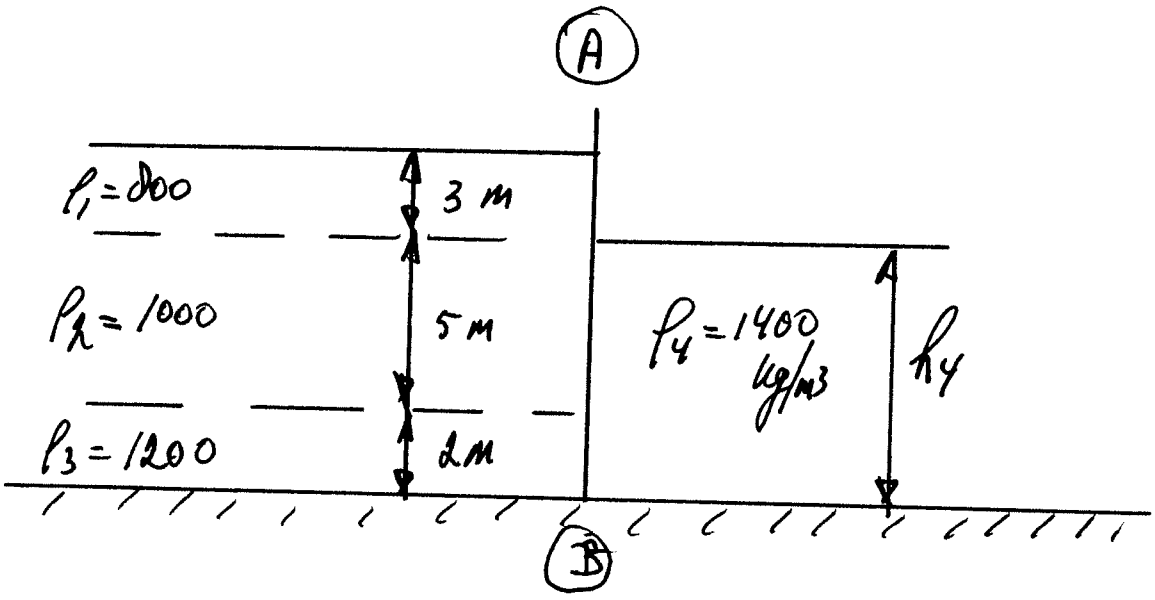
EXAMINATION FLUID MECHANICS I, 7 november 2008

1. On the left side of the gate AB there are 3 layers of fluid with densities $\rho_1 = 800$ kg/m^3, $\rho_2 = 1000$ kg/m^3, $\rho_3 = 1200$ kg/m^3 and layer thickness $h_1 = 3$ m, $h_2 = 5$ m, $h_3 = 2$ m.
   On the right side of the gate AB there is 1 layer of fluid with $\rho_4 = 1400$ kg/m^3 and thickness h_4.

   a. Compute the thickness h_4 when the fluid pressure at the bottom on both sides of the gate is equal.

   b. Make a plot of the resulting pressure distribution at the gate and compute the net pressure at each interface.

   c. Compute the total horizontal resulting pressure force at the gate.



