

## Hydraulics

### Tutorial Sheet 5 – Mass conservation and the continuity equation

1. Water flows along a pipe of 50 mm diameter with a mean velocity of  $1 \text{ m s}^{-1}$  until it meets a circular rod of 46 mm diameter arranged concentrically in the pipe. Draw a suitable control volume and calculate the mean velocity with which the water flows through the annular gap surrounding the rod. (Ans:  $6.51 \text{ m s}^{-1}$ )
2. You are walking and come to a small river that you have to cross, but there is no bridge and no crossing stones. You see that part of it is wide, and part is narrow. That narrow section looks so much easier ... Where should you cross so that you minimise problems?
3. Under conditions of turbulent flow in a channel, the mean horizontal velocity  $u$  at a point is also approximately given by

$$\frac{u}{u_{\max}} = \left(\frac{z}{d}\right)^{1/7},$$

where  $u_{\max}$  is the velocity at the surface,  $z$  is the distance above the bed, and  $d$  is the depth of flow. Calculate the volumetric flow rate per unit span and the mean velocity in the channel. (Ans:  $7/8 \times u_{\max}d$ ,  $7/8 \times u_{\max}$ ).