Hydraulics

Tutorial Sheet 10 – Pipe networks

1. Aviation fuel flows from tank A to tank B through two pipes connected in series. Determine the discharge, given the data:

	Pipe 1	Pipe 2
Length L	$300\,\mathrm{m}$	$240\,\mathrm{m}$
Diameter D	$600\,\mathrm{mm}$	$1\,\mathrm{m}$
Roughness	$2\,\mathrm{mm}$	$0.3\,\mathrm{mm}$
Total head loss ΔH	$6\,\mathrm{m}$	
Kinematic viscosity ν	$3\times10^{-6}\,\mathrm{m^2\,s^{-1}}$	
K_{entry}	0.5	
$\Delta H_{\text{expansion}}$	$(U_1-U_2)^2/2g$	
$K_{\text{exit}}=\alpha$	1.3	

Use the Haaland approximation for the friction coefficient λ. (*Ans*: $0.79\,\mathrm{m^3\,s^{-1}}$).

2. A new reservoir supplies water to a service reservoir $10\,\mathrm{km}$ away with a total supply head of $100\,\mathrm{m}$. It is required to supply $200\,\mathrm{L\,s^{-1}}$, at $20\,°\mathrm{C}$ ($\nu=10^{-6}\,\mathrm{m^2\,s^{-1}}$). Initially allow for an entry loss of $K=0.5$ and an exit loss of $\alpha=1.3$. Use the Haaland approximation for λ.
   a. Justify your decision to ignore entry and exit losses.
   b. Design the pipeline, namely calculate the diameter necessary, if it is to be made of galvanised iron with a roughness of $d=0.03\,\mathrm{mm}$, and round up to the nearest multiple of $25\,\mathrm{mm}$.
   c. What is the unregulated discharge in the pipeline?
   d. Calculate the head loss to be provided by a valve to regulate the flow to $200\,\mathrm{L\,s^{-1}}$.

   (*Ans*: $350\,\mathrm{mm}$, $217\,\mathrm{L\,s^{-1}}$, $15\,\mathrm{m}$).

3. Three reservoirs are connected by pipelines which meet at a junction. The data for the reservoirs and corresponding pipelines are

Reservoir/pipeline	1	2	3
Surface elevation H	$30\,\mathrm{m}$	$18\,\mathrm{m}$	$9\,\mathrm{m}$
Pipe diameter D	$1\,\mathrm{m}$	$0.45\,\mathrm{m}$	$0.6\,\mathrm{m}$
Area $=\pi D^2/4$	$0.785\,\mathrm{m^2}$	$0.159\,\mathrm{m^2}$	$0.283\,\mathrm{m^2}$
Relative roughness d/D	0.0002	0.002	0.001
Pipeline length L	$3000\,\mathrm{m}$	$600\,\mathrm{m}$	$1000\,\mathrm{m}$

Calculate the discharge in each of the three pipes, assuming a viscosity of $\nu=10^{-6}\,\mathrm{m^2\,s^{-1}}$, and neglecting all local losses.

Use formulae given in the lecture notes which automatically allow for changes in flow direction:

$$Q_{i\mathrm{J}} = A\,\mathrm{sign}\,(H_i - H_\mathrm{J})\sqrt{\frac{2g\,|H_i-H_\mathrm{J}|}{\lambda L/D}},$$

where $Q_{i\mathrm{J}}$ is the flow from reservoir i to junction J.

(*Ans*: Pipeline 1: $1.20\,\mathrm{m^3\,s^{-1}}$ from the reservoir to the junction, Pipeline 2: $0.33\,\mathrm{m^3\,s^{-1}}$ from junction to the reservoir, and Pipeline 3: $0.873\,\mathrm{m^3\,s^{-1}}$ from junction to reservoir).

4. Repeat Question 3 using *Excel Solver*.Was it easier?