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| **Test out Galileo's gravity experiment** |
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| Investigating velocity and acceleration down a slope |
| **Subject(s):** Design & Technology, Engineering**Approx time:** 50-80 minutes |  | **Key words / Topics:** * Acceleration
* Gravity
* Slope
* Velocity
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| **Stay safe** Whether you are a scientist researching a new medicine or an engineer solving climate change, safety always comes first. An adult must always be around and supervising when doing this activity. You are responsible for: • ensuring that any equipment used for this activity is in good working condition• behaving sensibly and following any safety instructions so as not to hurt or injure yourself or others  Please note that in the absence of any negligence or other breach of duty by us, this activity is carried out at your own risk. It is important to take extra care at the stages marked with this symbol: ⚠ |
| **Suggested Learning Outcomes**  |  |  |
| * To be able to record results of an experiment in a table
* To be able to produce a line graph
* To be able to explain how velocity changes with the angle of the slope
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| **Introduction** |  |  |
| In 1589, Galileo dropped two objects from the leaning tower of Pisa in Italy. He did this to show that the pull of gravity on an object is the same, irrespective of the weights of the objects. Galileo explained his ideas about motion and falling bodies in a book called ‘Two New Sciences’ which became the foundation-stone of physics and made an important contribution to engineering. One of the ideas in his book was to slow the motion to make the acceleration more obvious by rolling a ball down a ramp. This resource is a version of his experiment.This is one of a set of resources designed to allow learners to use Easter themes to develop their knowledge and skills in Mathematics, Science and Design & Technology. This resource involves measuring how the time that an egg takes to go down a slope varies with the angle of the slope. |
| **Purpose of this activity**In this activity learners will carry out an experiment (measuring the time that an egg takes to go down slopes of various angles), record the results in a table and presenting the results in a graph. This could be used as an engaging one-off main lesson activity to introduce handling data, the calculation of velocity and acceleration or the effect of gravity on objects. |
| **Activity** |  | **Teacher notes** |
| **Introduction (5-10 minutes)**Teacher to explain that learners are going to carry out an experiment to measure the speed at which an egg goes down a slope. Teacher to demonstrate the experimental set up as shown in the presentation**The experiment 35-50 minutes)**Learners will need to measure the distance between the two ends of the slope.1. The angle of the slope should be measured at the point of contact with the floor using a protractor.
2. Place the egg at the top of the slope.
3. Release the egg and measure the time it takes to roll down the slope. It is important that the egg is placed and released, with no force applied, as that would reduce the accuracy of the results.
4. Repeat the measurement two more times, and calculate the average speed
5. Change the angle and repeat the activity as many times as possible.

**Plenary (10-20 minutes)**Learners to present and compare their graphs. Learners to explain any observed differences. |  | This activity could be carried out in small teams, where individual team members are responsible for supporting the channel, measuring the angle, measuring the time, and recording the results.The channel could be plastic guttering or U-shaped electrical conduit. The egg should be either plastic or solid (i.e. boiled, if using a bird egg), to reduce the risk of breakage.The channel could be supported by being held at one end by a learner. If this is not sufficiently stable a table could be used, with the contact point along the channel changed to modify the angle.If protractors are not available and/or learners have knowledge of trigonometry, as an alternative to measuring the angle the height of the release point could be recorded. This then gives two sides of the triangle (opposite and hypotenuse), which means that the sine of the angle can be calculated.The mean average time in seconds = (Run A + Run B + Run C) / 3. The velocity = length of ramp (meters) / mean average time (seconds). |
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| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| * A series of channels at known angles could be set up in advance.
* Learners could be provided with a spreadsheet in which to enter the data, which would carry out the calculations for them.
 |  | * Learners could also calculate the average acceleration of the egg (= velocity / mean average time) and plot this against the angle of the slope.
* Learners could also calculate the potential and kinetic energy of the egg at different points.
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| A length of channel or gutteringA tape measureA protractorA stopwatchThe results tableA pen or pencilAn egg (plastic or boiled or solid)Weighing scales (for extension activity 2 only) |  |  Test out Galileo's gravity experiment presentationicon-pdf Test out Galileo's gravity experiment handout  |
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| **Additional websites** |  |  |
| * BBC bitesize revision resources describing motion, velocity, acceleration and distance <https://www.bbc.co.uk/bitesize/guides/zgtgw6f/revision/1>
* A slowed down video showing how a ball rolls down a ramp <https://www.youtube.com/watch?v=LQMQLcV0Mwg>
* A detailed technical explanation of how inclined planes influence the velocity of an object subject to gravitational acceleration <https://www.physicsclassroom.com/class/vectors/Lesson-3/Inclined-Planes>
* Similar experiments where the data is recorded using various arrangements of electronic sensors <http://www.pas.rochester.edu/~tdimino/phy141/lab01/Lab01B_InclinedPlane.pdf> and <https://spark.iop.org/investigating-motion-sloping-surface>
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| **Related activities (to build a full lesson)** |  |  |
| **Starters** (Options) * A slowed down video showing how a ball rolls down a ramp https://www.youtube.com/watch?v=LQMQLcV0Mwg
 | **Extension** (Options)* Learners could also calculate the average acceleration of the egg (= velocity / mean average time) and plot this against the angle of the slope.
* Learners could also calculate the potential and kinetic energy of the egg at different points.

 **Plenary*** Learners to present and compare their graphs. Learners to explain any observed differences.
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| **The Engineering Context** film |
| Understanding the movement of objects up and down slopes (or inclined planes) is needed for a wide range of engineering applications, ranging from screw jacks to the design of ramps to allow wheelchair access. This is also a consideration when design vehicle braking systems . |

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| **Curriculum links**  |
| **England: National Curriculum**Maths Key Stage 3Statistics* Construct and interpret appropriate tables, charts, and diagrams, including frequency tables, bar charts, pie charts, and pictograms for categorical data, and vertical line (or bar) charts for ungrouped and grouped numerical data

Ratio, proportion, and rates of change* Use compound units such as speed, unit pricing and density to solve problems

Science Key Stage 3Motion and forces - describing motion* speed and the quantitative relationship between average speed, distance, and time (speed = distance ÷ time)
 | **Northern Ireland Curriculum**Mathematics with Financial Capability Key Stage 3Developing pupils’ Knowledge, Understanding and SkillsKnowledge and understanding of handling data Science Key Stage 3Developing pupils’ Knowledge, Understanding and SkillsDevelop skills in scientific methods of enquiry to further scientific knowledge and understanding: planning for investigations,obtaining evidence, presenting and interpreting resultsForces and energyForces and energy transfer  |
| **Scotland: Curriculum for Excellence**ScienceForces, electricity, and waves* SCN4-07a
* SCN4-07b

MathsNumber, money, and measure* MNU3-10a
 | **Wales: National Curriculum** Science Key Stage 3Communication* 2. communicate logically by … charts, tables, bar charts, line graphs, … using a wide range of scientific vocabulary, terms, symbols, and conventions
* 3. work quantitatively, using appropriate mathematical conventions and using S.I. units appropriate to their work, e.g. kg, s, N, m, J, w.

How things work* 4. the forces in devices and their relationship to work done and power

Maths Key Stage 4Represent and communicate* select and construct appropriate charts, diagrams, and graphs with suitable scales

Using data skills - collect and record data, present and analyse data, interpret results* construct and interpret graphs and diagrams (including pie charts) to represent discrete or continuous data, with the learner choosing the most appropriate representation …
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| **Assessment opportunities** |
| * Formal assessment of the completed tables and graphs.
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