Cambridge Assessment International Education

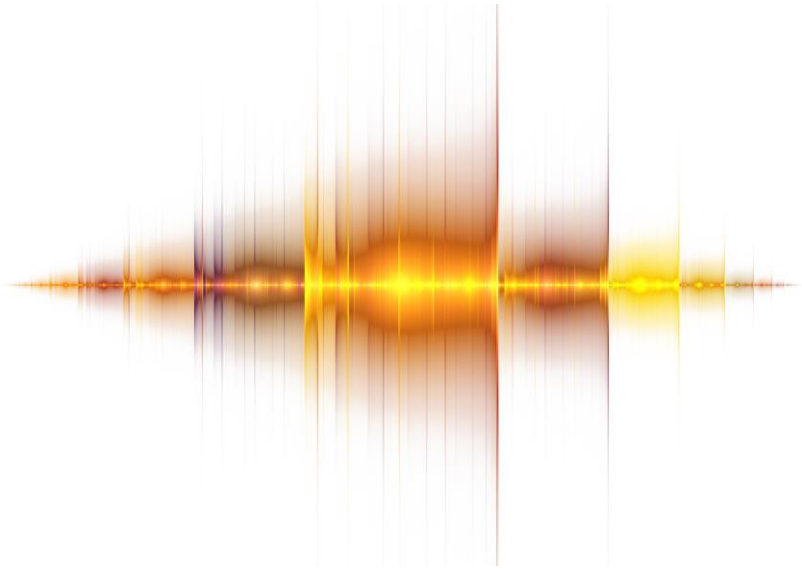
Teaching Pack

Static electricity

Cambridge O Level

Physics 5054

This *Teaching Pack* can also be used with the following syllabuses:
- Cambridge IGCSE™ Physics **0625**
- Cambridge IGCSE™ (9–1) Physics **0972**
- Cambridge IGCSE™ (9–1) Co-ordinated Sciences (Double Award) **0973**
- Cambridge IGCSE™ Combined Science **0653**
- Cambridge IGCSE™ Physical Science **0652**



Version 0.1

Cambridge Pathway

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Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide the opportunity to practise extended writing skills.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this pack will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Static electricity

This *Teaching Pack* focuses on an experiment to show the production and detection of electrostatic charges. Charging by induction is also demonstrated.

This experiment has links to the following syllabus content (see syllabus for detail):

- 18.1 Laws of electrostatics

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- Make and record observations
- Interpretation of experimental observations
- Plan experiments and investigations, including equipment selection

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 3.1 Balanced and unbalanced forces
- 27.1 Atomic model

Going forward

The knowledge and skills developed in this experiment will be useful when you teach learners about electric circuits and current.

Briefing lesson: Designing experiments

Resources	• Worksheets A and B
Learning objectives	By the end of the lesson: • ***all*** learners should be able to describe how scientific ideas are developed from observations. • ***most*** learners should be able to design an experiment based on observations. • ***some*** learners will be able to explain the importance of making accurate observations and using these to inform the design of experiments.

Timings	Activity
10 min	**Starter / Introduction** Show your learners a photograph of lightning and ask the question, 'do you agree that lightning is an example of electricity?' Most learners are likely to agree. Ask the class to discuss the following questions in groups: 1. What observations lead them to draw the conclusion that lightning is an example of electricity? 2. What further experiments or observations could be made to support this? Ask for contributions and use questioning to establish the difficulties in designing an experiment, even though this seems to be an obvious conclusion based on simple observations. This problem was solved when Benjamin Franklin used a kite to demonstrate static discharge.
15 min 5 min 10 min 15 min	**Main lesson** Provide learners with Worksheet A. Your learners should work through the worksheet independently at first. After five minutes they should share their thoughts with a partner and then use the next few minutes to improve their answer. Take feedback from each pair and develop a method as a class. Use questioning to challenge learners to consider alternative methods of achieving the same outcome. Ask your learners to work in groups to compile a list of occasions when they have experienced static electricity. Ask for examples and discuss how each of these could have been investigated further. Provide learners with Worksheet B. Provide an answer to the question and invite suggestions for alternative methods or improvements.
5 min	**Plenary** Ask your learners to provide examples of independent variables, dependent variables and control variables from any of the experiments discussed during the lesson. Discuss the examples provided and ensure your learners have an understanding of these variables.

