1. (a) When trees grow the radius, r, of the branches do not grow in direct proportion with their length, L. Longer branches tend to be disproportionately wider than shorter branches. Why do you think this is?

   (b) The square of the radius of a branch is directly proportional to the cube of the length. Express this result as a proportionality, in the form $r \propto L^p$ where you should specify the exponent p.

   (c) If a branch grows to twice its original length, by what factor has the radius of the branch increased?

   (d) Assuming the density of wood is constant, by what factor has its mass increased? Assume a cylindrical branch.

2. The formula for the volume of a cone is $V = \frac{1}{3}\pi r^2 h$, where r is the radius of the base and h is the height. What happens to the volume of a cone if it grows such that

   (a) the radius is doubled but the height remains the same?

   (b) the height is doubled but the radius remains the same?

   (c) both the height and radius are doubled?

   (d) Suppose a cone grows in such a way that the volume has increased by a factor of 10, but the radius has only doubled. By what factor has the height increased?

3. In the book *Gulliver's Travels*, by Jonathan Swift, the main character, Gulliver, encounters a number of different races of people, including the tiny Lilliputians and the giant Brobdingnagians. In Part II, He describes the people of Brobdingnag as "a comely Race of People" and "very well proportioned", which we can presume means identical in shape to Gulliver, except much taller. Gulliver estimates the farmer to be "as tall as an ordinary Spire-steeple". Assume this is about 60 feet – about 10 times Gulliver's height of 6 feet.

(a) If Gulliver is 160 lbs, how heavy do you expect the farmer to be?

(b) Suppose that Gulliver's thighs are roughly circular with a diameter of about 6 inches. What do you expect the diameter of the farmer's thighs to be?

(c) Human legs are built with a certain safety factor so that together they can support up to 4 times the weight of the human body. How much weight can Guliver's legs support?

(d) Assuming the strength of the leg (ie the weight it can support) scales in proportion to the cross sectional area of the leg, how much weight would the Brobdingnag farmer's legs be able to support? What would happen to the Brobdingnag farmer.

(e) What would the diameter of the framer's leg have to be in order to support his weight with the same safety factor as for the human body?