TEST EXAM FTV1 – RUG (2)
May 2018

Maximum # points for each question are indicated

Question 1

Consider an (open) cylindrical tank, completely filled with 4500 liter water. The cross-sectional area of the tank is 4,5 m^2. At a certain moment the tank starts to leak due to a hole in the bottom. It takes 20 seconds before the tank is completely empty. Friction can be ignored.
Density of water: $\rho=10^3$ $kg.m^{-3}$; $g=10$ $m.s^{-2}$

A) Calculate the cross sectional area of the leaking hole.
10

Suppose the tank would have had a second hole in its bottom with a cross-sectional area twice that of the first hole.

B) Still ignoring friction, how long would it have taken then to empty the tank?
10

Question 2

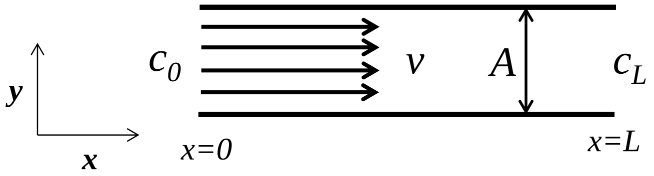
Consider a closed, cylindrical reactor with a diameter of 2 m and a height of 4 m. The tank is totally filled with fluid and well-stirred. At t=0, the temperature (T) of the fluid is 32 ^{0}C whereas the (constant) ambient air temperature is 20 ^{0}C. Because of heat transfer to the environment the temperature of the water will drop.
Density (ρ) and specific heat capacity (c_p) of the fluid are 2.10^3 kg/m^3 and 8.10^3 J/Kg.K, respectively.

A) Given that it takes 2 hrs for the water to cool down from 32 to 26 ^{0}C, calculate the average heat transfer coefficient (*U*) over the entire tank surface but with ignoring the surface area of the top and bottom of the reactor.
10

B) How much time does it take for the water to cool down from 32 to 26 ^{0}C if we take a reactor of the same diameter (2 m) but with a height of 8 m instead? **10**

Question 3

Consider a plug flow of water (velocity v) through a cylindrical pipe of diameter A and length L. At x=0 the concentration of compound c is c_0. Compound c is continuously converted into compound u by a first order chemical reaction with rate constant k.



A) Assuming steady-state, derive an expression for the concentration profile of c along the length of the pipe, i.e., give c as function of x.

10

B) What is the concentration of compound c at $x=L$ if k is either very small or very large? **10**

Question 4

Lake Geneva's famous fountain pumps 0.1 m^3 water per second vertically into the air to a height of 100 m. The cross-sectional area of the (vertical) pipe at the base of the fountain is 0.04 m^2. Friction losses can all be ignored and consider steady-state conditions. Make a drawing of the situation and clearly indicate possible reference points!

A) Calculate the power of the pump needed to do this.

10

B) Suppose the pipe at the base is at an angle of 45 degrees. If all other conditions remain the same, what height reaches the water in this case?

10

Question 5

One of threats of accidents on sea is the free-coming oil that can have disastrous effects on the eco-system. Consider a layer of oil floating on the surface of the ocean. Due to diffusion, over time part of the oil will penetrate into the water. Fortunately, part of the oil is removed (digested) by micro-organisms or chemically converted two less harmless compounds. But here we will ignore these processes and just focus on diffusion. A research team of Wetsus is hired to take water samples to monitor the level of contamination. As it seems, over a period of 1 week (t_e) the oil has penetrated to a depth of 75 cm. The concentration of oil at the oil-seawater interface (c_s) equals the (limit) solubility concentration of oil in seawater, 10 g/m^3.

A) What is the average oil concentration in the 75 cm seawater layer assuming a linear concentration gradient?

10

B) Calculate the (apparent) diffusion coefficient (D_A) of oil in seawater.

10

Final mark = total # points / 10