Examination Fluid Mechanics I (GEO3-4307) November 2009

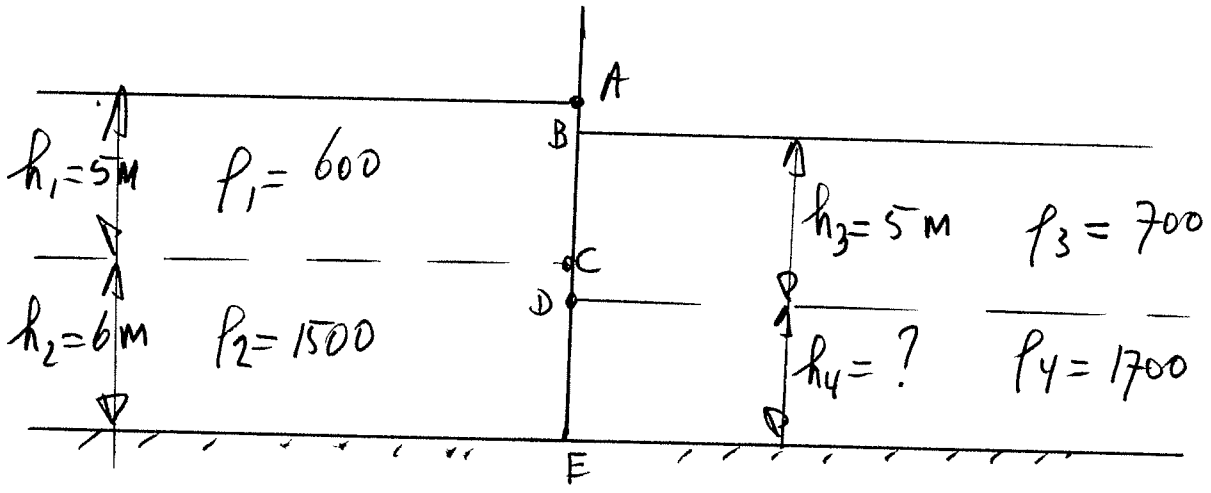
1. Left and right of a gate are two layers of fluid ($g = 10\ m/s^2$):

$\rho 1 = 600\ kg/m^3$,	$h_1 = 5\ m$
$\rho 2 = 1500\ kg/m^3$,	$h_2 = 6\ m$
$\rho 3 = 700\ kg/m^3$,	$h_3 = 5\ m$
$\rho 4 = 1700\ kg/m^3$,	$h_4 = ?$

a) compute the water depth h_4 at which the fluid pressure at the bottom on both sides of the gate is equal.

b) compute the resulting pressures at all interfaces (points A, B, C, D, and E) and make a plot of the pressure distribution.

c) compute the total resulting horizontal fluid force at the gate.



2 A channel with width b_0 = 200 m changes into a structure with a gate. The width of the gate is equal to the width b_1 = 50 m of the downstream channel.

Other data:
H_0 = energy height upstream = 1.25 m
a = opening of gate = 0.15 m
μ = contraction coëfficiënt = 0.66
g = 10 m/s²

