Cambridge Assessment
International Education

Teaching Pack

Pressure and the imploding can

Cambridge IGCSE™

Physics 0625

This *Teaching Pack* can also be used with the following syllabuses:

- Cambridge IGCSE™ (9–1) Physics **0972**
- Cambridge IGCSE™ Combined Science **0653**
- Cambridge IGCSE™ Co-ordinated Sciences (Double Award) **0654**
- Cambridge IGCSE™ (9–1) Co-ordinated Sciences (Double Award) **0973**
- Cambridge IGCSE™ Physical Science **0652**
- Cambridge O Level Physics **5054**

Version 2.0

Cambridge Pathway

Contents

Icons used in this pack:

Briefing lesson

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Lab lesson: Option 2 – virtual experiment

Debriefing lesson

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 experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.

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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 given here are guides; you may need to adapt the lessons to suit your circumstances.*

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

Experiment: Pressure and the imploding can

This *Teaching Pack* focuses on pressure and the imploding can experiment.

Pressure is defined as the force per unit area. Atmospheric pressure, the pressure of the Earth's atmosphere around us, allows us to observe this concept in action. In this experiment, you will create low pressure inside the can and this will result in the atmospheric pressure imploding the can.

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

- 1.8 Pressure
- 1.5 Forces
- 2.1.1 States of matter
- 1.8 Pressure changes

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

- demonstrate knowledge of how to safely use techniques, apparatus and materials
- make and record observations.

Prior knowledge

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

- 1.5 Forces
- 1.8 Pressure changes

Going forward

The knowledge and skills gained from this experiment will be useful for when you teach learners about the simple mercury barometer and the use of a manometer.

Briefing lesson: Pressure

Resources	• 100 g mass and 2 drawing pins (for each learner) • 2 pieces of white-tac for each learner • Glass or plastic bottle and balloons • Glass, cardboard (approx. 10 cm x 10 cm) and access to water • Plunger and smooth surface (e.g. table or tile) • Plastic bottle (or tin can) with two holes and access to water • Worksheets A and B or C
Learning objectives	By the end of the lesson: • ***all*** learners should be able to make observations. • ***most*** learners should be able to record observations and identify the tools used to make them. • ***some*** learners will be able to explain their observations in detail and link them to theoretical concepts.

Timings	**Activity**
10 min	**Starter/Introduction** Encourage your learners to discuss and list their responses to the following questions: 1. What tools can we use to make observations? 2. How can we record our observations? 3. What might we use our observations for? Collate your learners' ideas and discuss which are valid, efficient and most effective.
10 min 15 min 15 min	**Main lesson** Learners should collect a 100 g mass (1 N weight), two pieces of white-tac and two drawing pins. Explain to your learners how to carry out the experiment below: 1. Make the two pieces of white-tac into slightly flattened balls which are large enough so they can put a drawing pin on top. 2. Place one drawing pin on the first ball of white-tac with the point upwards. Place the 1 N weight on top of the pin (they will need to support it). The learners should observe the force of the mass pressing the pin into the white-tac. 3. Place the second drawing pin, point down, on the second ball of white-tac. They should not push the pin in, just hold it in position. Place the 1 N weight on top of the pin and observe the effect. 4. Invite learners to explain why the same weight is able to penetrate to a different depth in the white-tac depending on the orientation of the pin. Guide the discussion to the significance of the surface area (constant force). Provide your learners with Worksheet A. They should work in pairs to discuss the questions and write their own responses on the worksheet. Depending on timing, and your class, you could go through the answers orally or have them checked later. Your learners can work in pairs to carry out the four experiments and record their observations using Worksheet B. Abler learners can explain their observations. If equipment cannot be provided, use Worksheet C.
10 min	**Plenary** Return to the starter discussion. What tools have we used today? How have we recorded our observations? What have we used our observations for?

