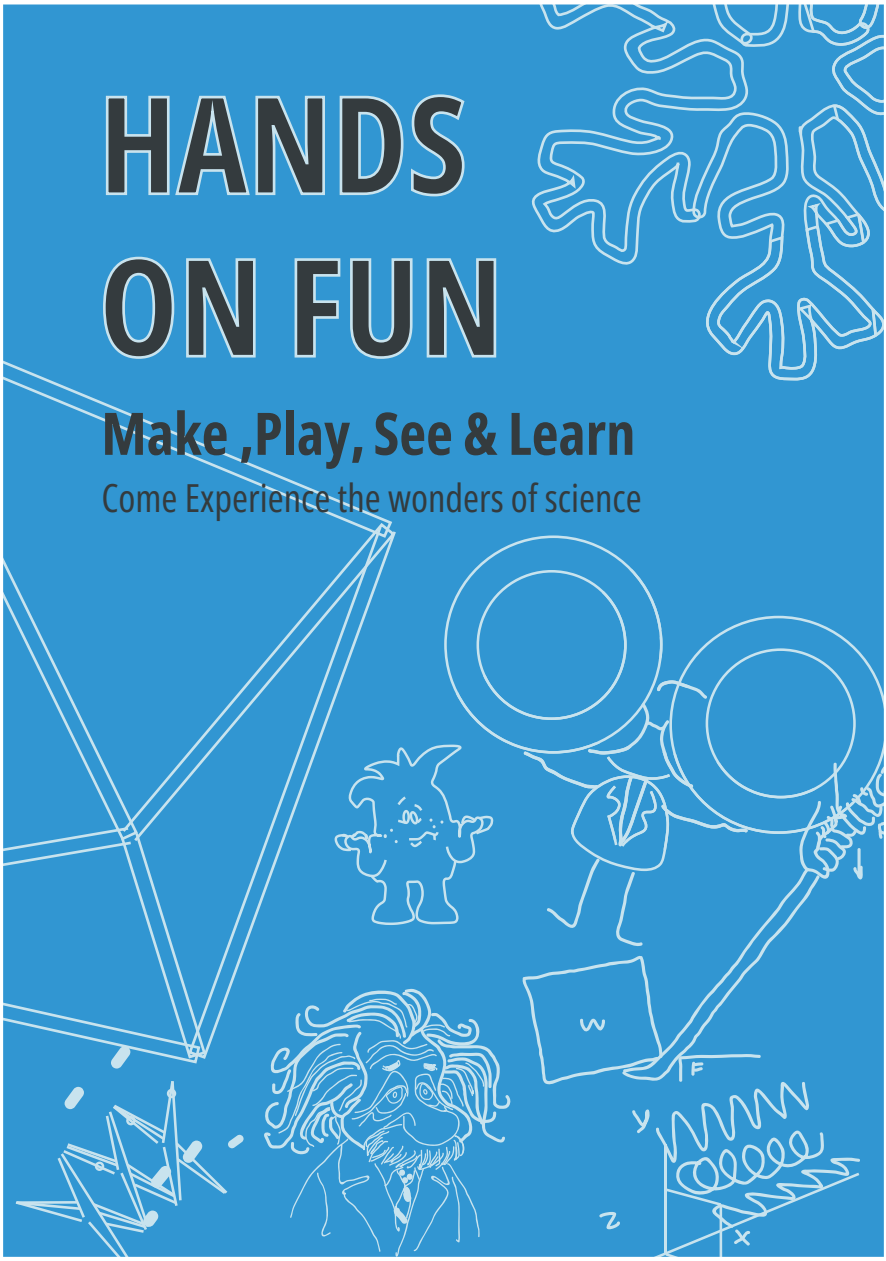
HANDS ON FUN

Make ,Play, See & Learn

Come Experience the wonders of science



Center for Creative Learning
IIT Gandhinagar

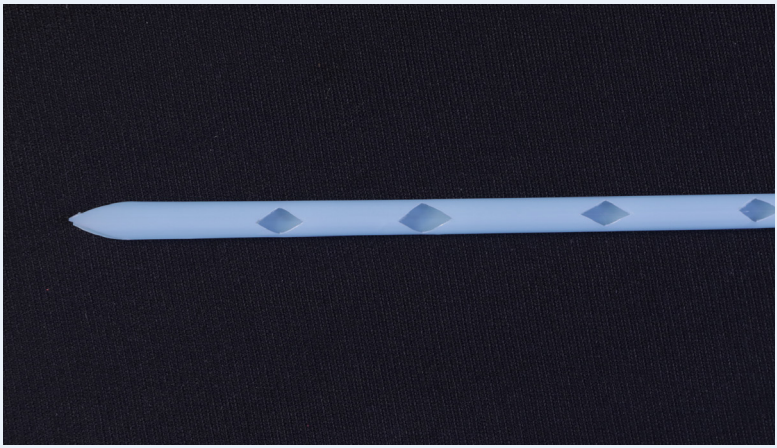
STRAW FLUTE

LEARNINGS

- Sound Waves
- Bernoulli's Principle
- Frequency
- Wavelength
- Vibration
- Pressure

MATERIALS REQUIRED

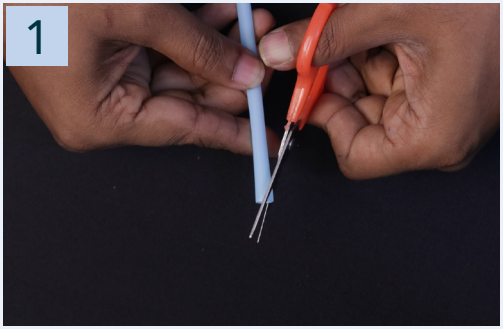
- Straw
- Scissors



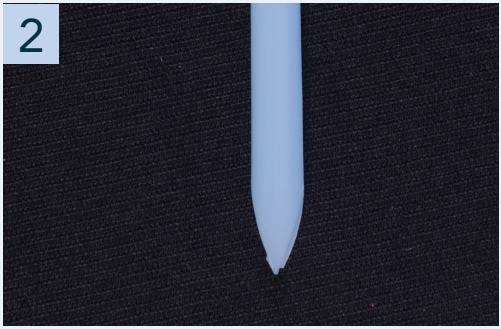
What do we do with plastic straws we get in the market? We generally throw them in the dustbin, don't we? But you can make a flute from the straw using no other material except scissors. Bring out the musician in you. Learn the science of sound waves with your own straw flute.

WHAT TO DO?

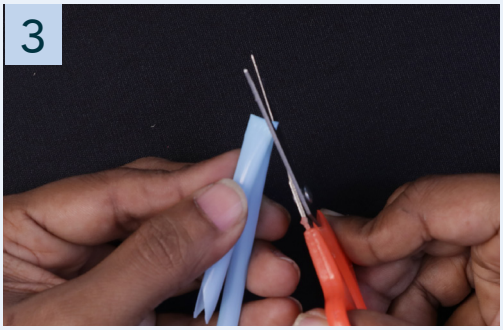
1. Make a V shape at the end of the straw by making two slant cuts. Flatten it slightly with your hand and a whistle is ready.
2. Blow into the straw from the V-end and it would produce a sound like a whistle. You can also put the other end of the straw inside your mouth and suck air instead of blowing.
3. Change the length of the straw by cutting it from the other end. You would see that the sound coming from the straw would change.
4. Make three holes on the length of the straw and your flute is ready. Place your fingers on different holes to produce different sounds.



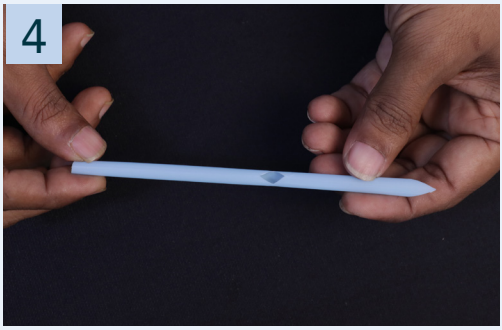
Make two slant cuts to make a V shape at the end of the straw.



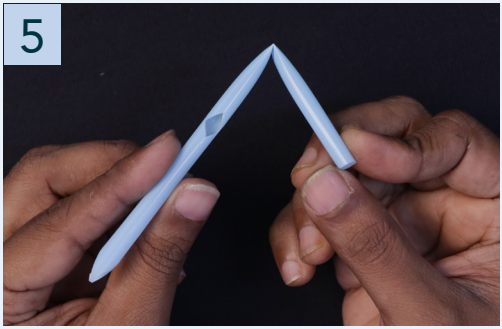
The straw should look like this after the cuts.



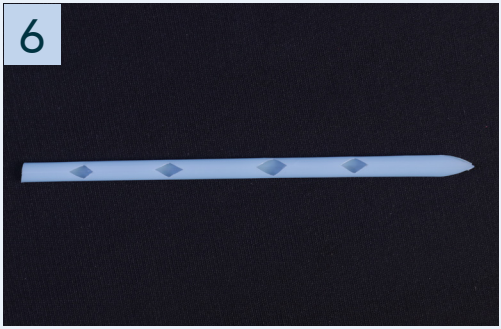
Make a hole on the length of the straw by bending and cutting it.



You should see a diamond shaped hole in the straw.



Make two more holes in the straw in the same manner.



Your straw flute is ready.

NOTES

WHAT'S GOING ON?

1. When you blow into the V end of the straw, the two flaps of the tip vibrate together. You can also see the vibrations if you suck air from the other end (instead of blowing in the V end).
2. Now the next question is: why does blowing into the straw produce vibrations?
3. When you blow into the straw, the speed of air inside the straw increases. As a result, the pressure inside the straw decreases.
4. This is called the Bernoulli's principle which states that whenever a fluid has a high speed, the pressure becomes low. As a result, the straw gets closed.
5. Once the straw is closed, the air stops going inside the straw and thus the pressure becomes normal, and the straw opens.
6. This process repeats again and again resulting in the vibration of the V end of the straw.
7. The vibrations move through air molecules and hit your eardrum. It is this vibration that you hear as a sound!
8. Changing the length of the straw (by clipping it off) changes the wavelength of the wave produced which leads to change in the pitch or frequency. Shorter the straw, shorter the wavelength and hence higher the frequency of sound produced.

NOTES

9. Now let's see why closing and opening of different holes results in different sounds. When you close all the holes in the flute, the frequency of sound produced is corresponding to the full length of the straw.
10. When you open the holes of the flute, it is as if the straw has been cut to that length and hence the frequency increases.

EXPLORE

1. Some animals can hear sounds that humans can't. Dogs and many other animals can hear frequencies that are too high for our ears. Whales, when they sing their whale songs, sometimes create pitches that are way too low for human ears, but whales can hear them just fine from hundreds of miles across the ocean!
2. The V end of the straw vibrates when you blow into it. Can you guess how many times does it vibrate in one second?
3. When the first hole (closer to your mouth) of the flute is open, the frequency of sound would be same regardless of whether the second and third holes are open or close.
4. How many different sounds are produced if you have three holes in your flute?

WATCH OUT

1. Make sure you don't keep your lips on the V shape. Keep the straw around 2cm inside your mouth and then blow.
2. Don't blow too hard inside the straw. Otherwise it won't produce a sound. The two flaps would permanently stick together.

3-IN-1 TOY

LEARNINGS

- Pressure
- Centrifugal Force
- Bernoulli's Principle
- Sound Waves
- Parabolic Motion

MATERIALS REQUIRED

- Straw
- EVA Sheet
- Glue
- Scissors
- Kebab Stick

Sprinkler, sprayer and flute in one toy! That's why it is called 3-in-1 toy. This seemingly simple and fun toy also explains the laws of sound, centripetal force and Bernoulli's principle.

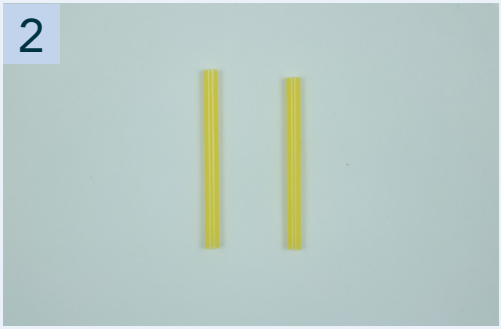
WHAT TO DO?

1. Take two straw pieces of around 6 cm length.
2. Stick these two pieces on a piece of EVA sheet such that one straw blocks half of other straw's opening.
3. Put one straw in a glass of water and blow from the other straw.
4. Now exchange the straws- the straw in water goes in the mouth and the straw in the mouth goes in the water. Observe what happens!
5. Now insert the kebab stick in the EVA foam and rotate the toy keeping the junction point of straws in water. Observe what happens.

1

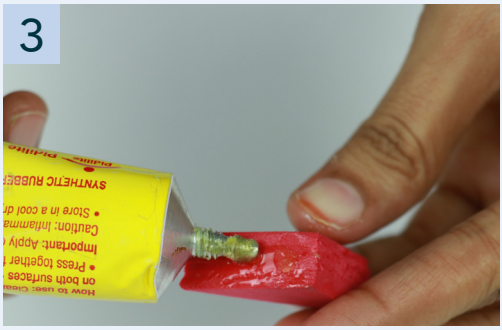
Material required for this activity.

2



Cut two small straw pieces.

3

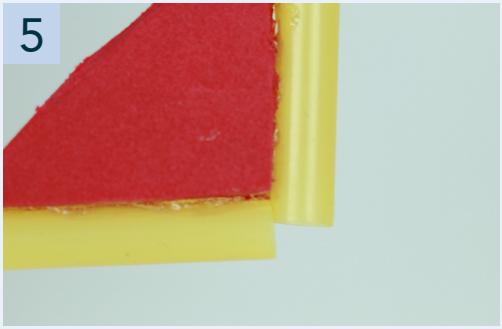


Apply glue on the EVA piece.

4

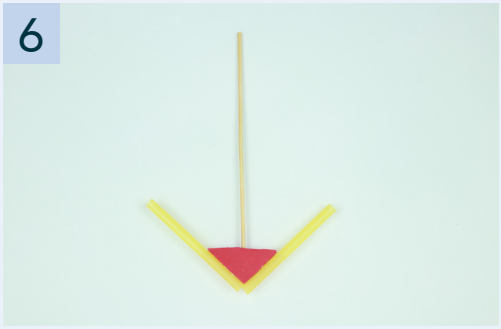
Paste the straw as shown.

5



Paste another straw such that it blocks half of the first straw's opening.

6



Insert a kebab stick in the middle.

NOTES

WHAT'S GOING ON?

1. When you blow through the straw whose opening is clear, you hear a whistle (due to vibration of straw tip).
2. When you blow through the straw whose opening is partially blocked by the other straw, you get a fantastic spray of water.
3. The blocked opening of the straw increases the speed of air at that point (smaller the area, larger the speed).
4. The air with high speed creates low pressure at the junction point of both the straws (Bernoulli's principle). Due to this low pressure, water is pushed upwards and sprayed in front.
5. When you rotate the toy with kebab stick, you get a sprinkler due to centrifugal force acting on the water in the straw.

EXPLORE

1. Try making the toy with different angles between the straws. At what angle does water go the farthest? Hint: the answer is not 45°.
2. What is the trajectory of the water drop when it drops to the ground from the straw? Is it spiral or parabolic?

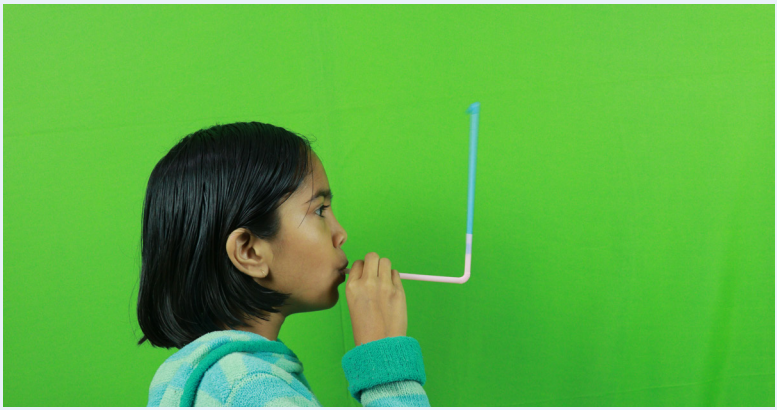
DOUBLE STRAW SPINNER

LEARNINGS

- Newton's Third Law
- Torque
- Friction

MATERIALS REQUIRED

- Bendable Straws
- Scissors



Join two straws and a spinner is ready. Simplest yet the most fascinating toy you can make in 5 minutes. Introduce yourself to Newton's third law with this toy.

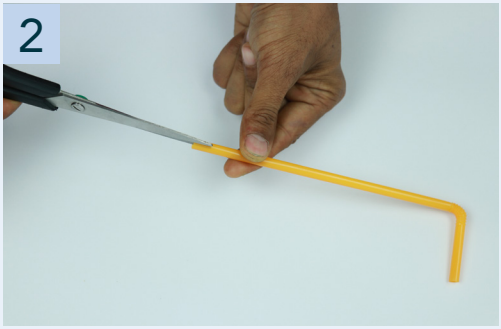
WHAT TO DO?

1. Take two bendable straws. Make a small cut along the length of one straw.
2. Push this straw with the cut in the other straw. This way the two straws will be joined together.
3. Orient the straws such that the longer end is in your mouth and the other end points towards you. Now blow in the longer straw and other end would go down.
4. Turn one straw such that the other end now points away from you and blow again. The straw will come towards you.
5. Now turn the straw in between the two positions above. The whole straw would start to rotate!

1

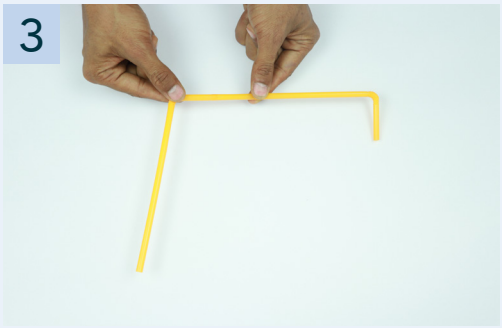
Material needed for this activity.

2



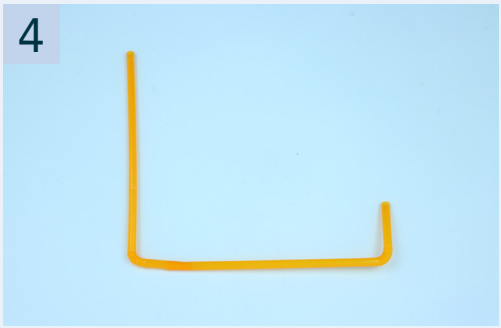
Make a small cut in one straw.

3



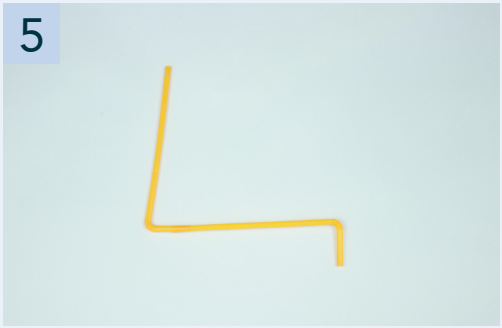
Insert it inside the other straw.

4



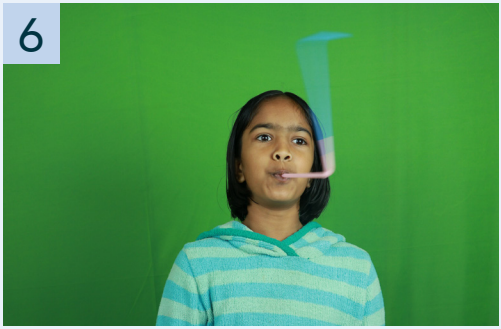
Orient the straws such that the longer end is in your mouth and the other end points towards you

5



Turn one straw such that the other end now points away from you and blow again.

6



Keep the straw in between the two positions and it would start to rotate!

NOTES

WHAT'S GOING ON?

1. When you blow air into the straw, air comes out from the other end. This air pushes the straw in opposite direction. This is due to Newton's third law of motion.
2. Newton's third law states that whenever an object A applies a force on a second object B, the object applies the same force on object A, in the opposite direction.
3. In this case, the air coming out from the straw is the action. The air pushing the straw in the opposite direction is the reaction. This reaction force causes the motion of straw.
4. This is the same principle on which rockets work. The rockets throw huge amounts of gases downwards when they take off. This pushes the rocket upwards.
5. Once the spacecraft is in outer space, it expels small amounts of gases to change its direction.
6. You can also see this law in action yourself. Stand on a skateboard with a ball. Now throw the ball forward and you will go backwards.

EXPLORE

1. Where does the expelled air apply force on the straw - the point where it comes out of the straw or the point where the straw is bent?
2. The ability of a force to rotate an object is called torque. If the force passes through the center of the object, it moves along a straight line. But when the line of force doesn't pass through the center, the object starts to rotate.
3. You have to hold the straw softly in your mouth otherwise it won't rotate due to friction.

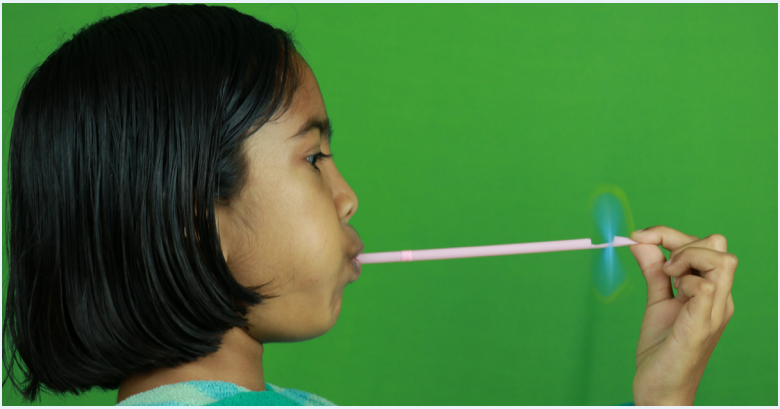
STRAW SPINNER

LEARNINGS

- Newton's Third Law
- Torque
- Friction

MATERIALS REQUIRED

- Straw
- Tape
- Scissors

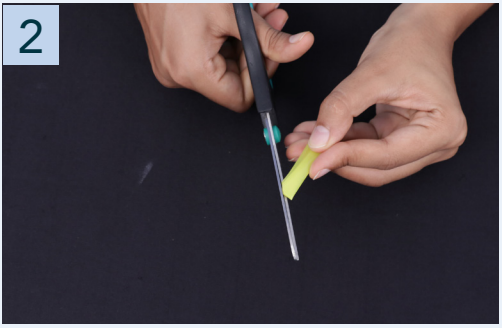


Make a spinner using only a straw, scissors and some tape - one of the most rewarding toy!

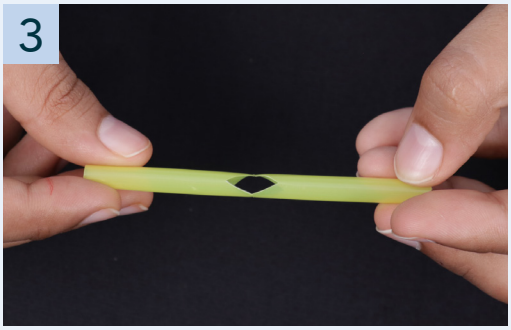
WHAT TO DO?

1. Take two straws of length 6 cm and 12 cm respectively.
2. Fold the shorter straw in half. Cut both the corners to make a diamond shaped hole in the center.
3. Flatten the ends of the straw and seal with tape. Cut any two diametrically opposite corners to make the spinner.
4. Cut a slot in the bigger straw. Place the shorter straw with the hole inside it. Make sure that it can rotate freely in the slot.
5. Close one end of the longer straw with one finger and blow. Your straw spinner is ready.

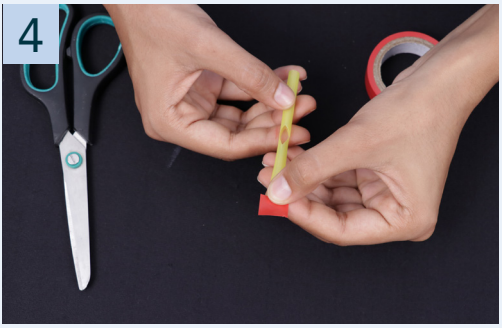
Fold the shorter straw in half.



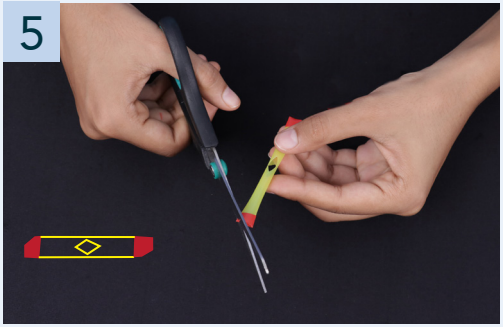
Cut both the corners of the straw.



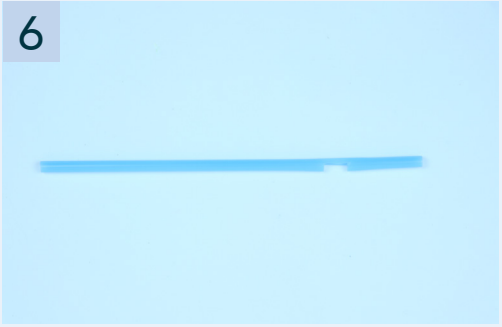
You would see a diamond shaped hole.



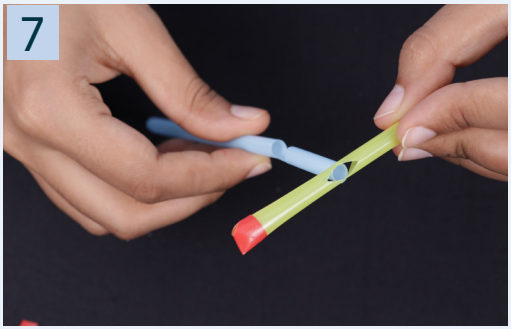
Flatten the ends of the straw and seal with tape



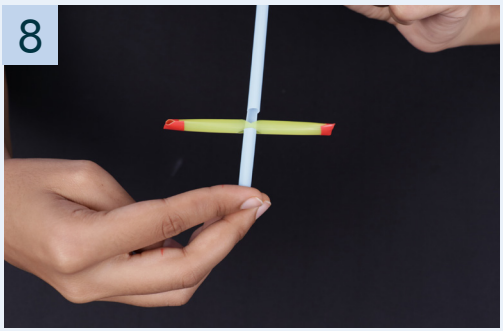
Flatten the ends of the straw and seal with tape



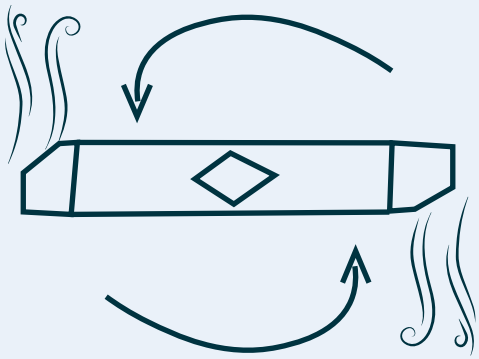
Cut out a slot in the bigger straw.



Place the shorter straw with the hole inside the slot.



The straw spinner is ready.



NOTES

WHAT'S GOING ON?

1. When you blow air inside the straw, it goes to the shorter straw as the end of the longer straw is closed by fingers.
2. The air comes out from the two cuts of the shorter straw. This air pushes the straw in opposite direction. This is due to Newton's third law of motion.
3. Newton's third law states that whenever an object A applies a force on a second object B, the object applies the same force on object A, in the opposite direction.
4. In this case, the air coming out from the straw is the action. The air pushing the straw in the opposite direction is the reaction. This reaction force causes the motion of smaller straw.
5. The diagonally opposite cuts ensure that both the forces try to rotate the straw in the same direction.

EXPLORE

1. Try changing the direction of rotation of the straw.
2. Can you rotate it with only hole in a spinner straw? You will observe that at the start, If the open slit of blowing straw is facing the closed end of spinning straw, it will not spin. Can you do some modification in the blowing straw to make the toy spin in any starting position?
3. An interesting observation is that even though there is a lot of open space for air to go out from the junction of two straws, it only goes towards the spinning straw and finally comes out of the holes. This is due to the low pressure created because of the high speed of air (Bernoulli's principle). The surrounding atmospheric air will also enter from the junction of two straws due to this low pressure.
4. The same thing can be seen in a gas stove. The pipe connecting the gas inlet to the burner is open (just after the nozzle) but the LPG doesn't spread in the room. On the contrary, the atmospheric air (which contains oxygen) is mixed with the LPG gas, helping it to burn efficiently.
5. Attach this straw spinner at the end of the Double Straw Spinner and you can make a hybrid spinner.

ANTI GRAVITY FUNNEL

LEARNINGS

Pressure

Bernoulli's Principle

Gravity

MATERIALS REQUIRED

Funnel

Plastic Ball

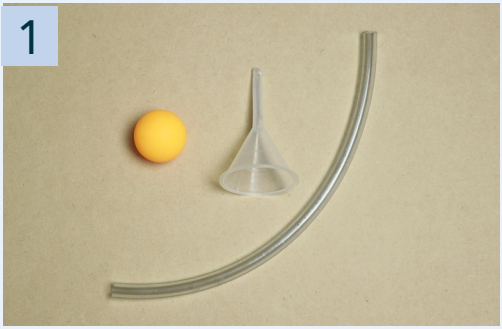
Flexible tube

This magical funnel completely defies gravity! The ball doesn't fall out from the funnel as long as you keep blowing inside.

WHAT TO DO?

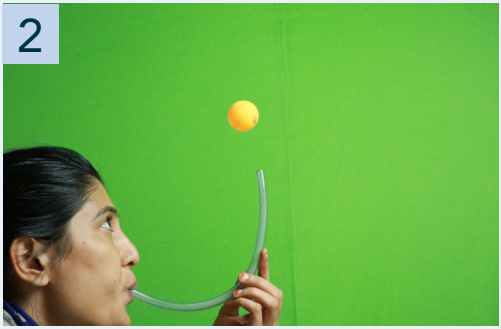
1. Connect a flexible tube to the narrow outlet of the funnel.
2. Put the plastic ball into the broad end of the funnel.
3. Blow air from the other end of the flexible tube. Surprisingly, the ball doesn't fall out of the funnel.
4. Keep blowing and gradually turn the funnel upside down.
5. The ball would stay in the funnel as long as you keep blowing air!

1



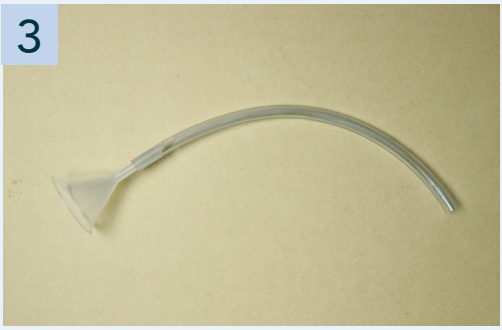
You will require a funnel, plastic ball and a flexible tube for this activity.

2



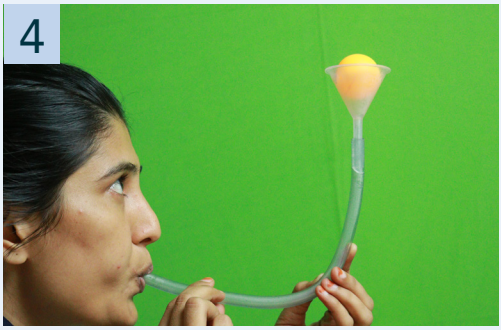
Try blowing air through the flexi pipe with the plastic ball on the other end and observe.

3



Now attach the funnel to the flexi tube as shown.

4



Place the ball in the funnel and try blowing the ball away.

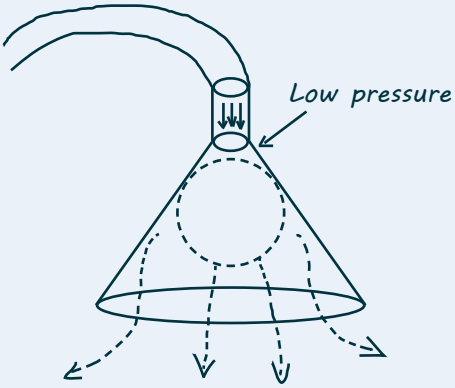
5

Now invert the funnel while blowing into the tube.

NOTES

WHAT'S GOING ON?

1. The air blown by you goes in the funnel with high speed and goes around the plastic ball.
2. The pressure at the top of the ball becomes low (high speed, low pressure: Bernoulli's principle).
3. Therefore, the pressure at the top of the ball is less compared to the pressure at its bottom (at the bottom of the ball, the pressure is the normal atmospheric pressure).
4. Due to this, the ball stays inside the funnel and does not fall down.



EXPLORE

1. The same activity can also be done with balloons instead of table tennis ball.
2. The ball also spins because the flow of air is not perfectly symmetrical.

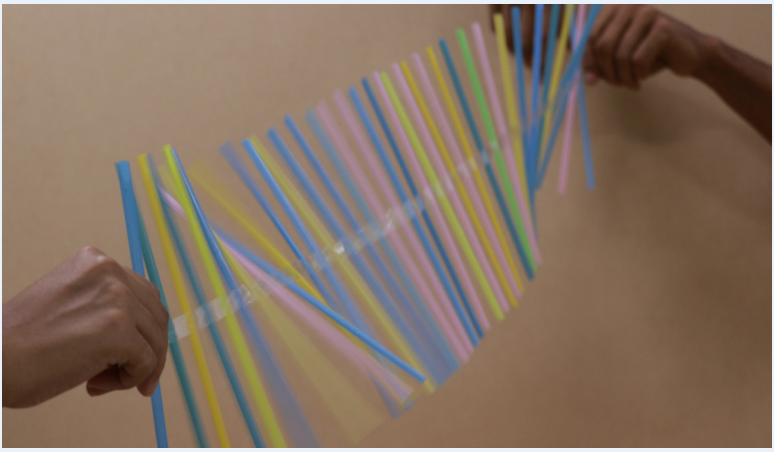
STRAW WAVE MODEL

LEARNINGS

- Wave Propagation
- Wavelength
- Frequency of a Wave
- DNA model

MATERIALS REQUIRED

- Straws
- Tape

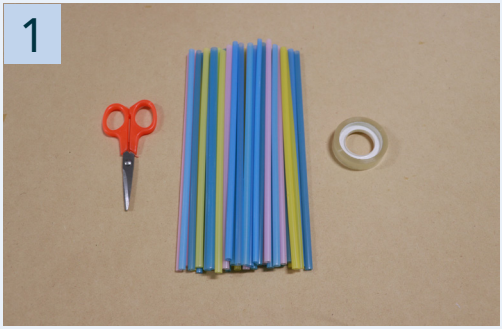


Have you ever wondered how sound or any other wave travels in a medium? This toy shows the propagation of waves using straws. On twisting, it also becomes a helical structure like a DNA!

WHAT TO DO?

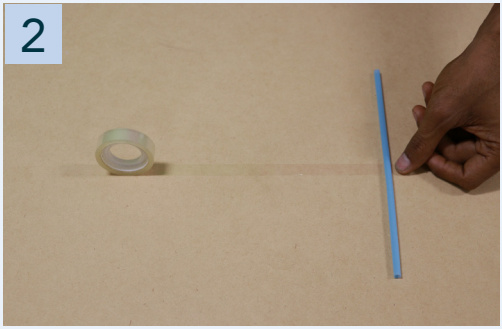
1. Place a long tape on the floor such that its sticky side is on the top.
2. Place 30 straws at equal lengths on the tape such that the tape is in the middle of the straws.
3. Now cover it with one more layer of tape and the model is ready. The straws would be sandwiched between two layers of tape.
4. Tap the model from one end and you would see the wave traveling to the other side and back.
5. When you twist the same model, it becomes a double helical structure (two helixes entangled with each other). This is same as the structure of a DNA

1



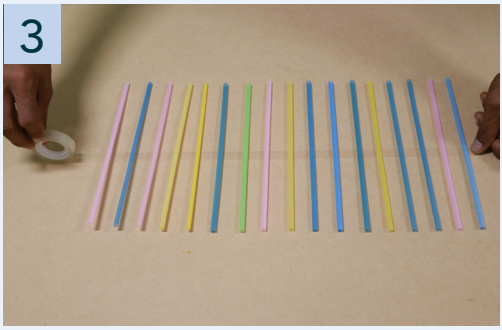
You will need straws and tape for this activity.

2



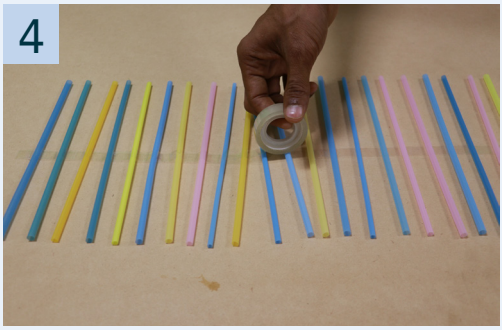
Place a long tape on the floor such that the sticky side is on the top.

3



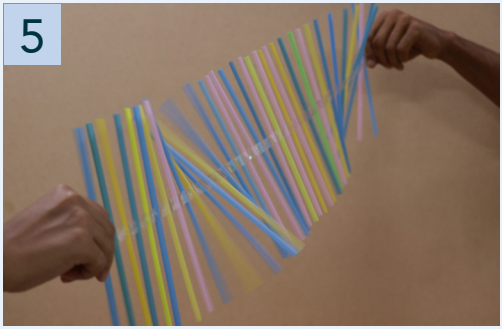
Place 30 straws at equal lengths on the tape such that the tape is in the middle of the straws.

4



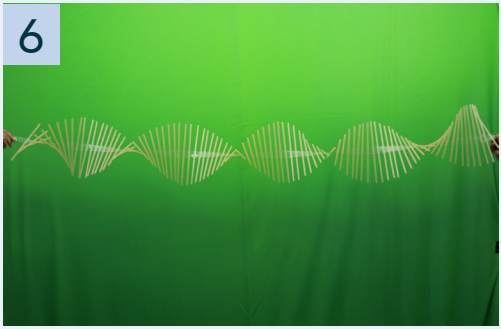
Cover the straws with one more layer of tape, such that it is exactly on top of the first layer.

5



Your Straw Wave Model is ready.

6



Twist the model to form the DNA structure.

NOTES

WHAT'S GOING ON?

1. When you tap one end, a pulse is produced and wave travels from one end to another and returns back.
2. The initial tap is transmitted to the adjacent straw and so on. The process gets repeated and the wave keeps on moving forward.
3. Notice that the straws don't go from one end to another. Only the motion of straws (called the wave) travels from one end to another.
4. This is similar to the waves which are produced when you drop a pebble in still water. The water remains at its place but the wave moves outward from the center.
5. In this wave model, energy is transmitted via the tape. When the tension in the tape is more (meaning the two ends are stretched tightly), the speed of transmission of wave increases. When the tension is less, the wave travels slowly.

EXPLORE

1. What happens to the speed of the wave if we use kebab sticks or cycle spokes in place of straws? Make another model with 20 straws, 20 kebab sticks and 20 cycle spokes. You will see that the wave travels slowly in kebab sticks as compared to straws and slowest in cycle spokes. This is because kebab sticks and cycle spokes are heavier and therefore take more energy to move.
2. Make another model with straws, but with sections containing straws of different length. Discuss the observations.
3. When you give it a twist, sine curve is created. Can you find the wavelength and frequency of that curve?

PUPPETEER WHISTLE

LEARNINGS

- Sound
- Vibration
- Bernoulli's Principle
- Pressure

MATERIALS REQUIRED

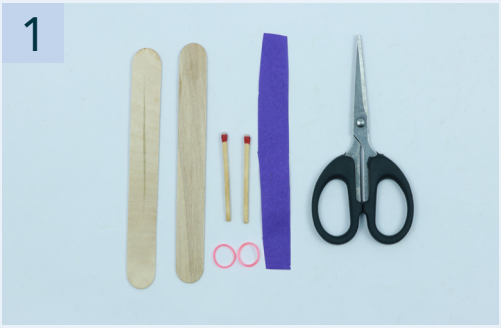
- Ice-cream Sticks
- Rubber band
- Paper
- Matchstick

This amazing toy generates a screechy high pitched sound when we blow into it. You can also understand how sound is produced using this model.

WHAT TO DO?

1. Take two ice-cream sticks and a strip of paper equal in length and width to that of the ice-cream stick
2. Place a small piece of matchstick on the ice-cream stick and then put the paper strip on the top.
3. Place another matchstick on the other end (on top of the paper strip)
4. Place another ice-cream stick at the top and tie them using rubber-bands on both ends
5. Blow into this structure and a weird, funny sound would be produced.

1

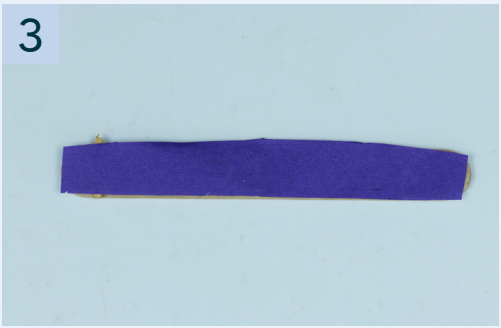


Take two ice-cream sticks and a strip of paper equal in length and width to that of the ice-cream stick

2

Place a small piece of matchstick on the ice-cream stick

3

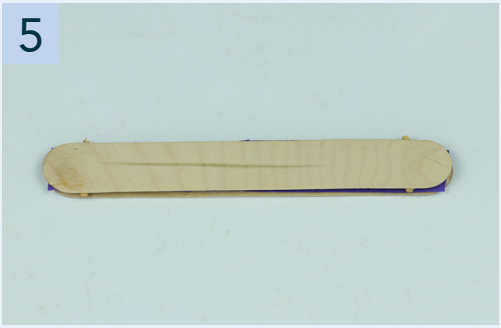


Place a small strip of paper on top.

4

Place another matchstick on the other end

5



Place another ice-cream stick at the top.

6

Tie them using rubber-bands on both ends

NOTES

WHAT'S GOING ON?

1. Sound is produced when something vibrates. The vibrating body causes the air to vibrate and you hear the sound.
2. The paper strip has some space to move up and down due to the placed matchstick. When you blow, the paper strip vibrates up and down very quickly - producing the sound.

EXPLORE

Modify the same model- use different type of paper strips, different width of paper strips, plastic instead of paper, different thickness of matchstick, etc.

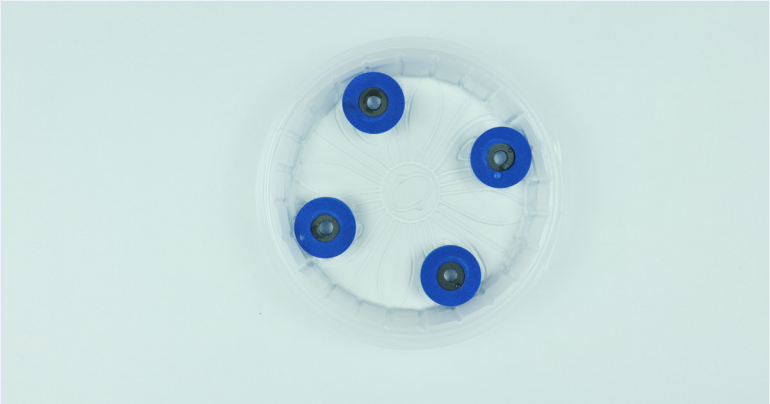
MAGNETIC GEOMETRY

LEARNINGS

- Geometry
- Poles of a Magnet
- Attraction and Repulsion

MATERIALS REQUIRED

- Ring Magnet
- Big Plate
- EVA Rings

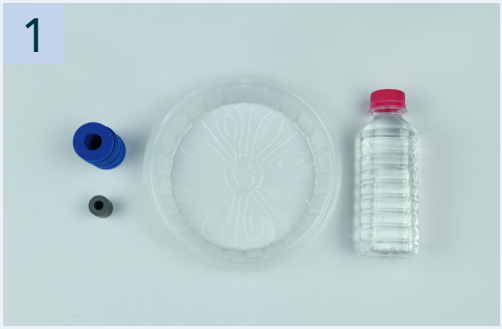


The magnets arrange themselves into different polygons when placed on water. Explore different geometrical shapes using magnets!

WHAT TO DO?

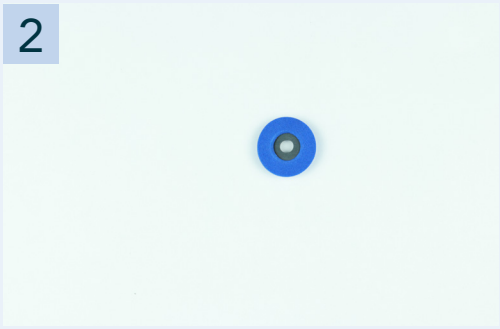
1. Place the ring magnets such that they repel each other. This means that the same poles of all the magnets should be facing in the same direction.
2. Take EVA rings and insert the magnets inside the rings, without changing the direction of magnets.
3. Fill the plate with water. Place the EVA rings on the water surface, one by one.
4. When you place two rings in water, they repel each other and stabilize at the diametrically opposite points.
5. When you put the third ring, the three rings automatically take the shape of an equilateral triangle.
6. Similarly, when you put the fourth ring, they orient themselves into a square shape.
7. When you put all the 7 ring, they take the shape of hexagon with one ring in the center.

1



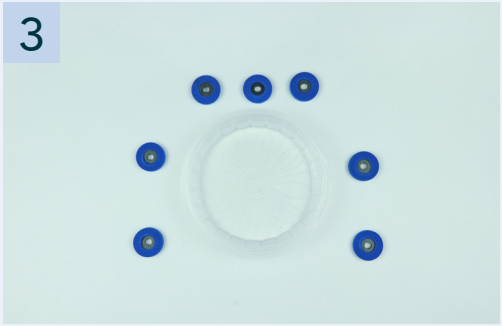
Material required for this activity.

2



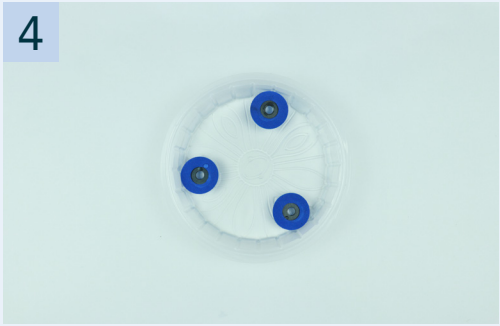
Fit the magnet in the EVA rings given.

3



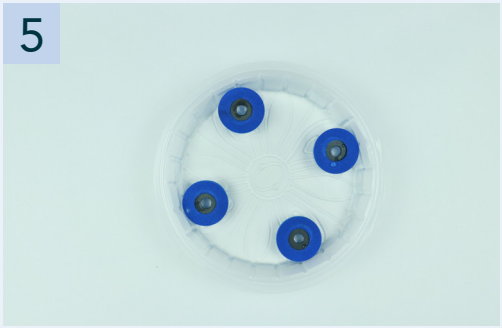
Do this for all the EVA rings. Take the given circular plate and add water to it.

4



Start adding the magnets such that they repel each other.

5

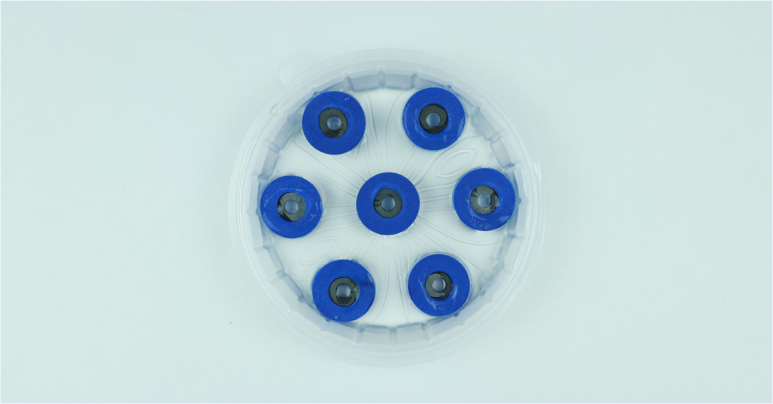


You will see the magnets make interesting geometric patterns

6

Keep adding magnets and observe different shapes.

NOTES



WHAT'S GOING ON?

1. As the magnetic poles of all magnets are oriented in the same direction, the magnets repel each other.
2. Due to this repelling force, the magnets arrange themselves such that the distance between the magnets is maximum.
3. This results in different polygons for different number of magnets.

EXPLORE

1. Try with more number of magnets and note the shape you get for each number.
2. Take vessels of different shapes. Does that affect the final position of the magnets?

BIRD WHISTLE

LEARNINGS

Torque
Weight
Friction

This is a very counter-intuitive model which defies gravity. The card sheet disc looks like Saturn rings when it rotates

MATERIALS REQUIRED

Toy motor
Plastic ball
Card paper
Battery
Scissors
Stiff Straw

WHAT TO DO?

1. Attach the toy motor terminals to a 9-volt battery.
2. Make two diametrically opposite holes (using scissors) on the ball to pass a stiff straw though it. You can also use an empty pen refill for this.
3. Attach this straw (with the ball) on the shaft of a toy motor.
4. Cut an annular disc from card paper such that it passes through the ball easily.
5. Spin the ball by switching on the motor. Hold the disc on the ball loosely and the disc will start spinning too. o
6. On leaving the disc, it will still keep spinning and look like Saturn rings on the ball. Even on inverting the spinning card, ring will not fall - It will keep spinning.

NOTES

WHAT'S GOING ON?

1. To understand the working of this toy, let's first understand how a hula hoop works. What makes a hula-hoop spin around a person's waist?
2. When you rotate the hula loop, you exert an upward force (from the hips) and another force which keeps it rotating.
3. Friction between the hoop and your clothes slows the hoop down. But it is friction which also helps to keep the hula-hoop up on your body while gravity pulls it down.
4. In case of our mechanical hula hoop, your waist motion is replaced by the spinning motor which hits the paper disc and provide the necessary force to spin it and supposedly defy gravity.

EXPLORE

1. Decorate the ball and discs such that they actually look like Saturn and its rings.
2. Try with different shapes of rings. The hole also doesn't have to be circular. Try with a square hole instead.

PASCAL BAG

LEARNINGS

Pascal's Law

Force

Pressure

MATERIALS REQUIRED

Plastic Bags

Flexible Tube

Glue gun or glue

T- Joint

Scissors

Tape

Showcase your strength by lift someone by just blowing air through a tube! This activity can be done by any tube and waste milk packets.

WHAT TO DO?

1. Attach two pieces of flexi tube (around 30 cm length) to two plastic bags using glue such that the connection is air-tight.
2. Join the two flexi tubes using a small T-connector and put another flexi tube on the third port of the T-connector.
3. Place a wooden log on the two plastic bags and ask a person to sit on it.
4. Ask another person to blow from the flexi tube.
5. To everyone's surprise, the person sitting on the plank rises up!