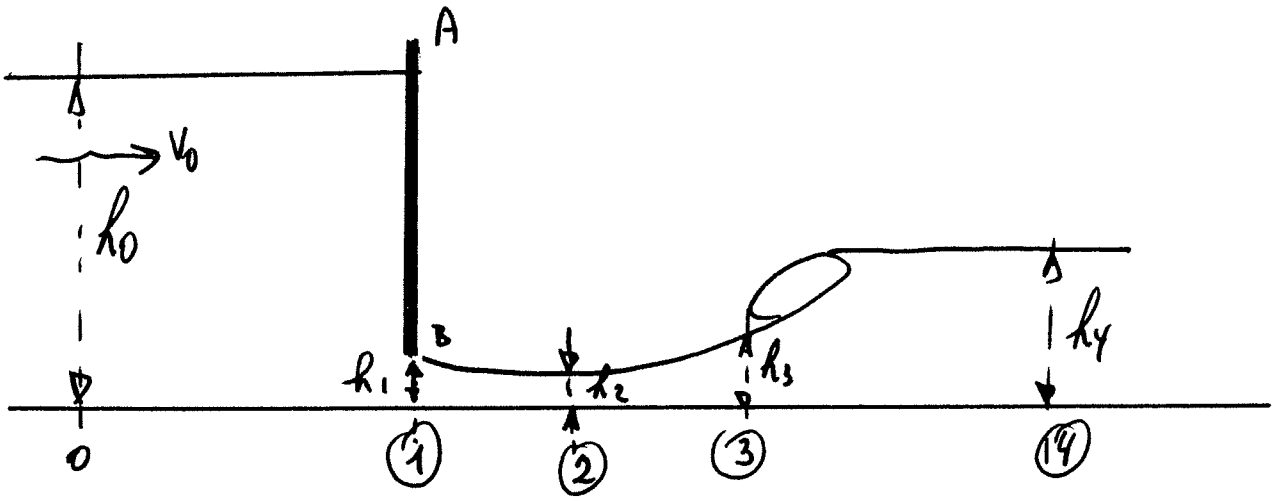
2 A channel with a horizontal bottom has a gate AB at the end with opening h_1. The velocity head upstream of the gate is measured by a Pitot-tube and is 0.02 m

Given are:

h_0 = water depth upstream= 1 m

μ = contraction coefficient =0.66

g = 10 m/s²



a) what is the velocity v_o upstream of the gate and what is the discharge q?

b) what is the depth h_2 and what is the depth h_1 under the gate; what is the Froude number at point 2

c) what is the water depth h_4

d) Make a sketch of the energy-line and compute the total energy loss between points 0 and 4

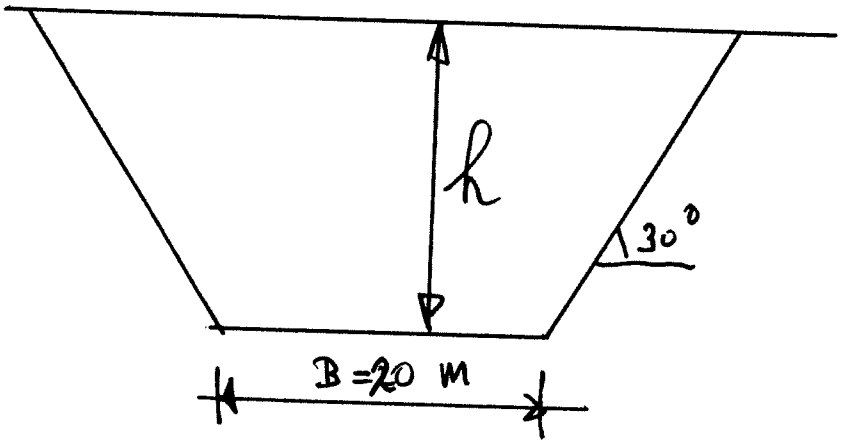
e) Compute the force at the gate?

f) The pressure along the gate is measured in 7 points (at 0.1, 0.2, 0.3, 0.4, 0.5, 0.6 and 0.7 m below the water surface); the pressure in the first 3 points is hydrostatic; the pressure in point 4 is p_4=3300 N/m², p_5=3700 N/m², p_6=3900 N/m², p_7=3400 N/m², what is the force at the gate based on the measured pressures?

g) how can you compute the water depth in point 3 just in front of the hydraulic jump? What do you have to know?

3. Given: uniform flow in a channel with trapezoidal cross-section:

h= 4.5 m	g = 10 m/s^2
I = 10^{-4}	viscosity= 10^{-6} m^2/s
B= 20 m	side slope angle=30 degrees



a. Compute discharge Q when k_s=0.1 m?

b. Show that flow is in the hydraulic rough regime.

c. Compute discharge when bed roughness is k_s=0.0001 m?

d. What is the flow velocity at the surface in the middle of the channel when k_s=0.1 m?

e. what is the water depth h if the discharge under a) is twice as large?

