

# Rolling Paper

## Apparatus

pieces of scrap paper – the paper will be crumpled afterwards. (a selection of A3 and A4 is good.),  
weight – such as a textbook, scissors, sticky-tape

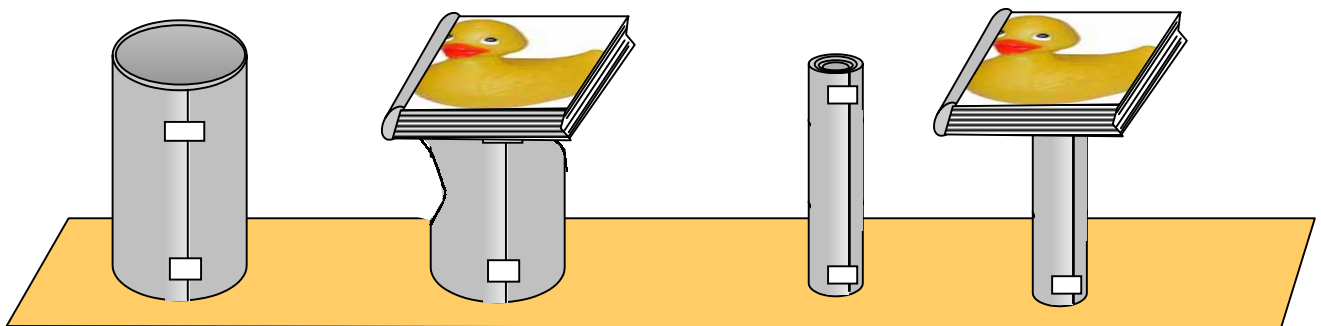
## Action

The students experiment with rolling the paper to form cylinders, and seeing if they can hold the weight of the textbook without buckling. They can investigate the effects of height and radius, and cross sectional area. They can cut pieces in half, quarters etc to change the cross section. If you have large enough pieces of paper (A3), they can also investigate the ability of a cylinder to support its own weight.

## The Physics

Thin walled structures tend to buckle, so there is a limit to the advantage to be gained by using hollow beams rather than solid beams. The weight of the load and the cylinder itself is not precisely over the base of the cylinder, hence a torque is exerted on the cylinder. If the walls are strong enough, the internal forces in the material will balance the torque. The paper rolls with smaller radius in which the paper forms multiple layers have thicker walls and are hence stronger. Shorter rolls are also stronger than taller ones as the torque will be less.

Any vertical column will buckle under its own weight if the ratio of its height to radius is too great. This is a limiting factor in the height of many structures, including trees.



## Accompanying sheet

### Rolling Paper

Roll the papers to make columns of various heights and radii.

Which columns can support the text book?

How does the strength change with height?

What about radius?

What happens when they fail? Explain why the columns collapse.