Slippery Sled Activity – Teacher Notes

Aim

This hands-on slippery sled activity aims to get Key Stage 1 through 4 students buzzing as they plan, build, and run their own experiments exploring how objects move across different surfaces. By getting stuck in, they'll directly see how friction from various materials affects movement. This investigation isn't just about sliding; it's a fantastic way for them to boost their teamwork and communication skills – key ingredients for any budding engineer! Plus, they'll get to grips with why choosing the right surfaces and even using lubricants matters when dealing with friction. Ultimately, the goal is to really understand how friction works and its impact on movement in the real world.

Relevance to National Curriculum

This slippery sled investigation offers a dynamic and practical route to reinforce core concepts within the Key Stages 1-4 science curricula, particularly around forces, motion, and materials. Beyond science, it naturally fosters mathematical skills through measurement and data analysis, and develops crucial practical skills in experimental design and execution. By providing a tangible experience of scientific principles in action, this activity helps solidify understanding in a way that's both engaging and memorable for students across different age groups.

Learning Outcomes

Key Stage 1-2 students will be able to:

- Identify different surfaces and describe how easily objects move across them.
- Suggest ways to make the sled move slower by increasing friction.
- Work with their group to build a sled designed to stay on a slope.
- Share their observations about which sled designs were most effective at resisting sliding.

Key Stage 3-4 students will be able to:

- Define friction as a force opposing motion and explain how different surfaces affect its magnitude.
- Measure the force needed to start the sled moving and use this to estimate the coefficient of static friction.
- Predict and measure the angle at which their sled begins to slide on a ramp.
- Analyse their results and discuss how design choices impacted the frictional forces acting on their sled.

Additional Observations

- Surfaces are complex and sliding occurs between the points that are in contact.
- Understand the difference between apparent and real contact area.
- Friction force is proportional to applied load.
- Fewer points in contact (smaller real contact area) results in less friction.

Warm-up activity

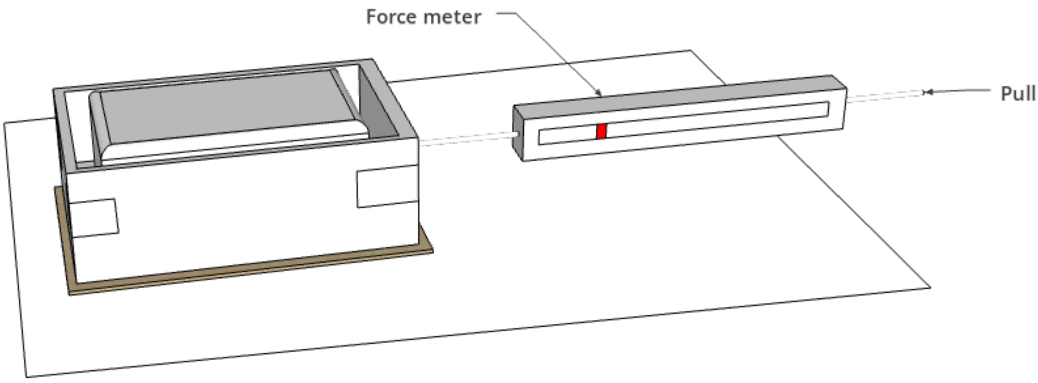
Can you think of other situations where a thin water layer reduces friction?