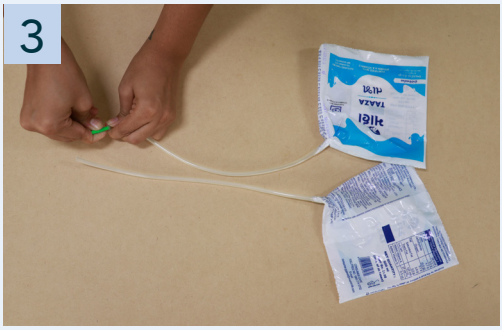
1

Insert the pipe into the plastic bag at one corner and seal it using tape.

2

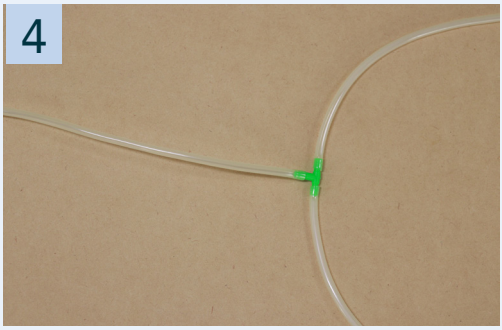
Use glue gun or normal glue to make the connection airtight.

3



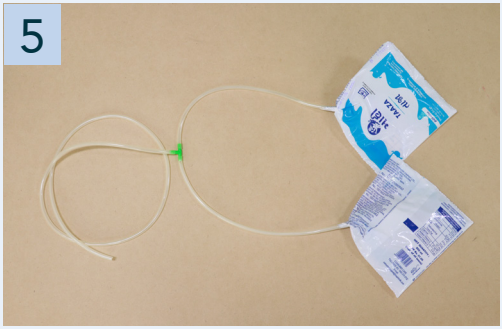
Make two such pouches and connect them using a T- connector.

4



Attach another flexi tube to the third opening of the T- connector.

5



Your Pascal Bag is ready.

6

Keep a heavy weight on a sheet and start blowing through the tube.

NOTES

WHAT'S GOING ON?

1. When you blow through the tube, pressure inside the plastic bags increases.
2. But as the bags have larger area, the upward force is amplified (force = pressure × area) which lifts the heavy load.
3. This is called Pascal's law. It states that pressure change at any point in a liquid (like water or oil) is transmitted throughout the liquid such that the same change occurs everywhere.
4. As the area at the other end is more, this same pressure results into a bigger force (Force = Pressure × Area)
5. Hydraulic lift used to lift cars at car washes is also based on Pascal's law. But how is a small force able to lift a car? Where does the energy come from?
6. Actually you spend the same amount of energy in lifting the car. It's just that the small force is applied for a larger distance. The lifting piston moves a large distance in downward direction to lift the car slightly upwards.
7. Similarly, you have to blow for a long time to push the person upwards for a small distance.

EXPLORE

1. What would happen if you take a thicker pipe to blow? Would that make it easier or more difficult for us to lift?
2. Why is it easier to ride a gear bicycle on a steep slope, as compared to a regular bicycle? Discuss.

HAND PUMP

LEARNINGS

- Pressure
- Valve
- Pump

MATERIALS REQUIRED

- Syringe
- Small Metal Ball
- Flexible Tube
- Scissors
- Glue
- One -way Valve

For 700 million people living in Indian villages, the hand pump provides safe drinking water. You can make your own hand pump using everyday objects. As you move the piston up and down, water gushes out from the pump's outlet.

WHAT TO DO?

1. Put a small metal ball inside the syringe by removing the plunger.
2. Make a small hole on the barrel of syringe using scissors.
3. Insert a one-way valve in this hole such that water can go out from the syringe but air can't come inside the syringe. Apply some glue to make the connection airtight.
4. Attach a long flexible tube at the front opening of the syringe.
5. Keep the open end of the flexible pipe inside a glass of water and move the plunger up and down.
6. Water would start to come out from the one-way valve.

1

Material required to make the hand pump.

2

Make a hole in the side of the syringe.

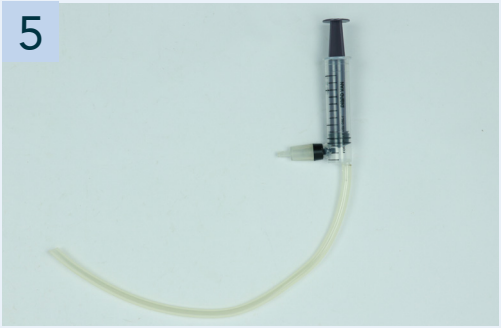
3

Make it air tight with the help of glue or glue gun.

4

Put the small metal ball inside the syringe.

5



Attach a long flexible tube at the front opening of the syringe.

6

Water would start to come out from the one-way valve.

NOTES

WHAT'S GOING ON?

1. There are two valves needed to make a pump. The one-way valve attached to the syringe is the first valve. The metal ball at the end of the syringe acts as the second valve.
2. When the piston moves upwards, the one-way valve doesn't let air to come inside, the pressure inside the syringe reduces. Due to this, the water from the flexible tube comes inside the syringe.
3. When the piston moves downward, the metal ball closes the front opening and the water goes out through the one-way valve at the side.
4. This cycle repeats itself, giving a continuous supply of water.

EXPLORE

1. Sometimes when a hand pump is started, you need to pour some water into the cylinder before it starts to pump water. Why?
2. What are the different types of pumps? Where are they used?
3. In this hand pump, water comes out when you move the plunger down. Is it also true for the traditional hand pumps? Find out.

DOUBLE HAND PUMP

LEARNINGS

Pressure

Valve

Pump

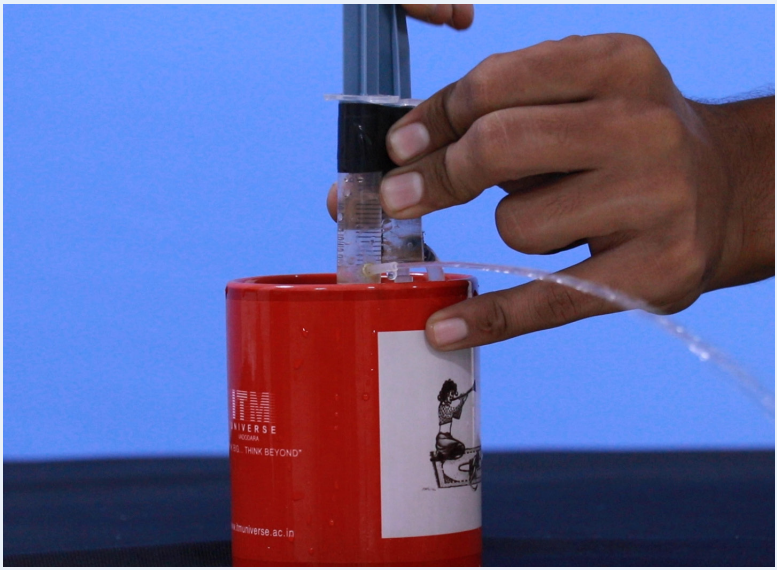
MATERIALS REQUIRED

2 Syringes

Flexible Tube

2 Small Metal Balls

Glue



For 700 million people living in Indian villages, the hand pump provides safe drinking water. You can make your own hand pump using everyday objects. As you move the piston up and down, water gushes out from the pump's outlet.

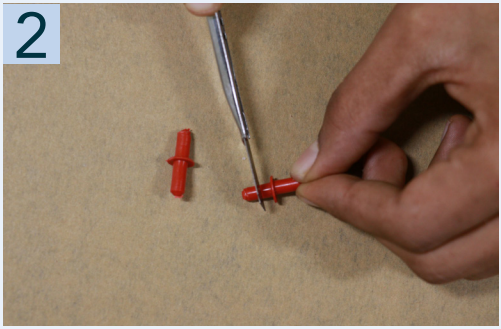
WHAT TO DO?

1. Make a small hole on the barrel of both syringes using scissors.
2. Join the hole of first syringe and the front opening of second syringe using flexible tube. Apply some glue to make sure that the connections are airtight.
3. Attach a long flexible tube at the front opening of the first syringe. Put a small metal ball inside both the syringes by removing the plungers.
4. Keep the open end of the flexible pipe inside water and move the plunger of the first syringe up and down. (Keep the plunger of the second syringe pushed out).
5. Water would come out of the hole of the second syringe

1

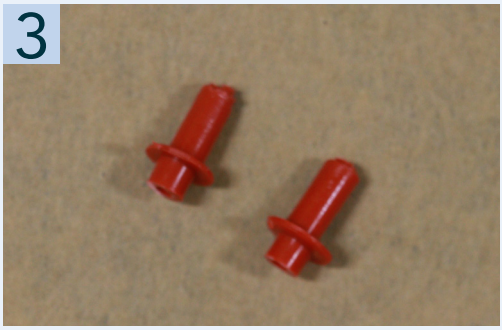
Make a hole at the side in both the syringes.

2



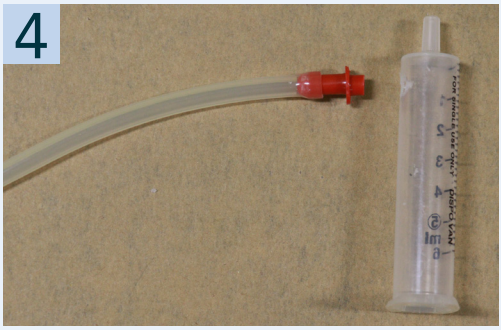
Cut one side of I-connectors.

3



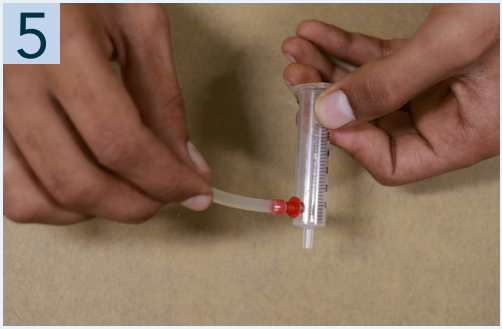
The connectors will look something like this after cutting.

4



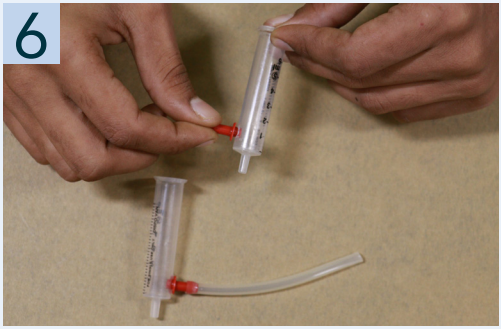
Attach the flexi tube to the longer side of the connector.

5



Attach the connector and flexi tube to the syringe. Use glue to make the connection airtight.

6

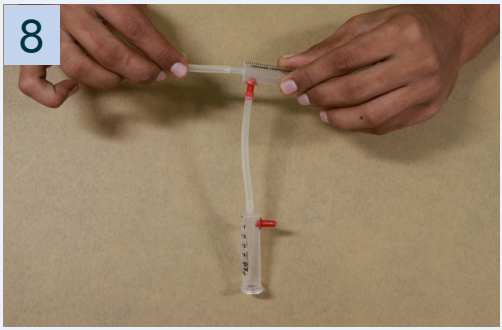


Attach the second connector to the other syringe. Use glue to make it airtight.

7

Join the two syringes with each other using flexi tube.

8

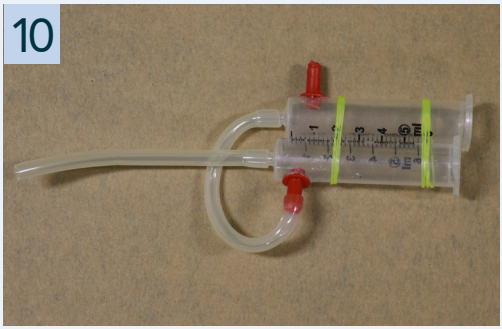


Attach another flexi tube to the other syringe.

9

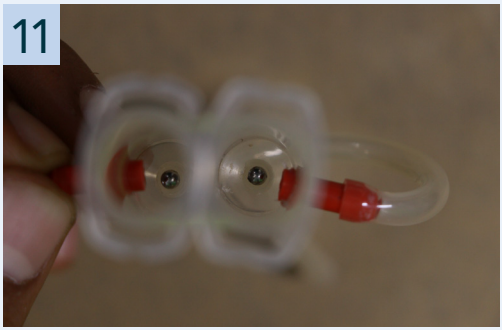
Bring both the syringes together.

10



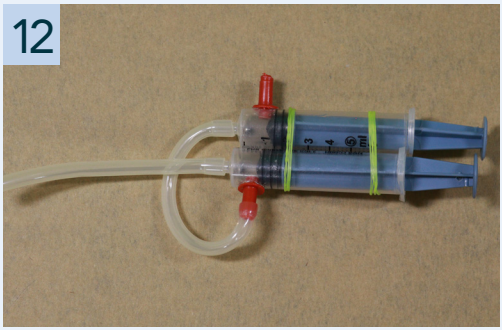
Tie both the syringes together using rubber bands.

11

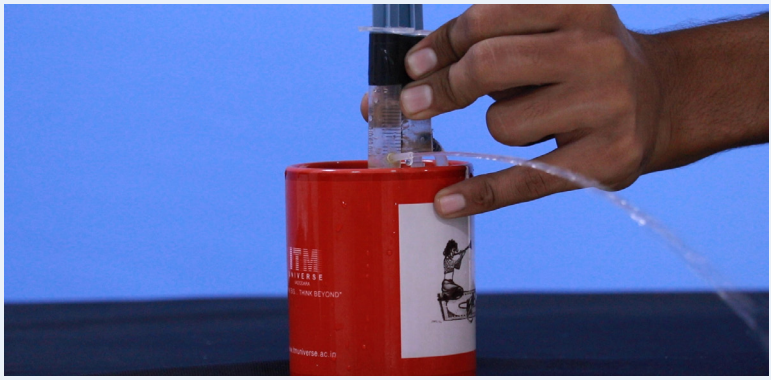


Insert two small metallic balls in both the syringes.

12



Insert the plunger in both the syringes and the Hand Pump is ready.

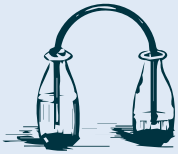


WHAT'S GOING ON?

1. There are two valves needed to make a pump. The metal balls in the syringes act as one-way valves. Water can come inside the cylinder through this but can't go out.
2. When the piston of the first syringe moves upwards, the pressure inside the syringe reduces. Due to this, the water inside the glass comes inside this syringe.
3. When the piston is moved downward, the metal ball closes the front opening and the water goes out through the flexible pipe to the second syringe.
4. From the second syringe, the water comes out from the side hole. This cycle repeats itself, giving a steady continuous supply of water.

EXPLORE

1. Sometimes when a hand pump is started, you need to pour some water into the cylinder before it starts to pump water. Why?
2. What are the different types of pumps? Where are they used?
3. In this hand pump, water comes out when you move the plunger down. Is it also true for the traditional hand pumps? Find out.



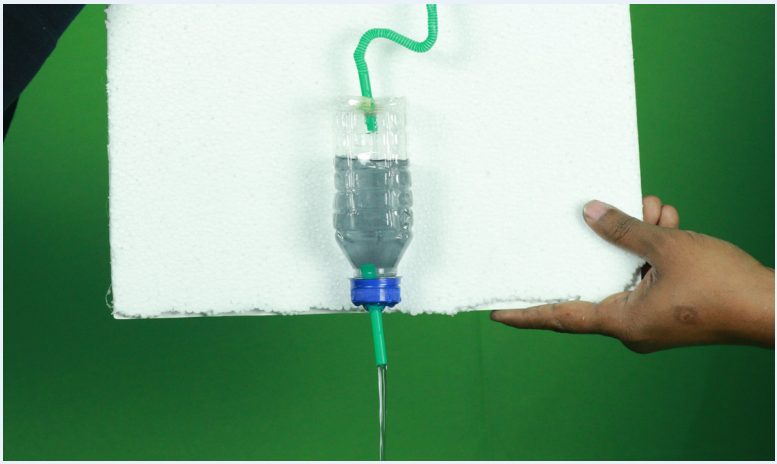
SMART SIPHON

LEARNINGS

- Air Pressure
- Gravity
- Siphon
- Potential Energy

MATERIALS REQUIRED

- Two Bottles
- Bendable Straws
- Food Color
- Glue
- Scissors

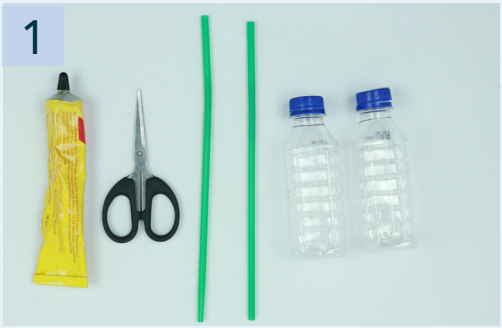


A simple siphon is basically a tube in an inverted 'U' shape, which can be used to transport liquid from a reservoir to a lower level. This usually requires to initially suck the tube to start the flow of liquid. But this smart siphon can be started without putting foul-tasting liquid in your mouth!

WHAT TO DO?

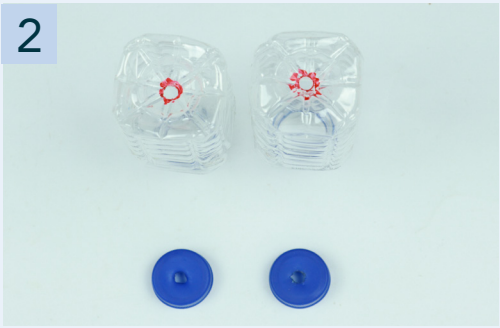
1. Make holes in the cap and the bottom of both the bottles using scissors.
2. The size of the hole should be slightly smaller than the straw so that it fits snugly in the hole.
3. Join both the bottles using a bendable straw. Seal all the joints with glue so that there is no leakage.
4. Mount the two bottles on a cardboard. Fill one bottle with water and flip the entire setup. Close one straw with your finger.
5. Keep one end of the siphon in colored water and release the other straw.
6. The water would start to flow .

1



Material required for this activity.

2

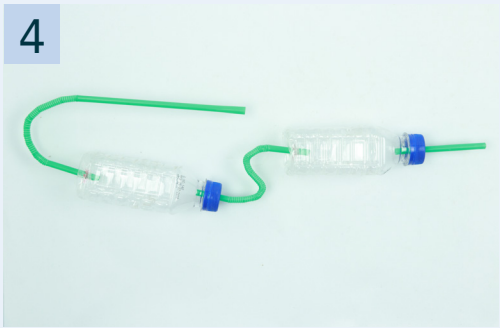


Make holes in the cap and bottom of both the bottles.

3

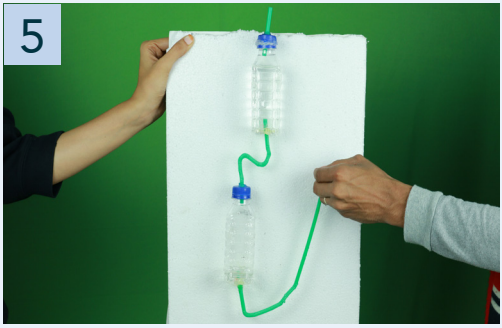
Attach the bendable straws to the two bottles.

4



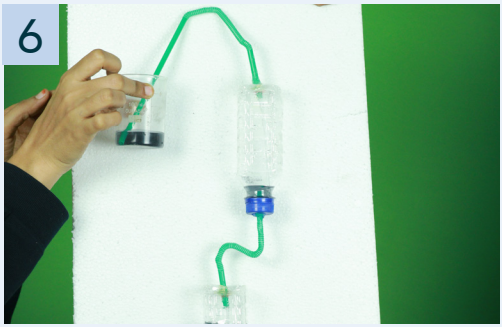
Join the bottles together.

5



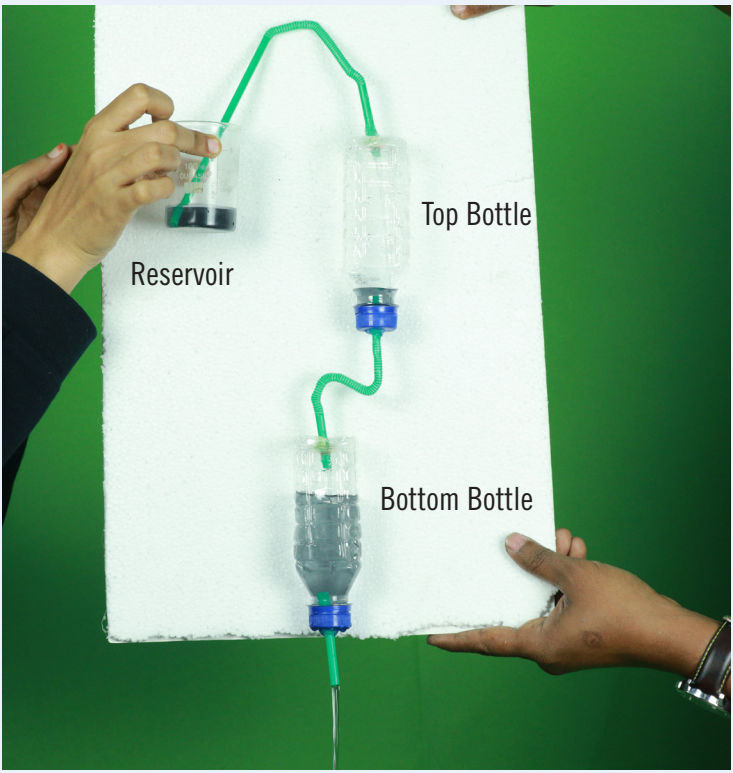
Fill the top bottle with water.

6



Invert the setup and close one straw with your finger. Keep one end of the siphon in colored water and then release the other straw.

NOTES



WHAT'S GOING ON?

1. The siphon works because of gravity. Overall, the liquid goes from a higher height to a lower height due to gravity.
2. There is some water in the bottom bottle at the start.
3. When it starts to drain from the bottle, the pressure inside this bottle decreases.
4. This causes water to flow from the reservoir into the bottom bottle, through the top bottle. The siphon keeps on working until the reservoir is empty.

EXPLORE

1. How high can you lift the siphon tube above the reservoir, and still get a functional siphon?
2. For maximum flow rate, is it better to use a thinner tube or a larger diameter tube?

VASUDEV KA PYALA

LEARNINGS

Pressure

Siphon

MATERIALS REQUIRED

Plastic Bottle

Bendable Straw

Glue

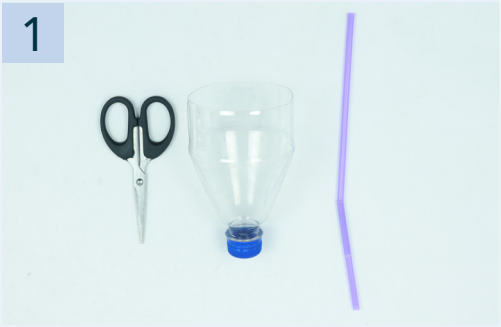
Cutter

This is a special cup which holds water till a certain level. But if you are greedy and fill the drink more than that, then suddenly it starts draining and doesn't stop until it's empty.

WHAT TO DO?

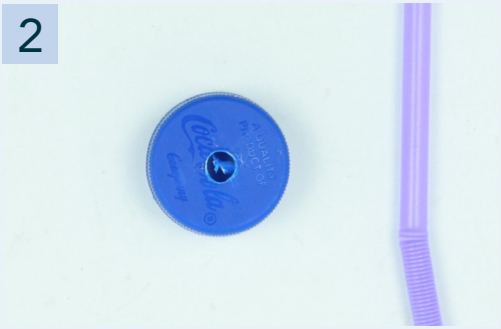
1. Cut a bottle in half and keep the top half with the cap for this experiment.
2. Make a hole in the cap of the bottle using scissors. The hole should be big enough to pass a straw through it.
3. Pass one end of a bendable straw through the cap and seal the joint with glue to prevent any leakage of water.
4. Bend the straw and put the other end near the cap. Your cup is ready.
5. Pour water inside the cup and observe what happens.

1



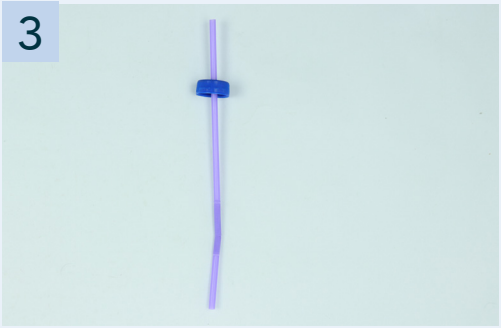
Material required for this activity.

2



Make a hole in the cap of the bottle using scissors. The hole should be big enough to pass a straw through it.

3



Pass one end of a bendable straw through the cap and seal the joint with glue to prevent any leakage of water.

4

Bend the straw and put the other end near the cap.

5

Your cup is ready. Pour water inside the cup and observe what happens.

6

Water will not come out till it reaches the top point of the straw.

WHAT'S GOING ON?

1. The bendable straw first goes upwards and then downwards. This basically acts as a siphon.
2. When you fill the cup with water, it also starts to rise in the straw. But the flow doesn't start because there is still no water in the portion of straw going out of the cup.
3. When the water reaches the highest point in the straw, it starts to go outside the cup.
4. Once this flow of water starts, more water goes inside the straw to replace the water that has gone out of the cup. This process goes on until all the water from the cup is emptied.
5. But once the flow stops, the cup needs to be filled to the topmost point to start the flow again.

EXPLORE

1. You must be wondering why the activity is named "Vasudev ka Pyala". There is a great mythological story involving Vasudev that can be enacted using this cup.
   Right after the birth of Krishna, his father Vasudev picked up the newborn baby, and carrying him in a basket on his head, he started towards Gokul. Gokul was a village of cowherds, located across the Yamuna river, where his

friend Nanda lived. When he was crossing the river, Yamuna said that she wanted to touch the feet of Krishna.

She also promises that as soon as she would touch the feet of the Lord, she would go down therefore Vasudev need not worry. And she started to rise, drowning Vasudeva. As soon as she touched the feet of the Lord (sitting at the top of our straw), as promised, the flow disappeared completely.

2. You can also use bucket and metal/PVC pipes to replicate the same phenomenon on a bigger scale.

STRAW SIPHON

LEARNINGS

Pressure

MATERIALS REQUIRED

Glass

Bendable Straws

Scissors

Food Color

These are two of the simplest siphons, which can be made using just some straws.

WHAT TO DO?

1. Fill a glass completely with water. Put some food color inside the water so that you can clearly see the flow.
2. Close one end of bendable the straw with your finger and put another end inside the water.
3. Remove your finger and water would start to flow out from the container. (If the flow is not starting, reduce the length of the bigger side of the straw siphon)
4. Now take 2 bendable straws (big ones) and make an M-shaped siphon.
5. Make sure that one hill of the M is a little higher than the other.
6. Dip the M-shaped structure inside the water (from the shorter side) and the siphoning would start.

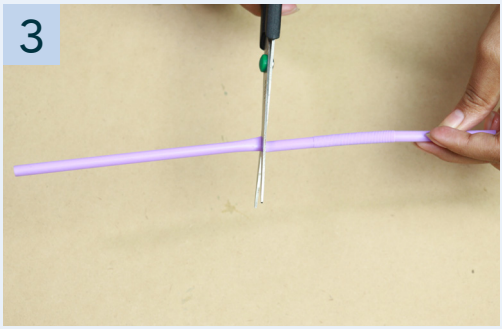
1

Close one end of the bendable straw with your finger and put another end inside water.

2

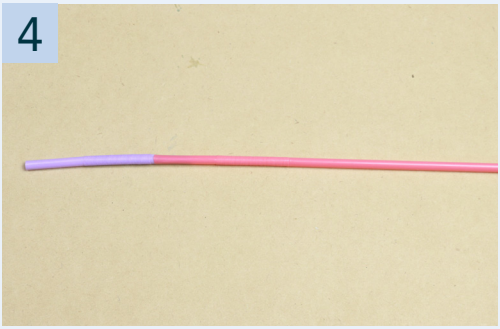
Water would start coming out of the straw.

3



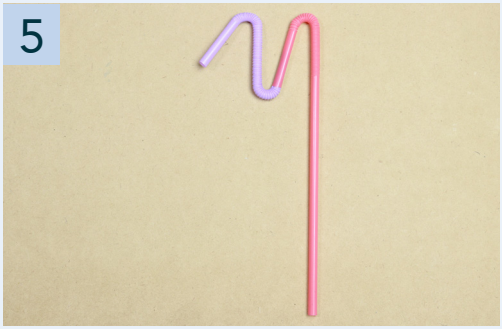
Cut one of the bendable straws.

4



Fit it inside another bendable straw.

5



Make a 'M" like structure, such that the loop on the right is slightly higher than the one on the left.

6

Fill a glass with water till the top, insert the siphon in the glass with a slight jerk.

NOTES

WHAT'S GOING ON?

1. When you dip the shorter side of the bendable straw inside water, the air in this part of the straw is replaced by water.
2. As the other end of the straw is covered with finger, this air can't go out of the straw and therefore gets compressed. The pressure of air inside the straw increases.
3. When you remove your finger, this compressed air expands and goes out of the straw. The pressure inside the straw momentarily becomes low (because of the temporary pressure fluctuations).
4. Due to the decrease in pressure, water level also rises up for some time. If you keep the bend near the water level, the water would shoot up and go out of the glass through the other leg of the bendable straw.
5. This siphoning would continue till the other end of the straw is dipped inside water.
6. For the M-shaped siphon, when you dip the structure in water, the water rises up in the straw from the shorter leg.
7. This water goes over the first hill and gains speed when it goes to the bottom.
8. Because of the slight jerk, the water rises again and overshoots the higher hill and finally comes out of the straw
9. You have to immerse the M quickly inside the water with a slight jerk. It is this slight jerk that provides the additional energy to cross the second hill of the M siphon.

SELF STARTING SIPHON

LEARNINGS

Pressure

MATERIALS REQUIRED

Plastic Bottle

Straw

Glue

Scissors

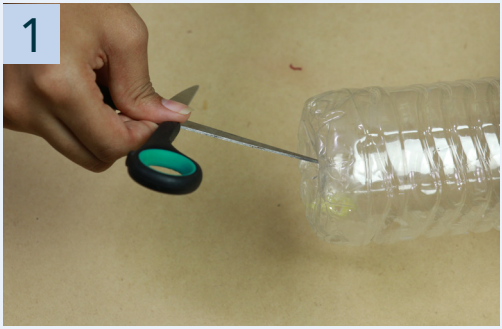
PVC Pipe

EVA sheet

WHAT TO DO?

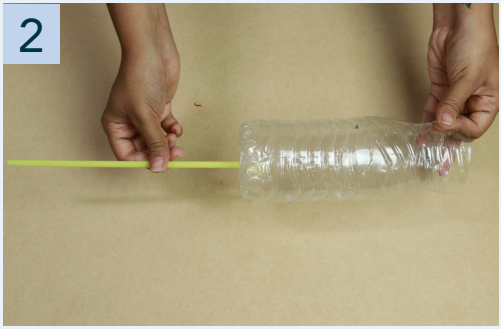
1. Cut the top part of the plastic bottle using scissors.
2. Make a small hole at the bottom of the bottle. Fix a straw in this hole. Apply glue so that the connection becomes airtight.
3. Make sure that the straw doesn't come out of the bottle from the top.
4. Take a PVC pipe and close its one end by sticking a piece of EVA Sheet. The length of the PVC pipe must be slightly larger than the length of the straw.
5. Fill the bottle completely with water.
6. The water above the straw would drain out of the bottle. But after that, the water would stop coming out of the bottle and maintain that level.
7. Now cover the straw with the PVC pipe. Surprisingly, the whole bottle would drain out this time.

1



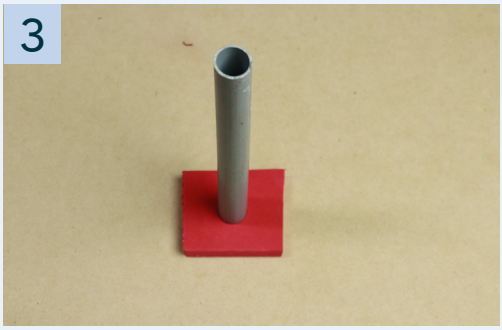
Make a hole at the bottom of the bottle.

2



Insert the straw in the hole at the bottom of the bottle.

3



Take a PVC pipe and gently rotate it on a piece of EVA sheet to cut out a circular piece.

4

Use glue to make it airtight.

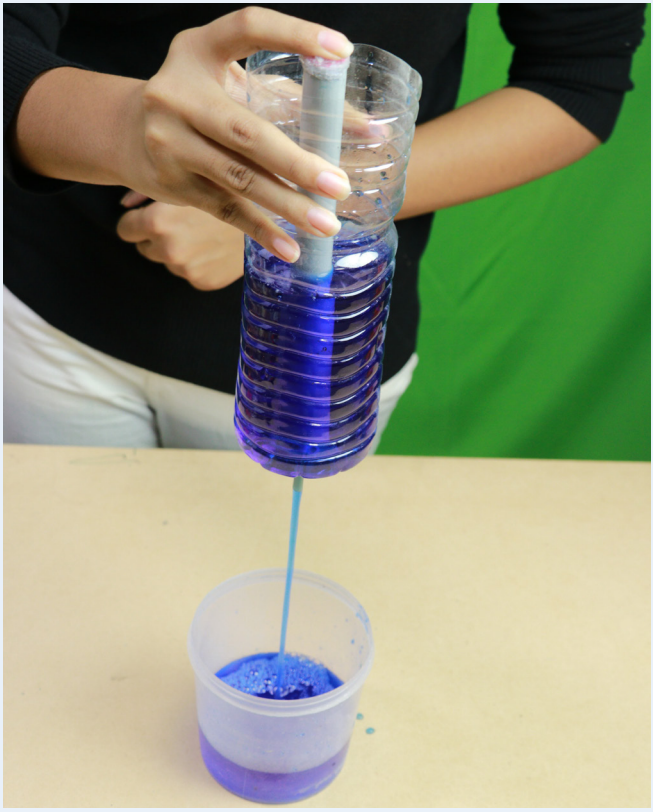
5

Fill the bottle with water.

6

Now cover the straw with PVC pipe.

NOTES



WHAT'S GOING ON?

1. At the start, the level of water is equal to the height of the straw inside the bottle.
2. When you put the PVC pipe into the bottle, it displaces some water due to which the level of water inside the bottle increases slightly.
3. Therefore, the water level goes a little higher than the height of the straw. So, water starts to drain out from the straw.
4. As air can't get inside the straw now, the drained water is replaced by more water from the bottle.
5. The water would continue to flow until the entire bottle becomes empty!

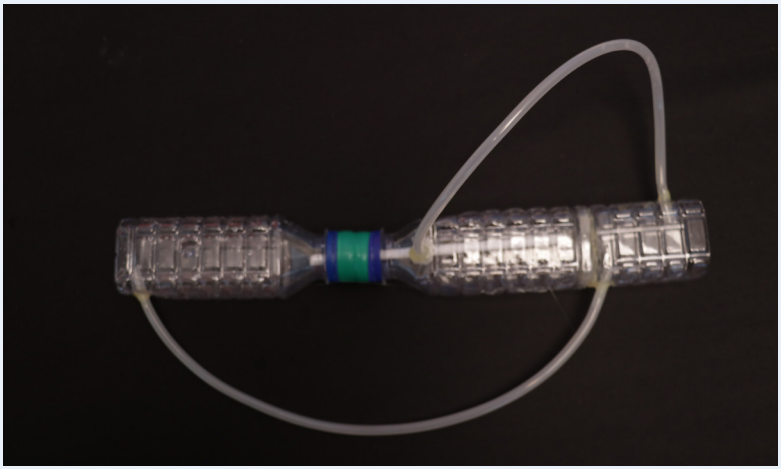
ANTI-GRAVITY FOUNTAIN

LEARNINGS

- Pressure
- Force
- Siphon

MATERIALS REQUIRED

- Three Plastic Bottles
- Flexible Tube
- Hard Straws
- Tape

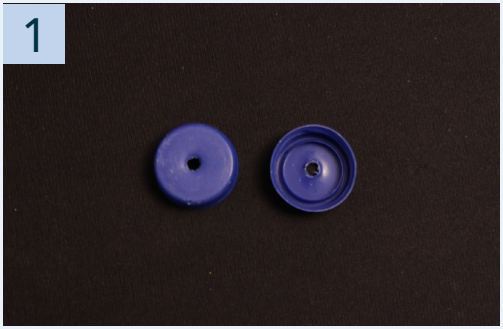


In this fountain, water seems to be going against gravity, defying the laws of physics! The famous name, Heron's Fountain, derives its name from a Greek mathematician, Heron, who invented this fountain in 120 B.C.

WHAT TO DO?

1. Take two empty water bottles and stick their caps together.
2. Make a hole in the middle of both caps and pass a stiff straw through them.
3. Take another bottle and cut its bottom portion. Join it to another bottle using glue gun.
4. Make two holes in half bottle, one near the top and one near the bottom.
5. Make holes (one each) in the other two bottles. Using flexi tube, connect the three bottles.
6. Fill the half bottle with colored water - it will go to the bottom bottle. Now flip the model - this will transfer all the water from bottom bottle to middle bottle.
7. Now we are ready for the final experiment - add some water to the half bottle and water will start to flow against gravity!

1

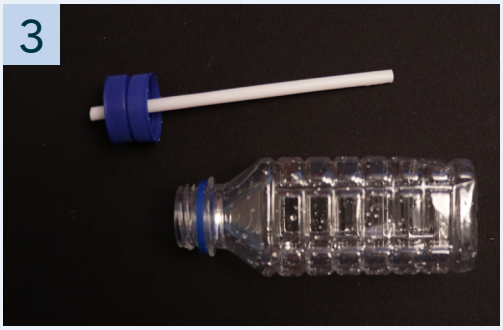


Make holes in the caps of both the bottles using scissors. Join them using glue.

2

Make holes in the half bottle at the top and bottom. Make holes (one each) in the other two bottles.

3

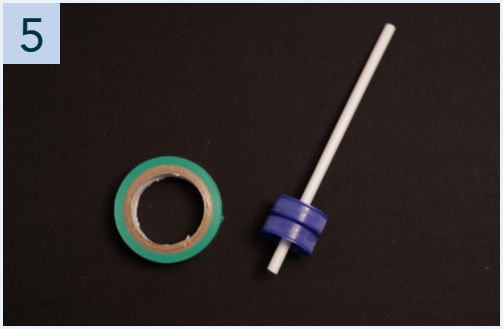


Pass a stiff straw through the two caps.

4

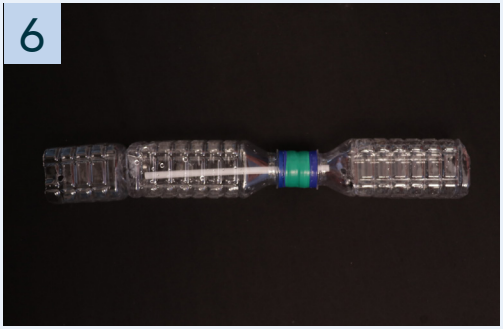
Apply glue to make the connection airtight.

5



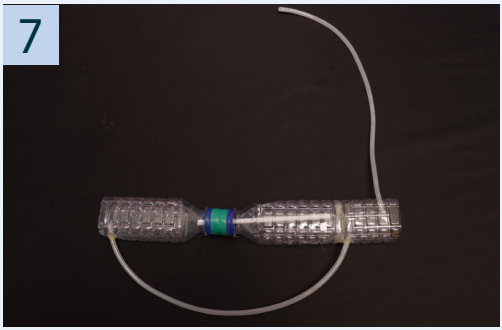
Apply some tape also, if required.

6



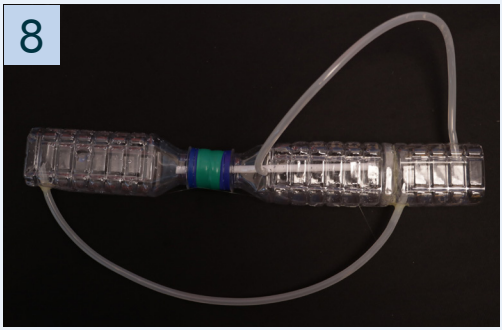
Stick the half bottle to the bottle with the longer straw.

7



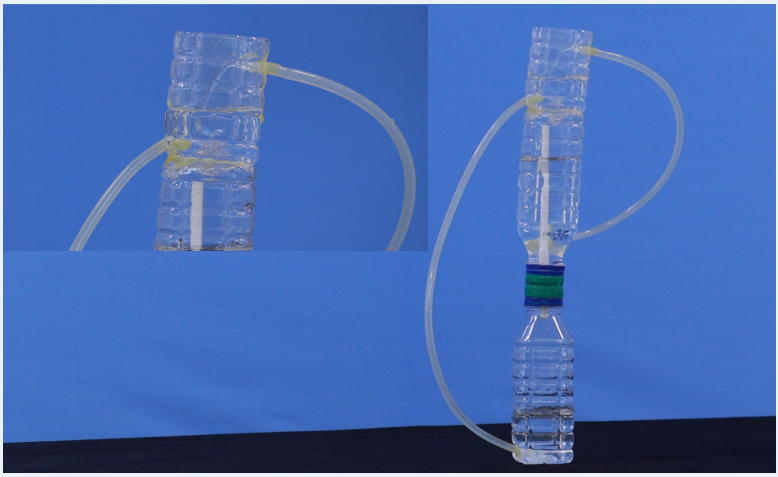
Join the half bottle and bottom bottle together as shown.

8



Join the half bottle and middle bottle together as shown.

NOTES



WHAT'S GOING ON?

1. As you add water in the half bottle, it goes to the bottom bottle.
2. Air is expelled from the bottom bottle to the middle bottle (through the stiff straw). This increases the pressure of air inside the middle bottle.
3. This increased pressure forces the water upwards, to the half bottle as a fountain!
4. At first glance, it feels like the water is really going against gravity but if you look closely, you would find that water is actually going from the middle bottle to the bottom bottle *through* the half bottle at the top. The flow stops when all the water from the middle bottle is drained.

EXPLORE

1. The first time that the fountain is demonstrated, it has all the appearances of a perpetual motion machine. It takes close observation to see that the height of the water in middle container is constantly decreasing. Find out more about perpetual motion machines. Are they possible?
2. Have you wondered how people had fountains before electricity was invented?

HEIGHT MIGHT

LEARNINGS

Pressure

Kinetic Energy

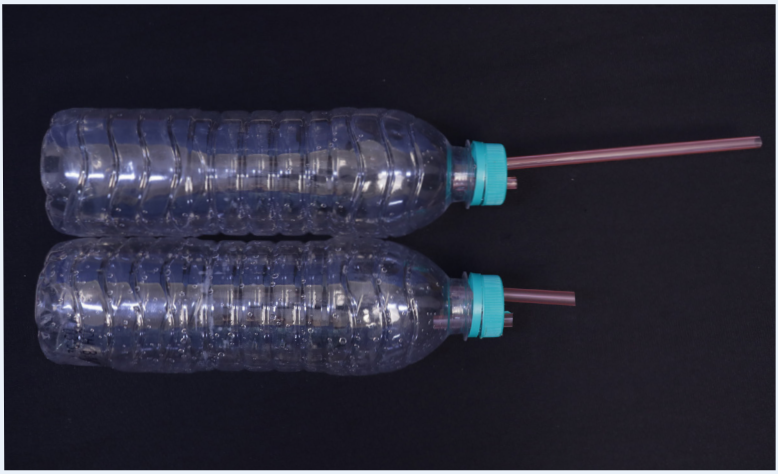
MATERIALS REQUIRED

Bottle

Straws

Glue

Scissors

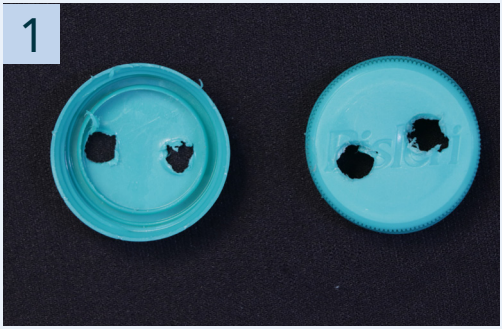


Two similar bottles (with one slight difference) are filled full with water. The question: on upturning the bottles together, which one will empty out first? Normally one would expect both the bottles to empty out together. But something unexpected happens!

WHAT TO DO?

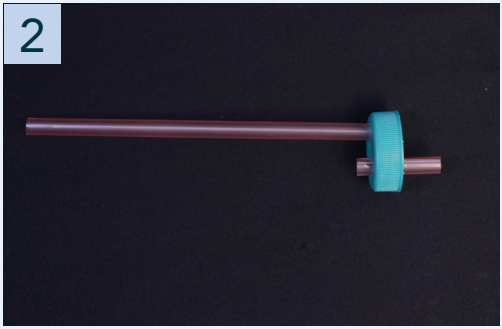
1. Take two plastic bottles and make two holes in each cap using scissors.
2. Take two stiff straws. Cut the straw in the first cap such that both the pieces are 3 cm long and put these straw pieces into first bottle cap.
3. Cut the straw in second cap such that the pieces are 3 cm and 12 cm long.
4. Apply glue on the joints for making them airtight.
5. Fill two bottles fully with water. Close the bottles and invert them simultaneously. Which bottle will drain out first?

1



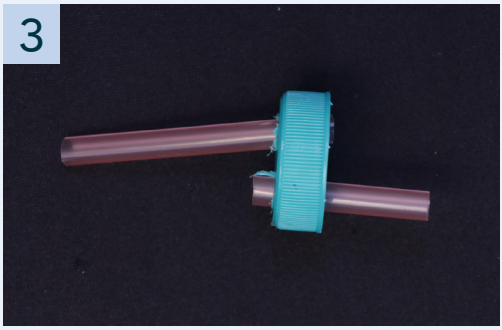
Make two holes in each cap using scissors.

2



Cut the straws in the first cap such that the pieces are 3 cm and 12 cm long.

3



Cut the straws in the second cap such that both the pieces are 3 cm long.

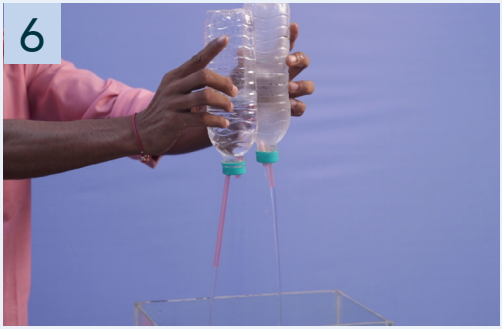
4

Apply glue on the joints for making them airtight.

5

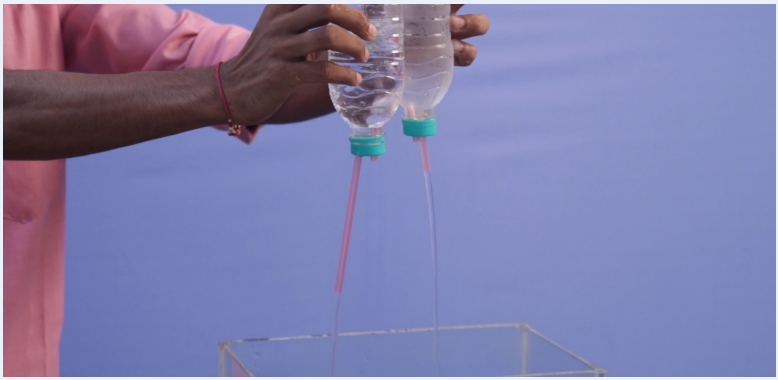
Fill the bottles with water and close them.

6



Invert both the bottles together.

NOTES



WHAT'S GOING ON?

1. The speed of water at the outlet of the straw would depend on the height of water on its top.
2. So the bottle with longer straw has a longer column of water above the outlet. Therefore, the liquid comes out with higher speed from the straw and drains out faster.
3. You can also confirm this by poking holes at different heights in a bottle. The holes near the bottom of the bottle would shoot water farthest.

EXPLORE

1. Water from the overhead tank always comes out at a higher speed on the ground floor of a building compared to the top floor. Can you think of other examples in real life?
2. You can use bendable straw at the bottom and bend it parallel to the ground. This way, you can clearly see that the water coming out of the longer straw has more range compared to the shorter straw (meaning, it falls farther away from the bottle). This also shows that the water from longer straw comes out at a higher speed.
3. Each bottle has two straws at the bottom. Why does the water come out only through the longer straw?
4. Try the same experiment with only one hole in the cap. After some time, the water stops coming out of the bottle. Why? What would happen if you attach a really long pipe to that one hole and hold the bottle really high?

BOYLE'S SYRINGE

LEARNINGS

Gas Laws

Pressure- Volume Relationship

Boyle's Law

MATERIALS REQUIRED

50 ml syringe

Balloon

Can you shrink and expand a balloon without touching it? Let's find out. Wear your magician's hat and surprise everyone with this experiment.

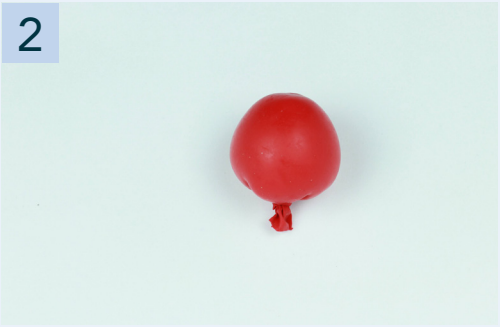
WHAT TO DO?

1. Take out the plunger from the 50 ml syringe and place the balloon inside the syringe.
2. Close the front opening of the syringe using your finger and push the plunger forward.
3. You will see the balloon shrinking in size. Now open the front opening by removing your finger and the balloon would return to its original size.
4. Again close the front opening and pull the plunger out. The balloon would become larger covering the whole volume of the syringe!

1

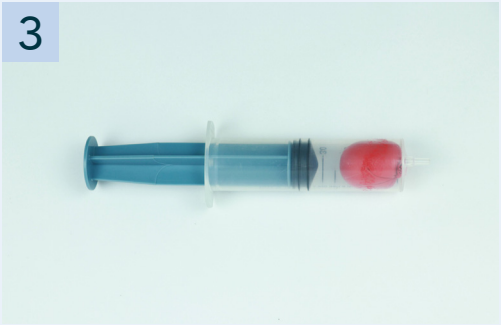
Material required for this activity.

2



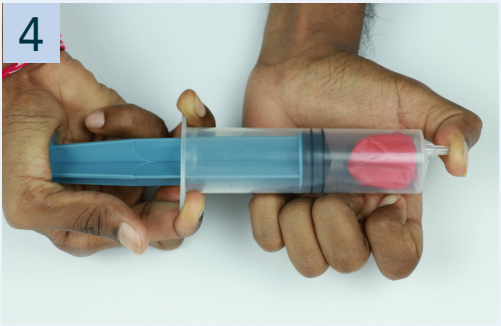
Fill up the balloon with a little air.

