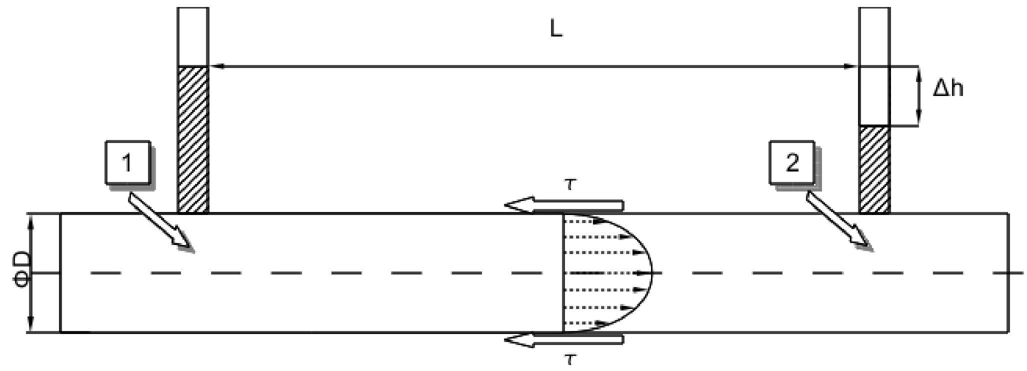

Figure 1: Drop in liquids pressure at distance L, as it flows through a pipe of diameter D.

Hydraulic pressure loss coefficient[1]

key words: Pressure loss, turbulent and laminar friction coefficient, Blasius' equation, Nikuradse or Moody diagram.
goals: The objective of this exercise is to measure pressure loss coefficient for an incompressible, turbulent and laminar flow through a pipeline.

1 Introduction

Any real life engineering phenomena is accompanied by energy dissipation. It is no different with a real fluid in motion. In case of a liquid flowing through a straight pipe energy losses are an effect of shear stresses (τ) acting against the flow. Those energy losses manifest itself by drop in **hydraulic head**[2] at consecutive cross-sections of the flow, and are referred to as **head losses**[3]. This is shown in Fig.1.

Pressure losses Δp_{loss} resulting from liquid's flow through a pipe of diameter D and length L are proportional to liquids dynamic pressure. And are defined by the so called **Darcy-Weisbach equation**

$$\Delta p_{loss} = \lambda \frac{L}{D} \frac{\rho V^2}{2} \tag{1}$$

The proportionality coefficient λ is the so called **Darcy friction factor**.

[1]In English nomenclature **Darcy friction factor**.
[2]Pressure expressed as **hight** of a static column of fluid. Expressed in meters, millimeters ...
[3]Also referred to as resistance head or friction head