- **Sledding on slightly wet snow:** As we mentioned in the "Fun Friction Fact," a little bit of melting creates that slippery layer. If the snow is too dry or powdery, there isn't that water layer, and the sled doesn't go as fast.
- **Ice skating:** The blades of ice skates exert pressure on the ice, causing a very thin layer of water to melt. This water acts as a lubricant, allowing the skates to glide smoothly across the ice.
- **Hydroplaning tyres (Formula 1 examples):** When a car drives through a significant amount of water on the road, the tires can lose contact with the road surface and instead ride on a thin layer of water. This drastically reduces friction, making it hard to steer or brake.
- **Surfing or bodyboarding:** A thin layer of water between the surfboard/bodyboard and the wave allows for a smoother and faster ride.
- **Lubricating a squeaky door hinge (temporary fix):** If you spray a bit of water on a squeaky hinge, it might temporarily reduce the friction and stop the squeak until the water evaporates.
- **Wet sanding:** When sanding wood or metal, water is often used to carry away debris and to act as a lubricant between the sandpaper and the material, reducing friction and heat buildup.
- **Some water slides:** The constant flow of water down a water slide creates a slippery surface, minimising friction and allowing people to slide down quickly.
- **Washing your hands:** The water between your hands when washing can greatly reduce friction and heat. You can try this by rubbing your hands together with and without water to see how hot they get.

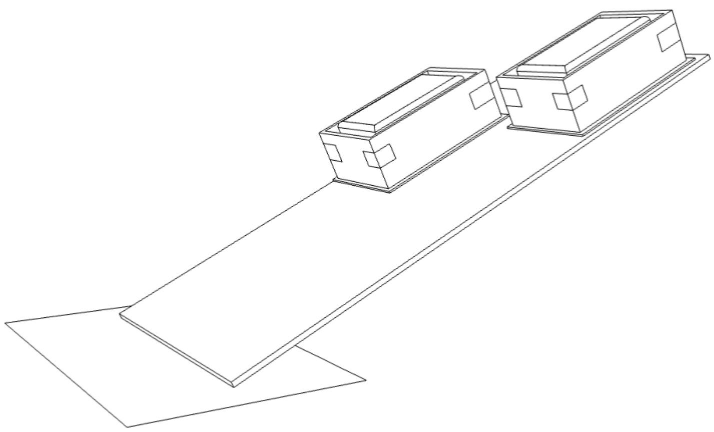
Activity Overview

The students will create a sled to understand the relationships between surfaces and force on friction. Try to make different groups use different materials.

In the first part the student will pull the sled across a flat surface and measure the friction force (pull force).



In the second part of the activity the students will use the ramp to find the height at which sliding occurs. Once the students have had time to iterate their designs, they will compete as groups to see whose sled can stick to the ramp the longest.



Materials

Items	Link / Alternatives	Use	Notes
Cereal box	A4 Card sheets, Tupperware box	To build the sled	Can test sled without attaching a surface
Sooth wooden MDF craft board	Amazon link, Old whiteboard	The ramp	Should be as smooth as possible (not plywood etc.)
Sandpaper		A surface to attach and test	
Paper		A surface to attach and test	
Bubble wrap		A surface to attach and test	May be difficult to attach to the sled
Velcro strip	Amazon link	A surface to attach and test	
Icing sugar	Candle wax (rub on), soap (rub on), white crayon (rub on)	Used as a solid lubricant in the test	Could use liquid but may become messy
Masking tape	Electrical tape, Sellotape		
Tape measure	Long ruler, string	To measure ramp height	Test sleds against each other if you don't have one
1kg bag of rice	Local supermarket	To put in the sled	

Force meter	Amazon Link	To measure pull force	Rubber band can be used and measured

