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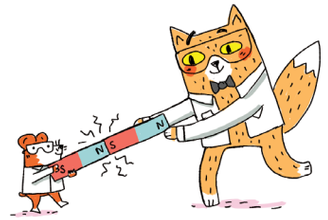
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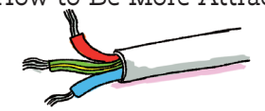
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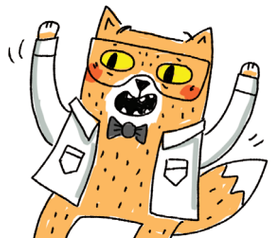
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# Contents



**Phenomenal Physics** 4
**What is Physics?** 6
**Chapter 1: Super Powers** 7
How to Be a Weightlifter 8
How to Balance on a Seesaw 10
How to Crack a Hard Nut 12
All Kinds of Energy 14
How to Put a Spring in Your Step 16
How to Stay Afloat 18
How to Dive Deep 20
How to Measure a Shark 22
How to Become Taller 24
How to See in the Dark 26
How to Avoid a Soaking 28
How to Split an Atom 30
Power Points 32
**Chapter 2: Going Through the Motions** 35
How To Get Moving! 36
How to Build a Rocket 38
How to Move Up a Gear 40
How to Keep on Going 42
How to Reach Terminal Velocity 44
How to Avoid a Crash 46
How to Slip Away 48
How to Walk a Tightrope 50
How to Take Off 52
Full of Hot Air 54
**Chapter 3: Electric Tricks** 55
How to Give Your Hair a Lift 56
How to Be Positive 58
How to Use Potato Power 60
How to Be a Conductor 62
How to Be More Attractive 64
How to See a Magnetic Field 66
How to Hover 68
How to Make Chips 70
How to Test for Intelligence 72
**Chapter 4: Out of This World** 75
How to Move at Superspeed 76
How to Get into Orbit 78
How to Walk on the Moon 80
How to See the Universe 82
How to See Behind a Star 84
How to Look Back in Time 86
The Long and the Short of It 88
How to Measure Space 90
How to Time Travel 92
Why is Space So Silent? 94
How Fast is the Universe? 96
How to End the Universe 98
**Chapter 5: Riding a Wave** 101
How to Create Waves 102
How to Bend a Spoon 104
How to Make a Rainbow 106
Spectacular Spectrum 108
How to See Skeletons 110
How to Explore the Microverse 112
How to Make a Sonic Boom 114
Emojis for Everyone 116
How to Keep Your Cocoa Warm 118
How to Keep the Noise Down 120
How to Look Around Corners 122
How to Be Radioactive 124
How to Be a Singing Star 126
**Index** 128