Lab lesson: Option 1 – run the experiment

Resources	• Teacher notes • Teacher walkthrough video • Worksheets D and E • Equipment as outlined in the notes
Learning objectives	By the end of the lesson: • ***all*** learners should be able to make and record observations. • ***most*** learners should be able to demonstrate knowledge of how to safely use techniques, apparatus and materials. • ***some*** learners will be able to recognise that an imbalance of pressure can produce forces that change the size and shape of a body.

Timings	Activity
10 min	**Starter/Introduction** Ask your learners to work in small groups to discuss and identify the necessary safety precautions for an experiment using a Bunsen burner and water. Collate their ideas through class discussion.
10 min	**Main lesson** Introduce the experiment and then demonstrate the setup. Make sure that you highlight the following safety points: • Do not move the can until steam is clearly observed. • Ensure you have a firm hold on the can before attempting to lift and move it. • Check the area around you is clear before moving hot equipment.
20 min	Learners should collect the equipment and set up the experiment following your example. They should follow the method on Worksheet D.
15 min	Your learners need to make and record observations. They could draw diagrams to break down the process and explain it in detail. Less able learners may use Worksheet E to structure their explanation. **Safety** Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe.
5 min	**Plenary** Return to the starter discussion from the briefing lesson. What tools have we used today? How have we recorded our observations? What have we used our observations for? Learners should discuss this in small groups before sharing their answers with the class.

Teacher notes

Watch the *Teacher walkthrough* video and read these notes.

Each group will require:

- access to water
- large tray
- ice (enough to make two ice-water baths in large trays)
- Bunsen burner, gauze and tripod
- heat mat
- can
- heat-resistant gloves OR tongs large enough to hold the can
- small beaker to measure 25 ml of water

Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
—	Burns	Flood burnt area with water for at least 10 minutes. For serious injuries see a doctor.

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 2–4 learners)
- the amount of equipment required
- whether you are demonstrating this experiment or allowing learners to attempt the experiment

Experiment
Circulate during the experiment in case learners encounter any difficulties.
Depending on the ability of the learners, you may wish to run this experiment as a demonstration instead. Ensure you have completed the experiment yourself before instructing the learners to attempt it.

Steps	Notes
1. Learners collect equipment from the front of the class.	
2. They should prepare an ice-water bath in the large tray.	*Learners may share trays, but the learners' equipment must be close to the tray and they must communicate with each other to avoid both using it at the same time.*
3. The Bunsen burner is placed on the heat mat. Over this, learners should arrange the tripod and gauze.	
4. Learners should place the can on top of the gauze. They should practise either: a. Using the heat-resistant gloves to remove the can, secure the lid and place in the tray. b. Using the tongs to remove the can, then tip it over quickly so that the open end of the can is submerged in the ice-water.	*In the video a can with a lid is used (option **a**). The same experiment can be carried out with a ring-pull drinks can (option **b**). Decide in advance which method is to be used and advise your learners accordingly.*

5. Learners place the can on the desk and pour approximately 25 cm^3 of water from the beaker into the can.

It is better to have slightly less water than too much. With more water it will take longer to boil. For a smaller can, less water is advised.

6. Learners should place the can on top of the gauze and ensure that it is stable.

Remind learners to check the stability of the equipment so there is no risk of boiling water being spilled during the experiment.

7. Learners check that they are happy with the set-up and that everything is secure – does it match your demonstration of the set-up?
8. Learners put on safety goggles and ensure chairs are out of the way. They must conduct this experiment standing up.
9. Learners light the Bunsen burner and ensure it is beneath the gauze and the can.
10. Learners observe the can.

Waiting for the steam may take some time. Ensure learners remain focused on the task.

11. When steam can be seen rising consistently from the can, it is time to perform the next stage of the experiment. Learners turn off the Bunsen burner. Either:
    a. Using the heat resistant gloves to remove the can, secure the lid and place in the tray.
    b. Using the tongs to remove the can, tip over quickly so that the open end of the can is submerged in the ice-water.