4. Flow velocity measurements have been carried out in a river with water depth h=5 m (υ=0.000001 m^2/s; kappa=0.4), as follows::

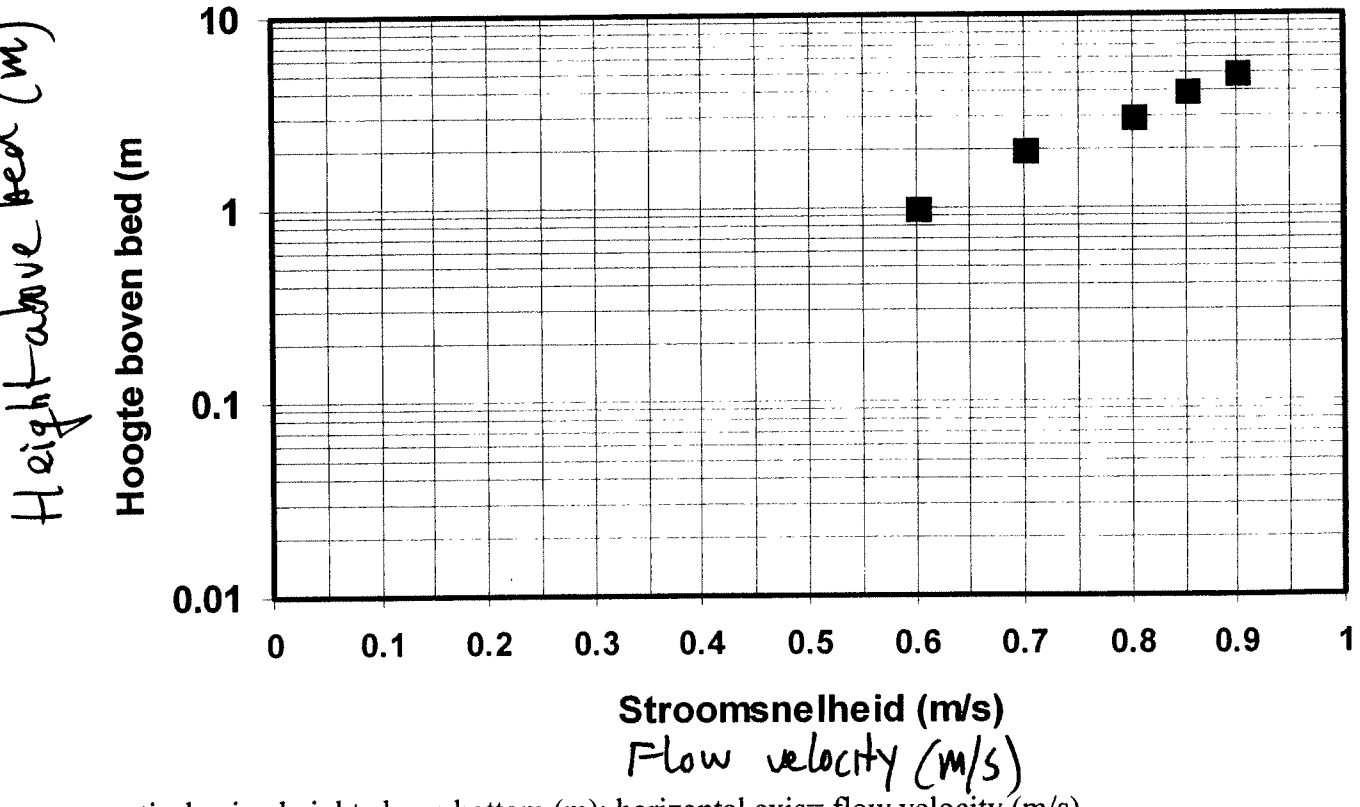
z_1= 1 m	u_1= 0.60 m/s
z_2= 2 m	u_2= 0.70 m/s
z_3= 3 m	u_3= 0.80 m/s
z_4= 4 m	u_4= 0.85 m/s
z_5= 5 m	u_5= 0.90 m/s

a) What is the depth-averaged flow velocity and at what height above the bed is the local velocity equal to the depth-averaged velocity?

b) Compute the bed-shear velocity u_* if the hydraulic roughness is k_s=0.5 m using the measured velocity in the lowest point only (z_1)?