3



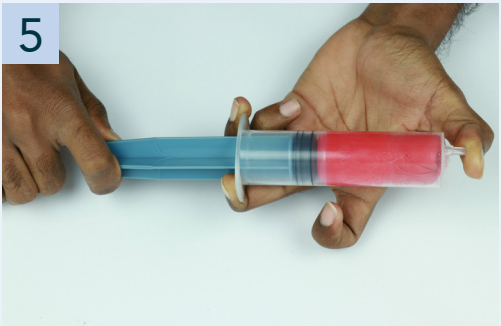
Place the balloon inside the syringe.

4



Close the discharge orifice at the front using your finger and push the plunger forward.

5



Again close the orifice and pull the plunger out- the balloon would become larger covering the whole volume of the syringe!

NOTES

WHAT'S GOING ON?

1. When you close the front opening of the syringe and push in its plunger, the pressure inside the syringe increases.
2. Due to this, the pressure inside the balloon also increases. Therefore, the volume of the balloon decreases. This is due to Boyle's law. It states that the pressure and volume of a gas are inversely proportional to each other.
3. Next, when you slowly pull the plunger out (and the small opening at the front is closed), the pressure inside the syringe (and hence, the balloon) decreases. Therefore, the balloon expands in size and covers almost the entire syringe.

EXPLORE

Breathing is also an example of Boyle's law. When you breathe in, the volume of the lungs increases - reducing the pressure inside them. This forces the outside air to go inside the lungs. When you exhale, the volume of lungs decreases and therefore the pressure increases. This causes the air to move out from the lungs into the atmosphere.

AIR GUN

LEARNINGS

Boyle's Law

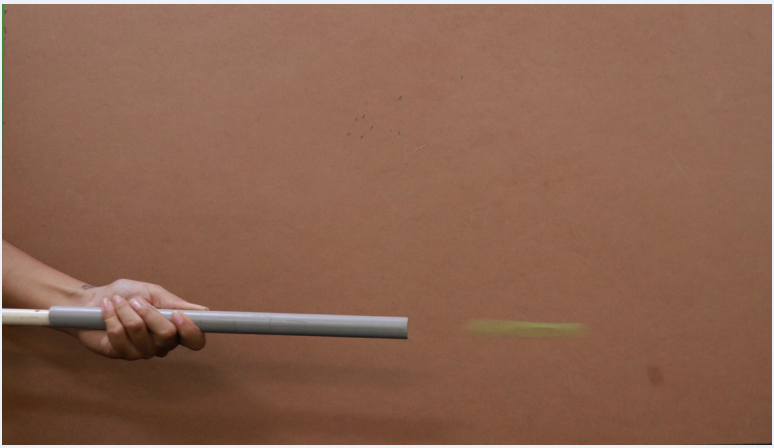
Pressure-Volume Relationship

Conservation of Energy

MATERIALS REQUIRED

PVC Pipes

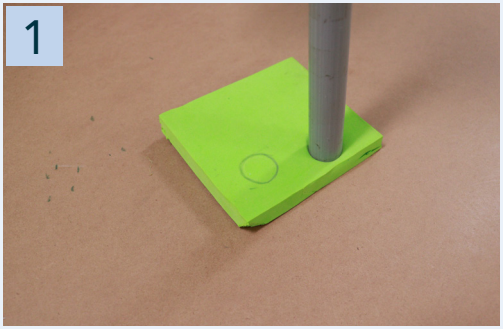
EVA Sheet



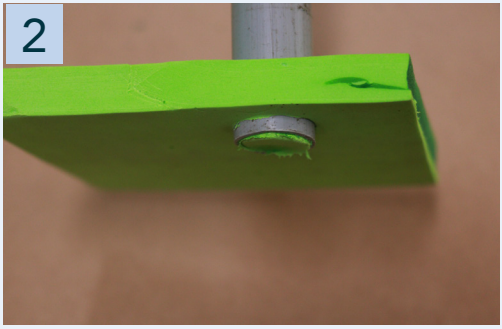
This simple and fun toy beautifully demonstrates the power of compressed air. Have a friendly battle with your friends where everyone comes armed with understanding of Boyle's Law.

WHAT TO DO?

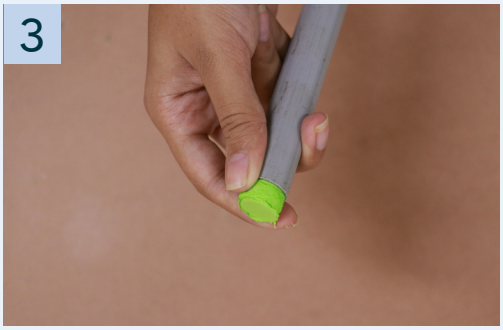
1. Take a PVC pipe and press it hard against the EVA sheet so that it is cut into a circular disc.
2. Make two discs in the same way. These discs would be used as plugs to close the pipe.
3. Fix the discs at both the ends of the PVC pipe.
4. Take another pipe and push the plug in quick motion from one side.
5. The disc from the other side would fly off with great speed.



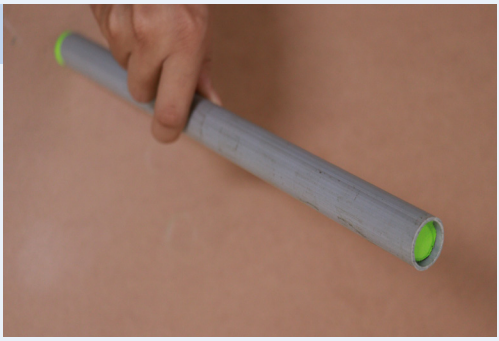
Press the pipe hard against the EVA sheet so that it is cut into a disc.



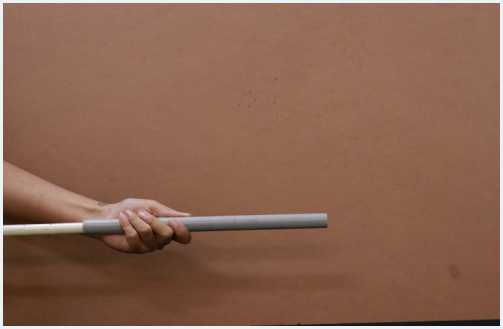
Make two such disks in the same way.



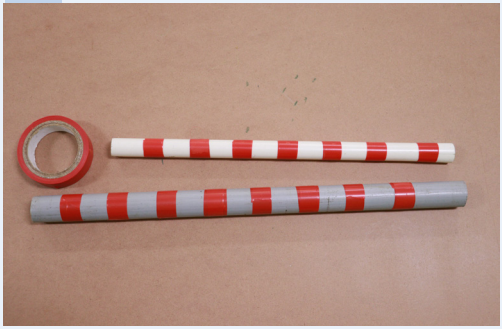
Fix the discs at both ends of the PVC pipe.



The PVC pipe would be closed from both ends after this.

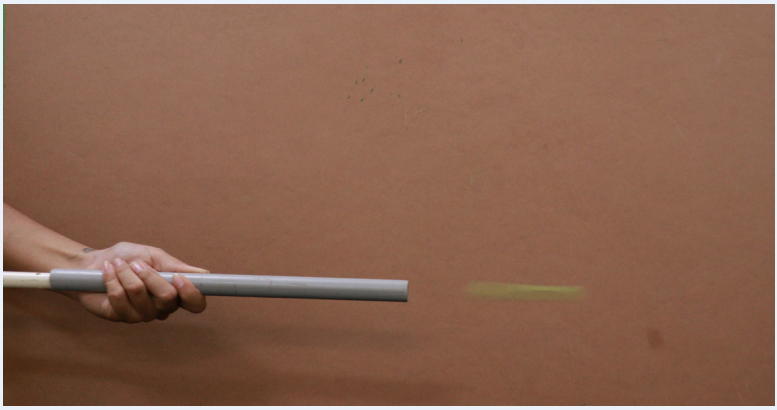


Your Air Gun is ready. Take a pipe and push the plug in quick motion from one side.



You can decorate your air gun as you want.

NOTES



WHAT'S GOING ON?

1. The PVC pipe is closed from both ends by the EVA plugs.
2. When you push one plug with the pipe, the same air is confined to a small space. Therefore, the pressure of air inside the PVC pipe increases.
3. This is called Boyle's Law which states that pressure exerted by a gas is inversely proportional to the volume it occupies (and the temperature and amount of gas remain unchanged).
4. This means that as the volume of a gas decreases, the pressure it exerts on the container increases. When the volume of the container is halved, the pressure is doubled.
5. This compressed air pushes the plug on the other side - making it fly off!

EXPLORE

1. Use pipes of different sizes and different objects as plugs and observe the difference.
2. Place the EVA plug at different locations in the pipe and find out which location results in maximum speed of the plug.

CAUTION: Don't aim any hard plug towards a person or a breakable object otherwise it may cause damage.

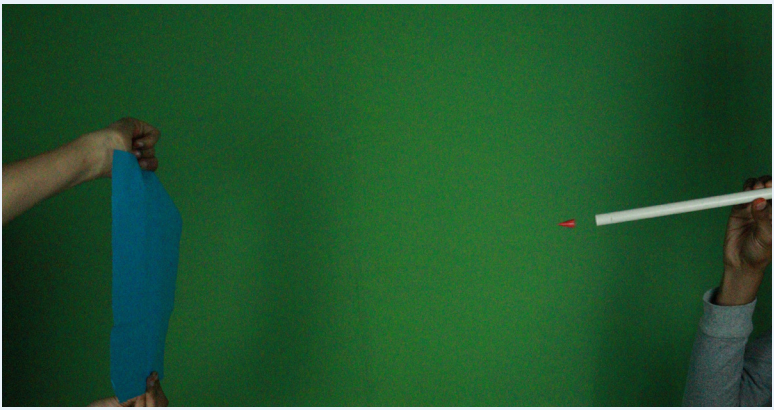
BLOW DART

LEARNINGS

- Gas Laws
- Boyle's Law
- Pressure-Volume Relationship

MATERIALS REQUIRED

- PVC Pipe
- Paper
- Cutter
- Glue
- Tape

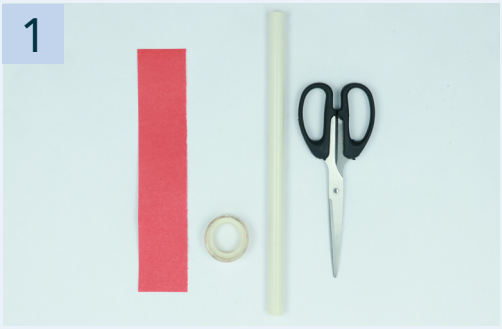


Make a blow dart using paper, hang a dartboard on a wall and play a game of darts with your friends!

WHAT TO DO?

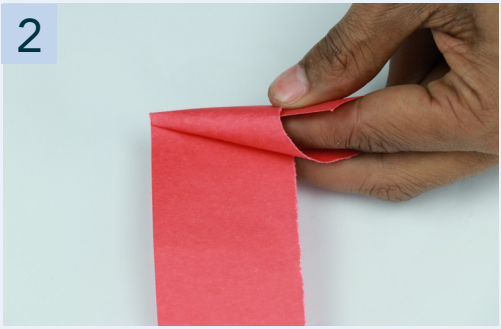
1. Make a paper cone with the help of paper and glue. Stick some tape on the cone to make it hard.
2. Make sure the diameter of the base of the cone is exactly equal to the diameter of the PVC pipe.
3. Insert the cone inside the pipe such that the pointy end of the cone faces forward and the open end faces towards you.
4. Blow inside the pipe with full force. The paper cone comes out of the pipe with a very high speed.
5. Place a newspaper in front of the cone and it would make a hole in it.

1



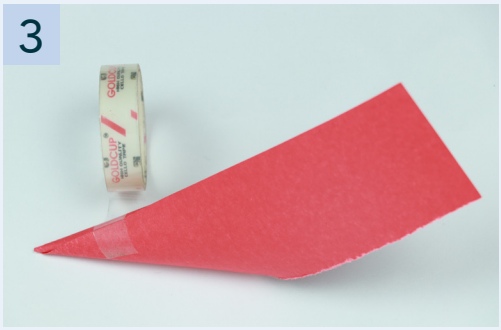
Material required for this activity.

2



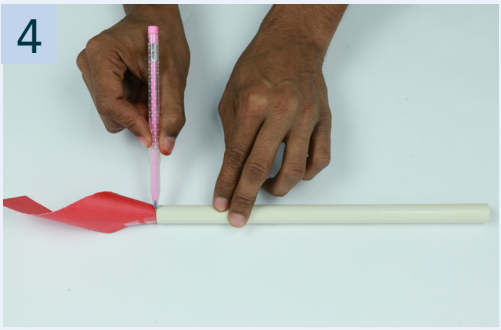
Make a cone by rolling a paper.

3



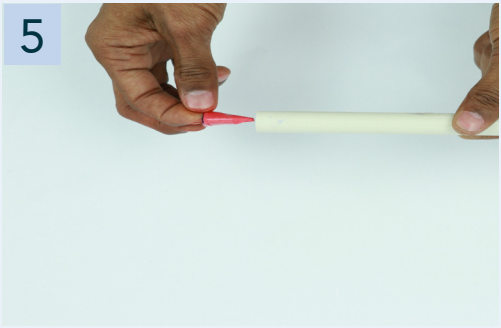
Apply some tape and glue to make it hard.

4



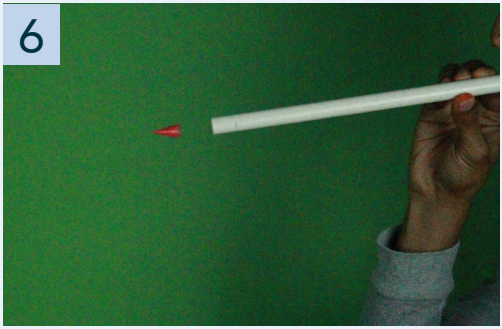
Insert the paper cone inside the PVC pipe and cut the extra paper.

5



Insert the cone inside the pipe such that the pointy end of the cone faces forward and the open end faces towards you.

6



Blow inside the pipe with full force.

NOTES

WHAT'S GOING ON?

1. When you blow air with your mouth, the air is confined to a small space. Therefore, the pressure of air inside the PVC pipe (between your mouth and the paper cone) increases.
2. This is due to Boyle's Law which states that pressure exerted by a gas is inversely proportional to the volume it occupies (and the temperature and amount of gas remain unchanged).
3. This means that as the volume of a gas decreases, the pressure increases. When the volume of the container is halved, the pressure is doubled.
4. This compressed air pushes the paper cone on the other side - making it fly off!

EXPLORE

1. Decide on a small target. Stand far from it and try to hit it with the dart.
2. Does the dart still work if you slowly blow air from your mouth? Why?

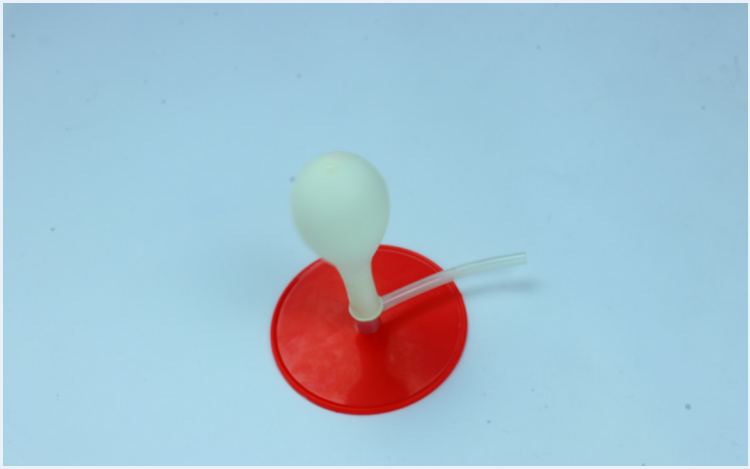
CAUTION: Do not hit another person using this dart. It may injure the eyes or other body parts depending on the sharpness.

CD HOVERCRAFT

LEARNINGS

Pressure

Friction



Make a working hovercraft from a disc and other everyday objects.

MATERIALS REQUIRED

Disc

Plastic cylinder

Balloon

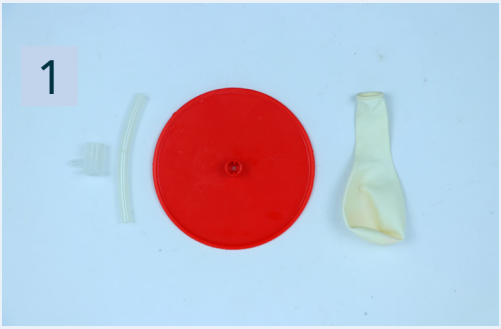
Flexible Tube

Rubber Band

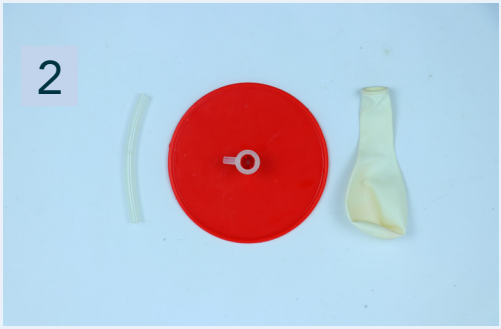
Tape

WHAT TO DO?

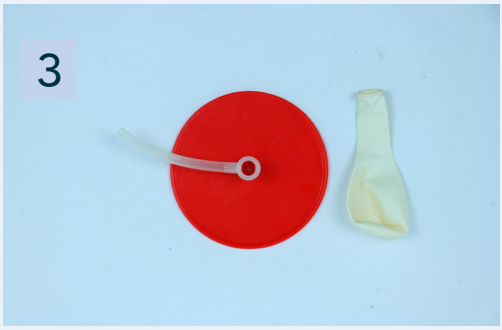
1. Add the cylindrical attachment to the center of the disc.
2. Attach the flexi tube to the attachement. Tie a balloon on the top using rubber band.
3. Now cover the hole in the bottom of the disc using your finger and inflate the balloon using the flexi tube.
4. You can also bend the flexi tube and stick it in this configuration using tape. The disc would also start to rotate!



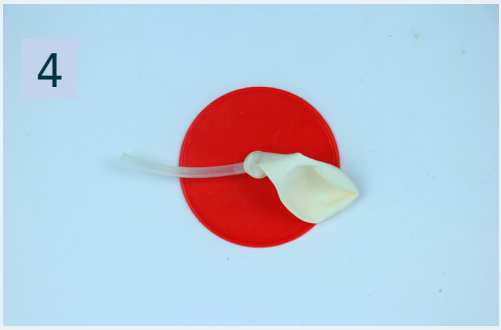
Material required to make the hovercraft.



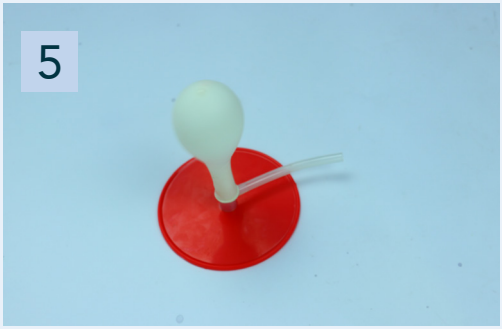
Add the cylindrical attachment to the center of the disc.



Attach the flexi tube to the attachment.



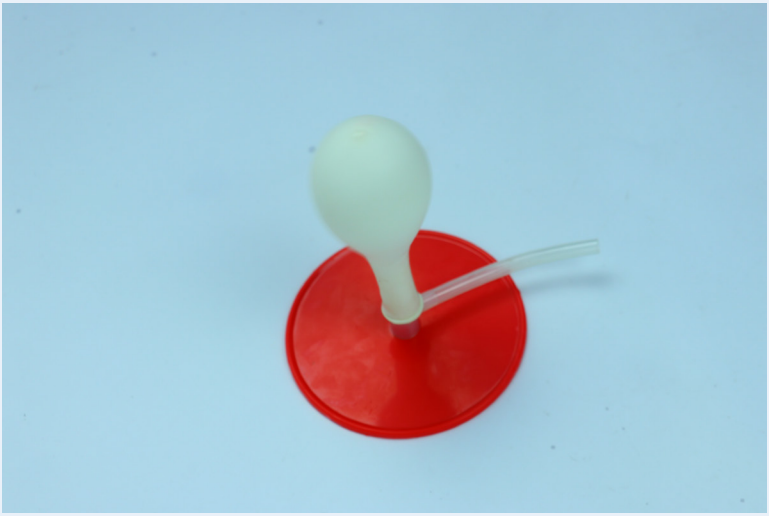
Tie a balloon on the top using rubber band.



Inflate the balloon using the flexi tube and let it go. The disc would hover on the ground.

You can also bend the flexi tube and stick it using tape. The disc would also start to rotate!

NOTES



WHAT'S GOING ON?

1. When you inflate the balloon and let it go, the air escapes from the bottom hole.
2. The disc skims smoothly on the cushion of air - due to low friction. Therefore, the Hovercraft gently glides on the plane surface.
3. When the flexi tube is bent, the escaping air also rotates the disc because the rection force doesn't pass through the center of mass and generates a torque.
4. Once the balloon gets deflated, the Hovercraft stops working and needs a refill.

EXPLORE

1. Hovercrafts create a cushion of air beneath them, and can glide on both water and land, making them an amphibian vehicle.
2. Unlike a helicopter, the objective of a hovercraft fan is not to completely lift it in air, but to just create a cushion of air beneath it on which it can glide. Therefore, it uses much less energy compared to a helicopter.

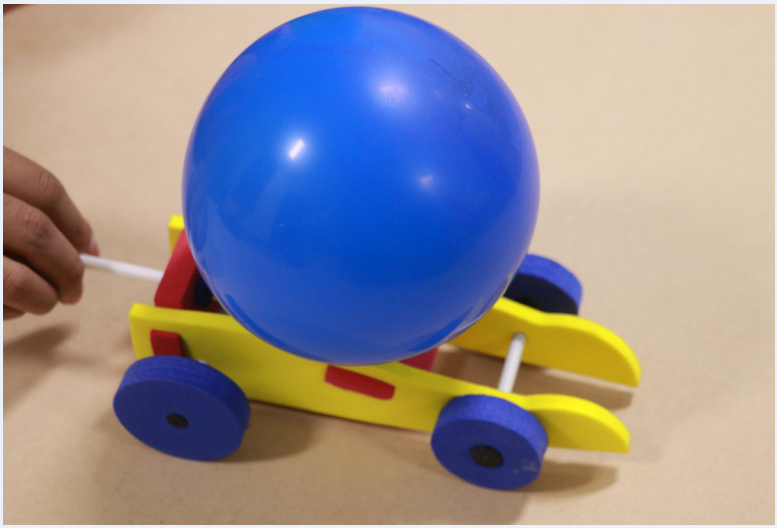
AIR POWERED CAR

LEARNINGS

- Newton's Third Law
- Conservation of Energy
- Potential Energy
- Kinetic Energy
- Pressure

MATERIALS REQUIRED

- EVA Pieces
- Stiff Straw
- Cycle Spoke
- Balloon
- Motor
- Fan
- Rubber Bands

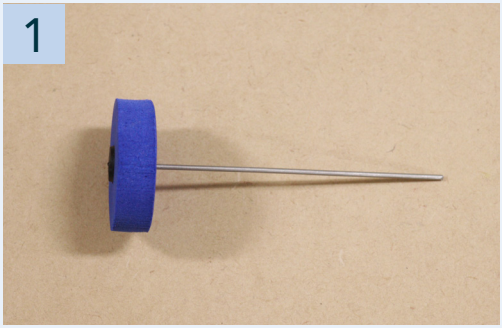


This air-powered car is your own race car which uses air pressure to zip it across a surface. This toy beautifully demonstrates how wind energy can be used to propel an object based on Newton's third law.

WHAT TO DO?

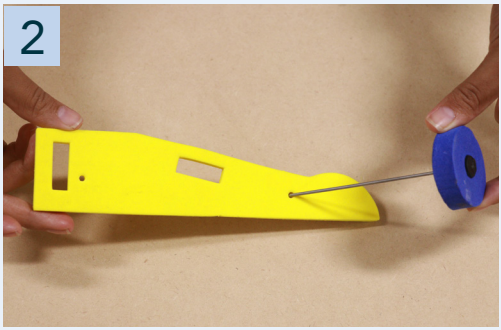
1. Make the car base using the given pieces. Attach the wheels using cycle spokes and straws.
2. Attach a balloon to the stiff straw using rubber band.
3. Also attach the small piece to hold the motor.
4. Attach a fan to the shaft of the motor.
5. Now the car can be powered by two methods. You can either inflate the balloon (and let go) or switch on the fan.
6. The car will move forward in both cases using air!

1



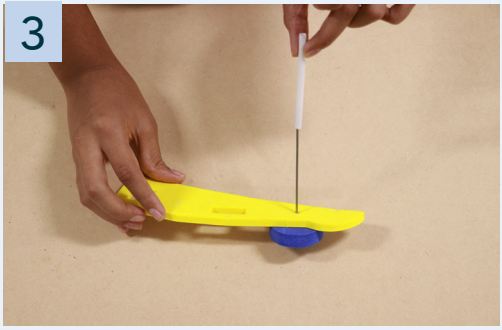
Insert cycle spokes in the big and small wheel.

2

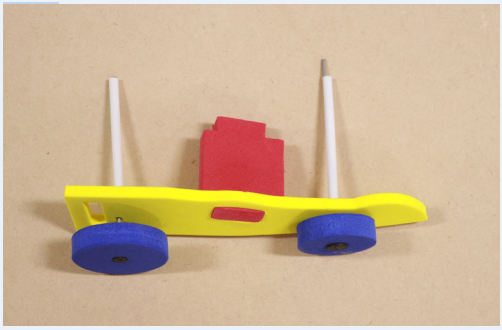


Pass the cycle spoke through the car base.

3

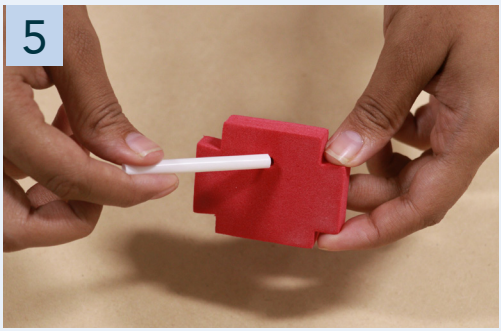


Add the straw on the spoke.



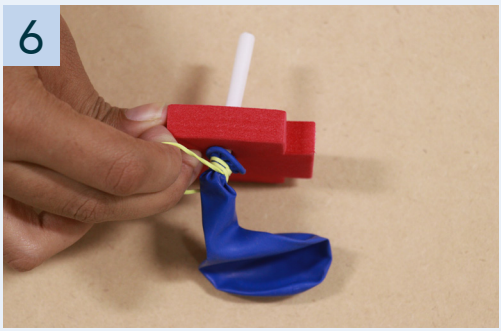
Do this for both the wheels and attach the red EVA piece.

5



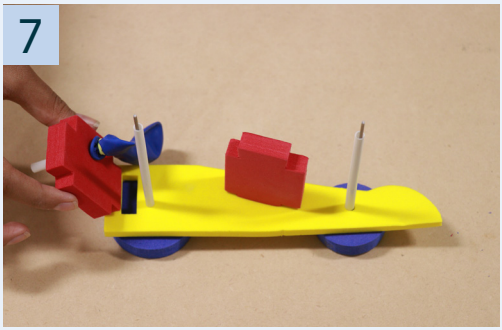
Insert the straw in the other EVA piece.

6



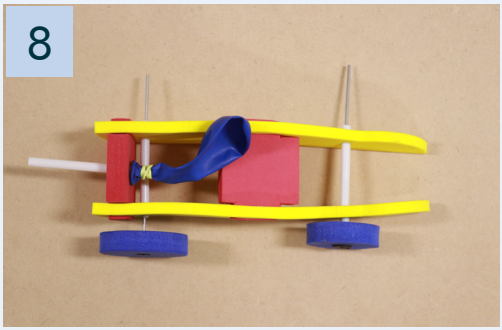
Attach a balloon to one side of the straw. Secure the balloon with the help of a rubber band.

7



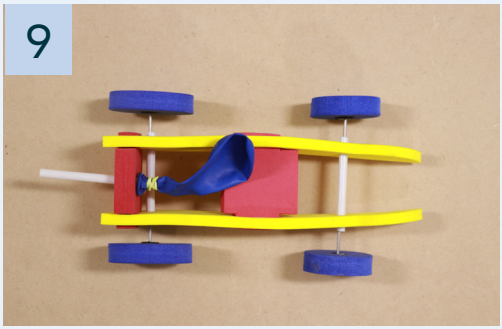
Attach the second piece to the main body such that the balloon is inside and the straw outside.

8



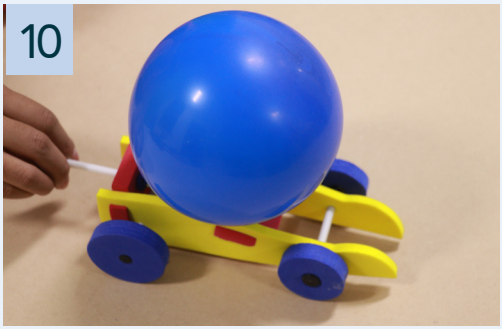
Start by fitting the center piece which is shown.

9

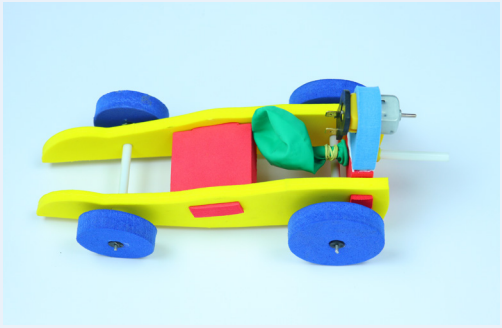


Add the second set of wheels.

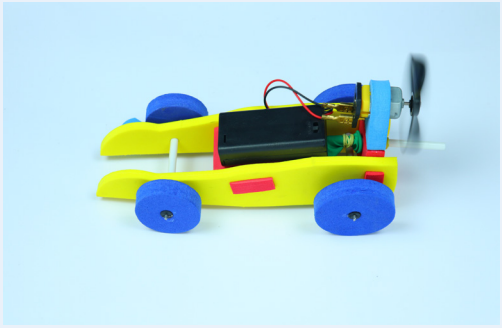
10



Inflate the balloon and let it go.



Insert the motor in the EVA hole stick the holder on the car.



Attach the fan to the motor shaft. Connect the terminals of the motor with the battery holder wire.

NOTES

WHAT'S GOING ON?

1. The balloon (or the fan) throws air behind the car which drives the car forward.
2. This is the car's propulsion system. The principle at work is Newton's Third Law of Motion: for every action, there is an equal but opposite reaction.
3. In the case of this Air-powered Car, the air coming out from the straw is the action. The air pushing against the car with the same force (in the opposite direction) is the reaction. This reaction force causes the forward motion of the car.
4. As you fill the balloon with air, you provide it potential energy. The potential energy of the balloon is converted to kinetic energy when the car moves.
5. The fan is powered by an electric motor which runs on a battery. The electrical energy of the battery is converted to kinetic energy when the car moves.

EXPLORE

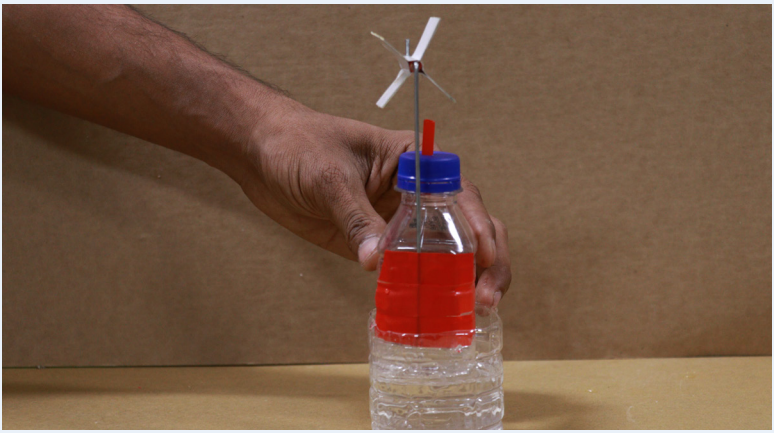
1. Create fun designs and colors on your car to really make it your own.
2. Change the size of the wheels to determine how that might affect the distance and direction your car travels.
3. Test different lengths and diameters of the propulsion straw to see which exhaust system supplies the most thrust.
4. Test different balloons to find the ideal balloon for the best speed and best distance traveled. The balloon suitable for maximum speed may not move the car to a maximum distance.
5. Organize a race for different balloon cars!

BOTTLE TURBINE

LEARNINGS

Pressure

Kinetic Energy



Created by a 9-year old Durga from a small village in Maharashtra, this bottle turbine has the moniker “Durga Jetty”. The story goes that one fine afternoon, bored, Durga picked up a couple of things lying around and started tinkering. What emerged out of it is a simple representation of a tidal turbine and a scholarship for Durga to get through school and college!

MATERIALS REQUIRED

Two plastic bottles

Thick Paper

Stiff Straw

Cycle spokes

Scissors

Tape

Glue

WHAT TO DO?

Take bottle cap, Straw piece, wire, bead and card sheet - use them to make the turbine assembly. fix it on a bottle, cut the base of the bottle. Now take a bigger bottle and cut it from top, and fill it with water. Now, move the smaller bottle up and down in water and observe. the fan on top spins when we move the bottle down.

1

Cut the base of the smaller bottle.

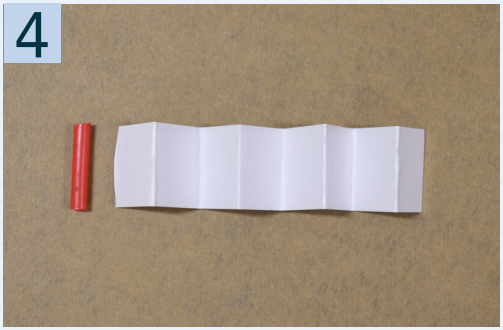
2

Make a hole in the bottle cap and insert a stiff straw. Seal it with glue.

3

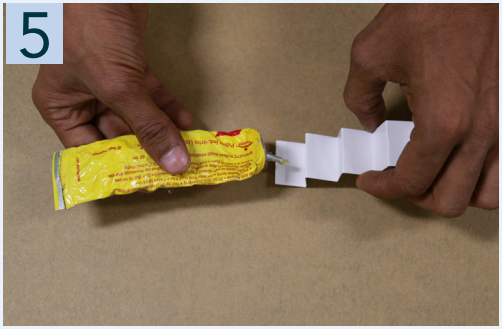
Cut the bigger bottle to make a container for the water.

4



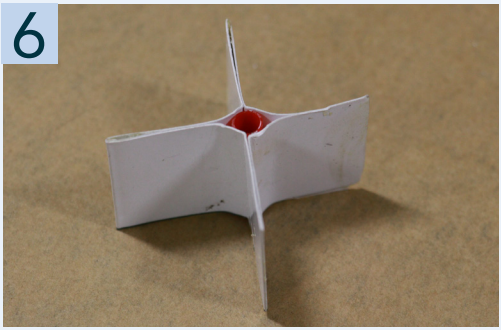
Make about 8 folds on the strip to stick around another small piece of the stiff straw.

5



Use glue to stick the strip to the straw.

6

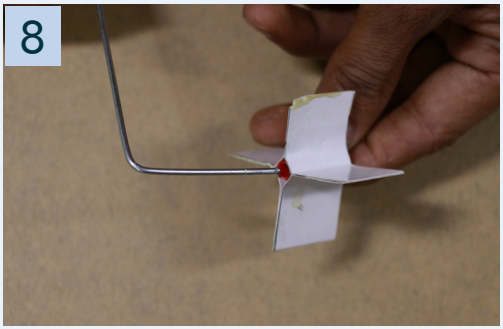


The turbine would look something like this.

7

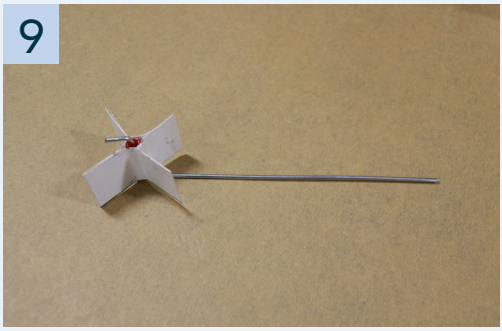
Take a cycle spoke and bend it at 90° after about 5cm.

8



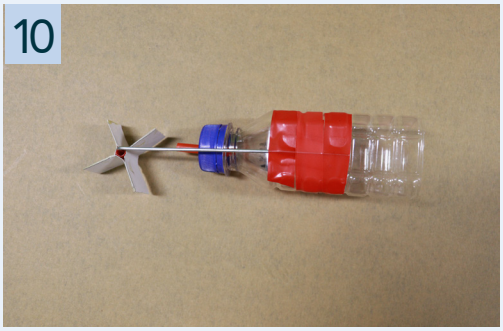
Insert the bent part of the cycle spoke in the straw of the turbine.

9



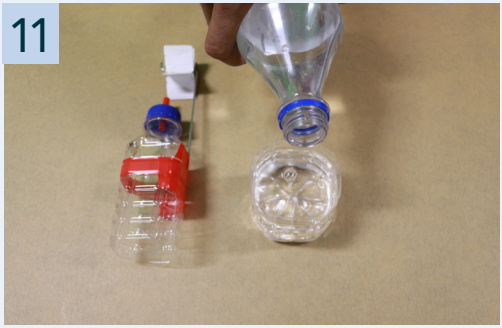
Bend the cycle spoke from the other end to stop the wheel from falling out.

10



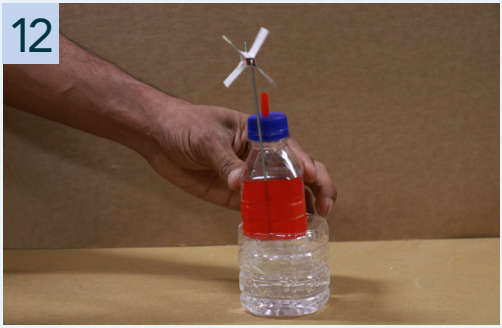
Stick the cycle spoke to the smaller bottle using tape. The Bottle Turbine is ready.

11



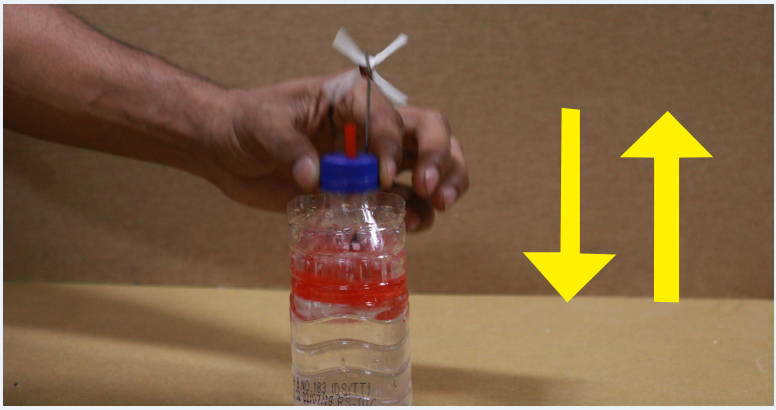
Fill the larger bottle with water.

12



Move the turbine up and down in the water and the fan would start to spin.

NOTES



WHAT'S GOING ON?

1. When the bottle is pushed down (inside the bigger bottle), water is filled inside the bottle and the air in the bottle is expelled out through the hole at the top.
2. When you move the bottle up and down in water, you are using your own energy (which you got from the food) to create motion (kinetic energy).
3. This air falls on the blades of the turbine and rotates it.

EXPLORE

1. Can you make a generator using the turbine? Connect some magnets to the turbine and rotate it inside a copper coil.
2. Which factors affect the speed of the spinner? Find out whether you should use a bigger bottle or smaller, number of blades of the turbine, area of the blades, etc. Create different versions of the model by varying these parameters and see which combination works best.

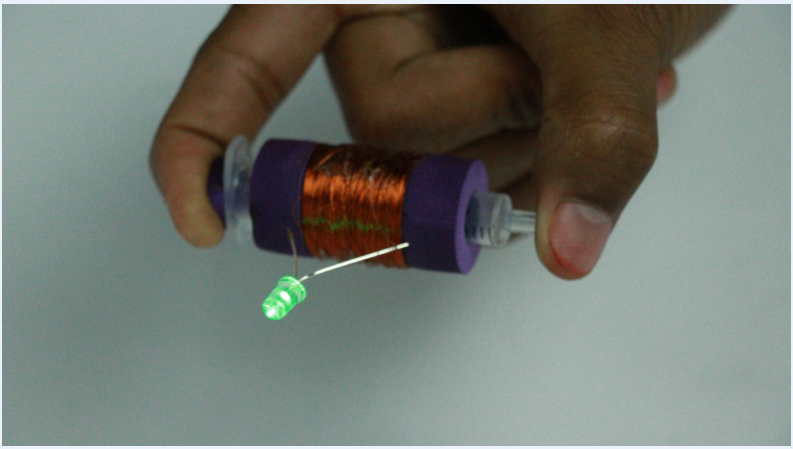
SYRINGE GENERATOR

LEARNINGS

- Electricity
- Magnetism
- Electromagnetic Induction
- Conservation of Energy

MATERIALS REQUIRED

- Syringe
- Copper Wire
- Neodymium Magnet
- LED
- Scissors



This is world's simplest generator which generates electricity using just a syringe, some wire and a magnet! So light the LED using some freshly produced electricity.

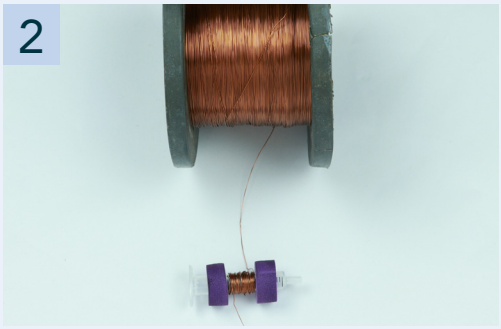
WHAT TO DO?

1. Wind the insulated copper wire on the syringe such that most of the wire remains in the middle of the syringe. Don't spread the wire too much on the syringe.
2. Make sure that you have at least 800 turns of wire on the syringe.
3. Remove insulation from both ends of the wire using scissors (you can also burn the insulation) and attach the two terminals of LED to both ends of the wire.
4. Insert a neodymium magnet inside the syringe. Shake the syringe back and forth and the LED would start to glow!

1

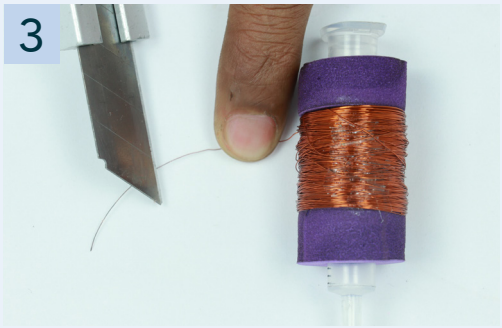
Pass the syringe through the two EVA sheet pieces as shown.

2



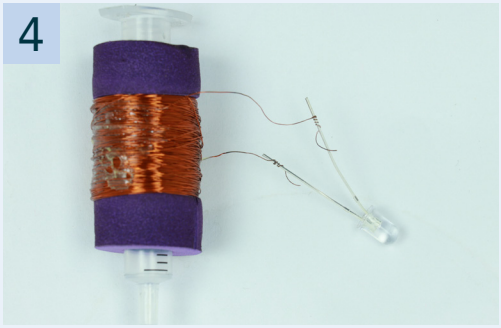
Wind the insulated copper wire on the syringe such that most of the wire remains in the middle of the syringe.

3



Remove insulation from both ends of the wire using scissors (you can also burn the insulation).

4

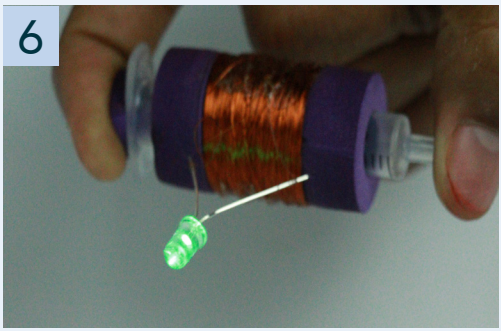


Attach the two legs of LED to both ends of the wire.

5

Place a neodymium magnet inside the syringe and close its open end.

6



Move the magnet inside the syringe by shaking the syringe back and forth, the LED starts to glow!

NOTES

WHAT'S GOING ON?

1. Whenever there is a relative motion between a conductor and a magnet (either the magnet moves or the conductor moves), there is a voltage generated across the conductor. This is called electromagnetic induction.
2. In the case of syringe generator, the copper coil is the conductor which is wrapped around the syringe and the magnet moves inside the syringe.
3. Some of the kinetic energy of the magnet gets converted to electrical energy. This also means that the magnet becomes slower when it moves through the coil.
4. The moving magnet inside the syringe produces voltage across the copper wire, which lights up the LED.
5. Most of the electricity we get in our houses is generated by this process of electromagnetic induction.

EXPLORE

1. Some energy is required to light up the LED. Where is that energy coming from? From the shaking of hands. The hand gets the energy from the food you ate in the morning. The energy in the food comes from the sun. So, the syringe generator is actually a solar generator!
2. When exactly does the LED glow? When the magnet is going inside the coil or when it is coming out? Voltage would be generated in both cases but the polarity of voltage would be different in both cases. Interestingly, LED only lights up when the longer leg is connected to the positive terminal. It won't glow in the opposite situation (when the longer leg is connected to the negative terminal). So the LED will light up only during one case - either when the magnet is going inside the coil or when it is coming out.
3. You can also check the above by placing the coil at one end of the syringe, instead of placing it in the middle. Then if you shake the magnet inside, it will light up only when the magnet is generating positive voltage on the longer leg of the LED. If you put the magnet in reverse direction inside the syringe, the LED won't light up.

MAGNETIC BRAKES

LEARNINGS

- Electromagnet
- Magnetism
- Eddy Currents
- Transformers
- Conservation of Energy
- Heat

MATERIALS REQUIRED

- Aluminium Pipe
- Neodymium Magnet

How are the bullet trains stopped? At such high speeds, the normal brakes which rely on friction and direct contact would be susceptible to brake wear and overheating. Therefore magnetic brakes are also used, which can stop the train without any contact.

WHAT TO DO?

1. Take the aluminium pipe and a neodymium magnet. The diameter of the magnet should be almost same as the diameter of the pipes.
2. Drop the neodymium magnet through it. Observe.

NOTES

WHAT'S GOING ON?

1. The magnetic field in the pipe keeps changing when the magnet falls through it.
2. Let's assume you put the magnet inside the pipe such that the north pole is facing downwards.
3. The changing magnetic field would induce current in the pipe known as eddy currents.
4. These eddy currents create a magnetic field in a direction which opposes the fall of the magnet.
5. In the area of the pipe below the magnet, the induced current produces a magnetic field such that its north pole is facing upwards. This will repel the magnet upwards.
6. In the area of the pipe above the magnet, the induced current produces a magnetic field such that its north pole is facing downwards. This will attract the magnet upwards.
7. As a result of this magnetic attraction and repulsion, the magnet falls much more slowly than the normal fall. You can easily catch the magnet with the same hand from which you drop it

EXPLORE

1. When the magnet is dropped from the top of the pipe, the potential energy should have been converted to kinetic energy of the magnet. But the magnet comes out slowly from the pipe. Where does the energy finally go? The eddy currents in the pipe generate heat and increase the temperature of the pipe.
2. After some time, the magnet comes down with a constant speed. This is because as the speed of the magnet increases, the strength of eddy current increases. At some time, the magnetic forces become equal to the gravitational force. And the magnet comes down with that speed.
3. Eddy currents are often generated in transformers,

leading to power losses. To combat this, thin laminated strips of metal are used in the construction of power transformers, rather than making the transformer out of one solid piece of metal. The thin strips are separated by insulating glue, which confines the eddy currents to the strips. This reduces the eddy currents, thus reducing the power loss.

4. Does the amount of heat/current generated depend on the mass of the magnet or just on the magnetic field.

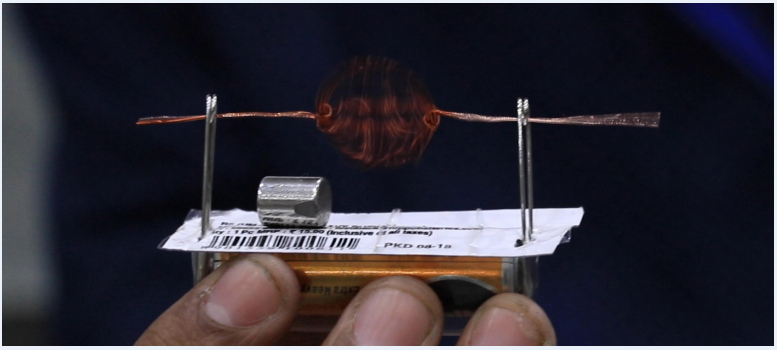
DC MOTOR

LEARNINGS

- Electricity
- Magnetism
- Torque
- Electromagnetic Induction
- Faraday's law
- Fleming's Left Hand Rule

MATERIALS REQUIRED

- AA Battery
- Magnet
- Wire
- Safety Pins
- Scissors



A motor is a device which converts electrical energy to mechanical energy. They are so ubiquitous (fans, watches, electric vehicles, pumps etc) that it is hard to imagine our lives without them. But have you made a motor yourself? Let's make a working DC motor using simple raw materials!

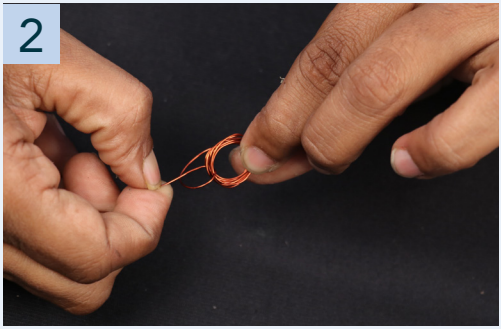
WHAT TO DO?

1. Take around 1 feet long insulated copper wire and wind the wire around your finger (4-5 turns) such that there is around 4 cm of straight wire on each side.
2. Tie knots on both sides such that both the knots are diametrically opposite.
3. From one side, scrape off the insulation completely using scissors. From the other side, remove insulation from three sides of the wire. One-fourth of this side should have insulation on it. This insulation will act like a brush or a commutator for the motor which would break the circuit in between.
4. Fix two safety pins such that one touches the positive terminal and the other one touches the negative terminal of the battery.
5. Place the coil in the round loops of the safety pins.
6. Place a magnet in the middle of the battery and the motor would start to rotate! You may have to flick the coil to start the rotation.

1

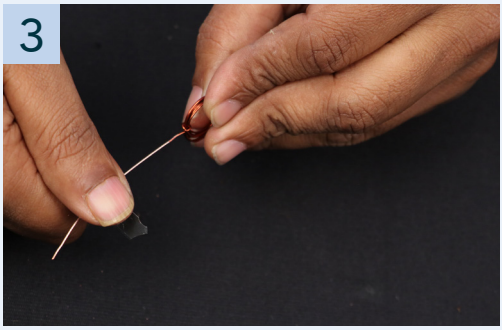
Wind the wire around your finger (4-5 turns) such that there is around 4 cm of straight wire on each side.