If this is not done quickly, the steam will condense, and the air pressure in the can will equalise.

12. Learners observe what happens next and record their observations from the experiment.

Clean-up

After the experiment learners should:

- Leave equipment to cool and then return the equipment to you.

Lab lesson: Option 2 – virtual experiment

Resources	• *Virtual experiment* video • Worksheets D and E
Learning objectives	By the end of the lesson: • ***all*** learners should be able to make and record observations. • ***most*** learners should be able to demonstrate knowledge of how to safely use techniques, apparatus and materials. • ***some*** learners will be able to recognise that an imbalance of pressure can produce forces that change the size and shape of a body.

Timings	Activity
10 min	**Starter/Introduction** Ask your learners to work in small groups to discuss and identify the necessary safety precautions for an experiment using a Bunsen burner and water. Collate their ideas through class discussion.
10 min	**Main lesson** Provide your learners with Worksheet D. Ask them to read the method carefully and identify the specific safety concerns for the experiment. Discuss these as a class.
20 min	Watch the video for the first time. Ask your learners to make initial notes of their observations. After the video discuss these as a class. Watch the video again, pausing to give extra time for learners to make more detailed observations as a class. Your learners should add to their previous observations. Run through the video a final time to discuss pressure and its effects in the experiment.
15 min	Learners need to make and record observations. They can use their notes from watching the virtual experiment video and draw diagrams to break down the process and explain it in detail. Less able learners may use Worksheet E to structure their work.
5 min	**Plenary** Return to the starter discussion from the briefing lesson. What tools have we used today? How have we recorded our observations? What have we used our observations for? Learners should discuss their responses in small groups before sharing their answers with the class.

Debriefing lesson: Understanding pressure

Resources	• Worksheets F, G, H and I • Aerosol can
Learning objectives	By the end of the lesson: • ***all*** learners should be able to explain that an imbalance of pressure can produce forces. • ***most*** learners should be able to explain that these forces change the size and shape of a body. • ***some*** learners will be able to identify other examples of imbalances of pressure producing forces.

Timings	Activity
10 min	**Starter/Introduction** Provide your learners with Worksheet F. They should work through the worksheet independently to begin with. After 3 minutes, they should share their thoughts with a partner. You should then take feedback from each pair so that the whole class can share their ideas (think, pair, share). All learners should have the same answer to the first question, but answers to the others may differ. This is not a problem, as long as they can justify their thinking.
15 min 15 min 10 min	**Main lesson** Give your learners Worksheet G. They should work through the activities independently. You might want to discuss their ideas for the extension question. After sufficient working time, go through questions 1-3 as a class. Provide learners with Worksheet H. They can work through the worksheet independently or you may want to allow them to discuss and draft their letter in pairs. Circulate around the room to read what the learners are writing. Ask a few learners to read their letters to the class. Learners provide feedback to their peers about what is good in the letters and what could be improved. Show the class the aerosol can. Explain how an aerosol can contain a compressed fluid. When sprayed, the fluid is forced out of a small hole and spreads out. Aerosols are very dangerous when heated. Ask learners to discuss in small groups why you should never put an aerosol on a fire. Circulate around the room to hear ideas and direct discussion. Bring their ideas together as a class. You can find videos online to show what can happen if an aerosol is placed in a fire.
10 min	**Plenary** Provide learners with Worksheet I. They can work in pairs to match up the questions and answers. If there is time, they can cut out and stick the questions and answers in the correct order.

Worksheets and answers

	Worksheets	Suggested answers
For use in the *Briefing lesson*:		
A: Pressure	**14**	**25**
B: Atmospheric pressure	**15–16**	**26–27**
C: Atmospheric pressure	**17–18**	**—**
For use in *Lab lesson: Option 1*:		
D: Method	**19**	**—**
E: Observations of the imploding can	**20**	**—**
For use in *Lab lesson: Option 2*:		
D: Method	**19**	**—**
E: Observations of the imploding can	**20**	**—**
For use in the *Debriefing lesson*:		
F: Making observations	**21**	**28**
G: Calculating pressure	**22**	**29**
H: Taking precautions	**23**	**—**
I: Match up	**24**	**30**

Worksheet A: Pressure

Read through the information below before completing the questions in the space provided.

