# Physics PAG P3: Motion

# Combined Science PAG P3: Motion

# Suggested Activity 1: Investigating acceleration of a trolley down a ramp

## Instructions and answers for teachers & technicians

These instructions cover the learner activity section which can be found on [page 8](#_Student_Activity). This Practical activity supports OCR GCSE Physics.

**When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.**

|  |
| --- |
| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/) and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

**OCR recommendations:**

**Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

In this experiment pupils will be investigating how to measure the acceleration of a trolley down a ramp and the effect of changing force on the acceleration.

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Physics**](http://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Physics**](http://www.ocr.org.uk/Images/323482-gcse-physics-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

**1a***[1]***:** Use of appropriate apparatus to make and record a range of measurements accurately, including: **i**[*i*]) length; **iv**[*iv*]) time

**3** *[15]*) Use of appropriate apparatus and techniques for measuring motion, including determination of: i) speed; ii) rate of change of speed (acceleration/deceleration)

### Aims

To use appropriate apparatus to measure speed, acceleration, force and mass.

To calculate acceleration using a = (v-u)/t

To plot a graph of force against acceleration to determine the relationship between these terms.

### Intended class time

50-60 minutes

### Links to Specifications:

### Gateway Science (Suite A) including Working Scientifically (WS)

PM2.1ii recall and apply:

**acceleration (m/s2) = change in velocity (m/s) / time (s)**

P2.1h apply formulae relating distance, time and speed, for uniform motion, and for motion with uniform acceleration

PM2.2i recall and apply:

**force (N) = mass (kg) x acceleration (m/s2)**

WS1.2e Evaluate methods and suggest possible improvements and further investigations

WS1.3a Presenting observations and other data using appropriate methods

WS1.3b Translating data from one form to another

WS1.3e Interpreting observations and other data

WS1.4a Use scientific vocabulary, terminology and definitions

WS1.4b Recognise the importance of scientific quantities and understand how they are determined

WS1.4c Use SI units and IUPAC chemical nomenclature unless inappropriate

WS2a Carry out experiments

WS2c Presenting observations using appropriate methods

### Twenty First Century Science (Suite B) including Ideas about Science (IaS)

P4.2.6a recall and apply the relationship:

**acceleration (m/s2) = change in speed (m/s) ÷ time taken (s)**

P4.2.6b explain how to use appropriate apparatus and techniques to investigate acceleration

P4.3.12 Recall and apply Newton’s second law relating force, mass and acceleration:

**Force (N) = mass (kg) x acceleration (m/s2)**

IaS1.2 Suggest appropriate apparatus, materials and techniques, justifying choice with reference to the precision, accuracy and validity of the data that will be collected

IaS1.4 Identify factors that need to be controlled, and the ways in which they could be controlled

IaS2.1 Present observations and other data using appropriate formats

IaS2.2 When processing data use SI units where appropriate (e.g. kg, g, mg, km, m, mm, kJ, J)

IaS2.4 Be able to translate data from one form to another

IaS2.7 When displaying data graphically select an appropriate graphical form, use appropriate axes and scales, plot data points correctly, draw an appropriate line of best fit, and indicate uncertainty (e.g. range bars)

IaS2.11 In a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions

### Mathematical Skills covered

M3b Change the subject of an equation

M3c Substitute numerical values into algebraic equations using appropriate units for physical quantities

M3d Solve simple algebraic equations

M4a Translate information between graphical and numerical form

M4b Understand that y=mx+c represents a linear relationship

M4c Plot two variables from experimental or other data

### Health and Safety

This is a very safe experiment when performed sensibly; masses may be heavy so care must be taken to not drop them. Placing a buffer at the end of the ramp or something soft for the trolley to land in is suggested so not to damage equipment. Eye protection should be worn.

### Method 1: Using ruler and stopwatch to calculate average speed and then acceleration

Learners calculate the speed the trolley is travelling at the bottom of the ramp by timing how long it takes for the trolley to travel the last 30 cm and using speed = distance ÷ time. Learners then time how long it takes the trolley to travel the whole length of the ramp.

Using acceleration = change in speed ÷ time and an initial speed of 0 m/s2. Learners can calculate the acceleration of the trolley.

### Method 2: Using light gates and data loggers

Learners set up two light gates one near the top and one near the bottom of the ramp. Depending on the data logger that you have you can either get them to measure the speeds of the trolley at both points and get the learners to calculate the acceleration or you can get the data loggers to work out the acceleration between the two light gates.