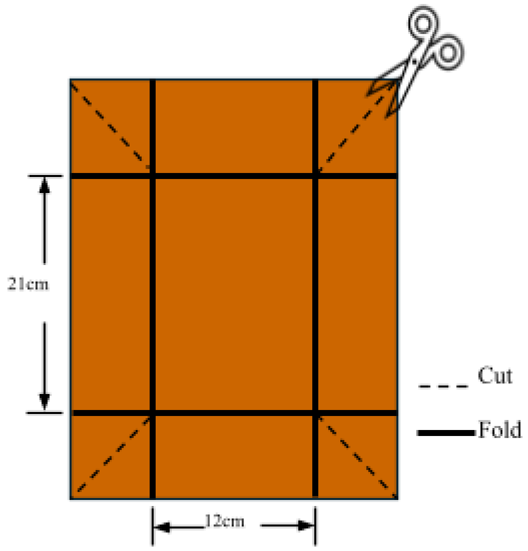
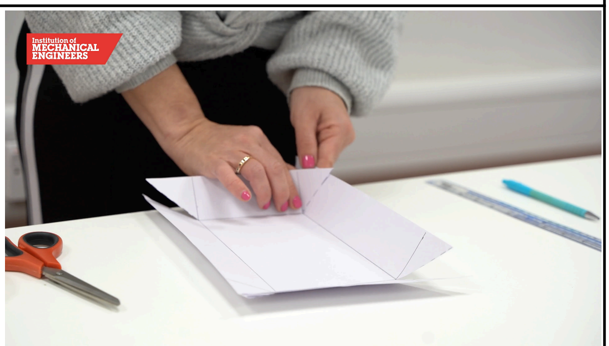
Main activity instructions

This section is to provide practical instructions on how to carry out the activity. It should be used as guidance to aid the student.

1 Building your sled

The class is to be split into groups, and each group is going to design and build their own sled using the readily available materials.

Provided in the following are general instructions to aid the students to build their sled:

Step 1 – Cut out an A4 piece of card. Then, draw the cut lines (dashed) and fold lines (bold) for the sled using a ruler.	
Step 2 – Cut the dashed lines first and then fold the bold lines.	

Step 3 – Lap the corners together and tape the sides forming a tray shape. Ensure the sled can fit the bag of rice inside.	

2 Adding your surfaces

Now that the sled structures are built, the next task is to add the surfaces to the bottom of the sled. It is up to the group to decide which material(s) to use and how they form the shape of the surface. For example, they may be creative and add strips or corrugate the surfaces.

A general guide to adding the surfaces is shown in the following:

Step 4– Cut and stick your surface(s) to the bottom of your sled using tape or glue.	

3 Adding the load and weighing the sled

We now need to determine the weight of the sleds. This enables us to ensure a fair test and determine the normal force in the deeper learning activity. Firstly, add the load. For this, you can use a 1 kg bag of rice. The weight can either be measured by hanging from a force meter or using a weighing scale. Once the weight has been measured, record the results in the tables provided.

Step 5 – Place the bag of rice into the sled and weigh it. If you can't way it, assume the weight is equal to the **1 kg** bag of rice.

4 Pull force test

Your sled is almost ready to be tested on the slope. However, it is always good practice to test your design before the real scenario. You can use a force meter to see how hard it is to pull; this will give you an indication of whether it will slide easily or remain on the slope for the longest. It will also help you to see if the design is robust. Using the force meter, pull you sled on a suitable surface and record the force.

Step 6 – Lay the ramp flat on the table and place the sled on the ramp. Attach a piece of string to the sled or pierce the hook through the sled and pull with the force meter. Record the surface(s) used and pull force in the tables.

5 Ramp test without lubrication

Now that you have performed the pull test on your sleds, it is now time to test them on the slope. This can be done in two ways. You can test different sleds against each other on the ramp, gradually increasing the angle of the slope, until the last one standing wins. Or you can place individual sleds on the ramp and measure the height at which the sled slides.

Step 7 – Place your sled(s) on the top of the ramp and gently tilt. Make note of the surfaces used on each sled and the height or order at which they slide.

6 Recording the data

Step 8 – Record all the data in the tables.

7 **Ramp test with lubrication (Icing sugar)**

Its now time to see how the sleds hold up a ramp covered in icing sugar (snow). Repeat the test including the pull force test to see the impact on friction. Again, record all the data in the tables.

Step 9 – Apply icing sugar to the ramp and repeat the test.	

Once you've completed the activities, asses your results and make conclusions as to which surface(s) create the most, or least friction. Try to think about which ones are rough and hard, and which ones are smooth. Also, think about how much area is in contact with the ramp. See if there is a relationship between these factors and the amount of friction. Then, complete the quiz.