2



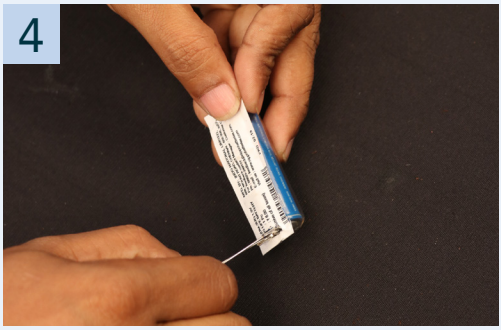
Tie knots on both sides such that both the knots are diametrically opposite.

3



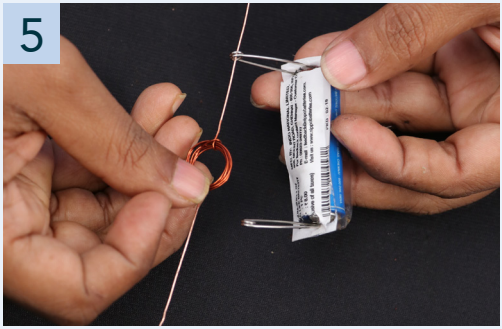
Remove the insulation completely from one side of wire. From other side, remove insulation from 3 sides.

4



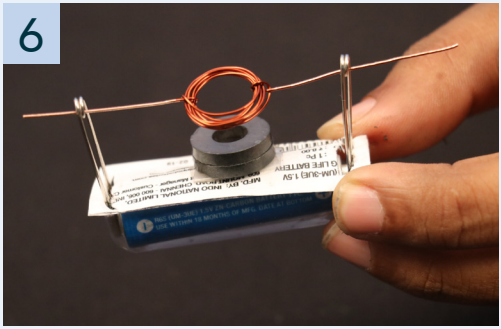
Insert two safety pins in the cover of the battery. The openable part of the safety pin should touch the battery.

5



Place the coil in the loops of the safety pins.

6



Place ring magnets on the battery and the motor would start to rotate!

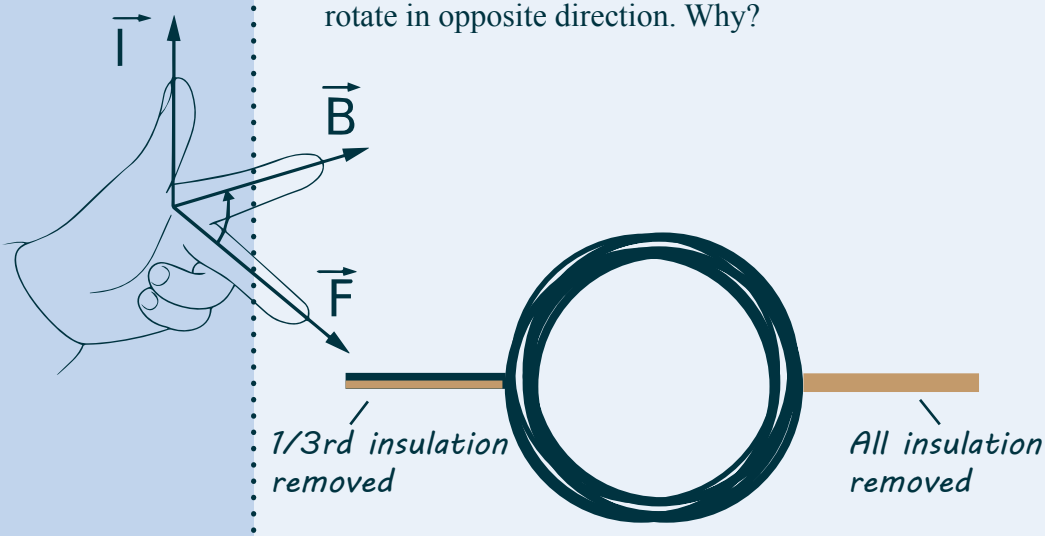
NOTES

WHAT'S GOING ON?

1. Until there is insulation on the wire, the current can't flow from the battery to the coil. Therefore you have to scrape the insulation from the ends so that the circuit can be completed.
2. When a current carrying conductor is placed in a magnetic field, it experiences a force whose direction can be predicted by Fleming's left hand rule. This force produces torque which is responsible for rotating the coil once it is connected to the battery terminals.
3. Some insulation is left on one side because after half rotation of the coil, the bottom half of the coil comes at the top having opposite direction of current (as compared to the top half). Therefore, the direction of force is also reversed. At that point, it is better if the flow of current through the coil is stopped. Therefore, the insulation is kept intact on the wire - to stop the flow of current.

EXPLORE

1. Predict the direction of rotation of the motor using Fleming's Left Hand Rule and check whether the motor really rotates in that direction.
2. Turn the whole motor upside down. Strangely, it starts to rotate in opposite direction. Why?



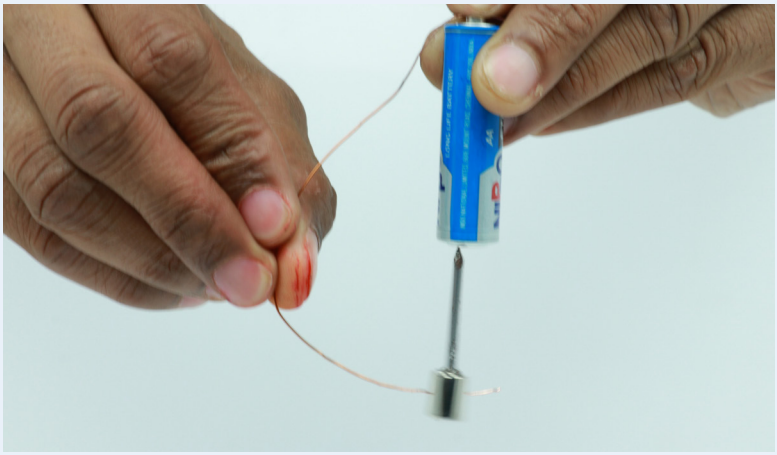
HOMOPOLAR MOTOR

LEARNINGS

- Electricity
- Magnetism
- Electromagnetic Induction
- Faraday's Law
- Fleming's Left Hand Rule
- Friction

MATERIALS REQUIRED

- AA Battery
- Neodymium Magnet
- Screw
- Electric Wire
- Paper Clip

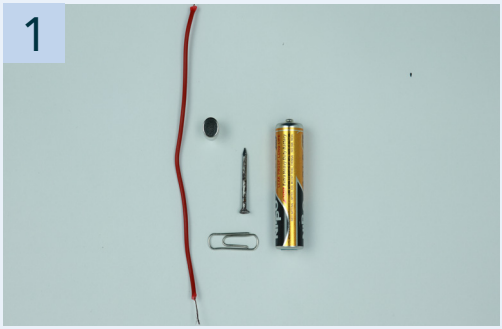


The homopolar motor is the simplest motor you can make. It was the first electrical motor ever built and was demonstrated by Michael Faraday in 1821 at the Royal Institution in London. Make your own homopolar motor and understand this historical invention.

WHAT TO DO?

1. Place the neodymium magnet on the head of the screw.
2. Touch the tip of the screw on the negative terminal of the battery. As the screw is connected to a magnet, it will stick to the battery.
3. Attach a paperclip at the bottom of the magnet so that you can see it rotating.
4. Place one end of the wire on the positive terminal and touch the other end of the wire to the magnet.
5. The screw would start to rotate at high speed. Rotating clip would look like blades of a fan.

1



Material required for this activity.

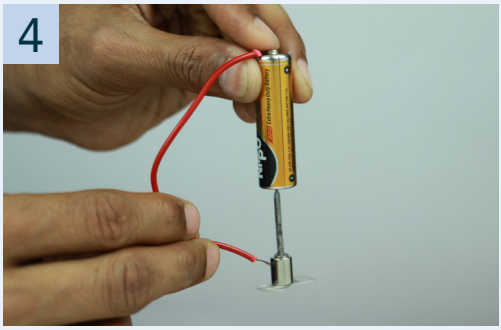
2

Place the neodymium magnet on the head of the screw.

3

Add the screw on the negative terminal of the battery.

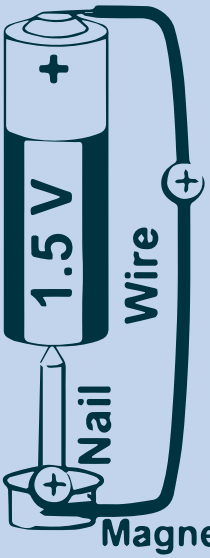
4



Place one end of the wire on the positive terminal and touch the other end to the magnet.

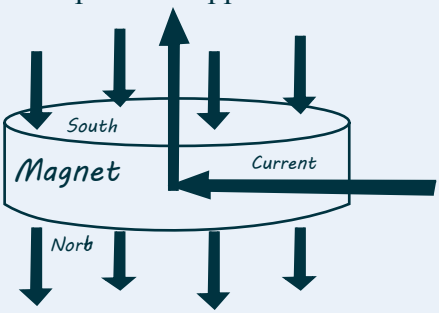
WHAT'S GOING ON?

1. When a current carrying coil is placed in a magnetic field, it experiences a force.
2. The direction of this force acting on the coil can be predicted using the Fleming's left hand rule (fore finger in the direction of magnetic field, center finger in the direction of current and the thumb would give the direction of force).
3. The neodymium magnet conducts electricity. Therefore, it generates the magnetic field and also acts as a conductor in this case.
4. When the electric wire is in contact with the magnet, the radial current inside the magnet is perpendicular to the direction of magnetic field.
5. This results in magnetic force in the tangential direction (according to Fleming's left hand rule). This force rotates the magnet.
6. The screw is placed between the magnet to reduce the area of contact and hence friction.
7. Current flowing in upwards direction inside the magnet is parallel to the magnetic field and therefore don't have any associated magnetic force.



EXPLORE

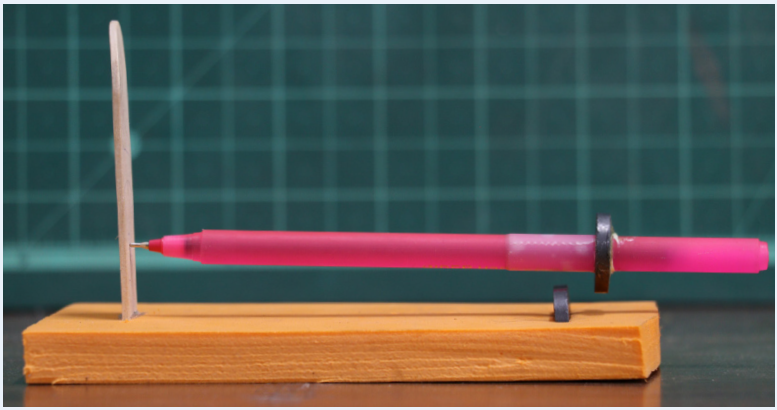
1. What happens to the direction of rotation if you invert the magnet?
2. Do you notice a small spark when you touch the wire with the magnet? Why does the spark occur?
3. The homopolar motors are very inefficient, hence unsuitable for practical applications.



LEVITATING PEN

LEARNINGS

- Magnetic Forces
- North and South Poles
- Levitation



Magnetic levitation is a method by which an object is suspended in air with no support other than magnetic fields. The pen stays horizontal under the action of magnetic forces. But is it really magnetic levitation?

MATERIALS REQUIRED

- EVA Sheet
- Ring Magnets
- Pen
- Ice Cream Stick
- Cutter

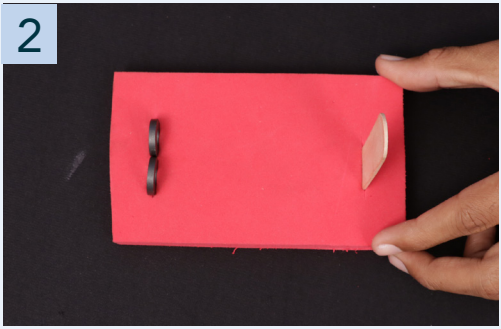
WHAT TO DO?

1. Take a piece of EVA sheet (8 cm x 12 cm) and make a small cut near the edge using cutter. The cut should be through which means that the cutter should come out from the other side.
2. Insert a piece of ice-cream stick in this cut.
3. Make another through cut on the other side and insert two ring magnets in this cut.
4. Fit one ring magnet in a pen. You can roll a piece of paper on the pen if the magnet is loose.
5. Adjust the magnets in such a way that both the magnets on the EVA sheet attract the magnet on the pen. If they are in repelling position, take out the magnets in the EVA sheet, rotate them by 180° and put them back in the sheet.
6. Adjust the magnet on the pen in such a way it is little behind the magnet on the base.
7. If required adjust the magnets little bit so that the pen hangs in the air.

1

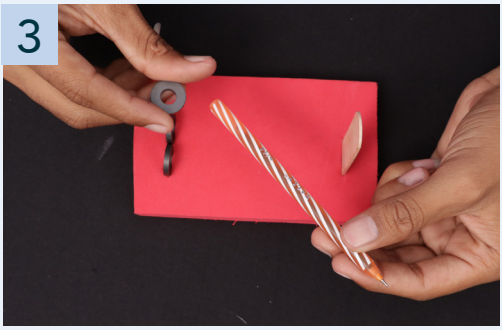
Make slits on both sides of the EVA sheet.

2



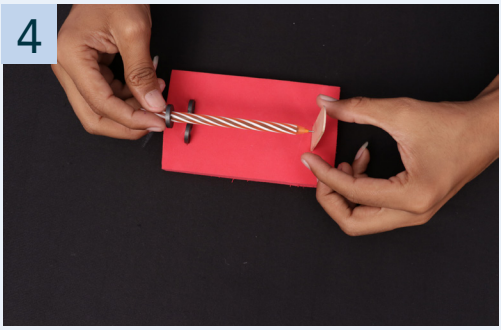
Insert the ice-cream stick and ring magnets in the two slits.

3



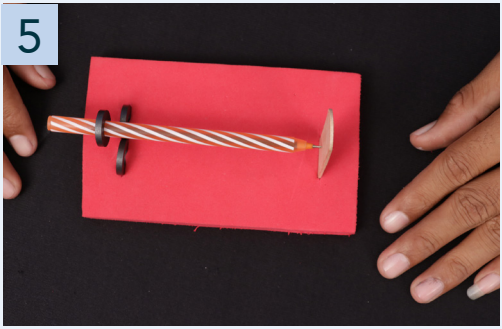
Fit a pen in a ring magnet.

4



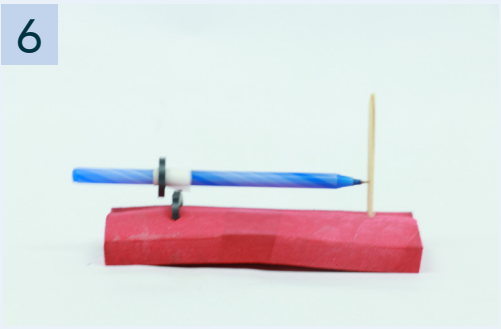
Adjust the magnets so that the pen hangs in the air.

5



Adjust the magnet on the pen in such a way it is a little behind the magnet on the base.

6



Your levitating pen stand is ready.

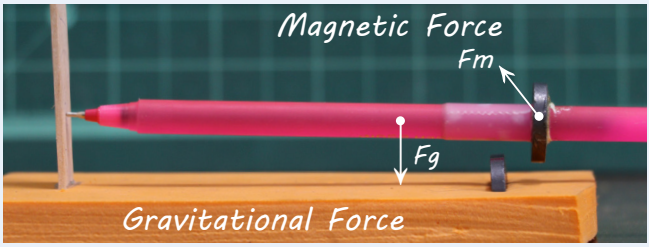
NOTES

WHAT'S GOING ON?

1. The magnets on the EVA sheet attract the pen forward but the ice-cream stick at the front holds it at its place.
2. The upward repulsion between the magnets balance the force of gravity and prevent it from falling down.
3. When you rotate the pen, it rotates for long time due to low friction at the tip.

EXPLORE

1. If you look closely, we can see that the ring magnet has four surfaces but a magnet generally has two poles (north and south). So what is the position of those poles?
2. Transrapid in China is the fastest commercial train. It has a top speed of 430 km/h. How does it achieve so high a speed? It floats in air without touching the track. Such a heavy train floats in air due to magnetic forces! Japan is also testing maglev trains, which have recorded the highest ever speeds, over 600 km/h during testing!
3. The levitation of pen is not really magnetic levitation as the pen is balanced on the ice-cream stick from its tip and not suspended in air entirely due to magnetic field. If you remove the ice-cream stick, the pen falls immediately.
4. There is a theorem called Earnshaw's theorem which states that a collection of point charges cannot be maintained in a stable stationary equilibrium solely by the electrostatic forces between the charges. It was was first applied to electrostatic fields but usually referenced to magnetic fields.



MAGNETIC SPRING FROG

LEARNINGS

- Potential Energy
- Kinetic Energy
- Poles of a Magnet
- Attraction and Repulsion
- Conservation of Energy

MATERIALS REQUIRED

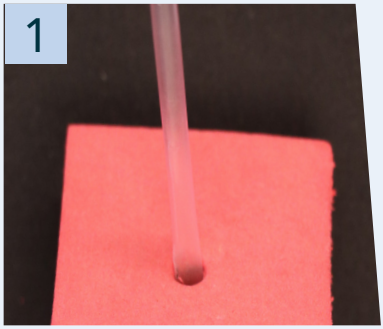
- Ferrite Ring Magnets
- EVA Sheet
- Straw

You have probably seen a metal spring. But have you seen a spring made out of magnets?
Make your own frog that can jump in the air - using magnets! There is no mechanical spring required as the magnets with same poles (north-north or south-south) act like a spring and propel the frog upwards.

WHAT TO DO?

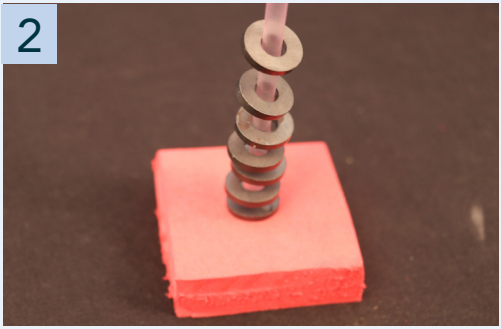
1. Take a small piece of EVA sheet and fix a stiff straw in it. The diameter of the magnet hole and the straw should be almost the same, otherwise the magnets don't stay horizontal
2. Stack ring magnets into the straw such that the two adjacent magnets repel each other.
3. Attach a cutout of a frog on the top magnet.

1



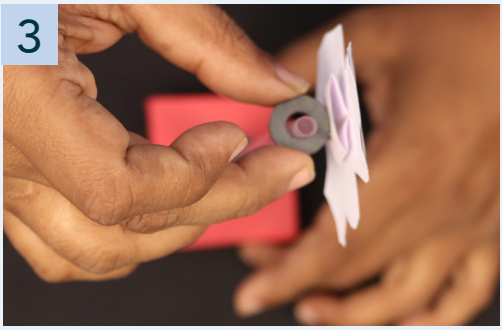
Fix a stiff straw in the EVA sheet.

2



Add multiple magnets such that they repel each other.

3



Attach the frog to the top magnet.

4

Your frog is ready to jump!

NOTES

WHAT'S GOING ON?

1. The magnets are placed such that same poles of magnets are towards each other. Therefore, the magnets repel each other when they are brought closer.
2. The whole system acts somewhat like a spring. When you bring the magnets closer, you have to apply some force to keep them together.
3. As soon as you stop applying the force, the magnets regain their original position and move away from each other.
4. The work done by you in bringing the magnets closer is stored as potential energy. On releasing the magnets, the potential energy gets released in the form of kinetic energy making the frog jump!

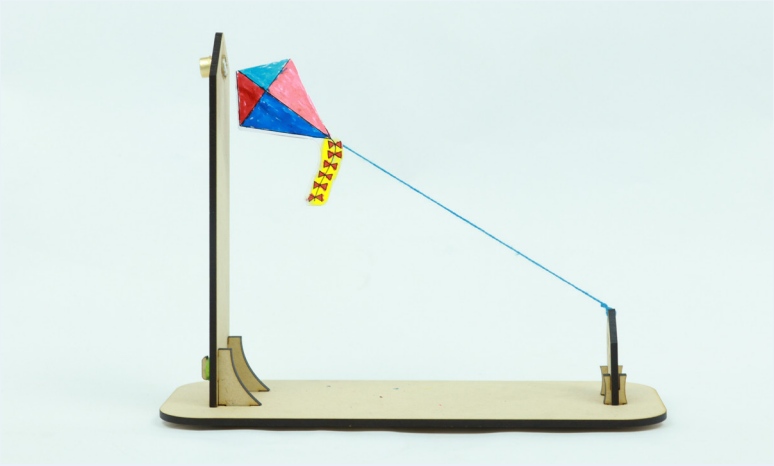
EXPLORE

1. If you have 10 magnets, how should you arrange them so that the frog jumps highest?
2. Hold the model at different angles. At which angle the frog jumps the most?
3. Take two ring magnets and place them on top of each other such that they repel each other. Now slide the top magnet slightly off the center and they will stick. Why?
4. All the odd and even numbered magnets would attract each other as they would have unlike poles facing each other.

MAGNETIC KITE

LEARNINGS

Magnetism



Have you ever flown a kite inside a room? This paper kite seems to stay in air at one place, without any assistance. How is this possible?

MATERIALS REQUIRED

- Magnet
- Thread
- EVA Sheet
- Iron Nail
- Paperclip

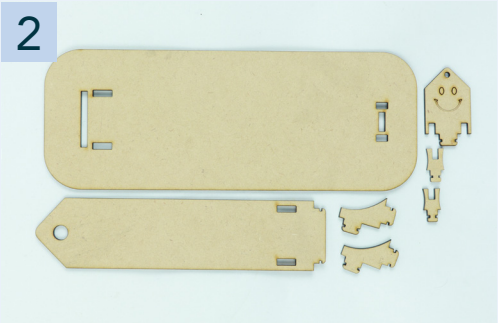
WHAT TO DO?

1. Tie a thread to the paperclip. Sandwich the paper clip between the kites and join them using glue.
2. Make a stand using MDF pieces. Fix the neodymium magnet in the hole at the top.
3. Take the kite with the thread and tie one end of the thread to the small stand.
4. Bring the other end with the kite near the magnets. Adjust the length of the thread such that there is a small gap between the magnets and the kite. The kite would seem to float in the air!

1

Material required for this activity.

2

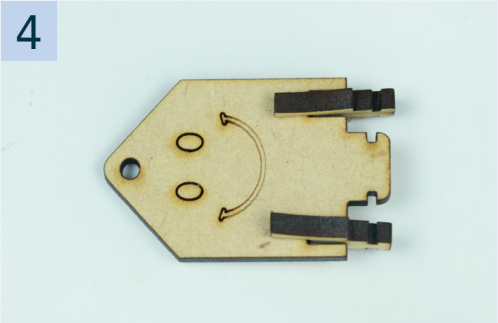


Take out the pieces from the sheet.

3

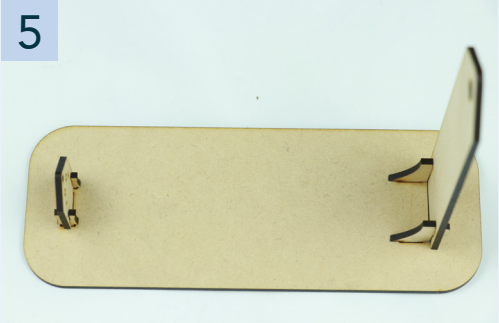
Attach the stand.

4



Add joints to the smaller piece as well.

5



Attach this to the base as well.

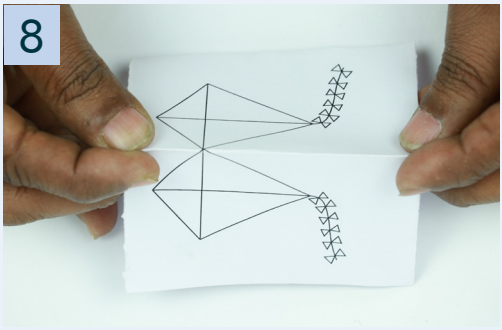
6

Fix a magnet in the hole of the larger stand as shown.

7

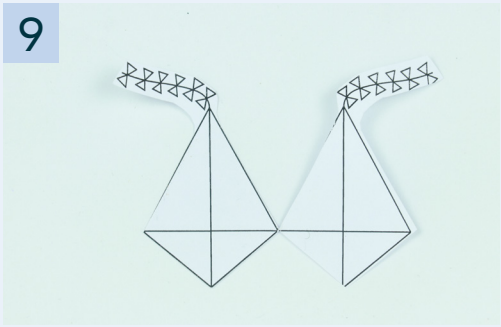
Fasten the magnet with the help of some hot glue if needed.

8



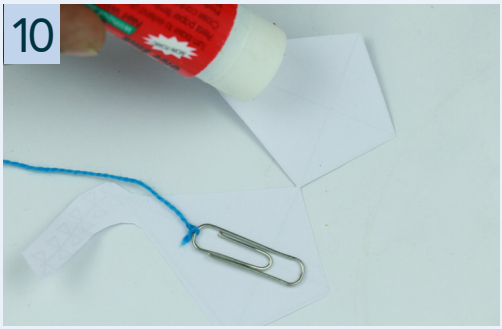
Take the kite that has been given

9



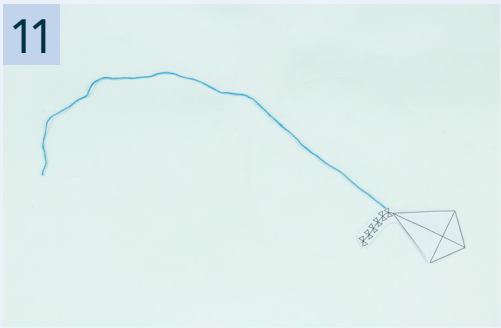
Cut out the kites leave them attached from the center.

10



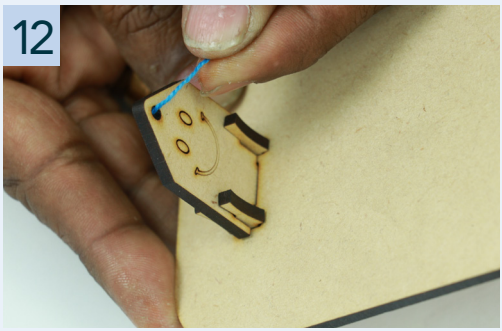
Take a paper clip and tie a thread to it.

11



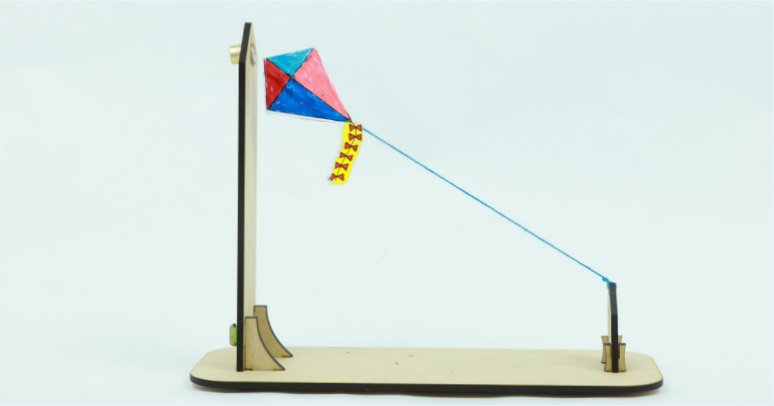
Stick the paper clip in the middle of the kite as shown.

12



Tie the thread to the hole in the small stand.

NOTES



WHAT'S GOING ON?

1. The paperclip inserted inside the kite is pulled by the magnet at the top of the stick.
2. The length of the string is adjusted such that the kite doesn't touch the magnet and at the same time, it is attracted by the magnet at the top. If the distance becomes more, the kite would just fall on the ground.
3. In this case, the kite floats in the air.

EXPLORE

This looks a very simple toy but requires a good degree of precision and trials to make it. Try with different magnets and different things instead of paper clip - also try to make bigger or smaller versions. You can also use other objects instead of a kite and make another toy!

OPTICS

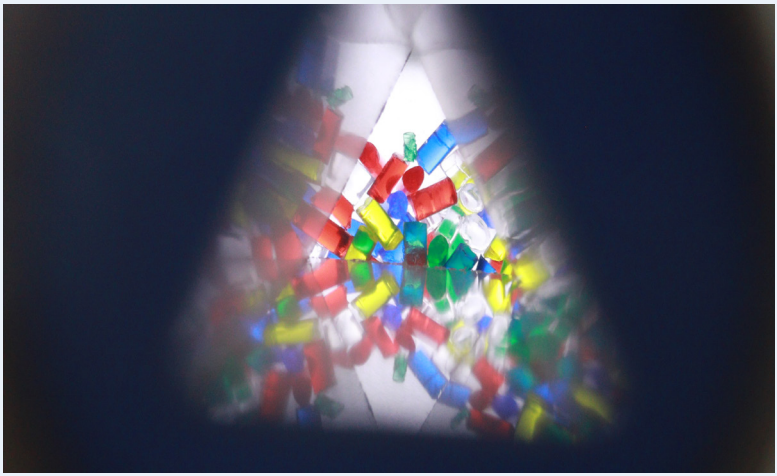
KALEIDOSCOPE

LEARNINGS

- Optics
- Reflection
- Plane Mirror
- Multiple Reflection

MATERIALS REQUIRED

- Cardboard Cylinder
- Mirror Prism
- EVA Sheet Circles
- Beads

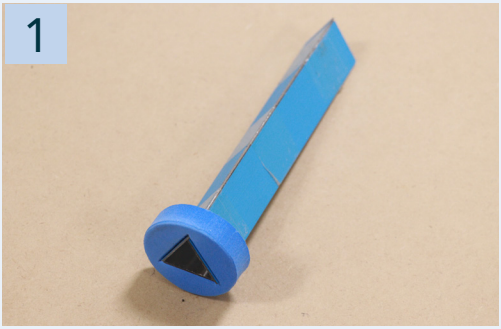


Kaleidoscope is a wonderful toy in which you can see amazing symmetric patterns due to repeated reflections. It has been a source of design inspiration for artists for a long time!

WHAT TO DO?

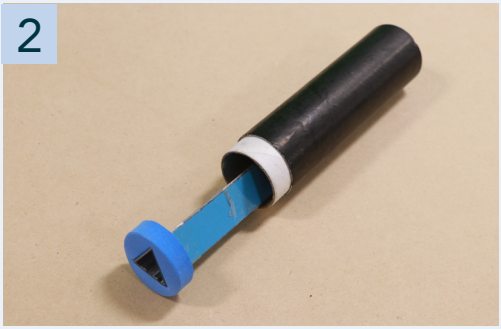
1. Add the triangilar prism to the EVA disc with the triangular hole.
2. Add this to the longer cylinder.
3. Add the second disc (with triangular hole) on the other side as well.
4. Add the larger cylinder to this.
5. The disc should fit snugly in this cylinder.
6. Add the bead box and EVA disc to complete the kaleidescope.

1



Add the triangular prism to the EVA disc with the triangular hole.

2

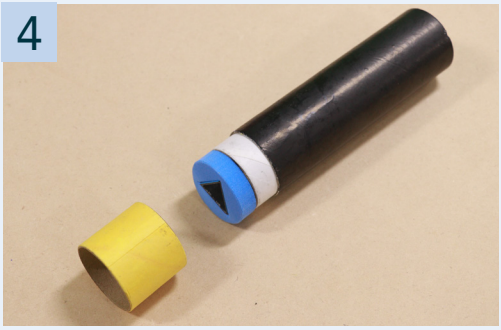


Add this to the cylinder.

3

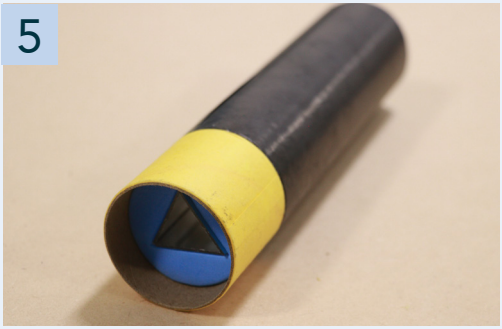
Add the second disc on the other side as well.

4



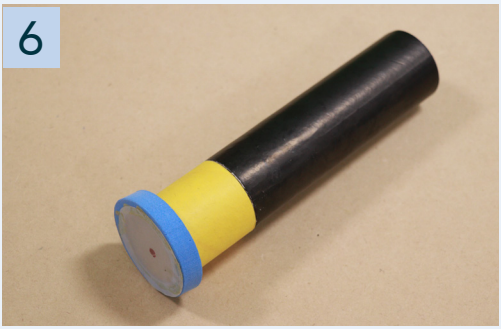
Add the larger cylinder to this.

5



The disc should fit snugly in this cylinder.

6



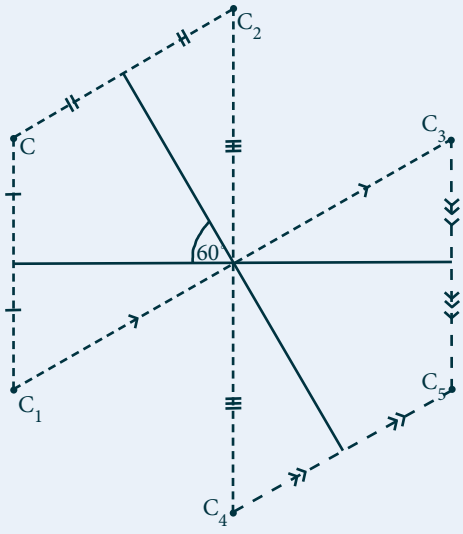
Add the bead box and EVA disc to complete the kaleidescope.

WHAT'S GOING ON?

1. A kaleidoscope is an optical instrument with two or more reflecting surfaces tilted to each other in an angle.
2. The patterns are a result of multiple reflections, which means that image of the beads also acts as an object for the other mirrors.
3. You might have seen multiple reflections earlier in a salon where the mirrors are placed facing each other. In that case, you can see thousands of images.
4. This activity never gets old because each time the pattern is different. Rotation of the kaleidoscope causes motion of the objects inside, resulting in a new pattern every time.
5. The concept is simple, but creates a wonderful end result that delights and entertains.

EXPLORE

1. Experiment by arranging mirrors in other geometrical shapes in the tube such as a square, pentagon, hexagon, etc.
2. For two mirrors, the number of images from multiple reflections is given by:
   Total number of reflections = $360/\theta - 1$,
   where θ = angle between two mirrors.



OPTICS

TOTAL INTERNAL REFLECTION

LEARNINGS

- Optics
- Reflection
- Refraction
- Total Internal Reflection

MATERIALS REQUIRED

- Water Bottle
- Laser Pointer
- Milk
- Incense Sticks
- Matchsticks

Generally light travels in a straight line but with total internal reflection, you can move the light along curved paths. The light is reflected multiple times while tracing a curved path.

WHAT TO DO?

1. Fill the bottle with water and add few drops of milk.
2. Burn some incense sticks and insert them in the bottle to fill the empty part with smoke.
3. Point the laser pointer towards the surface of the water. You will see that some light is reflected back in water while some of it bends slightly and goes in the air.
4. Increase the angle of incidence gradually. After some time, you will find that all the light is reflected back in the water.
5. Now open the side hole by removing the tape. Water would start to come out of the bottle. Make sure that the bottle lid is open otherwise water would stop coming out (Why?).
6. Find a dark room and shine the laser pointer towards the hole from the opposite side.
7. Interestingly, you would see that the laser beam would bend with water, instead of going straight.

1

Take a bottle of water and add a few drops of milk.

2

Fill up the remaining space in the bottle with incense stick smoke.

3

Take a laser and pass it through the water into the smoke.

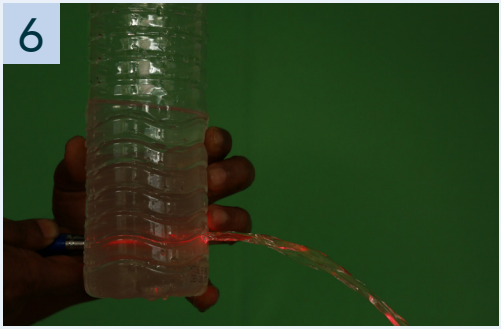
4

Keep on bending the laser light till it is reflected back into the water.

5

Make a hole in the bottle.

6



Let the water pour out of this hole. Point the laser through this hole and see the light bend.

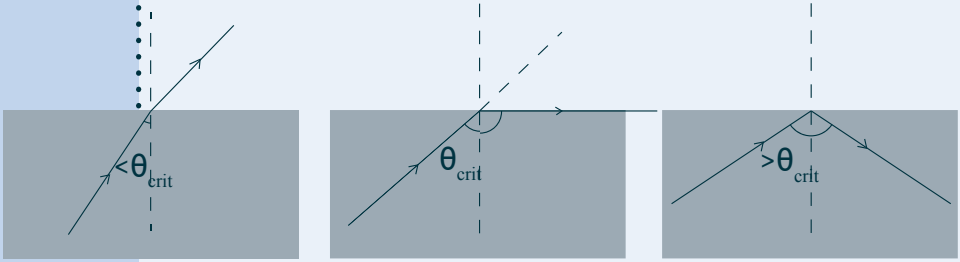
NOTES

WHAT'S GOING ON?

1. This happens because of total internal reflection. It is complete reflection of a light beam within a medium such as water or glass from the surrounding surfaces back into the medium.
2. In general, when a beam of light (the incident beam) hits the interface between two transparent mediums, such as water and air, part of the beam is reflected and part of it refracts (or bends) through the interface and goes into the other medium.
3. If the first medium (the medium in which light is traveling initially) has a higher refractive index than the second medium (the medium in which light goes after refraction), the light bends away from the normal.
4. As the angle of incidence increases, this refracted beam approaches the interface. This angle is called the critical angle for that pair of mediums.
5. At all angles less than the critical angle, both refraction and reflection occur in varying proportions.
6. Beyond the critical angle, all the light is reflected back into the first medium, so the reflected beam is as bright as the incident beam. This phenomenon is called total internal reflection, because almost 100 percent of the beam is reflected, which is better than the very best mirror surfaces.
7. For the water-air surface, the critical angle is 48.5°. For the glass-air boundary, it is around 40°.
8. For diamonds, the critical angle is even lesser - around 25°. Therefore, more light keeps reflecting and the diamond looks brighter!
9. Milk and the smoke help to disperse the light. They are added so that you can see the light through its entire path and not just at the end.

EXPLORE

1. Because the refractive index depends on the wavelength of light, the critical angle (and hence the angle of total internal reflection) also varies slightly with wavelength and, therefore, with color. The formula for calculating critical angle is, $\theta_{crit} = \sin^{-1}(n_r/n_i)$.
2. Total internal reflection helps transmit telecom data along optical fibers. Any light that is not aligned parallel to the axis of the fiber hits the wall of the fiber and is reflected (totally!) back inward, since the angle of incidence with which the light hits the wall is much larger than the critical angle. This helps prevent the signal from weakening too rapidly over long distances.
3. One of the largest fiber optic cable connects New Jersey in America to France, across the Atlantic Ocean!
4. Try yourself with an optical fiber cable. Shine laser light at one end and see if it comes out of the other end. Now bend the cable as much as you can from the middle. Does the light still come out of the other end? Discuss.
5. You may have seen lamps which utilize the phenomenon of total internal reflection. One light bulb is used to illuminate the ends of an array of optical fibers.
6. Due to total internal reflection, the surface of a swimming pool can act as a mirror and show the image of the objects inside. But, only when you look from inside the water (remember that for total internal reflection, the incident medium has to be the one having higher refractive index).



OPTICS

DISAPPEARING COIN

LEARNINGS

Refraction

Refractive Index

Angle of Refraction

MATERIALS REQUIRED

Coin

Transparent Glasses

Make the coin disappear using just water! Add this amazing activity in your bag of tricks and surprise everyone!

WHAT TO DO?

1. Take two empty transparent glasses. Put a coin underneath the first glass and another coin inside the second glass.
2. Start pouring water in both the glasses and see the coin from the side.
3. You will see that the coin beneath the first glass would disappear but you can still see the coin inside the second glass.

1

Put a coin underneath the first glass

2

Put another coin inside the second glass.

3

The setup would look like this.

4

Pour water in the first glass.

5

The coin inside the glass would still be visible.

6

Pour water in the second glass and the coin below the glass would disappear.

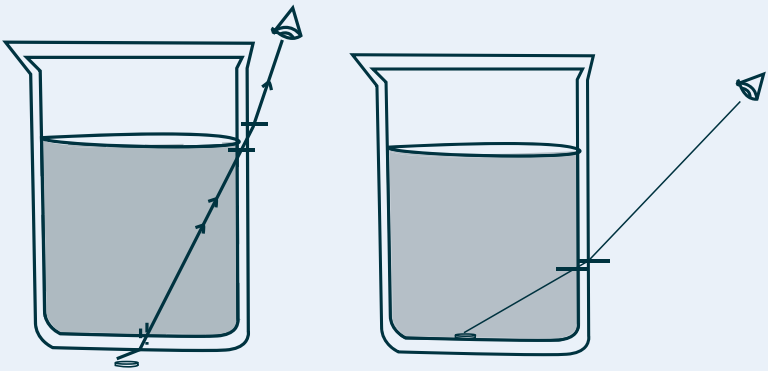
NOTES

WHAT'S GOING ON?

1. This is happening because of the refraction of light. In the first case (when the coin is under the glass), the light has to go from air to the glass then inside the water because the coin is under the glass and then again from water to glass to air and finally it reaches our eyes.
2. As the refractive index of air is much less than that of glass, the light bends at a larger angle and comes out from (almost) top of the glass.
3. In the second case, the light has to go from water to glass and then to air to reach our eyes. Light bends at a relatively smaller angle and you can see the coin from the side of the glass.

EXPLORE

1. The coin would of course be visible from the top of the glass in both the cases. You can only make the coin disappear when you see the coin from the side.
2. Repeat the same experiment again. But this time, pour some water on the coin before putting it under the glass. Does the coin still disappear?



OPTICS

MAGIC TEST TUBE

LEARNINGS

Refractive Index

Reflection

Reflection

MATERIALS REQUIRED

Test Tubes

Corn Oil

Glass Container

Make the glass test tube disappear using some oil. The test tube is clearly visible in water but completely disappears when immersed in corn oil.

WHAT TO DO?

1. Take two glass containers and fill one of them with water and the other with corn coil.
2. Take a test tube and immerse it completely in the water container. You would be able to see the test tube clearly inside water.
3. Now immerse another test tube in the corn oil. You will see that once the oil fills the test tube, it would suddenly disappear!
4. Now you are ready to join a broken test tube! Drop the pieces of a broken test tube inside the oil container (they would disappear once inside the oil).
5. Stir the container and then take out a whole, unbroken test tube from the solution! Of course, for the magic to work, you have to put an unbroken test tube in the oil container at the start!

NOTES

WHAT'S GOING ON?

1. Normally, you see a transparent object because of two reasons- reflection and refraction.
2. Reflection of light from the surface of the transparent object allows you to notice the highlights of the surface.
3. Due to refraction, the light passing through the object would bend. This changes how the background looks like through the object.
4. Both reflection and refraction take place due to difference in refractive index at the surface.
5. If there is no difference in the refractive index, then there is no reflection and refraction and you don't see an object. As far as light is concerned, there is no surface.
6. You can see the test tube clearly inside the water container because the refractive index of water and glass is different.
7. In the second case, the refractive index of corn oil and glass is (almost) the same. Therefore, you can't see glass objects inside corn oil.

EXPLORE

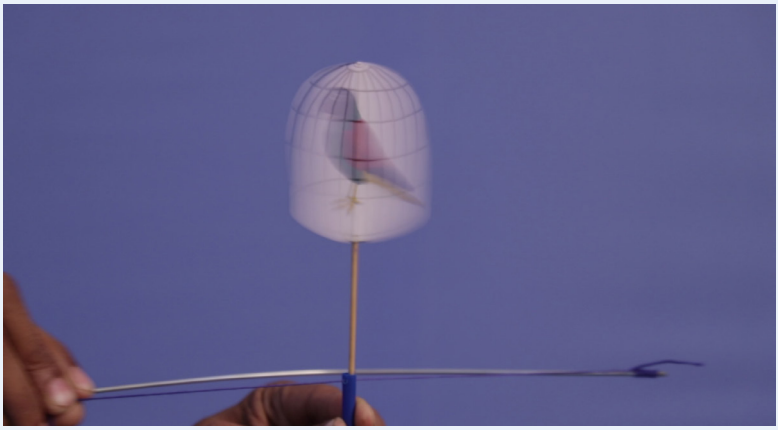
1. Take some glass bottles/jars and smash them into small pieces using a brick (CAUTION: Take the help of an adult to handle the glass pieces). Now write something on a paper and put the paper at the bottom of a container. Place the glass pieces at the top of the paper. You won't be able to see the writing. Now add oil in the container and the writing would magically appear!
2. In this case, the refractive index of the oil is equal to that of the glass test tube. Would an object still be visible if it is immersed in a liquid having a higher refractive index than the object?

OPTICS

BIRD IN CAGE

LEARNINGS

Persistence of Vision



MATERIALS REQUIRED

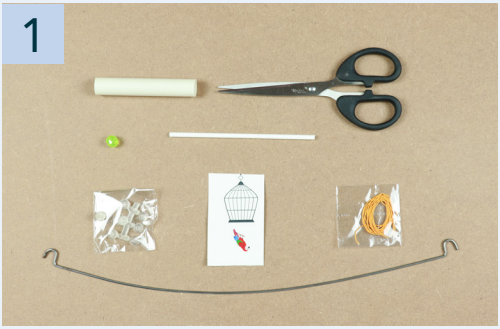
- Bird and Cage Stickers
- PVC Pipe
- Hard Straw
- Thread

A disk with a picture on each side is attached to a stick. When the stick is twirled quickly in the hand, the two pictures appear to blend into one. This device is called a thaumatrope that was very popular in the 19th century, before the era of television.

WHAT TO DO?

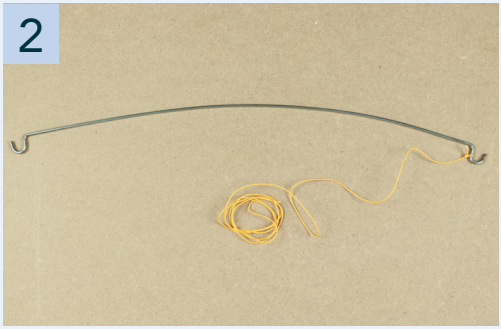
1. Stick the parrot and cage pictures using glue, sandwiching a hard straw between them.
2. Make two holes in a PVC pipe so that you can pass a thread through it.
3. Tie a string to the hooks on the wire bow and add rubber stoppers. Weave it through the holes of the PVC pipe.
4. Lift the thread from the PVC pipe with the end of the hard straw and rotate it 180° to loop it around the hard straw.
5. Now hold the PVC pipe with one hand and move the bow to-and-fro with the other hand.
6. The hard straw will rotate very fast and you will see the bird in the cage!

1



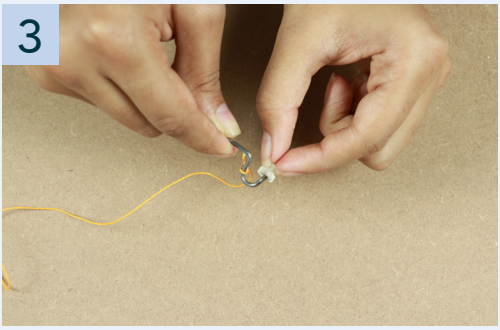
Start with making two holes on either sides of the PVC pipe given.

2



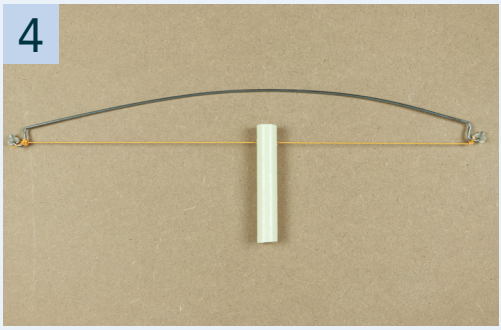
Tie the given string to the one of the hooks of the wire bow.

3



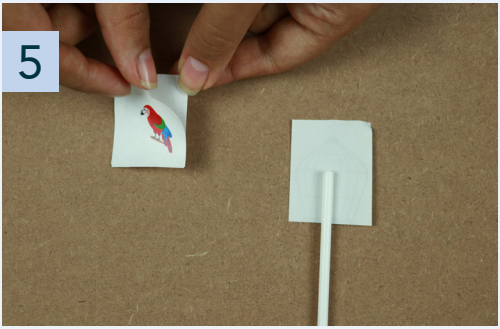
Add a rubber stopper to the bow

4



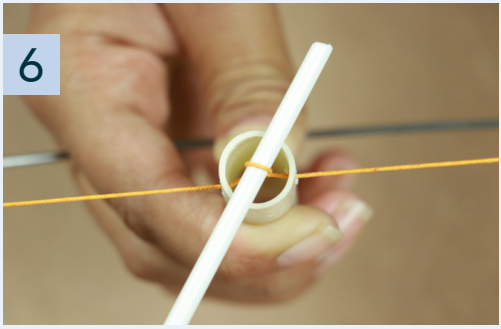
Pass the thread through the PVC pipe and tie the string to the other hook of the wire bow.

5



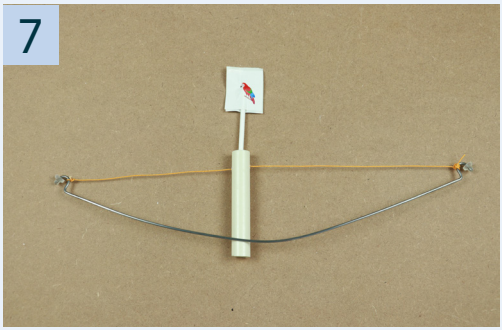
Peel the bird and cage sticker and attach the two back to back with a stiff straw in the center.

6



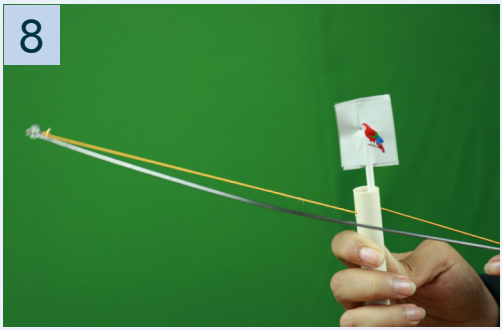
Use the stiff straw to lift out the string. Twist the loop once and put the straw inside the PVC pipe.

7



Your bird in cage is ready.

8



Hold the PVC pipe and move the bow back and forth. Watch the bird in the cage.

NOTES

WHAT'S GOING ON?

1. The reason you are able to see two images merge into one in this experiment is because when you see an image, it stays on your eye (or your brain?) for approximately 1/25th of a second.
2. This phenomenon is known as persistence of vision. That's why you can see the bird in the cage when you spin the two images.
3. Before cartoons and movies, people used to enjoy simple animations with a thaumatrope.