### Method 3: The effect of force on acceleration

Learners use a pulley and slotted masses to change the amount of force that causes a trolley to accelerate along a flat surface. They use light gates to work out the acceleration of the trolley with varying forces and plot a graph of their results. Using their graphs learners find the relationship between force and acceleration.

### Notes

Learners should be able to compare the acceleration calculated via both methods. Encourage learners to consider where the inaccuracies in their measurements may be. This is an opportunity to look at the accuracy of the measuring equipment they are using. It is also good for pupils to consider how they could improve on their experimental technique.

### Technician Notes

### For this practical the teacher will require for a class of 30:

* 15x trolleys
* 15x ramps
* 15x wooden blocks to prop up the ramps
* 15x metre rulers
* 15x stop watches
* 15x data loggers
* 15x card for top of trolley
* 15x pulleys
* 15x mass hangers and slotted masses
* string
* 30x light gates
* 30x goggles
* 30x graph paper
* 30x 30cm ruler

### Answers for quiz questions

**1ai [3 marks]**

No ✓

F = ma ✓

Mass is inversely proportional to acceleration ✓

**1aii [4 marks]**

Trolley down a ramp with two light gates ✓

Change mass by adding masses ✓

Use light gate to measure acceleration / speed and calculate acceleration ✓

Plot graph to see relationship ✓

**1b [2 marks]**

Correct gradient calculation using change in y ÷ change in x ✓

Answer between 2 and 2.25 m/s2 ✓

**1c [3 marks]**

acceleration = change in velocity ÷ time ✓

= 27 m/s ÷ 9.6 s ✓

= 2.8 m/s2 (to 2sf) ✓

### Document updates

v1 Published on the qualification pages

v1.1 January 2017 Consolidated labelling and formatting of activities

v1.2 February 2017 Correction to Combined Science labelling

v1.3 June 2021 Updated to digital accessibility standards



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# Physics PAG P3: Motion

# Combined Science PAG P3: Motion

# Suggested Activity 1: Investigating acceleration of a trolley down a ramp

## Learner Activity

### Introduction

In this experiment you will be investigating how to measure the acceleration of a trolley down a ramp and the effect of changing force on the acceleration.

### Aims

To use appropriate apparatus to measure speed, acceleration, force and mass.

To calculate acceleration using a = (v-u)/t

To plot a graph of force against acceleration to determine the relationship between these terms.

### Intended class time

50-60 minutes

### Equipment (per group)

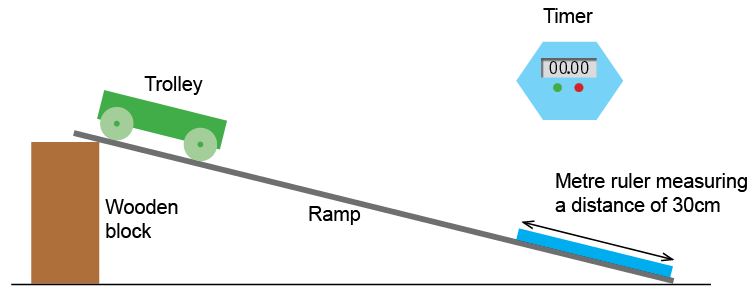
* trolley
* ramp
* wooden block to prop up the ramp
* metre ruler
* stop watch
* data logger
* card for top of trolley
* pulley
* mass hanger and slotted masses
* string
* 2x light gates
* goggles
* graph paper
* 30cm ruler

### Health and Safety

This is a very safe experiment when performed sensibly; masses may be heavy so care must be taken to not drop them. Placing a buffer at the end of the ramp or something soft for the trolley to land in is suggested so not to damage equipment. Eye protection should be worn.

### Method 1

1. Set up apparatus as shown below. Do not set the ramp at too steep an angle as it will make measuring time too difficult.

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1. Release (do not push) the trolley from the top of the ramp, start the timer and record the time taken for the trolley to move the whole distance of the ramp.
2. Repeat this 2 more times and calculate the mean. Record results in the table below.
3. Release (do not push) the trolley from the top of the ramp again but this time start the timer when the trolley reaches the marked last 30 cm of the ramp, record the time it takes for the trolley to travel the last 30 cm of the ramp.
4. Repeat this 2 more times and take an average. Record results in the table below.
5. Use your results to calculate the speed of the trolley when it was descending the last 30 cm of the ramp. Speed (m/s) = distance (m) ÷ time (s)
6. Use your result from above as the final speed and take the initial speed of the trolley as 0m/s. Calculate the acceleration of the trolley when descending the entire length of the ramp using acceleration (m/s2) = change in speed (m/s) ÷ time taken (s)

