Gravity and Pendulums

A unit of study

for Primary students

age 9-12

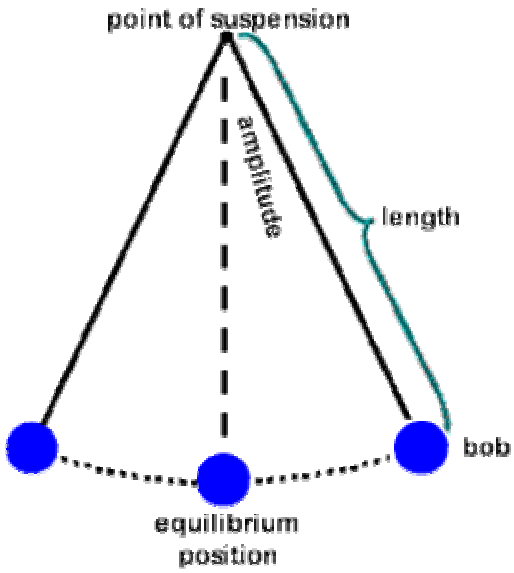
Gravity and pendulums

1. What is a pendulum?

A **pendulum** is a weight suspended on a string (or wire) so that it can swing freely. The weight is called a 'bob'. When a pendulum is set into motion sideways from its resting position it will always go back to its resting position. The bob goes back to the resting position because of the force of gravity.

The resting position is called 'the point is equilibrium'. To get back to its point of equilibrium the pendulum swings back and forth. This is called 'oscillation'. We say that the swinging pendulum is 'oscillating'. The distance the pendulum covers while oscillating is called 'amplitude'.

The time for one complete cycle, (a left swing and a right swing), is called the period. The time for one complete period depends on the length of the string.



Task

a. What is a 'bob'?

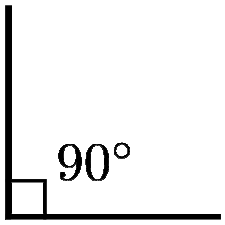
b. What is the 'resting position' called?

c. What does 'oscillating' mean?

d. What is a period?

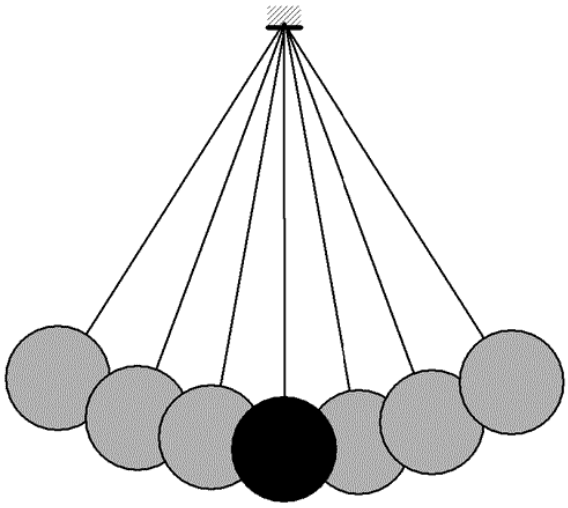
2. The earth's gravity and pendulums

The Earth's gravity attracts the 'bob' of the pendulum. When the bob is hanging still, the string is hanging straight down at a 90-degree angle to the Earth. This is because gravity is pulling the string and the bob to the Earth. The pendulum will stay there at rest until a force causes it to move.



When the pendulum is set into motion, it keeps moving, unless there is a force that acts to make it stop.

Gravity works on the pendulum while it is moving. The force of the movement becomes less as the force of gravity acts on the pendulum. The pendulum slows down. Finally the bob returns to the starting point and the pendulum is still once again. The force of gravity pulls the pendulum down toward the Earth.



Task

Why does a swinging pendulum finally stop?

3. What are pendulums used for?

Pendulums are used to regulate pendulum clocks, and are used in scientific instruments such as accelerometers, (which measure how fast things go), and seismometers, (which measure the strength of earthquakes). The word 'pendulum' comes from the Latin word *pendulus*, meaning 'hanging'. A swing is a pendulum. A Tarzan rope is a pendulum.

Task

Draw and label some things that work on the principle of the pendulum.

4. How do you make a pendulum?

A simple pendulum can be made with a string and a weight hung from a single point. Other material can be used for the string, such as a rod or wire.

Task

Draw a pendulum that you could make.

5. Do pendulums with different bobs swing at different rates?

The weight, (the bob), can be of any weight. It doesn't matter if the bob is heavy or light. Gravity will cause pendulums to swing at the same rate. However other forces such as wind or pushing can vary the rate. Think of a swing. If you lift the swing and let it go, and then walk away, it will act as a pendulum and gradually come to a stop. But if someone pushes the swing then it may go higher, depending on the strength of the push.

Task

Why do pendulums swing at the same rate?

What could vary the rate?

6. Who discovered the law of the pendulum?

The science of the way pendulums swing was discovered by Galileo Galilei in 1602. As a result of Galileo's discovery, pendulums were used for accurate timekeeping technology until the 1930s.

Galileo Galilei was born in Pisa, Italy on February 15, 1564. He was the oldest of seven children. His father was a musician and wool trader. In those days parents often chose the occupation their children would follow.

"I want you to be a medical doctor when you grow up," said his father. "You can earn a lot of money in medicine."

At age eleven, Galileo was sent to a church-based school where he was taught by monks. A monk was someone who dedicated their life to prayer and learning about God. During this time Galileo developed a strong faith in God and marveled at the creation…especially the mathematical laws that held the universe together.

After four years of studying at this school, Galileo decided that he wanted to become a monk.
"Dad," he told his father, "I believe that God is calling me to become a monk."