Some expected results and guidance on answers is given in the following. Remember, your results may differ because friction depends on many factors and is extremely difficult to control.

Expected results

Table 1: Results of the pull test

Group No.	Surface(s) used	Pull force (N)	Mass (g)
1	Card + Wood ramp (MDF)	5.2	1065
2			
3			
4			
5			

Table 2: Results of the unlubricated ramp test

Group No.	Surface(s) used	Order of sliding height (1-5) / measured height (cm)
1	Card + Wood ramp (MDF)	2 / 33
2	Velcro + Wood ramp (MDF)	1 / 30
3	Sand paper + Wood ramp (MDF)	3 / 40
4		
5		

Table 3

Results of the lubricated ramp test

Group No.	Surface(s) used	Order of sliding height (1-5) / measured height (cm)
1	Card + Wood ramp (MDF)	(2)
2	Velcro + Wood ramp (MDF)	(1)
3	Sand paper + Wood ramp (MDF)	(3)
4		
5		

Stretch activity

Table 4: Results of the unlubricated ramp test

Group No.	Surface(s) used	Static friction coefficient, μ_s	Calculated angle (rad)	Measured angle (rad)
1	Card + Wood ramp (MDF)	Middle	0.5 measured static CoF = **0.45** (26deg)	**0.58** (33deg)
2	Velcro + Wood ramp (MDF)	Lowest	0.6 measured static CoF = **0.54** (31deg)	**0.52** (30deg)
3	Sand paper + Wood ramp (MDF)	Highest	0.9 measured static CoF = **0.73** (42deg)	**0.73** (42deg)
4				
5				

Table 5: Results of the lubricated ramp test

Group No.	Surface(s) used	Static friction coefficient, μ_s	Calculated angle (rad)	Measured angle (rad)
1	Card + Wood ramp (MDF)	Middle		
2	Velcro + Wood ramp (MDF)	Lowest		
3	Sand paper + Wood ramp (MDF)	Highest		
4				
5				

Quiz Answers

Proof of concept quiz

What is friction?

- Friction is the resistance that one surface, or object, encounters when moving over another

Name the forces acting on the sled.

- Friction force and normal force (weight also ok)

What materials prevent the sled from sliding easier?

- Sandpaper and paper

Does icing sugar reduce friction?

- **Should be yes.**

Why does tilting the ramp cause the sled to slide?

- Tilting the ramp makes the sled slide because gravity pulls it more down the ramp rather than straight into the surface. Friction cannot hold the sled on the ramp.

Deeper learning quiz

Why is determining the coefficient of friction useful in engineering?

- It helps engineers predict how surfaces will interact, design safer and more efficient machines, and reduce wear and energy loss.

What condition needs to occur before the sled begins to slide?

- The component of gravity pulling the sled down the ramp must become larger than the **static** frictional force holding it in place.

How could you improve the accuracy of the experiment?

Examples:
- Measure the angle more precisely.
- Repeat the experiment several times.
- Use a consistent sled design.
- Control the environment. (humidity, ambient temperature, cleanliness/dust etc.)

What variables are difficult to control in the experiment?

Examples:
- Surface roughness.
- Distribution of icing sugar.
- Weight distribution.
- Environmental factors.

Can you think of reasons why the calculated angle may differ from the measured angle?

Examples:
- Measurement inaccuracies and errors.
- Simplified model.

Do your results support the hypothesis that '*applying icing sugar to a contact surface reduces the coefficient of friction'*. Justify your answer with an explanation of the underlying mechanism.

- Yes, the results support the hypothesis because the coefficient of friction decreased when icing sugar was applied. Icing sugar acts as a dry lubricant: its fine particles form a thin layer between the surfaces, reducing direct contact and adhesion, so the surfaces slide more easily.