EXPLORE

1. Try with other images. Come up with your own combinations of images.
2. Thaumatropes do not have to be round or rectangular. Experiment with different shapes.
3. Colored paper also makes interesting effects. Try black paper with brightly colored chalk drawings.

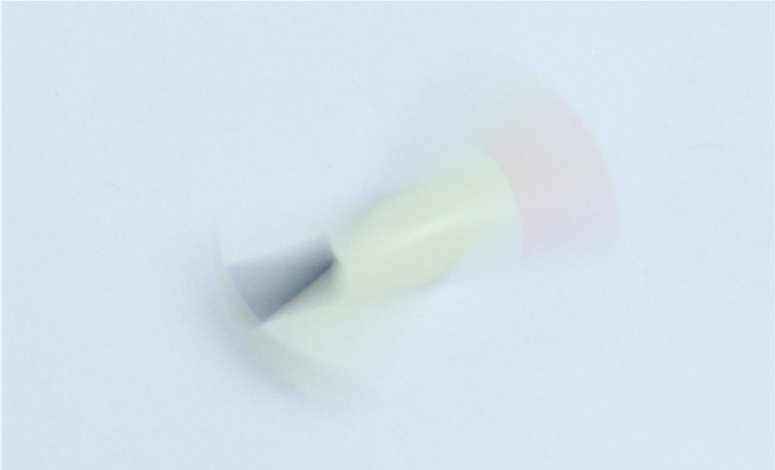
OPTICS

PIPE STROBOSCOPE

LEARNINGS

Rolling of a Circle

Cycloid



MATERIALS REQUIRED

PVC Pipe

Colored Tapes

Although there are two tapes on the pipe, you strangely see only one color when you rotate it!

WHAT TO DO?

1. Take a PVC pipe of length 6 cm and diameter 1.5 cm.
2. Stick two small pieces of tape of different color (black and red) at the opposite ends of the pipe.
3. Keep the PVC pipe at a flat surface (floor or a big table). Pinch one end of the pipe and then release suddenly.
4. The pipe would start to rotate, and you'll see four spots of only one color.

1

You will require this material for this activity.

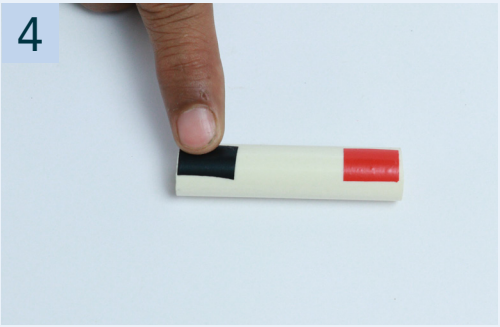
2

Take a 6cm PVC pipe and stick two different colored tapes at both ends as shown.

3

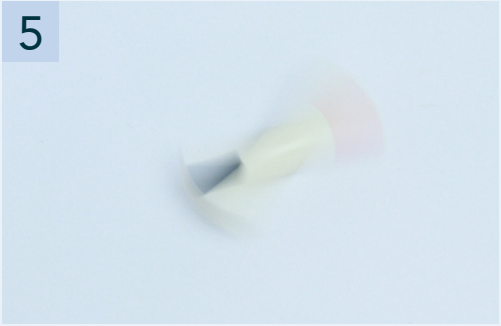
The tape pieces should not be too big.

4



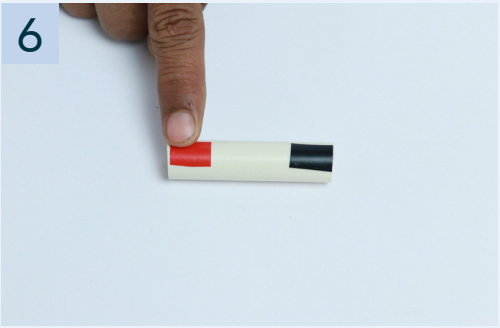
Keep the PVC pipe on a flat surface. Pinch one end of the pipe and then release suddenly.

5



The pipe would start to rotate, and you'll see four spots (black or red) due to the tape.

6



Do this for the other side as well. What will you see?

NOTES

WHAT'S GOING ON?

1. If you pinch the pipe from the black end, you would see black color when it rotates. If you pinch it from the red end, you would see red color on rotation.
2. This happens because the PVC pipe is rotating as well revolving.
3. At one end, the speeds of rotation and revolution are in different directions (the end where you pinch it to start). Therefore, the total speed is less and you can see that particular color.
4. At the other end, the two speeds are in the same direction. Therefore, the total speed is high and you can't see the other color.
5. The number of rotations completed by the pipe in one revolution is the ratio of the length of the pipe and its diameter. If this ratio is 4:1, you would see four spots.

EXPLORE

If the ratio of length and diameter is 4.1 : 1, then you see four spots and the spots move forward (wagon wheel effect). If the ratio is 3.9 : 1, the 4 spots move backward. What would happen if the ratio is exactly 3.5 : 1 ?

OPTICS

CD STROBOSCOPE

LEARNINGS

Stroboscopic Effect

Wagon Wheel Effect

Friction

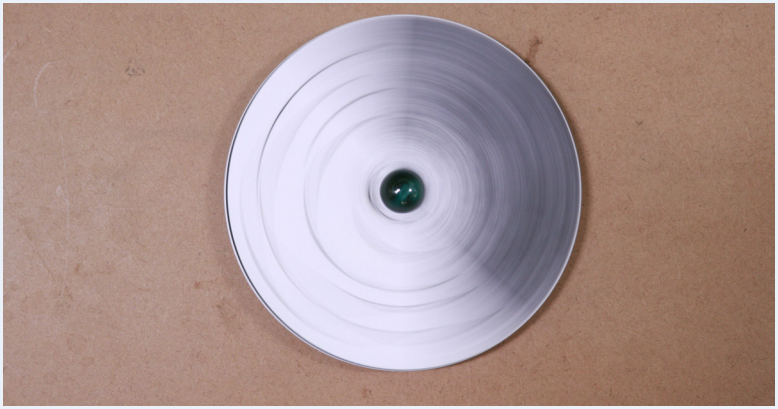
MATERIALS REQUIRED

Waste CD

Different Patterns

Marble

Glue



Rotate the CD on the marble and see some amazing patterns!

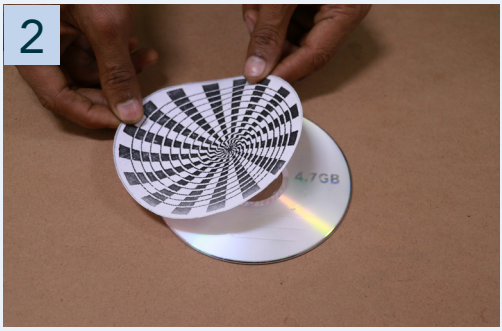
WHAT TO DO?

1. Stick the pattern on a CD using glue.
2. Stick a marble in the center hole of the CD.
3. The CD can now rotate on the marble. Spin it on a smooth surface. Observe the patterns on the CD.
4. Try this for different patterns - Benham's disc, Newton's disc and others.

1

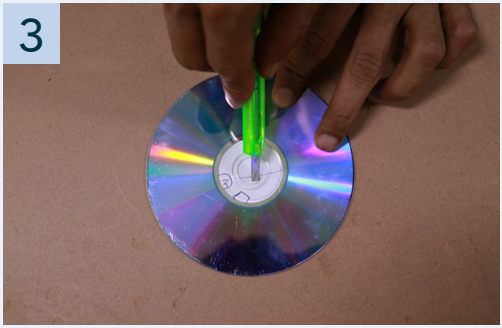
Apply glue on the CD.

2



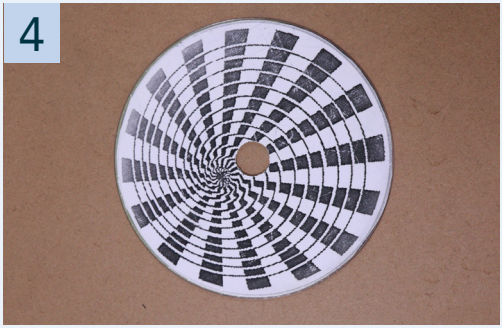
Stick the pattern on the CD.

3



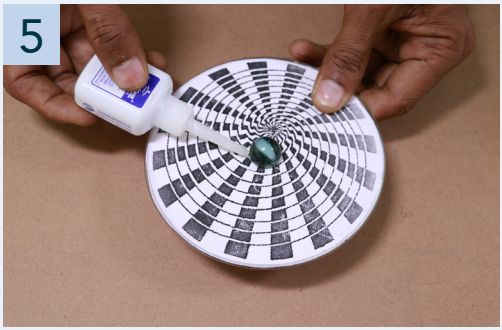
Cut out a small hole in the pattern as shown.

4



It would look something like this.

5



Fix a marble in the center hole of the CD. Do this for all the patterns.

6

The CD can now rotate on the marble. Spin it on a smooth surface..

NOTES

WHAT'S GOING ON?

1. Some dots would appear to rotate clockwise and some anticlockwise. And if you keep looking at it, the dots would also change direction with time.
2. This is due to the stroboscopic effect. It is a visual phenomenon which occurs when the continuous motion of a moving object is represented by a series of short samples.
3. The images (or samples) taken by our eyes would depend on the frequency with which the light is flickering. Due to this, the moving objects may even look still.
4. The moving object should be in rotational or other cyclic motion at a rate close to the sampling rate. It also accounts for the "wagon-wheel effect", so-called because in video, the car wheels sometimes appear to be turning backwards.
5. A strobe fountain, a stream of water droplets falling at regular intervals lit with a strobe light, is an example of the stroboscopic effect being applied to a cyclic motion that is not rotational. When viewed under normal light, this is a normal water fountain. When viewed under a strobe light with its frequency tuned to the rate at which the droplets fall, the droplets appear to be suspended in mid-air. Adjusting the strobe frequency can make the droplets seemingly move slowly up or down.

NOTES

EXPLORE

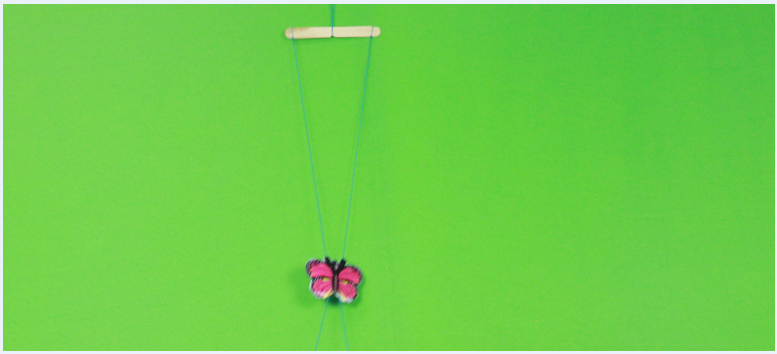
1. Stroboscopic effect may lead to unsafe situations in workplaces with rotating machinery.
2. If the frequency of fast rotating machinery or moving parts coincides with the frequency (or multiples of the frequency) of the light modulation, the machinery can appear to be stationary, potentially leading to hazardous situations.
3. Because of the illusion that the stroboscopic effect can give to moving machinery, it is advised that single-phase lighting is avoided.
4. For example, a factory that is lit from a single-phase supply with basic lighting will have a flicker of 100 or 120 Hz (depending on country, 50 Hz × 2 in Europe, 60 Hz × 2 in US, double the nominal frequency).
5. Therefore, any machinery rotating at multiples of 50 or 60 Hz (3000–3600rpm) may appear to not be turning, increasing the risk of injury to an operator.

CLIMBING BUTTERFLY

LEARNINGS

Friction

Gravity



As you pull the threads of this butterfly, it surprisingly climbs up. On releasing the threads, the butterfly comes down because of its own weight.

MATERIALS REQUIRED

Butterfly Cutout

Stiff Straw

Thread

Ice-cream Stick

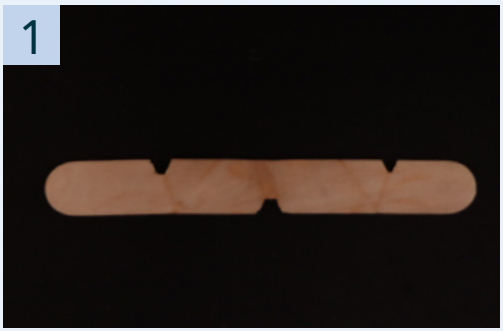
Glue

Scissors

WHAT TO DO?

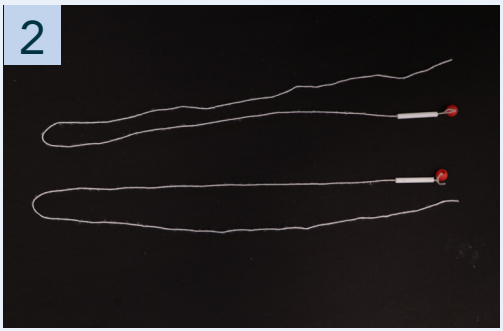
1. Take the two butterfly cutouts and apply glue on the blank side.
2. Take two stiff straws and stick them between the cutouts at a slant angle. You will now have two straws sandwiched between the butterflies.
3. Cut the extra straws which are popping out. The butterfly is ready.
4. Take an ice-cream stick and make three notches in it.
5. Take a needle with 2 m thread and weave it through the straw and tie one end to the notch at the end of the ice-cream stick. Do this for both the straws and the butterfly would hang on the ice-cream stick. Use the middle notch of the ice-cream stick to tie a thread and then hang it on the wall.
6. Tie a bead on the other end of the thread so that it doesn't come out of the straw. These beads will also act as handles.
7. Pull both beads alternately and the keep the thread tight. This will make the butterfly climb. On releasing the tension, the butterfly would come down because of its weight.

1



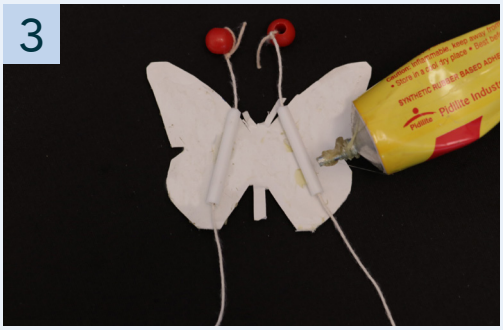
Take an ice-cream stick and make three notches in it.

2



Weave the thread through the straws and tie a bead on one end.

3



Stick the straws on the butterfly using glue.

4

Cover the straws using another butterfly.

5

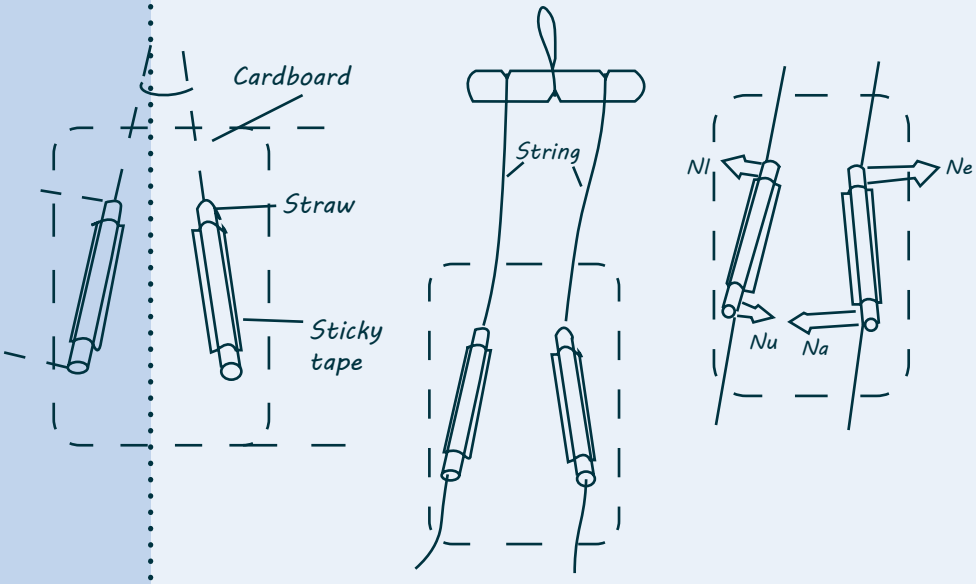
Pull the thread and watch the butterfly go up.

WHAT'S GOING ON?

1. When you pull the left thread, the associated straw tilts to the left and aligns with the thread. The normal forces acting on the left straw (N_l and N_u) becomes less.
2. In this situation, normal force acting on the right straw (N_e and N_a) increases. The frictional force also increases between the right straw and thread.
3. Therefore the butterfly holds its position for the right thread . The ice- cream stick is also pulled down from the left side and therefore the straw climbs on the left thread.
4. This keeps repeating for both threads and the butterfly moves upwards.
5. As soon as the threads are released, the butterfly slides down because there is not enough friction to hold it in its place.

EXPLORE

What is the minimum amount of tension required to just make the butterfly climb up?



SPOOKY SPOKE

LEARNINGS

- Friction
- Potential Energy
- Kinetic Energy
- Conservation of Energy
- Magnetism

MATERIALS REQUIRED

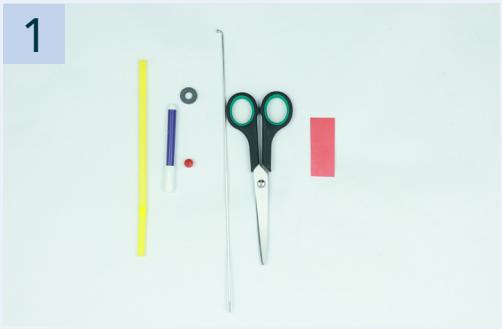
- Cycle Spoke
- Ring Magnet
- Card Paper Sheet
- Straw
- Scissors
- Bead

Rotate the ring magnet on the cycle spoke and see it descending down. With just a magnet and a cycle spoke, this amazing toy never ceases to amaze!

WHAT TO DO?

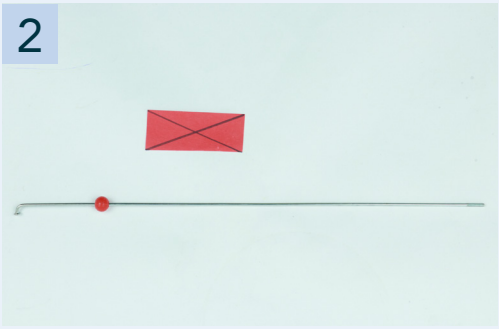
1. Take a cycle spoke and insert a small bead through the straight end of the spoke.
2. Now make a small rectangle using a card paper and poke a hole in the center using a pencil. The center of rectangle can be located by drawing the two diagonals and taking the intersection point.
3. Insert the rectangle on the top of the bead.
4. Now, insert a ring magnet in the cycle spoke and give it an initial turn using your hand.
5. Hold the spoke loosely from the top. When the magnet goes whirling down the spoke, it starts to vibrate and also rotates the rectangle at the bottom.

1



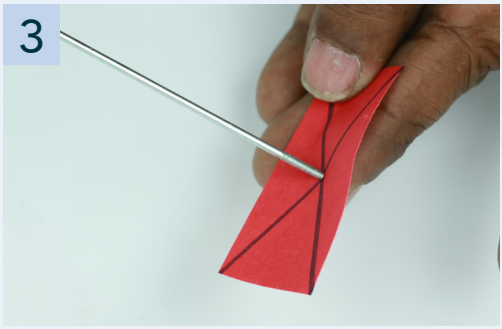
Material required for this activity.

2



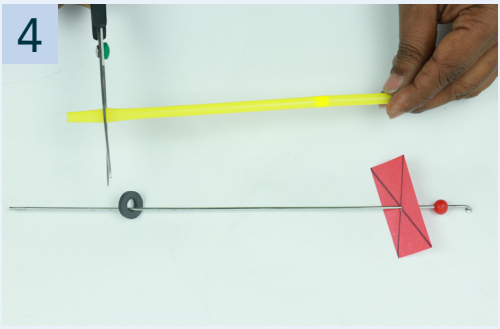
Insert a bead in the cycle spoke.

3



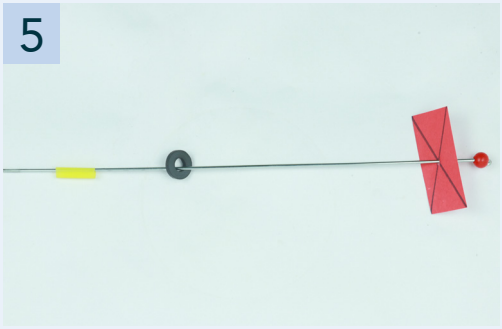
Take a small paper cutout. Make a hole in the center and add it to the spoke.

4



Add a ring magnet to the spoke and cut a small straw piece.

5



Add the straw piece to the spoke.

6

Hold the spoke vertically and release the magnet and the straw from the top.

NOTES

WHAT'S GOING ON?

1. The magnet sticks to the cycle spoke and thus wants to stay at the same place.
2. At the same time, gravity is also pulling the magnet down. As a result, the magnet falls and intermittently sticks to the spoke. This causes the magnet and the cycle spoke to move in circles like a hula hoop.
3. The potential energy of the magnet is converted into vibrational energy.
4. The vibrations of spoke induce the rotations in the rectangle below. The bead is inserted to reduce friction so that the rectangle can rotate freely.

EXPLORE

1. Repeat the experiment with Newton's Color Wheel instead of the rectangle and you can see amazing patterns when the wheel rotates.
2. Repeat the experiment with a piece of straw at the top of the magnet. The magnet will come down but the straw will just hang in the air because of the spinning!
3. Observe the fall of magnet several times. You will see that the magnet rotates in two distinct ways. Find out how you can make the magnet rotate in a particular way.
4. Notice that the speed of the magnet initially increases and then becomes constant.

ICE CREAM STRUCTURE

LEARNINGS

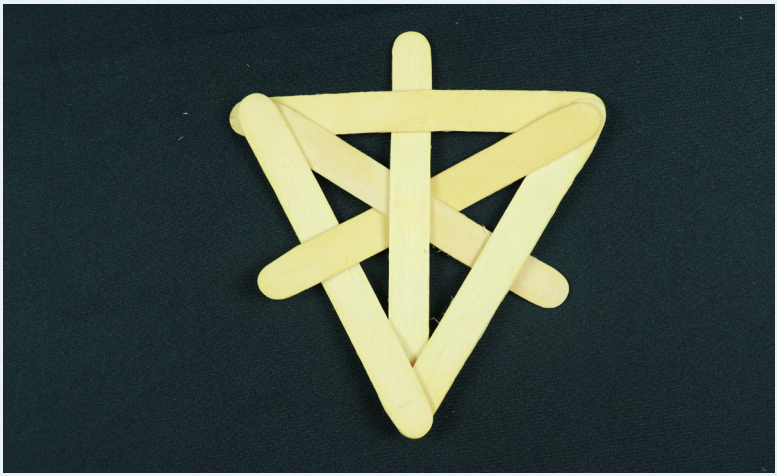
Friction

Geometrical Shapes

Structures

MATERIALS REQUIRED

Ice-cream Sticks

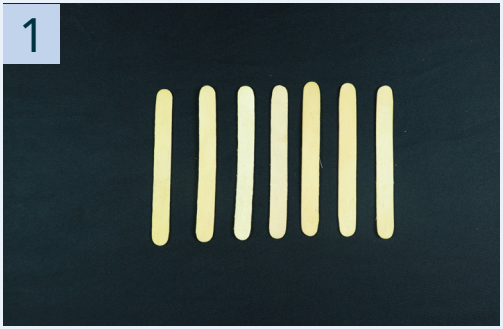


We generally throw the ice-cream sticks away, after eating the ice-cream. But you can make very interesting structures with these ice-cream sticks, without any glue or adhesives.

WHAT TO DO?

1. You can't make a stable structure with two or three sticks you would require a minimum of four sticks.
2. To make the basic 4 sticks structure, take 4 sticks and make two V shapes, such that both the top sticks face the same side.
3. Now slide one V inside the other such that each stick goes under and above the other sticks of another V.
4. Each stick touches exactly another 3 sticks. This is the simplest stable structure you can make with sticks, without any glue.
5. Make other structures using ice-cream sticks as shown in the images.
6. Count the total number of triangles in the final structure.

1



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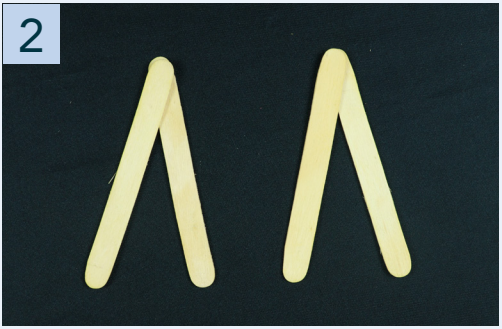

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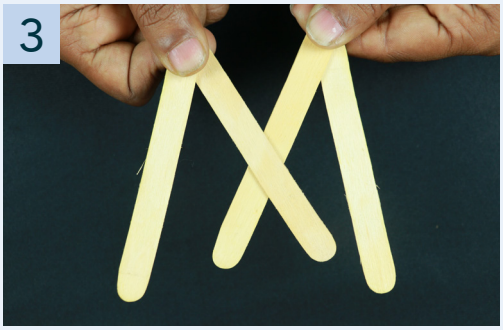

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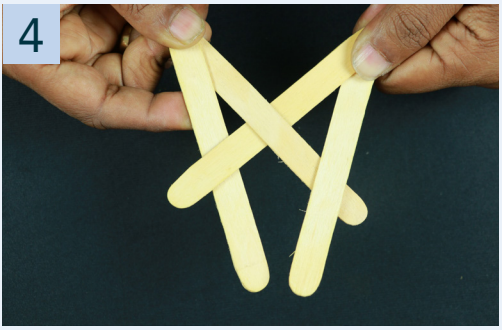

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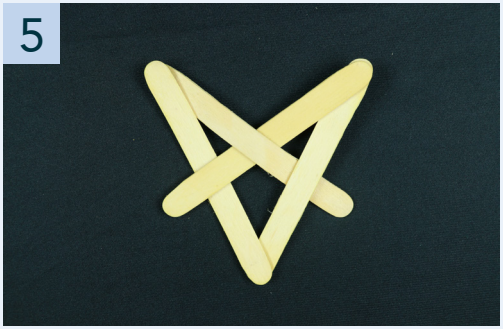

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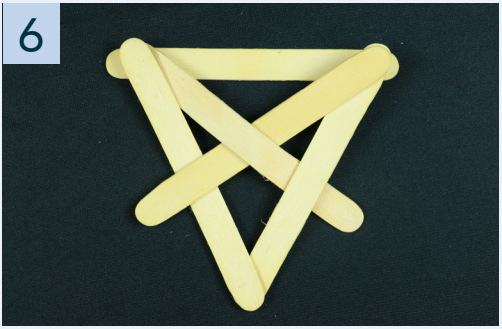

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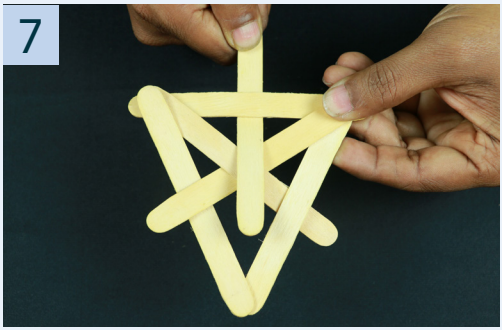

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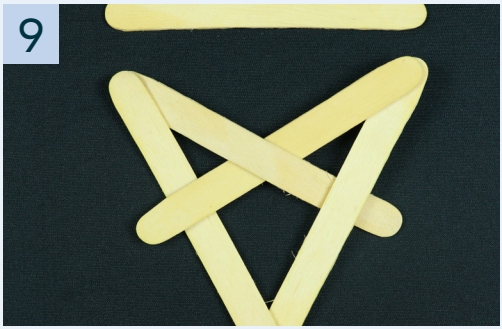

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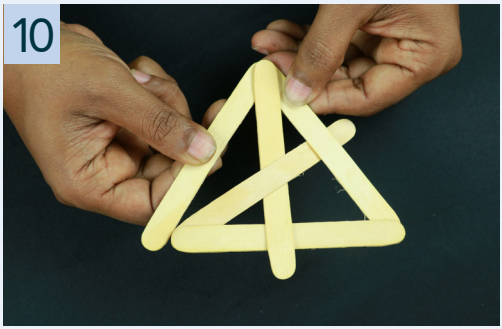

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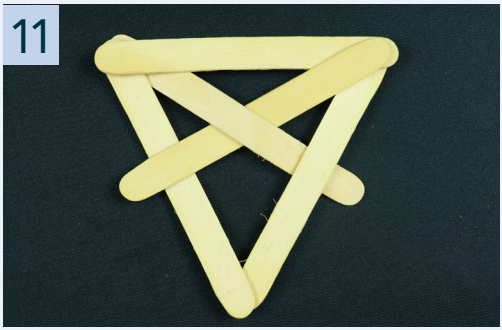

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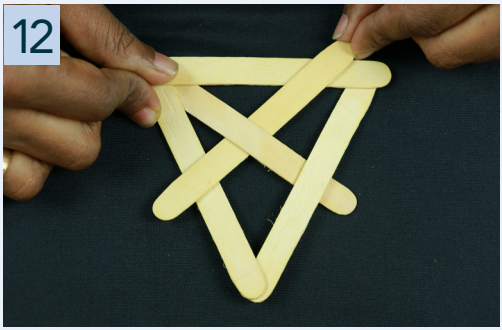

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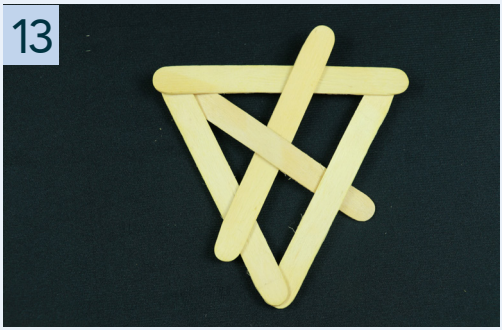

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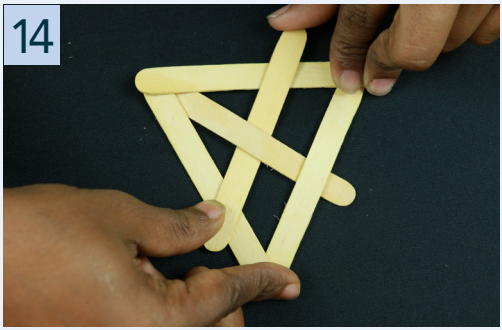

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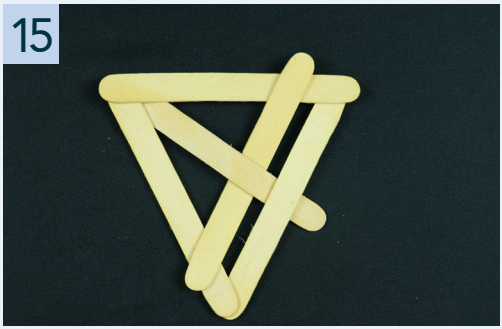

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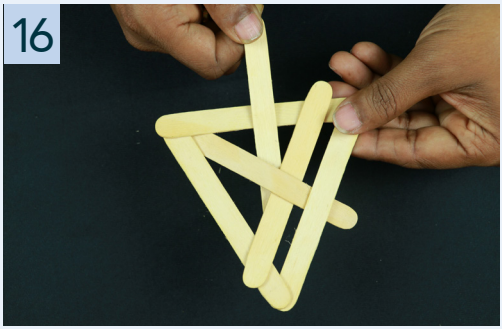

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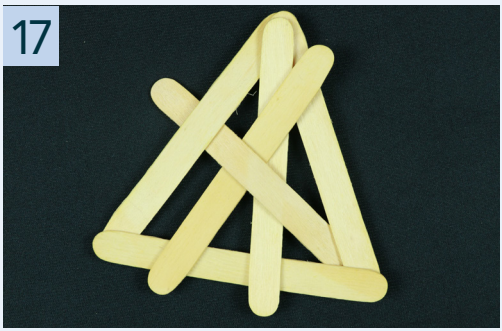

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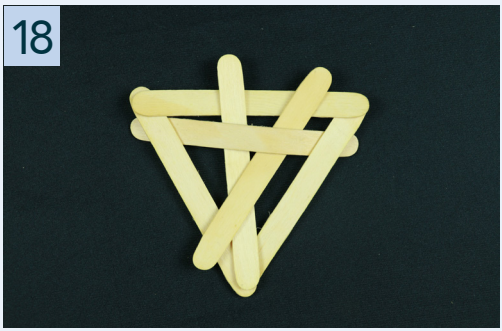
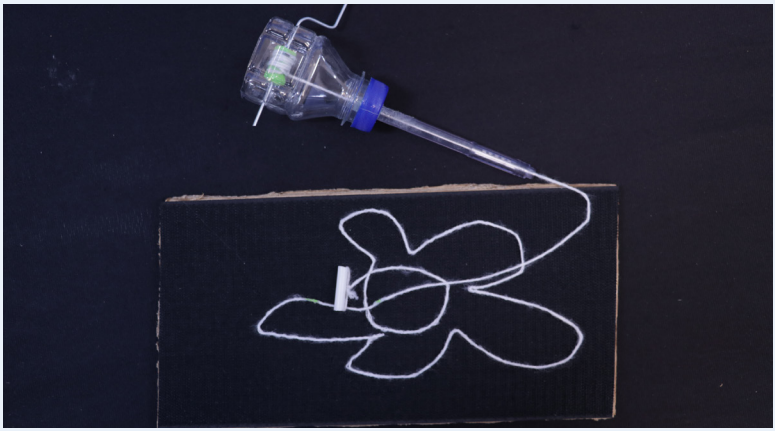


TOUCHING SLATE

LEARNINGS

Friction

Blind Slate



Just using some Velcro, woolen thread and an empty ball pen, you can create this slate for the visually impaired. This slate is called the "Touching Slate" because you can read the writing by touching it and somewhere it also touches the heart. It can be used to make really beautiful designs.

MATERIALS REQUIRED

Velcro sheet

Small bottle (~200 ml)

Cycle spoke

Rubber

Wool

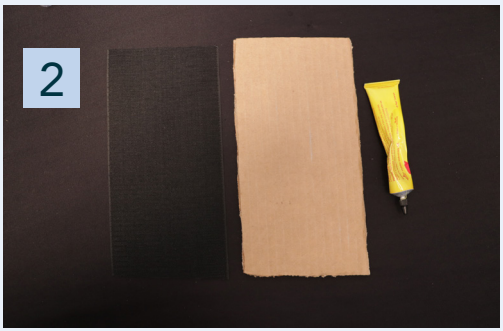
Empty Pen

Cutter

WHAT TO DO?

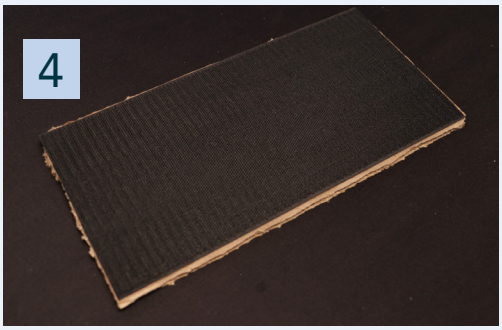
1. Apply glue to a thick piece of cardboard.
2. Velcro has two strips – the hooks and the loops – which stick together. Stick Velcro hook strips to the cardboard so that the whole area is covered. . This will be your drawing slate.
3. Cut the top part of an empty bottle (with the cap) using a cutter. Make a hole in the cap of the bottle can to fix a pen (you can also stick EVA sheet to the cap and then pass the pen though so that the pen remains attached tightly).
4. Make a pulley using an eraser by cutting some part from the middle and a Z-shaped crank using cycle spoke. Push one end of the crank in the pulley so that we can rotate the pulley using the crank.
5. Tie one end of a 3-feet long wool to the pulley. Cut the back end of the pen and push it through the bottle cap. Weave the other end of the wool through the pen.
6. Make a small hole on both ends of the bottle and fix the crank-pulley assembly on bottle through the holes.

Material required for this activity.

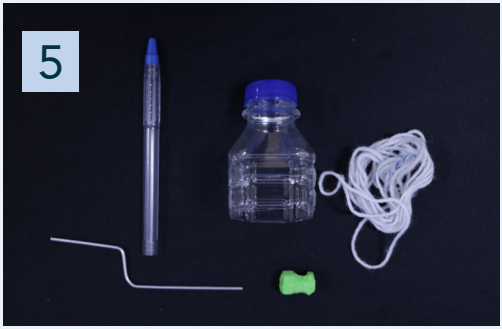


Velcro has two strips – the hooks and the loops – which stick together.

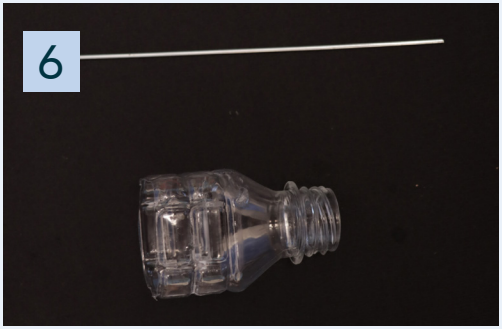
Apply glue to a thick piece of cardboard.



Stick Velcro hook strips to the cardboard so that the whole area is covered.

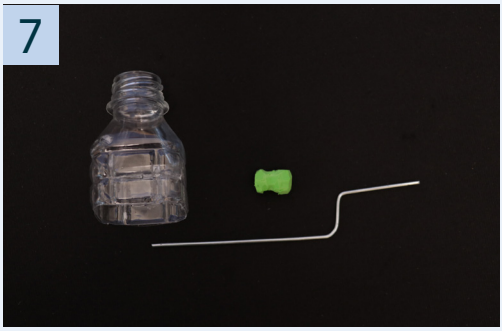


Cut the top part of an empty bottle (with the cap) using a cutter.



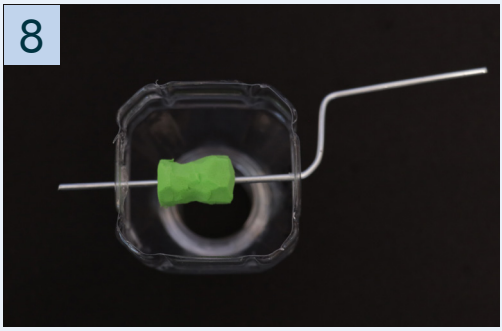
Bend the cycle spoke into a Z shape.

7



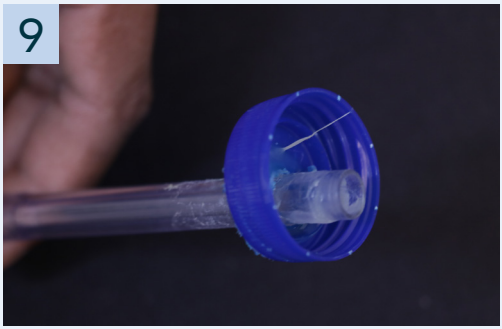
Make a pulley using an eraser by cutting some part from the middle and a Z-shaped crank using cycle spoke.

8



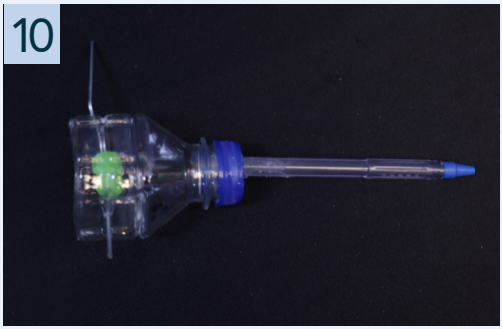
Push one end of the crank in the pulley so that we can rotate the pulley.

9



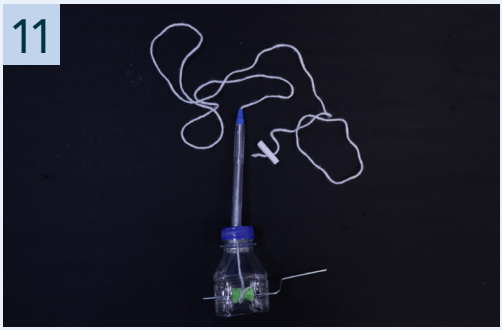
Make a hole in the cap of the bottle can to fix a pen

10



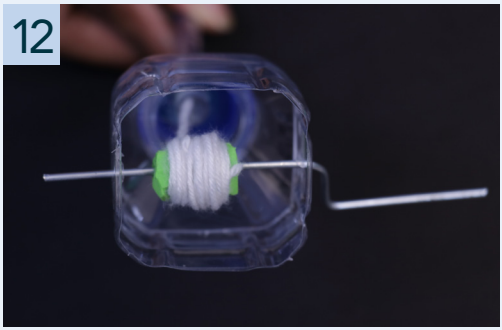
Cut the back end of the pen and push it through the bottle cap.

11



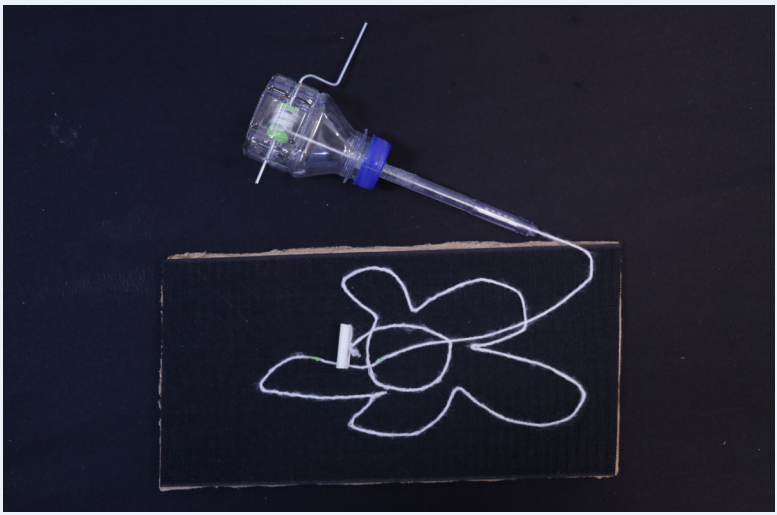
Tie one end of a 3-feet long wool to the pulley. Weave the other end of the wool through the pen.

12



Roll the wool on the pulley with the help of the crank.

NOTES



WHAT'S GOING ON?

1. Wool sticks nicely to Velcro (hooks and loops) which means that you can draw anything using wool on the Velcro slate.
2. The drawing pen is just like a fishing line. On rotating the crank, the wool will wind on the pulley. Therefore, the ink of this pen is reusable!
3. This slate can also be used by blind people who can feel the wool by touching it, like the Braille script.

EXPLORE

1. This toy was invented by an ISRO scientist Dileep Bhatt for his child who was visually impaired. His motivation was to provide an inexpensive and effective tool to 12 million blind children across the country.
2. Use different types of threads and see how they all behave with Velcro.

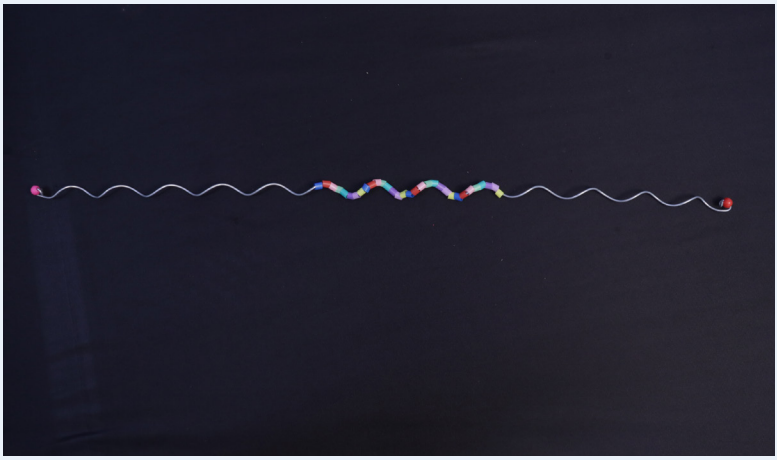
HELICAL SNAKE

LEARNINGS

- Wave
- Friction
- Sine curve
- Helix

MATERIALS REQUIRED

- Stiff Metal Wire
- Colored Straws
- Beads
- Scissors
- PVC Pipe

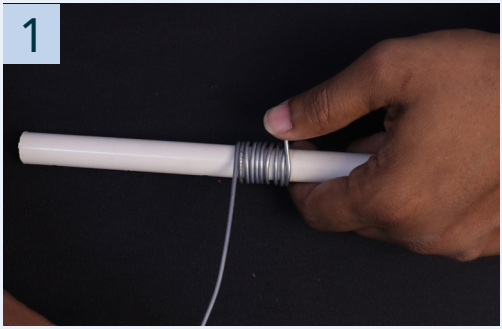


Colorful straw pieces slide down a helical spring and look like a snake slithering down or a liquid crystal. Immensely satisfying to watch!

WHAT TO DO?

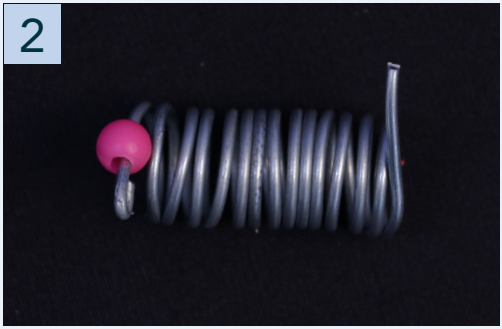
1. Coil the metal wire around PVC pipe to make a spring and take it out.
2. Pull both ends of this spring to make a long spring.
3. Cut small pieces of straws of different colors and insert them in the spring. Make sure that the pieces of straw are small otherwise the toy won't work.
4. Close both ends of the wire using beads so that the straw pieces don't come out.
5. Now flip the spring upside down and enjoy!

1



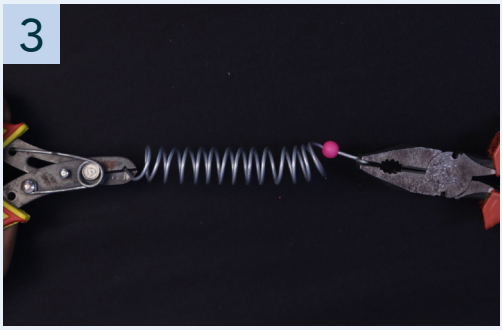
Coil the metal wire around a PVC pipe to make a spring.

2



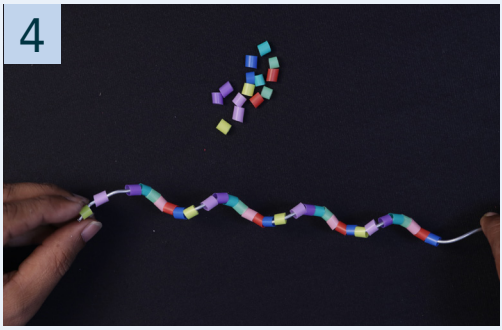
Take the spring out, cut the extra wire and loop it after adding a bead at one end.

3



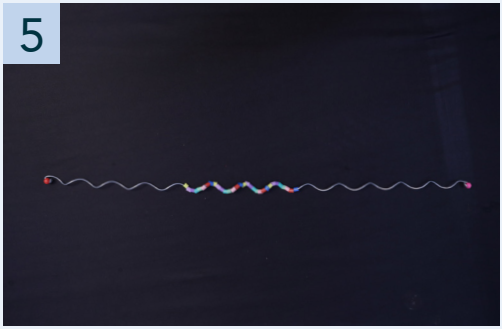
Pull both ends of this spring to make a long spring.

4



Cut small pieces of straws of different color and insert them inside the spring.

5

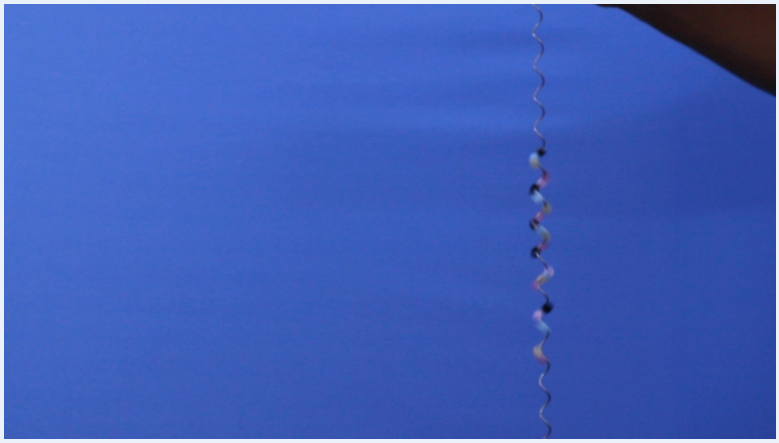


Close both ends of the wire using beads so that the straw pieces don't come out.

6

It should look something like this.

NOTES



WHAT'S GOING ON?

1. Gravity pulls the straw pieces down when the wire is held vertically.
2. Because of the helical structure of the wire, pieces of straw go down slowly due to friction.
3. The colorful straws blend into one another and form a continuous crystal-like structure.
4. The structure also looks like a sine curve when we see it from the side.

EXPLORE

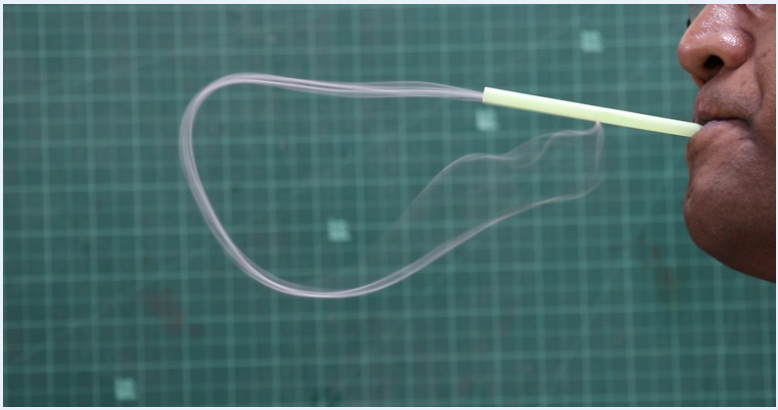
1. The height descended by a straw piece in one complete turn is called the pitch of the helix. When you stretch the wire, the pitch increases. On compressing it, the pitch decreases.
2. Take a metal spring (which is a regular helix) in which there is some distance between the consecutive turns. Dip it in ink, and roll it on the floor. The spring would trace a straight line on the floor!

STRAW LOOP

LEARNINGS

Drag force

Friction



MATERIALS REQUIRED

Straw

Thread

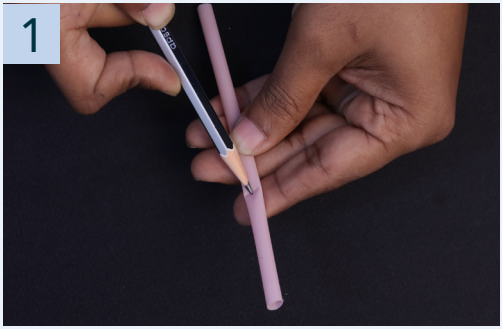
Pencil

Blow inside the straw and the loop keeps on rotating! You can make this toy in just few minutes and keep playing with it for hours.

