

Custard

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Acknowledgements

This resource was originally developed by the University of Reading to support outreach work delivered as part of the Chemistry for All project.

To find out more about the project, and get more resources to help widen participation, visit our Outreach resources hub: rsc.li/3CJX7M3.

Custard: teacher notes

Available from rsc.li/3zcvpLy

Guidance notes

This session should take approximately one hour to complete in full. It was initially created for 11–14 year-old learners but can be adapted for other age groups.

Download the PowerPoint presentation, technician notes and student workbook that accompany this resource at rsc.li/3zcvpLy.

Read our health & safety guidance, available from rsc.li/3IAmFA0, and carry out a risk assessment before running any live practical.

The safety equipment suggested is in line with CLEAPSS requirements. For non-hazardous substances, wearing lab coats can help to protect clothes. The safety rules might be different where you live so it is worth checking local and school guidance.

Learning objectives

- Explain what a non-Newtonian fluid is.
- Describe conditions where powders may become explosive.

Introduction

Use **slides 3–6** of the PowerPoint to recap the three states of matter and introduce Newtonian and non-Newtonian fluids with the video too. The background information given below can be used, along with the slide notes, to provide additional information.

Non-Newtonian fluids

Sir Isaac Newton described how ‘normal liquids or fluids’ behave and observed that they have a constant viscosity (thickness). The thickness, or viscosity, of fluids changes with changes in temperature or pressure. For example, water freezes and changes state from liquid to solid at 0°C, but it boils and changes state from liquid to gas at 100°C. At temperatures within these two extremes, water remains a liquid with constant viscosity.

Typically, fluids take on the shape of the container into which they are poured. These are ‘normal fluids’ otherwise known as Newtonian fluids. Some fluids don’t follow this rule. These ‘strange fluids’ are known as non-Newtonian fluids.

Stress and strain

In science, stress refers to a force applied to an object or material. The deformation of the material caused by that stress is described as strain. For example, a hammer hitting metal provides the stress which causes a dent in the metal known as strain.

Newtonian fluids don’t resist stress in the way solids do. If you hit water with a hammer, the liquid will not resist this stress much. Nor will it show signs of strain.

Non-Newtonian fluids change their viscosity under stress. If you apply a force to non-Newtonian fluids (for example, you hit, shake or jump on them), the sudden application of stress can cause them to become thicker and act like a solid. Sometimes this stress results in the opposite behaviour and the non-Newtonian fluids become runnier. In both cases, remove the stress (let the fluid sit still or only move them slowly) and they will return to their earlier state.

For context, often nothing comes out if you turn a tomato sauce bottle upside down. If you then shake or hit the bottle (apply stress), this causes the tomato sauce to become more liquid, so it flows out of the bottle.

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Available from [rsc.li/3zcwplY](https://www.rsc.li/3zcwplY)

Oobleck is a mixture of cornflour and water named after a substance in a Dr Seuss book. This liquid is a runny goo until you apply stress to it and then it suddenly acts like a solid. You can hit a bowl full of oobleck with a hammer, and instead of splashing everywhere, the particles lock together. You can roll oobleck into a solid ball in your hand, but when you stop moving it the oobleck reverts to its liquid state and oozes out through your fingers. In this case, the oobleck's viscosity increases with applied stress.

The table summarises four types of behaviours shown by non-Newtonian fluids with examples of fluids which demonstrate these behaviours.

Type of behaviour	Description	Example
Dilatant or shear thickening	Viscosity increases with increased stress	Oobleck
Shear thinning	Viscosity decreases with increased stress	Tomato sauce
Rheopectic	Viscosity increases with stress over time	Cream – the longer you whip it the thicker it gets
Thixotropic	Viscosity decreases with stress over time	Honey – keep stirring, and solid honey becomes liquid

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Available from rsc.li/3zcwplY

Activity 1: custard slime

In this activity, learners will work in pairs to make custard slime by mixing water and custard powder. If time and resources are available, the learners could complete this activity individually.

Slide 8 of the PowerPoint can be used to introduce the activity. The instructions are also provided in the student workbook.

Once your learners have made their slime, ask them to write their answers to the questions in the workbook (also shown on **slide 9**).