Lab lesson: Option 1 – run the experiment

Resources	• Teacher notes • Teacher walkthrough video • Worksheets C and D • Equipment as outlined in the notes
Learning objectives	By the end of the lesson: • ***all*** learners should be able to describe the production and detection of electrostatic charges. • ***most*** learners should be able to plan and carry out a set of experiments to investigate electrostatic charge. • ***some*** learners will be able to explain charging by induction.

Timings	Activity
5 min	**Starter / Introduction** Show a picture of a learner with their hair standing on end because they are touching a Van de Graaff generator. Alternatively, this could be demonstrated. Ask your learners to discuss what is happening in the picture and why. Learners do not need to be able to fully explain but they should understand that the hair has gained electrostatic charge.
5 min	**Main lesson** Learners are provided with Worksheet C. They should discuss the statements and predict whether each is true or false.
10 min	Learners are shown the available equipment. Inform them that a polythene rod becomes negatively charged when it is rubbed with the cloth. Learners should work in groups of two to three to suggest how the equipment could be used to investigate each statement on Worksheet C.
25 min	Following their discussions and your feedback, learners should collect the equipment and begin their experiments. Learners should test the predictions they made on Worksheet C and add their observations. Worksheet D gives an example of a completed method for you to refer to as you circulate the classroom and check learners' methods. Alternative methods may be equally valid.
10 min	Each group is provided with a gold-leaf electroscope and asked to investigate the effect of bringing a charged object towards the top plate. The teacher demonstrates charging by induction using a gold-leaf electroscope. Learners are given the opportunity to replicate the method. **Safety** Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate.

Lab lesson: *continued*

Timings	Activity
	**Plenary** Each group should consider at least three methods using different charged objects to investigate the following statement: Small torn up scraps of paper have no charge so they will not be attracted or repelled by charged objects. Evaluate the suggestions and ask the class to decide whether one option is better than the others.

Teacher notes

Watch the static electricity video (teacher version) and read these notes.

Each group will require:

- Polythene rod
- Perspex rod
- Cloth
- Watch glass
- Access to running water
- Scraps of paper
- Balloons
- Gold leaf electroscope (optional demonstration)

Teacher method

This is your version of the method for this experiment that accompanies the *Teacher walkthrough* video.

Do not share this method with learners. Give them **Worksheet D**.

Before you begin

Plan how you will group your learners during the experiment session.

Think about:

- the number of groups you will need (group size 2–3 learners)
- the amount of equipment required
- access to running water
- whether you wish to demonstrate the gold leaf electroscope or allow learners to investigate it

Experiment

Walk around the learners during the experiment in case they encounter any difficulties.

Step	Notes
1. Learners should collect all the equipment they need.	
2. A balloon is rubbed with a cloth and gains a charge. It is attracted to the wall.	
3. Learners charge a polythene rod using a cloth and place it on an upturned watch glass.	*Learners are told the polythene rod gains a negative charge.*
4. A balloon is charged by a cloth and when it is brought towards the rod, the rod is seen to experience a force.	*The balloon and rod should not touch each other.*
5. A Perspex rod is rubbed with a cloth. It is moved towards the negatively charged polythene rod on the watch glass.	
6. Learners turn on a tap and adjust it so there is a fine stream of running water. The polythene and Perspex rods are charged in turn and brought towards the stream of water.	*Any charged objects can be used at this stage, e.g. the balloon, the cloths.*
7. Learners investigate charging by induction by moving positively and negatively charged objects towards small scraps of paper.	*The effect should be observed without the rod touching the paper.*

8. Learners could use a gold leaf electroscope to demonstrate charging by induction. A charged polythene rod is moved towards the top plate so the gold leaf is deflected.

