1. An axial flow fan 1.83 m in diameter is designed to run at a speed of 1400 rpm with an average air velocity of 12.2 m/s. A quarter (1/4) scale model has been built to obtain a check on the design. The rotational speed of the fan is 4200 rpm.
   a) Determine the axial air velocity of the model so that the similarity with the full scale fan is preserved. The effect of Reynolds number change in similarity may be neglected.
   b) A sufficiently large pressure vessel becomes available in which the complete model can be placed. The absolute viscosity of air is pressure independent and the temperature is the same for both the prototype test and the model test. The prototype is designed for 100 kPa ambient pressure. At what pressure should the model be tested in order to achieve complete similarity? (Note that the kinematic viscosity (ν) depends on the density whereas the absolute viscosity (μ) is μ =μ(T) ) (Ans: 9.15 m/s, 533 kPa)

2. A centrifugal pump is required to operate at a speed of 350 rpm and a head of 123 m and a capacity of 6.75 m$^3$/s. In designing, a model of this pump is desired; the laboratory conditions impose a maximum capacity of 0.135 m$^3$/s and power consumption of 225 kW. If the model and the prototype efficiencies are assumed to be 80 %, find the speed and the scale ratio of the model ( $d_{model} / d_{prototype}$ ). (Ans: 2671 rpm, 0.318)

3. A multistage pump is formed by mounting five identical impellers on the same shaft. It delivers a head of 100 m at a volumetric flow rate of 0.02 m$^3$/s when it is operating at 1450 rpm. When one of the impellers is broken, it is removed. In order to obtain the same head from the four stage pump, determine the required volumetric flow rate and rotational speed. Neglect the Reynolds number effects. (Ans.: 0.02236 m$^3$/s, 1621 rpm)

4. The performance characteristics of a pump operating at 1450 rpm are given in the following figure. It is desirable to pump water against a head of 45 m at a volumetric flow rate of 0.05 m$^3$/s. Determine
   a) The rotational speed of the pump,
   b) The efficiency of the pump and
   c) The power consumption of the pump.
   (Ans.: a) 1520 rpm, b) 79.8%, c) 27.66 kW)
5. The performance characteristics of a pump operating at 1450 rpm are given in the following figure. It is desirable to pump water against a head of 35 m at a volumetric flow rate of 0.05 m$^3$/s. Determine
   a) The percentage reduction in the diameter of the pump impeller,
   b) The efficiency of the pump and
   c) The power consumption of the pump.
   (Ans.: a) 3.4%, b) 79%, c) 21.73 kW)

6. A turbine is designed to operate under a net head of 80 m when the volumetric flow rate of water is 2 m$^3$/s. The performance of this design is to be predicted in the laboratory by using a 1/4 scale model, to be run at the same efficiency as the prototype. The model turbine is operating
under a head of 10 m, yielding a power output of 3.5 kW. Neglecting the Reynolds number effects, determine

   a) the volumetric flow rate for the model and
   b) the efficiency of the prototype.

(Ans: a)0.0442 m$^3$/s, b) 80.72%)

7. The performance characteristics of a pump operating at 1450 rpm can be approximated as

   $$h = 50 - 4000 Q^2$$ and $$\eta = 32 Q - 320 Q^2$$

where $h$ is in m and $Q$ in m$^3$/s.

It is desirable to pump water against a head of 45 m at a volumetric flow rate of 0.05 m$^3$/s by changing the speed. Neglecting Reynolds number effects, determine

   a) the rotational speed of the pump, 
   b) the efficiency of the pump and 
   c) the power consumption of the pump.

(Ans: a)1520 rpm, b) 79.8%, c) 27.66 kW)