Pressure is defined as the force per unit area. The more concentrated the force over a smaller area, the higher the pressure.

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

Pressure is measured in Pascals (Pa), force is measured in Newtons (N) and area in metres squared (m^2).

1. Fill in the spaces below:

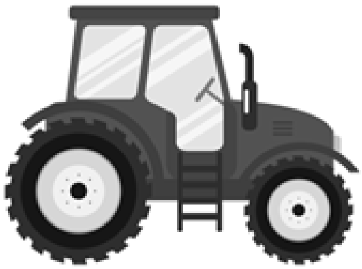
   a. 1 Pascal = ………. N/m^2

   b. For a given area, increasing the force will ………………………. the pressure.

   c. For a given force, increasing the area will ……………………… the pressure.

2. Discuss and answer the following questions.

   a. Why do tractors have large flat tyres?



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   b. Why do you sink in snow less when you wear skis?

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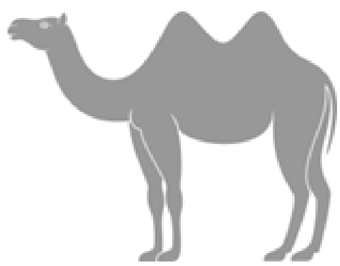
   c. Why do camels have large flat feet?



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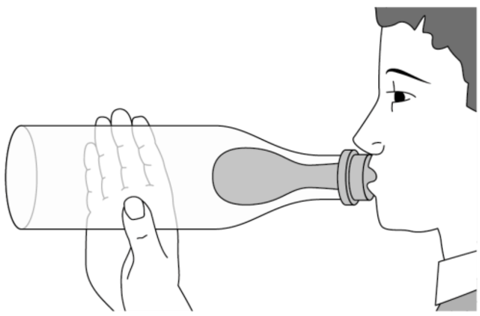
Worksheet B: Atmospheric pressure

Atmospheric pressure

- is caused by the weight of air above us
- decreases with altitude
- acts in all directions
- Average sea-level pressure is 101 000 Pa.

Write observations for the experiments below:

<table>
<tr>
<td>A balloon is placed inside a bottle creating a seal over the rim. Try to blow it up.
</td>
<td>What do you observe?
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Explain why this happens.
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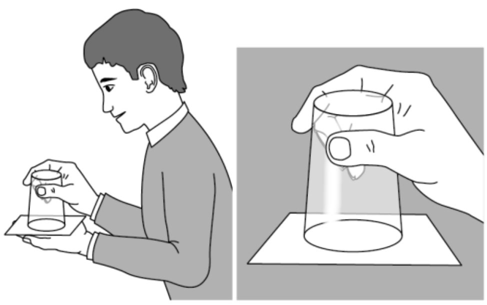
<td>Almost fill a glass with water, place a square of cardboard firmly over the top and turn it upside down slowly.

Carefully take your hand away and see what happens.
</td>
<td>What do you observe?
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Explain why this happens.
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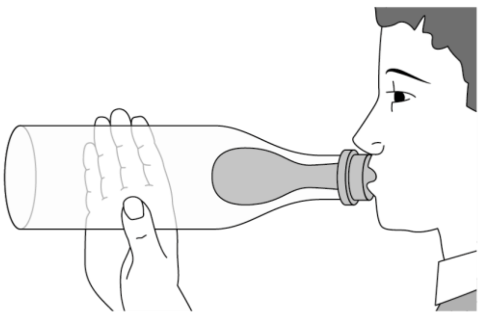
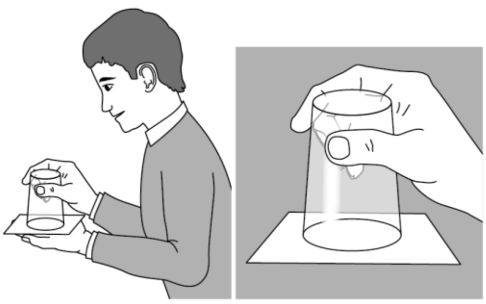
Worksheet B: Atmospheric pressure