You may choose to demonstrate this.

9. The top plate is earthed by touching it with a finger.
10. The finger is removed and the charged rod is moved away from the plate. The gold leaf remains charged.

Clean-up

After the experiment learners should:

- tidy up their work space
- ensure any spillages have been mopped up
- return all equipment to you

Lab lesson: Option 2 – virtual experiment

Resources	• Virtual experiment video • Worksheets C and E
Learning objectives	By the end of the lesson: • ***all*** learners should be able to describe the production and detection of electrostatic charges. • ***most*** learners should be able to plan a set of experiments to investigate electrostatic charge. • ***some*** learners will be able to explain charging by induction.

Timings	Activity
5 min	**Starter / Introduction** Show a picture of a learner with their hair standing on end because they are touching a Van de Graaff generator. Ask your learners to discuss what is happening in the picture and why. Learners do not need to be able to fully explain but they should understand that the hair has gained electrostatic charge.
5 min	**Main lesson** Learners are provided with Worksheet C. They should discuss the statements and predict whether each is true or false.
15 min	Provide learners with Worksheet E. Inform them that the polythene rod becomes negatively charged when it is rubbed with the cloth. Learners should work in groups of two to three to suggest how the equipment could be used to investigate each statement on Worksheet C. Circulate and provide support to your learners. At this stage your learners are only expected to develop ideas and justify their thinking.
5 min	Watch the first part of the virtual experiment video. Ask your learners to compare their predictions to the information in the video and complete Worksheet C.
15 min	Your learners should evaluate the suitability of the method they devised on Worksheet E. Ask them to exchange sheets with a partner. In silence, they should use a coloured pen to mark a dot at any point where they identify a weakness in the method or think an improvement could be made. They should then swap sheets back and spend 3 minutes working through the suggestions independently. Each pair should then discuss the improvements they decided to make.
10 min	Watch the next section of the virtual video. Discuss why the gold leaf has deflected and how this is an example of charging by induction. Watch the final section of the video.

Lab lesson: *continued*

Timings	Activity
5 min	**Plenary** Each group should consider at least three methods using different charged objects to investigate the following statement: Small torn up scraps of paper have no charge so they will not be attracted or repelled by charged objects. Evaluate the suggestions and ask the class to decide whether one option is better than the others.

Debriefing lesson: Electrostatic charge and electrons

Resources	• Access to the Internet and a projector • Worksheets F, G and H
Learning objectives	By the end of the lesson: • ***all*** learners should be able to describe how positively and negatively charged objects interact. • ***most*** learners should be able to describe the addition or removal of electrons when a body is charged. • ***some*** learners will be able to explain the importance of a systematic method when investigating charging by induction.

Timings	Activity
5 min	**Starter / Introduction** Ask your learners to draw and label a basic diagram of an atom, including protons, neutrons and electrons. Ask them to label the charges associated with each particle. Use questioning to establish that when two insulating materials are rubbed together, negative electrons are transferred from one object to the other. Highlight the similarity between the words electron, electrostatic and electricity.
15 min	**Main lesson** Provide your learners with Worksheet F. Provide answers to the worksheet questions while learners self-assess their work. Use questioning to identify and address any misconceptions.
5 min	Provide your learners with Worksheet G.
10 min	Provide answers to the worksheet questions then show the simulation. This should help your learners to visualise the process. https://phet.colorado.edu/sims/html/balloons-and-static-electricity/latest/balloons-and-static-electricity_en.html
5 min	State that dust often sticks to television screens and that this is an example of charging by induction. Ask your learners to discuss this in pairs and attempt to explain the phenomena. Select individuals to make suggestions and help the group to produce a suitable explanation.
15 min	Provide your learners with Worksheet H. Provide answers to the worksheet questions while learners self-assess their work.

