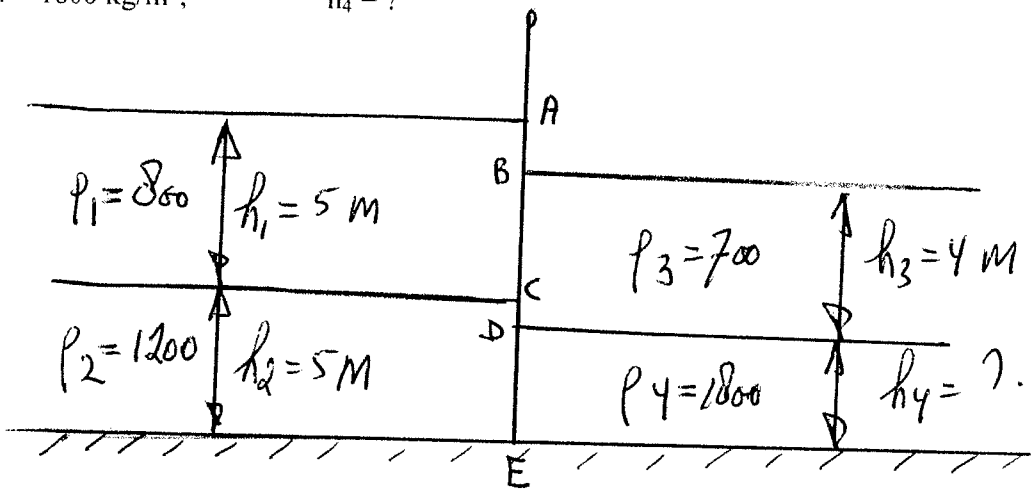
Examination Fluid Mechanics I (GEO3-4307) 12 November 2010

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

$\rho 1 = 800\ kg/m^3$, $h_1 = 5\ m$
$\rho 2 = 1200\ kg/m^3$, $h_2 = 5\ m$
$\rho 3 = 700\ kg/m^3$, $h_3 = 4\ m$
$\rho 4 = 1800\ kg/m^3$, $h_4 = ?$



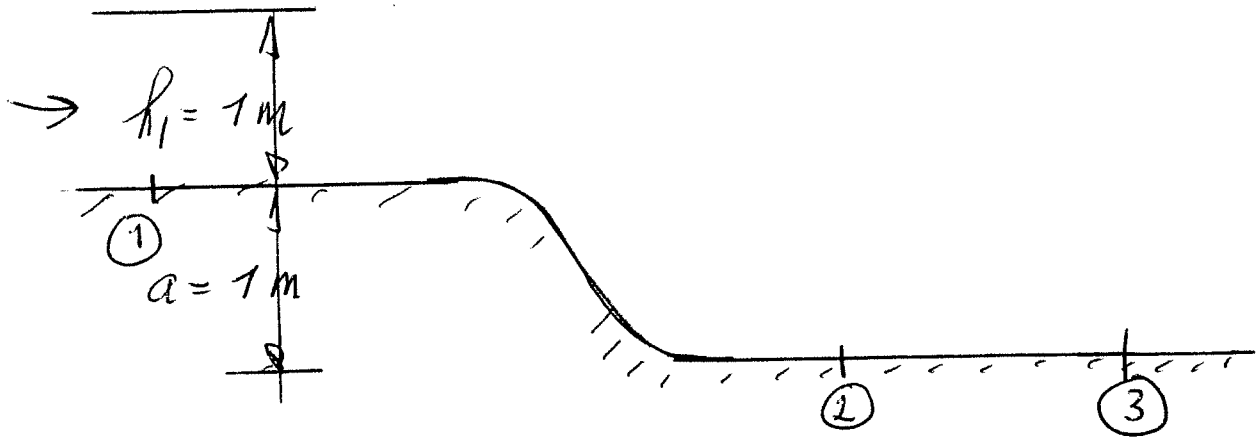
a) Compute the depth h_4 at which the pressure at the bottom is equal on both sides.

b) Compute the resulting (=net) pressures at points B,C, D and E and make a sketch of the pressure distribution.

c) Compute the net pressure force at the gate (use 2 methods)
- using net pressure distribution
- using two forces on both sides.

2. Data of the flow over a weir are:

$q = 5\ m^2/s$; $h_1 = 1\ m$; $g = 10\ m/s^2$; viscosity coefficient= $10^{-6}\ m^2/s$



a) What is de flow velocity at point 1 and what type of flow is present at point 1 (compute Froude number)?

b) Compute water depth h_2 in point 2?
What are the two solutions and what do you take and why?