WHAT TO DO?

1. Cut a straw in half. Make a hole in the center of the straw using the pencil (or a pin) .
2. Rotate a pencil in the hole to make it smoother.
3. Take the cotton thread and weave it through the hole in the same direction as you put the pencil. This is to ensure that the thread wouldn't get stuck in the hole while passing through it.
4. Bring the ends of the thread together but do not tie a knot. Take some glue on your index finger and twist the two ends of the thread to join them together.
5. Now blow through the straw and you will be surprised to see the whole thread loop goes round and round.

1



Use a pencil to make a hole on one face of the straw.

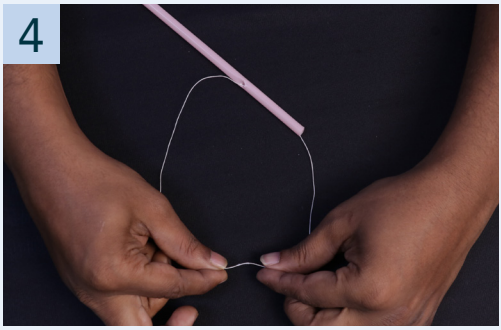
2

Rotate a pencil in the hole to make it smoother.

3

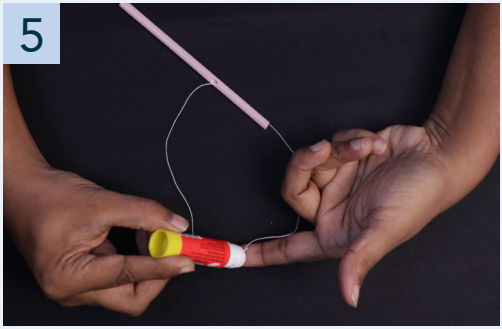
Pass the thread through the hole in the same direction the hole was made.

4



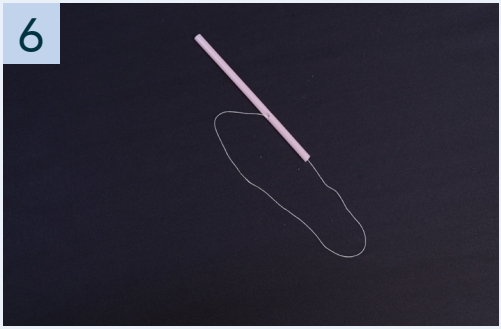
Bring the ends of the thread together but do not tie a knot.

5



Take some glue on your index finger and twist the two ends of the thread to join them together.

6



The straw loop is ready.

NOTES

WHAT'S GOING ON?

1. As you blow air into the straw, the air drags the thread forward with it.
2. For the drag, the fibers of the thread should obstruct the flow of air. So a thread which is very smooth (for example, nylon) will not work best.
3. High speed air also creates low pressure which keeps the thread up for some distance.

EXPLORE

Try using different sizes and types of thread. See which thread suits best for the toy.

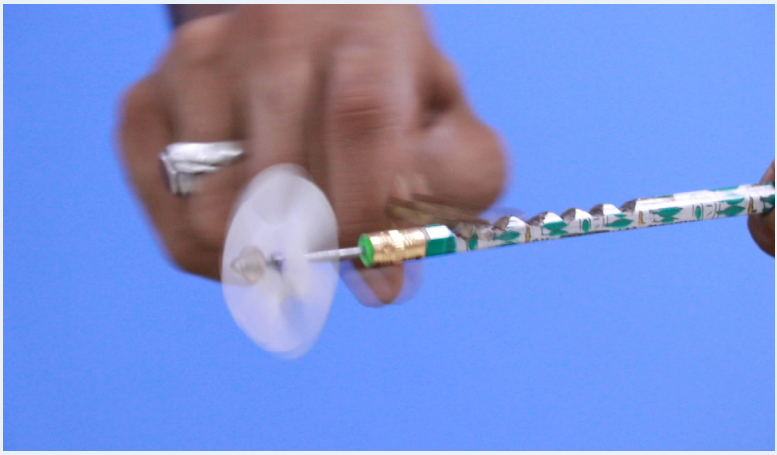
PENCIL SPINNER

LEARNINGS

- 2D Motion
- Vibrations
- Force
- Circular Motion

MATERIALS REQUIRED

- Pencil
- Kebab Stick
- Paper cutter

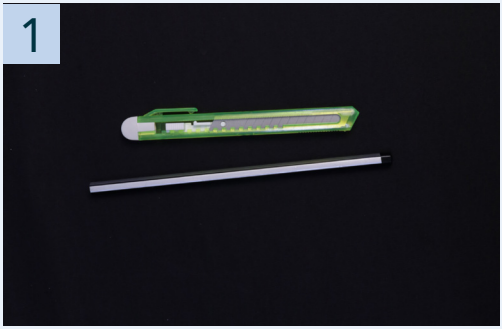


This hundred-year-old toy seems basic and simple at first . But It's interesting that six people have written research papers on it (towards a Ph. D.). Yet the exact physics is not very clear.

WHAT TO DO?

1. Take a pencil with an attached eraser at one end. Insert a pushpin (or nail or a small stick) with a paper in the eraser. Make sure that the paper can easily rotate on the pin.
2. Make grooves on the pencil by cutting it using a paper cutter and our toy is ready.
3. Hold the pencil from one end and rub a kebab stick on the grooves - It will make the paper spin!

1

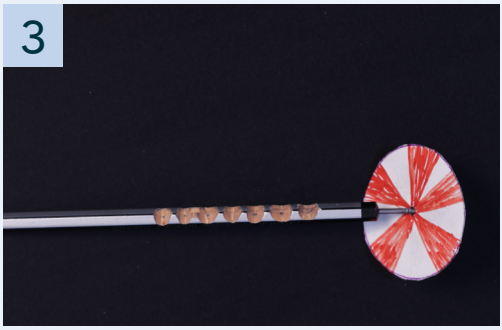


Make grooves in the pencil by making slant cuts using a cutter.

2

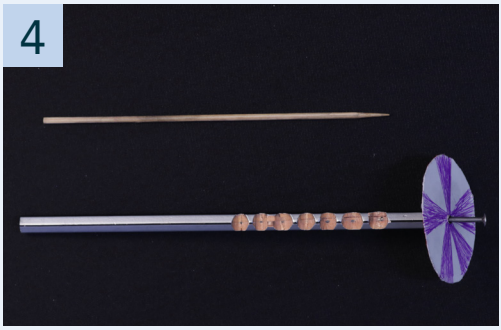
The pencil will look like this after making the grooves.

3



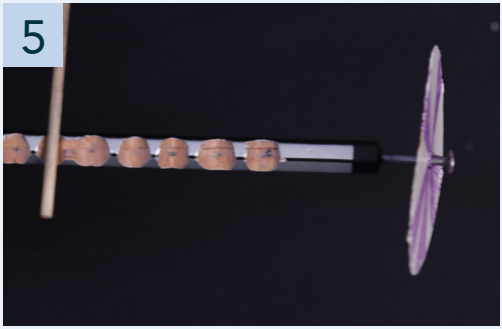
Insert a pushpin with a paper in the eraser.

4



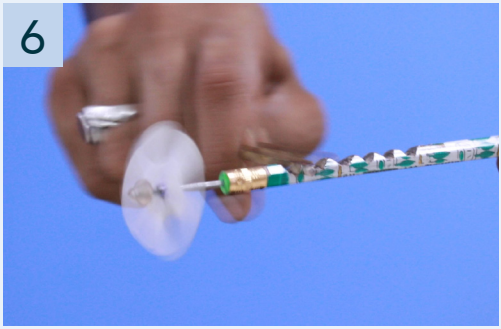
Rub a kebab stick on the grooves of the pencil.

5



The paper would start to rotate!

6



NOTES

WHAT'S GOING ON?

1. As you rub the stick on the pencil, vibrations are generated in the pencil.
2. These vibrations rotate the paper at the end of the pencil.

EXPLORE

1. The paper can be rotated in two directions. Play with the toy and figure out how you can rotate it in a particular direction.
2. Would the paper still rotate if you hold the pencil firmly below the notches?

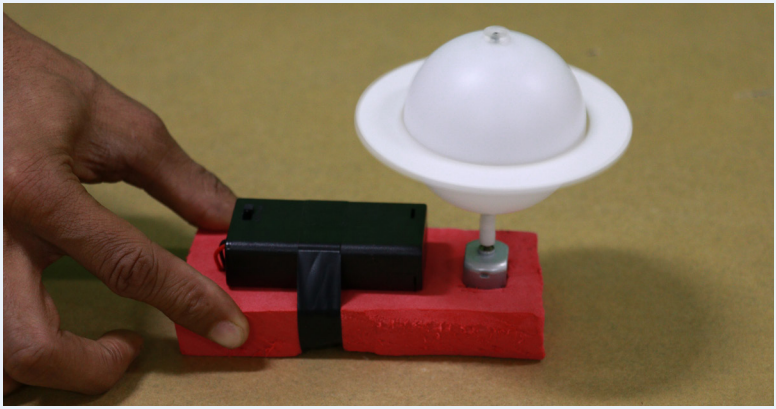
MECHANICAL HULA HOOP

LEARNINGS

Torque

Weight

Friction



MATERIALS REQUIRED

Toy Motor

Plastic Ball

Paper Disc

Battery

Scissors

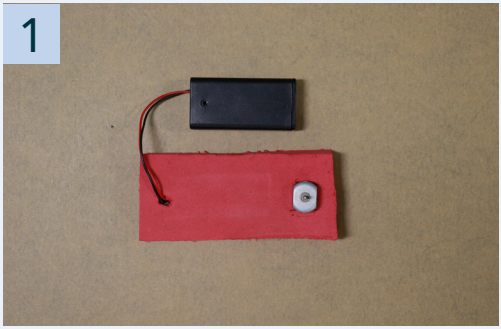
Stiff Straw

This is a very counter-intuitive model which defies gravity. The paper disc looks like Saturn rings when it rotates.

WHAT TO DO?

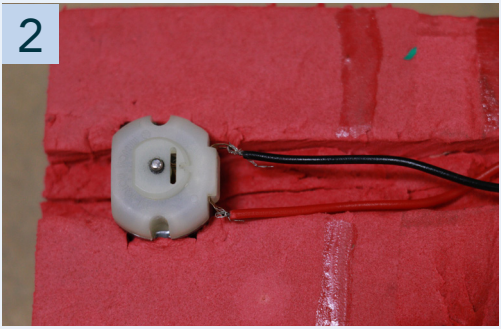
1. Fix motor in a slot in the EVA sheet. Also pass the wire from the battery holder through another hole.
2. Attach the wire to the motor from below the sheet.
3. Add the part shown to the motor to hold the stiff straw.
4. Pass the stiff straw through the hole in the plastic ball.
5. Attach the stiff straw (with the ball) to the motor.
6. Spin the ball by switching on the motor. Hold the disc on the ball loosely and the disc will start spinning too.
7. On leaving the disc, it will still keep spinning and look like Saturn rings on the ball. Even on inverting the motor, the disc will not fall and will keep spinning.

1



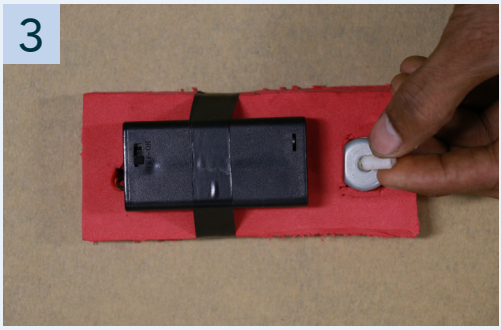
Fix motor in a slot in the EVA sheet. Also pass the wire from the battery holder through another hole.

2



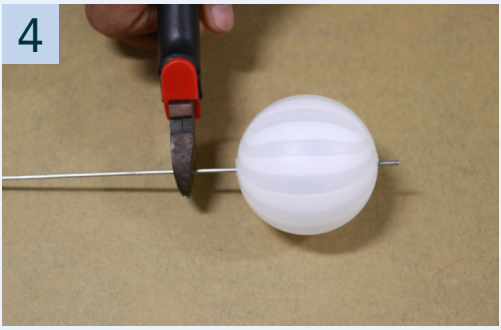
Attach the wire to the motor from below the sheet.

3



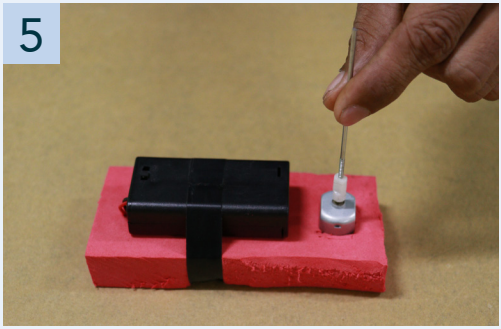
Add the part shown to the motor to hold the cycle spoke.

4



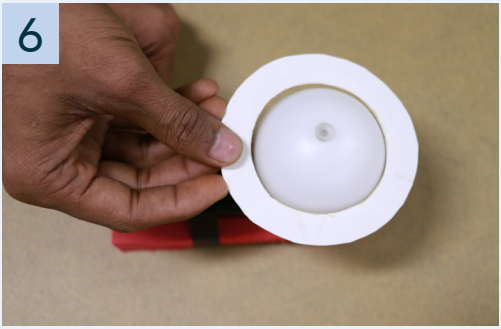
Pass a cycle spoke through the hole in the plastic ball.

5



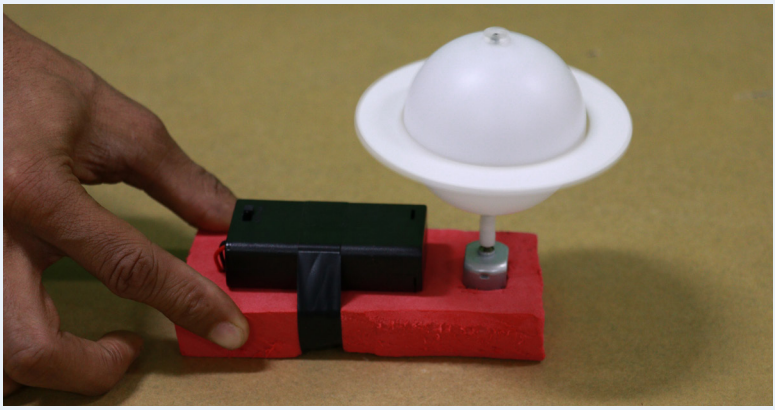
Attach the cycle spoke to the motor.

6



Turn on the motor and adjust the disc such that it becomes stable on the ball.

NOTES



WHAT'S GOING ON?

1. To understand the working of this toy, let's first understand how a hula hoop works. What makes a hula-hoop spin around a person's waist?
2. When you rotate the hula loop, you exert an upward force (from the hips) and another force which keeps it rotating.
3. Friction between the hoop and your clothes slows the hoop down. But it is also friction which keep the hula-hoop up on your body while gravity pulls it down.
4. In case of our mechanical hula hoop, the motion of the waist is replaced by the spinning motor which hits the paper disc and provides the necessary force to spin it and supposedly defy gravity.

EXPLORE

1. Decorate the ball and disc such that they actually look like Saturn and its rings.
2. Try with different shapes of rings. The hole also doesn't have to be circular. Try with a square hole instead.

STANDING CD

LEARNINGS

Angular Momentum

Torque

Moment of Inertia

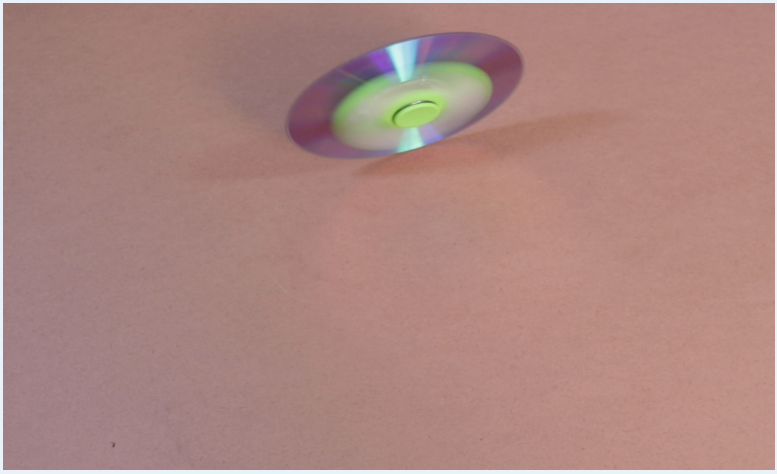
Gyroscope

MATERIALS REQUIRED

CD

Fidget Spinner

Glue



A very fascinating toy that takes the already popular toy - fidget spinner - and makes it even more interesting. The CD falls down when you try to balance it but when you rotate the fidget spinner, the CD stands for a long time.

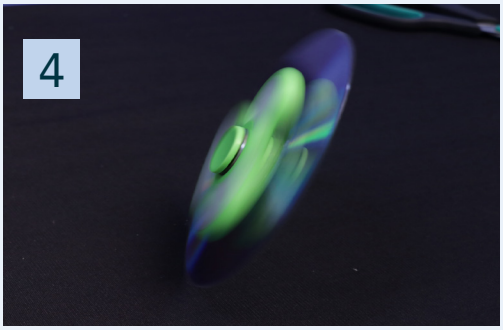
WHAT TO DO?

1. Take a fidget spinner and stick it to a CD exactly at the center.
2. Try to balance the CD on the ground. It will fall down very quickly and will not keep standing.
3. Now spin the fidget spinner and put the CD on the ground. Surprisingly it will stay up.

For this activity you will need a CD, fidget spinner and instant adhesive.

Take the fidget spinner and stick it to the CD exactly at the center, using adhesive.

Your Standing CD is ready.



Spin the fidget spinner and put the CD on the ground. Surprisingly it will stay up.

NOTES

WHAT'S GOING ON?

1. As the fidget spinner spins at a fast speed, it prevents the CD from falling.
2. The CD stays at the point of contact and doesn't fall. The spinner acts like a gyroscope because of conservation of angular momentum.
3. The CD also starts to rotate slowly on the ground.
4. That is why gyroscopes are used for maintaining orientation in rockets and ships.

EXPLORE

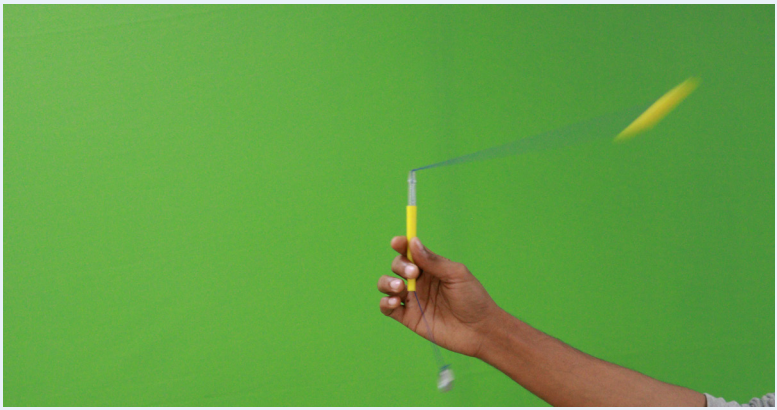
1. What happens if you spin the fidget spinner in opposite direction?
2. Try to predict the direction of rotation of CD based on the rotation of the fidget spinner.

CAUTION: Be careful while using the instant adhesive. Use goggles to protect your eyes.

CENTRIFUGAL WEIGHT LIFTER

LEARNINGS

Centrifugal Force



MATERIALS REQUIRED

Nuts

Thread

Empty Pen/ Stiff Straw

Have you ever heard of the story of David and Goliath? David, a small boy fights a giant and defeats him! In this toy, a small weight is rotated and used to lift a much larger weight.

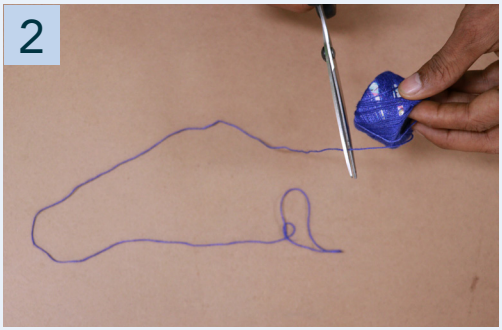
WHAT TO DO?

1. Tie one end of the thread to the cap of the pen.
2. Pass the thread through the pen body or the stiff straw and tie the nuts on the other end.
3. Now hold the pen and keep the cap side up. The nuts being heavier than the cap, would lie on the ground.
4. Start rotating the cap by rotating the pen body and observe.

1

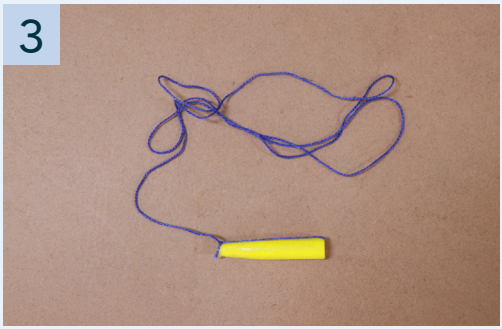
Material required to make the centrifugal weight lifter.

2



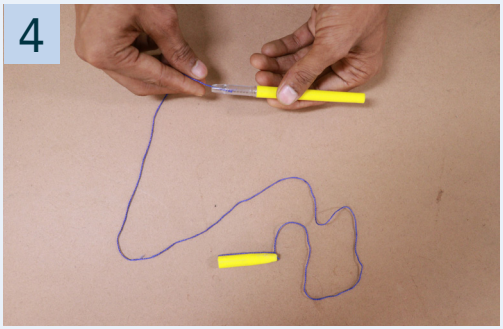
Cut a slightly longer piece of thread.

3



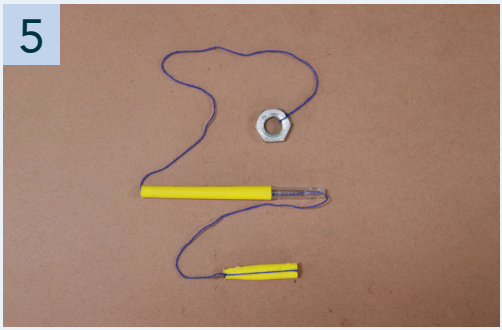
Tie the cap of the pen, to one end of the thread.

4



Pass the thread through the pen body or the stiff straw.

5

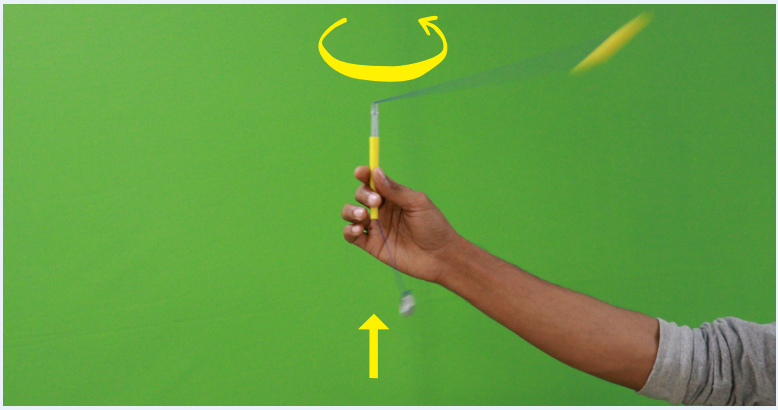


Tie the nuts on the other end

6

Start rotating the cap by rotating the pen body and observe.

NOTES



WHAT'S GOING ON?

1. As the bigger weight is hanging with the thread, tension is generated in the thread.
2. To rotate any object, it requires a force towards the center called the centripetal force. In this case, the tension in the string provides the necessary centripetal force for the marble.
3. This in turn lifts the bigger weight. The lift of larger weight depends on the speed of rotation of the smaller weight. The faster you rotate, the bigger load you can lift.

EXPLORE

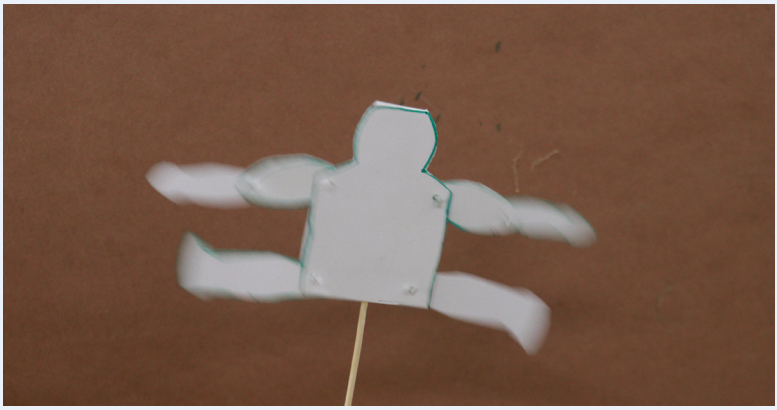
If you keep rotating the marble with constant angular speed, you can lift any weight, provided you have a sufficiently large rope. As the length of the rope increases, the tension in the rope increases and hence you can lift a larger weight.

DANCING MAN

LEARNINGS

Centrifugal Force

Rotation



Dancing is basically moving your hands and legs around. Here is an interesting toy that moves its hands and legs using centrifugal force!

MATERIALS REQUIRED

Card Sheet

Kebab Stick

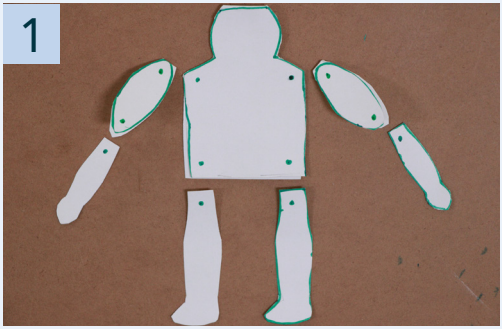
Glue

Thread

WHAT TO DO?

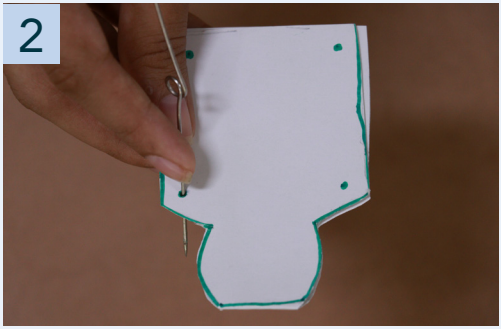
1. Take out the different body parts from the sheet. The body and shoulder arms are doubled so that we can hinge the legs and elbows in them easily.
2. Pierce all the cut pieces using a needle to join body, shoulder arms, legs and elbows together.
3. Open the doubled-up body, apply glue, stick a kebab stick inside and fold it.
4. Take the shoulder arm and elbows and hinge them with a needle and a thread by making knots on both sides. After this, the shoulder arm and elbows should be able to move relative to each other.
5. Similarly join all the body parts with needle and thread and our dancing man is ready.
6. On twirling the stick, it will move its hands and legs – executing a dance!

1



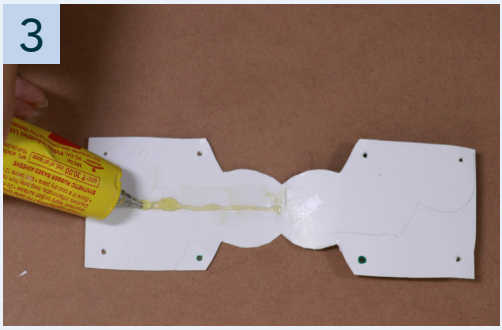
You should have the following shapes.

2



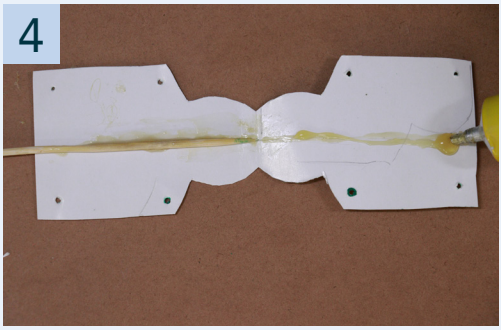
Use a safety pin or kebab stick to punch holes in the places marked.

3



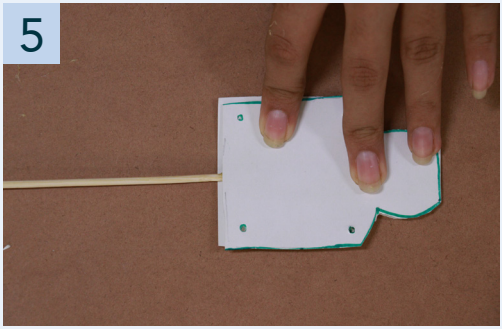
Apply glue to one side of the torso.

4



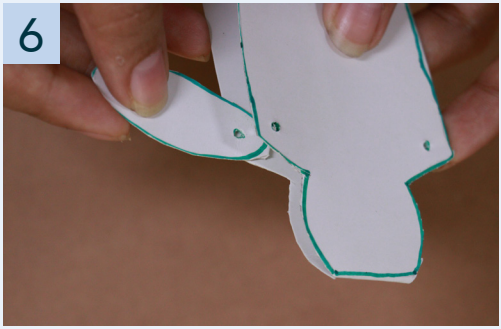
Stick the two faces together such that the kebab stick is in the center.

5



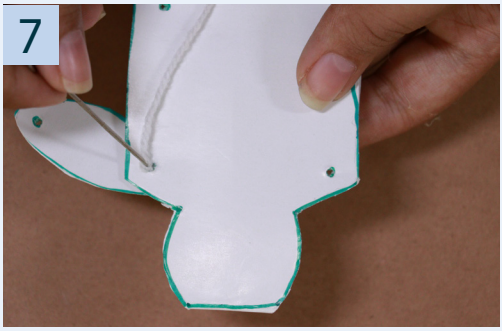
Press it firmly to stick. Leave the sides open a little.

6



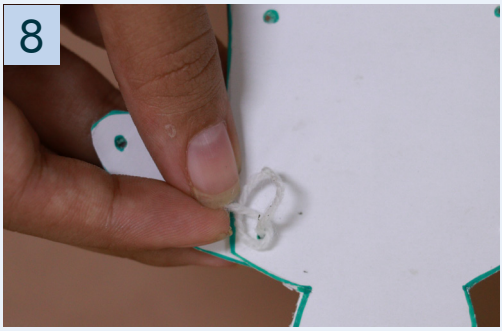
Attach the arm as shown.

7



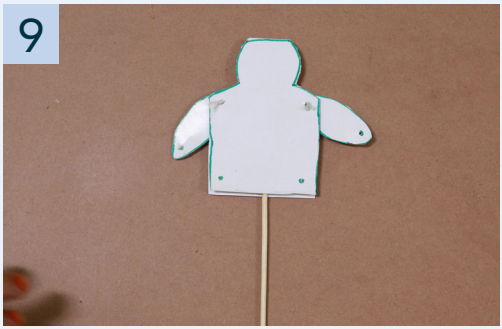
Use a needle or safety pin to pass the thread through the torso and hand.

8



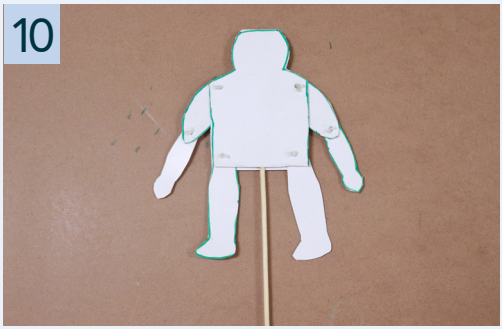
Tie knots at both ends and cut the extra thread.

9



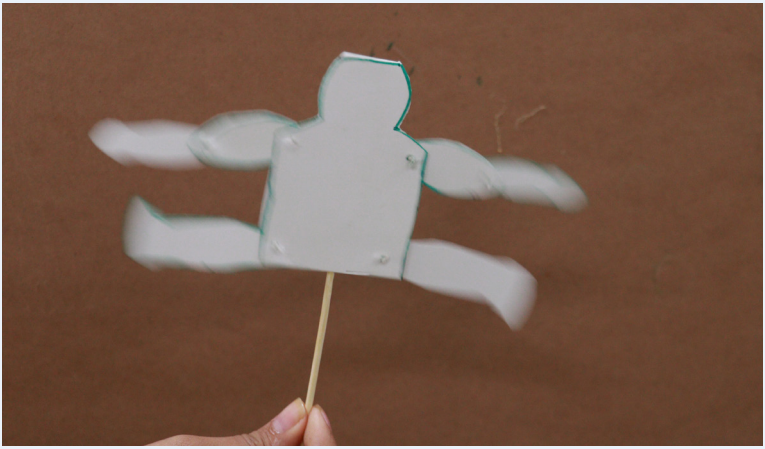
Attach a hand on the other side as well.

10



Attach all the parts to the torso.

NOTES



WHAT'S GOING ON?

1. Any object, when rotated, tries to fly out due to centrifugal force.
2. The hands and legs of the man will also fly out when we rotate it.
3. The man on stick will 'dance' randomly as you rotate the stick counterclockwise and clockwise in jerky motion.
4. The dance movements are the result of centrifugal force acting on the man at the joints.

EXPLORE

1. When you sit on a merry-go-round, you feel that you would go outwards if you release the grip. But actually, you would go in a tangential direction at that moment.
2. Decorate and paint your dancing man with bright color.

FLUTTERING BUTTERFLY

LEARNINGS

Friction

Joints

Hinges

MATERIALS REQUIRED

Paper

Straw

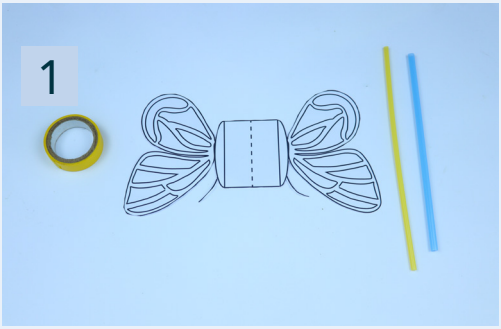
Kebab stick

Glue

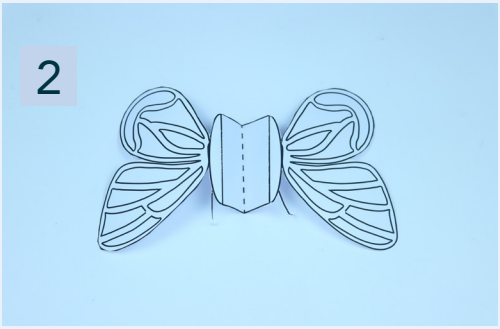
A toy butterfly that can flutter without motors or any mechanical parts!

WHAT TO DO?

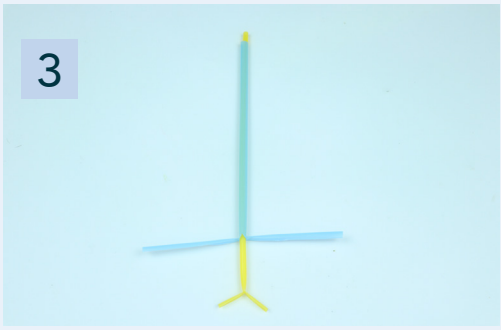
1. Take the paper butterfly and fold it as shown in the picture.
2. Stick the middle part of the butterfly using glue.
3. Make cuts in the thin and thick straws using scissors.
4. Stick the ends of the thinner straw to the middle of the butterfly.
5. Stick the ends of the thicker straw to the wings of the butterfly.
6. Hold the thin straw and move the thick straw up and down to flutter the wings of the butterfly!



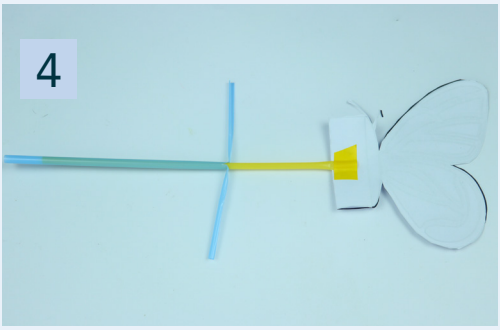
Take the paper butterfly and fold it as shown.



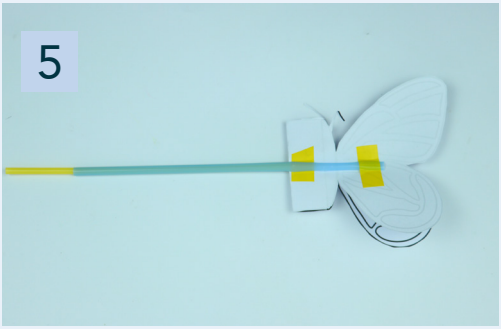
Stick the middle part of the butterfly with glue.



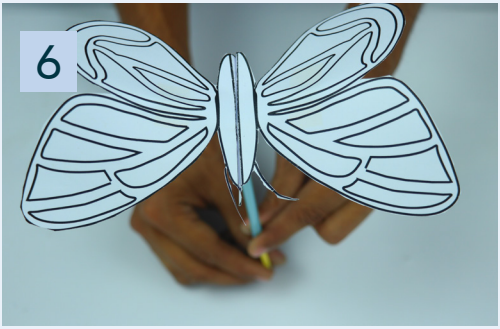
Make cuts in the two straws (thin straw and thick straw) using scissors.



Stick the ends of the thinner straw to the middle of the butterfly.



Stick the ends of the thicker straw to the wings of the butterfly.



Hold the thin straw and move the thick straw up and down to flutter the wings of the butterfly!

NOTES

WHAT'S GOING ON?

1. The inner straw is attached to the center of the butterfly and acts as an anchor to hold the butterfly.
2. The ends of the outer straw are attached to the wings of the butterfly. Therefore, the wings move when you move the straw up and down.
3. The butterfly looks like fluttering its wings!

EXPLORE

Make two butterflies and make them move together through common power.

MAGIC WATER THERMOMETER

LEARNINGS

- Heat and Expansion
- Convection and Conduction of Heat
- Temperature-Volume Relationship
- Charles Law
- Friction
- Conservation of Energy

MATERIALS REQUIRED

- Glass bottle
- Transparent Straw
- Food Color
- Cutter

You have probably placed the thermometer in your mouth when you had a fever. How does the thermometer show the temperature? Make your own thermometer and check the temperature with it!

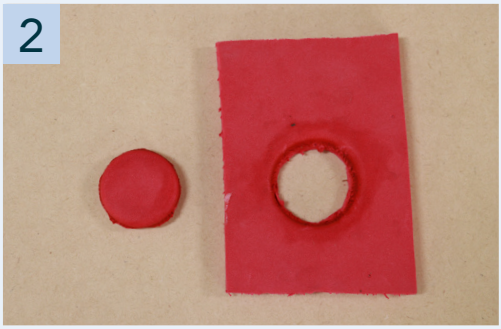
WHAT TO DO?

1. Take a small piece of EVA sheet to tightly close the opening of the glass bottle.
2. Make a small hole at the center of this cap.
3. Pass a transparent straw through this hole. Apply glue to ensure that all the connections are airtight.
4. Put some colored water inside the bottle and close it. Make sure that the lower end of the straw is dipped in water.
5. Rub your palms vigorously and hold the bottle.
6. You will observe that the water rises inside the straw

1

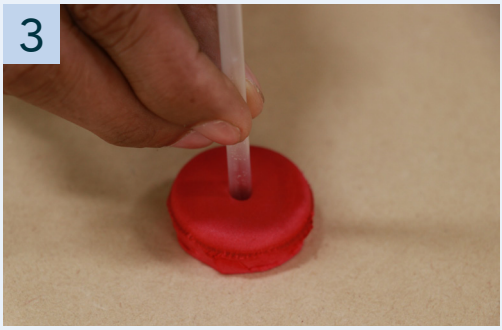
Gently push and rotate the bottle to cut the EVA sheet. You can also use a cutter to cut the circle.

2



This would give you an air tight cap for the glass bottle.

3



Pass a transparent straw through the center.

4

Put some colored water inside the bottle and close it.

5

Rub your palms vigorously and hold the bottle.

6

You will observe that the water rises inside the straw.

NOTES

WHAT'S GOING ON?

1. When you rub your palms, they become warm because of friction. The energy from the movement of your hands gets converted to heat energy.
2. When you hold the bottle with the warm hands, the heat is transferred to the air inside the bottle.
3. The hot air inside the bottle expands and occupies more space.
4. This is due to Charles's Law. It states that the volume occupied by a gas is directly proportional to its temperature (if the pressure and amount of gas remain unchanged). It means that as the temperature of a gas increases, the volume also increases.
5. As the air requires more volume, the water is forced to rise up inside the straw.
6. The warmer the air, the more volume it occupies and the more water rises in the straw. Therefore, the straw works like a thermometer.

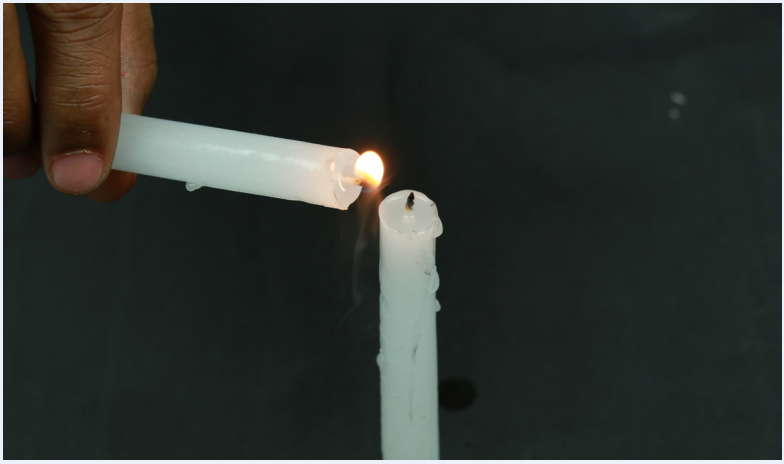
EXPLORE

1. Calibrate your thermometer to show the actual temperature. Mark the straw at various places according to the amount of water rising for different temperatures.
2. If the straw is thinner, the water will rise higher. This is because the air in the bottle expands by a fixed amount for a particular temperature. Therefore, lesser diameter of the straw would result in more height.

MAGIC CANDLE

LEARNINGS

Combustion



MATERIALS REQUIRED

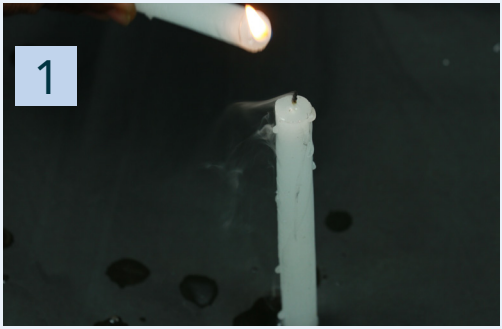
Candle

Matchbox

Light this magic candle without even touching it!

WHAT TO DO?

1. Light a candle with a matchstick and place it on the ground.
2. Blow the candle and immediately bring another flame (from a matchstick or lighter) into the smoke.
3. The flame will travel through the smoke and light the candle again.



Extinguish the candle.

Bring another candle close to the smoke of the first candle.

The candle will light up again.

NOTES

WHAT'S GOING ON?

1. When you burn a thread, it instantly burns and converts to ash.
2. When you burn paraffin wax, it melts but does not catch fire.
3. So, when you light a candle, what really burns inside a candle? Is it the thread, the solid wax or something else?
4. It is essentially the wax vapor that burns in a candle.
5. When you extinguish the candle, the smoke from it also contains lot of unburnt wax vapor.
6. These unburnt wax vapors come in contact with the flame, catch fire and eventually light the extinguished candle again.

EXPLORE

Try the same activity with an earthen lamp (diya or deepak) and see if it works.

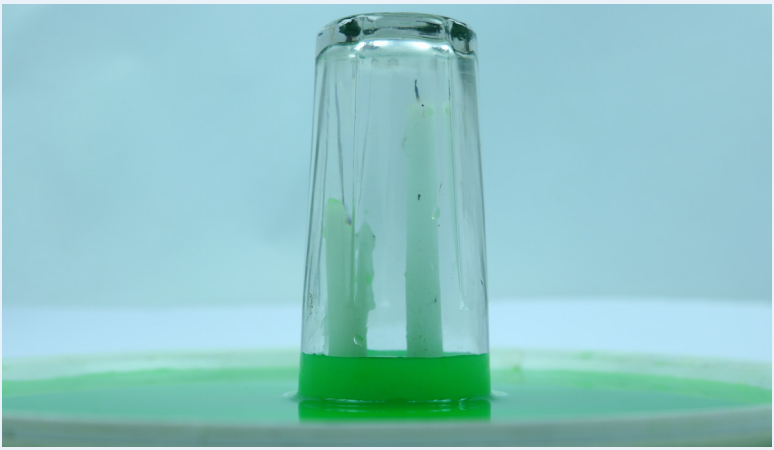
RISING WATER IN A GLASS

LEARNINGS

- Combustion
- Composition of Air
- Charles Law
- Temperature-Volume Relationship
- Heat

MATERIALS REQUIRED

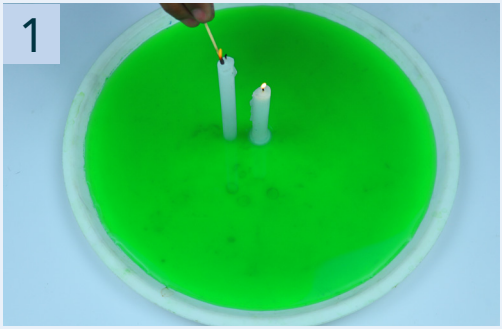
- Plate
- Candle
- Matchstick
- Food Color



Can you pick a coin immersed in water from a plate without wetting your hands? Yes, if you have a glass and a candle!

WHAT TO DO?

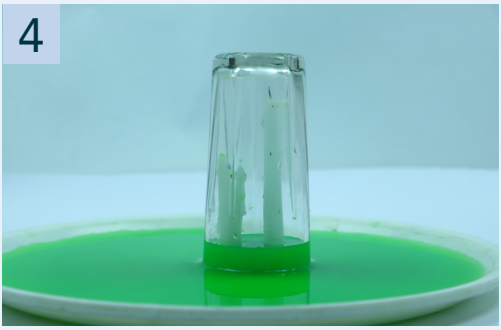
1. Place a candle inside a plate and fill it with colored water.
2. Cover the burning candle with a glass.
3. You will notice that the candle extinguishes after some time and water rises inside the glass.



Fix two candles (one long, and one short) to a plate. Add some water and food coloring to the plate.

Light up both the candles.

Take a glass and invert it on top of the candles.



You will see the water rise up in the glass.

NOTES

WHAT'S GOING ON?

1. Burning is a combustion reaction which requires oxygen along with fuel. The paraffin wax reacts with oxygen in air when it burns.
   $C_{25}H_{52} + 38\ O_2 \rightarrow 25\ CO_2 + 26\ H_2O$
2. When you cover the candle with glass, the oxygen inside the glass is consumed and the candle is extinguished after some time.
3. But why does the water rise in the glass? Is it because of the vacuum generated by depletion of oxygen inside the glass?
4. Repeat the experiment again. Notice that all the water rises in the candle after the candle is extinguished. If the rise were due to depletion of oxygen, it should have been gradual.
5. And if you look at the above equation, the total amount of gas actually increases during the burning of wax because the H_2O produced is also in vapor state. One explanation is that the water vapors condense after some time, resulting in low pressure.
6. What are other factors that can make the water rise inside the glass?
7. Try the same experiment with two candles of different length. This time the amount of water rising in the glass would be significantly more than the previous case.
8. This also can't be explained using the oxygen depletion theory. As the amount of oxygen is same in the glass (~20%), the water should also rise to the same level regardless of the number of candles.
9. The reason water rises in the glass is that air expands when heated.
10. When the candle is burning, the air around the flame becomes hot. This gas would be less dense (and hence would have less amount of air) than the air at room temperature. But this gas would be at the same atmospheric pressure as it is in touch with the atmosphere.
11. When you put the glass on the candle, you trap this less

dense air. When the flame goes out, the gas cools down and the pressure goes down. To fill this empty space, water from the plate goes inside the glass.

EXPLORE

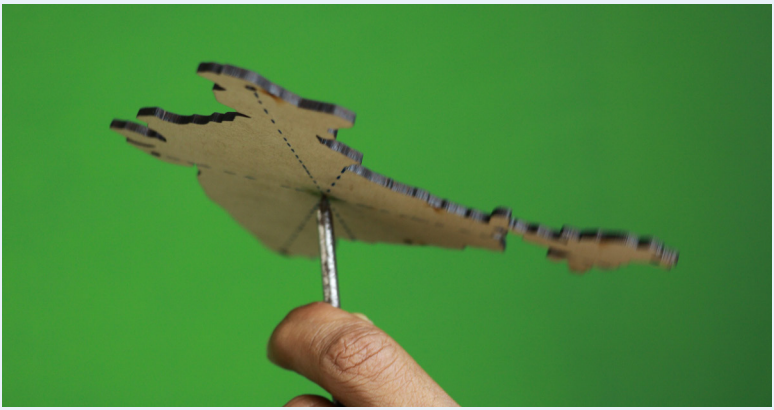
1. In the experiment with two candles, the longer candle is extinguished first, even though CO_2 is heavier than oxygen. Why?
2. Because the CO_2 produced is at a higher temperature and hence lighter than air (even though its molecular weight is more than air)
3. This is why people should crawl when leaving a building on fire.

FINDING CENTER OF MASS OF A RANDOM SHAPE

LEARNINGS

Center of Mass

Center of Gravity



You can probably find the center of simple shapes such as circles and squares pretty easily. But how do you find the "middle" of an irregular shape such as the map of India? In this activity, we will see how to do it using just string and paper clips!

MATERIALS REQUIRED

MDF Cutouts

String

Pencil

Scale

Paper Clip

Nut

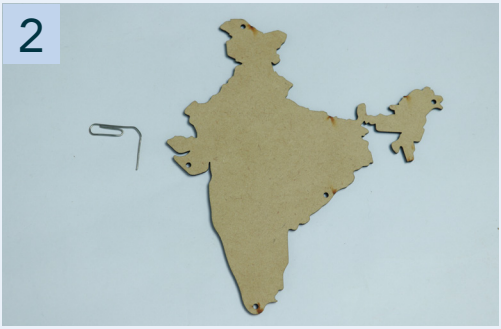
WHAT TO DO?

1. Take a piece of thread (about one foot long) and tie a nut at one end. You can use any small object as a weight.
2. There are several small holes around the edge of the shape. They are made as close as possible to the edge. This is important for the accuracy of this method.
3. Now poke one end of the paper clip (or pushpin) through one of the holes. Make sure that the shape can swing easily from the hook.
4. Hold the paper clip such that both the shape and the thread are free to move on the paper clip. Use a pencil and ruler to draw a straight line on the paper along the string.
5. Repeat the process with different holes. The intersection of these lines would give the center of mass of the shape.
6. Balance the shape by putting your finger or a nail on the center of mass.