Debriefing lesson: *continued*

Timings	Activity
	**Plenary** Show a picture of anti-static shoes. Explain that many electronics can be damaged by static discharge and that people who work with those electronics must take precautions such as wearing anti-static shoes. Ask your learners to discuss whether anti-static shoes would also be effective in preventing against electric shocks. Divide the class into two groups: those who think this would be the case and those who disagree. Ask each group to nominate a candidate to explain why. Through discussion establish that anti-static shoes must have soles that are good conductors. This is the opposite of footwear designed to protect against electric shocks.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson:*		
A: Designing experiments	**17**	**26**
B: Observations and experimental design	**18**	**27**
For use in *Lab lesson: Option 1:*		
C: Statements about static electricity	**19**	**28**
D: Method	**20**	**–**
For use in *Lab lesson: Option 2:*		
C: Statements about static electricity	**19**	**28**
E: Investigating static electricity	**21**	**–**
For use in the *Debriefing lesson:*		
F: Static electricity and electrons	**22**	**29**
G: Charging by induction 1	**23**	**30**
H: Charging by induction 2	**24**	**31**

Worksheet A: Designing experiments

The Ancient Greeks observed that when amber was rubbed with animal fur it could be used to pick up dust and dry straw. It was later discovered that other substances acted in a similar way when rubbed with fur. This invisible force between objects sometimes caused them to come together and sometimes pushed them apart. The objects did not need to touch in order to experience the force.

Based on these observations, suggest a method that the Greeks could have used to confirm whether the strength of force from the amber changes with distance.

Equipment required:

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Method:

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Worksheet B: Observations and experimental design

A learner explained to their friends that when they walk through their living room they often receive a tiny electric shock when they touch the metal door handle. The shock is not painful but they are curious about why it happens.

One of their friends suggested the shock was due to the carpet and other carpets would not cause this. Another friend disagreed and asserted it was due to the material of the soles of their shoes. A third friend blamed the metal door handle for the shock.

Suggest how the learner could investigate whether each of their friends is correct.

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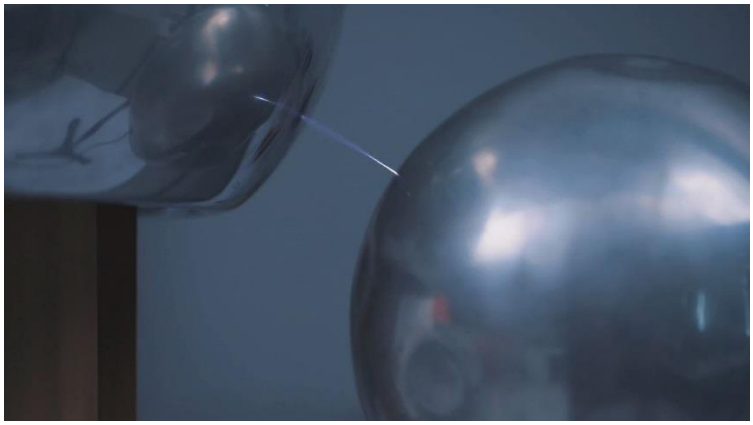
Worksheet C: Statements about static electricity