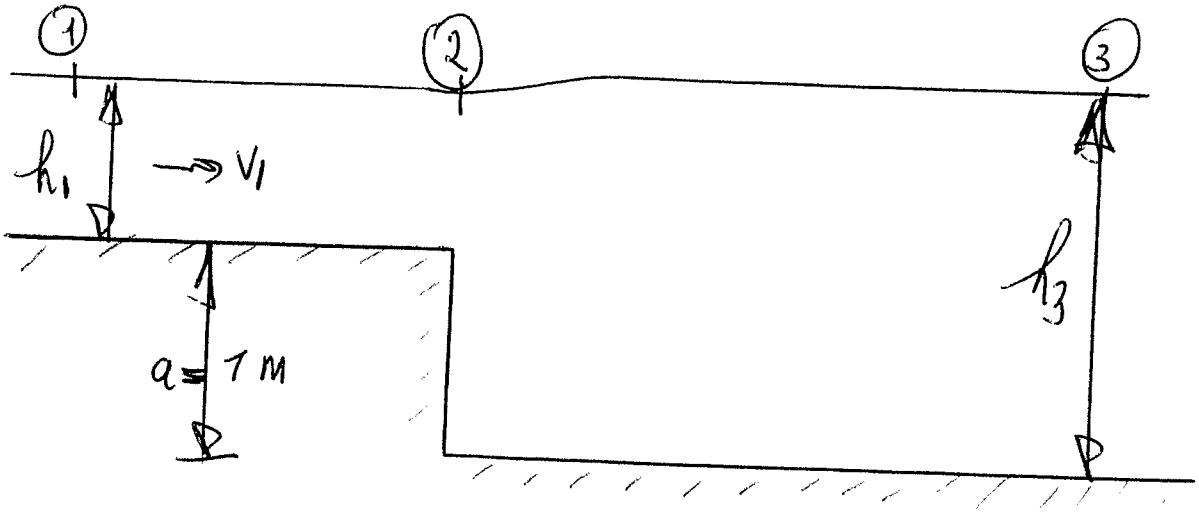
c) What hydraulic phenomenon will occur between points 2 and 3?
Compute the water depth h_3 at downstream side of this phenomenon.

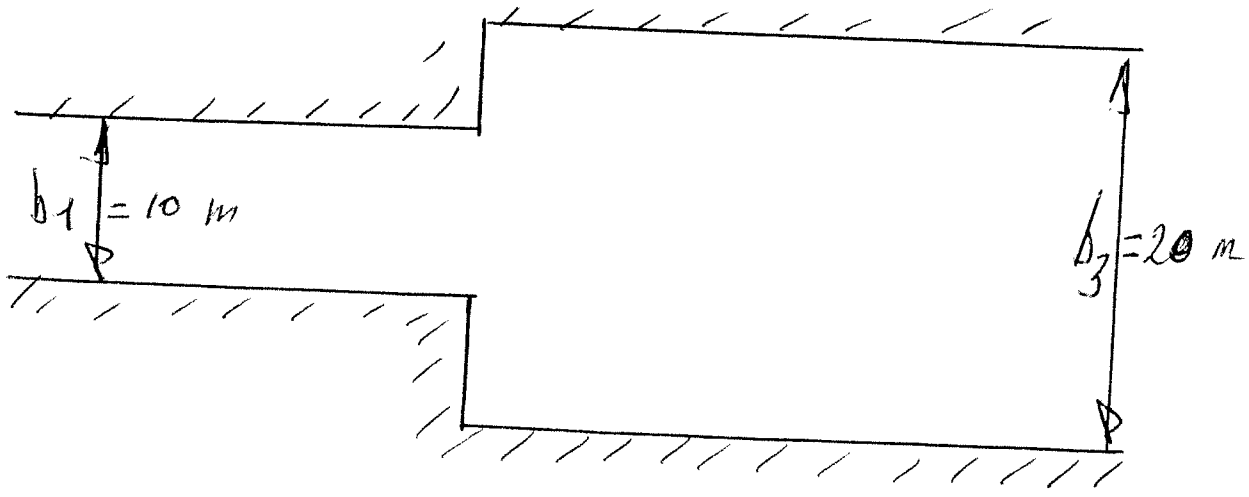
d) Compute energy heights in points 1, 2, 3?
Make a sketch of energy line between points 1 and 3.
What is the energy loss and where does it occur?

3. **A channel with width b_1 = 10 m changes into a wider channel with width b_3= 20 m.**
The bottom of this latter channel is at a= 1 m below the bottom of the other channel.