Press the plunger onto a smooth surface. Try to pull it away. 	What do you observe? ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... Explain why this happens. ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………...
The bottle has two holes, one higher than the other. Fill it with water and put on the lid. If the top hole is covered, what happens to the water coming out of the lower hole? 	What do you observe? ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... Explain why this happens. ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………... ……………………………………………….………...

Worksheet C: Atmospheric pressure

Atmospheric pressure
- is caused by the weight of air above us
- decreases with altitude
- acts in all directions
- Average sea-level pressure is 101 000 Pa.

Think about the role of atmospheric pressure in the experiments below:

A balloon is placed inside a bottle creating a seal over the rim. It is almost impossible to blow up. 	Explain why this happens.
When a glass is almost filled with water and a square of cardboard is placed firmly over the top, it can be turned upside down slowly and the water stays in place. Carefully take your hand away and see what happens. 	Explain why this happens.

Worksheet C: Atmospheric pressure

Press the plunger onto a smooth surface. Try to pull it away 	What do you observe? ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... Explain why this happens. ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………...
The bottle has two holes, one higher than the other. It is filled with water and closed with the lid. When the top hole is uncovered, water comes out of the lower hole. When the top hole is covered, the water stops coming out of the bottom hole. 	What do you observe? ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... Explain why this happens. ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………... ………………………………………………….………...

Worksheet D: Method

Follow the instructions to carry out the experiment.

1. Collect all of your equipment from the front of the class. You will need:
   - access to water
   - a large tray
   - ice (enough to make an ice-water bath in the large tray)
   - Bunsen burner, gauze and tripod
   - heat mat
   - an empty can
   - heat-resistant gloves OR tongs large enough to hold the can
   - small beaker to measure 25 cm^3 of water
2. Put on your safety goggles and ensure chairs are out of the way. You must conduct this experiment standing up.
3. Prepare an ice-water bath in the large tray
4. Set up the Bunsen burner on the heat mat. Place the tripod and gauze above the Bunsen burner.
5. Place the can on top of the gauze. Practise either:
   a. Using the heat resistant gloves to remove the can, secure the lid and place in the tray.
   b. Using the tongs to remove the can, then tip it over quickly so that the open end of the can is submerged in the ice-water. If this is not done quickly, the water vapour will condense and pour out, and air will refill the can.
6. Place the can on the desk and pour approximately 25 cm^3 of water from the beaker into the can.
7. Place the can on top of the gauze. Ensure that it is stable.
8. Check that you are happy with the set-up and that everything is secure – does it match your teacher's demonstration of the set-up?
9. Light the Bunsen burner and ensure it is beneath the gauze and the can.
10. Observe the can.

Eventually you should notice steam rising from the can.

11. When steam is rising consistently from the can, it is time to perform the next stage of the experiment. Turn off the Bunsen burner, and either:
    a. Use the heat-resistant gloves to remove the can, secure the lid and place in the tray.
    b. Use the tongs to remove the can, then tip it over quickly so that the open end of the can is submerged in the ice-water.

If this is not done quickly, the water vapour will condense, and air will refill the can.

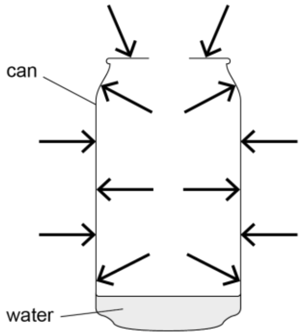
12. Observe what happens next.