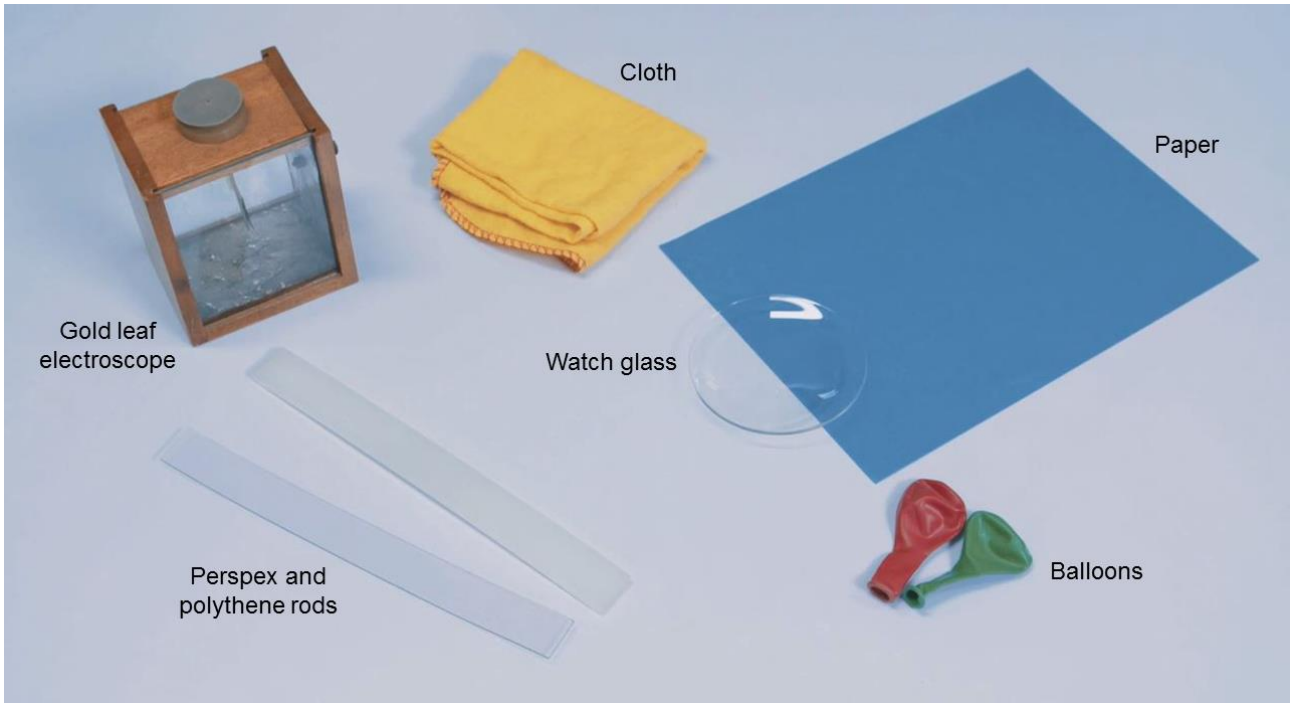
Read the following statements and predict whether they are true or false:

Statement	**Prediction**		**Observation**	
	True	False	True	False
"If a balloon is rubbed with a cloth it will stick to a wall".				
"If a balloon is rubbed with a cloth it becomes negatively charged. It would therefore repel a charged polythene rod".				
"A Perspex rod becomes positively charged when it is rubbed with a cloth".				
"A thin stream of water from a tap will be attracted towards a positively charged rod but deflected away from a negatively charged rod".				
"Small torn up scraps of paper have no charge so they will not be attracted or repelled by charged objects".				

Worksheet D: Method

1. Collect all your equipment.
2. Rub a balloon with a cloth for 30 seconds.
3. Move the balloon close to a wall and observe whether it is attracted.
4. Repeat the experiment.
5. Rub a polythene rod with a different cloth for 30 seconds.
6. Place it on an upturned watch glass.
7. Rub a balloon with a cloth for 30 seconds.
8. Move the balloon towards the end of the polythene rod and make observations.
9. Rub a Perspex rod with a different cloth for 30 seconds.
10. Move the Perspex rod towards the end of the polythene rod and make observations.
11. Turn on a tap and adjust it so there is a fine stream of running water.
12. Rub the polythene rod with a cloth and move it close to the stream of water. Make observations.
13. Repeat using the Perspex rod.
14. Rub the polythene rod with a cloth and move it close to some small scraps of paper. Make observations.
15. Repeat using the Perspex rod.

Worksheet E: Investigating static electricity



Suggest how the equipment above may be used to investigate each of the statements on Worksheet C.

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Worksheet F: Static electricity and electrons

1. A polythene rod becomes negatively charged when rubbed with a cloth. Explain whether the rod has lost or gained electrons.

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2. A Perspex rod is charged with a cloth. When brought towards a charged polythene rod it is attracted. Explain whether electrons have been added or removed from the Perspex rod.

