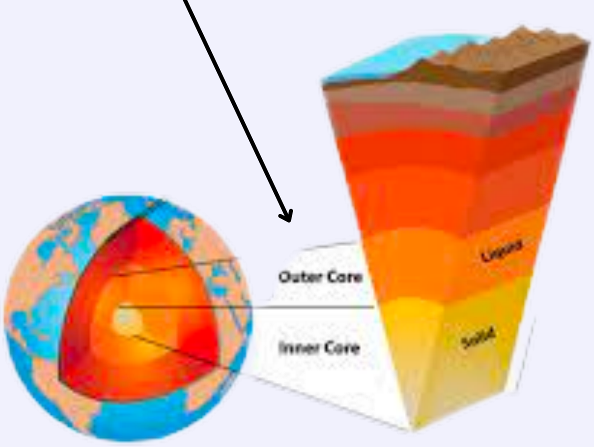
Ever wondered how a compass knows which way is North? Well, it's all thanks to the Earth itself! You see, the Earth is like this huge magnet. It has a North pole and a South pole, just like the magnets you might have played with.

A compass is designed with a special needle or magnetized bar that can move freely. One end of the needle is attracted to the North Pole, while the other end is pulled towards the South Pole. When you hold the compass flat, the needle automatically lines up in a North-South direction. This clever alignment allows us to figure out which way is North.

Earth's Magnetic North Pole

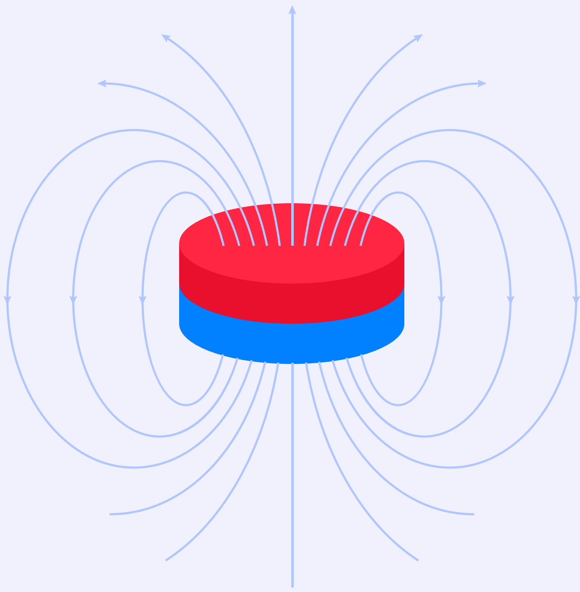
Earth's actual north pole and magnetic north pole are not precisely the same. They are about 1200 miles apart. That number might seem significant, but the Earth itself is so huge that it barely makes a difference. Earth's magnetic north pole changes! The magnetic properties come from the iron core, which slowly rotates. In 250 million years, the magnetic north pole will be on the South pole!

This orange layer is what gives Earth its magnetic properties



ELECTROMAGNETS: WHAT ARE THEY?

An electromagnet is a magnet made out of electricity. A simple electromagnet consists of a wire wrapped around a metal pole. The great thing about an electromagnet is that you can change how strong you want it to be. The image on the right is a simple electromagnet; the battery sends electricity into the wire, which then magnetizes the nail, making it a magnet. All electromagnets have coils that pass electricity. As these coils turn, the electric current passing through the coils works to form a magnetic field. It is this magnetic field that creates the magnetic abilities of an electromagnet.



In Real Life

Have you ever wondered how your headphones work? How about motors, generators, or an electric doorbell? They all use electromagnets! Everyday appliances that you use contain electromagnets. On the left is a headphone. Headphones are very common, especially among teenagers. Some other common household appliances that use electromagnets are fans, refrigerators, and microwaves ovens. Clearly, electromagnets play a significant role in and around our house. Learning about these things can help us right now and in the future.

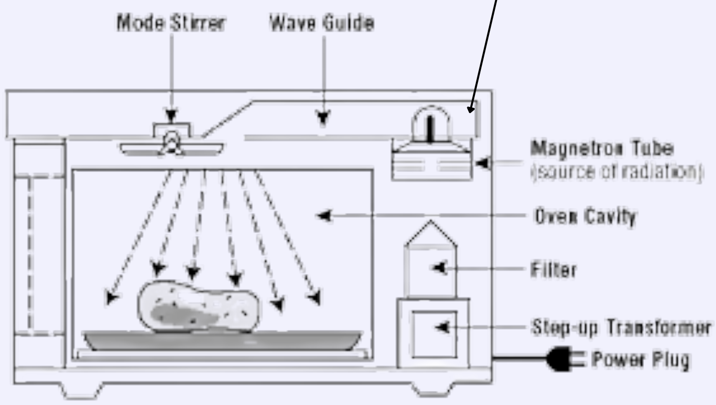
ELECTROMAGNETS: EXAMPLES

Common items that use electromagnets:

- Vacuum Cleaners
- Refrigerators
- blenders
- driers
- Microwaves
- Dish washers

Without electromagnets, our lives would be way harder!

The electromagnet in the microwave



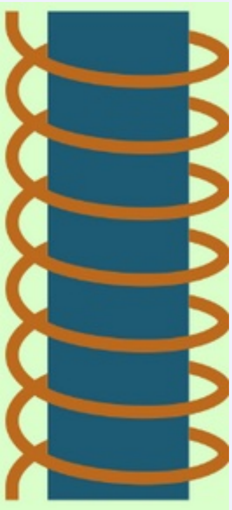
Microwaves, like many other machines, utilize electromagnets in their operation. Electromagnets are created by passing an electric current through a wire coil, generating a magnetic field. This magnetic field can be manipulated to achieve specific functions within the microwave.

In a microwave, the main component that employs an electromagnet is the magnetron. The magnetron is responsible for generating the microwaves that heat up food. Inside the magnetron, there is a vacuum tube that houses a filament, a series of resonant cavities, and a magnetron antenna.

When the microwave is turned on, an electrical current is supplied to the filament, causing it to heat up and release electrons. These electrons are accelerated by high voltage and move toward the resonant cavities. As the electrons move through the cavities, they interact with the magnetic field generated by the electromagnet.

BUILDING AN ELECTROMAGNET

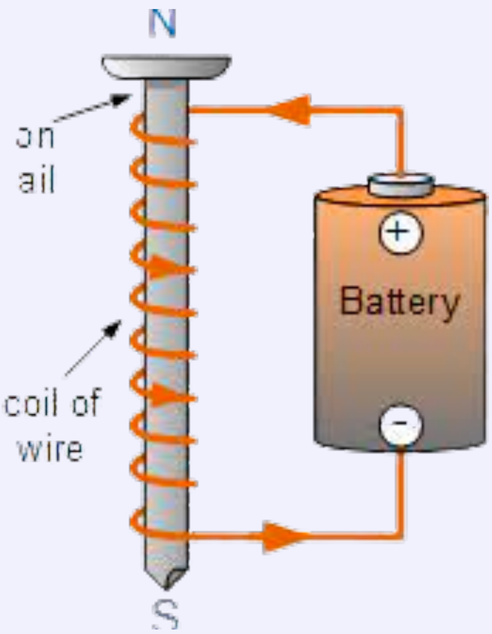
Materials:



- wire
- any battery
- iron nail
- any magnetic objects

Directions:

1. Wrap the wire around the nail, as many times as you'd like.
2. Tape one end of the wire to the positive side of the battery, and the other end to the negative side.
3. You have an electromagnet! Try using it to pick up any magnetic objects around your house, like iron fillings or an actual magnet.



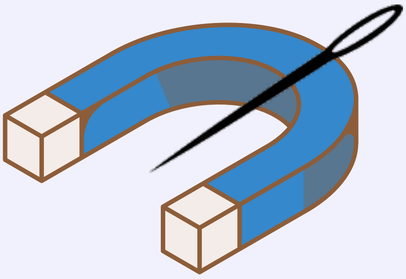
BUILDING A COMPASS

THE HIKER'S DILEMMA

John was hiking through the woods and got lost. He had a piece of cork, a bowl, a bottle of water, a magnet, and a needle in his bag. Help him build a magnet! Make sure to have adult supervision in this activity!

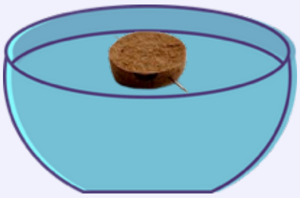
Directions:

Step 1: Take the cork and cut off 1/4 an inch of the cork to make a cork disk



Step 2: Magnetize the needle by rubbing it on the magnet. This temporarily transfers magnetic properties to the needle.

Step 3: Push the needle through the cork like this



Step 4: Pour the water in the bowl and place the cork with the needle inside the bowl

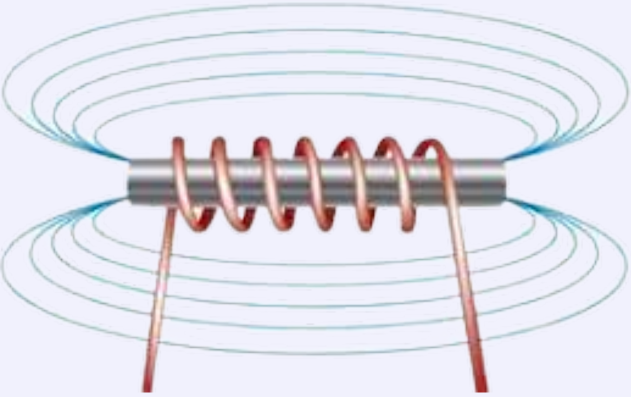
Your compass is finished! John thanks you for helping him build a compass!

THOUGHT PROVOKING

What causes Earth's Magnetic pole to change? (Hint: the answer lies in one of Earth's layers)

Give an example of a household item that uses an electromagnet.

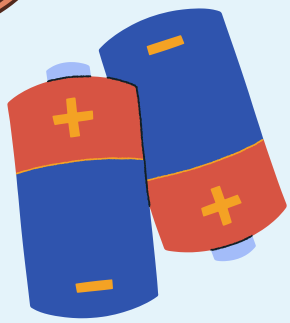
Explain how the object works using the electromagnet. Look online for help!



2.6 PENNY BATTERIES

What makes a penny such a good battery?

Questions of the day



What is electricity and how is it created?

How does a penny conduct electricity?

How can you tell if a battery is "dead" or still has some charge left in it?