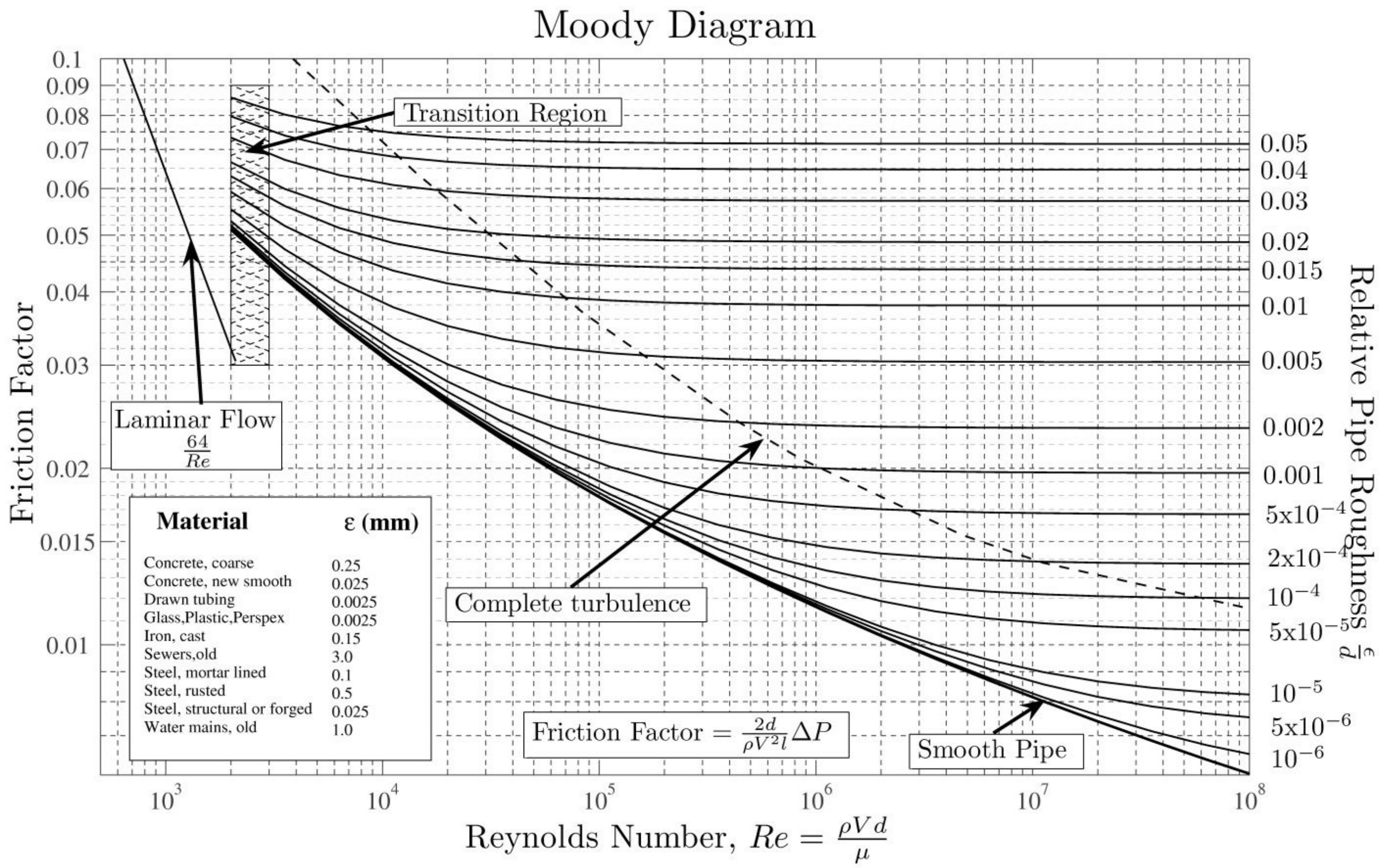

Figure 2: Nikuradse or Moody diagram. Relates friction factor, Reynolds number and relative roughness for flows through circular pipes. From `http://en.wikipedia.org/wiki/Moody_chart`

Friction coefficient λ varies strongly with the Reynolds number[4]. For laminar flows ($Re < 2300$) it might be calculated analytically from Hagen-Poiseuille equation to be:

$$\lambda = \frac{64}{Re} \tag{2}$$

However for turbulent flows empirical formulas are used. A good approximation is given by the Blasius[5] formula (for flows where $Re < 8 * 10^4$):

$$\lambda = \frac{0.316}{\sqrt[4]{Re}} \tag{3}$$

Equation 1 and 2 are valid only in case of **smooth** and **circular** pipes. In case of rough surfaces values of the friction factor are found by experiment. Such experiment were performed by Johann Nikuradse[6]. Figure 1 shows the so called Nikuradse diagram[7] relating friction factor λ, Reynolds number and relative roughness of the pipe.

2 Measurements and calculations

Using the experimental setups for laminar and turbulent flows investigate pressure losses. Perform appropriate measurements and calculations.

2.1 Pressure loss coefficient for turbulent flow

1. Get acquainted with the experimental setup, check how manometers are connected and what is being measured.
2. Copy all the necessary dimensions of the investigated installation to your report.
3. Start the flow through the installation, manipulate the flow rate with a valve.
4. Using a stopwatch measure a time t necessary to fill the reference tank of volume V.
5. Note the pressure losses.

[4] $Re = \frac{V*D}{\nu}$, Pipe diameter D is used as characteristic length.

[5] Paul Richard Heinrich Blasius (1883-1970) was a German fluid dynamics engineer.

[6] Johann Nikuradse (November 20, 1894 July 18, 1979) Georgia-born German engineer and physicist.Lived mostly in Gttingen.

[7] In English nomenclature **Moody chart**.

6. Repeat the measurements at different flow rates. Ask the tutor for the number of test you should perform.
7. Stop the flow through the installation when finished.
8. Note water temperature.
9. For each of the measurements calculate: pressure loss, flow velocity, Reynolds number and friction factor λ.
10. Plot the results on a $\lambda(Re)$ plot, and compare with Blasius formula 3.
11. Comment on the results.

2.2 Pressure loss coefficient for laminar flow

1. Get acquainted with the experimental setup, check how manometers are connected and what is being measured.
2. Copy all the necessary dimensions to your report.
3. Start the flow, manipulate the flow rate by changing hight H of the water source.
4. Using a stopwatch measure a time t necessary to fill graduated cylinder used for reference.
5. Measure the pressure drop.
6. Repeat the measurements at different flow rates. Ask the tutor for the number of test you should perform.
7. Note water temperature.
8. For each of the measurements calculate: pressure loss, flow velocity, Reynolds number and friction factor λ.
9. Plot the results on a $\lambda(Re)$ plot, and compare with formula 2.
10. Comment on the results.

Dear student,
should you have any remarks, observations or comments concerning this instruction. Please do not hesitate to make them.