Fluid Mechanics II, Part A (FYS451). Final Exam 27.4.2012

Notice: Using the course book, White: Fluid Mechanics, during the test is allowed.

1. Explain shortly
a) the use of dimensional analysis in scaled model experiments
b) physical interpretation of Reynolds number.

c) The speed of propagation C of a capillary wave in deep water is known to be a function only of density ρ, wavelength λ, and surface tension Y. Find the proper functional relationship, completing it with a dimensionless constant. For a given density and wavelength, how does the propagation speed change if the surface tension is doubled?

2. A steady push on the piston in Fig 1. causes a flow rate Q=0.9 cm^3/s through the needle. The fluid has ρ= 900 kg/m^3 and μ= 0.002 kg/m·s. What force F is required to maintain the flow?

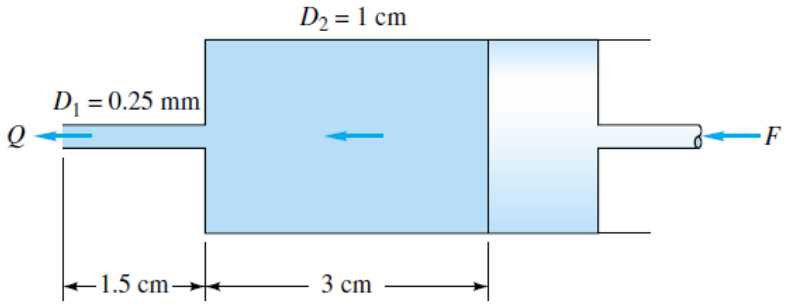

Figure 1.

3. Two infinite plates a distance h apart are parallel to the xz plane with the upper plate moving at speed V, as in Fig. 2. There is a fluid of viscosity μ and constant pressure between the plates. Neglecting gravity and assuming incompressible turbulent flow $u(y)$ between the plates, use the logarithmic law and appropriate boundary conditions to derive a formula for dimensionless wall shear stress versus dimensionless plate velocity. Sketch a typical shape of the profile $u(y)$.

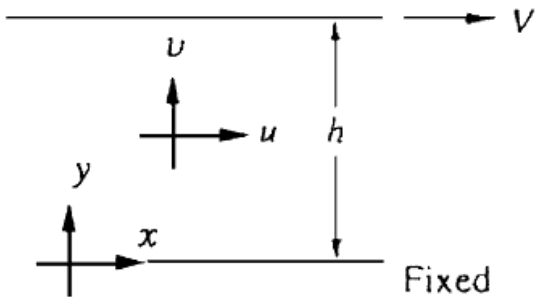

Figure 2.

4. GIVE YOUR ASWER TO THIS PROBLEM ON THE SEPARATE ANSWER SHEET PROVIDED.

A centrifugal pump is used to pump water at temperature 20ºC from tank 1 to tank 2 through a pipeline (see Figure 3). Both tanks are 'large' and water surface level in tank 2 is 11 m higher than in tank 1. Tank 1 is open to atmosphere while tank 2 is closed and the pressure of the gas above water surface is 10 kPa higher than atmospheric pressure. The pipe is hydraulically smooth, its length L = 22 m and diameter D = 60 mm. The sum of loss coefficients of all minor losses in the pipeline is $\Sigma K_i = 4.0$. The impeller diameter of the pump is 290 mm. The characteristic curves of the pump are given in Figure A1 of the answer sheet.

a) Sketch the characteristic curve of the pipeline (system curve) in the pump performance diagram given in Figure A1. Use the partially filled table (Table AI) in the answer sheet in tabulating the numerical values needed,
b) Mark the operating point of the pump-pipeline system in the diagram.
c) Using the diagram, <u>estimate</u> the flow rate Q, power P_A ('brake horse power'), the required net positive suction head NPSHr and the efficiency of the pump η at the operating point (with accuracy provided by the diagram).

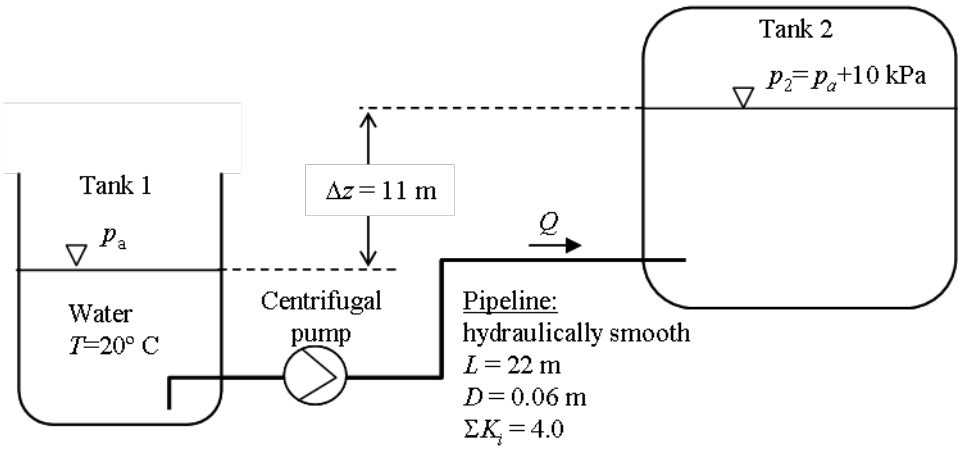

Figure 3

!!!!!!!!!!!!! <u>READ THE PROBLEMS CAREFULLY</u> !!!!!!!!!!

