Unit Overview: Years 5 & 6

Summary of learning goals

Special Topic 3 *Modelling Motion: Developing Mathematics Concepts Through STEM Activity* is a practical, inquiry-based unit in which teachers challenge students to use simple equipment to predict, observe and represent motion. Students create a series of graphs to directly represent motion, time falling balls, and construct instruments to measure forces in one and then two dimensions. They then interpret these representations to develop concepts of force and motion.

Mathematics and science concepts addressed include: creating and interpreting graphs modelling motion; using mathematical models to make predictions; speed as distance travelled per unit time; acceleration and deceleration; and the effect of forces such as gravity and friction. Students also develop skills in measurement of distance, time, speed, and force, as well as an appreciation of the value of accuracy in measurement.

Students build transferable mathematical modelling skills so that, at the end of this unit, they should be able to model a variety of motions of personal interest in areas such as athletics, swimming, and other sports.

Australian Curriculum: Mathematics — Year 5

ACMMG108: Choose appropriate units of measurement for length, area, volume, capacity and mass.

ACMMG114: Describe translations, reflections and rotations of two-dimensional shapes. Identify line and rotational symmetries.

ACMNA291: Use efficient mental and written strategies and apply appropriate digital technologies to solve problems.

ACMSP118: Pose questions and collect categorical or numerical data by observation or survey.

ACMSP119: Construct displays, including column graphs, dot plots and tables, appropriate for data type, with and without the use of digital technologies.

ACMSP120: Describe and interpret different data sets in context.

Australian Curriculum: Mathematics — Year 6

ACMMG135: Connect decimal representations to the metric system.

- Recognising the equivalence of measurements such as 1.25 metres and 125 centimetres.

ACMNA123: Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems involving all four operations with whole numbers.

ACMNA131: Make connections between equivalent fractions, decimals and percentages.

- Connecting fractions, decimals and percentages as different representations of the same number, moving fluently between representations and choosing the appropriate one for the problem being solved.

ACMSP147: Interpret and compare a range of data displays, including side-by-side column graphs for two categorical variables.

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Australian Curriculum: Science — Years 5 & 6

ACSIS090: Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate.

- Constructing tables, graphs and other graphic organisers to show trends in data.
- Identifying patterns in data and developing explanations that fit these patterns.

ACSIS107: Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate.

ACSIS218: Compare data with predictions and use as evidence in developing explanations.

- Sharing ideas as to whether observations match predictions, and discussing possible reasons for predictions being incorrect

ACSIS221: Compare data with predictions and use as evidence in developing explanations.

Summary of lessons

Who is this unit for?

This version of the unit is suitable for all students in Years 5 and 6. Students need some prior knowledge of the measurement of time, at least to tenths of seconds, and distance in centimetres.

Lessons are sequential, with Lesson 1 critical in establishing an understanding of how the length of the 'streamers' in the graphs obtained relate to speed.

Ideally, students should complete all seven lessons. However, an alternative pathway is to complete Lessons 1 to 4, followed by Lesson 7, the final lesson in which students draw on and consolidate the knowledge obtained through their engagement with the previous lessons. Projects can be undertaken any time after Lesson 4.

Lesson 1: Constant Speed

The challenge in this lesson is for students to walk at a constant speed, first slowly and then faster, and discover that faster speed corresponds to travelling a greater distance in unit time. Students make 'streamer graphs' using paper streamers to represent the distances walked per second, using a real or virtual metronome to mark equal time intervals (seconds).

Lesson 2: Rolling Downhill

The challenge in this lesson is for students to discover what happens to the speed of a ball when it rolls downhill. Students predict what will happen and discuss their predictions, before working in groups to create 'streamer graphs' using paper streamers to represent the distances the ball rolls each second.

Lesson 3: Falling Balls

In this lesson students discover the height from which a ball needs to be released for it to take 1 second to hit the ground. Students use a variety of measuring devices to find the heights for a half second and a quarter second drop and use their results to predict and then measure the height for a 1 second drop.

Lesson 4: Rolling Uphill

In this lesson students undertake two activities showing deceleration. First, they predict what will happen when a ball rolls uphill, the work in groups to create 'streamer graphs' representing the decreasing distances that the ball rolls each second. Students then investigate how far a ball rolls along a flat track with its surface altered to have more friction (covered in different ribbons), linking increased roughness with more deceleration.

Lesson 5: Measuring Forces

The challenge in this lesson is for students to make and calibrate their own forcemeter and use it to measure pushes and pulls. Students discover what happens when two forces pull in opposite directions and draw force diagrams to represent the results.

Lesson 6: Modelling Force and Motion

Students make a streamer graph of the motion of a car or trolley when it is pulled in opposite directions. The forces on the car are provided by masses on strings over pulleys. After discussions about the use of pulleys and forcemeter accuracy, students set up their equipment and predict what will happen. They then create streamer graphs to represent the distances the car or trolley moves each second.

Lesson 7: Complex Motion

Students investigate the motion of a ball in two dimensions, as it travels across a sloping table. They predict the path of the ball, before tracing its path on butcher's paper. Then they change the angle of the launcher so that the ball hits a specified target on the table. Class discussion focuses on the shape of the path of the ball and the forces which affect it, and the changes in speed which are occurring.

Reflection on this sequence

Rationale

Our modern understanding of motion began with Galileo's measurement and modelling of simple motions of a ball on a slope. The seven *Modelling Motion* lessons draw on Galileo's experiments to systematically develop students' ability to model motion, using graphs derived directly from the motion, with all the uncertainties and errors of the real world.

These STEM activities would not be possible without the mathematics, technology, and the science working in concert to construct new understandings. Finding activities that use mathematics authentically to integrate the STEM subjects has often proved challenging. The *Modelling Motion* lessons provide students with an authentic STEM experience where mathematics is central to understanding the science and technology. The use of paper streamers to create graphs to model the motions highlights the critical features of the representations and facilitates their interpretation.

A focus of the unit is on students constructing, sharing, and comparing their models in small groups and in whole-class discussions. Activities and projects are included to extend students' understanding.

The sequence within each lesson of 'predict — observe — represent — interpret — reflect' offers opportunities for students to develop new knowledge and explore relationships between key ideas. This is further strengthened by the sequential nature of the activities, where each lesson builds on the knowledge obtained in the previous ones.

reSolve Mathematics is Purposeful

Activities provide students with the opportunity to create and interpret graphical representations of real world situations in a purposeful way. Using real data obtained from cross disciplinary STEM activities exposes the 'messy' nature of real experiments, with the possibility of finding underlying simple patterns and revealing deep connections between mathematics and fundamental scientific concepts.

reSolve Tasks are Challenging Yet Accessible

Students are motivated by the hands-on nature of these STEM activities. In most activities, the use of 'streamer graphs' enables students to experience the power of authentic graphical representation without the need for engaging with numerical data. The nature of the activities also allows students to demonstrate and share their different skills, including practical skills to devise creative solutions to challenges related to the equipment and measurement of distance and time.

Because of the hands-on nature of the activities and the practical challenges, there are many opportunities for teachers to adjust the level of challenge. Extension activities are also provided in most lessons. The projects are ideal for enrichment.

reSolve Classrooms Have a Knowledge Building Culture

The unit is designed to develop collaborative knowledge building by encouraging students to engage in both small-group and whole-class discussions based on their predictions and actual data obtained from the activities. Students work collaboratively to conduct experiments, display their results, and build understanding.