May the force be with you

UNIT A2

This unit looks at two views of force, those of Aristotle and Newton. It seeks to show how scientists' ideas of force have changed over time and how they often run counter to our common sense ideas.

Using this unit

No previous knowledge about force is assumed.

The unit requires work in small groups and so is not suitable for homework without amendment.

Useful resources

A. Stinner, "The story of force: from Aristotle to Einstein" *Physics Education*, March 1994, Vol 29, Number 2, pp. 77-85.

This article provides a useful summary of the development of the notion of force from Aristotle to Einstein.

Extension idea

Pupils could make a newtonmeter to measure force.

They could investigate different ways of reducing friction.

Links with KS3 programme of study

- How scientists worked in the past, including the roles of experimentation, creative thought and values in changing scientific ideas (Sc1 ideas and evidence).
- The interplay between empirical questions, evidence and scientific explanations using historical and contemporary examples (Sc1 ideas and evidence).
- Forces and motion (Sc4 physical processes).

Moral and spiritual aims

- To show that scientists' ideas can change over time.
- To show that the conduct of science is not value-free but can be shaped by differing views of the world and life.

TEACHER'S NOTES

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Notes on the activities

Activity 1: Drawing forces

This activity will help to identify those pupils who have an Aristotelian view of force as impetus.

The only force drawn on the ball should be gravity.

Activity 2: What is force?

This activity requires pupils to think about what they mean by a force. Their answers can be discussed to aid identification of any misconceptions of force they may have.

5. •Pear falling: force due to gravity, air resistance.
   •Compass pointing: magnetism (Earth's magnetic field).
   •Skier pushing on poles: forward force - originates from muscles in skier's arms, arms pushing exerts a force; force due to gravity - helps only if sliding downhill; resistance - from friction, air resistance.
   •Bow and arrow: stretching - elastic force in string.
6. •Forces are to do with living things.
   DISAGREE - force due to gravity, magnetism, electricity have nothing to do with living things.
   •A push or a pull are examples of forces.
   AGREE
   •A force is needed to change the shape of something.
   *DISAGREE - a force **may** change the shape of something, but heat can change the shape of a block of ice without any force.*
   •Forces are types of energy.
   DISAGREE - but if force acts through a distance, energy is expended.
   •Weight is a force.
   AGREE
   •Stretching a spring needs a force.
   AGREE
   •Gravity is a type of force.
   DISAGREE - weight is the force.
   •Moving always needs a force.
   *DISAGREE - if an object is moving in free space, it needs no force to **continue** moving. To **change** the movement of an object, a force is required.*
   •Friction is a type of force.
   AGREE

Activity 3: Aristotle or Newton?

Here the pupils are asked a key question that will identify whether they have a Newtonian or an Aristotelian view of force. Aristotle lived in Greece; he was born in 384 BC, educated at the University of Athens and his favourite subject was biology.

Activity 4: Time for a thought experiment

This thought experiment is designed to take the pupil through the various processes necessary to shed the Aristotelian view of force and arrive at a more currently acceptable Newtonian view of force.

This 'thought experiment' was first devised by Galileo Galilei (1564-1642). Galileo was one of the giants on whose shoulders Newton stood. Others might have included Aristotle and Copernicus. (See the inscription on the rim of £2 coins.)

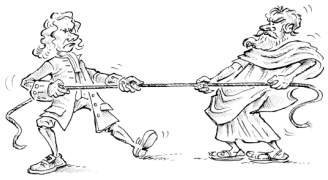
You may want to discuss what happens in 'outer space' to reinforce the Newtonian concept of force.

Activity 5: For further study

3. Without gravity the universe would not exist!
   a), b) If gravity were weaker or stronger, everything would be very different. If gravity were increased, one consequence would be that the atmospheric pressure would be so strong it would crush us; if it were weaker, there would be little or no atmosphere. The actual value of gravity is finely poised for the Universe even to exist and of course consequently for our existence.
   (For further information, see *Charis Science Units 1-11*, unit 9, 'There's no place like home'.)

