Scientist Badge
Pack Holiday 1997

Topics

Movement and Mechanics

The Natural World
Light
Electricity and Magnets
Floating and Sinking

Movement and Mechanics

Materials needed for movement and mechanics.

Sheets of paper.
Plastic cups.
Large Books.
Heavy and light balls.
Tin tray.
Chairs.
Various coins.
Rulers.
Irregular card shapes.
Soap.
Pencil.
Cotton reels.
Large tin with screw on lid.
Sardine tin.

String.
Sellotape.
Drawing pins.
Cardboard box with lid.
Heavy weight.
Cotton.
Elastic Bands.
Wheeled toy car.
Tin cans.
Two brooms.
Hook.
Matchsticks.
Marble.
Hollow metal tube.

Glass.
Glass jar.
Card.
Mug of water.
Two bowls of water.
Tennis ball.
Smooth rubber ball.
Metal+wooden trays.
Small flat bottle.
Rope.
Modelling clay.
Candles.
Bucket.

Building Bridges

Equipment: Paper, Plastic cup, large books

Method: First make a ‘river’ by putting the two books about 15cm apart. The aim is to now use ordinary paper to build a bridge across the river, strong enough to take the weight of the cup. First try to do it with a plain sheet of paper, then use a folded sheet, then try a zig-zag pattern.

Expected Result: The zig-zag pattern, with the folds running across the river, gives the strongest bridge.

Explanation: Two things give the bridge its strength. First, if you look at the bridge from one side it will appear to be about 1cm thick because of the folds and this helps. The main thing however, is that the ends of the bridge form a series of triangles (with the books on which they rest, and a triangle is a very strong shape.

Note: Try making a triangle and a square out of pieces from a construction kit. The square is easily pushed out of shape, but the triangle is almost solid.

Gravity

When an apple falls from a tree, why does it fall down to the ground? A famous scientist called Isaac Newton puzzled over this problem while sitting in an orchard many years ago. He suggested that the apple and the Earth both had an invisible force that pulled other objects towards them. But the Earth was so large, and had such a powerful force it was able the pull the apple down to the ground. This force around objects is called **Gravity.**

Investigating Falling

In the 1590's, a scientist called Galileo put forward a theory that all objects are pulled down to Earth at the same speed no matter what they weigh.

Equipment: Heavy and light balls, tin tray, chair.

Method: Stand on a chair and drop the objects down onto the tray (try to release the objects at the same time). Listen for the sound of them hitting the tray. Which one lands first?

Expected Result: You should find that they land together.

Explanation: Gravity pulls them down to Earth at the same speed even thought one is heavier than the other.

Falling Coins

Equipment: Two coins, two rulers

Method: Place one ruler diagonally hanging off the table. Put one coin on the end of the ruler hanging over the table, the other on the edge of table at the opposite end of the ruler. Strike the ruler edge hanging over the table with the second ruler. Which coin hits the ground first?

Expected Result: Both coins hit the ground at the same time, despite the fact they take different paths.

Explanation: The coin on the end of the ruler simply falls straight down under the pull of gravity when you hit the ruler from under it. The other coin is knocked off the table by the ruler but still hits the ground at the same time because the Earth is still pulling it down at the same rate as the one that is just falling vertically. The fact that it is also moving horizontally does not affect its vertical motion.

Objects have weight because gravity pulls on them. The greater the pull of gravity on an object the more it weighs. People do not feel their weight if there is no gravity pulling on them or if they are floating freely. When you bounce on a trampoline you feel weightless when you are up in the air, but the feeling will last only until you come down to Earth again. The pull of the Earth's gravity gets less the further out in space you are, so things weight less in space. Astronauts float about in their spacecraft because there is little gravity to keep them down. The tides in the oceans on the Earth are caused by the pull of gravity of the Moon and the Sun.

<u>Balancing</u>

Rest a book on the edge of a table and gradually ease it over the edge. It will balance with part of the book off the table until you push it too far and upset the balance. All objects have a point where they are held in balance by the force of Gravity. This balancing point is called the **centre of gravity** because it is the place where the whole weight of the objects seems to be centred.

Finding the Balancing Point

Equipment: irregular card shapes with holes in the edge, string, weight, coin, tape, something to pin them up on.

Method: Cut out an irregular shape from a piece of card and make three holes around the edge. Tie the weight to the string. When you hold up the string, the weight will make it hang straight down in a vertical line This is called a **plumb line**. Hang you shape and the plumb line on a pin and draw a straight line down the string. Do the same with the other two holes. The balancing point is where the three lines cross. Repeat this with a boat shaped card. Now tape a coin onto a corner of the shape. How does the weight change the balancing point? Where do you think is the best place for cargo to be stowed on a real ship?