a. Make a plot of the energy line along the total traject

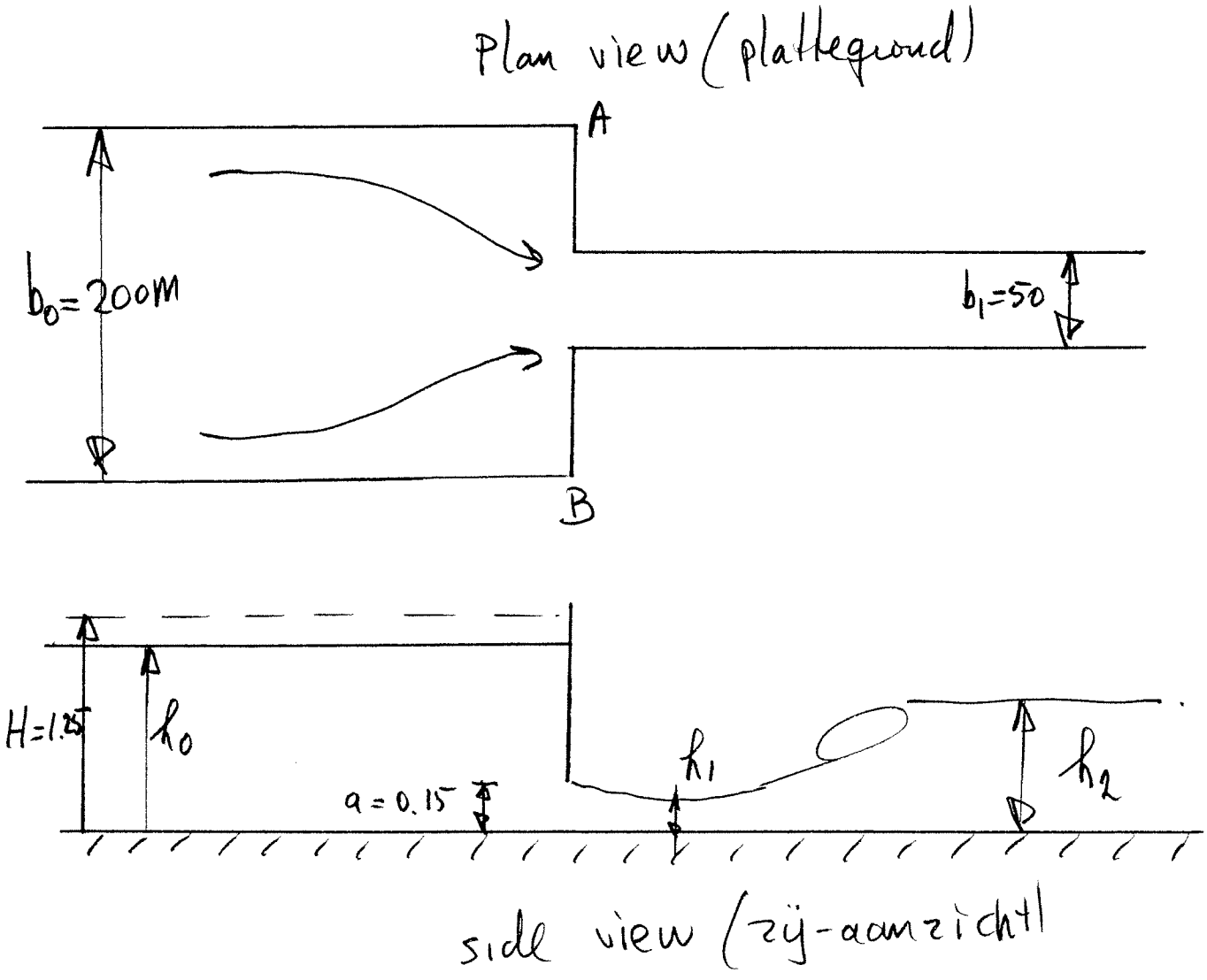
b Compute water depth h_1

c. Compute discharge Q

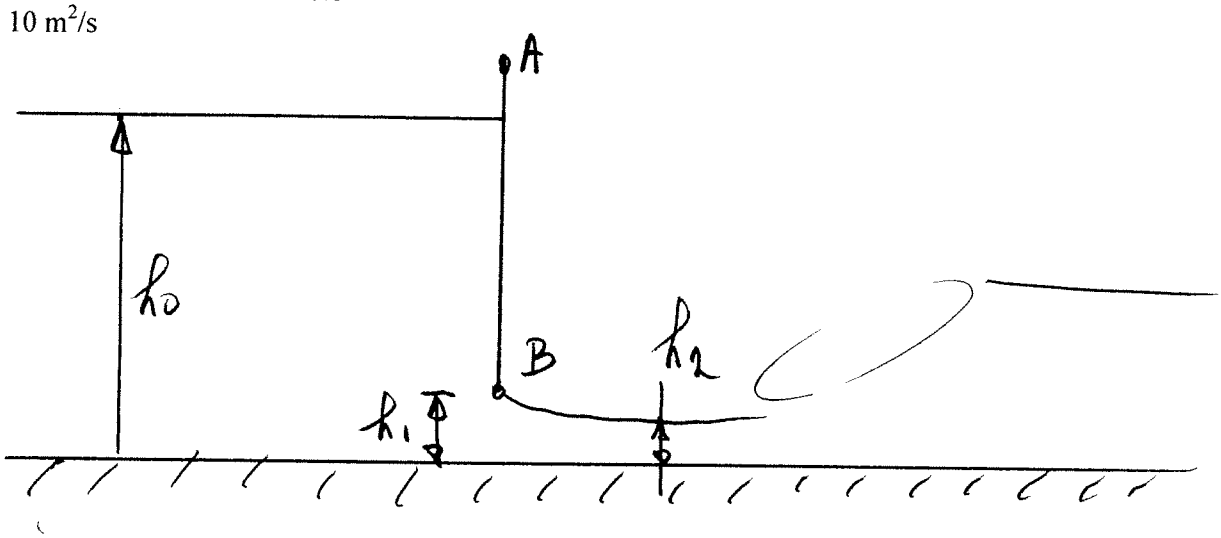
d. Compute the water depth h_2

e. Compute the water depth h_0

f. Compute the force at the wall AB (including the gate)