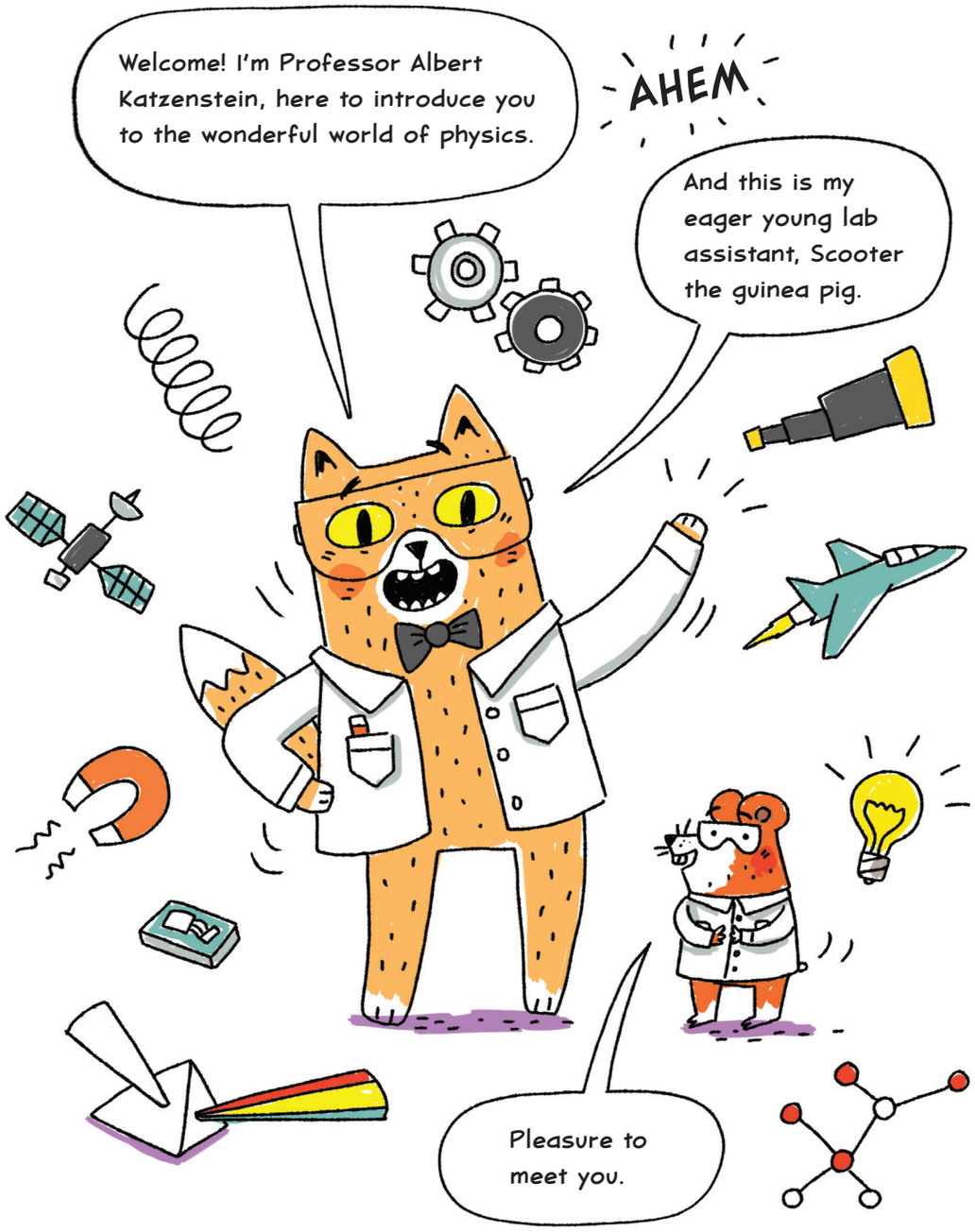




## PROFESSOR ALBERT KATZENSTEIN'S

### Foreword to

# Phenomenal Physics













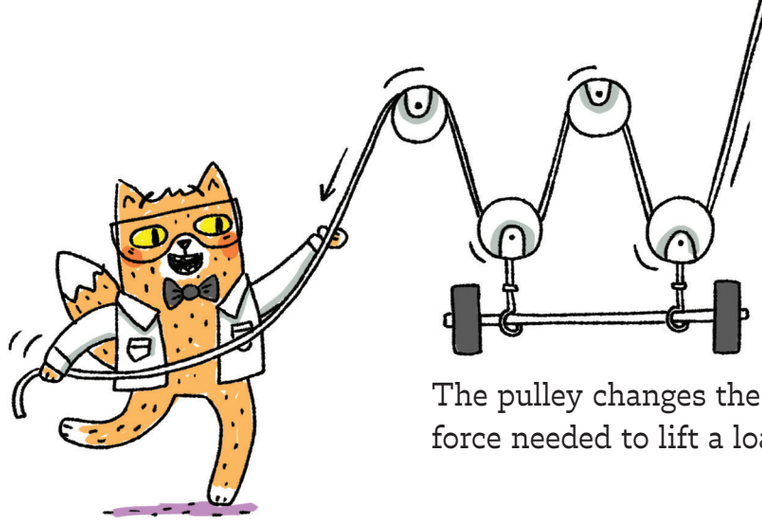
# Super Powers

## (Energy and Forces)







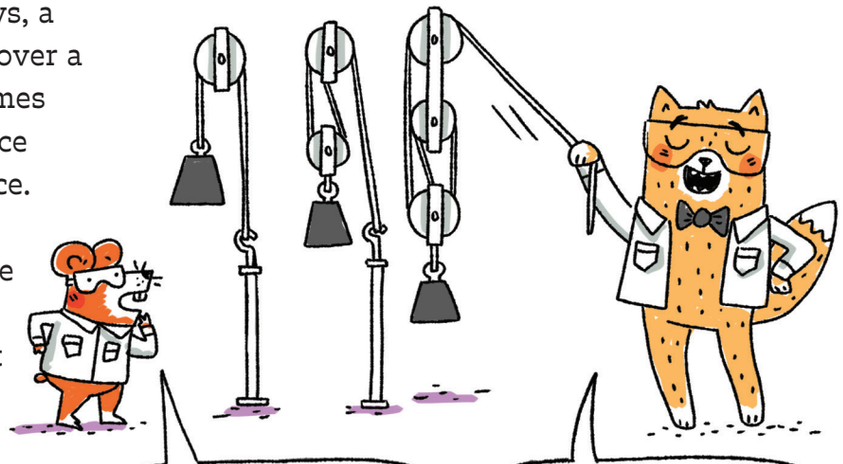



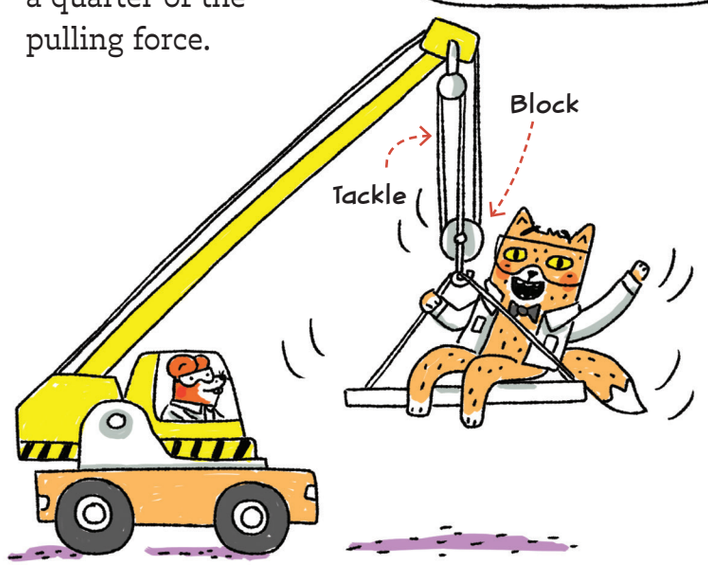
**Pulleys** are simple machines that help make lifting easier. They are made up of a cable running over one or more wheels.

The pulley changes the direction of the pulling force needed to lift a load.

