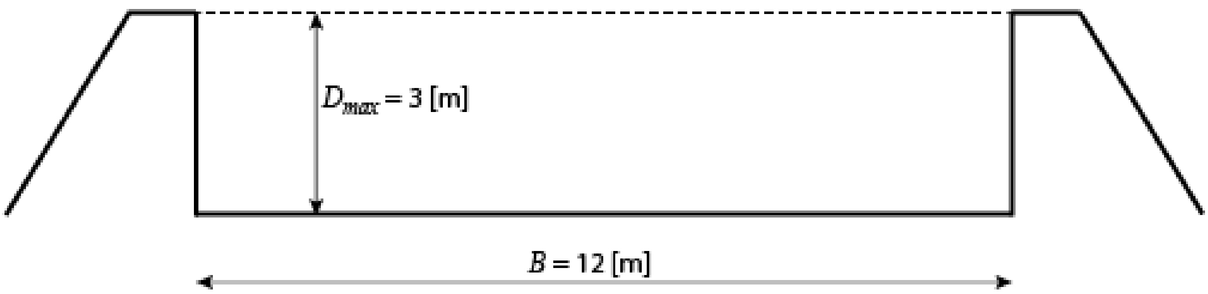
Name: ……………………………………….   Student number: …………………

TECHNICAL HYDRAULICS – Exam October 2018

Question 1. **(33/133 points)**

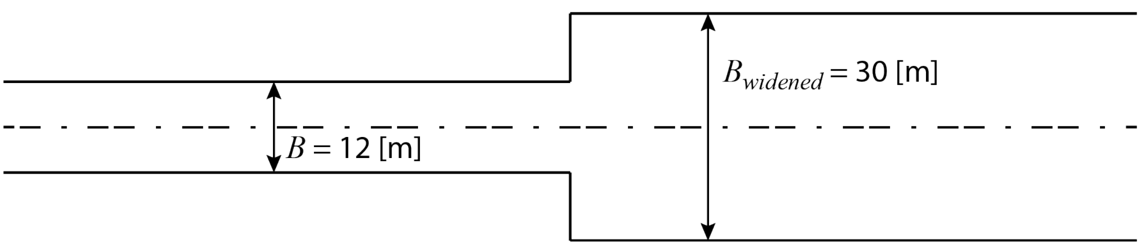
A trained reach of a river has invariable geometric characteristics: its longitudinal bottom slope is $J_f = 0.01$ and its cross-sectional shape is rectangular with a width of $B = 12$ [m]. The crest levels of both banks are 3 [m] above the bottom level. The Manning-Strickler friction coefficient is estimated at $K_s = 40$ [$m^{1/3}$ s^{-1}].



Consider the flood discharge with a recurrence period of 20 years, which is estimated at Q = 100 [m^3 s^{-1}].

1. Compute the normal flow depth (2 points) and critical flow depths (2 points) and determine the flow regime (2 points). (6 points)
2. Draw the specific energy curve. Represent the points for flow depths of 1.0 [m], 1.25 [m], 1.5 [m], 2.0 [m], 2.5 [m] and 3.5 [m]. Represent also the critical and normal flow depths on the specific energy curve. (3 points)

In the framework of a river restoration project, the river width is increased to 30 [m]. The transition between the trained reach upstream and the widened reach is sudden. The crests of both banks are still 3 [m] above the channel bottom and the bottom slope is unchanged.