KEY WORDS

- Battery
- Zinc
- Copper
- Electricity
- Power
- Energy
- Vinegar
- Voltmeter
- Scissors

C	F	W	W	F	G	Y	D	Z	M	R	V	R	U	K
S	D	P	I	S	H	H	X	I	S	E	O	G	X	I
V	W	C	J	C	Y	A	U	N	M	P	L	B	P	W
S	C	I	S	S	O	R	S	C	B	P	T	T	J	O
K	N	G	R	A	G	E	N	I	V	O	M	U	K	U
A	Q	A	Y	T	I	C	I	R	T	C	E	L	E	Z
S	R	T	X	C	Q	X	Y	E	C	T	T	J	I	D
N	X	W	A	G	T	T	C	K	E	N	E	R	G	Y
C	A	B	B	A	T	T	E	R	Y	D	R	N	Z	O
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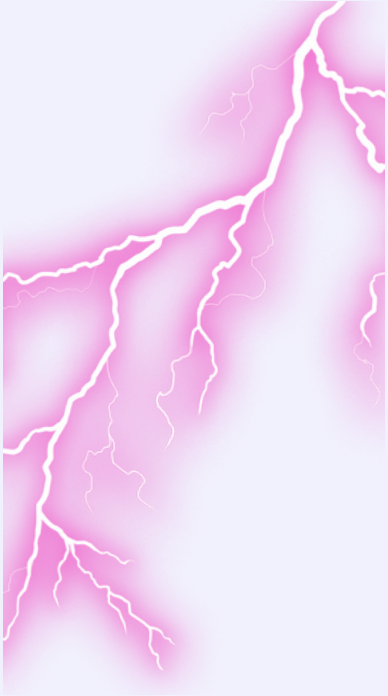
ELECTRICITY AND BATTERIES

What is Electricity?



Electricity is a form of energy resulting from the movement of charged particles, such as electrons or ions. It is generated by various means, including chemical reactions, electromagnetism, and nuclear reactions. Electricity is used to power a wide range of devices and systems, from small electronic devices such as smartphones and computers to large power grids that supply electricity to cities and industries. Electricity is a fundamental part of modern life and is used for lighting, heating, transportation, and communication, as well as powering many other applications.

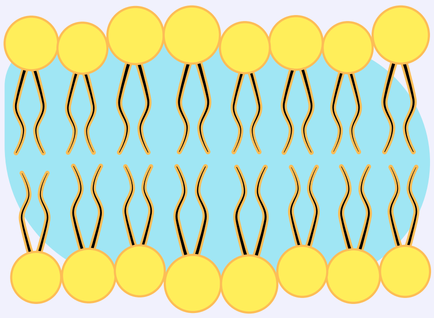
What are Batteries?

A battery is a device that converts stored chemical energy into electrical energy. Batteries are composed of one or more electrochemical cells consisting of two electrodes (an anode and a cathode) separated by an electrolyte. The chemical reactions that occur within the battery cause electrons to flow through an external circuit, producing an electrical current that can be used to power various devices. Batteries power a wide range of devices that we use daily, including smartphones, laptops, tablets, remote controls, flashlights, and toys. They are also used in larger items such as cars, boats, and airplanes and are essential for powering portable and wireless devices. Without batteries, many of our daily activities would be much more challenging and inefficient.

WHAT IS A PENNY BATTERY?

Penny Batteries

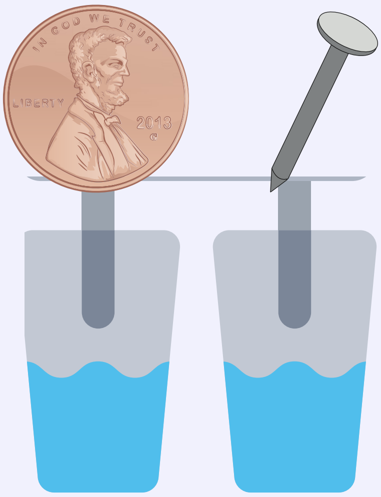
Penny batteries, also known as voltaic cells, are a type of battery that can be made at home using simple materials like copper coins, zinc nails, and vinegar. They are called penny batteries because they can be made by using pennies as one of the electrodes, an electrical conductor used to contact the nonmetallic part of a circuit. The concept of voltaic cells dates back to the late 18th century when famous Italian physicist Alessandro Volta discovered that two different metals separated by an electrolyte (a conducting medium that conducts electricity through the movement of ions present in the medium) could produce an electric current.



An electric current is produced through the movement of ions through an electrolyte, a conducting medium that conducts electricity through the movement of ions present in the medium.

Simple Science

A penny battery uses two different kinds of metal, like a copper penny and a zinc nail, and a special liquid called an electrolyte made from vinegar and salt. When the metals and the electrolyte are put together correctly, a chemical reaction occurs, generating a tiny amount of electricity.



CAPABILITIES AND SAFETY

Uses of a Penny Battery

Although penny batteries are not very powerful, they can still be used to power small electronic devices or science experiments that require low levels of electricity. One example of a device that penny batteries can power is an LED light. By connecting several penny batteries in a series, it is possible to create a circuit that will light up an LED, which can be used as a small emergency source of light. Another example of a device that can be powered by penny batteries is a small motor or generator. By connecting a penny battery to a simple motor made from a magnet and a coil of wire, it is possible to create a simple electric motor that can be used to power a toy or other small devices.

Proper Safety Measures

When working with batteries and electricity, it's essential to be aware of safety concerns such as electrical shocks, chemical burns, fires, and explosions. To mitigate these risks, wear appropriate protective equipment, such as full-sleeved clothing, gloves, and protective glasses. Also, please store batteries in a cool, dry place. Follow the proper instructions when using and charging batteries, and turn off the power supply before working on electrical equipment. Keep a fire extinguisher and first aid kit on hand in case of a fire, and educate yourself on how to respond quickly and safely if an accident occurs.

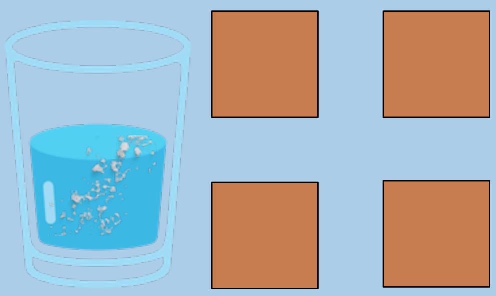
BUILDING A PENNY BATTERY

Materials

Five pennies (after 1982 pennies), mat board, a piece of 100-grit sandpaper, salt, wires, water, vinegar, and a red LED light

Instructions

1. Make a saturated salt water solution by mixing 2 tablespoons of salt in a glass of water until the salt no longer dissolves. Then, add a spoon of vinegar to the solution. While doing so, cut the mat board into 4 separate 1/2-inch squares.



2. Soak the mat board pieces in the salt-and-vinegar solution. Once the pieces are thoroughly wet, take them out and place them on a paper towel so they are still damp but not dripping. Use sandpaper to remove the copper from one side of each of the four pennies, and leave the fifth penny intact. Sand until you see zinc (a shiny silver color) covering the entire face of the coin. When you're done, the sanded coins should have a bronze-colored copper side and a silver-colored zinc side.

BUILDING A PENNY BATTERY

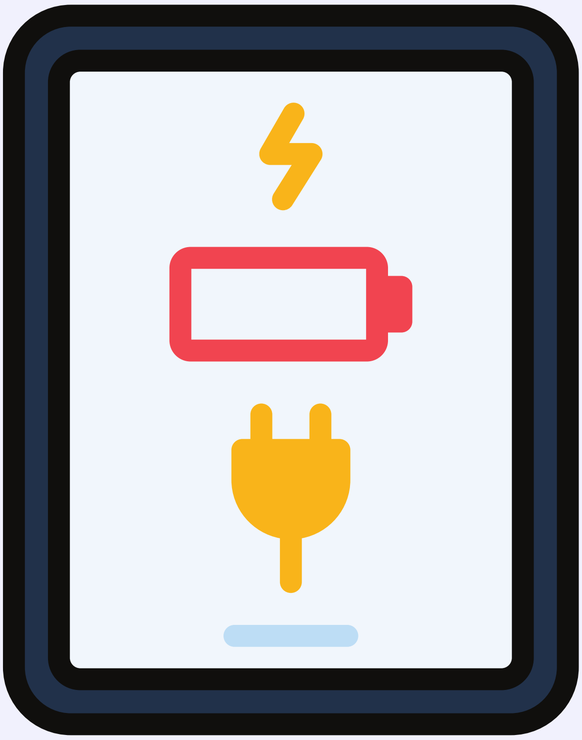
3. Take one of your sanded pennies with the zinc side facing up (copper side down), and place a damp piece of mat board on it. Then repeat the process, stacking the pennies on top of each other in the appropriate order (zinc side facing up) with a damp 1/2-inch piece of mat board in between each penny. Finally, place the unsanded penny at the very top.

4. Lastly, connect the LED to the penny by placing one wire at the bottom of the stack and one at the top. Your LED should be shining bright red!

How does this work?

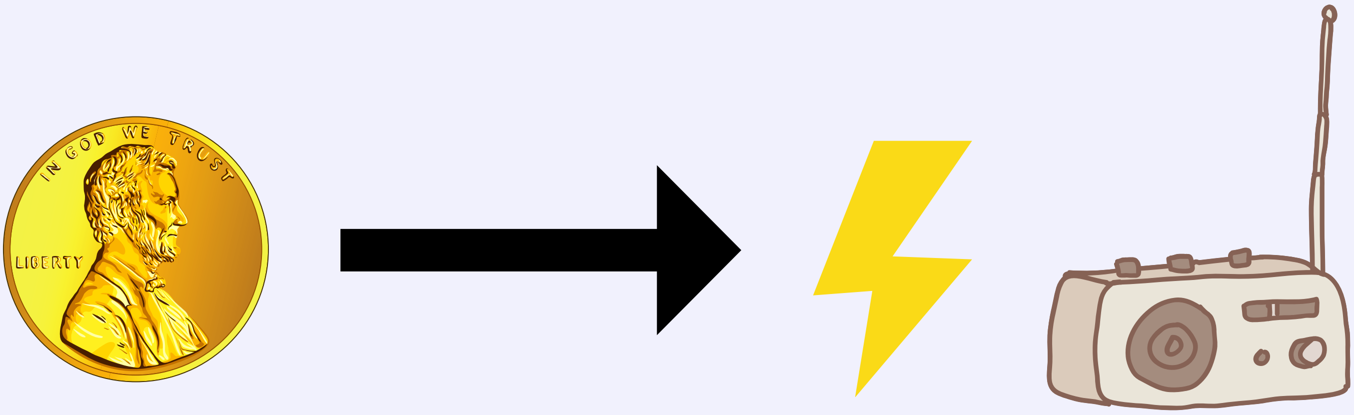
Batteries convert chemical energy into electrical energy using two metal electrodes and an electrolyte. Pennies made after 1982 have zinc cores that can create a zinc electrode when sanded. By stacking pennies and matboards soaked in salty vinegar water, you can create a voltaic pile or battery, generating over 0.6 volts per cell. A stack of three cells is enough to power a red LED, which is visible throughout this experiment.

