Fluid Mechanics I, Part A (FYSS351) Final Exam (4 h) 22.10.2010

-Notice: The course book; White, Fluid Mechanics is allowed in the exam.
-Both finnish and english can be used in answering.
-Mikäli tehtävissä on tuntemattomia englanninkielisiä sanoja, voit pyytää sanakirjaa (tai käännöstä) assistentilta.

1. a) Explain shortly (but precisely) the meanining of the following concepts:
   a1) Newtonian fluid (Newtoninen neste),
   a2) Turbulent flow (Turbulentti virtaus)
   a3) Rotational flow (Pyörteellinen virtaus).

   b) Explain shortly (but precisely) the physical interpretation of the following quantities:
   b1) $\nabla \cdot \vec{v}$; where $\vec{v}$ is flow velocity of a fluid.
   b2) $\int_A \vec{\tau} \cdot d\vec{A}$; given that $\vec{\sigma} = -p\vec{I} + \vec{\tau}$ is the total stress tensor of an incompressible Newtonian fluid, p is its pressure, $\vec{I}$ is unit tensor and A is an arbitrary surface in the fluid.

2. The rectangular dam gate shown in Figure 1 is hinged at point H in a dam wall. The gate is 2m wide normal to the plane of the figure. Calculate the minimum force $\vec{F}$ acting at point A required to hold the gate closed.

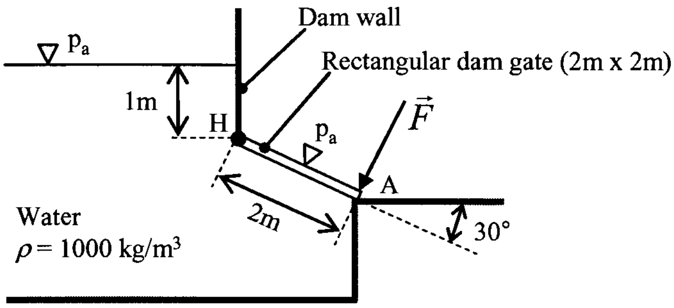

Figure 1

3. A closed tank of volume $V = 1\ \mathrm{m}^3$ is filled with salt solution with initial density $\rho_{S0} = 1100\ \mathrm{kg/m^3}$. Pure water of density $\rho_W = 1000\ \mathrm{kg/m^3}$ flows in the tank and salt solution flows out of the tank at volumetric flow rate Q=0.01 m^3/s (see Figure 2).
   a) Using Reynolds transport theorem, derive a formula for the density of solution ρ_S in the tank as a function of time assuming instantaneous mixing of incoming pure water and the salt solution in the tank.
   b) At what time does the density of solution reach the value $\rho_S = 1001\ \mathrm{kg/m^3}$.

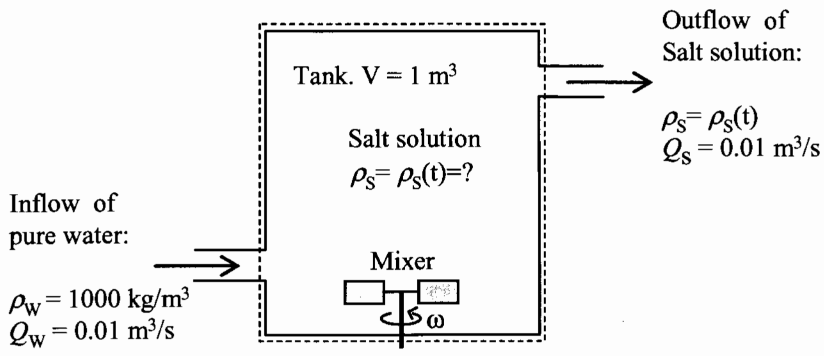

Figure 2

4. The horizontal turbine shown in Figure 3 is supplied with water at flow rate $Q = 0.6\ m^3/s$ through the inlet pipe of diameter 0.3 m. The outlet pipe has diameter 0.4 m. The pressure difference across the turbine is measured to be 75 kPa. Calculate the shaft power $\dot{W}_S$ delivered by the turbine.

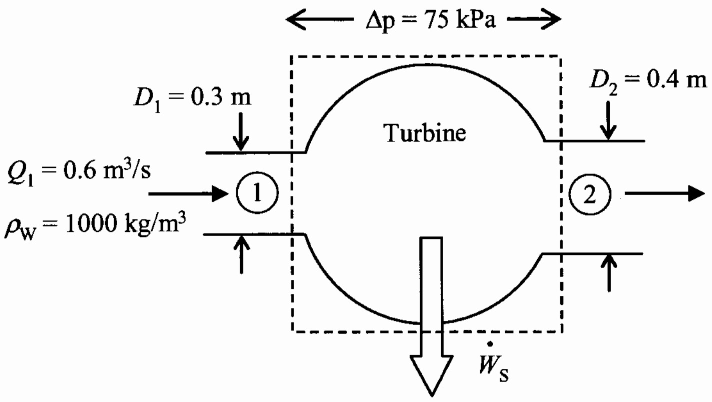

Figure 3

!!!!!!!!!!!!! READ THE PROBLEMS CAREFULLY !!!!!!!!!