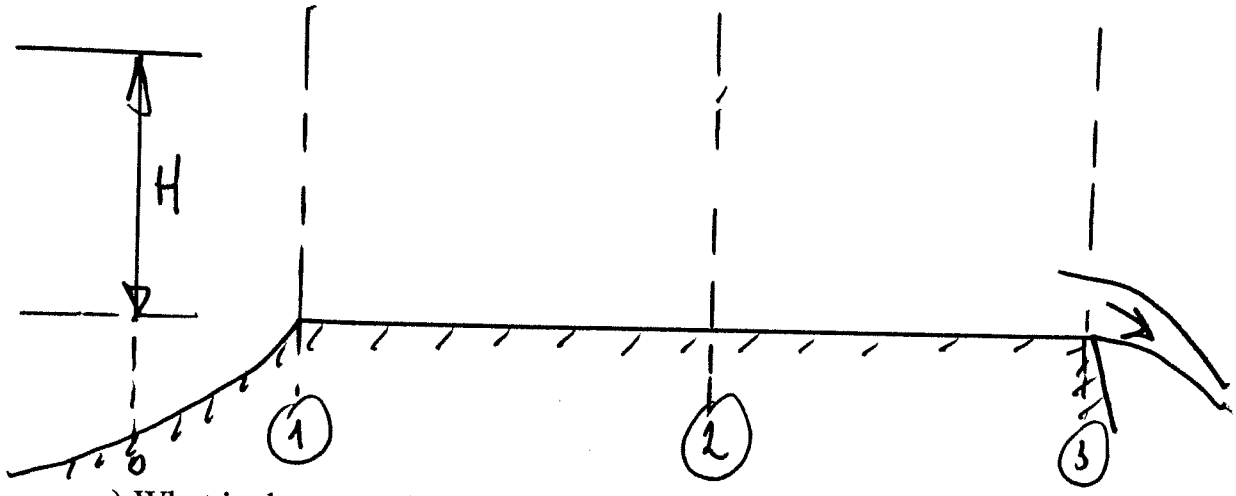
c) Compute the bed-shear velocity u_* and the hydraulic roughness k_s based on the measured velocities of the lowest two points z_1 and z_2?

d) Same; using all points; fit a line through the point (by eye)



vertical axis= height above bottom (m); horizontal axis= flow velocity (m/s)

5. A deep reservoir is connected to a channel with horizontal bottom. Free overflow at the end of the channel.
Discharge per unit width $q = 0.5\ m^2/s$ ($g = 10\ m/s^2$). H=0.6 m; C=100 $m^{0.5}/s$



a) What is de water depth at the end of the channel (point 3)?
b) What is the water depth at the entrance of the channel (point 1)?
c) What is the length of the channel?
d) wat is de water depth in the middle of the channel (point 2)?
e) what is the Chezy-value of the downstream section 2-3 to raise the water level in point 2 by 0.05 m?
f) What is the water level in the reservoir to force the discharge through the channel when section 2-3 has the new Chezy value? How can you compute this? Describe the method?

6. Theoretical questions

a. When is the fluid pressure hydrostatic?

b. When is it allowed to apply the law of Bernouilli bween two points When is it allowed to apply the momentum equation?

c. What is the difference between the momentum equations of Euler and Navier-Stokes?

d. Which three terms do we have in the Bernouilli equation?

e. What is the principle of the Pitot-tube; make a sketch?

f. How can a fluid particle describe a curved path? Which forces do occur?

g. In turbulent flow there are three hydraulic regimes; what is the most essential feature of each regime?

h. How many water depth regimes are possible for a known, constant discharge q? What is the most essential feature of each regime? When is there only one water depth possible?

i. When does a hydraulic jump occur? How can you manipulate a hydraulic jump(by changing the boundary conditions at the upper or lower boundary)?

J Which three forces control fluid mechanics? Which of these three forces is NOT important in uniform river flow? Which of these three forces is NOT important for the flow over a small weir?