APPLICATION



Suppose you live in a rural area with limited access to electricity. How could you use penny batteries to power a small electronic device like a flashlight or radio?

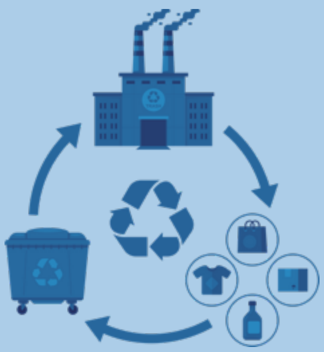
What materials would you use to build the penny battery?



THOUGHT PROVOKING

How can the principles behind the penny battery be applied to other fields of science or engineering?

For example, can batteries be used to store renewable energy or power electric vehicles?



What are the environmental impacts of batteries, and how can we minimize the negative effects of their production and disposal?

What are some historically famous or new inventions where batteries have played a critical role in technology or society?

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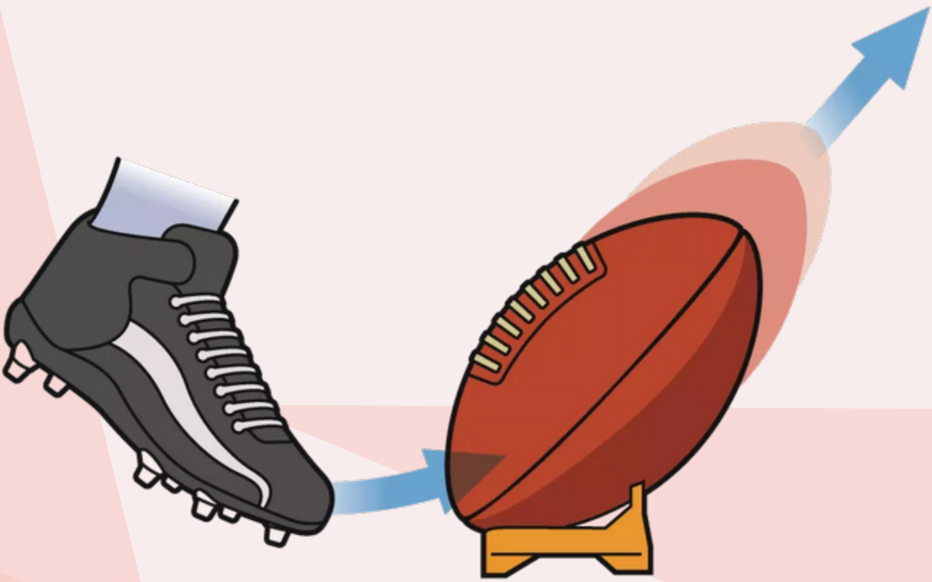
OBJECTS IN MOTION



CHECK OUT OUR YOUTUBE CHANNEL!

SMF

3.1 NEWTONS LAWS

What are Newtons Laws and how do they appear in today's society

Questions of the Day

Who is Isaac Newton?

Why do your feet hurt after you jump from a height?

How do the mass and acceleration of an object affect the force of the object?

Key words

- Gravity
- Friction
- Force
- Acceleration
- Mass
- Weight
- Rest
- Normal

N	O	R	W	S	Q	Q	L	K	J	A	Z	X	W	O
I	I	O	E	A	L	P	W	P	U	H	U	F	K	X
J	G	G	Z	S	J	J	C	F	W	E	A	B	R	F
W	L	N	O	I	T	A	R	E	L	E	C	C	A	A
Q	N	I	F	R	I	C	T	I	O	N	I	R	A	M
R	O	P	Y	G	E	F	F	T	S	K	B	G	O	L
H	V	F	R	X	N	O	R	M	A	L	R	F	H	F
Y	V	X	Z	X	B	E	M	A	S	S	S	N	X	T
X	Y	T	I	V	A	R	G	C	G	H	Z	G	F	L
F	F	H	Z	B	Q	E	I	N	B	O	E	C	S	W

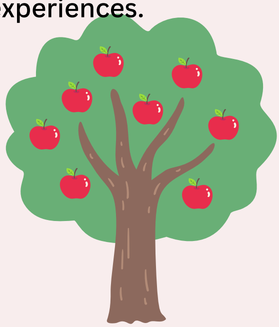
ISAAC NEWTON

Isaac Newton, born in England in 1643, is famous for his contributions to the field of physics. Newton lived during the Scientific Revolution, a period when our understanding of nature began to shift from preconceived religious ideas to a basis in observations and logical interpretations of the world. Enlightened by this new approach to science, Isaac Newton studied a range of concepts, from fundamental math to astronomy.

Discovery of Gravity and Laws

You might already be familiar with Isaac Newton's discovery of gravity. The story goes that after being struck on the head by a falling apple, Newton realized that there was an invisible force acting on the apple, causing it to fall to Earth. He referred to this force as gravity, a term derived from the Latin word for "heavy." But as you know from the first unit, the weight of an object doesn't effect how much gravity the object experiences.

$$\sum F = M . a$$



THE FIRST LAW

An object at rest stays at rest, and an object in motion will stay in motion unless acted upon by a net force.

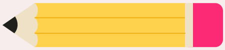
Before: After:

Important Definitions:

Rest: When an object is not moving and has no acceleration.

Net Force: This is the combination of all forces acting on an object. When the net force is zero, the object is considered to be either not moving or at rest.

Imagine This!



After a very busy day at school, you realize that you have left your favorite pencil on your desk in class. When you arrive at school the next day, you find the pencil exactly where you left it. According to Newton's First Law, this is because no net force was exerted on the object; therefore, the object remained in a state of rest, or in other words, did not move.

The second part of the law, which states that an object in motion will stay in motion, is somewhat more difficult to grasp because, on Earth, forces are always at play. When we roll a ball, it eventually stops moving due to friction. However, if no forces were acting on the ball, it would roll indefinitely. Imagine an environment devoid of forces, or visualize an extremely slippery surface that never slows you down - consider, for example, a golf ball in space.

THE SECOND LAW

Newton's Second Law: Force = Mass * Acceleration

Important Definitions

Mass: the ability of an object to resist a change in motion or the amount of matter (stuff) in an object and is measured in kilograms (kg).

Acceleration: change in speed over time and is measured in meters per second squared ($\frac{m}{s^2}$)

Sheldon's Mass: 75 kg

Sheldon's Acceleration: 2 $\frac{m}{s^2}$

What is Sheldon's Force?

Wrong Answer: 150

Correct Answer: 150 Newtons (N) - remember to use proper units for force

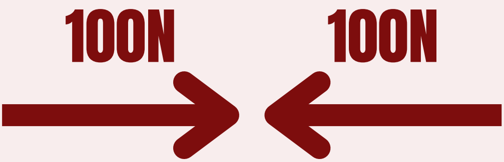
How can we make Sheldon more powerful or have a greater force? Well, we have two options. We can either increase his mass or we can train him to accelerate faster. Let's say we decide to do the second option. Now, Sheldon has a new acceleration of 3$\frac{m}{s^2}$

Since his acceleration has increased, Sheldon's force also increases by the same factor. After doing the calculations, his force comes out to be 225 N!

THE THIRD LAW

For every action force, there is an equal and opposite reaction force.

Newton's Third Law states that when two objects collide or touch, the forces exerted on each object are equal and opposite. For example, when you high-five your friend, both hands will experience the same force, but in opposite directions. One hand will experience a force, while the other hand will experience an equal and opposite force. If you experienced a force of 100N to the right, your friend would experience the same 100N force, but to the left.



Let's go back to the example of the pencil that you left on your desk. We concluded that the pencil did not move because there was not a net force on the pencil. But what about gravity? Doesn't that create a force on the pencil?

Indeed, gravity does exert a force on the pencil. However, what we haven't accounted for is the equal and opposite reaction between the pencil and the table. The weight of the pencil on the table is counteracted by a force from the table on the pencil, known as the normal force, which comes into play when two objects are in contact with one another. Normal forces act perpendicular (at 90 degrees) to the contact surface between the two objects. Since the normal force and the weight of the pencil are equal and opposite, they cancel each other out, resulting in a net force of 0. This means the pencil remains at rest.

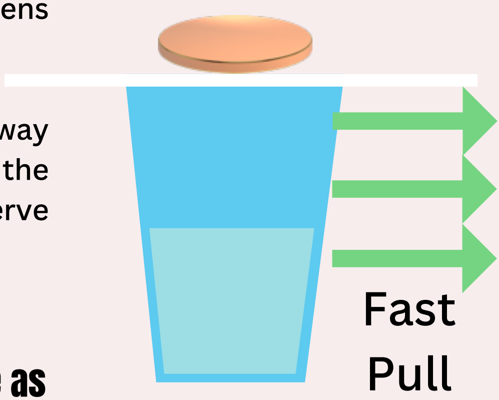
PENNY DROP LAB

Essential Question: How does varying the applied force/acceleration on a system change the outcome when friction is present in the experiment.

Procedure:

1. Set a cup on a flat surface
2. Put an index card over the cup
3. Put a penny on top of the index card
4. Slowly pull the index card away from the cup in a straight line and observe what happens to the penny
5. Flick the index card away from the cup (parallel to the top of the cup) and observe what happens to the penny
6. Repeat until you answer:

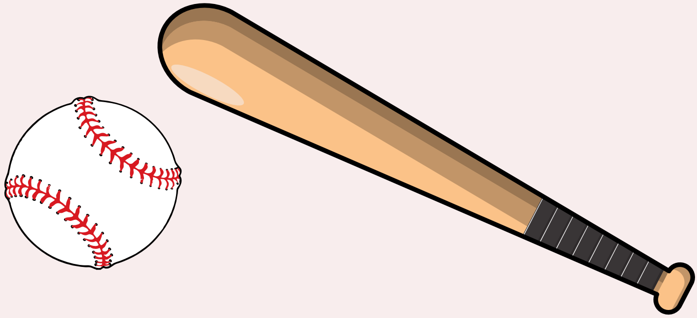
Why did the pennies move as they did in both situations?