Ask learners to share their answers with another pair. Bring the whole class together to discuss their observations using the answers shown on **slide 10** of the PowerPoint.

Explain the idea of the viscosity (fluidity) being related to the amount of stress the slime is under.

Answers

- (a) When custard slime is stirred, a force is being applied by the spoon/rod and it behaves as a non-Newtonian fluid.
- (b) When stirring stops there is no longer a force on the custard slime, so it acts like a Newtonian fluid.

Activity 2: custard bomb demonstration

Watch the video on **slide 12** of the PowerPoint, also available from bit.ly/3jwL2Ez, showing the custard bomb. Tell your learners that you will be doing a similar demonstration.

However, if you are unable to do the demonstration in class, the video can be used to enable learners to answer the questions.

There are different ways to complete this demonstration. If you have not done this demonstration before, the video and guidance available at rsc.li/3PI1hQD will be helpful as teacher guidance is provided for each stage, including the safety considerations and how you can set up the equipment to achieve the best results.

To maintain interest and attention during the demonstration, you might like to ask the learners to rate the explosion in terms of loudness, size of flame and how far the lid goes.

Equipment

- 500–750 g catering tin (coffee tin or similar) with a soft resealable lid
 - A few grams of custard powder (icing sugar/corn flour/lycopodium powder could also be used as alternatives, but the powder must be completely dry)
 - Sieve
 - Tea light
 - Tubing
 - Bulb pipette filler
1. The coffee tin should have a hole in the side. A tube is fed through this hole into the tin and a bulb pipette filler is placed on the end of the tube. This allows air to be blown into the tin to puff the powder into the air above the lit tea light.
 2. Add a pile of the powder into the can separated away from the tea light. The position of the powder pile can be changed, so you may want to test different arrangements to see which works best for you. CLEAPSS recommends using a small funnel loaded with powder or running the tube to the opposite side of the tin so that the powder is puffed up and back towards the flame, as this creates a larger explosion (but is not as reliable).
 3. Light the candle and firmly close the lid. Immediately squeeze the pipette bulb to puff up the powder into the air above the candle. (Be careful not to blow the lid off with the air pressure.)

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4. If all works as it should, the powder should rapidly combust, causing a large flash and blowing the lid off the tin.

Safety

- This demonstration must always be practised in advance.
- This demonstration is only suitable for adults, so should never be conducted by learners.
- CLEAPSS members should consult SRA002, available from bit.ly/3JCmiVU. The quantities and method used should be as outlined above and not deviated from.
- Safety screens should be used to protect the demonstrator and audience. The safety screens should be positioned close to the can so that the lid is only able to escape vertically.
- Eye protection must be worn by the demonstrator, and learners must be at least 2–3 metres away.

Disposal

- As there is an inhalation risk associated with the powders that can be used in this demonstration, care must be taken to avoid disturbing any unreacted dust when disposing of the remains after the demonstration.

Give your learners the opportunity to discuss the questions from **slide 13** of the PowerPoint in pairs. (These questions are also included in the student workbook.)

- (a) Did the bomb work? If not, why not?
- (b) What could you change to improve the custard bomb?
- (c) Was the design in the video reliable? Can we always trust what we see?

Tell the learners to write their answers in their student workbooks.

After five minutes, discuss your learners' answers as a class and, if time allows and it is safe to do so, practically test a few of the learners' ideas to see if they do improve the experiment.

If time is available, learners could explore the properties of non-Newtonian fluids further in the 'What is the best way to escape from quicksand?' activity available in the Quicksand student workbook, available from rsc.li/3PhT8f2.

Implications of non-Newtonian fluids

Show learners the two questions on **slide 14** of the PowerPoint and give them two minutes to discuss their ideas in pairs. Bring their ideas together in a whole-class discussion using the answers in the slide's notes.

Career link

Consumer products technician

Link the properties and uses of non-Newtonian fluids to the career profile of a consumer products technician, available from rsc.li/3HR7C31 and **slide 15**. Watch the video of Robert, a consumer products technician, who uses his understanding of materials, such as non-Newtonian fluids, to develop desirable properties for consumer products, including cosmetics, adhesives and cleaning products.