The Incredible Strength of Ants

Key Learning Content

This film explains why an ant is able to lift more than fifty times its own body weight, by considering the cross-sectional area and volume of its muscles. As an object grows bigger, its volume increases more quickly than its surface area. Since volume is related to weight, and muscle surface area to strength, the very small muscles of ants are more efficient than the muscles of larger animals. The relationship $k:k^2:k^3$ between length, area and volume scale factors is implicit in the film's explanation. Results are also presented in graph form.

Core Outcomes

Learning Points

- Be able to understand that areas of similar figures are in the ratio of the square of corresponding sides.
- Be able to understand that volumes of similar figures are in the ratio of the cube of corresponding sides.
- Be able to calculate squares, square roots, cubes and cube roots.
- Be able to solve word problems about ratio and proportion.

Suggested Activities

- Verify the square-cube law with simple solids.
- Apply the square-cube law to solve simple word problems about the size of objects.
- Calculate the relative strength of different animals by considering their size.

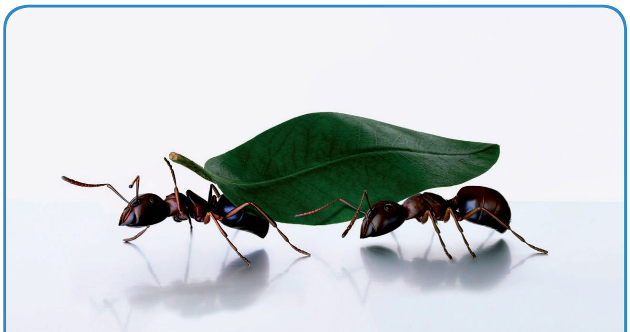
Extension Outcomes

Learning Points

- Be able to interpret information presented in a range of linear and non-linear graphs.
- Be able to set up problems involving direct proportion and relate algebraic solutions to graph representation of the equations.
- Be able to understand the concept of a variable rate of change.
- Be able to determine gradients and rates of change by differentiation and relate these to graphs.

Suggested Activities

- Plot graphs of power relationships such as $y = x^2$ *and* $y = x^3$ and understand the key features of their shapes.
- Work out the gradients of power curves and look for an algebraic pattern to the answers.



Ants are considered the strongest animals in the world because they can lift weights disproportionate to their tiny size.

Related Films

To use before the lesson plan:

Proportion: The Vitruvian Man	This film takes a detailed look at the ideal proportions of the human body.

To use after the lesson plan:

Aiming for the Outer Planets	This film identifies a very practical use of mathematical proportion that enables spacecraft to venture far into space.
The Emperor's Chess Board	This film shows how a reward that grows at a constant rate across the squares of a chess board can rapidly grow out of control.
Heptathlon	This film describes how modern athletics uses fractional powers to work out who wins medals.
Modelling the Spitfire	This film records the production of a scale model of the famous aircraft.
Queen Hatshepsut's Ship	This film features the production a scale model of an ancient Egyptian boat which belonged to ancient Egypt's only female Pharaoh.

Guide Lesson Plan

Introduction

Ask the students what animal they think is the strongest in the world. Then ask the same question relative to the animal's size. Ask how you might practically determine the answer to this question using mathematical theory.

Show Film

The Incredible Strength of Ants

Main Activity

Foundation

Take a range of solid shapes, e.g. cube, sphere, cone and pyramid. Check that the students know or can find formulae for the surface areas and volumes of these shapes. Give basic dimensions for the shapes and ask the students to work out their surface areas and volumes. Next, double, triple and quadruple the dimensions and verify that the square-cube law holds.

Main Activity cont ...

Advanced

Set word problems involving surface area and volume that require use of the $k:k^2:k^3$ scale factor relationship.

Example: a regular cone with a volume of $100cm^3$ has its top cut off two-thirds of the way up from its base. Work out the volume of the frustum that remains.

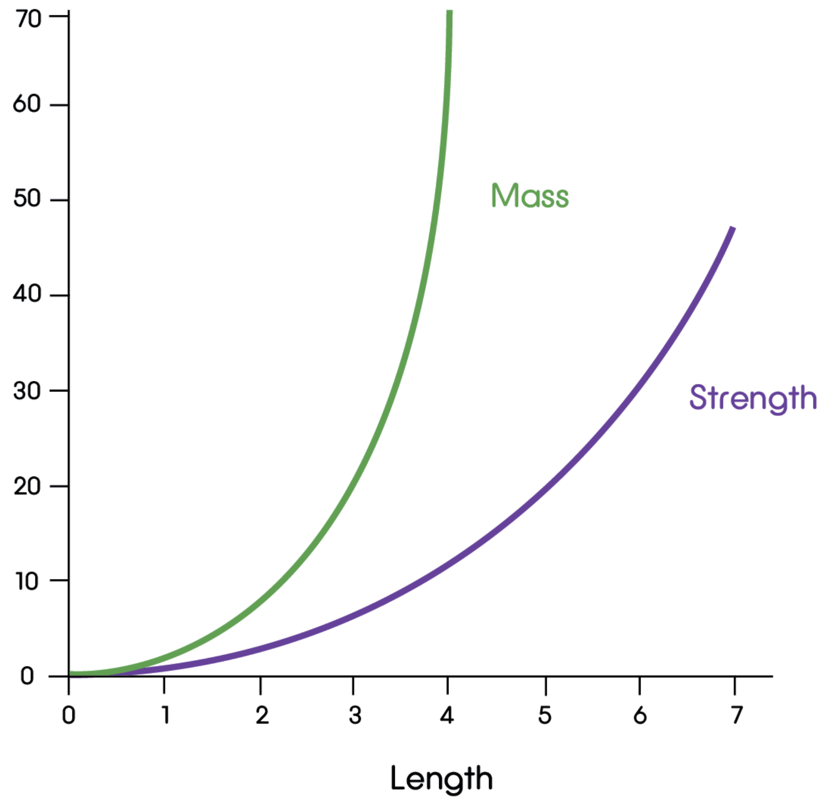
Extension Activity

Set problems requiring students to work backwards through the square-cube relationship.

Example: A sphere has radius k, where k is a constant. A second sphere has exactly half the volume of the original sphere. What is the radius of the second sphere, and what is the ratio of both spheres' surface areas in terms of k?

Optional Extra

Explain the principles of simple differentiation, that the gradient of a curve $y = x^n$ is given by $dy/dx = nx^{n-1}$, and use this to illustrate the different rates of change of square numbers and cube numbers. Draw graphs to check the results by manually calculating gradients.



This graph shows that as the muscle length increases, strength increases. It also shows that muscle mass increases at a much faster rate.