PHYC10007: Physics for Biomedicine
Tutorial Sheet 5 — *Fluids*

Discussion/Conceptual questions — *Last updated: 29/08/2014*

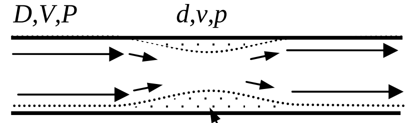
1. What important assumptions make Bernoulli's equation only approximately valid for the flow of air?
2. Water flows at speed V through a pipe of diameter D. If the pipe branches into two pipes each of diameter $D/2$, what will be the speed of water flow in the two pipes? What is the ratio of the total flow rates in the two sections of the pipe (before and after the branch)?

Problem-solving questions

3. A large cylindrical tank of water with a diameter of 10 m is filled with water to a depth of 10 m. A small hole with area 2 cm^2 is punched in the bottom of the tank, allowing the water to stream out. Assume that the speed of the water at the surface is negligible.

   (a) Find the speed of water as it leaves the tank.
   (b) What mass of water flows out of the tank each second?

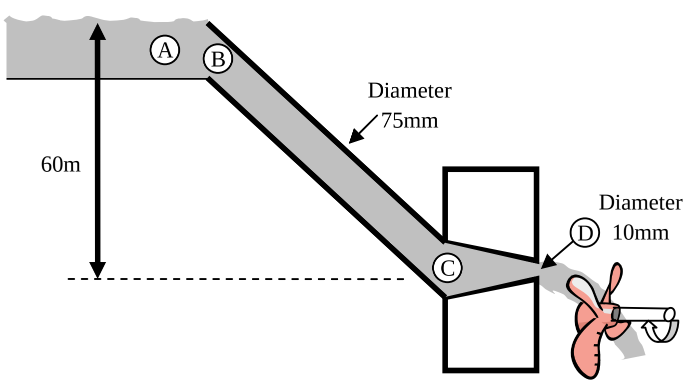
4. Consider an artery with diameter D, but with some plaque deposits as shown restricting the diameter to d. The flow velocity and pressure are V, P and v, p in the unrestricted and restricted regions, as indicated.



   For this problem, assume an ideal fluid, and use the Bernoulli equation where appropriate.

   a) Find the ratio of water velocities in the restricted and unrestricted parts of the pipe, v/V.
   b) As the plaque restriction develops over time, reducing d, does the pressure at the constriction increase or decrease?
   c) What is the pressure after the constriction?
   d) Derive an expression for the pressure difference between the restricted and unrestricted regions, $p - P$, in terms of the flow rate and the parameters denoted in the figure.

5. On the west side of Lake Taupo in New Zealand there is a small hydroelectric generator. This is fed from a water pipe with upper end in a river at altitude of 60m relative to the generator. The pipe is 75mm in diameter, and feeds into the water turbine through a conical section where the diameter reduces a 10mm diameter exit aperture. Assume an ideal fluid; that is, ignore friction, viscosity, and turbulence effects.



   a) Through which part, if any, is the water flux (volume of water per unit time) greatest:

      (B) the top of the 75mm pipe
      (C) the bottom
      (D) through the 10mm diameter exit aperture

(E) it is the same in all cases.

b) Through which part, if any, is the water velocity greatest?

c) Using Bernoulli's equation, or otherwise, find the velocity of the water leaving the exit aperture, and then using continuity, or otherwise, the water velocity at (C), the bottom of the pipe.

d) Find the pressure of the water, relative to atmospheric pressure, at (C), the bottom of the pipe.

e) Find the volumetric flow rate, in litres per second.

f) Find the maximum power that could be generated, assuming a 100% efficient generator.