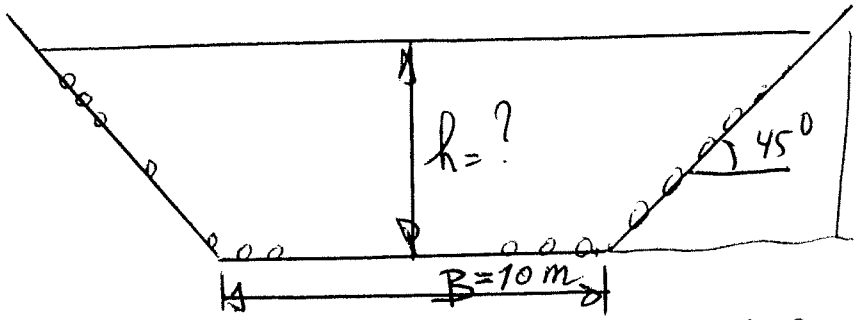
Other data:
h_1 = water depth upstream = 1 m
v_1 = velocity upstream = 1 m/s
h_3 = water depth downstream = 2.05 m
g = 10 m/s²

a. Compute discharge Q
b. Compute the net force at the wall of transition point 2
c. Compute the net hydrostatic ~~pressure~~ Force at the wall of point 2
d. Explain the difference between both values





4. A uniform river has a trapezoidal cross-section with:
h= ? m, Q= 30 m^3/s, I = bottom slope= 0.001, B = 10 m, g= 10 m/s^2,
side slope angle = 45 degrees,
viscosity= 0.00001 m^2/s



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

b) compute the water depth if k_s = 0.0001 m; what is hydraulic roughness regime?

c) flow velocity measurements have been done in the middle of the channel (κ=0.4)

u_1= 0.7 m/s at z_1= 0.1 m
u_2= 0.9 m/s at z_2= 0.3 m

what is the bed-shear stress u_* and what is the bed roughness k_s?

sin = over / schuin

schuin = over / sin 45°

$\frac{1}{2\sqrt{2}} h$

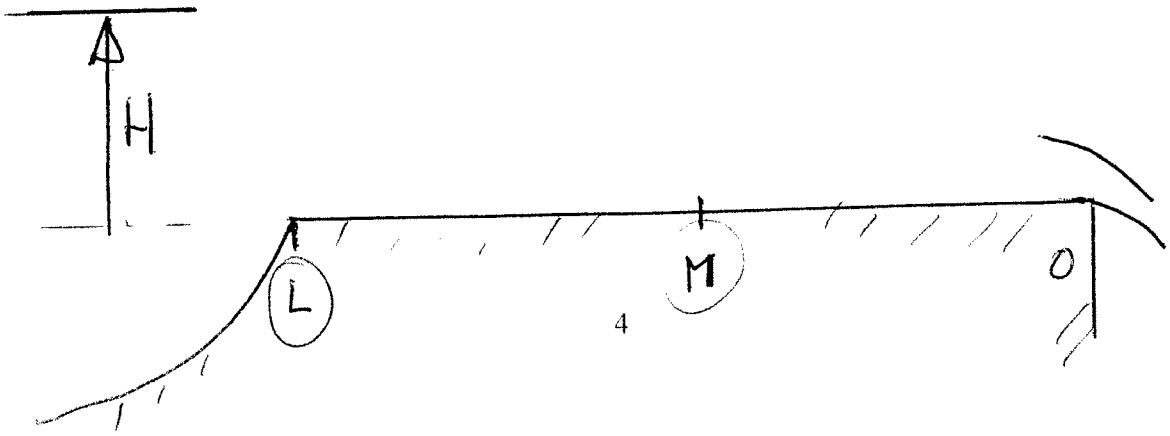
$h\sqrt{2}$

tan = h / a

a = h / tan

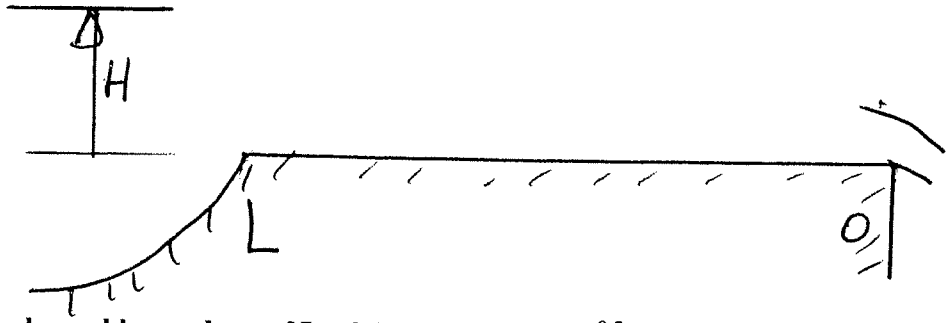
5 A deep reservoir is connected to a channel with horizontal bottom.
At the end there is a free outlet.
The discharge per unit width is q = 0.5 m^2/s (g = 10 m/s^2). H=0.6 m; C=100 $m^{0.5}/s$

a) What is the water depth at the outlet?
What is the water depth at the entrance of the channel?
b) What is the length of the channel?
c) What is the water depth in the middle of the channel?
d) One half of the channel will be made more rough to increase the water level in the middle with 0.05 m. What half (left or right) of the channel has to be selected? What C-value is required to do this?