Intended Outcome: In the first situation, the penny moved with the index card. In the second, the penny fell into the cup.

THOUGHT PROVOKING

In real life, objects that hit projectiles have recoil, backward propulsion that occurs in response to a hit. Consider a baseball bat that hits a baseball with a mass of 0.2 kilograms with an acceleration of 400 m/s^2.

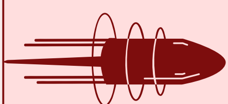


1. What law explains why the batter experiences recoil?
2. What is the force of baseball in Newton? (hint: consider units)
3. What modifications can be made to the bat, the ball, and/or the surrounding environment to ensure less recoil and therefore, make the bat more controllable for new players?

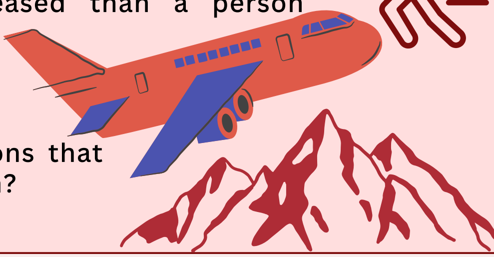
3.2 TYPES OF ENERGY

What are the different types of energy in our world?

Questions of the day



Why is it that a bullet being fired would result in more energy being released than a person running?



What is one of the reasons that an airplane can fly so high?

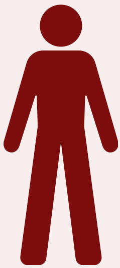
Key words

- Energy
- Potential
- Kinetic
- Acceleration
- Elastic
- Chemical
- Velocity
- Weight

Q	G	E	N	E	R	G	Y	Y	H	X	E	X	C	V
P	D	V	T	C	L	W	X	P	R	L	R	N	J	E
X	C	P	Z	D	C	V	W	O	O	P	V	I	D	L
J	Y	H	W	M	H	M	R	T	K	W	C	H	K	O
J	E	A	E	R	I	X	N	E	B	O	H	E	I	C
T	L	W	I	M	M	P	T	N	U	S	G	I	N	I
L	O	Q	G	D	I	C	I	T	S	A	L	E	E	T
K	C	F	H	Y	O	C	V	I	B	X	J	X	T	Y
L	W	L	T	E	Z	P	A	A	H	K	A	O	I	B
J	N	O	I	T	A	R	E	L	E	C	C	A	C	H

WHAT IS ENERGY?

Energy



Since Sheldon here has mass, he has energy

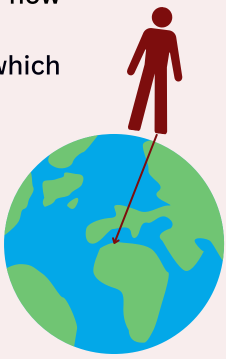
By definition, energy is the capacity to do work. It exists in various forms, such as kinetic energy, potential energy, and elastic energy. Energy is constantly transitioning from one form to another. Just as mass can be measured in kilograms and height in inches, energy can be measured in units called Joules (J) or Kilojoules (kJ). Energy cannot be created or destroyed, and every object with mass possesses energy.

Important Definitions

- Energy - the ability to do work
- Velocity - how fast an object is traveling in a given direction
- Gravity Constant - the downward acceleration of gravity on Earth (always 9.81)
- Spring Constant - a measure of how stiff a spring (e.g. rubber band) is
- Acceleration - the rate at which velocity changes

This rubber band has a spring constant of 0.81

Sheldon is running at a velocity of 23 m/s to the right



The acceleration of gravity pulling Sheldon down is 9.81 meters per second squared

KINETIC ENERGY

Kinetic energy can be defined as the energy an object possesses due to its motion, and it varies based on the object's mass. For example, a runner possesses kinetic energy because they are in motion. The runner's kinetic energy can change depending on their mass and the speed at which they are running.

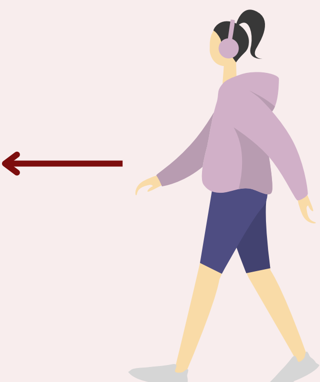
$$KE = \frac{1}{2} \times m \times v^2$$

Kinetic Energy

Mass

Velocity squared (this means velocity times velocity)

Example:



Martha is walking. As she has a definite body weight and some velocity (walking speed) she has kinetic energy. If her mass was 100 kilograms and her velocity was 25 meters per second left, calculate the kinetic energy of Martha using the equation for kinetic energy.

She hears someone calling behind her and quickly snaps around and starts to walk towards them. What is the change in kinetic energy if she starts walking backward at the same speed?

POTENTIAL ENERGY

Potential energy can be defined as the energy stored in an object based on its position and mass. It is often understood as the energy that can be converted into another form. For example, when a runner begins to run, their potential energy is converted into kinetic energy. Similarly, when you knock a book off a desk, its potential energy is converted into kinetic energy.

$$PE = m \times g \times h$$

Potential Energy

Mass

Gravity constant (9.81 m/s^2)

Object's height

Sheldon and Jenna are standing on a hill and, therefore, possess potential energy. However, because Sheldon is standing at a higher elevation than Jenna, he has more potential energy.

Example:

If Sheldon is standing 100 meters high off the ground, and Jenna is standing 50 meters above the ground, and both of them have a mass of 50 kilograms, what's the difference in potential energy between both of them?

ELASTIC ENERGY

Elastic energy, also known as spring potential energy, can be defined as the energy stored in an object when it is being stretched or compressed. For instance, a stretched rubber band possesses elastic energy. The amount of elastic energy depends on the spring constant, which measures the stiffness of the object, and the horizontal distance that the object travels when stretched.

$$U = \frac{1}{2} \times k \times x^2$$

Elastic Energy

Spring Constant

Horizontal distance traveled squared (this means the horizontal distance traveled times itself)

Example:

Bouncy balls and stretched rubber band possess elastic energy because it has moved a distance from its original position around one thumb. This is due to the inherent spring constant within rubber bands.

If the rubber band is stretched 0.85 meters and has a spring constant of 0.6, what is the elastic energy of the rubber band?

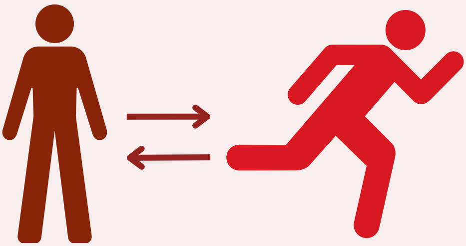
Challenge question: If a rubber band with a spring constant of 0.85 holds energy of 57 J when stretched, how far has it been stretched?

CHANGES IN ENERGY

While energy cannot be created or destroyed, it can be transformed into another type of energy. For instance, potential energy can be converted into kinetic energy and kinetic energy can be reverted back to potential energy. However, the pivotal question is, when does this transition occur?

Potential to Kinetic & Kinetic to Potential

When an object at rest starts moving, its potential energy is converted into kinetic energy. In the example below, Sheldon's potential energy is converted into kinetic energy once he starts running. Conversely, his kinetic energy is converted back into potential energy when he stops.



Elastic to Kinetic & Kinetic to Potential

When a spring (e.g. rubber band) is launched, its elastic energy is converted into kinetic energy, and its kinetic energy is converted into potential energy once it hits the ground.

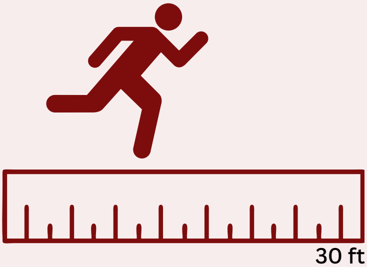
APPLICATION

Experiment#1: Elastic Energy

1. Take any rubber band
2. Extend it back a bit (2-3 cm)
3. Launch it
4. Record how far it lands
5. Repeat steps 1-3 except extend it as far back as you can this time

Experiment#2: Kinetic Energy

1. Stand on a scale (mass)
2. Walk exactly 30 ft and have someone time you
3. Repeat steps 1-2 while jogging
4. Repeat steps 1-2 while sprinting

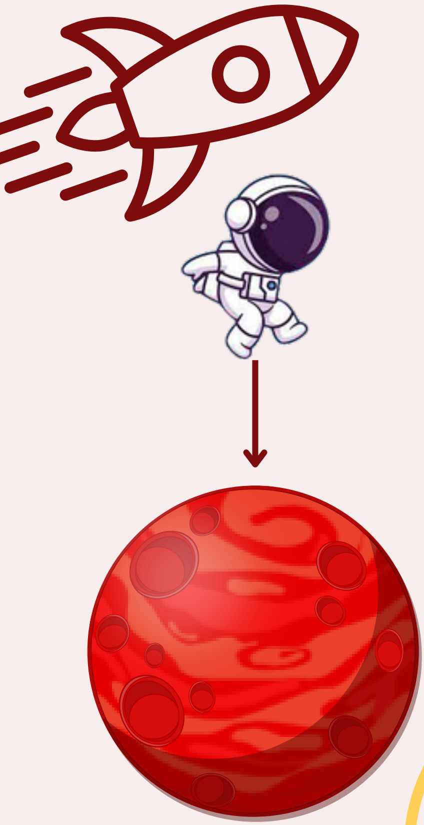


Questions?

1. Did the rubber band travel more distance when extended farther back or extended back only a little?
2. Why do you think this is? (You need to mention formula(s) in your answer).

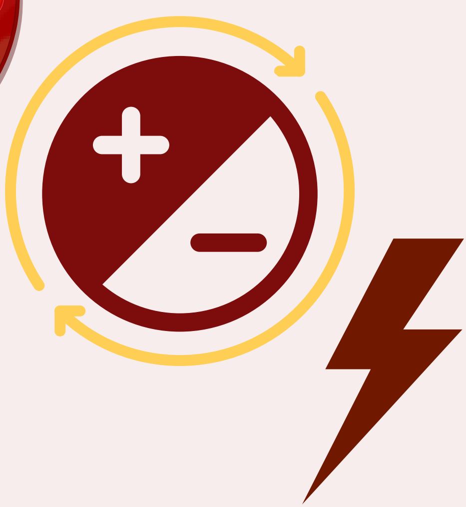
1. What was your kinetic energy each time?
2. How did your kinetic energy change when you walked, jogged, and sprinted?