### Results

Times for trolley to descend ramp

|  |  |  |  |
| --- | --- | --- | --- |
| **Time 1 (s)** | **Time 2 (s)** | **Time 3 (s)** | **Mean time (s)** |
|  |  |  |  |

Time for trolley to descend last 30 cm of ramp

|  |  |  |  |
| --- | --- | --- | --- |
| **Time 1 (s)** | **Time 2 (s)** | **Time 3 (s)** | **Mean time (s)** |
|  |  |  |  |

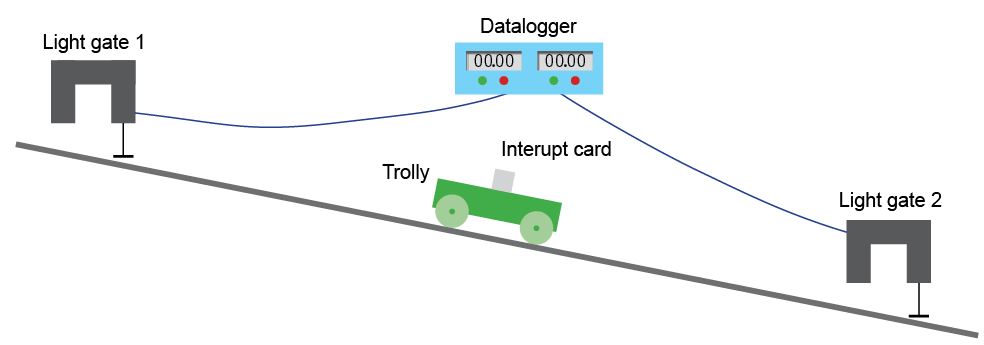
Speed of trolley while descend the last 30 cm of ramp

m/s

Acceleration of trolley

m/s2

### Method 2

1. Set up apparatus as shown below. Keep the angle of the slop the same as it was for the first experiment.
2. Set up the data logger so that the acceleration of the trolley between the two light gates is recorded. If this is not possible than set them up to record the speed at each point and calculate the acceleration using acceleration (m/s2) = change in speed (m/s) ÷ time (s)
3. Release (do not push) the trolley from the top of the ramp, record in the table below the acceleration of the trolley.
4. Repeat 2 more times and calculate the mean acceleration of the trolley.