With a set of pulleys, a weak pulling force over a long distance becomes a strong pulling force over a short distance.

Using a longer cable over two wheels can halve the effort needed to lift a load. Using four wheels means that you only need about a quarter of the pulling force.

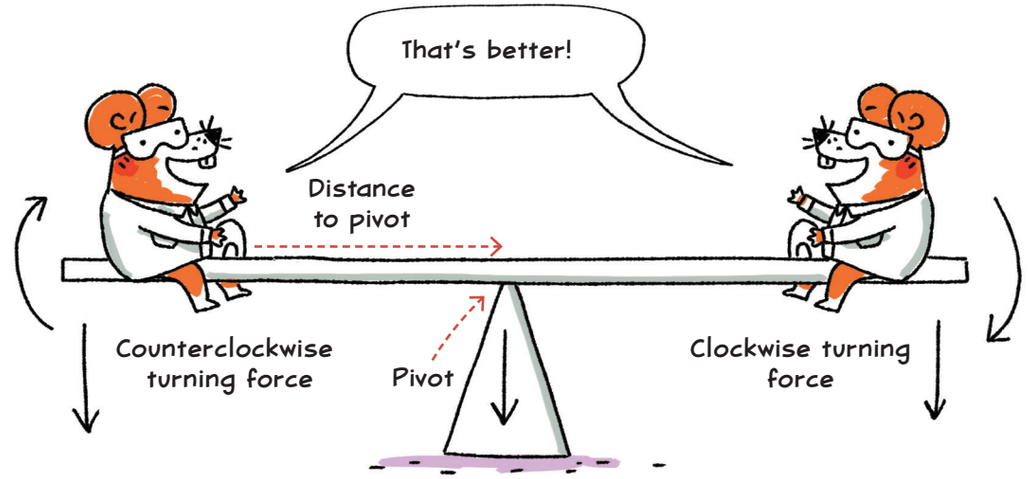



The more cable and wheels used in a pulley system, the heavier the weight that can be lifted. Cranes use a pulley system called a **block** and **tackle** to help lift heavy loads.