THOUGHT PROVOKING



If Sheldon, who has a weight of 28.0 N, jumps off of a big spaceship, 10,000 meters high onto an undiscovered planet and falls at a constant speed of 28.0 m/s, what is his potential energy as he falls on a clifftop 1 minute later?

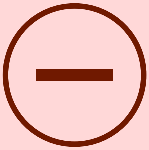
Is it possible for potential energy to be negative? If so, when? If not, why not?



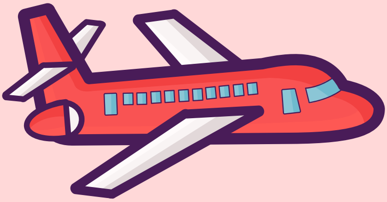
3.3 SYSTEMS AND REFERENCES

What is the importance of understanding the scope of motion?

Questions of the day



Is it possible to have a negative acceleration but still have a positive velocity? If so, how?



Why do you feel like you are not in motion when you are in a plane?

Key words

- Reference
- System
- View
- Position
- Orientation
- Open
- Closed
- External
- Relative

O	R	I	E	N	T	A	T	I	O	N	W	I	Q	N
V	P	R	E	F	E	R	E	N	C	E	U	N	S	A
R	V	W	E	E	V	C	O	E	D	W	C	U	Y	Z
G	R	E	L	A	T	I	V	E	K	E	B	C	S	I
K	W	S	M	M	T	Q	S	J	D	I	X	B	T	X
L	A	L	F	I	U	O	K	K	J	V	S	K	E	A
N	T	Q	S	U	L	I	I	M	B	Z	N	V	M	M
Z	K	O	A	C	J	S	Z	N	F	X	E	S	B	L
K	P	X	R	T	D	U	G	Y	J	D	P	J	C	V
E	X	T	E	R	N	A	L	E	Y	L	O	R	D	O

SYSTEMS

A system can be defined as a collection of objects. Let's consider the pencil box that you take to school. If I were to ask you what objects the pencil box system contains, you would list items like an eraser and a pencil. Now, what if I asked you to name objects within a school system? Well, things such as teachers, students, chairs, classrooms, and whiteboards are all part of a school, and therefore, belong to the school system. Now, what if I asked you about an Earth system? An Earth system would encompass absolutely everything that exists on Earth, including forces and atoms! Why do we make the effort to identify or refer to clusters of objects as systems? Well, recognizing a system simplifies the problem at hand. Understanding the type of system you are working with allows for easier comprehension of every variable within that system, including forces, energy, and the individual items themselves.

Earth System

Car System

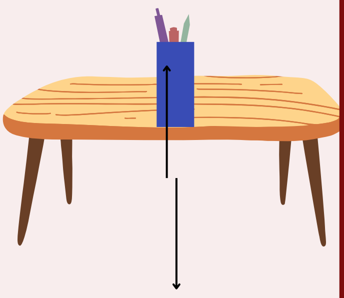
You have first-hand experiences with systems every day. For example, when you are in a car, you don't feel its movement. This is because you are a part of the car's system and the car is traveling the same speed as you are.

SYSTEMS

Look at the unknown system on the right. The objects belonging to the system are a pencil box and a desk. For an easier understanding, I will refer to the system as a box-desk system. Now I need you to refer to prior knowledge. What forces are present in the system? The two obvious ones would be a gravity force and a normal force exerted on the box by the table. While there is probably a frictional force present, let's disregard that for now. Notice that none of the objects within the system are moving. This means that none of the objects are accelerating and so according to Newton's second law (F=ma), there is a net force of 0 within the system as there is no acceleration or movement.

Parts of the System

Whole System



SELF-REFLECTION ACTIVITY

Think of a game you have played recently. Name the system. Think about what kind of characters or avatars are available. What is the game's currency?

Example Answer: The game I am thinking of is called Fortnite Battle Royale and I will name the system the "Tilted Tower system", named after one of the locations in the game. The system contains many skyscrapers and the location is known for having a building that gets destroyed by a meteor every few months. This location has a lot of moving characters trying to beat each other and get the win.

TYPES OF SYSTEMS

CLOSED SYSTEMS

Closed systems are systems in which matter is contained and not allowed to exit the system. The universe serves as an example of a closed system because matter cannot leave or enter it. In physics, a closed system can also be defined as a system where external forces are not considered to act on an object, although energy exchange with the surroundings is permitted.

Similar to the prisoner or a cup of coffee in a cup, the matter is jailed within a closed system and cannot escape.

OPEN SYSTEMS

Open systems, as the name suggests, allow the transfer of various elements through them. Your pencil box serves as an example of an open system because it is frequently opened and objects are placed into or taken out from it. In physics, an open system can also be defined as a system where external forces are present. As these external forces are exerted, they can cause the system to lose energy.

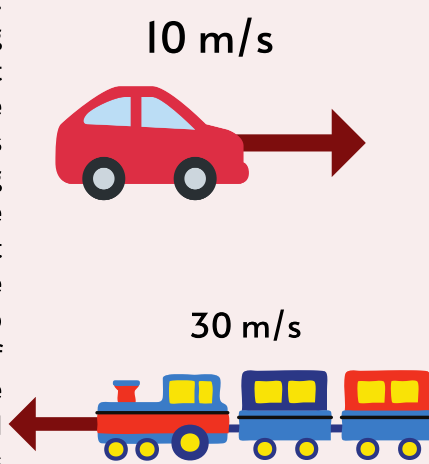
The stovetop is an example of an open system because matter escapes into the atmosphere in the form of carbon monoxide.

References

Reference is a strange concept to grasp. Whether or not you know what the term means, you probably already have a loose idea of it. References establish some sort of relationship between objects. For example, setting my classmates as a reference, I sit 5 feet away from them in school. Easy right? In physics, however, relativity becomes more than a 2-dimensional concept. In physics, references describe the motion, orientation, or position of an object in regard to other(s).

Train vs Car Reference

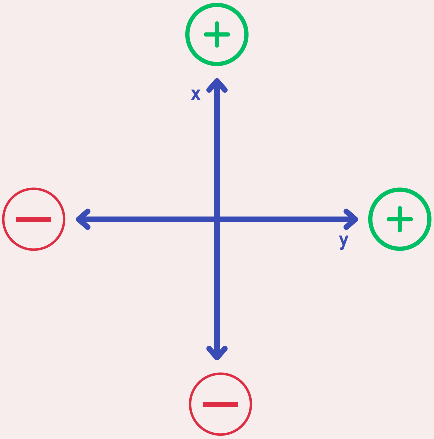
Let's examine the visual on the right. A car and a train are moving alongside each other but in different directions. First, let's consider the car's motion as our reference. In this reference frame, the train is moving at 40 m/s, but in the opposite direction. If the car were not moving, it would appear that the train is moving at 30 m/s relative to our assumed reference. However, if the car were moving at 10 m/s in the same direction as the train, it would appear to the car that the train is moving at 20 m/s, as that is the difference in their speeds.



REFERENCES (CONT.)

Directional References

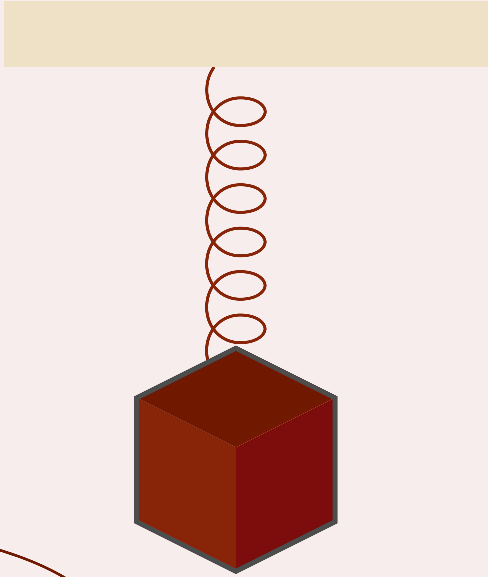
The first step to solving any physics problem is choosing a reference, which is how you look at something. In other words, this means identifying 1. the direction an object is traveling and 2. whether that direction will be a positive or negative direction. Consider gravity for example: some people say that gravity is a negative value because it goes downwards while others maintain that it is a positive value. This is because they use the opposite reference that uses the "up" direction as the positive direction. Sometimes calculations with an opposite reference tend to be easier as positive numbers are more calculation friendly.

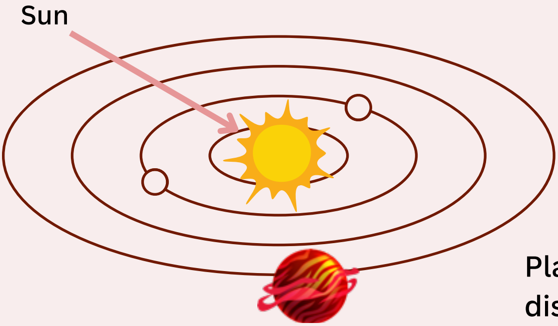


The coordinate axis on the left is known as the "standard reference." In the standard reference, the positive direction is considered to be up and right, while the negative direction is down and left. Following this reference, gravity is regarded as a negative value in calculations because it always acts downward.

APPLICATION

A spring with a mass attached to it is hanging off a ceiling. It begins moving up and down after someone pulled down on the mass and lets the spring go. Is the system now open or closed? Was it ever open or closed?

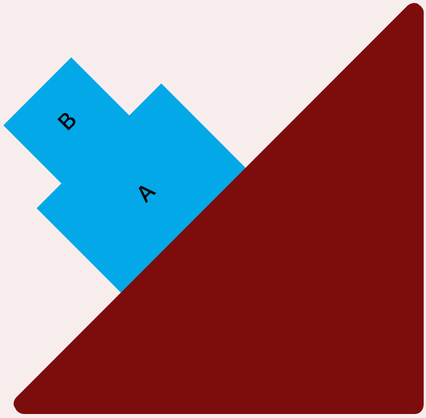




Planet A, a newly-discovered planet, is found to be the farthest planet from the Sun. Is Planet A considered an open system or a closed system? Why?

THOUGHT PROVOKING

A car is moving at 50 m/s in a straight line around the circumference of the Earth. Describe what reference is used to arrive at this number and label it on the system drawn below.

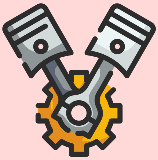


Label all the forces and their directions of the system consisting of Object A and Object B.