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3. A balloon is charged with a cloth. The balloon is attracted towards a charged Perspex rod. The cloth that was used to charge the balloon is moved towards the Perspex rod. Explain whether the cloth will be attracted to the rod or repelled. Your answer should refer to the transfer of electrons.

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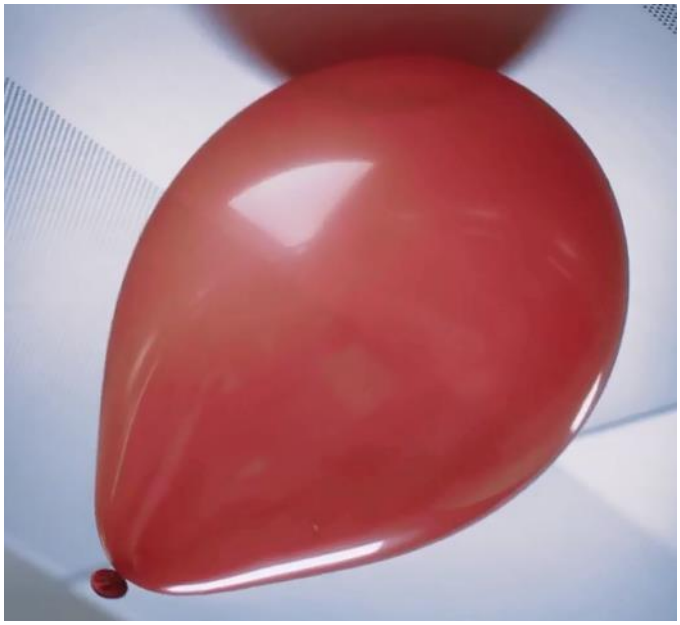
Worksheet G: Charging by induction 1

Charging by induction occurs when a charged body is used to charge a neutral object.



An example of charging by induction is when a balloon is made to stick to a wall or ceiling. Order the following statements to explain how this occurs:

Statement	**Order** (1-7)
The balloon is moved towards a neutrally charged wall.	
The balloon becomes negatively charged.	
Electrons are removed from the cloth and added to the balloon.	
The surface of the wall becomes positively charged (charging by induction).	
A balloon is rubbed with a cloth.	
The negatively charged balloon is attracted to the positively charged wall.	
Electrons in the wall are repelled by the negatively charged balloon.	

Worksheet H: Charging by induction 2

The picture above shows a gold leaf electroscope. The metal top plate is attached to a metal stem. A section of gold leaf is attached to the bottom of the stem.

A gold leaf electroscope can be charged by induction. However, it is important to follow the method in the correct order. Use your understanding of electrostatic charge and the transfer of electrons to explain steps two to five.

1. Charge an object. In this example a negatively charged object is used (e.g. polythene).

2. Move the charged object towards the top plate of the gold leaf electroscope, until the gold leaf is deflected.

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3. Touch the top plate with a finger.

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4. Remove the finger.

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5. Move the charged object away from the top plate. The gold leaf should remain deflected.

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Worksheet A: Suggested Answers

The Ancient Greeks observed that when amber was rubbed with animal fur it could be used to pick up dust and dry straw. It was later discovered that other substances acted in a similar way when rubbed with fur. This invisible force between objects sometimes caused them to come together and sometimes pushed them apart. The objects did not need to touch in order to experience the force.

Based on these observations, suggest a method that the Greeks could have used to confirm whether the strength of force from the amber changes with distance.

Equipment required:

Amber

Pieces of straw of different sizes/lengths/masses/weights (accept dust or paper)

Fur

A measuring device, such as a ruler

Method:

Indicative content (other methods may be equally effective)

Place the straw on a flat surface.

Rub a piece of amber with some fur.

Move the amber towards the straw.

Use a ruler to measure the distance from the amber to the straw at the point where the straw is seen to move towards the amber.

Record the distance at which straw of different sizes becomes attracted to the amber.

Repeat the experiment several (three) times.

