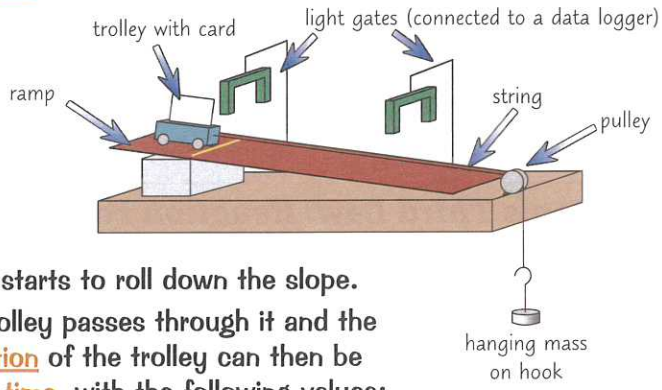
Investigating Motion

Doing an experiment for yourself can really help you to understand what's going on with $F = ma$ (p.149).

You can Investigate the Motion of a Trolley on a Ramp

PRACTICAL

1) Measure the mass of the trolley, the unit masses and the hanging hook. Measure the length of the piece of card which will interrupt the light gate beams. Then set up your apparatus as shown in the diagram below, but don't attach the string to the trolley.
2) Adjust the height of the ramp until the trolley just starts to move.
3) Mark a line on the ramp just before the first light gate — this is to make sure the trolley travels the same distance every time. The light gate will record the initial speed of the trolley as it begins to move.
4) Attach the trolley to the hanging mass by the string. Hold the trolley still at the start line, and then let go of it so that it starts to roll down the slope.
5) Each light gate will record the time when the trolley passes through it and the speed of the trolley at that time. The acceleration of the trolley can then be found using acceleration = change in speed ÷ time, with the following values:
   - the initial speed of the trolley as it passes through the first light gate (it'll be roughly 0 m/s),
   - the final speed of the trolley, which equals the speed of the trolley through the second light gate,
   - the time it takes the trolley to travel between the two light gates.



By changing the height of the ramp so that the trolley just begins to move, it means that any other forces that are applied (like the force due to gravity caused by the hanging mass) will be the main cause of the trolley accelerating as it travels down the ramp (page 149). The size of this acceleration depends on the mass of the trolley and the size of the accelerating force.

- To investigate the effect of the trolley's mass: add masses one at a time to the trolley. Keep the mass on the hook constant (so the accelerating force is constant — where the force is equal to the mass on hook × acceleration due to gravity). Repeat steps 2-5 of the experiment above each time.
- To investigate the effect of the accelerating force: start with all the masses loaded onto the trolley and transfer the masses to the hook one at a time. Again, repeat steps 2-5 each time you move a mass.

  You transfer the masses because you need to keep the mass of the whole system (the mass of the trolley + the mass on the hook) the same. This is because the accelerating force causes BOTH the trolley and the hanging masses to accelerate.

You should find that as the accelerating force increases, the acceleration increases (for a given trolley mass). So force and acceleration are proportional. As the mass of the trolley increases its acceleration decreases (for a given force) — mass and acceleration are inversely proportional.

You can use Different Equipment to Measure Distance and Time

Light gates (p.210) are often the best option for short time intervals. They get rid of the human error caused by reaction times (p.155). But light gates aren't the only way to find the speed of an object:

1) For finding something like a person's walking speed, the distances and times you'll look at are quite large. You can use a rolling tape measure (one of those clicky wheel things) and markers to measure and mark out distances. And for any times longer than five seconds, you can use a regular stopwatch.
2) If you're feeling a bit high-tech, you could also record a video of the moving object and look at how far it travels each frame. If you know how many frames per second the camera records, you can find the distance travelled by the object in a given number of frames and the time that it takes to do so.

My acceleration increases with nearby cake...

Make sure you know multiple methods for measuring the speed (distance travelled in a time) of an object.

Q1 Why is it better to use a light gate instead of a stopwatch to measure short time intervals? [1 mark]

PRACTICAL

Investigating Motion

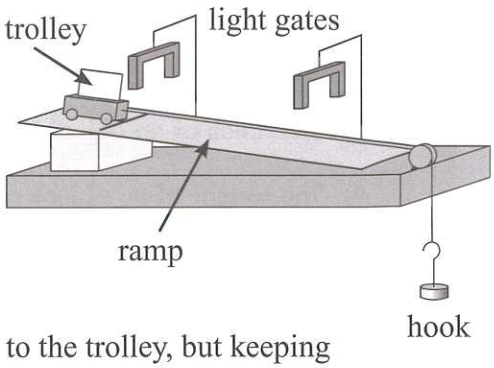
1 A student uses the apparatus in **Figure 1** to investigate the effect of changing the mass of a trolley on its acceleration. The trolley is on a ramp to compensate for friction.

Grade 6-7

The student records the mass of the trolley and the weight of the hook. The hook has a weight of 1.5 N.

When the hook is allowed to fall, the trolley accelerates. The student then records the time it takes the trolley to travel between the two light gates and the speed of the trolley as it passes through each light gate.

Figure 1



The student repeats this process, each time adding a mass to the trolley, but keeping the hook the same. Every time she adds a mass to the trolley, she changes the height of the ramp so that friction between the ramp and the trolley can be ignored.

a) Give **one** benefit of using light gates to take measurements.

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[1]

b) Describe how the student uses her measurements to determine the acceleration of the trolley.

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[1]

c) i) Calculate the acceleration of the trolley when the total mass of the system is 3 kg.

Acceleration = ... m/s^2

[3]

ii) Predict how the acceleration of the trolley will change as the mass of the trolley is increased.

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[1]

d) The student wants to calculate the uncertainty of one of her mean results. Describe how she can do this.

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[2]

[Total 8 marks]