Expected Result: The coin will cause the centre of gravity to be shifted.

Explanation: The best place to store the cargo would be at the centre of gravity, to prevent the ship from rolling or tipping due to the weight of the cargo..

The Magic Box

A box is a regular shape so you would expect the balancing point to be in the middle. This trick will show you how to defy the laws of balancing and surprise your friends.

Equipment: Cardboard box with lid, heavy weight, sellotape.

Method: Tape the weight into one corner of the box. Then put on the lid and show it to your friends. Open the lid away from the weight and let them see the box looks empty. Tell them the box is magic ad you can balance it on air. Then place the box on a table and gradually ease it off the edge.

Expected Result: If you leave the corner with the weight in it on the table the rest of the box will hang in the air as if by magic.

Explanation: Because the centre of gravity of the box is still on the table, the table is still supporting the weight of the box so it will not fall to Earth.

Objects can balance when their centre of gravity allows them to stay upright or poised in position. You can use this fact to make a balancing toy with the gymnast and tightrope.

Make a Gymnast

Carefully cut out 2 card shapes of the gymnast and colour them in. Stick one coin behind each hand using sticky tape, then stick the two halves of the figure together. When it is dry, it will balance on its nose almost anywhere. Try making a tightrope with a piece of string and balancing the gymnast on it. Although the figure looks heavier at the top, the weight of the coins keeps the centre of gravity under the nose so it will balance.

Start and Stop

Objects that are still do not want to move and objects that are moving do not want to stop. This tendency of something to stay still or keep moving is called **inertia** (the word comes from the Latin word for lazy). To make something start or stop moving, you must overcome its inertia. You can do this by pushing or pulling the object. These pushes and pulls are known as **forces**. The heavier something is the more force it needs to start or stop it moving.

Getting Things Moving

Equipment: cotton, elastic band, wheeled toy car, heavy books, tin cans.

Method: Tie a length of cotton around some heavy books. Rest a board across two cans and put the books on top. Gently pull the cotton, the books should start moving quite easily. Now keep the cotton slack and give it a really hard tug. What happens? Now try pulling a toy car loaded with books, with an elastic band. Notice that the harder you pull, the longer the band becomes. Does it need more pulling power to start an object moving or to keep it going?

Expected Result: This time the cotton should break because the books have too much inertia to start moving quickly. When you pull the car the band is longer when it first starts to move then when the car is moving.

Explanation: You have to pull harder to start the car moving because you are having to overcome its inertia. Once the car is moving you need less force.

Next time you are in a car, notice what happens if the driver pulls away suddenly. your inertia pushes you back into the seat, you are not moving and your body wants to stay still. If the driver stops suddenly you will continue forward as your inertia resists stopping, your body does not want to stop moving. Seat belts help to overcome your inertia and hold you firmly in your seat.

The Lazy Coin

Equipment: A glass, piece of card, coin.

Method: Balance the card across the top of the glass and balance the coin in the middle of the card. Can you make the coin fall straight down into the glass without touching the coin?

Expected Result: If you flick the card forwards the coin should drop into the glass.

Explanation: The coin does not move with the card because of inertia, it wants to remain where it is, so it drops into the glass.

The Tablecloth Trick

Equipment: A mug of water, sheet of paper, table.

Method: Stand the mug of water on the paper on a table. Can you pull the paper out without spilling the water in the mug? (the outside of the mug must be dry not wet)

Expected Result: If you pull the paper with a sharp jerk, the mug should stay where it is.

Explanation: The mug has too much inertia to be moved by the sudden jerk.

Sliding Along

One way of moving things is to slide them over another surface. Think about pulling a sledge. Does it slide more easily on ice or on a concrete path? When two rough or uneven surfaces rub together an invisible force called **friction** holds them back and makes moving difficult. Moving is easier when there is little friction between the two surfaces.

Investigate Friction

Equipment: Selection of objects (stone, wood, rubber, ice, matchbox etc), smooth piece of wood.

Method: Arrange a selection of objects in a line along the edge of the wood. Slowly raise the wood until the objects begin to move. Note which ones move first. Repeat with a metal tray.

Expected Result: Some objects will move more easily than others.

Explanation: Some objects will move more easily than others because there is less friction between their outer surface and the surface of the board and tray. Feel the objects that move easily, they should feel smooth.

Friction in Water

Equipment: Two shallow bowls of water, tennis ball, smooth rubber ball.

Method: Try spinning each ball in a dish. Which one move more easily? Why?

Expected Result: The rubber ball will spin easier than the tennis ball.

Explanation: The smooth surface of the rubber ball causes less friction so the rubber ball moves more easily than the tennis ball. This is why a fast boat has a smooth hull.