This will happen quickly; make sure you pay close attention.

13. Record your observations from the experiment.
14. Leave the can in the tray to cool. Leave the Bunsen burner, tripod, gauze and tongs on the heat mat to cool. Return the tongs/gloves, goggles and beaker.

Worksheet E: Observations of the imploding can

Complete the diagrams and explanations to record your observations of the experiment.

	Initially the water and air inside the can are at room temperature. The pressure of the air inside the can is equal to the atmospheric pressure outside the can. Arrows represent the force spread over the area of the can. Note that there are equal amounts inside and outside because the pressure is the same.
	The can is placed over the Bunsen burner and is heated. Steam coming out of the top of the can means that … ………………………………………………………… ………………………………………………………… The steam now fills the can. This means the pressure in the can … ………………………………………………………… …………………………………………………………
	The can is carefully lifted off the tripod and immersed in the ice-water. The steam inside of the can … ………………………………………………………… ………………………………………………………… ………………………………………………………… ………………………………………………………… …………………………………………………………
	The can … ………………………………………………………… ………………………………………………………… This is because the pressure inside the can ………………………………………………………… …………………………………………………………

Worksheet F: Making observations

Look at the picture below.

Source: http://www.railroad.net/forums/viewtopic.php?f=9&t=63568

Answer the following questions:

1. What do you see in this picture? (Observations)
2. What do you think about this picture? (Deductions)
3. What do you think has led to this? (Hypothesis)
4. What are the reasons for your hypothesis? (Scientific thinking)

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Worksheet G: Calculating pressure

Carry out the calculations of pressure, force and surface area.

Recall: $\text{pressure} = \dfrac{\text{force}}{\text{area}}$

1. A worker has a weight of 800 N and wears big work boots.

   a. Calculate the worker's pressure when he stands with both feet on the ground. Each boot has a surface area of 0.032 m^2.

   b. The worker uses his ladder to clean a very large tanker. The two feet of the ladder have a surface area of just 0.005 m^2. Calculate the pressure of the ladder on the ground with the worker on it.

2. If a person falls into the water of a frozen lake, a ladder can be used to prevent the rescuers also falling through the ice. Explain how a ladder can be used in this way.

3. The empty tanker has a weight 210 000 N. The total surface area of the tankers steel wheels is 0.002 m^2.

   a. Calculate the pressure of the tanker on the ground.

   b. If a lorry with the same weight as the tanker exerts a pressure of 150 000 Pa, what is the total surface area of its rubber wheels in contact with the ground?

   c. Would loading the tanker and the lorry cause an increase or decrease of pressure on the ground? Explain each case carefully and consider all factors.

4. The tanker has a surface area of 40 m^2. The pressure inside the tanker is 78 000 Pa below the atmospheric pressure outside the tanker when it is crushed. Calculate the force that has been applied to the tanker by the atmosphere around it.

Extension:

5. Estimate the force required to crush the can used in the experiment in the last lesson.

Worksheet H: Taking precautions

The tanker pictured on **Worksheet F** became crushed because it was steam-cleaned and then sealed. There were no vents to re-introduce the air that had been displaced. As the steam inside cooled, the pressure inside the tanker decreased to become much lower than the atmospheric pressure. The tanker collapsed under the immense force created by the pressure difference, just like the can in our experiment.

As the owner of a tanker company, write a letter to the staff responsible for cleaning the tankers. Explain the safety issues and precautions that they must take to ensure the tankers do not implode after being cleaned. Include a clear explanation of pressure so that they understand why these precautions need to be taken.