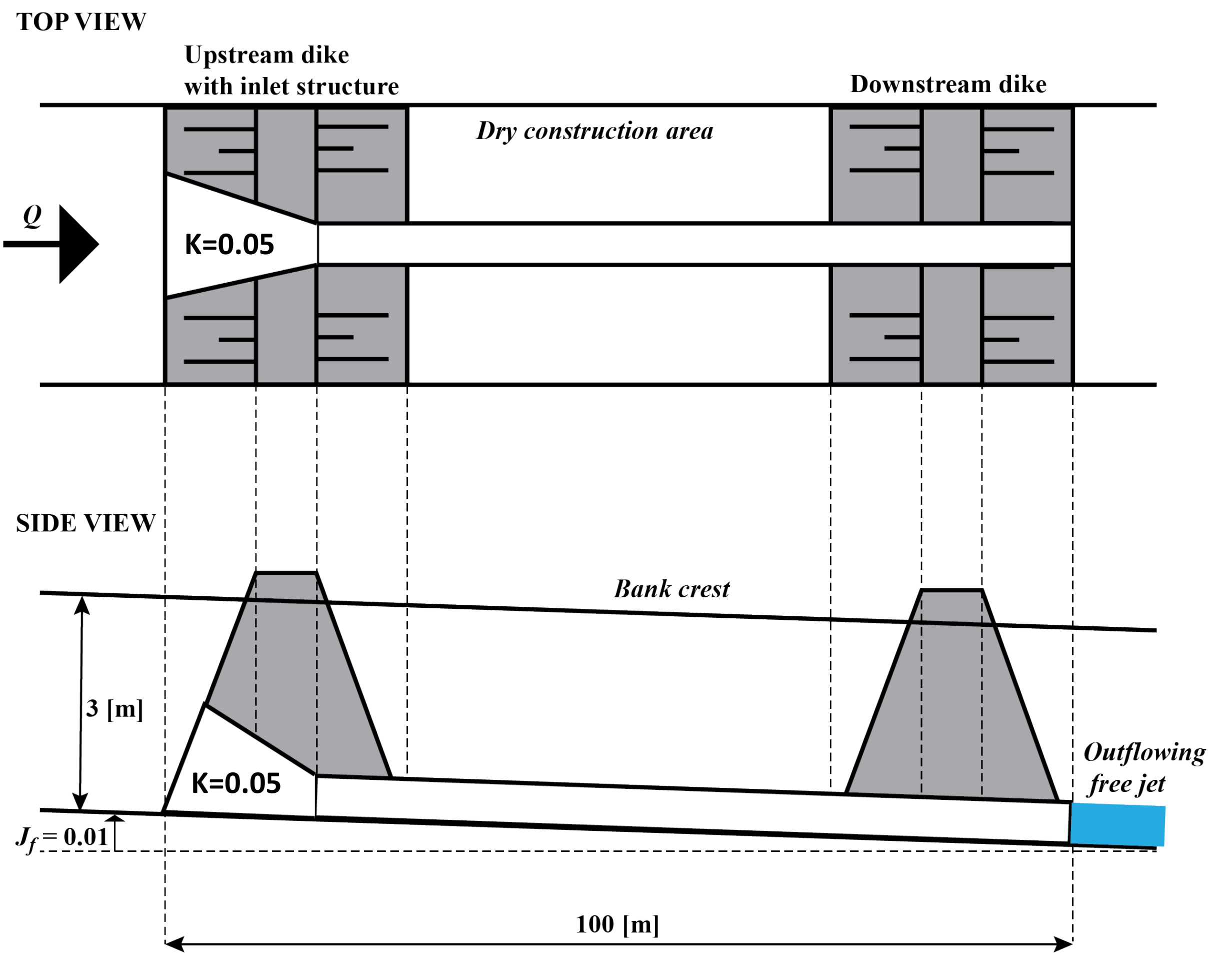
Unfortunately, the flood discharge occurs during the construction works.

3. Compute the normal flow depth (2 points) and the critical flow depth (2 points) and determine the flow regime (2 points). (6 points)
4. Draw the specific energy curve. Represent the points for flow depths of 0.3 [m], 0.5 [m], 0.8 [m], 1.0 [m], 1.5 [m] and 3.5 [m]. Represent also the critical and normal flow depths on the specific energy curve. (3 points)
5. Draw qualitatively the backwater curves, and indicate the bottom, normal depths and critical depths. Name the different branches of the backwater curves. (10 points)

6. Indicate the relevant points of the backwater curves in the specific energy diagram. (5 points)

Question 2. (Please use a new sheet) **(25/133 points)**

A dry reach is established in order to enable the construction of the widening. It is separated from the river by dikes upstream and downstream. The entire river discharge is deviated over the entire length of the dry reach by means of 100 [m] long concrete pipe with diameter D = 1.25 [m] and equivalent sand roughness k_s = 0.0002 [m].
An inlet structure is built in the upstream dike as transition between the open-channel cross-section and the pipe. This inlet structure induces minor energy losses characterized by a loss coefficient of K = 0.05. The water flows freely out of the pipe without inducing minor energy losses. The situation is schematized in the figure, which is not on scale.



1. Establish the equation that allows determining the discharge in the pipe as a function of the water level at the upstream face of the upstream dike. (15 points)
2. Determine the maximum river discharge Q_{max} before inundations occur in the reach upstream (due to insufficient capacity of the pipe). (4 points)
3. Justify the value of the Darcy-Weisbach friction coefficient f used in your computations. (6 points).