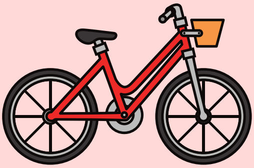
3.4 MACHINES

What are machines and what are the mechanics behind them?

Questions of the day




How is an automobile able to move with just a press on the accelerator and turn using a steering wheel? (how do the engine and parts of an automobile work together)




Why do you get tired more quickly running than biking even though your legs are propelling you in both scenarios?

KEY WORDS

- Lever
- Machine
- Momentum
- Rotation
- Torque
- Propel
- Steering
- Engine
- Wedge

W	P	E	Q	N	Z	T	E	G	K	P	V	N	P	A
T	Y	N	S	O	B	X	W	M	P	S	J	J	U	U
L	G	O	T	I	L	K	M	P	F	E	G	D	E	W
E	Y	U	E	T	E	B	I	D	X	M	X	Z	D	E
P	H	C	E	A	V	T	K	T	J	N	Q	T	N	I
O	X	W	R	T	E	O	M	M	A	C	H	I	N	E
R	N	Z	I	O	R	R	U	G	Z	Z	G	D	D	V
P	C	I	N	R	J	Q	S	O	X	N	C	A	X	L
F	E	F	G	Q	A	U	R	P	E	Y	H	A	Z	G
U	Z	F	F	A	O	E	M	U	T	N	E	M	O	M

WHAT ARE MACHINES?

By definition, machines are physical systems or devices that use power to apply force and control movement to an object. There are two main categories of machines, automated and human-controlled.

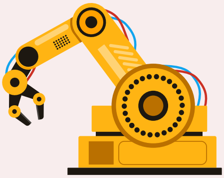
Human Controlled Machines

Human-controlled machines require human interactions and labor in order to work. This is seen in machines such as the lever, a steering wheel, or machines that manufacture parts.

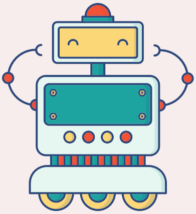
A wheelbarrow is an example of a human-powered machine as it requires physical force and labor to operate and move.

A mop is another example of a human-powered machine as in order for it to clean a surface you need to apply force to it.

Automated Machines



There are also automated machines that do not require human interaction and are completely independent. These machines typically utilize sensors and computer software, including machine learning algorithms, which make them more accurate and precise compared to human-operated machines. In the real world, this technology is commonly found in engines and motors that power various vehicles and objects, such as automobiles and lawnmowers.

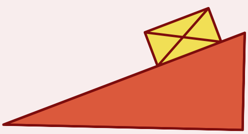


TYPES OF MACHINES

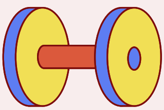
What is a Simple Machine?

Simple machines are mechanical devices that help apply a force to modify motion and perform work

The Big Six of Simple Machines:

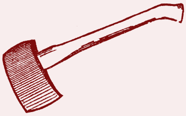


Inclined plane

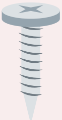


Wheel and axle

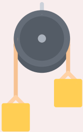
Lever



Wedge



Screw



Pulley

Why Use Machines?

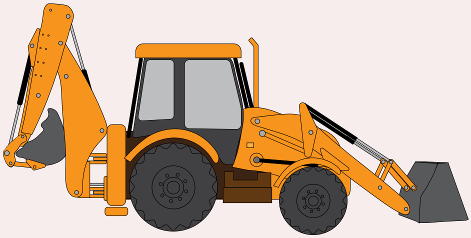
Efficiency! The utilization of machines greatly simplifies and expedites tasks, often enhancing precision as well. For instance, machines enable swift transportation from one place to another, thanks to motors, engines, and bicycles. Machines can be found everywhere we look, from fans to cellphones, serving various purposes. In manufacturing, machines streamline the production of parts, allowing for precise and large-scale manufacturing, surpassing the limitations of handmade goods. The possibilities and applications of machines are endless, but the overarching concept is their immense benefit in facilitating everyday tasks and occupations.

HOW DO MACHINES WORK?

Although machines may seem complex, they are often just a bunch of simple machines working together. Each and every complex machine is made up of two or more simple machines.

Screwdriver

Shovel



Backhoe

For example, a screwdriver is just a wheel and axle and a wedge working together. A backhoe is just a lever and wedge acting together which allows the complex machine to dig and lift up dirt. The same is seen with a manual handheld shovel, where a lever and wedge work together to make it easy to dig out and lift dirt. Although they seem very complex, machines are essentially just a bunch of parts working together to make a task easier. There is some physics behind this, but that is also relatively easy to understand.

THE PHYSICS BEHIND MACHINES

Momentum and Torque

Momentum is the amount of strength or force an object gets as it moves. Torque is the measure of the force that can cause an object to rotate about an axis.

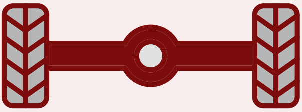
$$P = MV$$

Momentum Mass Velocity

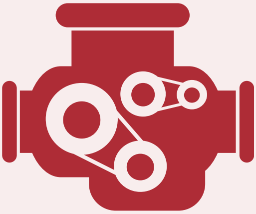
$$T = FR$$

Torque Force Radius

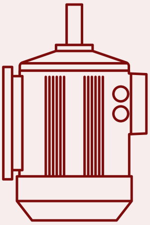
According to momentum, a rotating object will stay rotating at a certain angular velocity (the measurement for the spin of an object) unless acted upon. This is seen especially in machines, in specific car engines. The engines in cars rotate about an axis, which creates torque, which is the strength of a vehicle. This torque is what allows a car to accelerate from 0 to 60 miles per hour in a certain amount of seconds (the more torque generated, the shorter this acceleration period will be). This is true in any spinning objects, such as motors and wheels.



Wheel and Axis



Car Engine

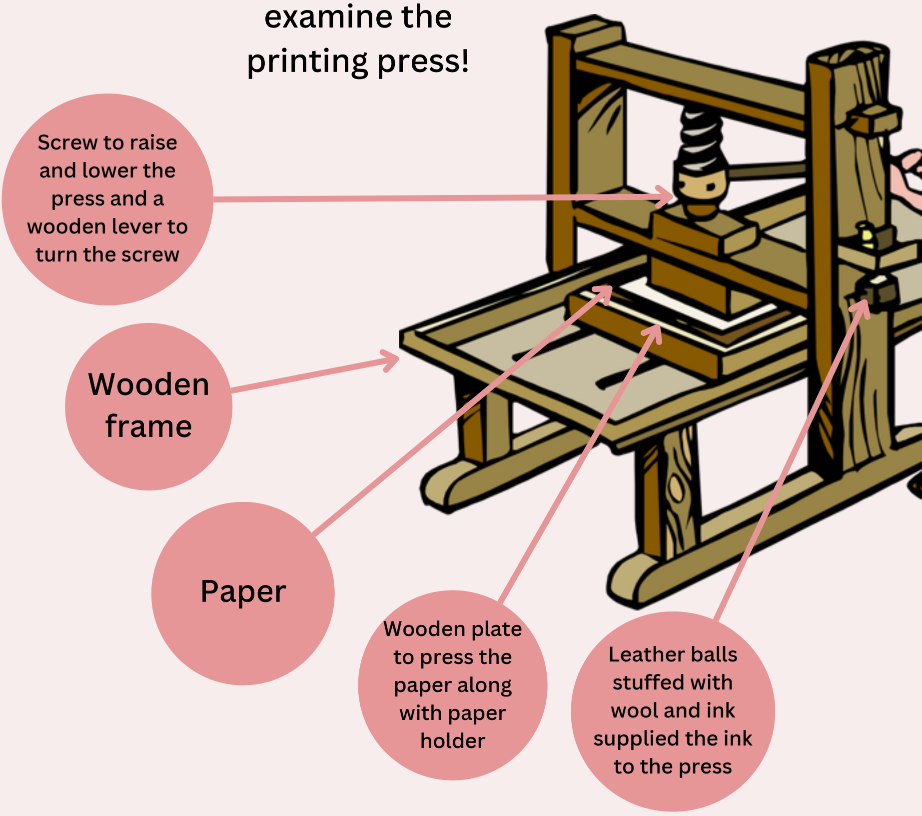


Motor

CONSTRUCTING A MACHINE

Constructing a machine is not exceedingly difficult. It primarily necessitates applying the physics principles mentioned earlier and assembling a variety of components, including gears, screws, and building materials. Once you possess a blueprint outlining what you intend to construct, a plan for its operation, and the necessary parts for its construction, building the machine itself becomes relatively straightforward.

For example, let's examine the printing press!

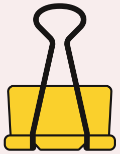


APPLICATION

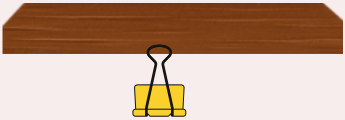
Make a homemade scale!

Materials: 2 paper cups, a small flat piece of wood, and a binder clip

1. Place the surface of the binder clip on the ground so that the sides pointing inward are facing up



2. Place the middle of the piece of wood on the binder clip (faced perpendicular to the board, balancing it



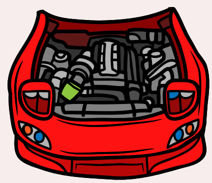
3. Place each cup on the opposite sides of the wood and fill the cups up with objects to test the scale

4. When done, it should look similar to this!

THOUGHT PROVOKING

Which one is a more efficient machine and why?

VS



A bicycle or a gas fueled car's engine?

Why are solar panels so efficient and preferable over burning fossil fuels for harnessing energy?

Why are you able to bounce back up on a trampoline?

3.5 CARS ON A ROLL GRAVITY

How do forces change a car's motion?

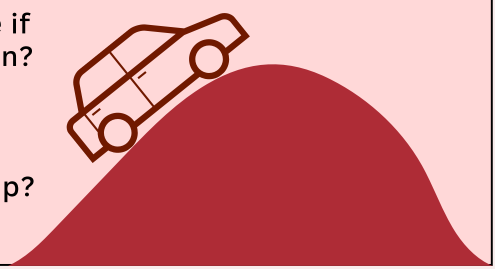
Questions of the day

How are forces on a car impacted by terrain and the car's properties?

What happens on a car ride if you increase the suspension?

How does a car move?

When does a car start to slip?