1

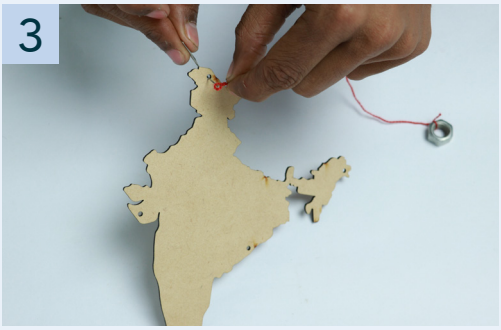
Tie the tread to the nut.

2



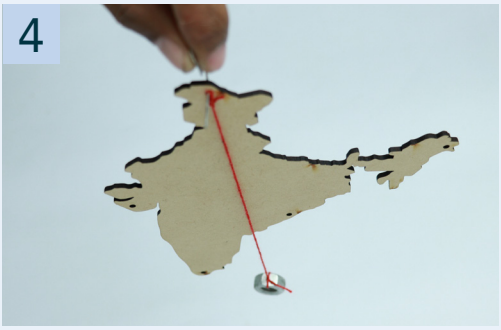
Pull out the free end of the paper clip as shown.

3



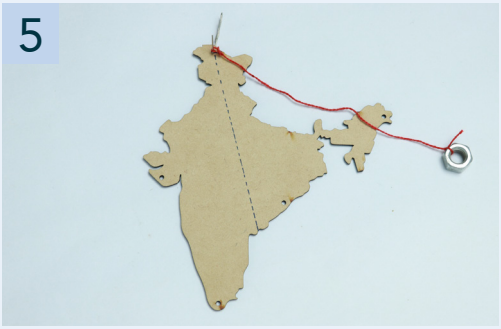
Pass the paper clip through any hole on the shape. Put the thread loop on the paperclip

4



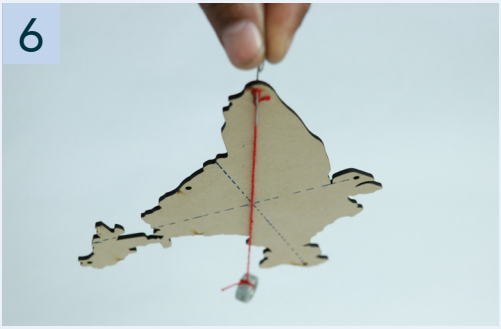
Hold the paper clip, such that both the shape and the thread are free to move on the paper clip.

5



Mark a line where the thread naturally falls.

6



Repeat the process with different holes.

NOTES

WHAT'S GOING ON?

1. How do you define the exact center of an irregular object? One way to do this is to find the object's center of mass.
2. The center of mass is the point about which an object will balance if you try to rest it on your fingertip. Or if you hang an object, for example a picture frame from a nail, the center of mass will hang directly below the nail.
3. For symmetrical objects, finding the center of mass is relatively easy. For example, for a rectangle, you know the center of mass is in the middle of the rectangle and you can find that with a ruler.
4. If you hang a shape from a single point, you know the center of mass will always rest directly below that point. So, if you hang a shape from two different points (one at a time) and draw a line straight down from each point, the center of mass is where those lines intersect.

EXPLORE

1. Try balancing the object on a nail by putting the center of mass on the nail.
2. Note that due to small variables in the activity (such as friction on the hook that prevents the paper from rotating perfectly or the holes not being close enough to the edge of the paper), if you draw multiple lines, they might not all intersect in exactly the same place but they should still be fairly close to one another.
3. Figure out how you can find center of mass for a 3D object.
4. Make different shapes with cardboard and find their center of mass using this method.

BALANCING BIRD

LEARNINGS

Center of Mass

MATERIALS REQUIRED

MDF Kit

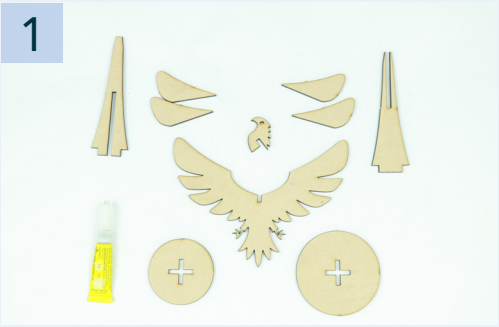
Glue

This is a classic toy which uses center of mass to balance the bird in a position which seems counter-intuitive and unstable at first sight. It's a fascinating model which looks magical and surprising.

WHAT TO DO?

1. Make the stand of the bird.
2. Attach the MDF parts below the wings of the bird using glue.
3. The balancing bird is ready. Place the beak of the bird on the stand and it will balance perfectly!

1



Take out the pieces from the flat sheet given.

2

Use the long pieces tio make the shaft.

3

Add the circular disks.

4

The stand should look something like this.

5

Use glue to stick these two pieces together.

6

Stick these pieces to the bottom of the wings.

Add the face to the body.

Your balancing bird is ready.

NOTES

WHAT'S GOING ON?

1. Any object can be balanced on its center of mass.
2. The bird is symmetrical on the left and right side. Therefore, the center of mass would be definitely on the center line.
3. By attaching the MDF parts below the wings, the center of mass comes exactly on the beak.
4. Therefore, the bird gets balanced on the beak.
5. When you try to balance the bird without attaching the parts below its wings, it won't balance because the center of mass would lie slightly below on the center line.

EXPLORE

Make other interesting models using the same concept. As long as the center of mass lies on the stand, it can be balanced on the stand.

CENTRIFUGAL DUSTBIN

LEARNINGS

Centrifugal Force

Friction

This dustbin keeps spinning and holds the waste even when it is turned upside down!

MATERIALS REQUIRED

MDF Kit

Motor

Paper Cup

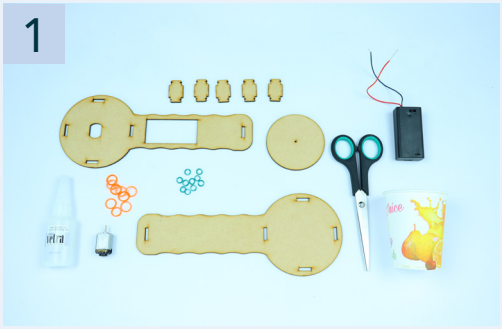
Battery

Glue

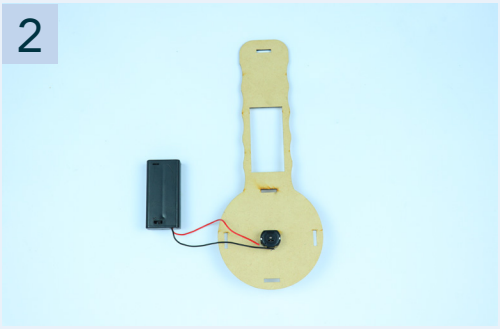
WHAT TO DO?

1. Insert the batteries in the battery holder and connect it to the terminals of the motor.
2. Place the motor in the MDF stand and attach the circular disc to the shaft of the motor.
3. Stick a paper cup to the disc using glue.
4. Close the top and your Centrifugal Dustbin is ready.

1



2



Attach the wire of battery holder to the terminals of the motor.

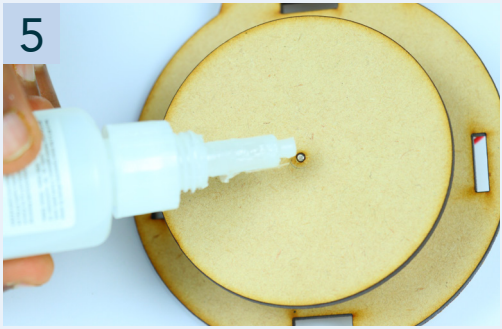
3

Fit the battery holder in the slot.

4

Attach the circular disc to the motor shaft.

5



Apply some glue to secure the disc at this position. Make sure the glue doesn't go inside the motor.

6

Attach the second part of the handle using the connectors.

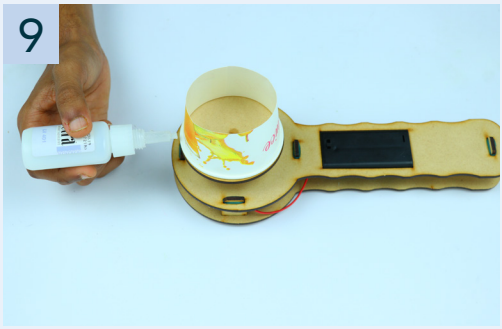
7

Fix the connectors using rubber bands.

8

The model should look like this.

9



Stick a paper cup on the top of the disc. The Centrifugal Dustbin is ready.

10

Switch on the motor and the cup would start to rotate. Now you can put waste in this dustbin.

NOTES

WHAT'S GOING ON?

1. Any object, when rotated, tries to fly out due to centrifugal force.
2. The waste particles in the paper cup will also fly out when it starts to rotate.
3. Due to this, the waste will stick to the walls of the cup.
4. Even when you turn this Dustbin upside down, the waste doesn't fall down.

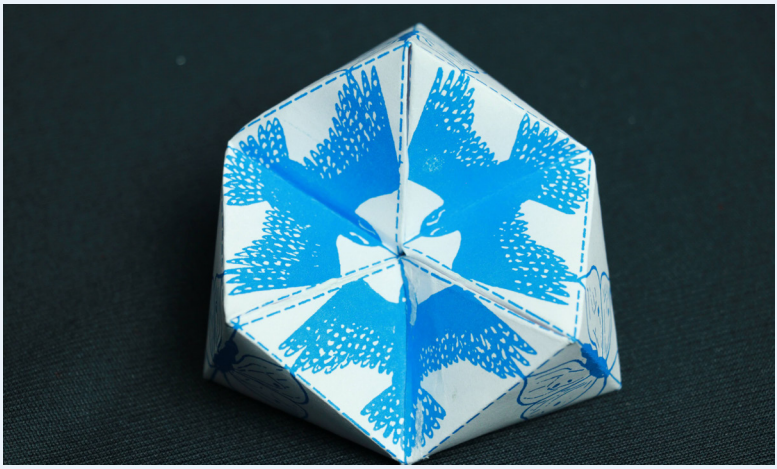
EXPLORE

Which force balances the force of gravity when you turn the dustbin upside down? The centrifugal force acts away from the center and therefore, can't balance gravity. It is the frictional force which acts in the upward direction. The normal reaction increases due to the rotation which in turn increases the frictional force.

3D FLEXAGON

LEARNINGS

- Tetrahedron
- Geometry
- Triangles
- Computational origami



Flexagons are a great toy, as well as can be used to depict an equation, a scientific fact, or a story. This is the 3D version of the flexagon which reveals a different image every time you rotate (or flex) it.

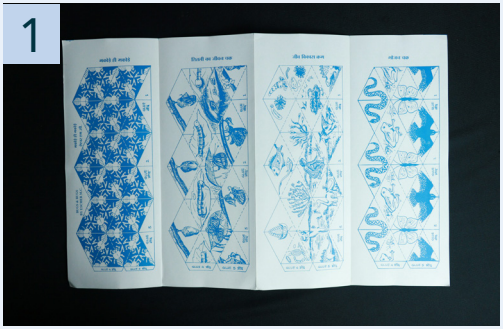
MATERIALS REQUIRED

- Paper
- Glue
- Scale

WHAT TO DO?

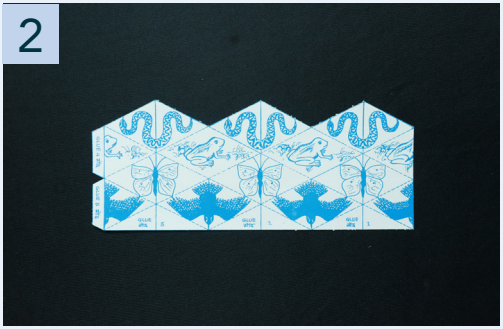
1. Select any one of the template from given paper.
2. Cut the template along the dark markings.
3. Fold the paper along the slant dotted lines using a scale.
4. Make proper crease on the paper.
5. Glue the paper where “Glue” is printed and stick to the other end of the paper such that it looks like a prism from above.
6. You will see diamonds on each facet of the prism.
7. Fold these half diamonds inside on all the three sides.
8. Now you will see a hexagonal shape with petals on top and bottom.
9. Crease these petal inwards to complete the flexagon.

1



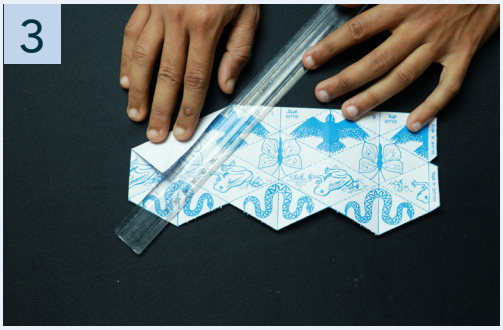
Select any one of the template from given paper.

2



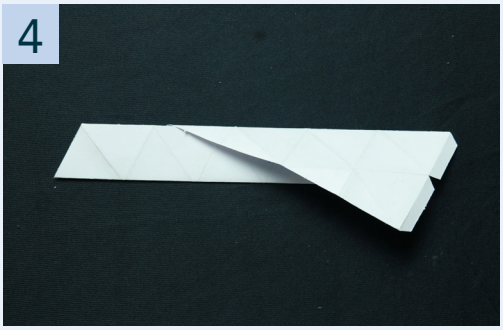
Cut the template along the dark markings.

3



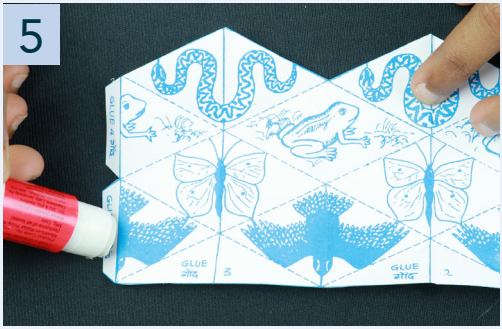
Fold the paper along the slant dotted lines using a scale.

4



Make sure that the creases are crisp.

5



Apply glue on the paper as per the markings.

6

Stick both ends of the paper together.

7

It should look like a prism from above.

8

Push the top and bottom triangles towards the center.

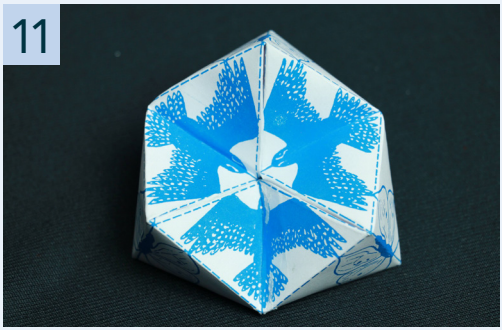
9

You should have three such hexagons.

10

Push in the hexagon points to make three pyramid like structures.

11



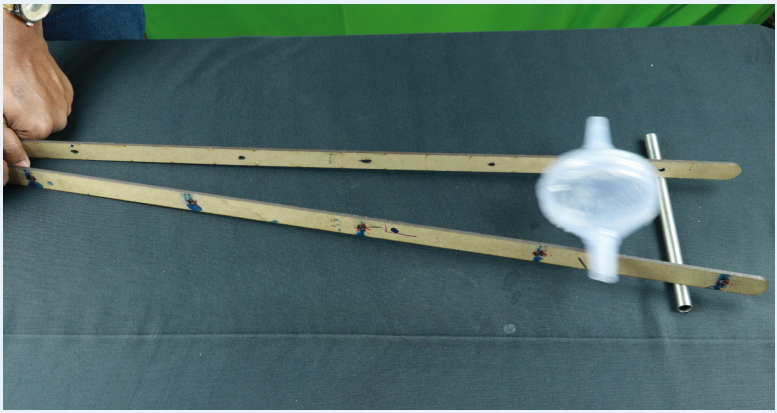
Your flexagon is ready.

UPHILL ROLLER

LEARNINGS

Center of Mass

Energy Conservation



Generally things move towards lower height but this magical roller seems to defy gravity and moves up on its own!

MATERIALS REQUIRED

Two Funnels with Same Shape and Size

Piece of PVC Pipe

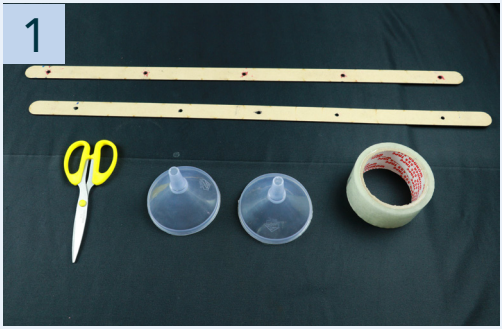
Glue/ Tape

Sticks

WHAT TO DO?

1. Take two funnels and stick them together using glue.
2. Make a V-shaped ramp using two sticks. Place a book (or any other object) such that the open end of the V is a little higher than the closed end.
3. Put a piece of PVC pipe on the ramp, on the higher height. The pipe will roll down from the higher height to lower height (i.e... from the place where the scales are far from each other to the place where the scales touch each other).
4. Now place the roller made from the funnels on the lower height of the ramp. Surprisingly, you will find this roller climbs from the lower end of the slope to the higher end on its own!

1

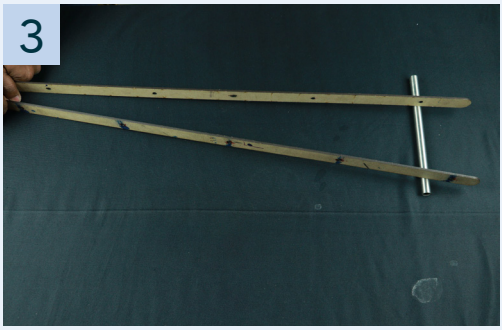


Material required for this activity.

2

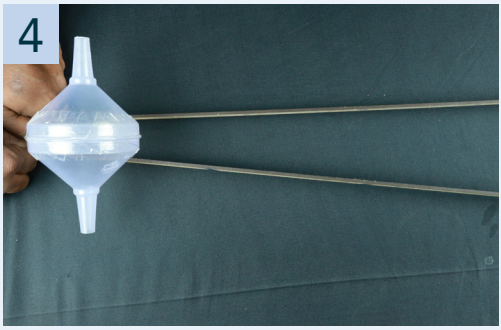
Stick the two funnels together.

3



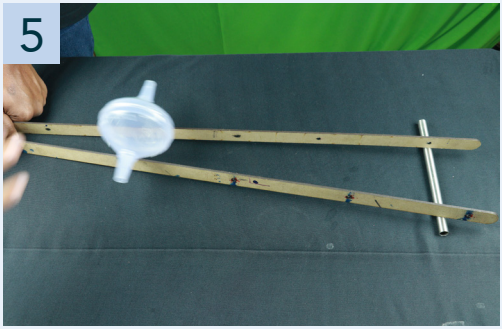
Make a V-shaped ramp using two sticks and place an object below the open end of the V.

4



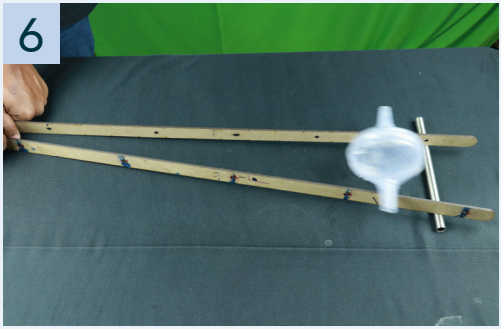
Now place the roller made from the funnels on the lower height of the ramp.

5



Leave the funnel from the lower end.

6



Surprisingly, you will find this roller climbs from the lower end of to the higher end on its own.

NOTES

WHAT'S GOING ON?

1. This is happening because of the special shape of the funnels. The center of mass of the roller is effectively going down, even though it seems to climb up the slope.
2. Measure the height of the roller from the ground at the start and then again measure the height when it has climbed up the slope.
3. You would find that the center of the roller is actually at a lower height at the end of the experiment.
4. Therefore, the potential energy is converted to kinetic energy which makes it climb up the slope.
5. The PVC pipe can't go from lower end to the higher end because its ends are always at a fixed height from the track. Therefore, the center of mass doesn't go from a higher height to a lower height when you move up the slope.

EXPLORE

Can you think of any other shape that can also work in this activity? Make a different roller and roll it up the slope. As long as the center of mass of the object moves downward, the experiment would work. Try with a spherical ball.

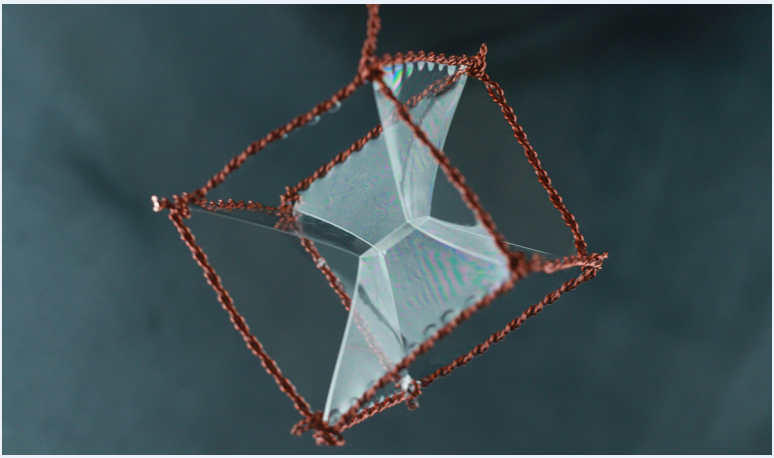
MINIMUM SOAP FILM

LEARNINGS

- Surface Area
- Surface Tension
- 3D Shapes
- Shortest Path

MATERIALS REQUIRED

- Copper Wire
- Soap Solution



Bubbles are a fascinating phenomenon in itself. We can spend hours looking at them. But bubbles can be useful in calculating the shortest path between various points!

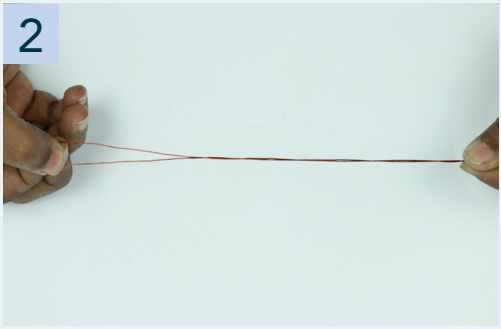
WHAT TO DO?

1. Twist or braid the copper wire to make it stiff.
2. Use this stiff wire to make the 3D shapes.
3. Make different 3D shapes like, octahedron, tetrahedron, cube etc
4. Dip the structures in soap water by tying a thread at one end of the structure. When we take them out, the soap film created would be the shortest distance between those points.

1

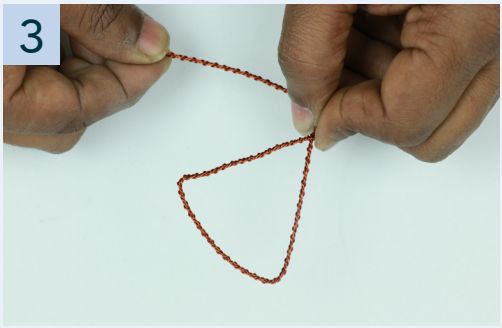
Materials required for this activity.

2



Twist or braid the copper wire to make it stiff.

3



Use this stiff wire to make the 3D shapes.

4

Make different 3D shapes like, octahedron, tetrahedron, cube etc.

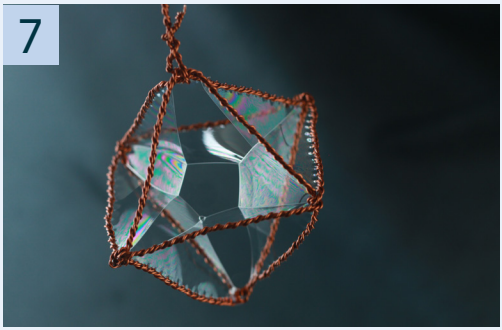
5

Dip the shapes in soap solution

6

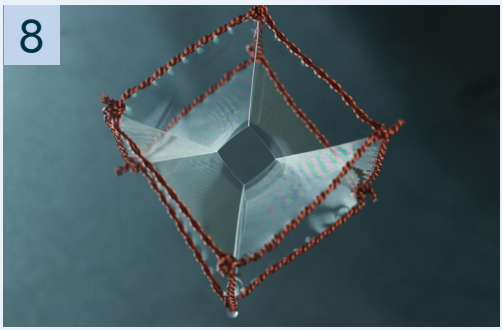
A film connecting the vertices will be formed.

7



Observe the shapes for different polyhedrons.

8



What do you observe?

.....

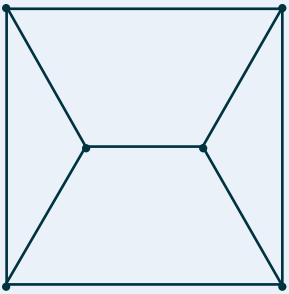
NOTES

WHAT'S GOING ON?

1. Soap films basically take a shape of minimum surface area. So to find out the shortest path to connect various locations, soap film is the way to go.
2. This is a non-trivial problem, and to find the shortest path to connect 64 cities, even today's fastest computers can take forever. But our soap film can give the answer in less than a second!
3. If you try it with a cube, you get a smaller square in the center of the cube.
4. In case of a tetrahedron, you will see 6 planes meeting at the center of the tetrahedron. This never gets boring as you can always experiment with more new shapes.

EXPLORE

1. For a square, the connecting path of minimum distance is given below . Can you prove that it is indeed shorter than connecting the diagonals directly?



2. Bubbles form because water has reduced surface tension in the presence of soap. Hydrogen atoms in one water molecule are attracted to oxygen atoms in another water molecule (cohesion). They like each other and they cling together. Soap molecules help them be more "stretchy" or flexible by breaking in-between and decreasing the force of the attraction. Soap also helps the bubble last longer by reducing evaporation. People have made bubbles so large that you can easily fit inside. Find how you can make bigger bubbles and try to go inside them. You can also make nested bubbles - a bubble inside another bubble!

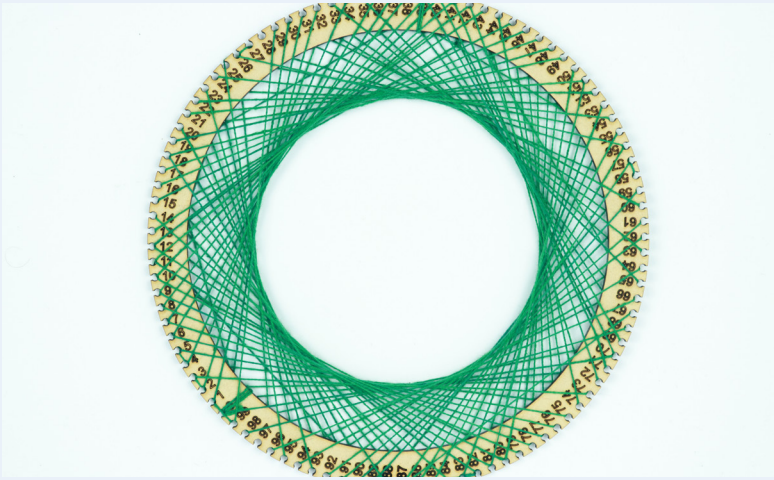
CURVE STITCHING: CIRCLE

LEARNINGS

- Addition
- Patterning Skills
- Circle
- Curve Through Straight Line

MATERIALS REQUIRED

- Threads
- MDF Disc



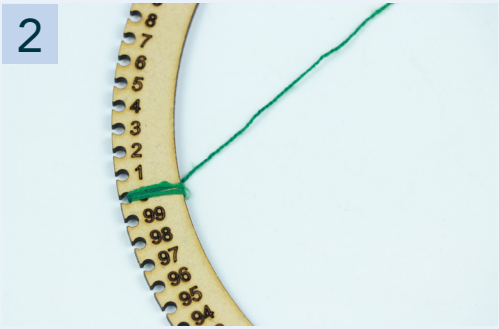
Make figures within a circular ring just using thread! Ideas of addition, subtraction, multiplication, sequences, and patterns can be developed while creating an amazing art.

WHAT TO DO?

1. The ring has 100 slots marked from 0 to 99 in clockwise direction.
   Tie the thread in following pattern:
2. Pick the location numbered as 0. Add 30 to this number - you will get 30. Tie the thread between the two slots (0, 30).
3. Continue this process for the next slot. Connect the slot to a number 30 more than that value. This means that you have to connect (30, 60), (60, 90), (90, 20) and so on.
4. For the addition value above 99, use modulo (remainder) operation. For example, for the slot 90, you get 120 after adding 30. (120 modulo 100) = 20, therefore, connect the slots (90, 20).
5. Do this for all the slots.
6. Observe the shape by this curve stitching exercise.

1

2



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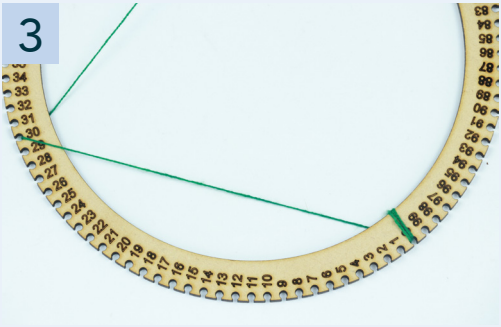

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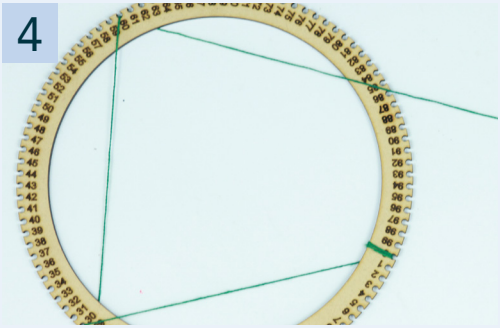

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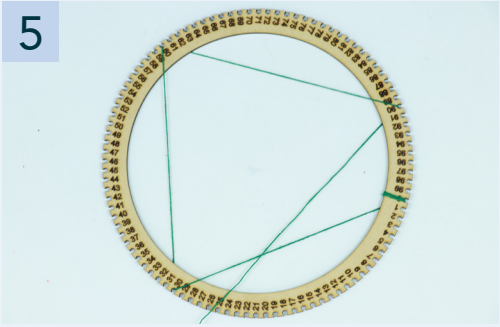

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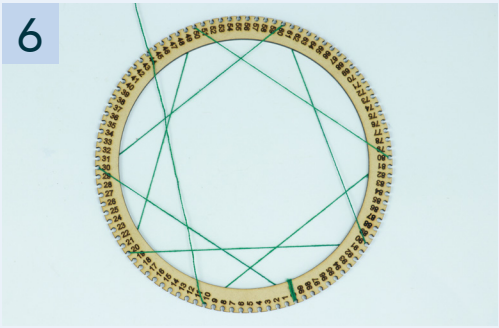
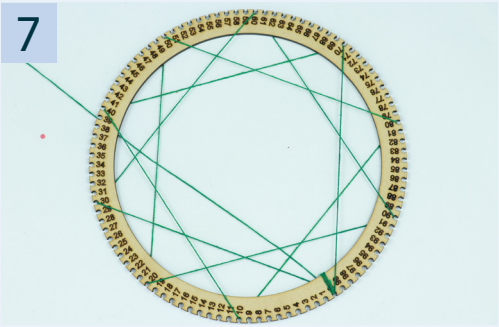


7



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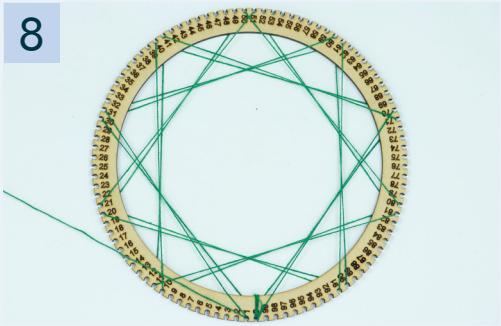

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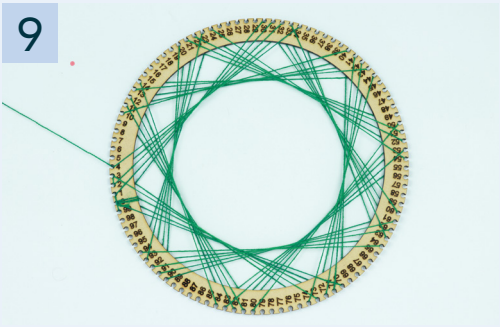

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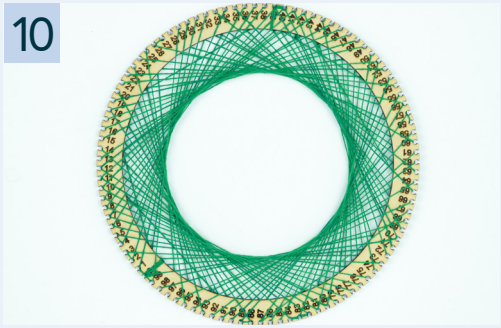


NOTES

WHAT'S GOING ON?

1. In this exercise, connections are formed between (n, n+30) pair. The curve formed from these connections is a circle.
2. If you choose a smaller number, i.e., $k < 30$, you will get a larger circle (as the lines stay near the circumference).
3. If you choose $k = 1$, the result is just a big 100-sided polygon and the lines never cross.
4. As you keep increasing the value of k, you would get gradually smaller circles, till $k = 50$. If you choose $k = 50$, all the lines cross at the center, which means that the radius of the generated circle is 0.
5. For $k > 50$, you would get the repeat result, already achieved in $1 < k < 50$. For example, $k = 10$ gives the same circle as $k = 90$; $k = 20$ gives the same circle as $k = 80$ and so on.

EXPLORE

Make circles of different k value in the same ring but with threads of different colors. Compare the results and discuss.

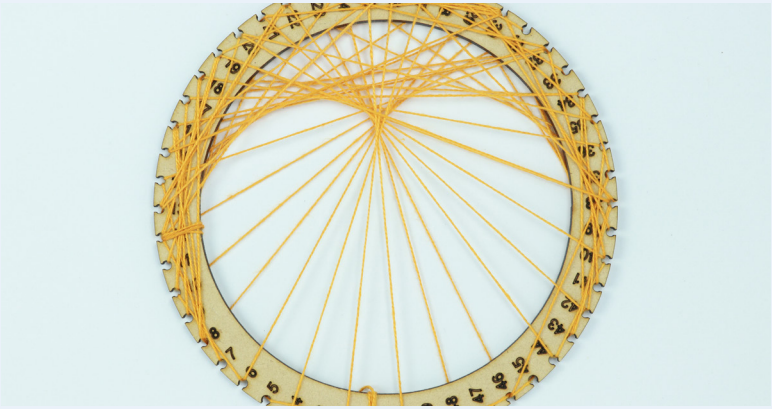
CURVE STITCHING: CARDIOID

LEARNINGS

- Addition
- Patterning Skills
- Circle
- Curve Through Straight Line

MATERIALS REQUIRED

- Threads
- MDF Disc



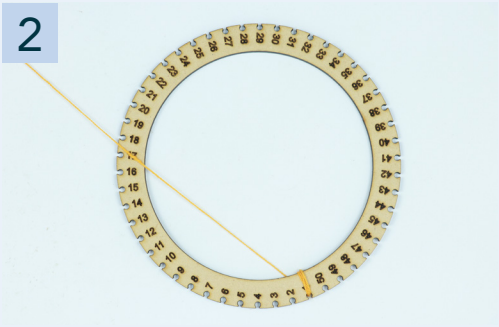
Make figures within a circular ring just using thread! Ideas of addition, subtraction, multiplication, sequences, and patterns can be developed while creating an amazing art.

WHAT TO DO?

1. The ring has 50 slots marked from 1 to 50 in clockwise direction.
   Tie the thread in following pattern:
2. Pick the location numbered as 1. Multiply it with 2 - you will get 2. Tie the thread between the two slots (1, 2).
3. Repeat this for all the slots - connect them to a number double the value. This means that you have to connect (2, 4), (4, 8), (8,16), (16,32), (32, 14) and so on.
4. For the multiplication value above 50, use modulo (remainder) operation. For example, for the slot 32, you get 64 after multiplying it by 2. (64 modulo 50) = 14, therefore, connect the slots (32, 14).
5. Do this for all the slots.
6. Observe the shape by this curve stitching exercise.

1

2



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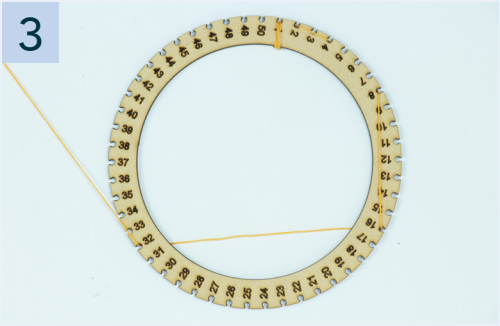

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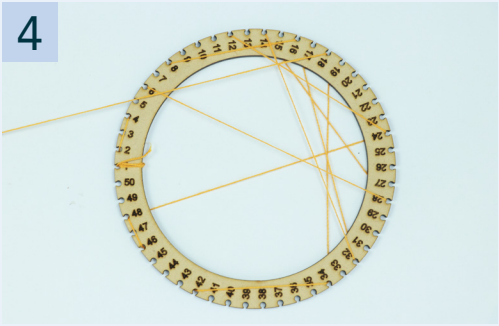

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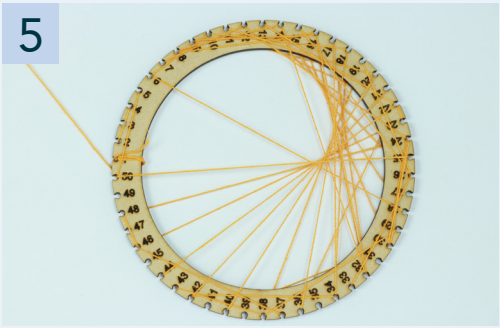


6

NOTES

WHAT'S GOING ON?

1. In this exercise, connections are formed between (n, 2n) pair. The curve formed by making paired connection by multiplying the number with 2 is called a cardioid.
2. A cardioid is a curve traced by a point on the perimeter of a circle that is rolling around a fixed circle (radius of both circles are the same).
3. Make circles of different k value in the same ring but with threads of different colors. Compare the results and discuss.

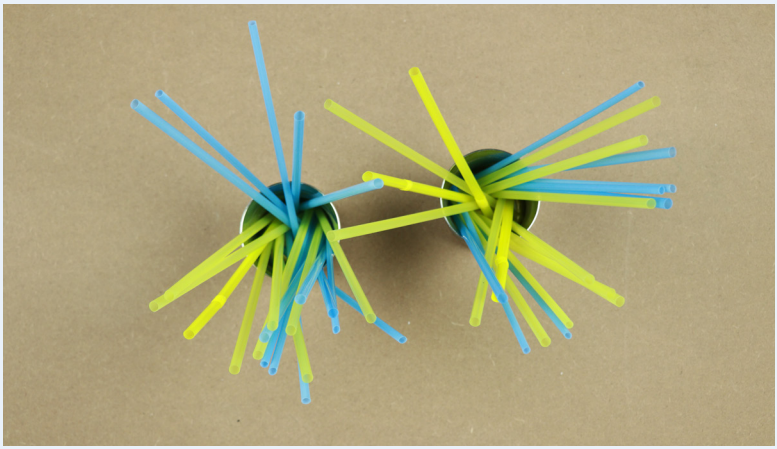
EXPLORE

1. In this exercise, which curve do you get by forming between (n, 3n) pairs? This curve is called a nephroid which is a double cardioid.
2. This curve is traced by a point on the perimeter of a circle that is rolling around a fixed circle (radius of the fixed circle is double the rotating circle).
3. Notice your mug carefully the next time you go for coffee. The light from the bulb is reflected inside the mug and forms a bright arc on the coffee - and it looks suspiciously like a cardioid curve!

STRAW MIXING PUZZLE

LEARNINGS

Conservation of Matter



MATERIALS REQUIRED

Straws of 2 Different Colors

Glasses

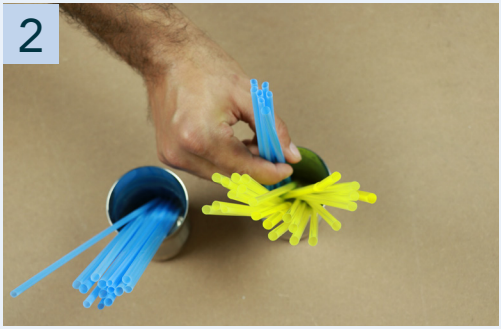
WHAT TO DO?

1. Take 2 glasses filled with straws of different color (blue and yellow).
2. Pick any number of straws from the first glass (having blue straws) and place them in the second glass (yellow straws).
3. Mix thoroughly and transport the same number of straws from the second glass to the first.
4. Which glass has more impurity - meaning, does the yellow glass has more blue straws or the blue glass has more yellow straws?
5. You will be surprised that the impurity in both the glasses remains the same.

1

Take 2 glasses filled with straws of different color.

2

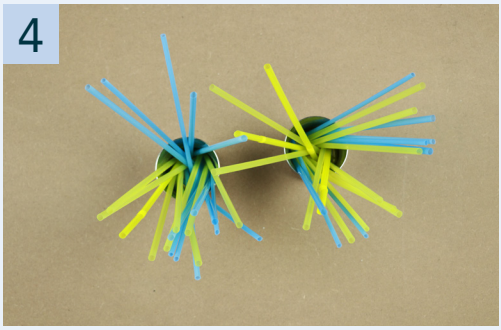


Pick any number of straws from the first glass and place them in the second glass.

3

Mix thoroughly and transport the same number of straws from the second glass to the first.

4



You will be surprised that the impurity in both the glasses remains the same.

NOTES

WHAT'S GOING ON?

1. Let's assume you picked 3 straws from the first glass (blue) and placed them in the second glass (yellow).
2. When you transport the 3 straws back, they can be:
   - **3 blue:** in this case, both the glasses don't have any impurity and therefore, amount of impurity is equal.
   - **1 blue, 2 yellow:** both the glasses have the same impurity (2 straws of different color in both glasses)
   - **2 blue, 1 yellow:** both glasses still have the same impurity (1 straw of different color in both glasses)
   - **3 yellow:** the glasses have the same impurity of 3 straws of different color.
3. The crucial condition for the magic to work is that you have to transport the same number of straws in both steps
4. This is similar to law of conservation of matter. After the process of transporting the straws, the number of straws in both the glasses is still same. Let's assume that after the process, there are 2 blue straws in the second glass.
5. As no straws were taken out, these 2 blue straws must have replaced the 2 yellow straws from the second glass.
6. And these replaced yellow straws would now surely be in the first glass (as no straws were taken out).
7. Therefore, no matter how many straws are exchanged, as long as the same number of straws are exchanged, the amount of impurity (blue straws in yellow glass and yellow straws in blue glass) remains the same.

EXPLORE

1. Repeat the same cycle with different number of straws transported every time and convince yourself that the impurity always remains the same.
2. Even if you start the next cycle where you left off the first one, the impurity remains the same. In other words, start by transporting straws from the glasses which already have mixed straws and the experiment still works.

BERNOULLI'S BAG

LEARNINGS

- Bernoulli's Principle
- Volume of Lungs
- Respiration
- Weight of Air
- Buoyancy

MATERIALS REQUIRED

- Large Plastic Bag

How many breaths would you require to fill a 10 liter plastic bag? With a little practice and some knowledge of science, you can do this in just one go!

WHAT TO DO?

1. Take a plastic tube and close it from one end by tying a knot. Your Bernoulli's bag is ready!
2. Hold the sealed end, remove all the air from the bag and ask a friend to blow in the bag by keeping the mouth inside the tube (no outside air is allowed).
3. Now squeeze the trapped air to one side and the volume of the bag is a good measure of the volume of the lungs.
4. Now give the sealed end to your friend, and blow into the bag keeping your mouth around 10 cm away from the opening.
5. To everyone's surprise, the bag would completely fill with air this time!

1

Hold the sealed end, remove all the air from the bag.

2

Ask a friend to blow in the bag by keeping the mouth inside the tube (no outside air is allowed).

3

Now squeeze the trapped air to one side.

4

Measure of the volume of the bag. the diameter is almost equal to a 1L water bottle.

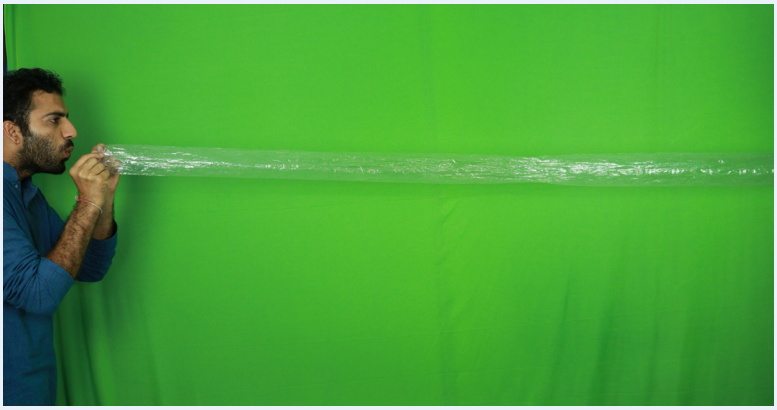
5

Squeeze the bag again to empty it.

6

Blow into the bag keeping your mouth around 10 cm away from the opening.

NOTES



WHAT'S GOING ON?

1. The bag is filled with air completely the second time because atmospheric air is also drawn into the bag along with the air from your lungs.
2. In 1738, a scientist named Daniel Bernoulli observed that a stream of moving air is surrounded by an area of low atmospheric pressure. In fact, the faster the stream of air moves, the lower the pressure drops around it.
3. When you blow into the bag, you create an area of low pressure. The outside air also goes inside the bag and fills it completely.

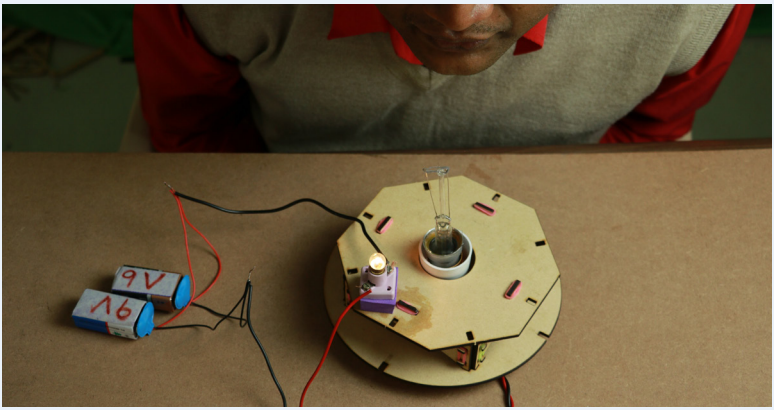
EXPLORE

1. Firefighters use Bernoulli's principle to quickly and efficiently force smoke out of a building. Instead of placing the fans up against the doorway or window, a space is left between the opening and the fan in order to force a greater amount of air into the building. Firefighters call this "Positive Air Flow."
2. Which gas is present in most quantity when you fill the Bernoulli bag with your mouth? Discuss.
3. What would be the weight of the bag if we measured it on a weighing scale? It turns out that the weight would be zero, no matter the size of the bag - due to buoyancy!

LIGHT BULB MYSTERY

LEARNINGS

- Resistance
- Heating Effect of Current
- Power
- Series and Parallel Connection



This special bulb lights up when you blow into the filament of another bulb!

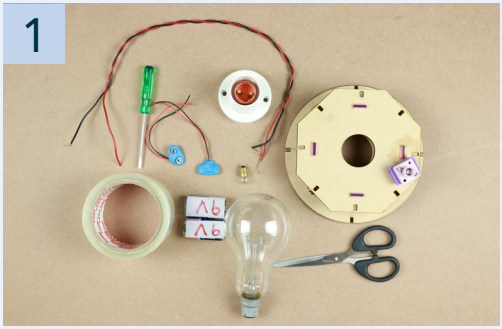
MATERIALS REQUIRED

- 200W Bulb and Holder
- Torch Bulb and Holder
- Ice
- Tape

WHAT TO DO?

1. Connect two bulbs of 200W and 1.5W with a 9V battery in series.
2. You'll find that the small bulb lights up and the large one doesn't. But even the small one glows for a few seconds and then dies out.
3. Now take out the 200W bulb from its holder and remove its glass. Cover the glass with sticky tape before breaking it to keep the glass pieces together. Take out the filament carefully from the glass cover and make sure that it doesn't break during this process.
4. Place the 200W bulb again in the holder. You'll again see the small bulb lighting for a few moments and then dying out.
5. Now blow at the filament of 200W bulb. Surprisingly, the small bulb would light up!

1



Things needed for this activity.

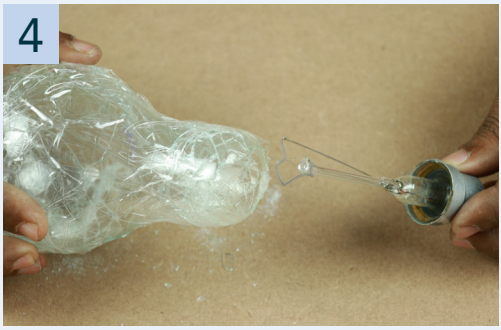
2

Cover the glass of the 200 W bulb with tape.

3

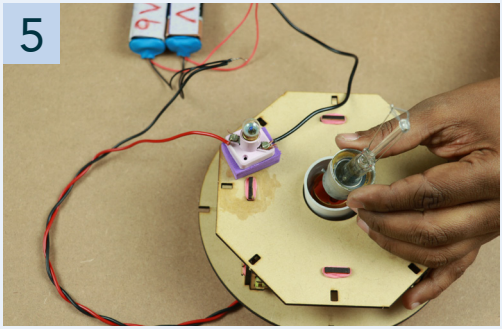
Break the glass from the bottom to detach it from the bulb.

4



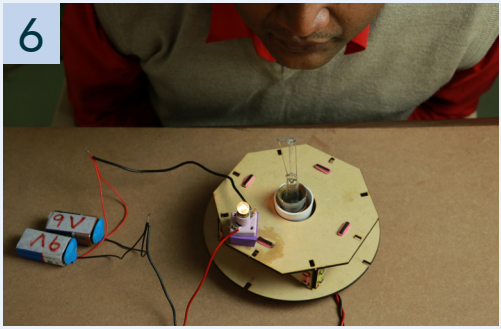
Carefully take out the bulb filament from the glass.

5



Insert the filament in the holder. Make sure that the two bulbs are connected in series.

6



Blow at the filament and the small bulb would glow brightly!

NOTES

WHAT'S GOING ON?

1. When you insert the small bulb, the circuit is completed. As the voltage is less (9V), the amount of current passing though the circuit is also small.
2. Therefore, the big 200W bulb doesn't glow. But the small bulb glows as it requires only a small current.
3. Whenever there is a flow of current inside a conductor, the temperature of the conductor increases. Therefore, after a few seconds, the filament of the 200W bulb gets hot. You can see this for yourself by touching the filament yourself.
4. This increase in temperature increases the resistance of the filament (the more the temperature of a conductor, the more its resistance).
5. When you blow at the filament, it cools down (convective cooling) and the resistance decreases again.
6. Due to this decrease in resistance, the small bulb lights up again.