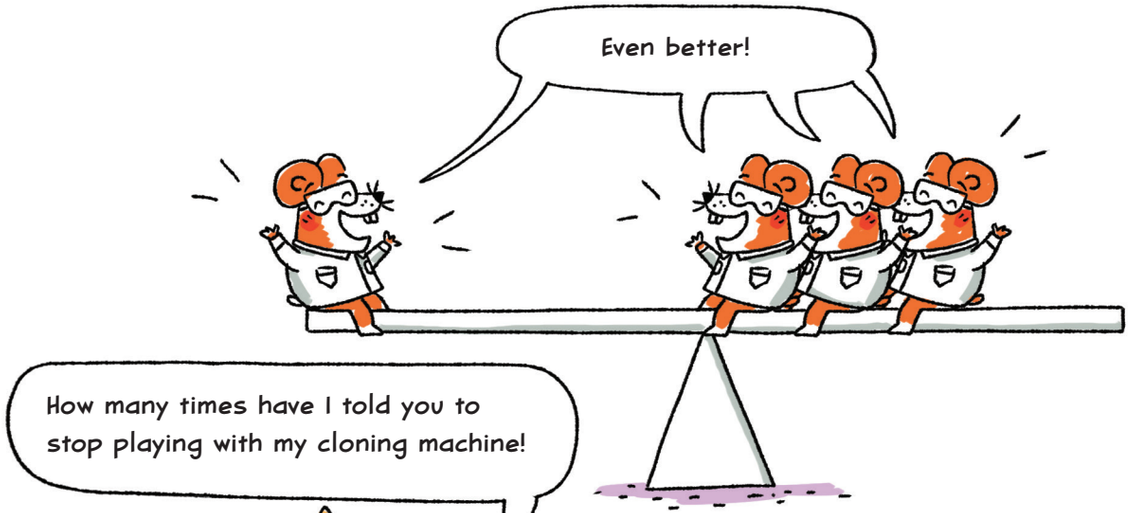


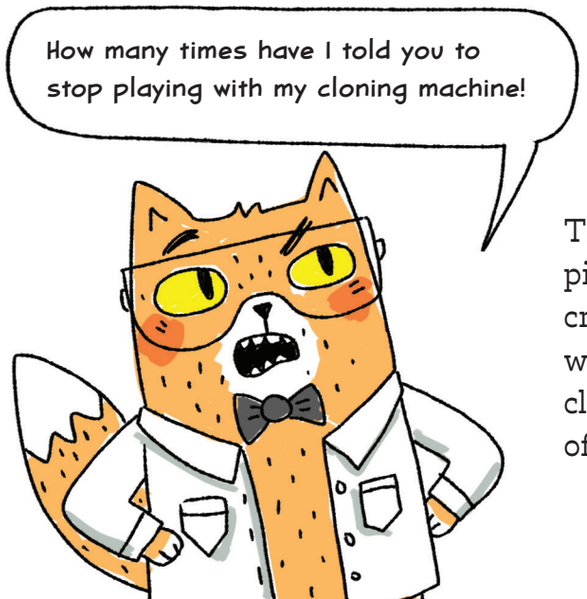



The weight of people on a seesaw creates a **downward force**, which turns the seesaw around its pivot. When the turning forces at each end are equal but in opposite directions, the seesaw is balanced.

The turning effect of a force is called the **moment** of the force. The moment is calculated by multiplying the turning force by the distance from the pivot.




The farther a person sits from the pivot, the greater the moment they create, and their end of the seesaw will move downward. If they move closer to the pivot, they produce less of a turning force, and their end rises.