Friction always makes it harder to move things but this can sometimes be very useful. For example, the friction between the soles of your shoes and the ground stops you slipping over when you walk, and the wheels of a car could not grip the road without friction. Imagine how difficult life would be without friction. Try rubbing some margarine on to the handle of a door and then try to turn the handle. You will find you need friction to open the door.

Sometimes it is very useful to increase the amount of friction between things to keep them moving. For example, in icy conditions grit is spread on the roads to make the surface rougher, and increase the friction between the tyres and the road. This helps the tyres to grip the road.

Reducing Friction with Water

Equipment: A smooth metal tray, books, small flat bottle, water, soap.

Method: Prop up the tray on the books to make a slope. Wet one side of the tray and try sliding the bottle down each side in turn. Now rub soap on the wet side and slide the bottle down again. On which surface does the bottle slide most easily?

Expected Result: The bottle should slide easiest on the soapy water, then the water, and is hardest to slide on the metal.

Explanation: There is most friction between the glass and the dry metal of the tray. Even though they feel smooth, there are bumps in the glass and the metal. The water fills in some of the bumps in the surfaces so there is less friction. The soap fills in even more bumps and the bottle slides very easily. In fact the bottle slides on a layer of soapy water, not on the metal. Wet things are slippery because water smoothes out the bumps in surfaces. This can be dangerous, it is easy for a car to skid on a wet road.

Pulley Power

Pulleys are a special sort of wheel. A pulley wheel has a groove all round the rim for a rope to fit into. If you attach one end of the rope to a heavy load you will be able to lift it more easily.

Broom and Rope Trick

Equipment: Two brooms, rope.

Method: Amaze your friends with your super strength using this simple trick. Ask two or four friends to hold two brooms apart. Attach a length of rope to one broom and thread it round the two brooms. Take hold of the free end yourself. Ask your friends to try and keep the brooms apart while you try and pull them together. If you dust the brooms with talcum powder first it will reduce the friction and make it easier for you to pull the brooms together.

Expected Result: You should find that you are easily able to beat the pulling power of your friends.

Explanation: You are actually using a pulley. You can exert a greater force than if your friends were just holding the end of the rope (like tug-of-war) but you need to pull more of the rope to get the same effect.

Make Your Own Pulleys

Levers and Lifting

One of the simplest ways of lifting heavy things more easily is to use a lever. Levers work by increasing pushing force underneath the object so a large load can be moved with a small effort. Levers lift objects most easily when the resting point, the **fulcrum**, is close to the object and the pushing point is as far away as possible.

Lift a Book With a Ruler

Equipment: Heavy book, ruler, fulcrum (matchbox or similar)

Method: Lift the heavy book and notice how heavy it is. Make a lever by using a ruler balanced across a matchbox. Make sure that the fulcrum (the place where the ruler rests across the matchbox) is close to one end of the ruler. Place the book on the end of the ruler nearest to the fulcrum. How easy is it to lift the book now using the lever?

Expected Result: You should find that you can lift the book easily by pressing down gently on the other end of the ruler.

Explanation: Using a lever multiplies the force you put on it. Notice how far down you have to push the ruler and how high the book is lifted.

Jumping Coin Trick

Equipment: A ruler, a pencil, two large coins.

Method: Put the pencil under the middle of the ruler and place a coin on one end. Drop the second coin from a height of about 1 foot so it hits the ruler at about the 3 inch mark. Notice how high the first coin jumps into the air. Now repeat the trick but drop the second coin right at the end of the ruler at the same height. How high does the coin jump?

Expected Result: You should see that the first coin jumps much higher into the air this time.

Explanation: Again, you are using a lever to magnify the force pushing the other coin into the air.

Swinging

A pendulum is a rod or string with a weight called a bob on the end. In the 16th century Galileo noticed that the chandelier in the cathedral at Pisa took the same time to complete one swing whether the swing was a long one or a short one. He also found that the time of the swing depended on the length of the pendulum, the weight on the end made no difference.

Investigating Pendulums

Equipment: String and some weights, a hook, a watch with a second hand.

Method: Cut two lengths of string about 1m long. Tie a small weight to one and a larger weight to the other. Tie each pendulum in turn to a hook or somewhere where it can swing freely. Set the pendulum swinging gently and see how it takes to swing to and fro ten time. How do the times compare? Now try some experiments with one weight. First put it on a long string and time it, then a short one. What happens?

Expected Result: You will find that both pendulums take the same amount of time to complete ten swings even though they have different weights on the end. You will find that the pendulum with the shorter string swings much faster than the one with the longer string.

