VCE Mathematical Methods Unit 1

Sample context for assessment: Scaling human measures

Introduction

This task uses a simple model of a human body to explore the effects of scaling linear dimensions on surface area and volume. Related topics in the application of mathematics in biology are allometry, power laws, the square–cube law, isometric scaling, geometric similarity and biomechanics.

Part 1

Consider a cube:

1. Plot the graphs of surface area and volume as functions of side length, for side lengths from 0 cm to 100 cm in steps of 10 cm.
2. Plot the graph of side length as a function of surface area, for surface area from 0 to 6 square metres.
3. Plot the graph of side length as a function of volume, for volume from 0 to 1 cubic metre.
4. Provide several examples of calculations that show how to determine a side length that would produce a specified surface area or volume.

Part 2

Consider a sphere:

1. Plot the graphs of surface area and volume as functions of radius, for radiuses from 0 cm to 50 cm in steps of 10 cm.
2. Plot the graph of radius as a function of surface area, for surface area from 0 to 4 square metres.
3. Plot the graph of radius as a function of volume, for volume from 0 to 1 cubic metre.
4. Provide several examples of calculations that show how to determine a radius that would produce a specified surface area or volume.

Part 3

A rough model of the human body can be made by considering the arms and legs as cylinders, the torso as a rectangular prism and the head as a sphere.

1. Using reasonable approximate measurements from a friend, form such a model, specify the relevant linear dimensions in centimetres and calculate the surface area in square centimetres and volume in cubic centimetres for this model.
2. Consider scaling factors for a similarity transformation (dilation) of linear dimensions from 0.1 to 2 in steps of 0.1. Plot a graph of surface area in terms of scaling factor and a graph of volume in terms of scaling factor.

Part 4

Investigate examples of large statues throughout history, such as the Colossus of Rhodes, and the biomechanics of bone strength and mass under scaling.

Areas of study

The following content from the areas of study is addressed through this task.

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| **Unit 1** | |
| **Area of study** | **Content dot points** |
| Functions and graphs | 1, 2, 3 |
| Algebra | 1, 2, 4, 5 |
| Calculus | – |
| Probability and statistics | – |

Outcomes

The following outcomes, key knowledge and key skills are addressed through this task.

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| **Unit 1** | | |
| **Outcome** | **Key knowledge dot points** | **Key skills dot points** |
| 1 | 1, 2, 3, 4, 5 | 1, 2, 3, 11, 13, 14 |
| 2 | 1, 2, 5 | 1, 2, 3, 5, 6 |
| 3 | 3, 4, 5, 8 | 3, 5, 6, 7, 12, 13 |