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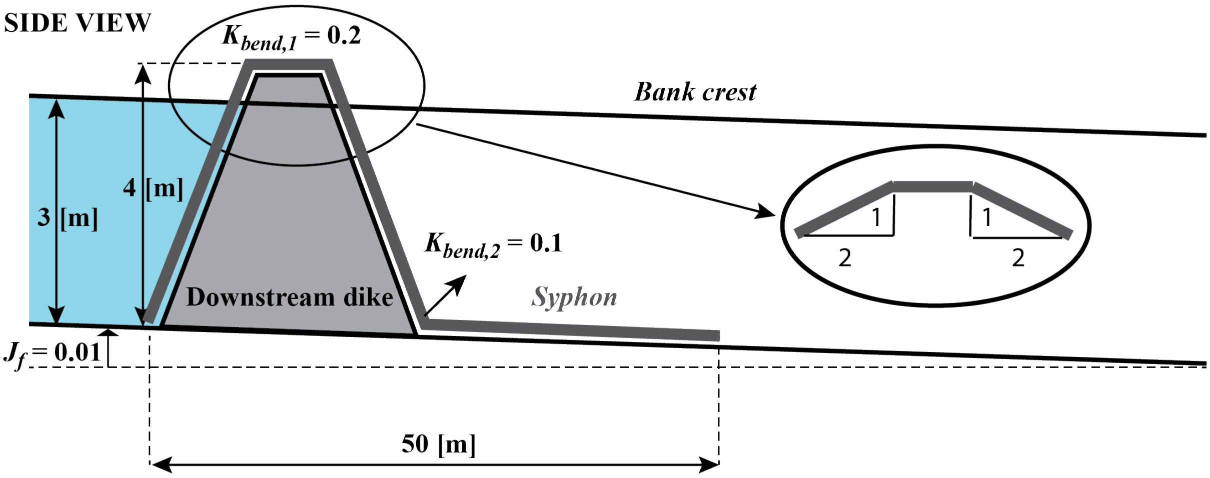
Question 3. (Please use a new sheet) **(45/133 points)**

Due to the occurrence of a large flood, the dry reach of the previous question has been inundated. A syphon is used to empty the reach. The syphon has a total length of 62 [m], a diameter of D = 0.35 [m] and an equivalent sand roughness of k_s = 0.0005 [m]. The geometry of the syphon is indicated in the figure:



Consider the situation at the beginning of the emptying process, when the water level upstream is 3.0 m. The water flow in the syphon has been initiated by suction. Assume that there are minor energy losses at the inflow characterized by a loss coefficient of K_{inflow} = 0.2, minor energy losses in the double-bend at the highest point of the syphon with a loss coefficient of $K_{bend,1}$ = 0.2 and minor energy losses in the second bend with a loss coefficient of $K_{bend,2}$ = 0.1 (see Figure).

1. Establish the equation that allows determining the initial discharge in the syphon. (15 points)
2. Determine the initial discharge in the syphon. (4 points)
3. Justify the value of the Darcy-Weisbach friction coefficient f used in your computations. (6 points)
4. Draw the total energy line and the potential energy line. (10 points)
5. Determine the value and the location of the lowest pressure in the syphon (6 points). Discuss the risk of cavitation (4 points). (10 points)

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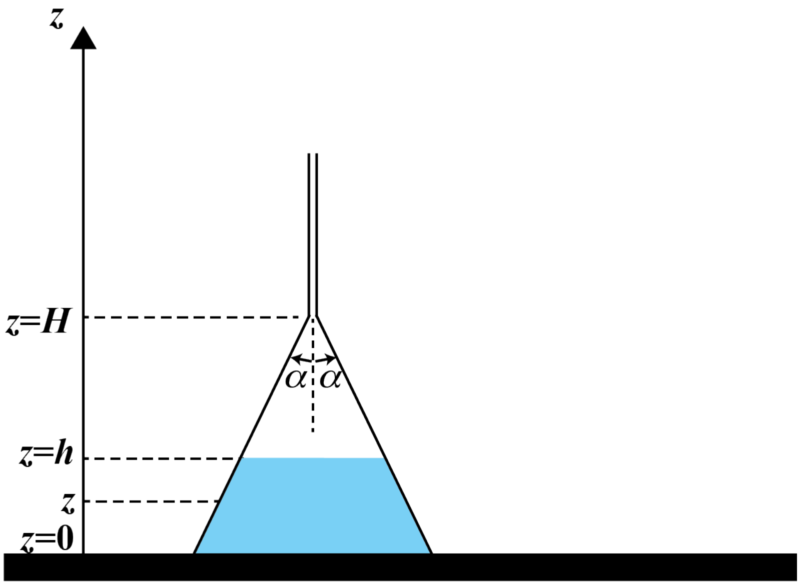
Question 4. Please use a new sheet **(30/133 points)**

Consider a funnel of conical shape (3D) as sketched in the figure. The funnel is flipped upside down and put on a horizontal table. The funnel is slowly filled up to a height *h* with a liquid of density ρ through a pipe at its top, which has negligible diameter and remains open.



1. Determine the direction and sense of the resulting hydrostatic force on the funnel. Justify your answer. (5 points)
2. Determine the analytical expression for the resultant hydrostatic force as a function of ρ, g, h, H and α. (15 points)
3. Demonstrate that the funnel requires a finite weight in order to avoid being lifted from the table. Determine the minimum required weight. (10 points)