Dear All,

below I summarize the modalities of the **final exam** for the course of **River Hydraulics from the Hillslopes to the Estuary**.

As already explained during the lessons, you have two possibilities:

I) Oral examination;

II) Written Relation and Oral Presentation on the **homeworks** assigned during the lessons.

If you choose the **oral examination** modality, I will ask you **two questions** about **any of the various topics** we have treated during our classes. You will be required to answer to the question (by writing on a sheet of paper or on the blackboard) with particular emphasis on: **i)** the formulation of the considered problem; **ii)** the assumptions and/or the simplifications made; **iii)** the reasoning leading to the final results; **iv)** the physical and/or practical implications of your treatment of the problem.

If you choose the **homework examination** modality, you are required to produce a **written relation** (max 5 to 10 pages) on the homeworks assigned during the lessons and listed in the attached file. This relation will then be **discussed orally**, through a **power point presentation**. Clearly, during this presentation you are expected to answer to possible questions on **what you have done,** e.g. why a given procedure has been chosen, which are the assumptions embedded in this choice and the possible limitations, how the procedure was implemented and which is the physical interpretation of the results, etc.

Each **written relation** should be organized including the following sections: *Introduction, Material and Methods, Results, Discussion, Conclusions*. The **relations** should be sent by email to stefano.lanzoni@unipd.it at least two days before the oral presentation. If the files are too large, you can put them in a dropbox folder and send me by mail the dropbox link.

Besides the notions delivered during the lessons, you can take advantage of the book by Chaudry (Chaudhry M. H., Open-Channel Flow. Prentice Hall, 1993) and, as far as HEC-RAS and QGIS are concerned, of the numerous guides available online.

Please let me know if you need any clarification.

Best regards,

Stefano Lanzoni

Homework List.

Using the computational tools you prefer (e.g. Matlab, Python, Excel, ect) perform the following homework.

Homework 1. Free surface profiles in open channels

1.1 *Compute, and plot* the *water surface profile* that establishes downstream a *sluice gate* placed in an open channel sufficiently long for ensuring the formation of the uniform flow depth far downstream (Figure 1). The channel has a rectangular cross section of width B = 10 m, a bed slope $S = 0.001$ and is characterized by a Gauckler-Strickler coefficient K_{GS} = 20 $m^{1/3}/s$. The gate opening is a = 0.5 m and allows to convey a discharge Q = 20 m^3/s. The gate edge is sharp and, hence, the contraction coefficient can be taken equal to C_c = 0.61. Check for the possible formation of a hydraulic jump and, in case, localize it using the conjugate depth relation.

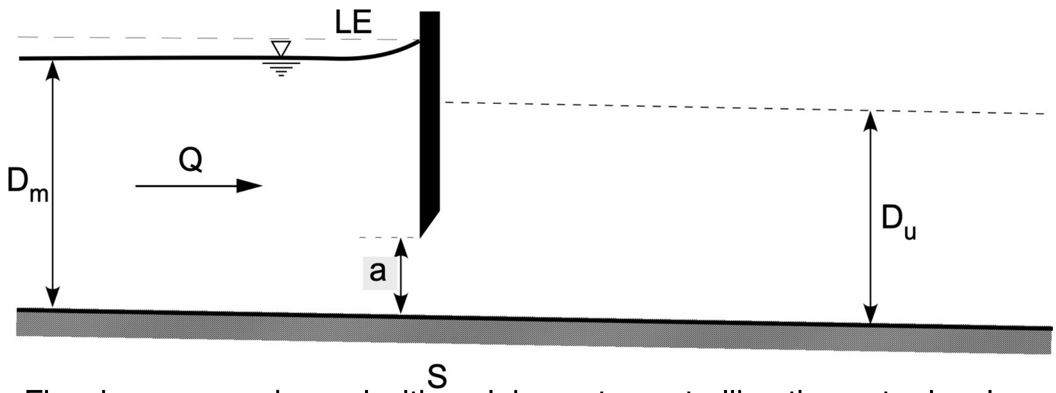

Figure 1: Flow in an open channel with a sluice gate controlling the water level.

1.2 *Compute, plot and discuss* the free surface profiles which form in a long, mild-slope channel (of overall length L) in which an assigned unit length discharge q_l is injected laterally. The channel reach subject to this discharge injection has a length $L_{\Delta q}$ (Figure 2). In the analysis, assume that the downstream channel section is characterized by critical flow conditions. Evaluate how the free surface profiles vary as the injected discharge decreases/increases.