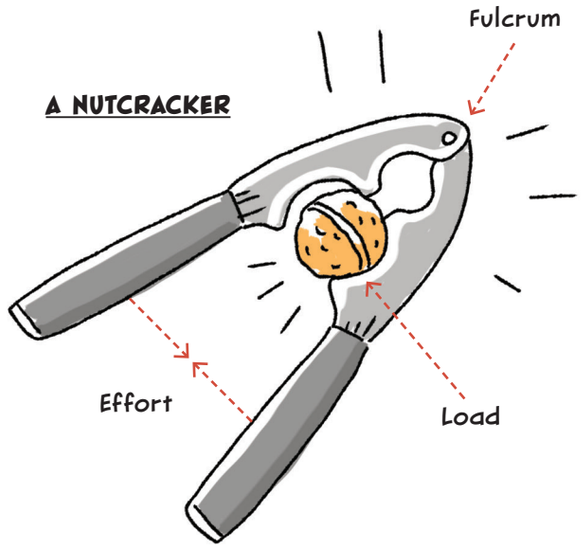




Nutcrackers are a **force multiplier**. They convert a weak force over a long distance into a strong force over a short distance. A light squeeze on the handles becomes a hard squeeze around the nut.

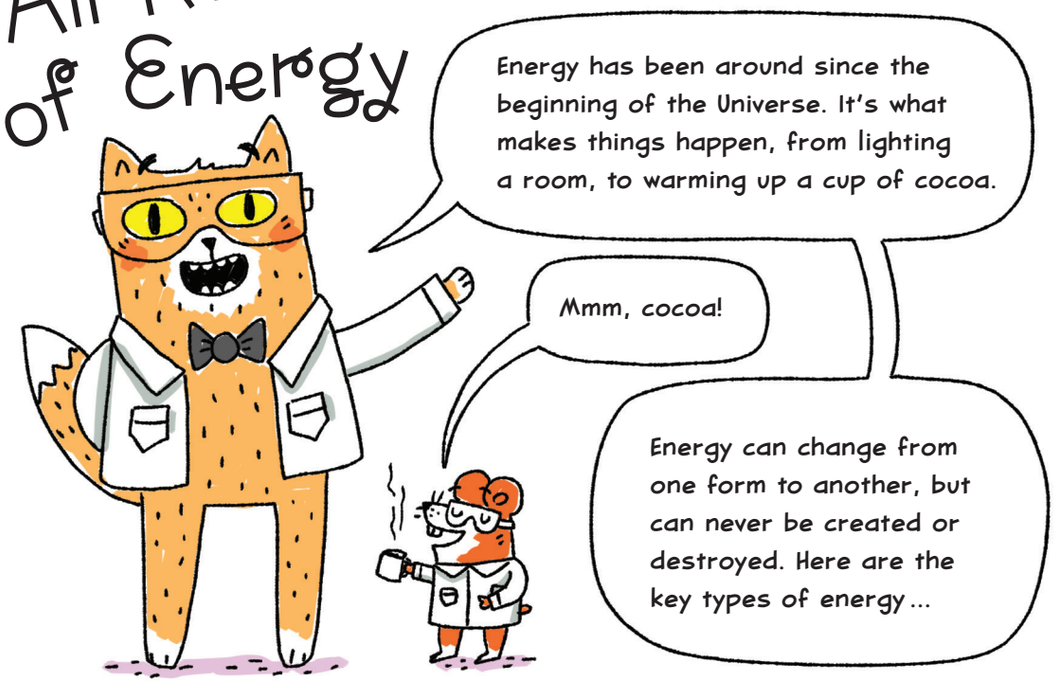
They work as a pair of **levers**, or rigid bars, that move around a fixed point called a **fulcrum**. The nut fits between the levers. When the levers are squeezed together, they press on the nut, causing its shell to crack open.

Other kinds of levers include pliers, wrenches, and bottle openers.