"Do you want to live your life in poverty?" replied his father. "You have a good brain, son. You will study medicine!"

So Galileo was hastily withdrawn from this school.

In 1581, at the age of 17, he entered the University of Pisa to study medicine, as his father wished. But Galileo soon realized that he was more interested in mathematics than medicine, so changed course to become a mathematician.

Although Galileo was not able to serve God by becoming a monk, he did serve God in another way. His keen interest in science and mathematics led him to make remarkable discoveries that changed the world.

Some of his discoveries were the telescope, which he used to prove that the earth was not the centre of the universe. He discovered that the earth and other planets in our solar system travel around the sun. This was a new idea and different to what had been previously believed. Galileo also invented the thermometer and made some important discoveries about gravity.

At age twenty, Galileo noticed a lamp swinging overhead while he was in a cathedral. Curious to find out how long it took the lamp to swing back and forth, he used his pulse to time large and small swings. Galileo discovered something that no one else had ever realized: the period of each swing was exactly the same. (The period is the time in which a pendulum takes to return to the position it was in at the beginning.)

Galileo also noticed that the period of the pendulum is not dependent on the material from which it is made or on its weight. The pendulum's period is influenced by its length alone. The longer the pendulum string, the longer its period.

Task

Why did Galileo become interested in pendulums?
How did he hit on the idea that pendulums have a constant period?
Why did Galileo become interested in pendulums?

7. Galileo’s famous discovery about gravity

At the time that Galileo arrived at the University, some debate had started up on a "law of nature”, that had been believed by an earlier scientist, Aristotle. The belief was that heavier objects fell faster than lighter objects. Aristotle's word had been accepted as gospel truth, and there had been few attempts to actually test Aristotle's conclusions by actually conducting an experiment!

According to legend, Galileo decided to try. He needed to be able to drop the objects from a great height. The perfect building was nearby: the Tower of Pisa, 54 meters high. Galileo climbed up to the top of the building carrying a variety of balls of varying size and weight, and dumped them off of the top. A huge crowd of students and professors stood at ground level, eager to see the result. They all landed at the base of the building at the same time. Galileo had proved that Aristotle was wrong!

Task

What is the connection between Galileo’s discovery on the Tower of Pisa and the principle that different weights of bobs swing at the same rate?

8. About truth

There were many times in Galileo's life when he had to stand up for the truth. People were not willing to change from their old ideas, that the earth was the centre of the universe. Galileo proved earlier scientists wrong with his new discoveries. Life was not easy for him and he was faced with much opposition.

Christians know the God of all truth, and we can look to His book, the Bible, for truth. We will not always be popular, but God wants us to be strong in standing for the truth.
Jesus said, "You shall know the truth and my truth will set you free." (John 8:32)

Task

a. How do you think Galileo made such remarkable discoveries?
b. What is something that is true today, that many people do not believe?
c. How do we know the Bible is true?
d. If someone told you that you can get to heaven by following any religion you like, what would you say?
e. Read these Bible passages and write a short reflection for each one. What do these verses tell us about truth?
    - John 18:38 Everyone that is of the truth hears my voice.
    - John 10:1-8 The Good Shepherd. The sheep hear His voice.
    - Matthew 7:13-14 The broad and narrow way.
    - John 14:5-7 Jesus said, "I am the way, the truth and the life…"

Science experiments

Pendulums Experiment 1
Build a pendulum

Follow these steps to build a pendulum:

1. Take a ball (the 'bob'), some string, a ruler, and strong sticky tape.
2. Place the ruler on a desk so that 10 cm (4 inches) of the ruler is on the desk and 20 cm (8 inches) extends over the side. Tape it to the desk.
3. Wrap one end of the string around the ball once. Wrap a piece of tape around the ball, covering the string. Put two pieces of tape where the string hangs off the ball.
4. Tie or tape the other end of the string around the ruler.

Now you are ready to do the experiment.

1. Set the pendulum in motion by pulling it up and letting it go.
2. Predict what will happen.
3. Observe how the pendulum swings back and forth (periods), and time how long it takes to stop. *(Note – one swing back and forth makes one period)*
4. Write your results.
5. Why do you think it happened?
6. Now repeat the experiment using different lengths of string.
7. Record any differences in results.

	Prediction	**Results**	**Why do you think this happened?**
Pendulum 1			
Pendulum 2 (longer string)			
Pendulum 3 (shorter string)			

Pendulums Experiment 2
Bobs of different mass

1. Make a pendulum using the same length of string as the last one, but a bob of different mass. (The ball was the 'bob' in the first experiment.) e.g. You could use a marble, a bigger ball, a rock, a pebble
2. Predict what might happen.
3. Set the pendulum in motion and count the number of periods it completes until it stops. Write your results and why you think this happened.
4. Repeat the experiment using different bobs of different mass.

Type of bob	Prediction	Results	Why do you think this happened?

Pendulums Experiment 3
Pendulums can follow different paths

1. Take a pendulum that you have already made.
2. Release the pendulum so that it follows a particular path, e.g. straight line, at a different angle or in a circular/oval path.
3. Count the number of periods the pendulum completes in 2 minutes.
4. Record your results.
5. Now repeat the experiment and set the pendulum swinging to follow a different path.
6. Examine your results to see whether the path followed affected the number of periods the pendulum made in 2 minutes.
7. Explain why this happened.

Type of path	**Prediction**	**Results**	**Why do you think this happened?**

References

http://inventors.about.com/od/gstartinventors/a/Galileo_Galilei.htm

http://muse.tau.ac.il/museum/galileo/pendulum.html

http://www.hps.cam.ac.uk/starry/galileo.html