4. Without friction, you would not be able to run or walk and cars would not move.

May the force be with you

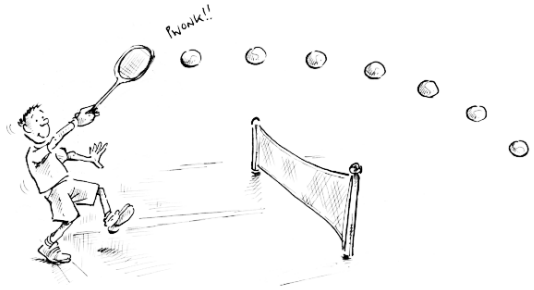


UNIT A2

Many good ideas in science have come from clever people whose ideas were not always accepted at the time. Sometimes their ideas were accepted but later they turned out to be wrong. This is your chance to compare the views of two great scientists and decide which you think is correct.

1 Drawing forces

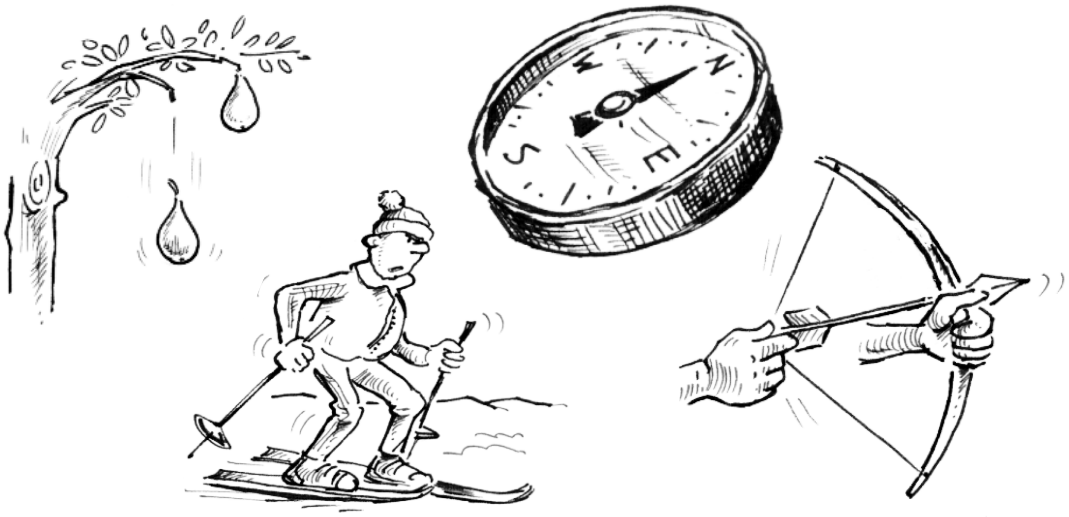
The picture below shows a tennis player hitting a ball. The picture shows the ball at different stages of its movement.



Sketch the picture and add arrows to show where you think the forces could be acting.

2 What is force?

1. Look at these cartoon pictures and name as many forces as you can.



2 What is force? continued ...

2. Look at these statements. For each statement try to decide whether you agree with it, disagree with it or are not sure about it.

	Agree	Disagree	Not sure
Forces are to do with living things			
A push or a pull are examples of forces			
A force is needed to change the shape of something			
Forces are types of energy			
Weight is a force			
Stretching a spring needs a force			
Gravity is a type of force			
Moving always needs a force			
Friction is a type of force			

3 Aristotle or Newton?

Two of the many scientists who have studied forces and how they act are the ancient Greek thinker Aristotle and the seventeenth-century English scientist Sir Isaac Newton.

1. Here are some facts about Newton and Aristotle. Match them up to each person:

One lived in Greece.	One was English.
One was born in 1642 AD.	One was born in 384 BC.
One was educated at the University of Athens.	One was educated at the University of Cambridge.
One survived the plague.	One had biology as his favourite subject.

2. They also had different ideas about how forces work. Look at this statement:

'A force is needed to keep something moving.'

Do you think this statement is true or false? Take a class vote.

If you think the statement is true, you agree with Aristotle.
If you think it is false, you agree with Newton.