Explanation: The actual reason for this is the same as that for the experiment where you drop different weights and they hit the floor at the same time, falling under gravity does not depend upon your weight.

Shifting Pendulums

Equipment: Modelling clay, string, two chairs.

Method: Cut two pieces of string about 45 cm long and attach a piece of clay to each piece. Tie some string tightly between the backs of two chairs. Tie the pendulums to the line of string. Hold one pendulum still and start the other swinging. What happens when you let go of the second pendulum?

Expected Result:

Explanation:

<u>Stretch and Twist</u>

Some substances, such as elastic or rubber, stretch when you pull them but spring back to their original shape and size when you let them go.

Make a creeping Crawler

Equipment: A cotton reel, a small elastic band, matchsticks, a candle, sticky tape, pencil, scissors or penknife.

Method: Cut a slice about 10mm thick from the candle. Make a hole through the middle using a sharp pencil. Make a groove in one side of the slice using a pencil point. Push the elastic band through the hole in the slice and place a matchstick through the loop. Pull the elastic band tight so the matchstick fits in the groove. Thread the other end of the elastic band through the hole in the cotton reel. Push half a matchstick through the loop of the elastic band that comes through the reel. Tape the loop and half the matchstick firmly to the end of the cotton reel so they cannot turn round. Now wind up your toy by turning the long matchstick round and round.

Expected Result: When you put it down, the toy will start to crawl.

Explanation: As you turn the matchstick, you twist and tighten the elastic band. As the band unwinds, it releases the energy stored in the twisted elastic and makes the toy move.

Magic rolling Tin

Equipment: A large tin with a lid, a hammer and nail to make holes, an elastic band, a heavy nut or weight, string.

Method: Cut the elastic band into one long piece and thread it through holes in the tin so it crosses over itself in the middle of the tin. Knot the ends together at the lid. Tie on the weight inside the can where the band crosses. Press on the lid and roll the tin forward. What happens?

Expected Result: You will find you have made an obedient tin which always comes back to you.

Explanation: This is because the heavy weight stays hanging below the elastic band so the elastic becomes twisted (if you push the tin too hard it wont work because the weight will spin too). The tin rolls back on its own because it is driven along by the energy stored up in the twisted rubber.

In a Spin

When an object spins round, it creates a force called centrifugal force, which pulls it outwards. You can feel this force if you attach a piece of string to a ball and whirl it round and round in a circle. Centrifugal force is used in the machines at fairgrounds and to spin clothes dry. It even keeps satellites in orbit around the Earth.

Pick up the Marble

Equipment: Marble, glass jar.

Method: Place the marble on a table and cover it with a glass jar. Now try to lift the marble without touching it.

Expected Result: If you spin the jar around, this will start the marble spinning too. Eventually it will be pressed against the sides of the jar and you can lift the jar.

Explanation: The marble is pressed against the sides of the jar by centrifugal force. The mouth of the jar is narrower than the sides so the marble cannot fly out if you lift the jar.

Spinning Water

Equipment: Bucket of water, lots of space.

Method: Half fill a bucket with water, and try spinning it round in a circle outside. Where does the water go?

Expected Result: The water will not fall out of the bucket if you spin it fast enough (even if it is upside down).

Explanation: Centrifugal force will keep the water pressed against the bottom and sides of the bucket while it spins around.

<u>Machines and Movement</u>

People use a variety of machines to make moving easier. The power to drive these machines comes from animals, which pull carts, ploughs and sledges, and also from natural forces, such as the wind and running water. Windmills and water-mills have been used for thousands of years. Today most machines are driven by electricity.

Make a Water Wheel

Equipment: Cotton reel or similar tube, thin card, pencil, scissors, glue or tape.

Method: Cut four pieces of card about 1 by 1½ inches. Fold each blade in half and glue half of it onto the reel. Push the pencil through the hole in the middle of the reel and hold it under a gently running tap.

Expected Result: The force of the water will turn you water wheel around.

Explanation: This is how mills used to get the power to turn the grinder to grind the corn in the old days. It is also basically how a hydroelectric power plant works. Water falls from a dam, turning wheels, which turn a huge dynamo to make electricity.

Make a Steam Boat

Equipment: Three candles (Nightlights), tin (like a sardine tin), hollow metal tube (used for tablets?), clay.

Method: Place the three candles inside the tin. Pour about 2cm of water into the tube. Make a small hole in the screw cap of the rube and use clay to fix the metal tube inside the tin over the candles. Put the steam boat in some water (you will need space for the tin to move). Light the candles and watch what happens.

Expected Result: The boat should start to move through the water.

Explanation: As the candles heat the water in the tube, it boils and turns to steam. The steam shoots out of the hole in the tube and pushes the boat forward.