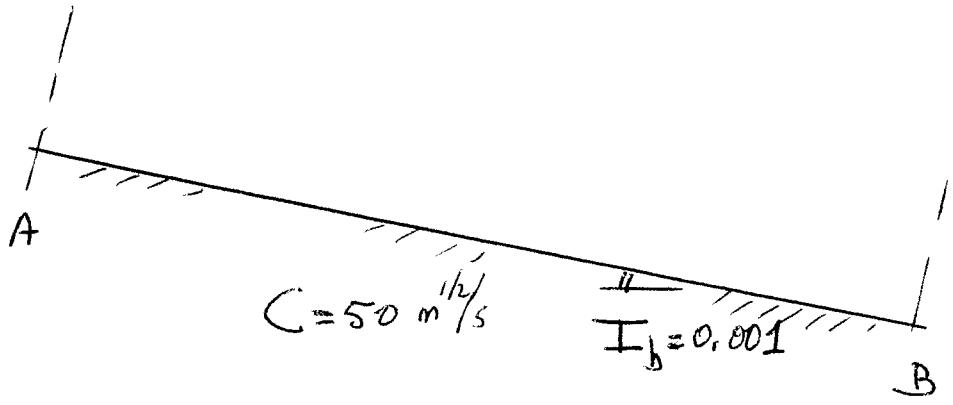
6. **A deep reservoir is connected to a channel with horizontal bottom.**
At the end there is a free outlet.
H=0.6 m; C= 60 $m^{0.5}/s$, L= 300 m

Give three equations to determine the discharge and the water depths at the outlet h_o and the entrance h_L of the channel and Can you solve this system of equations?



7. **A channel has a slope of I_b= 0.001 and C= 50 $m^{0.5}/s$, q= 5 m^2/s**
The water depth at the downstream end is equal to the critical depth
The water depth will adjust in upstream direction to the equilibrium depth.

a) Compute the critical depth and the equilibrium depth
b) What is the approximate length L at which the equilibrium depth is present?



8. Theoretical questions

a) What force is neglected in the equation of Bernoulli?
When is it allowed to use the Bernoulli equation and when the momentum equation?

b) What is the difference between the momentum equation of Euler and Reynolds?
What is the difference between the Navier-Stokes equations and the Reynolds equations?

c) The velocity in point A= 1 m/s. The velocity in point B= 1.1 m/s.
The distance between both points is 10 m. What is the convective acceleration?
The velocity in a point is 1 m/s. The velocity in the same point is 1.1 m/s after 15 minutes. What is the acceleration?

d) What is the concept of hydraulic radius?
What is the hydraulic radius of a circular cross-section?
What is the bed-shear stress in a river with hydraulic radius R and slope I?

e) What four parameters determine the bed roughness as given by the Chezy-coefficient C?
How can you determine the Nikuradse roughness k_s of sand waves?

f) What is the bed-shear stress in uniform, laminar flow with depth h and slope I?
What is the bed-shear stress in uniform turbulent flow with depth h and slope I?

g) How can a fluid particle describe a curved path? Which type of forces do occur?
How can a fluid particle describe a curved path in a cup with moving water?

h) 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?

i) A reservoir is closed by a dam. At depth H below the water surface, there is an outlet
What is the velocity in the outlet?
Is there a difference in velocity if the reservoir is filled with oil in stead of water?

j) What is a hydraulic jump over a horizontal bottom and when does it occur?
How can you manipulate a hydraulic jump (upstream or downstream)?
The depth upstream is 0.1 m, the velocity upstream is 3 m/s.
The depth downstream is 0.5 m;
What is the energy loss (in meters)?

k) 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?
What are three roughness regimes? What parameter is used to determine the roughness regime?

l) What is a static pitot-tube? What is a dynamic pitot-tube?
The velocity head measured is 0.1 m at mid-depth of the flow.
A small plate with area 0.01 m^2 (square with sides 0.1 m) is held in place close to the pitot tube.
What is the force at the plate?

m) The flow velocities near the surface of a river often are smaller than those at lower levels.
What are possible cause for this?
How can you measure the bed-shear stress in a river with a bottom of stones (2 methods)?

n) The water surface slope in a non-uniform river can be described by the Belanger equation
Which three forces are included? In what case can we obtain an analytical solution?
What is the equilibrium depth in this equation?
If a weir is placed to raise the water depth, how can you find the length where the depth is equal to the equilibrium depth?