Boxes on a Trolley

Apparatus

three identical boxes filled to have different masses and sealed up, large trolley which will hold all three boxes in a row across the trolley with a regular surface

Action

The students examine the boxes to see which is heaviest and which is lightest. They then predict which will fall off the back of a trolley when it is accelerated. They should consider which direction the trolley accelerates, and predict which way the boxes will fall off. They then place the three boxes on the trolley and accelerate it to check their predictions. They should repeat the experiment a few times, changing the box positions, as small differences in surfaces will make one box or another fall off first.

The Physics

The boxes will all fall off together. Assuming the mass of the boxes is not so great as to squash the surface of the box or trolley, the acceleration due to friction will not depend on the mass of the box. The maximum possible acceleration due to friction (which is the net force holding the boxes to the trolley and hence accelerating it) is the maximum acceleration is $a_{max} = \mu N / m = \mu mg / m = \mu g$. The acceleration does not depend on mass, only on μ, which should be the same for all boxes. Note that the net force acting is in the direction of movement, which is forwards, and this is the frictional force. Many students have difficulty with the idea that friction is causing the motion of the box.

Note that it may be easier to decelerate the trolley by stopping it suddenly with a foot rather than pulling on it. In this case the boxes slide the other way.

A student at the University of Sydney pulling the trolley with boxes.

Accompanying sheet

Boxes on a Trolley

Examine the three boxes.
Which will fall off the trolley first when you accelerate it? Why?

Place the boxes in a row across the back of the trolley.
What happens when you accelerate it?
What force is accelerating the boxes? In what direction is this force acting?

Which box falls off first?