# All Kinds of Energy





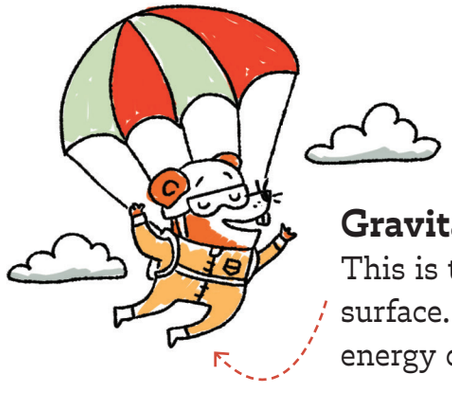

## Chemical

This is energy stored in the bonds between atoms and released through chemical reactions. Chemical energy is held in batteries, fuel, and food.



## Kinetic

Kinetic energy is stored in a moving object. This depends on the object's speed and mass. The faster an object moves or the greater its mass, the more kinetic energy.



## Gravitational

This is the energy of an object above the Earth's surface. The amount of an object's potential energy depends on its position.





## Elastic

This is the potential energy held in an elastic object, such as a spring, when it is compressed or stretched. The energy is released when the elastic object springs back to its original shape.

## Acoustic

Sound energy is made when an object, such as a guitar string, vibrates.



## Radiant

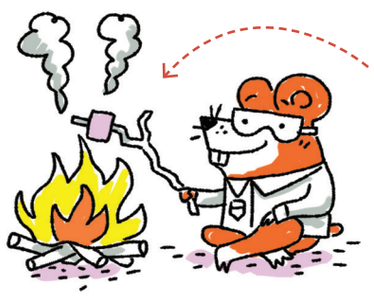
All objects give off radiant energy, carried by electromagnetic waves such as light, radio waves, or X-rays.



## Electrical

Electrical energy is the movement of electrons, which can pass through a wire as electricity, or hit the ground as lightning.





## Thermal

Heat energy is produced by vibrating atoms in a substance. The faster they vibrate, the hotter the substance becomes.

## Magnetic

This is the energy stored in the magnetic field surrounding two magnets that attract or repel each other.





## Nuclear

Stored in atoms, nuclear energy is released when the atoms are fused together or split apart through nuclear fusion or fission.



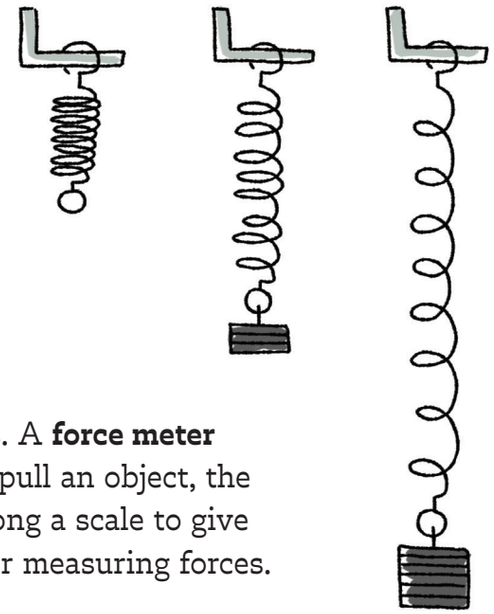




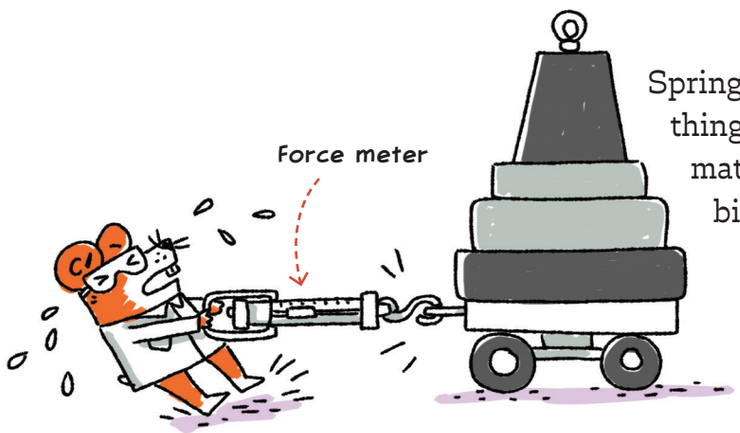

A spring is an elastic object that returns to its original shape when stretched, compressed, or bent.