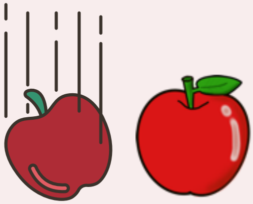
KEY WORDS

- Roll-force
- Tires
- Center-of-gravity
- Stability
- Suspension
- Impact
- Air-pressure
- Roll-over
- Traction

W	T	L	C	E	N	T	E	R	H	O	A	Y	I	G
U	I	C	S	U	A	A	I	C	R	M	A	T	J	U
T	B	Y	A	V	P	K	T	R	A	C	T	I	O	N
K	X	Y	R	P	R	M	G	W	E	D	L	V	L	A
K	X	F	T	S	M	Z	P	N	Y	S	L	A	I	K
S	T	A	B	I	L	I	T	Y	C	W	O	R	F	G
E	D	L	Z	L	L	O	R	Y	Y	C	R	G	B	S
O	V	E	R	D	F	Z	V	X	E	C	R	O	F	B
M	M	N	O	I	S	N	E	P	S	U	S	O	I	R
R	E	R	U	S	S	E	R	P	E	I	I	Q	O	H

HOW CAN A CAR CHANGE ITS FORCE?

Gravity



The apple on the left has a force while the apple on the right has no force.

Recap on Velocity, Acceleration, and Forces

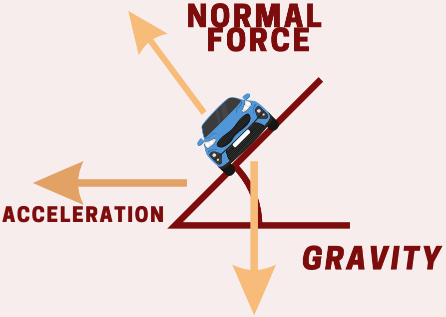
When an object is moving, it is called speed, and when you add a direction to the speed, you call it velocity. An object that is speeding up or slowing down has an acceleration and also has a direction and a number to it. If we have both the acceleration and the mass of the object, we can solve for the force that is being exerted on the object and the direction, by multiplying the acceleration and time.

The Car is changing its Force because of turning

How Can a Car Change its Force?

A car can change its force in several ways. It can slow down due to factors such as friction, the person driving pushing the brakes or going up an incline.

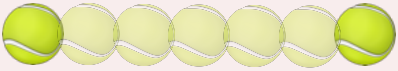
It can also speed up due to someone pressing the gas pedal or a car hitting it from behind. Because force, acceleration, and velocity all have a direction given to them, they will change when the car is speeding up or slowing down as well.

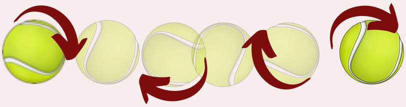


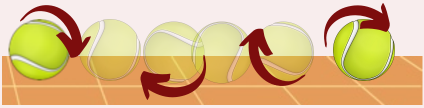
WHAT IS ROLL FORCE?

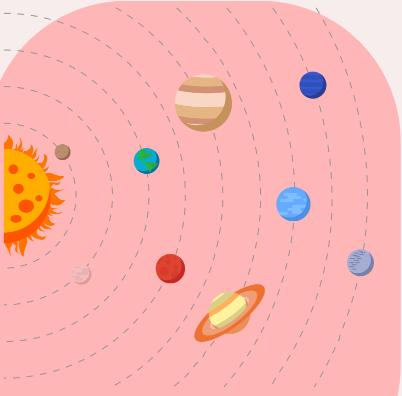
Types of Motion

Cars can exhibit two types of motion: translational motion and rolling motion. Translational motion occurs when all points of an object move in the same direction. For instance, a rocket launched straight up demonstrates translational movement. On the other hand, rolling motion, also known as roll force, occurs when a moving object, such as a wheel, experiences the effects of normal force, friction, and gravity. However, if the object is not on a surface, it is not subjected to roll force, even if it is rotating.


The tennis ball has translational motion


A rotating tennis ball with translational motion but no roll force


A rolling tennis ball with translational motion and roll force

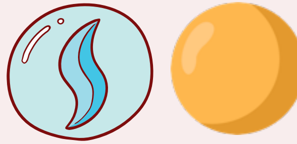

Inertia Is also the reason why planets are rotating the sun

What is Inertia

Inertia is another factor that influences roll force. It is calculated by multiplying the mass of an object by the square of its radius from the center, and then multiplying it by a constant factor based on the object's shape and weight distribution. If an object has greater inertia, it will exhibit higher resistance to rotational motion. In other words, the lower the inertia, the less force is required to initiate movement in the object.

EXPERIMENT

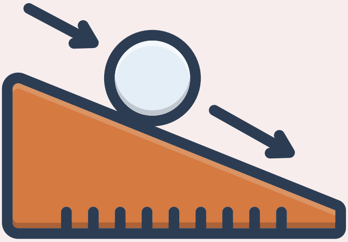
Materials:



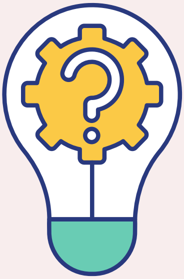
- Small Sphere (marble, ping-pong ball, etc.)

- 2 Surfaces (1 really smooth [ice, glass, etc.] and one normal surface [cardboard, wood, etc.])

Procedure:

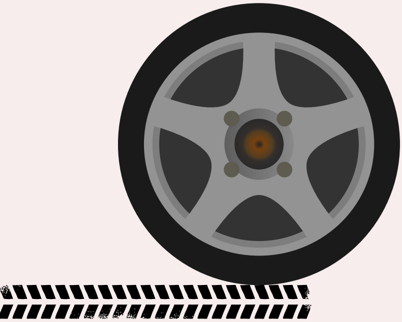


1. Create a ramp with the material and place the sphere at the top.
2. Observe how the sphere moves down the ramp.
3. Change the starting height of the sphere or increase the height of the ramp and observe the changes in the sphere.
4. Change the surface and observe how the sphere behaves differently.
5. Try to come up with an explanation or theory based on your observations.



HOW CAN WE CHANGE ROLL FORCE?

Roll force can be influenced by various factors, particularly in the context of a tire. The shape of the wheel, weight distribution, and the type of road surface can significantly impact roll force. Alterations in these factors can lead to substantial changes in the driver's control over the car and the overall experience of the passengers.



For instance, if a tire has lower air pressure, it will experience reduced roll force. This is also one of the contributing factors to hydroplaning, which occurs when a car's tires lose grip on the road and begin to skid. It is for this reason that when embarking on a trip in cold weather, it is advised to inflate your car's tires with higher air pressure.

Another factor that can significantly affect the amount of roll force in a tire is the number of spokes it has. The spokes in a tire contribute to its rigidity, preventing deformation when the car is in motion. If a tire has fewer spokes, resulting in decreased stiffness, it will require more energy to keep the tire rolling.

Tire Spoke

HOW CAN WE CHANGE ROLL FORCE?

When an object rolls down a ramp, converting potential energy to kinetic energy, it experiences a loss in translational motion. However, due to some of the energy being converted to rotational motion, the rolling object will move slower than an object with more kinetic energy, even if both objects possess the same total energy. In other words, if we allow a rolling object and a non-rolling object to slide down a ramp, the non-rolling object will reach the bottom first.

Rotational Inertia

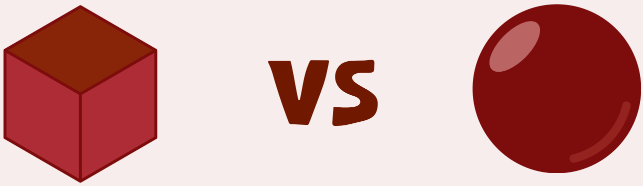
Inertia is a very large topic and it is very hard to describe it in a few pages. However, I will sum up the main concepts you need to know about how inertia affects roll force. Inertia's equation mass times radius squared if we change one of those factors we can get a different roll force value. This means higher mass or radius of an object means more roll force.

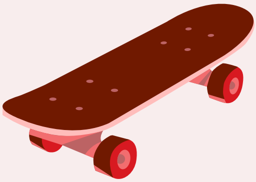
Quick Recap

- Roll Force is caused by friction, gravity, and normal force
- Roll Force can be changed in many ways from tire pressure, an object's resistance to deformation, to the type of surface the object is being used on
- A greater role force requires more energy for the object to keep moving

THOUGHT PROVOKING

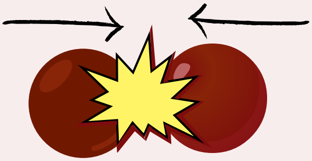
What would reach the bottom of the ramp first? (same mass and ramp)





What are some examples of common objects that rely on roll force to work properly?

Imagine 2 rolling balls. What would happen to their rolling speed and how fast they are moving if they hit each other?



Does speed stay constant when a car is taking a turn or driving alongside a curve?

3.6 ROLLER COASTERS

What do builders have to consider to garuntee a rider's safety?

Questions of the day

Where do you feel the most force on a roller coaster?

Why does your roller coaster not stop in the middle?

Why do roller coasters not fall off the track when they go upside down?

KEY WORDS

- HELIX
- BANKED
- TURN
- HEADCHOPPER
- HILL
- WAVE
- WHIPLASH
- LOOP
- CREST

W	D	F	J	Z	W	L	V	V	V	G	A	J	O	I
G	H	E	A	D	C	H	O	P	P	E	R	H	O	X
Y	Z	F	K	R	E	X	I	L	E	H	I	Y	L	L
B	H	R	E	N	V	S	S	P	U	L	J	F	O	Y
Y	N	S	L	B	A	M	Y	B	L	G	C	A	O	P
L	T	R	Z	W	W	B	W	Z	R	A	E	M	P	B
I	H	A	H	F	Y	U	X	Y	H	C	S	P	P	X
P	G	A	B	M	A	O	L	I	F	T	M	H	C	E
V	U	M	Z	G	S	R	C	I	B	V	E	I	O	C
F	Q	D	A	I	D	O	V	E	T	U	R	N	X	H

ROLLER COASTERS IN MOTION

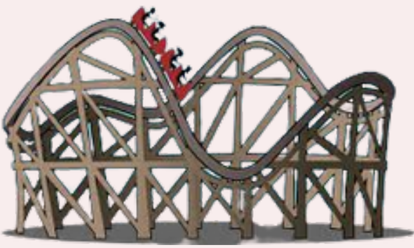
Roller coasters are driven by one of the most important forces existing; gravity. As noticed, roller coasters begin at one of the lowest points on a ride. The only reason a roller coaster is able to defy gravity and travel upwards is because of the tension given by the chains and motor. However, after the chains take the riders to the peak, all the upcoming hills must be shorter than this one.