ANSWER SHEET FOR PROBLEM 4: **Name:** _____
Fluid Mechanics II (FYSS451 Part A).
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List the definitions and formulas that you need here:

Table AI: Calculation of the characteristic curve of the pipeline: Mark the symbols of the quantities (intermediate results) that you need on the heading row and tabulate their numerical values at flow rates Q given in the first column. (You may not need all the columns, though). Use no more than three significant digits. Plot the resulting characteristic curve in Figure A1

Q [l/s]					H [m]
0					
4					
8					
10					
12					
14					
16					
18					
20					

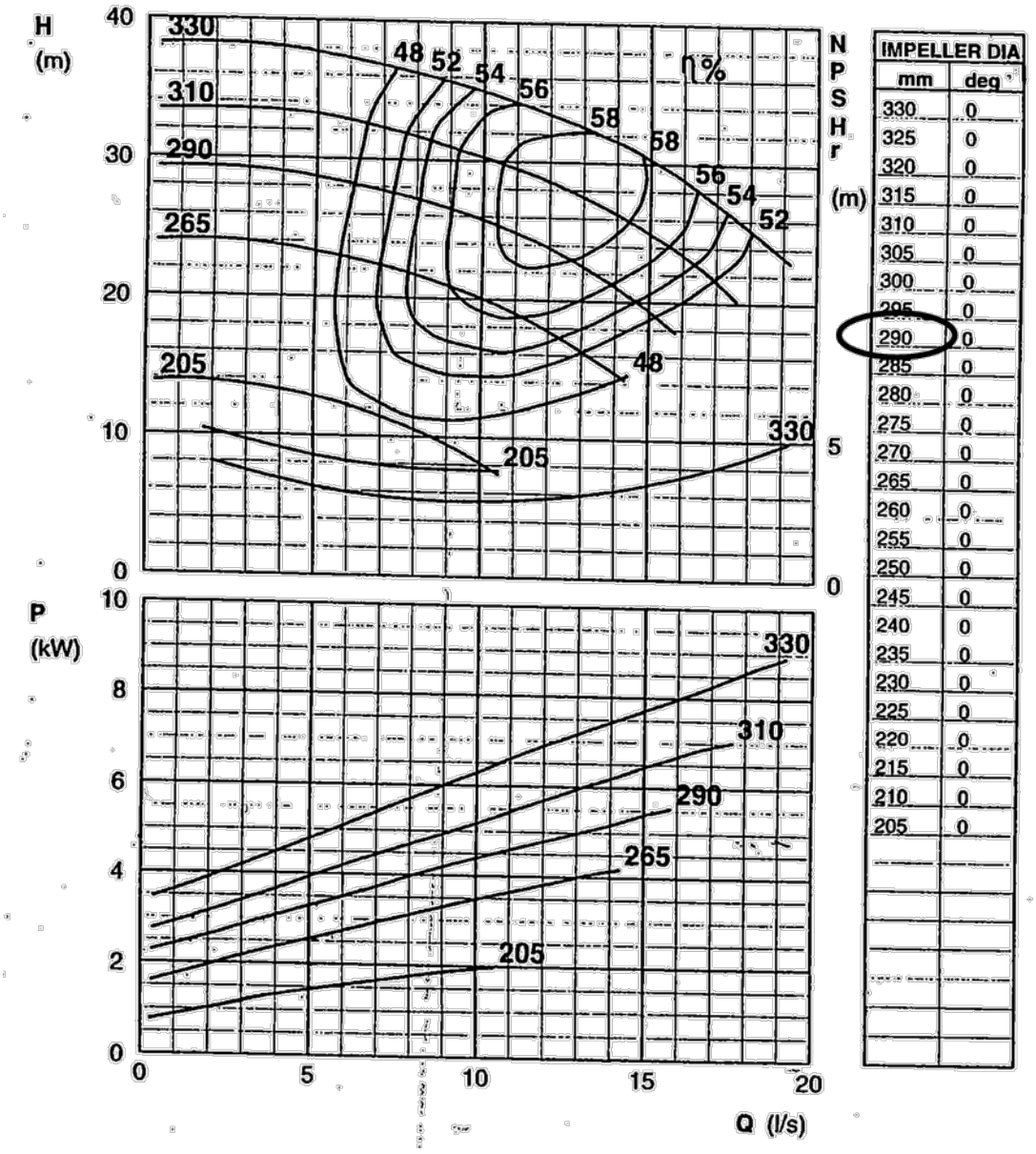

Figure A1: Characteristic curves of the centrifugal pump

ANSWERS to problem 4 (c):

Values at operating point (obtained graphically from Figure A1):

Flow rate Q = _____ l/s
Power P_A = _____ kW
NPSHr = _____ m
Efficiency η = _____ %