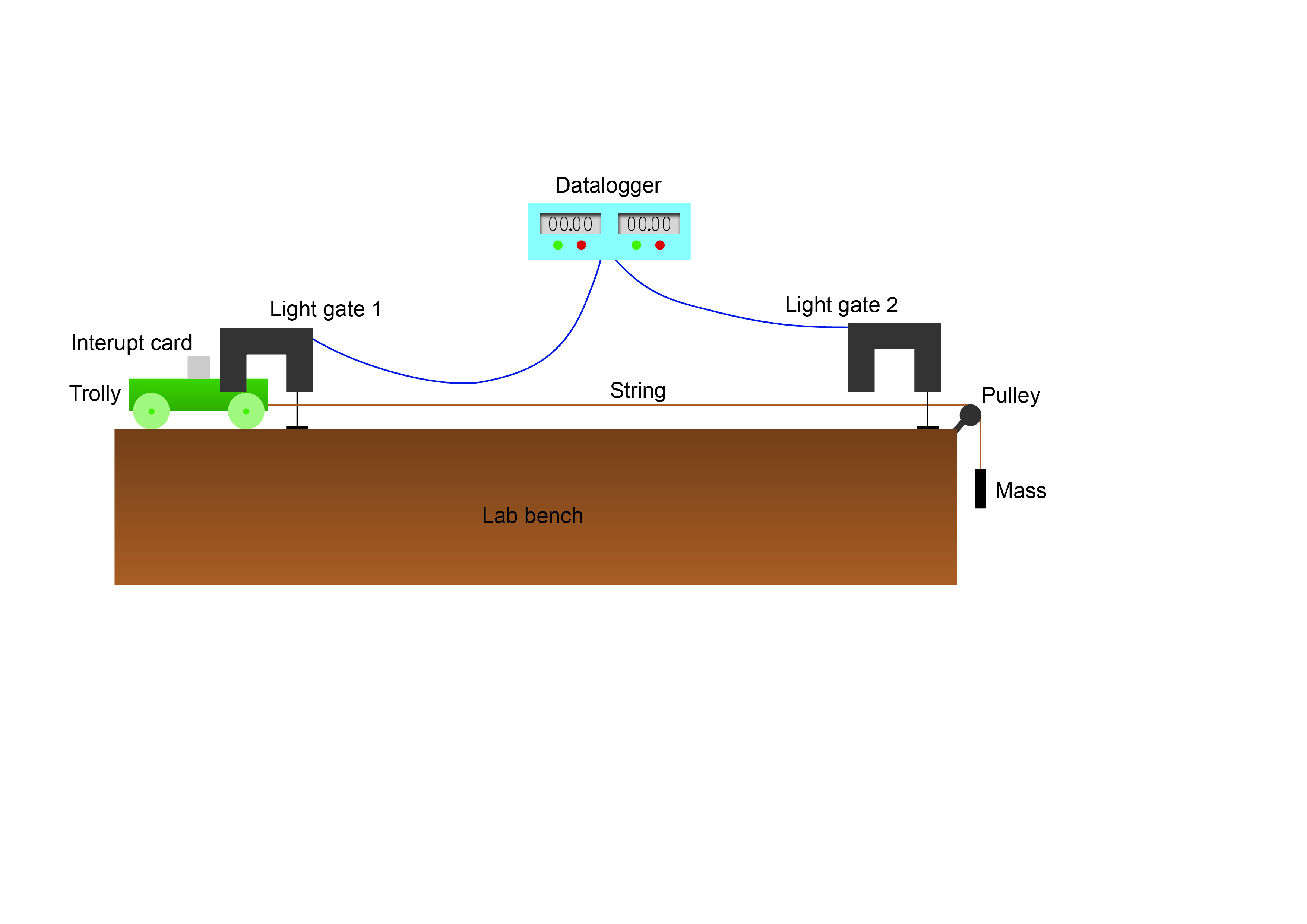
### Results

|  |  |  |  |
| --- | --- | --- | --- |
| **Acceleration 1 (m/s2)** | **Acceleration 2 (m/s2)** | **Acceleration 3 (m/s2)** | **Mean acceleration (m/s2)** |
|  |  |  |  |

### Evaluation

|  |  |  |
| --- | --- | --- |
|  | Compare and contrast the two different methods of measuring the acceleration. Where were the potential errors and inaccuracies? |  |
|  |  |  |
|  | Which method was more accurate and why? |  |
|  |  |  |

### Method 3 How does force effect acceleration?

1. Set up apparatus as shown below, choose a length of string so that the mass does not touch the ground.
2. Set up the data logger so that the acceleration of the trolley between the two light gates is recorded. If this is not possible than set them up to record the speed at each point and calculate the acceleration using acceleration (m/s2) = change in speed (m/s) ÷ time (s)
3. Start with a force of 1 N (100 g) and record the acceleration in the table below.
4. Increase the force by 1 N each time and record the accelerations in the table below.
5. Repeat this 2 more times and calculate means.
6. Plot a graph of force against acceleration

### Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Force (N)** | **Acceleration 1 (m/s2)** | **Acceleration 2 (m/s2)** | **Acceleration 3 (m/s2)** | **Mean acceleration (m/s2)** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

### Graph paperEvaluation

|  |  |  |
| --- | --- | --- |
|  | What does the graph show? |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
|  | What type of mathematical relationship does this graph suggest exists between force and acceleration? |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
|  | What law is this evidence for? |  |
|  |  |  |

### Quiz - test your knowledge and understanding

|  |  |  |
| --- | --- | --- |
| **1. (a) (i)** | Two students are measuring the acceleration of a trolley down a ramp. They predict that if they increase the mass of the trolley the acceleration will also increase. Are they correct? Write down why. **[3 marks]** |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **(a) (ii)** | What experiment could the students do to test this? Include any measurements they need to make and the equipment used. **[4 marks]** |  |
|  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **(b)** | In a different experiment students recorded the velocity and time as the trolley descended the ramp. They got the following results and plotted a graph. | | | |  |
| Time(s) | Velocity (m/s) |
| 1 | 2.2 |
| 2 | 4.3 |
| 3 | 6.6 |
| 4 | 9 |
| 5 | 10.9 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Use the graph to work out the acceleration of the trolley. **[2 marks]** | | |  |
|  |  | | |  |
|  |  |  | m/s2 |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **(c)** | A car accelerates from rest to a final speed of 27 m/s in a time of 9.6 s. Work out the acceleration of the car. Give your answer to 2 s.f. **[3 marks]** | | |  |
|  |  | | |  |
|  |  |  | m/s2 |  |

### DfE Apparatus and Techniques covered

If you are using the OCR Practical Activity Learner Record Sheet ([**Physics**](http://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) you may be able to tick off the following skills:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Physics** | | | |  | ***Combined Science*** | | | |
| 1a-i | 1a-iv | 3-i | 3-ii |  | *1-i* | *1-iv* | *15-i* | *15-ii* |