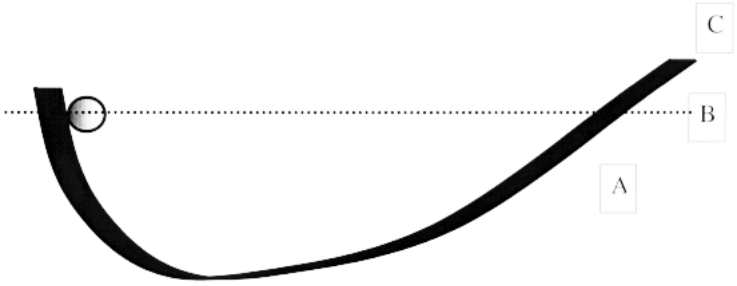
We will now try to see who is right: Aristotle or Newton.

4 Time for a thought experiment

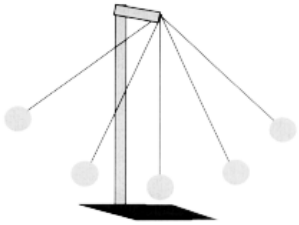
Imagine a completely polished track and on it is a perfectly smooth ball at rest. Also imagine that there will be no friction and no air resistance to slow the ball down. The only force acting on it then is the force due to gravity.

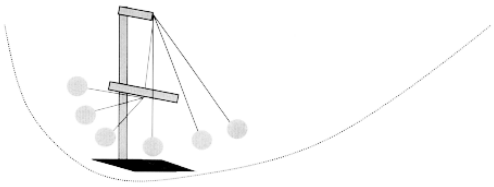
1. Copy the diagram and draw in pencil the path the ball takes when it is released.

2. Now look at this track:



Describe what you think will happen if the ball is allowed to roll from this position. Will it reach position A, B or C? You can test your prediction using a pendulum. The pendulum bob will move in a very similar way to the ball on the track above. Notice again that the pendulum will always try to swing back to the same position. It is other forces that stop it doing so, counter forces like friction (where the string rubs on the hook) and air resistance.





3. Now look at this track: describe what you think will happen to the ball now.

The ball will keep moving until a force acts on it. The ball will move with a constant speed. The only force acting on the ball is the force due to gravity (which is keeping it on the track and stopping it floating off into space).

4 Time for a thought experiment continued ...

4. The original statement in Activity 3 was 'A force is needed to keep something moving'. You have discovered that an object **can** move **without** a force acting upon it and so Newton was correct, and the statement is false.

Aristotle's view of force was believed to be a 'scientific fact' for very many years. It wasn't until Galileo and Newton came along and showed that his ideas were wrong that other scientists had to change their view of force. The problem is that Aristotle's views are 'common sense' ideas about force. Newton's ideas are not 'common sense'. But that is often the problem with science, it doesn't always agree with common sense!
Newton's work on force was very important. We now use the word newton (symbol N) for the units in which force is measured.

If what scientists count as 'a scientific fact' may change, how do you know what is true? Can science help us to find out what is true? Does truth change?

Sir Isaac Newton summarised his thoughts on forces in three laws, known as Newton's three laws of motion. His first law can be summarised as:

'A force is required to start or stop something moving or to change its direction, but a force is not needed to keep something moving.'

In 1962 it was realised that the Chinese had discovered this before Newton. In a book written in the fourth or third century BC called *The Mo hing*, there is a similar statement to Newton's first law:

'The cessation of motion is due to the opposing force . . . If there is no opposing force . . . the motion will never stop. This is as true as that an ox is not a horse.'

Take a look at the rim of a £2 coin, which has a famous saying by Newton on it, 'on the shoulders of giants'. Newton believed he was standing on giants' shoulders. Can you think of any? Without the work of scientists before him, he would not have been able to make the discoveries that he did.

5 For further study

1. Design a poster showing the difference between Newton's and Aristotle's views of force.
2. Construct a survey to find out which view of force is more common: Newton's view or Aristotle's view.
3. What would change in the way you live if the force due to gravity became (a) much stronger or (b) much weaker than it is at present?
4. What would the world be like without forces like friction? Could a bicycle ever stop? Can you think of some other problems if there were no forces like friction?