Worksheet B: Suggested Answers

A learner explained to their friends that when they walk through their living room they often receive a tiny electric shock when they touch the metal door handle. The shock is not painful but they are curious about why it happens.

One of their friends suggested the shock was due to the carpet and other carpets would not cause this. Another friend disagreed and asserted it was due to the material of the soles of their shoes. A third friend blamed the metal door handle for the shock.

Suggest how the learner could investigate whether each of their friends is correct.

Three separate experiments are required

Experiment 1

1. *Use several sections of carpet of different materials.*
2. *Use one pair of shoes (the pair that resulted in shocks).*
3. *Rub the shoes on a section of carpet a given number of times, e.g. 30 times.*
4. *Touch a metal object that is earthed and observe whether a shock is received.*
5. *Repeat several times and record any variation in the shock received.*
6. *Repeat the experiment for each section of carpet.*

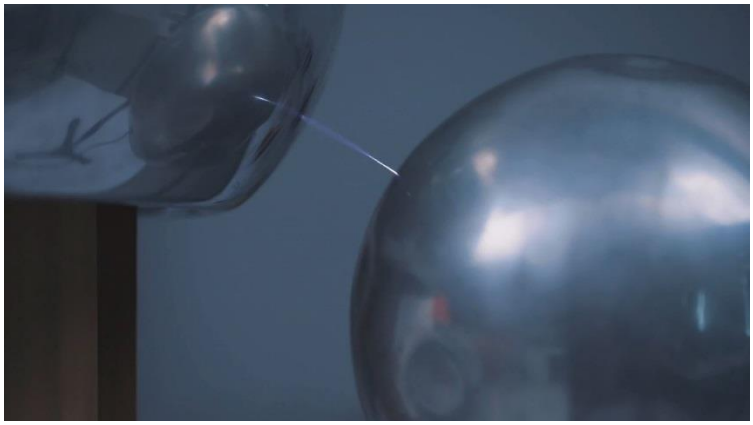
Experiment 2

1. *Use several different pairs of shoes, each with a sole made of a different material.*
2. *Use one type of carpet (the carpet that resulted in shocks).*
3. *Rub a pair of shoes on the carpet a given number of times, e.g. 30 times.*
4. *Touch a metal object that is earthed and observe whether a shock is received.*
5. *Repeat several times and record any variation in the shock received.*
6. *Repeat the experiment for each pair of shoes.*

Experiment 3

1. *Use the carpet and shoes that resulted in shocks.*
2. *Rub the shoes on the carpet a given number of times, e.g. 30 times.*
3. *Touch the metal door handle and observe whether a shock is received.*
4. *Repeat several times and record any variation in the shock received.*
5. *Repeat the experiment but rather than the door handle, use a range of other metal and non-metals objects.*

Worksheet C: Suggested Answers



Read the following statements and predict whether they are true or false:

Statement	Prediction		Observation	
	True	False	True	False
"If a balloon is rubbed with a cloth it will stick to a wall".			✓	
"If a balloon is rubbed with a cloth it becomes negatively charged. It would therefore repel a charged polythene rod".			✓	
"A Perspex rod becomes positively charged when it is rubbed with a cloth".			✓	
"A thin stream of water from a tap will be attracted towards a positively charged rod but deflected away from a negatively charged rod".				✓
"Small torn up scraps of paper have no charge so they will not be attracted or repelled by charged objects".				✓

Worksheet F: Suggested Answers

1. A polythene rod becomes negatively charged when rubbed with a cloth. Explain whether the rod has lost or gained electrons.

   Electrons have a negative charge.

   The polythene rod becomes negatively charged so it has more electrons than protons.

   It must have gained these electrons from the cloth.

2. A Perspex rod is charged with a cloth. When brought towards a charged polythene rod it is attracted. Explain whether electrons have been added or removed from the Perspex rod.

   The Perspex rod is attracted to the negatively charged polythene rod. Unlike charges attract so it must therefore have a positive charge.

   Electrons have a negative charge.

   The Perspex rod is positively charged so it must contain fewer electrons than protons.

