Example problem

Level: Upper primary or junior secondary

Simple modelling

Hyperthermia

Describe the real-world problem

Danger for children left in hot cars

Monday, December 5, 2015. A King County man will face police questioning over suspicion of negligence after allegedly leaving his two-year-old grandson alone in a car in a shopping centre parking lot on Saturday. Police were forced to smash a window of the locked car to rescue the toddler, who was on the verge of dehydration.

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Hyperthermia, or heat-related illness, occurs when a person's body absorbs more heat from the environment than the body can dissipate through cooling. The human body's cooling mechanisms include perspiration, which is a loss of fluid. Losing a lot of fluid results in dehydration. More than 400 children have died in cars from hyperthermia in the United States since 2005. The children have ranged in age from 5 days to 14 years; more than half have been less than 24 months old.

Child deaths from vehicular heatstroke, United States, by year		Circumstances leading to child vehicular death
2005	47	Child forgotten by adult 54% of cases
2006	29	
2007	36	
2008	43	Child playing unattended in vehicle 29% of cases
2009	33	
2010	49	
2011	33	
2012	34	Child intentionally left in vehicle by adult 17% of cases
2013	44	
2014	31	
2015	24	
Source: Null, J. (2016). Heatstroke deaths of children in vehicles. Department of Meteorology and Climate Science, San Jose State University. http://noheatstroke.org		

Specify the mathematical problem

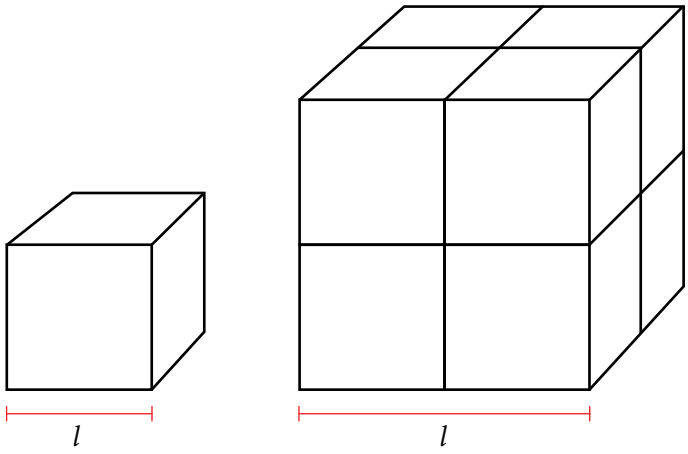
Investigate why small children and animals are so much at risk in locked cars in hot weather.

Formulate the mathematical model

The rate of fluid loss from a body depends on (is proportional to) its surface area, SA.

The amount of fluid in a body depends on (is proportional to) its volume, Vol.

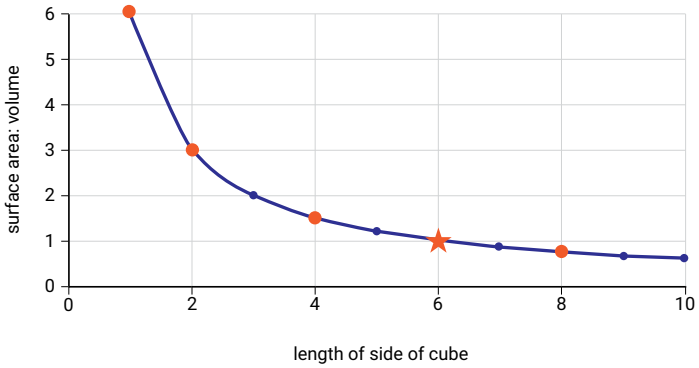
So a critical factor is the surface area/volume ratio of the body. We begin by considering blocks of different dimensions.



SA small cube = 6 Vol small cube = 1 SA/Vol small cube = 6

SA large cube = 24 Vol large cube = 8 SA/Vol large cube = 3

Solve the mathematics



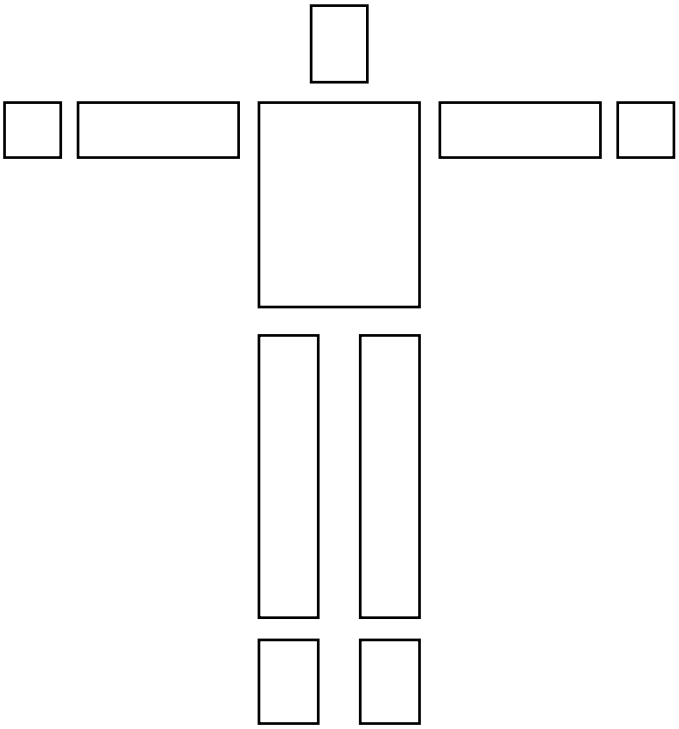
Create a graph plotting the ratio for blocks with lengths from 1 to 10. This shows that smaller cubes have higher surface area/volume ratios than larger cubes. That is, smaller cubes have a greater surface area through which to lose fluid relative to the volume of fluid they have to lose. Smaller cubes will lose fluid at a greater rate than larger cubes.

Interpret the solution

Applying this logic to the problem of children in cars suggests that children (smaller people) will have a higher surface area/volume ratio than adults (larger people) do. Therefore, they will lose fluid more quickly. Therefore, they are at greater risk of dehydration.

Evaluate the model

The diagram below suggests how to extend the simple cube approach to construct more elaborate representations, using cuboids, cylinders or spheres, to construct physical models of children, adults, animals and so on. Associated mathematical development will call on knowledge of mensuration. There is opportunity for students to construct representations of animals of choice.



Report the solution

Students should write out a report following the modelling framework structure.