Stretching or compressing a spring gives it elastic potential energy that will pull it back to its original position.

The stretch of a spring is proportional to the stretching force applied to it. This is **Hooke's Law**. If a weight stretches a spring by one length, twice the weight will stretch it by twice the length.

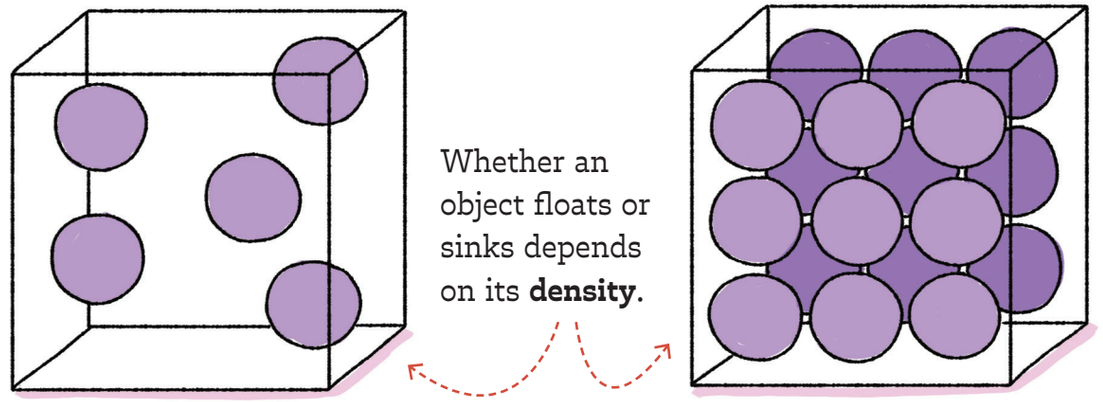


Springs are useful for measuring forces. A **force meter** has a spring inside. When it is used to pull an object, the spring is stretched, pulling a marker along a scale to give a measure in **Newtons** (N), the units for measuring forces.




Springs are used in many things, such as scales, mattresses, and mountain bike suspensions.



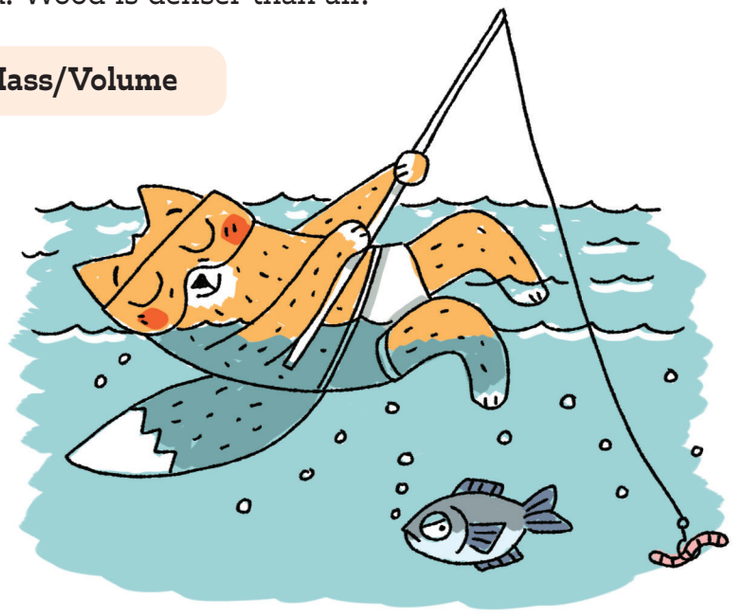



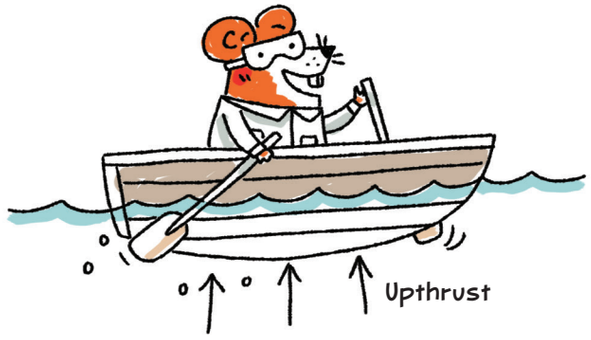
Whether an object floats or sinks depends on its **density**.