3. 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_o= water depth upstream = 1 m
μ = contraction coefficient= 0.6
g = 10 m^2/s



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) compute the force at the gate?

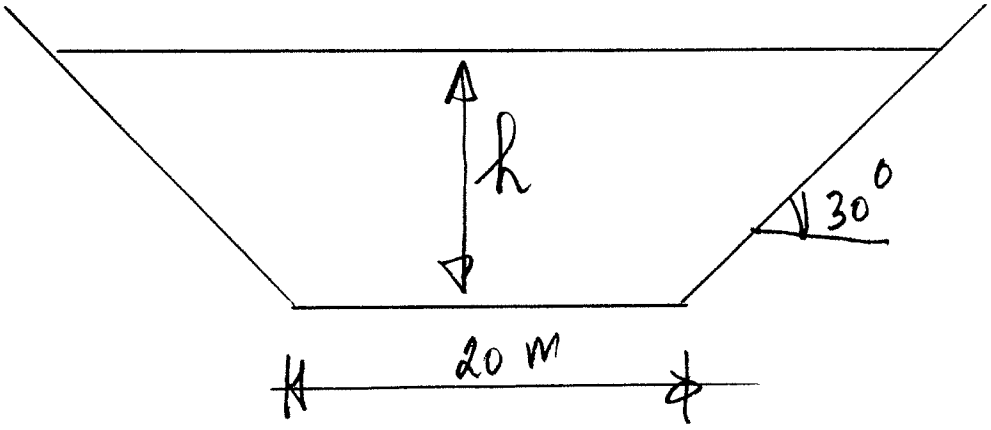
d) The pressures along the gate are measured in 7points

z1= 0.1 m	p1= hydrostatic
z2= 0.2 m	p2= hydrostatic
z3= 0.3 m	p3= hydrostatic
z4= 0.4 m	p4= 3300 N/m^2
z5= 0.5 m	p5= 3700 N/m^2
z6= 0.6 m	p6= 3900 N/m^2
z7= 0.7 m	p7= 3400 N/m^2

What is the force at the gate based on the pressure measurements?

What is the hydrostatic force at the gate?

4. A unform river has a trapezoidal cross-section with
   h= 4.5 m I = 0.0001, B = 20 m, g= 10 m/s^2, side slope angle = 30 degrees,
   viscosity= 0.00001 m^2/s



a) compute the discharge Q if k_s = 0.1 m; what is hydraulic roughness regime?

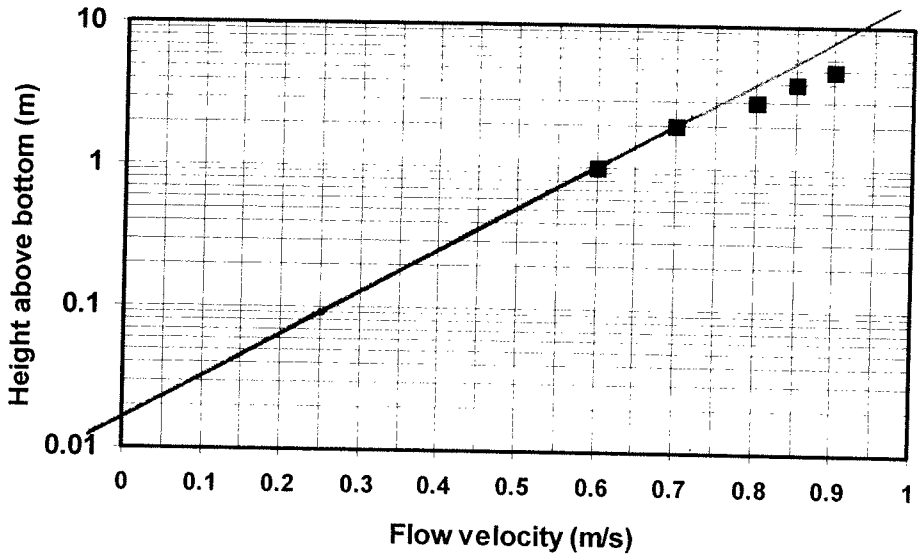
b) compute the discharge Qif k_s = 0.0001 m; what is hydraulic roughness regime

