Department of Mechanical, Materials and Manufacturing Engineering
THERMODYNAMICS & FLUID MECHANICS I (MMME1048)

Fluid Mechanics – Self-Assessment Example Sheet - Pipe flow, Extended Bernoulli and Pumps

Links to pages 113-124 Fluid Mechanics notes

Note: $\mu = 10^{-3}\ Pa\ s$ for water

1. Water flows through a 12mm internal diameter drawn copper pipe at a rate of 20 litres per minute. Calculate the pressure drop per metre length of pipe.

   Assume the density of water is 1000 kg/m^3 and viscosity 0.001 Pas.

   [about 8.4 kPa +/- 0.5Pa depending on reading of Moody chart]

2. A pump provides a pressure rise of 0.5 bar for a water flow rate of 30 litres per minute. If the input mechanical power is 40 Watts, calculate the efficiency of the pump.

   [62.5 %]

3. Water flows steadily along a uniform bore pipe with a velocity of 1 m/s. at the inlet, the elevation is 384 m above datum and the pressure is 2.5 bar gauge. At the outlet, the elevation is 290 m and the pressure is 1.5 bar gauge.

   a) What is the head loss due to friction?

   b) If the pipe bore is 200 mm and the length is 20 km, what is the value of the friction factor?

   [a) 104.2 m, b) 0.0051]

4. The pump shown in figure Q4 (next page) draws 220 m^3/hour of water from the reservoir and discharges it through the nozzle to atmosphere. The total friction head loss is 5 m (including entry loss into inlet pipe). Estimate the pump power in kW delivered to the water.

[33.79 kW]

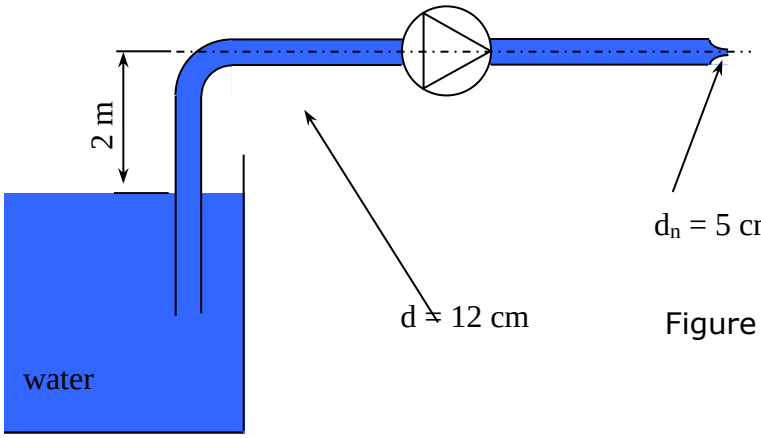

Figure Q4.

5. Two reservoirs (A and B) are separated by an intervening high ridge of land which has a maximum height of 30 m above the surface of A and 70 m above the surface of B. A pipeline is to be constructed to carry water at a constant rate over the ridge from A to B. The pipe discharges at the level of the reservoir at B. A water pump is to be fitted into the pipeline at a height of 2 m above the surface of A to ensure that the pressure in the pipeline at the point of maximum elevation is equal to atmospheric pressure (1.01 bar).

   There is a short length of pipe leading from the reservoir A to the pump. The length of pipe from the pump outlet to the point of maximum elevation is 350 m and the remaining length is 2000 m. The pipe has a uniform diameter of 400 mm and the Darcy friction factor, *f*, is 0.005 throughout. Additional friction losses in the installation amount to three times the velocity head in the pipe for the 350 m section, from the pump outlet to the highest point in the pipe, and four times the velocity head for the 2000 m section, between the highest point and the pipe discharge. There is also a friction head loss across the pump. However, the difference in water velocity and in the elevation between the pump inlet and outlet may be neglected. Determine:

   a) the velocity of flow in the pipe;

   b) the absolute pressure of the water at the pump outlet;

   c) the friction head loss across the pump, given that the pump inlet pressure is 0.6 bar absolute and that the actual mechanical power input is 245 kW.

   [a) 3.63 m/s, b) 5.11 bar, c) 8.8 m]

6. Water flows into a pump at atmospheric pressure (1 bar) and is delivered by the pump to a fire hose at a pressure of 14 bar gauge. The friction head loss across the pump is 35 m of water, but the pipe entrance loss is negligible. The hose has an internal diameter of 75 mm, a length of 400 m and the friction factor is 0.01. The outlet end of the hose is attached to a nozzle, the outlet of which is held 10 m above pump inlet level.

   When directed vertically upwards the water jet is required to reach a height of 30 m above nozzle outlet. Neglecting friction loss in the nozzle and changes in kinetic energy and potential energy between pump inlet and pump outlet, determine:

   a) the nozzle outlet velocity;

   b) the nozzle outlet diameter;

   c) the pump input power;

   d) the ideal pump input power, neglecting pump friction;

   e) the rate of change of internal energy of the water in the pump, assuming no heat transfer.

   f) the temperature increase of the water across the pump, assuming no heat transfer. (specific heat capacity for water is 4.18 kJ/kgK)

[a) 24.26 m/s, b) 0.0267 m, c) 23.72 kW, d) 19.05 kW, e) 4.67 kW, f) 0.082 °C]