This is because roller coasters have no added energy to their system, preventing them from going higher than they started. As the cart is pulled up to Peak A, the potential energy of the system increases. As it travels through the track, the roller coaster experiences friction, taking its potential energy and turning it into kinetic and thermal energy (friction). This loss of energy prevents roller coasters from going higher than they began. As shown, Peak B and Peak C are all lower in height than Peak A in order to keep the cart in motion. These fundamentals are the principles that must be kept in mind when building a roller coaster.

ROLLER COASTERS IN MOTION

Why does the amount of energy in a system matter?

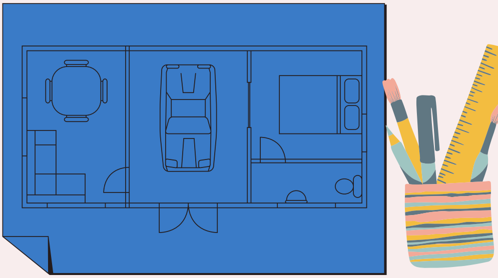
The amount of energy within a system determines the distance a roller coaster can travel. Potential energy, resulting from gravity, increases with height, and a greater amount of energy allows for more transfer to kinetic energy. Energy cannot be created or destroyed; it can only be transferred. When there is less energy in a system, it has limited potential for action, resulting in fewer peaks and loops on the roller coaster.



The longer the track, the more energy needed to finish the ride.

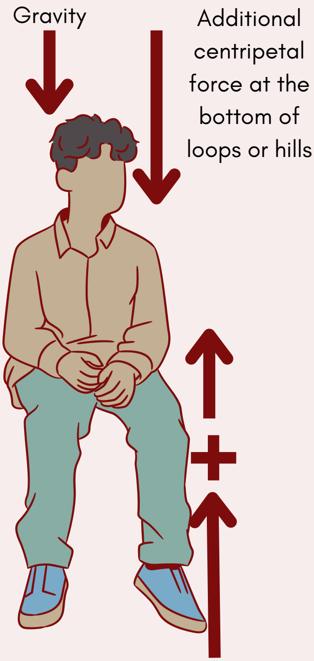
How are Roller Coasters built?

The task of building a roller coaster requires some of the most knowledgeable architects in the field. This is because while a builder wants to entertain their customers, they must always consider user safety. In order to do this, they must understand the topic of physics. This includes various factors such as friction, normal force, centripetal force, air resistance, gravity, and many other things. To start off with, an engineer must understand how high each bump of a roller coaster can be. This is because after a car is taken to the top, the roller coaster must not stall. The next bumps cannot be the same height, or higher, than the original starting point. This is because of friction, which takes away kinetic energy from the system, decreasing how far the roller coaster can travel.



HOW ARE ROLLER COASTERS BUILT?

All forces must be equal or else a person would either sink through their seat or fly up into the air.



Normal force from the seat of the roller coaster is equal to both gravity's and centripetal's force

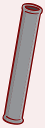
The only exception to this is when extra energy is added to the cars. This happens when there are additional chains bringing the cars up or if there are rollers boosting the cars at a further speed. The next component to be taken into account is the G-force applied to the rider. G-force is how many times the acceleration of gravity a person feels. Earth currently accelerates everyone at 9.81 m/s, so 2G's would be 19.62 m/s. 3G's would be 3 times gravity and so on. A normal human can only withstand 9 G's, meaning a person who weighs 80 kgs would now weigh 720 kgs. This is, however, the limit to someone's body, and generally a rollercoaster will limit their G-force to 5G's. This is made so even the younger or more frail population will be able to ride along. The final major aspect an architect must bear in mind is if a roller coaster can go through a loop. This means defying gravity and therefore require careful calculations to ensure the roller coaster doesn't stall and roll backward. An interesting fact to understand however is that mass does not need to be taken into account when building a roller coaster.

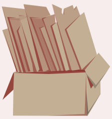
BUILDING A MODEL ROLLER COASTER

Building a roller coaster may seem complex at first, but the logic behind it is simple. The main rule to follow is that the highest point of a roller coaster is the starting point.

Materials:

- Cardboard
- Some sort of piping (construction paper rolls work)
- Tape or glue





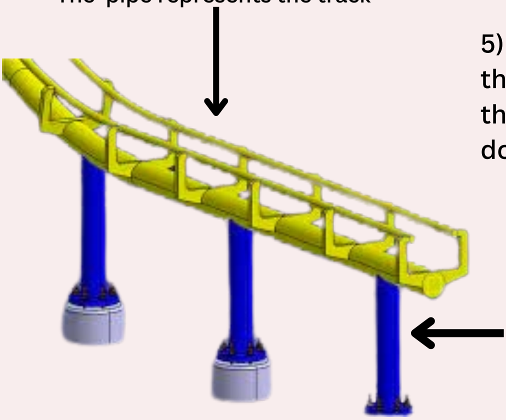
1) Begin the roller coaster by building a structure to hold the beginning.

2) Lay the pipe going down the structure(after gluing together enough materials to make a long enough ramp)

3) add a curved portion at the bottom

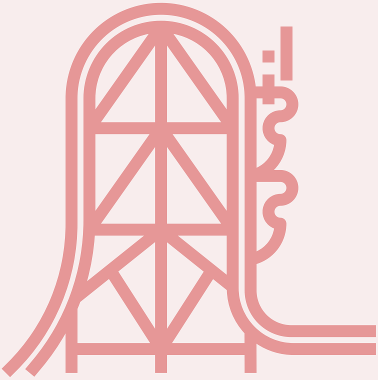
4) Add another support for the other hill. Experiment with this height to see how high it can go.

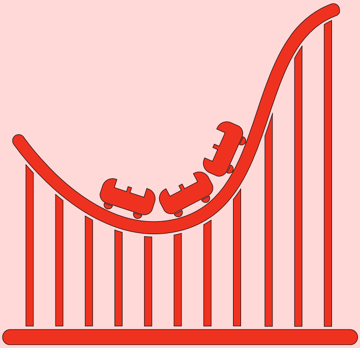
5) Lay tracks going up onto the next support, and add the remaining part leading downwards at the end.



ELEMENTS OF OUR ROLLER COASTER

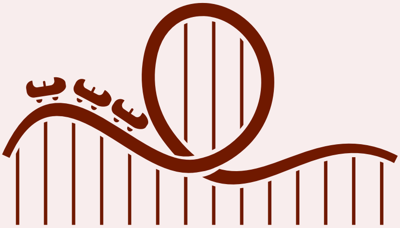
One important science to roller coasters is the force acting on each person. At the top of each peak, or while riding down, there's a moment of weightlessness that riders experience. This is because the roller coaster is moving at the same speed and same direction as gravity. You may even be lifted out of your seat if it wasn't for the restraints.





Riders may also experience additional forces acting on them, particularly at the bottom of each dip on the roller coaster. This occurs because, at the bottom, the roller coaster is attempting to accelerate upwards, counteracting the force of gravity. When the force experienced is twice as strong as gravity, it is referred to as 2G, with "G" representing the force of gravity.

The last type of force experienced by riders is centripetal force. This occurs when a rider goes inside a loop. This force is when the rider's acceleration is towards the center of a loop, and the most force on a roller coaster is felt during this loop. This is because gravity, acceleration, and normal force all act on a rider at the same time.



APPLYING ROLLER COASTER KNOWLEDGE

Rider's situation

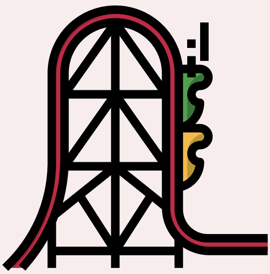
A rider gets on the roller coaster but is scared that the ride will stall in the middle and that they wouldn't be able to go over the first hill. Use your knowledge to assure the rider that the ride won't stop and explain why.

Determine if the following rollercoasters will work as planned.

Explain how you would feel at the top of a rollercoaster compared to the bottom.

THOUGHT PROVOKING

Which roller coaster would reach the end first?



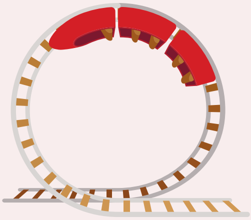
VS

Travels 50 meters upwards at a constant rate of 3 m/s, and accelerates downwards for 50 meters by gravity's acceleration.

Travels up the initial hill at 4 m/s for 37 meters, and keeps an average speed of 20 m/s for 250 meters

If a roller coaster has loops and bunny hills, can it still have the same velocity throughout the whole roller coaster? Can it have the same speed?

How can an engineer make a roller coaster so that the cars don't need to be attached to the tracks and still won't derail through a loop?



THANK YOU

We would like to express our heartfelt gratitude to all those who have made the creation of this book, "Science and Beyond," possible. Through the collaborative efforts of STEM Made Fun and the dedicated individuals who contributed their time, expertise, and passion, we have aimed to make science accessible, engaging, and enjoyable for young minds everywhere.

To our Team of Volunteers: A special thank you to the incredible team of volunteers who generously shared their knowledge and enthusiasm to help bring this book to life. Your commitment to inspiring the next generation of STEM enthusiasts is truly commendable. Without your hard work and dedication, this project would not have been possible.

To the Contributing Authors and Experts: We extend our deepest appreciation to the contributing authors and experts who generously shared their expertise and insights within the pages of this book. Your contributions have provided invaluable knowledge and have helped foster a love for science among our young readers. Your passion for your respective fields shines through and inspires curiosity and wonder.

THANK YOU

To the Parents, Educators, and Supporters: We would like to express our gratitude to the parents, educators, and supporters who have championed our cause and believed in the power of STEM education. Your unwavering support and encouragement have been instrumental in our mission to make STEM education fun and accessible for all. Thank you for embracing the importance of science and for nurturing the curiosity and potential of our future scientists, engineers, and innovators.

To the Readers: Lastly, we extend a heartfelt thank you to the young readers who have embarked on this exciting scientific journey with us. Your curiosity, enthusiasm, and eagerness to explore the wonders of the world are the driving force behind STEM Made Fun. We hope this book inspires you to embrace science, dream big, and reach for the stars. Remember, the possibilities are limitless when you combine curiosity with knowledge!

Thank you all for being a part of STEM Made Fun's mission to ignite a passion for science and beyond. Together, we are shaping a brighter future where the wonders of STEM are accessible to all.

With heartfelt appreciation,

Krishiv & Aashrith Founder, STEM Made Fun