   Electrons have therefore been removed from the Perspex rod and transferred to the cloth.

3. A balloon is charged with a cloth. The balloon is attracted towards a charged Perspex rod. The cloth that was used to charge the balloon is moved towards the Perspex rod. Explain whether the cloth will be attracted to the rod or repelled. Your answer should refer to the transfer of electrons.

   The cloth will be repelled by the Perspex rod.

   The balloon is attracted towards the positively charged Perspex rod. It must therefore have a negative charge.

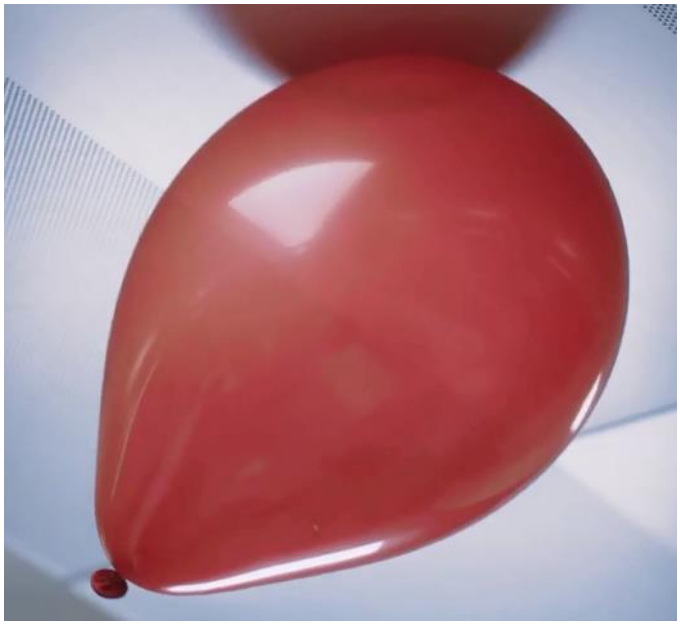
   The balloon is negatively charged because electrons have been transferred from the cloth.

   Electrons have been removed from the cloth so the cloth is positively charged.

   Like charges repel so the positively charged cloth will be repelled by the positively charged Perspex rod.

Worksheet G: Suggested Answers

Charging by induction occurs when a charged body is used to charge a neutral object.



An example of charging by induction is when a balloon is made to stick to a wall or ceiling. Order the following statements to explain how this occurs:

Statement	**Order** (1–7)
The balloon is moved towards a neutrally charged wall.	4
The balloon becomes negatively charged.	3
Electrons are removed from the cloth and added to the balloon.	2
The surface of the wall becomes positively charged (charging by induction).	6
A balloon is rubbed with a cloth.	1
The negatively charged balloon is attracted to the positively charged wall.	7
Electrons in the wall are repelled by the negatively charged balloon.	5

Worksheet H: Suggested Answers

The picture above shows a gold leaf electroscope. The metal top plate is attached to a metal stem. A section of gold leaf is attached to the bottom of the stem.

A gold leaf electroscope can be charged by induction. However, it is important to follow the method in the correct order. Use your understanding of electrostatic charge and the transfer of electrons to explain steps two to five.

1. Charge an object. In this example a negatively charged object is used (e.g. polythene).

2. Move the charged object towards the top plate of the gold leaf electroscope, until the gold leaf is deflected.

   Electrons in the top plate are repelled by the negatively charged object.
   The top plate becomes positively charged.
   The stem and gold leaf gain electrons and become negatively charged.
   Like charges repel so the gold leaf is deflected away from the stem.

3. Touch the top plate with a finger.

   Electrons are added to the positive top plate from the finger.
   The top plate becomes neutrally charged.
   The stem and gold leaf remain neutrally charged.

4. Remove the finger.

   The top plate, stem and gold-leaf have had an overall increase in electrons so they are negatively charged.

5. Move the charged object away from the top plate. The gold leaf should remain deflected.

   Like charges repel so the gold leaf is deflected away from the stem.

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