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Worksheet I: Match up

Match up the sentences below:

Force divided by area is the equation for…	the pressure inside is lower than outside.
For a given force, increasing the area…	the pressure inside is higher than outside.
For a given area, increasing the force…	reduces the pressure.
The can in our experiment implodes because…	in all directions.
An aerosol can might explode when heated because…	pressure.
A force may produce…	heating.
Atmospheric pressure acts…	a change in the size and shape of a body.
Pressure can be increased by…	increases the pressure.
Pressure can be decreased by…	cooling.

Worksheet A: Answers

1. Fill in the spaces below:

a. 1 Pascal = *1* N/m^2

b. For a given area, increasing the force will *increase* the pressure.

c. For a given force, increasing the area will *decrease* the pressure.

2. Discuss and answer the following questions.

a. Why do tractors have large flat tyres?

Large flat tyres have a large surface area. This spreads the weight/force of the tractor, reducing the pressure so it does not get stuck in the mud.

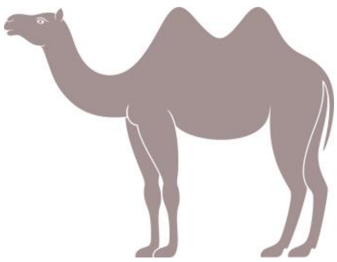
b. Why do you sink in snow less when you wear skis?

Skis have a larger surface area than your feet so this reduces the pressure on the snow even though your weight is identical

c. Why do camels have large flat feet?

Large flat feet have a large surface area.

This spreads the weight/force of the camel, reducing the pressure and helping the camel to walk on sand without sinking.

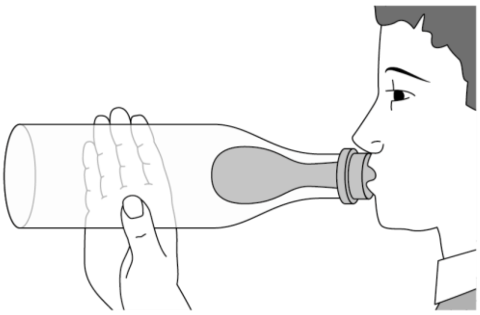
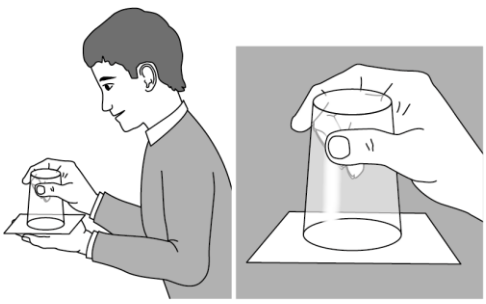


Worksheet B: Answers

Atmospheric pressure

- is caused by the weight of air above us
- decreases with altitude
- acts in all directions
- Average *sea-level pressure* is 101 000 Pa.

Write observations for the experiments below:

A balloon is placed inside a bottle creating a seal over the rim. Try to blow it up. 	What do you observe? *It is difficult to blow up the balloon inside the bottle.* Explain why this happens. *To blow up the balloon the air blown into the bottle must be at a higher pressure than the air already inside the bottle.* *To blow up the balloon, the air already inside the bottle has to be compressed.*
Almost fill a glass with water, place a square of cardboard firmly over the top and turn it upside down slowly. Carefully take your hand away and see what happens 	What do you observe? *The cardboard stays attached to the glass, holding the water inside for some time.* Explain why this happens. *The water creates a seal between the glass and the cardboard. The atmospheric pressure presses on the card, holding the water in place.* *Once the card becomes soaked and is no longer stiff, it collapses and the atmospheric pressure is no longer enough to hold the water in.*

Worksheet B: Answers

Press the plunger into a smooth surface. Try to pull it away. 	What do you observe? *The plunger is difficult to pull away.* Explain why this happens. *When the plunger is pushed down, the air inside is pushed out, leaving a lower pressure inside the plunger cup than outside. The atmospheric pressure acting on the outside of the plunger cup holds it in place.*
The bottle has two holes, one higher than the other. Fill it with water and put on the lid. If the top hole is covered, what happens to the water coming out of the lower hole? 	What do you observe? *The water streaming out of the lower hole can be stopped by covering the top hole.* Explain why this happens. *The water only streams out of the lower hole if air can get into the bottle via the top hole. That air exerts pressure on the water in the bottle, pushing it out of the hole at the bottom.*

Worksheet F: Answers

Look at the picture below.