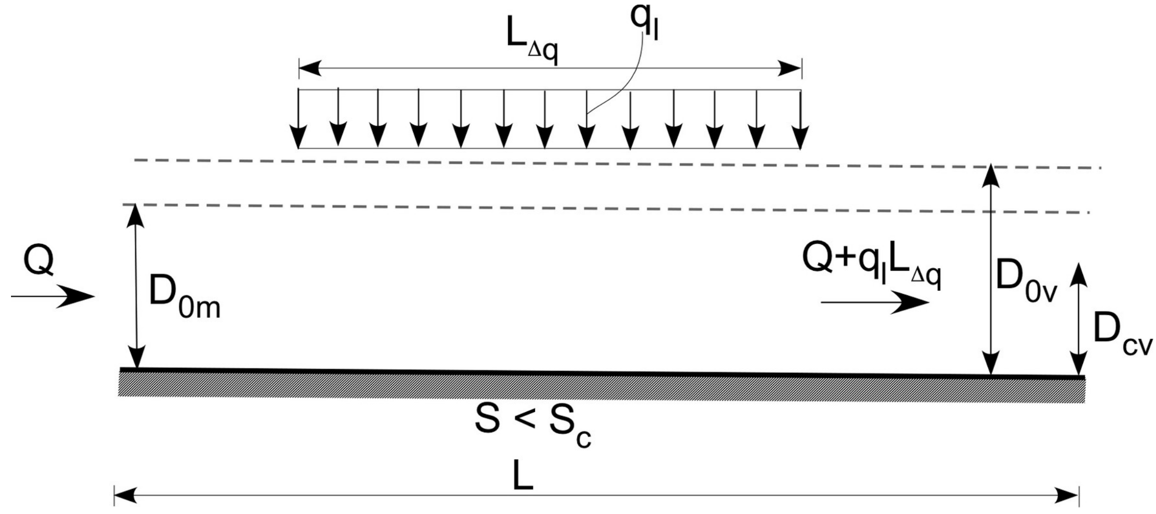

Figure 2: Lateral injection of discharge in an open channel with a mild (sub-critical) bed slope and a critical flow condition imposed at the downstream end section.

1.3 *Compute, plot and discuss* the free surface profiles which form in a rectangular channel with mild slope immediately after the break of a barrage placed in the central section of the channel (Figure 3). Prescribe the initial water depth $D(t_0)$ upstream of the barrage and assume that the bed slope S equals the friction slope S_f. Compute and plot also the along channel distributions of the flow discharge Q and of the Froude number at various instants after the dam break.

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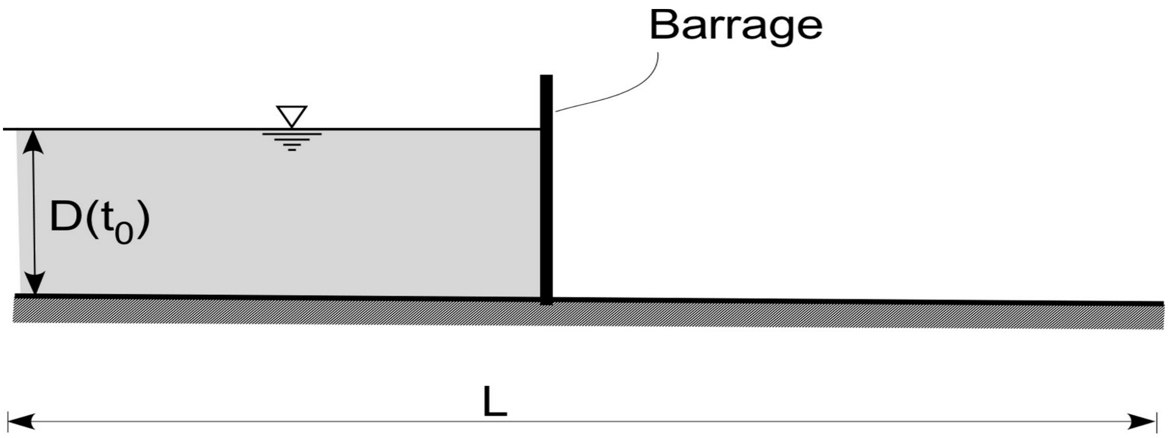

Figure 3: Initial configuration ($t=t_0$) of the water level before the collapse of the barrage. The water contained upstream of the barrage has a flow depth $D(t_0)$ and a negligibly small velocity.

In problems 1.2 and 1.3 assume that the channel has a rectangular cross-section of width B. The selection of physically sounding values of the relevant parameters (e.g., channel length, bed slope, flow discharge, bed friction, etc) represents an integral part of the homework.

Homework 2. Flow field characteristics in a reach of the Po River**.**

Using the HEC-RAS and QGIS:

- Analyze the geometry of a Po River reach starting from Cremona and ending about 100 km downstream. Using the DTM, consider the bed topography included between the left and the right embankments. Extract a suitable number of cross section geometries from the DTM and implement a full 1D model. Next, implement a full 2D model, discretizing the flowing areas with an appropriate grid discretization and suitable break lines to set physical obstacles and other elements interacting with the flow;

- Use the hydrographs provided for the Cremona section, considering at least three values of the return times (e.g. 100, 200, and 500 years). Use these hydrograms as upstream boundary conditions (i.e. flow entering the domain) in the 1D and 2D models. Choose an appropriate downstream boundary condition in both models, justifying your choice);

- Run the 1D and 2D models and export the results from RAS Mapper in QGIS. Compare and discuss the result obtained with the 1D and the 2D approaches for the different flow rates. Furthermore, evaluate the sensitivity or these results to possible uncertainties associated with the selection of the flow resistance, motivating your final choice.