EXPLORE

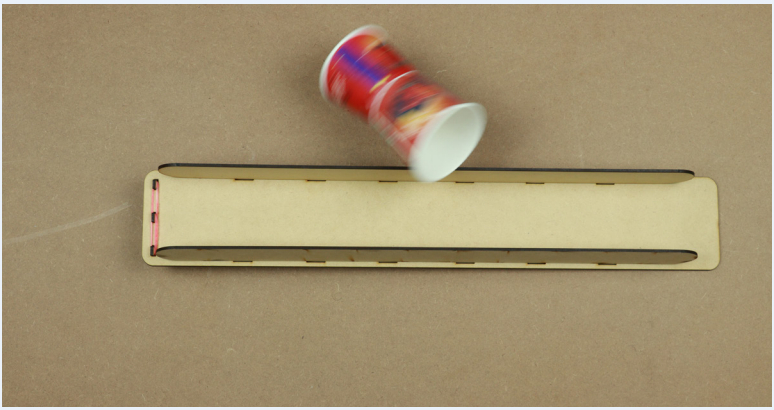
1. This dependence of temperature on resistance is used to make temperature sensors. The sensors give electric current based on the temperature, which can be read and calibrated using a processor to find the temperature.
2. You can also use ice to reduce the temperature of the filament. The small bulb would glow even more strongly with ice because it reduces the temperature of the filament even more.
3. Heat the filament of 200W bulb with a matchstick. The smaller bulb would glow less brightly now.

FLYING WHEELS

LEARNINGS

Stable Equilibrium

Unstable Equilibrium



MATERIALS REQUIRED

Paper Cups

MDF Track

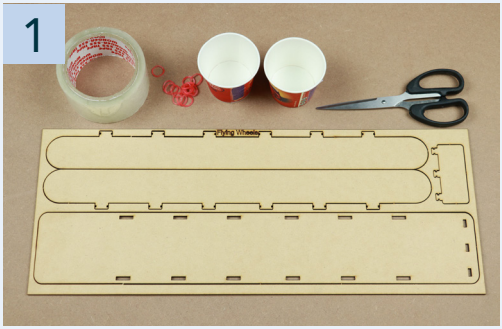
Tape

Which roller would go down smoothly down the tracks? Let's find out!

WHAT TO DO?

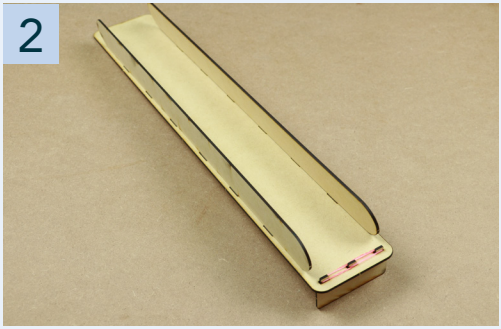
1. Take four paper cups which are slightly tapered in shape.
2. Join two of them together with their bases touching each other and the other two with their open sides touching each other.
3. Roll both these rollers from the tracks made out of MDF sheet.
4. Which roller would follow the tracks and which one is likely to be derailed?

1



This activity will require the following.

2



Assemble the MDF parts to make the track.

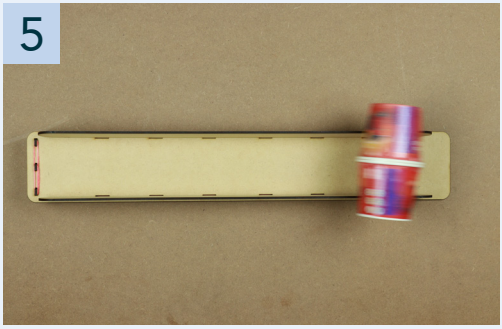
3

Stick two paper cups with their open sides touching each other.

4

Tape two more cups together with their bases touching each other.

5



Roll the first roller on the track. It will surprisingly stay on the track.

6

Roll the second roller on the track. This roller will fall off the track quickly.

NOTES

WHAT'S GOING ON?

1. If you take tyres of two different diameters and join them together, the system automatically turns towards the circle of smaller diameter.
2. This is because for the same rotation of the axle, the bigger tyre covers a larger distance and the smaller tyre covers a shorter distance. This results in turning towards the smaller tyre.
3. The same principle can be applied to the rollers. Let's understand why the first roller (cups joined at their open ends) easily rolls down the tracks.
4. When you place the roller on the tracks, it is never placed exactly at the center of the tracks. Even if it is slightly off-center, the two radii that are in touch with both the rails are different.
5. Let's assume that the roller is placed slightly to the left. This means that the left radius is more and the right radius is less. Thus, the roller would turn to right, towards the smaller radius.
6. Therefore, the roller would correct itself and move towards the center position. If it goes slightly to the right, it would again come towards the center itself.
7. This is called a stable equilibrium. The roller automatically makes sure that it stays at the center of the track. If there is a slight deviation to the left, the system corrects itself by going to the right and vice versa.
8. The second roller in contrast is a disaster. Let's assume that the roller is placed slightly to the left. This time, the left radius is less and the right radius is more. Thus, if there is an initial left error, the roller moves even further to the left, increasing the error. This is called an unstable equilibrium.
9. Therefore, even a slightest error would keep on increasing and the roller would eventually go off the tracks.

NOTES

EXPLORE

The wheels of the train are designed like the first roller. Therefore, whenever the train has to maneuver a turn, the radii on both sides have to be different because they are covering different distances. Let's assume that the train has to take a right turn. Due to centrifugal force, the wheels would shift slightly outwards, to the left. And as the wheels are tapered, the left side would automatically have a larger diameter and the right side would have a smaller diameter facilitating the turn.

SMOKING KILLS

LEARNINGS

- Pressure
- Harmful Effects of Smoking
- Valves

MATERIALS REQUIRED

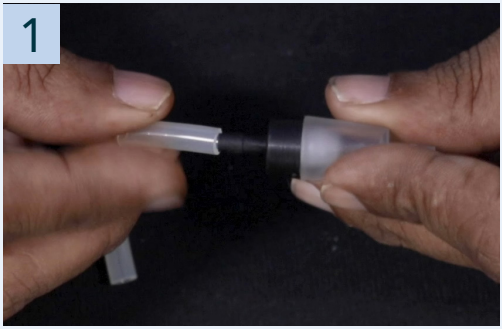
- One 10 ml Syringe
- One 2.5 ml Syringe
- Two one-way valves
- Flexi Tube
- Glue

This model demonstrates the effect of smoking on the lungs. You can see the black tar for yourself, which is deposited in the lungs after smoking the cigarette.

WHAT TO DO?

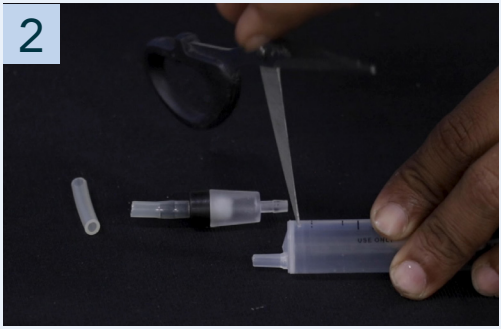
1. Make a hole near the end of the 10 ml syringe and fix a one-way valve in the hole. Place the valve such that air can come inside the syringe through this valve but can't go out.
2. Attach a 2.5 ml syringe to this valve using flexi tube.
3. Fix another valve at the inlet of the 10 ml syringe using flexi tube. Place this valve such that air can go out of the syringe through this valve but can't come in.
4. Put a small piece of cotton inside the second valve.
5. Remove the plunger of the 2.5 ml syringe and firmly attach a cigarette on the top using EVA sheet.
6. Ignite the cigarette and repeatedly move the plunger of the 10 ml syringe up and down. The cigarette will be finished in some time.
7. Take out the cotton from the valve and you will see black tar deposited on it.

1



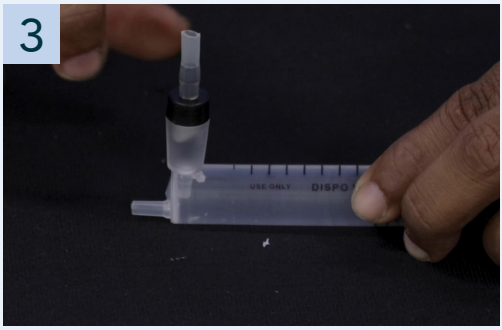
Attach a small flexi tube to the one-way valve.

2



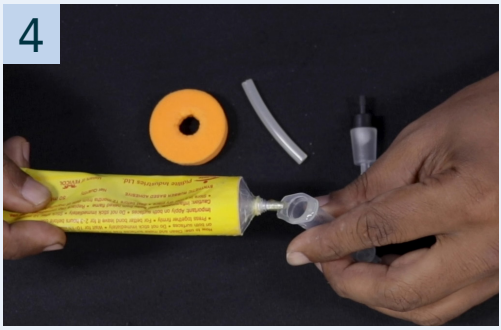
Make a hole in the 10 ml syringe.

3



Attach the valve to the 10 ml syringe.

4

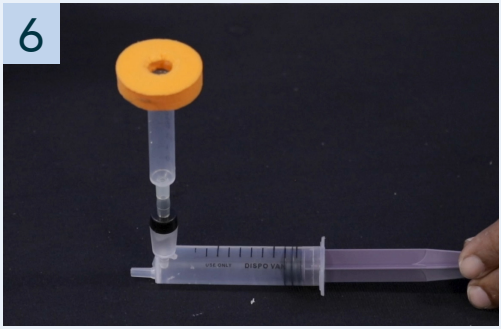


Apply glue to the 2.5 ml syringe.

5

Stick the syringe to the EVA disc.

6

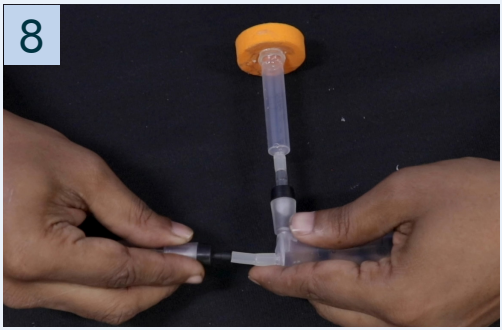


Attach this to the bigger syringe.

7

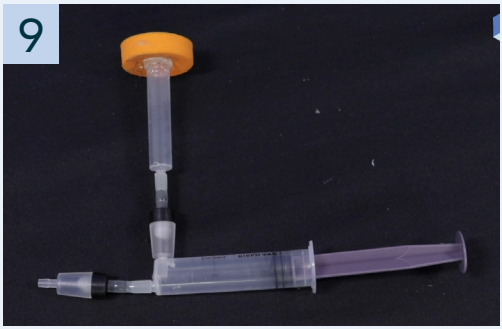
Insert cotton in the second one-way valve.

8



Attach another one-way valve to the front opening of bigger syringe

9



The model is ready

10

Insert a cigarette inside the EVA disc

11

Light the cigarette and move the plunger up and down. The cigarette will be finished in some time.

NOTES

WHAT'S GOING ON?

1. When you pull the plunger of the syringe, the front valve is closed. Air, along with the smoke, comes inside through the side valve and fills the syringe.
2. When you push the plunger back, the side valve is closed and all the air (along with smoke) goes out from the front valve.
3. The cotton inside the valve traps the tar in the smoke.
4. When the cigarette is finished, you can see the black, greasy tar deposited on the cotton.
5. The syringes also become brown in color, due to deposition of tar.
6. Weigh the model before and after the experiment. A single cigarette results in deposition of 27 mg of tar! For unfiltered cigarettes (beedi), 55 mg tar is deposited for the same amount of smoking.
7. This tar sticks inside the lungs when somebody smokes a cigarette. Over time, a healthy pink lung turns grey and eventually becomes black as more tar accumulates.
8. This results in lung diseases such as emphysema, chronic bronchitis, and lung cancer.
9. The tar also paralyzes the cilia in the lungs. Cilia are tiny, hair-like structures that line the trachea. They help trap pollutants, but when they're damaged, the toxins in tar can travel deeper into the lungs.
10. The toxins are also carried into the bloodstream and begin moving to other parts of your body. They can affect every organ in the body and beyond cancer, can lead to heart disease, diabetes etc.

NOTES

EXPLORE

1. This can also be demonstrated without using one-way valves. Take a 2L bottle and make two holes, one near the bottom of the bottle and another on the centre of the cap.
2. Close the bottom hole and fill the bottle with water. Insert a cigarette in the hole of the cap.
3. Open the bottom hole. As the water starts to drain from the bottle, pressure inside the bottle decreases.
4. Due to this, air (along with smoke) comes from hole in the cap of the bottle.
5. Once the bottle becomes empty, immediately close the bottom hole.
6. Remove the cap and place some tissue paper in its place.
7. Blow through the hole at the bottom. The tar would be deposited on the cotton.

CAUTION: Do not perform this activity in a closed room. The smoke accumulated in the room might be harmful to the participants.

BOTTLE TORNADO

LEARNINGS

Pressure

MATERIALS REQUIRED

Plastic Bottle

Scissors

You have probably heard stories about a genie inside a bottle or lamp. But have you seen a tornado trapped inside a bottle? You can make one yourself, without resorting to magic but some science!

WHAT TO DO?

1. Take a 2L plastic bottle and make a small hole in the cap.
2. Fill the bottle with water and close the cap.
3. Turn the bottle upside down to drain the water. After some time, the flow of water stops.
4. Now spin the bottle after inverting and keep swirling until you see the formation of what looks to be a tornado!
5. The water begins to swirl in the shape of a vortex and flows out of the bottle. The whole bottle gets empty really quickly.

NOTES

WHAT'S GOING ON?

1. When you rotate the bottle upside down, some of the water comes out of the bottle. After that, the flow of water stops.
2. This is because the pressure at the top of water becomes low (the same air expands to cover more volume).
3. When you swirl the bottle, a vortex or tornado is formed which lets air to go inside the bottle from outside.
4. Due to this, pressure at the top doesn't become low. The flow of water continues and the bottle becomes empty really quickly.
5. If you've ever watched the water drain from a sink, you've seen a vortex.
6. A vortex is a type of motion that causes liquids and gases travel in spirals around a center line.

EXPLORE

1. This experiment can also be done with two bottles. Take 2 caps of the bottles and stick them back to back using glue/tape. Make a hole at the centre of the joined caps. Fill one of the bottles with water and join both the bottles using the caps. Now turn the bottles upside down. As before, water doesn't go to the second bottle. But when you spin the bottles, a tornado is formed and water goes from one bottle to another.
2. Compare the time taken to empty the bottles in both cases (one bottle vs two bottles). Discuss the results.

BOILING WATER IN A PAPER CUP

LEARNINGS

Heat

Combustion

MATERIALS REQUIRED

Paper Cup

Candle

Matchstick

Can you boil water in a paper cup if you can't find other utensils? Surely you can!

WHAT TO DO?

1. Take a paper cup and fill it with water.
2. Light a candle and place the cup on the candle. Make sure that the cup is filled with water before putting it on the flame.
3. To everyone's surprise, the cup doesn't burn even when the water starts to boil.

NOTES

WHAT'S GOING ON?

1. You would observe that the water soon starts boiling and the paper cup is unharmed (apart from the black soot deposited on the outside).
2. On the other hand, if you try with an empty cup, it readily catches fire and soon burns completely.
3. Most papers require a temperature of around 200-250° Celsius to burn. As water boils at 100° Celsius, its temperature doesn't rise above 100° Celsius before all the water has converted to steam.
4. As the paper is in contact with water, its temperature also doesn't cross 100° Celsius.
5. So you can safely boil water in a paper cup - as long as the flame doesn't touch the part of glass which is not in contact with water.

EXPLORE

1. Try with plastic or styrofoam cups. Are you still able to boil water without burning the cup?
2. You can also use balloons for this activity. Fill a large balloon with water, hang it at a height and ask your friend to stand below it. Now take a candle and try to pop the balloon by burning it. Your friend will be safe as long as there is water inside the balloon!

RABBIT TRAIN

LEARNINGS

Friction

Make the rabbit move using an empty matchbox and some thread. On moving one hand, the matchbox goes forward in one direction. Paste a photo of a rabbit on the matchbox and the rabbit runs on the thread.

MATERIALS REQUIRED

Empty Matchbox

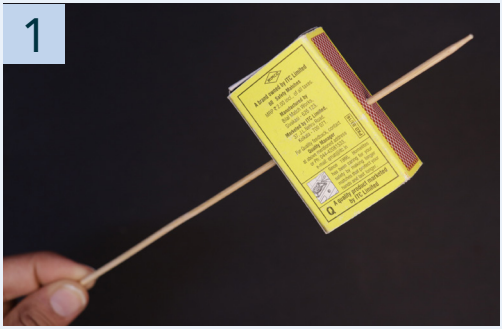
Thread

Sketch Pens

WHAT TO DO?

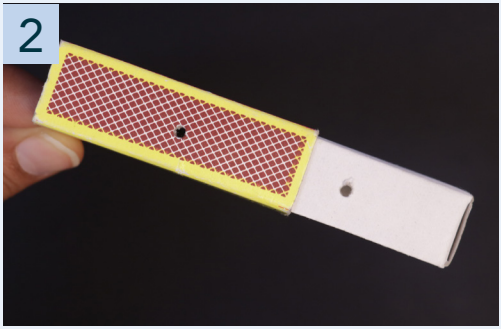
1. Make four holes on the matchbox- two on the drawer and two on the strike surfaces.
2. Make two more holes on the drawer on the same side.
3. Take a needle with a long thread and pass it through the holes as shown in the pictures.
4. Tie the two ends of the thread to complete the loop.
5. Paste a photo of a rabbit on the matchstick to make it more interesting.
6. Hold the string loop in both the hands. Turn and twist both the threads alternately. The matchbox would travel on the string track.

1



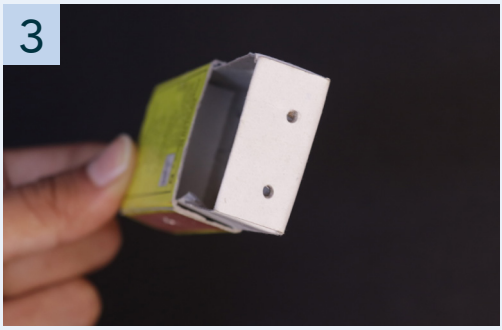
Make a hole through an empty matchbox.

2



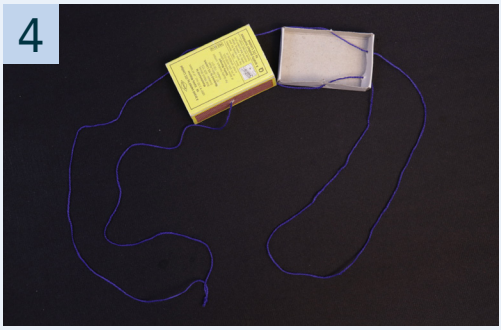
You will get 4 holes as a result.

3



Make two more holes on one side of the tray.

4



Thread the matchbox as shown.

5

Close the matchbox.

6

Color and stick a rabbit on the matchbox and the Rabbit train is ready.

NOTES

WHAT'S GOING ON?

1. The string loop passes from the sides of the matchbox.
2. When you pull the left side of the string, matchbox tilts to that side and gets aligned with the thread.
3. In this situation, normal force acting on the right string increases. Hence, the frictional force also increases between the right string and the matchbox.
4. Therefore the matchbox holds its position for the right string and moves on the left thread.
5. The mechanism moves only in one direction and you will have to bring it back once it reaches the end.

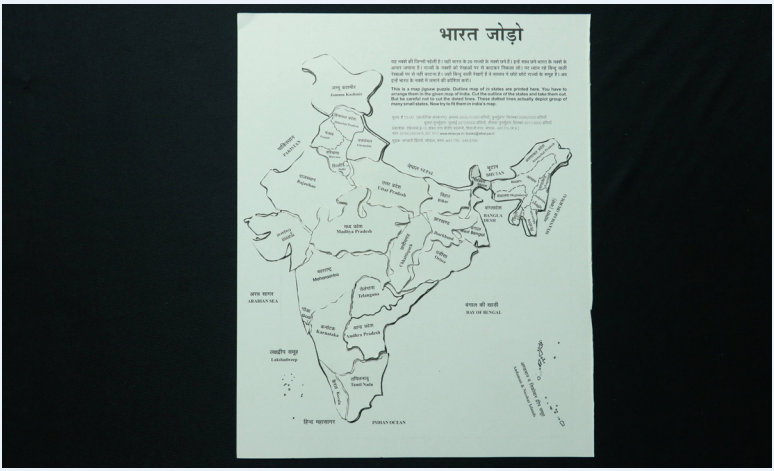
EXPLORE

What role does friction play in moving the rabbit forward? If there is no friction, would it move at all?

BHARAT JODO

LEARNINGS

The Geography of India

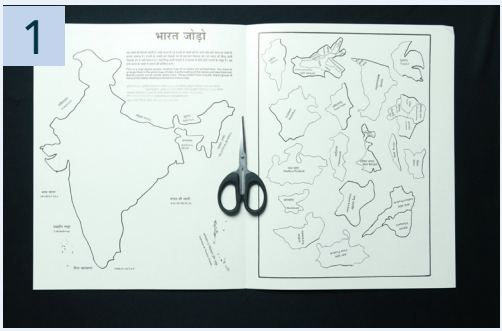


This is a map jigsaw puzzle. Outline map of 29 states are printed here.

WHAT TO DO?

1. Cut the outline of the states and take them out.
1. You have to arrange them in the given map of India.
2. But be careful not to cut the dotted lines. These dotted lines actually depict group of many small states.
3. Now try to fit them in India's map.

1



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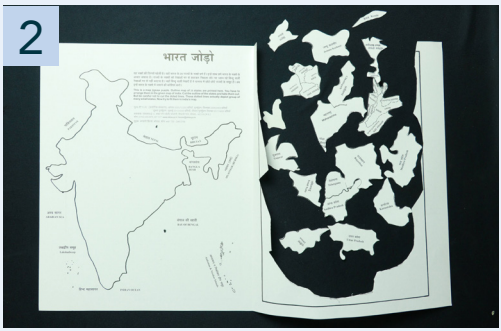

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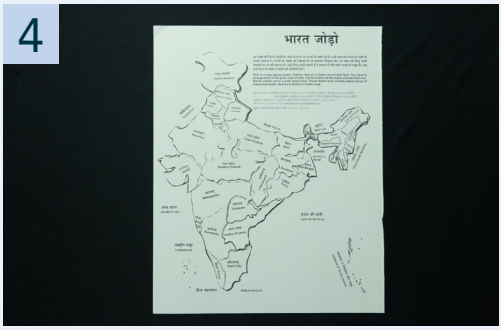


CARD FLIP MAGIC

LEARNINGS

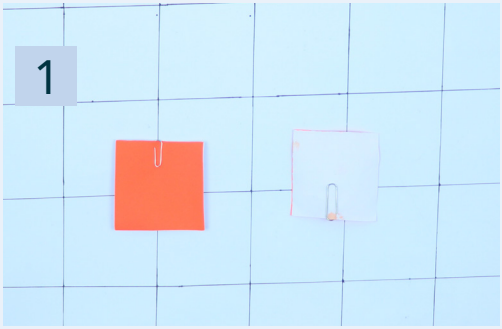
- Counting
- Odd and Even Numbers
- Patterns and Relationships
- Rows and Columns
- Coordinates
- Parity Check

MATERIALS REQUIRED

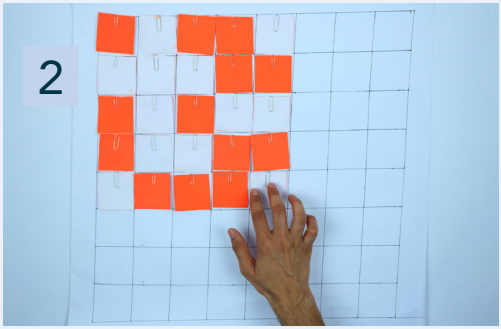
- Colored Paper
- Scissors

When data is stored on a disk or transmitted from one computer to another, we usually assume that it doesn't get changed in the process. But sometimes things go wrong and the data is changed accidentally.

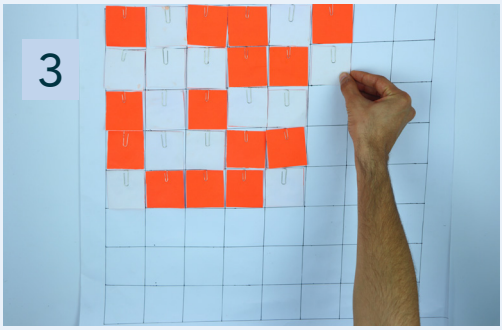
This is a magic trick in which the demonstrator is magically able to figure which one out of dozens of cards has been turned over, using the same methods that computers use to figure out if an error has occurred in data transmission and storage.



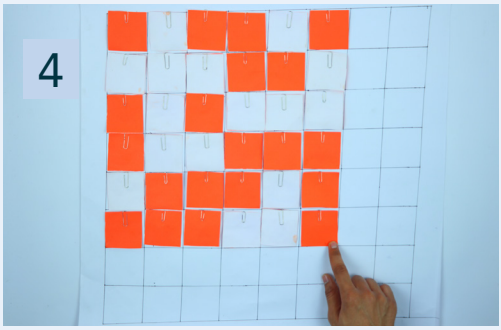
Make cards which are colored from one side.



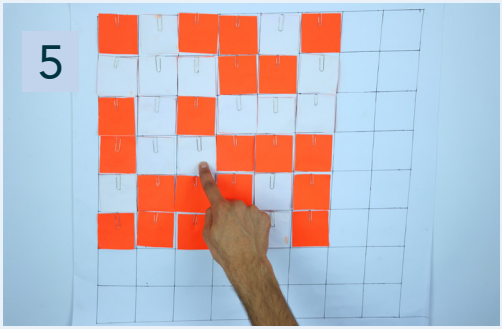
Ask someone to make a random 5×5 grid of cards.



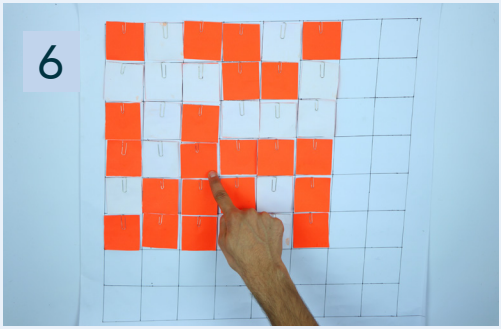
Add another column and row "just to make it a little harder" and make a 6x6 grid.



Make sure that you have an even number of colored cards in all rows and columns after this.



Now go out of the room and ask the participant to choose any card and flip it.



You would be able to tell which card was flipped by the participant!

NOTES

WHAT'S GOING ON?

1. Ask somebody from the audience to lay out the cards randomly in a 5×5 grid.
2. Casually add another row and column "just to make it a little harder". These extra cards are the key to the trick.
3. While adding this extra row and column, make sure that you have an even number of colored cards in all rows and columns (keep in mind that 0 is an even number). The extra card added is called the "parity" card.
4. Close your eyes and ask someone from the audience to flip one of the cards from the grid.
5. After the flip, the row and column containing the changed card would have odd number of colored cards.
6. Therefore, the intersection of row and column having odd number of colored card is the location of the flipped card.
7. One interesting thing to notice is that when you place the last card at the lower right corner, the even parity of the column above would automatically ensure the even parity of the row to its left.
8. Computers also add a "parity" bit to make sure that the data hasn't corrupted during transmission. Adding the extra parity bit helps to detect the error during storage and transmission.

EXPLORE

1. This activity is adapted from the book CS Unplugged which has numerous physical activities related to computer science.
2. What happens if two cards are flipped? Can you figure out the cards that are flipped? Can you at least tell that some cards are flipped? What happens when you flip three cards? Four?
3. Will it work if you perform the trick with odd parity (odd number of colored cards in rows or columns)? This is

NOTES

possible, but the lower right-hand card only works out the same for its row and column if the numbers of rows and columns are both even or both odd. For example, a 5×9 grid will work fine, or a 4×6, but a 3×4 grid won't.

4. Try with other objects. Anything that has two "states" (coins, playing cards etc) is suitable for the activity.
5. This same checking technique is used with book codes and bar codes.
6. Published books have a ten- or 13-digit code usually found on the back cover. The last digit is a check digit, just like the parity bits in the exercise. This means that if you order a book using its ISBN (International Standard Book Number), the website can check that you haven't made a mistake. They calculate the last digit by inserting the first twelve digits in a formula. Then they simply compare the received and calculated check digit. That way you don't end up getting the wrong book!

2D FLEXAGON

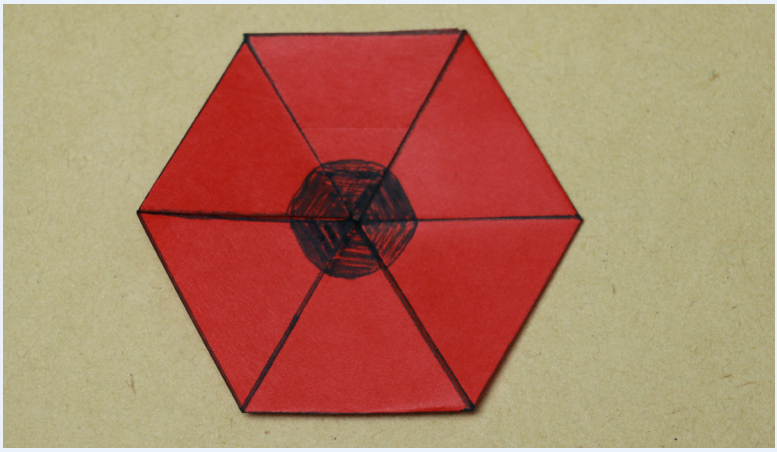
LEARNINGS

Tetrahedron

Geometry

Triangles

Computational Origami



Designed by Harvard mathematician , this is one of the most amazing rotating paper model. On rotating each time, a different facet of the model will be exposed. This dynamic paper model can be graphically used to demonstrate food chain, water cycle or just about any fact in an engaging way.

MATERIALS REQUIRED

Paper

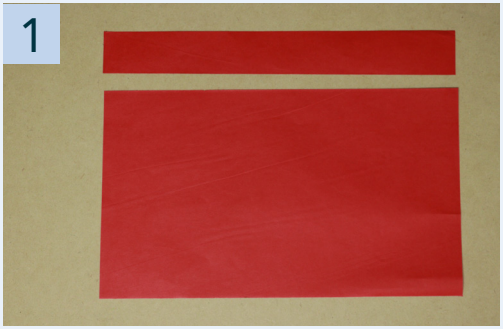
Glue

Scale

WHAT TO DO?

1. Cut out a strip of paper.
2. Fold one corner of the strip such that you trisect the corner angle. The triangles formed after this would be equilateral triangles.
3. Fold the corner and make a line where the corner touches the middle line.
4. Use this line to fold equilateral triangles.
5. Make ten such triangles and tear off the extra strip.
6. Fold the strip backwards after three triangles.
7. Make a front fold after the sixth triangle.
8. Lock the front strip below the back strip.
9. Apply glue on the last triangle and paste it on the first triangle.
10. Draw different images on the faces and keep opening from the middle to get a different image.

1



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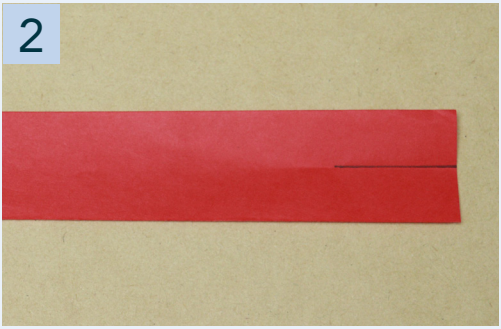

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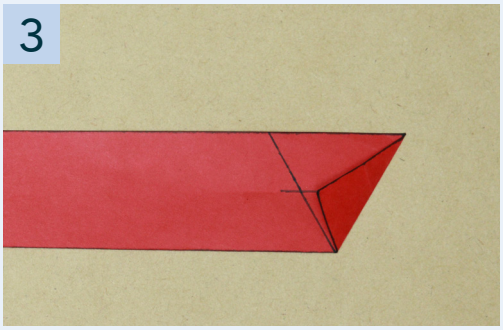

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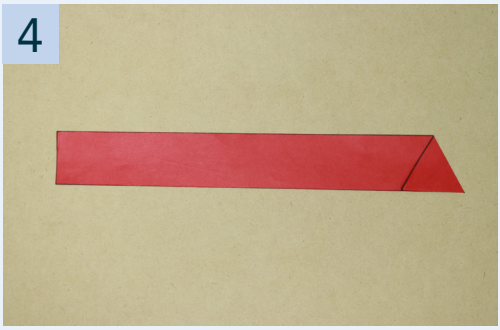

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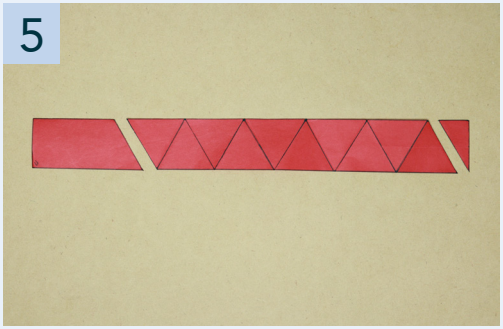

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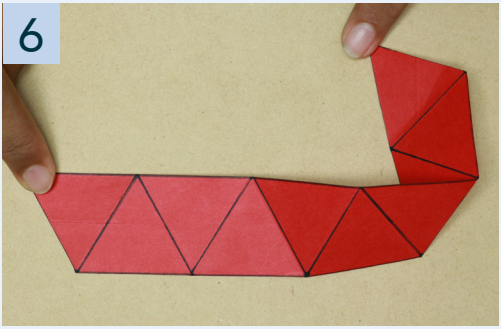

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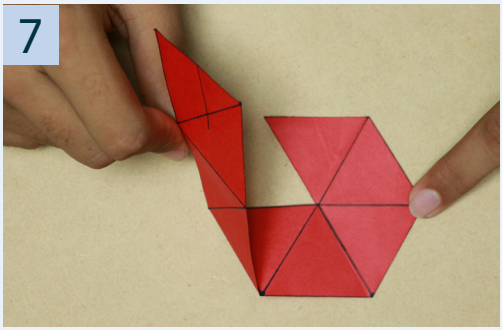

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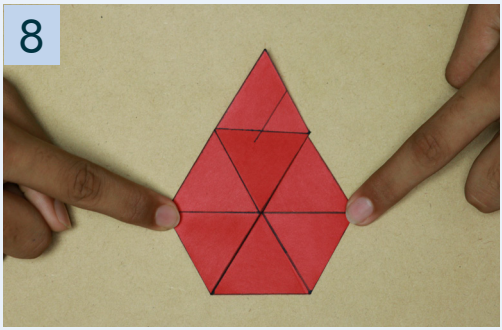

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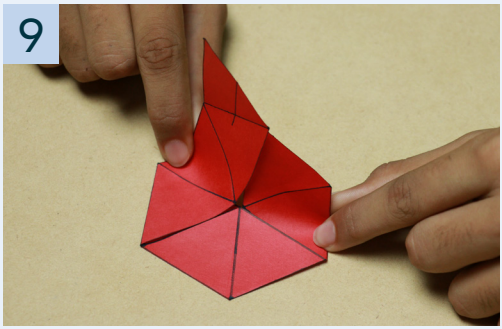

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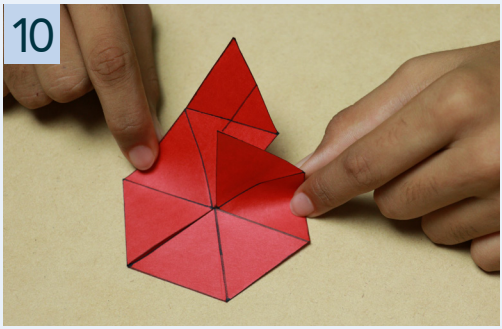

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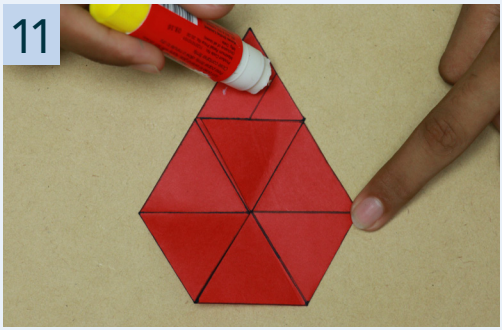

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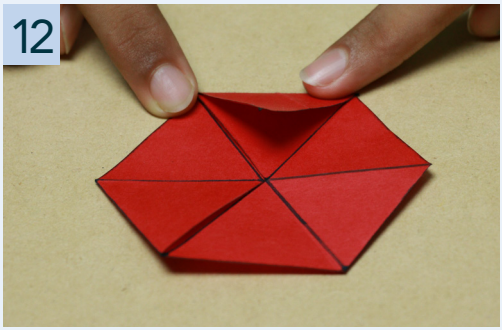


FIDGET GENERATOR

LEARNINGS

Electricity and Magnetism

Electromagnetic Induction

MATERIALS REQUIRED

Fidget Spinner

LED

Copper Wire

Nut and Bolt

Neodymium Magnet

MDF Kit

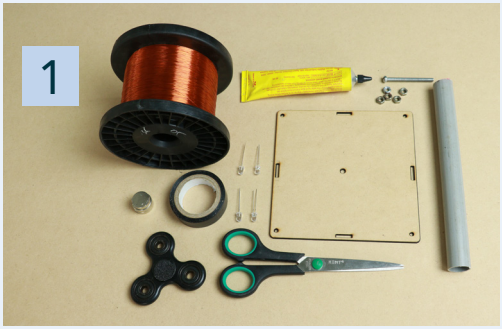
Glue

Electricity is produced when a magnet rotates near a coil (wire) or vice versa. This enchanting model illustrates this principle beautifully using a toy already with every child- the fidget spinner

WHAT TO DO?

1. Make three coils using insulated copper wire (36 gauge- very thin) with 700 turns each by rotating the wire on a PVC pipe or any other cylindrical object.
2. Remove the insulation from the ends of the coils and attach an LED. You can use a paper cutter to remove the insulation or just burn the wire using a matchstick.
3. Make a platform using the MDF kit.
4. Stick the coils on the platform using glue. The distance between the coils should be such that when the fidget spinner rotates, it should be able to pass from the top of all the four coils.
5. Attach 3 Neodymium magnets on the fidget spinner using super glue.
6. Drill a hole in the fidget spinner and put it on the bottle cap through the cycle spoke. Now when we rotate the fidget spinner, the LEDs light up and so does the maker who built them!

1



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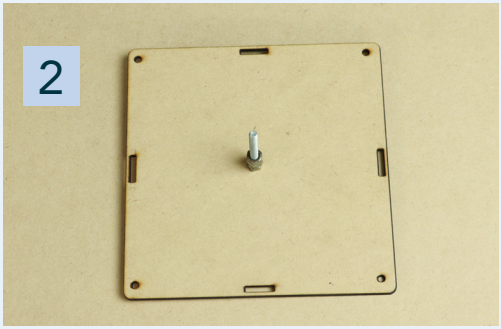

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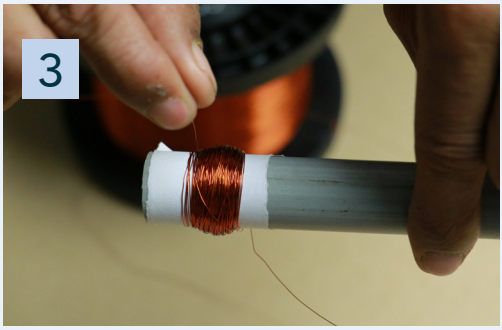

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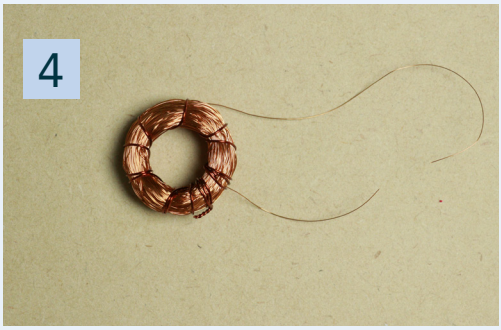

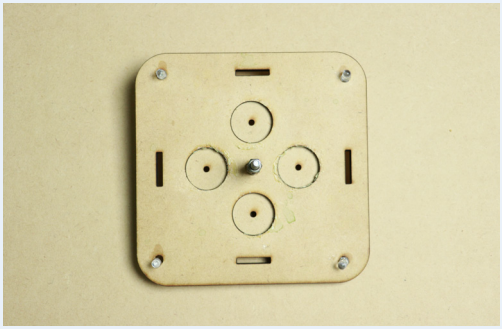

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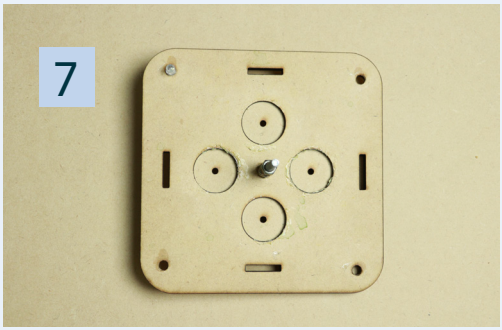

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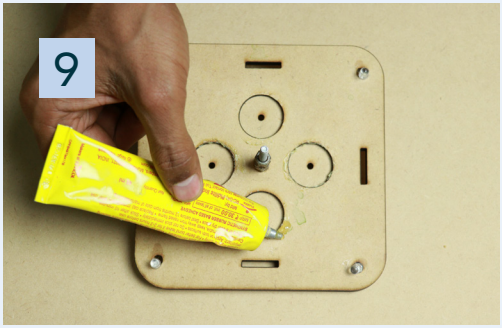

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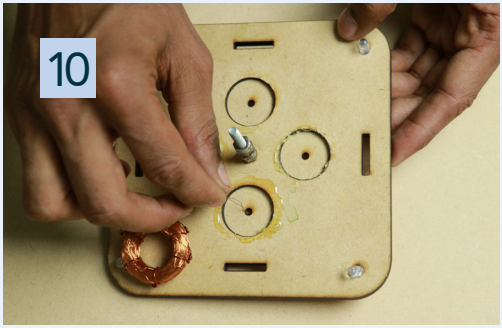

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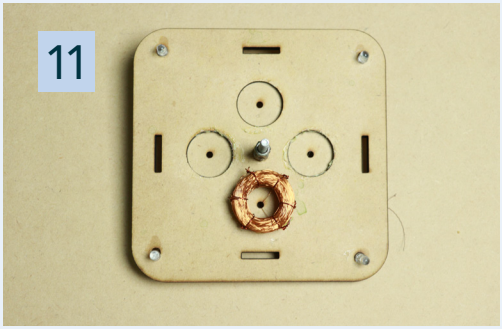

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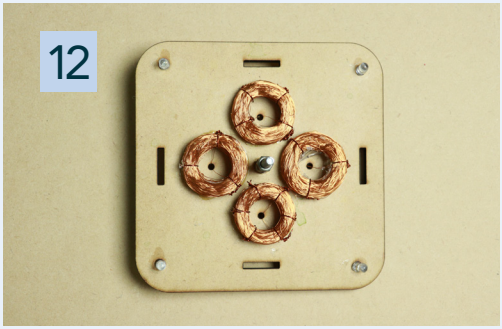

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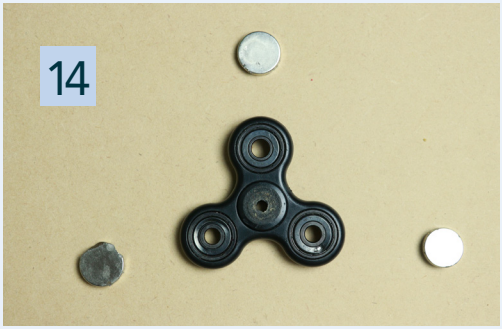

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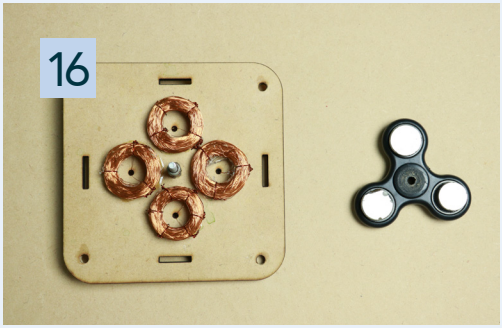


18

NOTES

WHAT'S GOING ON?

1. 1. Whenever there is a relative motion between a conductor and a magnet (either the magnet moves or the conductor moves), there is a voltage generated across the conductor. This was first discovered by Michael Faraday in 1831.
2. 2. The magnets attached to the fidget spinner are rotating on the coils during the spin. The generated voltage lights up the LEDs. Amount of voltage generated is directly proportional to the speed of rotation and the number of turns in the coil. Therefore, we should either spin the fidget spinner fast or have more turns in our coils if we want our LED bulb to glow brighter.

EXPLORE

1. Why do you have to remove the insulation from the wire before connecting the LEDs?
2. Would the model still work if you used uninsulated wire to make the coils also? Discuss.

BALLOON PUMP

LEARNINGS

- Valve
- Pressure
- Pump

MATERIALS REQUIRED

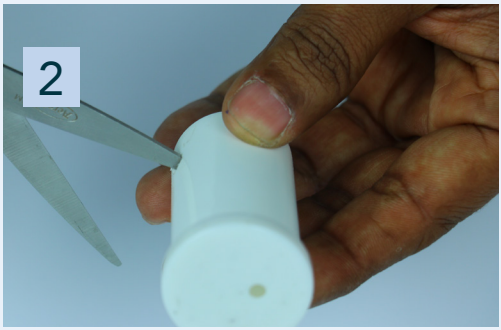
- Cycle Tube
- Plastic Cans
- Tape
- Stiff Straw
- Scissors
- Balloon

How does a valve work and what is its use in a pump? You can understand that by making a working balloon pump. This pump can be used to inflate a balloon and even pop it!

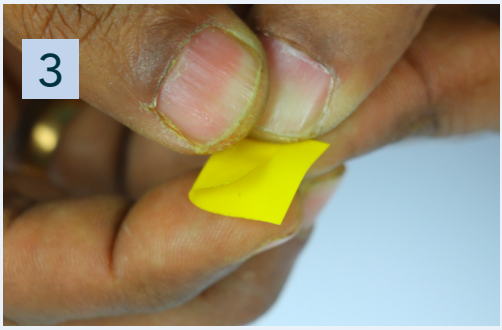
WHAT TO DO?

1. Make a small hole near the bottom of the first can.
2. Take a 4 cm sticky tape and stick 1 cm of the tape on itself. Now stick the tape on the inner side of the first cap such that the doubled tape lies on the hole. This becomes a little flap which can open and close and would act as the delivery valve.
3. The valve is like a one-way traffic – allowing flow only in one direction.
4. Attach a balloon to the stiff straw using rubber band and insert it in the side hole. Now insert the can in the cycle tube.
5. Take the second can and make hole in the bottom. Paste another piece of tape on the outside of the second can (as described in second step). This tape would act as the suction valve.
6. Insert the second can also in the cycle tube.
7. Press the cycle tube repeatedly from the middle to inflate the balloon!

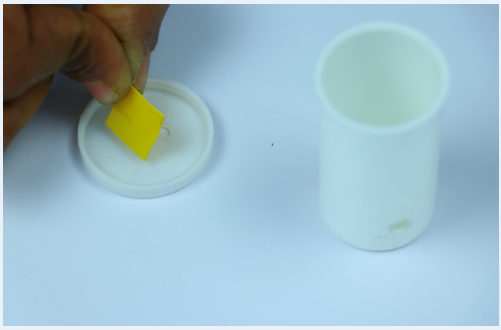
Materials required for the activity



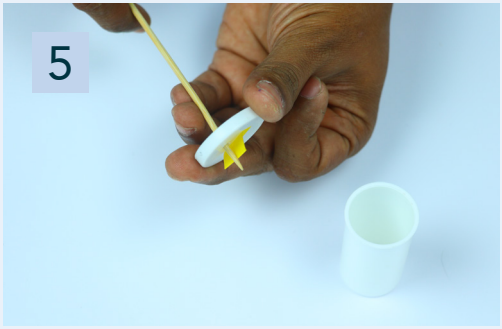
Make a small hole near the bottom of the first can.



Take a small piece of sticky tape and stick around 1 cm of the tape on itself.



Paste this tape on the inner side of the first cap.

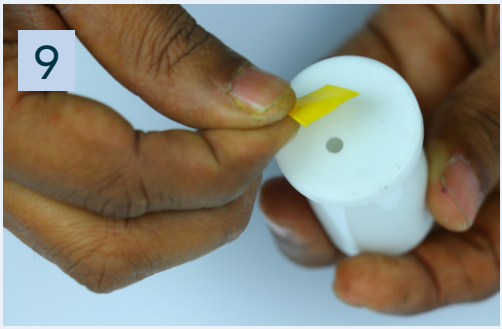


This will make a one-way valve. The air can come inside the can but can't go out.

Insert a stiff straw in the side hole. Apply some glue to make the connection airtight.

Insert this can in the cycle tube.

Take the second can and make a hole at the bottom using scissors.

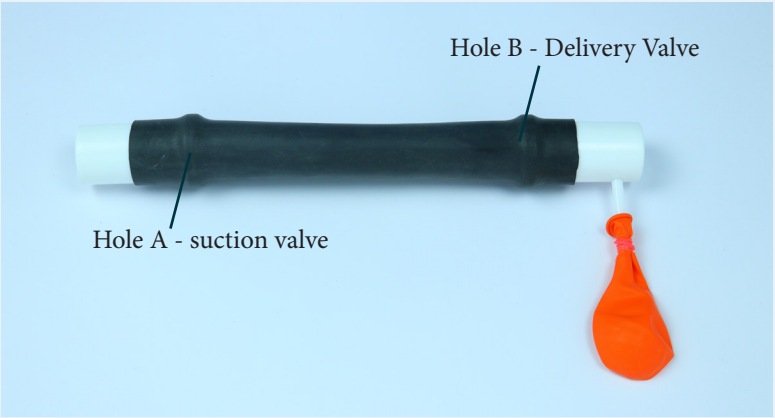


Paste another piece of tape on the outside of the second cap (in the same way as steps 3 and 4).

Insert the second can in the cycle tube. Attach a balloon to the stiff straw using a rubber band.

Now press the cycle tube repeatedly from the middle and the balloon will get inflated.

NOTES



WHAT'S GOING ON?

1. The pump has two holes which have one-way valves on them - hole A (away from balloon) and hole B (close to balloon).
2. When the pump contracts, the existing air in the pump moves into the balloon through hole B as the hole A is closed.
3. When the pump expands, fresh air enters inside the pump through hole A. The air already inside the balloon doesn't come out in this step as hole B is closed.
4. Continuously repeating these steps fill the balloon with air and can eventually pop it!

EXPLORE

1. One-way valves are used extensively with the pumps and compressors because generally we want the fluids to flow in a particular direction and don't want them to return in the opposite direction.
2. Try filling water in the balloon using this pump.