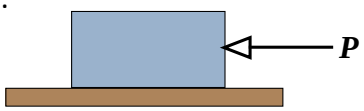
In this practical activity you will investigate friction. You will consider what factors affect friction and how friction can be increased and decreased.

Consider a block at rest on a horizontal table. If a force P is applied horizontally to the block, what will happen to the block?

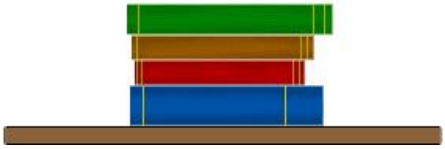


Think about …

Will the block slide across the table?
Why might the block remain at rest?
Why might the block slide?

Try these

1 Make a list of the factors you think will influence a friction force. Investigate your ideas – you could try using several books.



2a Sketch a graph showing how you think the friction force, F, varies with an increasing pulling force, P.

b How do you think the general shape of your graph will change if the mass of the book is increased?

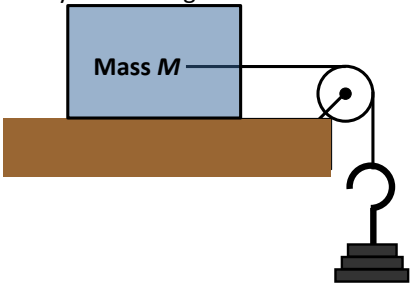
Pull horizontally

3 The maximum friction force, F_{MAX}, which can be reached between two surfaces in contact is known as **limiting friction.** As friction is a contact force, we might ask how it is related to the normal contact force.

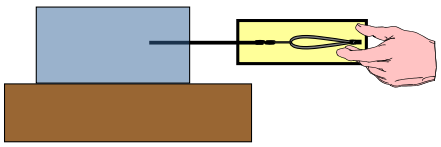
Carry out an experiment to investigate how the maximum friction force, F_{MAX}, varies with the normal contact force, N.

You will need:
book(s)
wooden block(s)
masses and mass hanger,
pulley and clamp (or an elastoscale).

This type of practical apparatus may help your investigation



… or you could use an elastoscale …



a Draw a diagram of your experimental apparatus.

Think about …

What forces are acting on the block?

b Add small masses to the mass hanger until the block just starts to move, or use the elastoscale to measure the force required to make the block start to move.
You can vary the normal contact force, N, by using blocks of different mass, or you could add masses to the block.
Keep a record of the force required to make the block start to slide.

Be consistent
Make sure the block is in the same position each time so that it experiences the same roughness.
Gently tap the surface to see if the block will start to move.
Whether you are using a pulley or an elastoscale, make sure the force is applied to the block horizontally.

c Just as the block starts to slide, the limiting friction F_{MAX} is equal to the force causing the block to slide.
Plot a graph showing how F_{MAX} varies with normal contact force, N.
What does the shape of your graph tell you about the relationship between N and F_{MAX}?

Think about:

How could you increase the friction force between a car's tyres and the road?

The coefficient of friction, μ, is constant for a given pair of surfaces in contact. In any situation in which friction is an important feature you will need to find a value for μ experimentally.

What feature of the graph would you use to estimate the value of μ for the surfaces in your experiment?

Extension

Carry out experiments to find estimates for the value of μ for different combinations of surfaces.

You will need
Several blocks made of different materials and several different horizontal surfaces. It would be useful to use blocks that have the same mass, perhaps 1 kilogram.

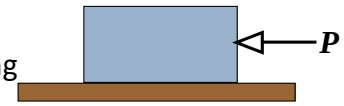
Information sheet Modelling friction forces

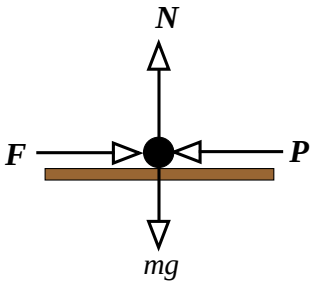
Mathematicians use the model $F \leq \mu N$

where F is the friction force acting between two surfaces in contact, μ is a constant due to the nature of the two surfaces, and N is the normal contact force.

The constant μ is called the coefficient of friction.

Consider a block at rest on a horizontal table. A force *P* is applied horizontally to the block in such a way as to attempt to slide the block along the table. The force P is gradually increased until sliding just occurs. This situation and a full force diagram relating to it are shown on the right.

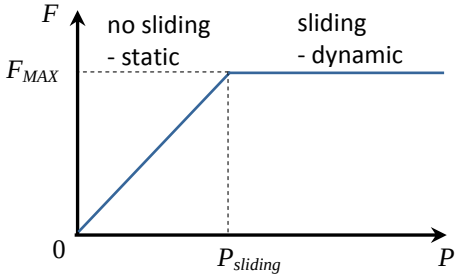




- **The frictional force, F, acts along the two surfaces in contact.**
- **When a force acts to move two surfaces in contact, the frictional force acts in a direction to oppose the motion.**
- **Before sliding takes place, the friction force increases and is equal in magnitude to the force, P, which is trying to cause sliding between the surfaces. This maintains the body in equilibrium.**
- **There is a maximum friction force, F_{MAX}, which can be achieved between two surfaces in contact.**
- **Just as sliding takes place, the friction force reaches its maximum value, F_{MAX}, so $P_{sliding} = F_{MAX}$**
- **When sliding is taking place $P \geq F_{MAX}$**

A graph of F against P is shown.

When the bodies in contact are not moving, the friction force F satisfies $F \leq F_{MAX}$; in this case $F \leq \mu N$.
When the bodies are moving, $F = \mu N$.



Reflect on your work

Think about how friction is used in everyday life. For example, could you walk if there were no friction force? Would your shoelaces stay tied up? Could you carry something on a tray if there were no friction?

Suggest how friction could be increased or decreased in any of the examples.

If you had graphs of F_{MAX} plotted against N for different pairs of materials in contact, how could you tell which combination of materials had the highest coefficient of friction?