c) what is the depth h, if Q= 200 m^3/s and k_s = 0.1 m

5. Flow velocity measurements have been carried out in a river with water depth h= 6 m, as follows:

z1= 1 m	u1= 0.6 m/s
z2= 2 m	u2= 0.7 m/s
z3= 3 m	u3= 0.8 m/s
z4= 4 m	u4= 0.85 m/s
z5= 5 m	u5= 0.9 m/s

viscosity= 0.000001 m^2/s, kappa $\kappa = 0.4$



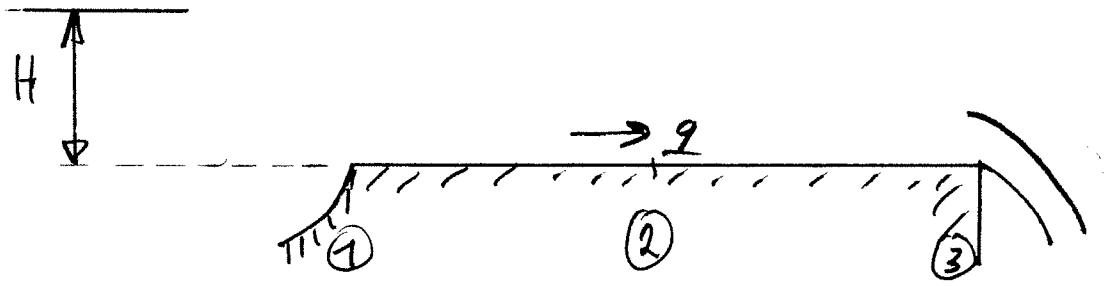
a) what is the depth-averaged flow velocity and at what height above the bottom is the local velocity equal to the depth-averaged velocity?

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 (z1) only?

c) compute the bed-shear velocity u_* and the hydraulic roughness k_s using the measured velocities in the lowest two points (z1 and z2)

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

6. A deep reservoir is connected to a channel with a horizontal bottom
   Free overflow at end of channel
   $q = 0.5\ m^2/s$, $g = 10\ m/s^2$ $H = 0.6$ m, $C = 100\ m^{0.5}/s$



a) what is the water depth h3 at the end of the channel and at the entrance h1 of the channel?

b) what is the length of the channel?

c) what is the water depth h2 in the middle of the channel?

7. Theoretical questions

a) Why is the fluid pressure in a uniform river hydrostatic?

b) When is it allowed to use the Bernoulli equation and when the momentum equation?

c) What is the difference between the momentum equation of Euler and the Reynolds equations?

d) What three terms do we have in the Bernoulli equation?

e) How can a fluid particle describe a curved path? Which type of forces do occur?

f) The Froude number is the ratio of .....
The Reynolds number is the ratio of .....

g) How many water depth regimes are possible for a given discharge q?
What is the most essential feature of each regime?
When is there only one water depth possible?

h) What is a hydraulic jump and when does it occur?
How can you manipulate a hydraulic jump (upstream or downstream)?
The depth upstream is 0.05 m, the velocity upstream is 3 m/s.
The depth downstream is 0.3 m; the velocity downstream is 0.5 m/s.
What is the energy loss (in meters)?

i) In what type of flow regime does a viscous sublayer occur?
What is the thickness of the viscous sublayer: 0.1, 1 or 10 mm?

j) What is a static pitot-tube?
What is a dynamic pitot-tube?

k) The bed of river is covered by grass. How can yo determine the effective roughness k_s of it?

l) The flow velocities near the surface of a river often are smaller than those at lower levels.
What are possible cause for this?

m) The dimension of the Chezy coefficient is $m^{0.5}/s$. Why?

n) The Belanger equation can be used to compute the water level changes in a river (upstream of a weir). Which three forces are included?

o) You are in a boat (length=20 m) on a small river attached to an anchor. The boat does not move. you have a rope, a stone, a watch, a piece of wood and a ruler with a length of 0.5 m.
How can you estimate the discharge q per unit width?