Source: http://www.railroad.net/forums/viewtopic.php?f=9&t=63568

Answer the following questions:

1. What do you see in this picture? (Observations)
2. What do you think about this picture? (Deductions)
3. What do you think has led to this? (Hypothesis)
4. What are the reasons for your hypothesis? (Scientific thinking)

1. The tanker is compressed or squashed. It looks like it has been sucked in on itself.
2. The tanker may have had some structural problems. Something has occurred inside the tanker. This is an issue that could be dangerous or costly to the company
3. Something has happened inside the tanker to lower the pressure so that the atmospheric pressure is greater leading to the collapse.
4. The bending in the tanker looks like the same effects of the steam condensing in the can in the experiment. It is likely that heating has occurred inside the container and then it has been sealed so that the internal pressure has reduced and the force of the higher atmospheric pressure outside has caused it to implode.

Worksheet G: Answers

1. A worker has a weight of 800 N and wears big work boots.
   a. Calculate the worker's pressure when he stands with both feet on the ground. Each boot has a surface area of 0.032 m^2.

      P = F/A = 800 / (2 x 0.032) = 12 500 Pa

   b. The worker uses his ladder to clean a very large tanker. The two feet of the ladder have a surface area of just 0.005 m^2. Calculate the pressure of the ladder on the ground with the worker on it.

      P = F/A = 800 / 0.005 = 160 000 Pa

2. If a person falls through the surface ice into the water of a frozen lake, a ladder can be used to prevent the rescuers also falling through the ice. Explain how a ladder can be used in this way.

   It can be laid down flat on the ice. This provides a larger surface area than if a person walked out on the ice. This spreads the weight of the rescuers and reduces the risk of the ice breaking further.

3. The empty tanker has a weight 210 000 N. The total surface area of the tankers steel wheels is 0.002 m^2.
   a. Calculate the pressure of the tanker on the ground.

      P = F/A = 210 000 / 0.002 = 105 million Pa

   b. If a lorry with the same weight exerts a pressure of 150 000Pa, what is the total surface area of its rubber wheels in contact with the ground?

      A = F/P = 210 000 / 150 000 = 1.4 m^2

   c. Would loading the tanker and the lorry cause an increase or decrease of pressure on the ground? Explain each case carefully and consider all factors.

      Loading the tanker increases the force, which leads to an increase of pressure.

      Loading the lorry increases the force, which leads to an increase of pressure.

      However, loading the lorry may cause the rubber tyres to be compressed, which increases the surface area of the tyres in contact with the ground. This would mean the pressure does not increase as much as for the tanker with the same weight.

4. The tanker has a surface area of 40 m^2. The pressure inside the tanker is 78 000 Pa below the atmospheric pressure outside the tanker when it is crushed. Calculate the force that has been applied to the tanker by the atmosphere around it.

   F = P x A = 3 120 000 N

Extension:

5. Estimate the force required to crush the can used in the last lesson.

   Learners should use values from the tanker question to scale down the force required. The final answer is not important, instead look at learner's scientific thinking and application of logic.

Worksheet I: Answers

Match up the sentences below:

Force divided by area is the equation for…	pressure.
For a given force, increasing the area…	reduces the pressure.
For a given area, increasing the force…	increases the pressure.
The can in our experiment implodes because…	the pressure inside is lower than outside.
An aerosol can might explode when heated because…	the pressure inside is higher than outside.
A force may produce…	a change in the size and shape of a body.
Atmospheric pressure acts…	in all directions.
Pressure can be increased by…	heating.
Pressure can be decreased by…	cooling.

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