Density is how much mass is contained in an object. Steel is denser than wood. Wood is denser than air.

**Density = Mass/Volume**

For an object to float in water, its average density needs to be less than that of water. While a metal coin may be denser and sink, a metal ship is full of air so its average density is less than water.






A boat floats because of a force called **upthrust**. This upward force is equal to the weight of the water that the boat displaces. If the weight of the boat is less than the upthrust, it will float.

# How to Dive Deep

AAAARGHHH!

Calm down, Scooter. Everything's under control.

But ... SCARY FISH!!!!

You're perfectly safe in my paws.

And nothing's going to get through this window—the glass is as thick as a brick.

Why so thick?

Down here in the deepest ocean, the water pressure can be hundreds of times more than on the surface. That's because of the weight of all that water above us.

If you went outside, all the gases in your body would be quickly compressed. You'd be squashed!

GULP!



How come the fish aren't squished?

Because they don't have air inside their bodies. They are mostly water, which can't easily be compressed.

I still feel under pressure. Can we return to the surface?

I can control this submersible to go up and down at any time.

Propeller

The sub has ballast tanks that can be filled with air or water.

Ballast pump

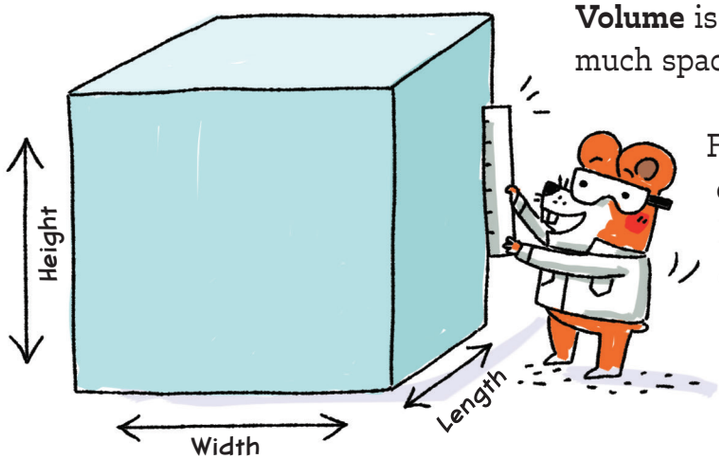
Ballast tanks

To dive, I let water into the tanks, increasing the sub's average density.

To surface, I pump air into the tanks, reducing the sub's average density.

With all this up and down, I think last night's dinner is ready to surface, too!




**Volume** is the measure of how much space an object takes up.

For a simple shape like a cube, you can measure the length of each side to find out its volume.

**Length x Width x Height = Volume**

But for a complex shape, you can use the water displacement method.

A submerged object displaces a volume of liquid that matches its own volume.



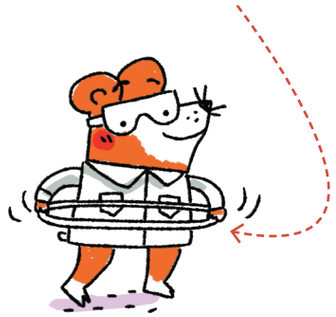



So, if you drop an orange into a pitcher of water and measure the difference in water level, that's the volume of the orange.






All solids can be stretched or compressed to some degree by using force. The change of shape is called **deformation**.





If an object springs back to its original shape after the force is removed, this is called **elastic deformation**. If the object stays stretched or compressed, this is called **plastic deformation**.

An elastic band shrinks back after stretching, so this is **elastic deformation**.

A squashed soda bottle stays squashed, so this is **plastic deformation**.




Brittle materials, such as glass and ceramics, break very quickly if stretched or compressed.

Elastic materials have an elastic limit from which they will not spring back. If a spring is stretched to this limit, it will no longer act as a spring.

The disks between human backbones or vertebra act like a spring and are compressed by gravity. After a night's sleep, you might gain a tiny amount in height as the disks between your vertebrae stretch out, but once you're up they become compressed again, and you shrink.

