**Prince Mohammad bin Fahd University**

Core Curriculum: Department of Engineering

**GEEN 3311 Introduction to Fluid Mechanics**

**Section 103 for Dr Feroz Shaik**

**Report: Determination of Flow in Pipes**

**Due date: Saturday 3rd April 2021 @ 23:59 [blackboard]**


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# Problem Statement

In this project we aim to determine the flow with the help of flow measurement devices such as venturi and orifice meter. The main idea is to find out the coefficient of discharge of the two devices so that we can finally measure the actual flow which is quite different from the theoretical flow due to several reasons such as frictional losses etc.

The venturi meter has a converging conical inlet, a cylindrical throat and a diverging recovery cone. It has no projections into the fluid, no sharp corners and no sudden changes in contour. Venturi meter is with a uniform cylindrical section before converging entrance, a throat and divergent outlet. The converging inlet section decreases the area of the fluid stream, causing the velocity to increase and the pressure to decrease. The low pressure is measured in the centre of the cylindrical throat as the pressure will be at its lowest value, where neither the pressure nor the velocity will be changing. As the fluid enters the diverging section the pressure is largely recovered lowering the velocity of the fluid. The major disadvantages of this type of flow detection are the high initial costs for installation and difficulty in installation and inspection.

An orifice meter is essentially a cylindrical tube that contains a plate with a thin hole in the middle of it. The thin hole essentially forces the fluid to flow faster through the hole in order to maintain flow rate. The point of maximum convergence usually occurs slightly downstream from the actual physical orifice this is the reason orifice meters are less accurate than venturi meters, as we cannot use the exact location and diameter of the point of maximum convergence in calculations. Beyond the vena contracta point, the fluid expands again and velocity decreases as pressure increases. These two devices will help us to measure actual flow in pipes.

# Project Scope

In this project we aim to determine the coefficient of discharge of the two devices. The apparatus consists of a venturi meter and an orifice meter, fitted in separate pipes. Both the pipe consists of separate flow control valves and common inlet and outlet. Sump tank with centrifugal pump is provided for water circulation through pipes. The pressure tapings are provided at inlet and outlet of venturi/orifice. Pressure tapings are connected to a differential pressure transmitter (DPT). Discharge is measured by ow sensor.

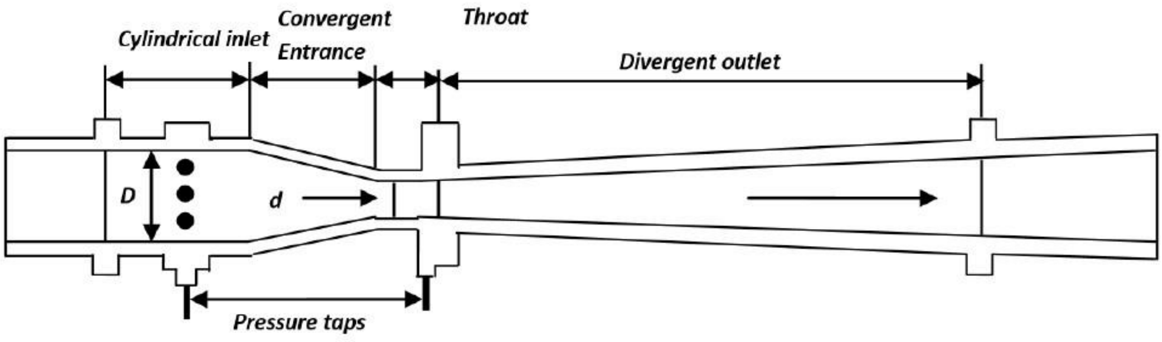
We will also try to examine which device will suit the best in which condition for example: The simple construction and maintenance of an Orifice meter gives it an edge over the expensive initial cost, installation and maintenance of the Venturi meter. Also, one of the major disadvantages of Orifice meter that was observed during the experiment was, due to sharp edges orifice meter has high clogging possibilities while it is not the same with the venturi meter.

However, at this point of time we are not going for in-situ flow measurements as it requires more complicated instruments. The main objectives of our project shall be as follows:

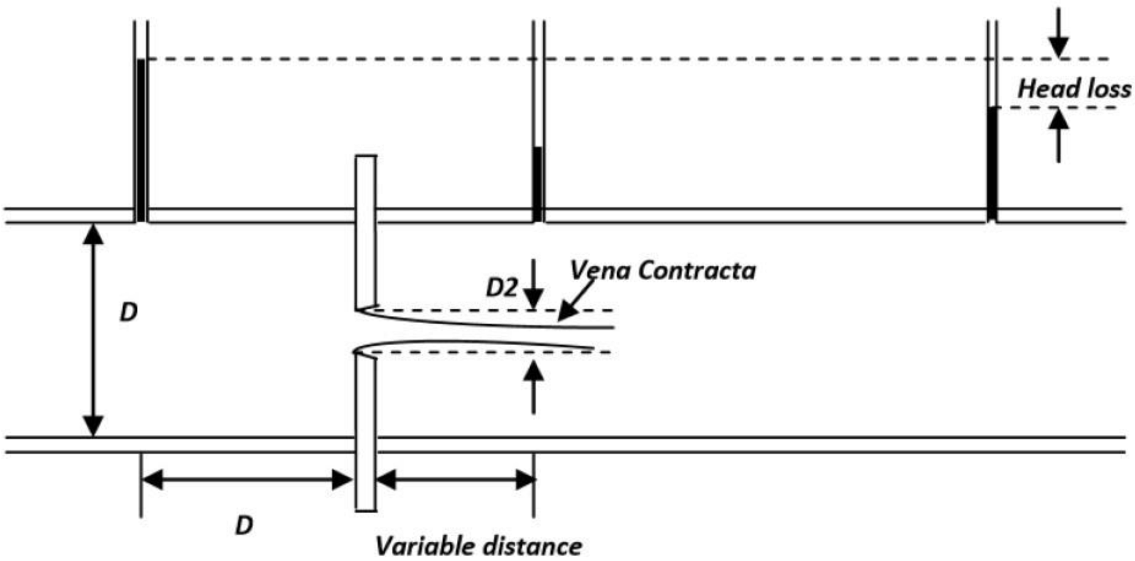
- To find the coefficient of discharge of venturi meter.
- To find the coefficient of discharge of orifice meter.

# Introduction

Venturi meter and orifice meter are the commonly used ow meters for measuring mass or volumetric ow rate or velocity of the flowing fluid. These flow meters are also known as variable head meters. They are categorized as full-bore meter as measurement of the fluid takes place when it flows through a conduit or channel.




If a constriction is placed in a closed channel carrying a stream of fluid, there will be an increase in velocity, and hence increase in kinetic energy, at the constriction, from energy balance, as given by Bernoulli's Theorem, there must be a corresponding reduction in pressure. Rate of discharge from the constriction can be calculated by knowing this pressure reduction, the area available for flow at the constriction, the density of fluid, the coefficient of discharge. The last named defined as the ratio of actual flow to the theoretical flow.



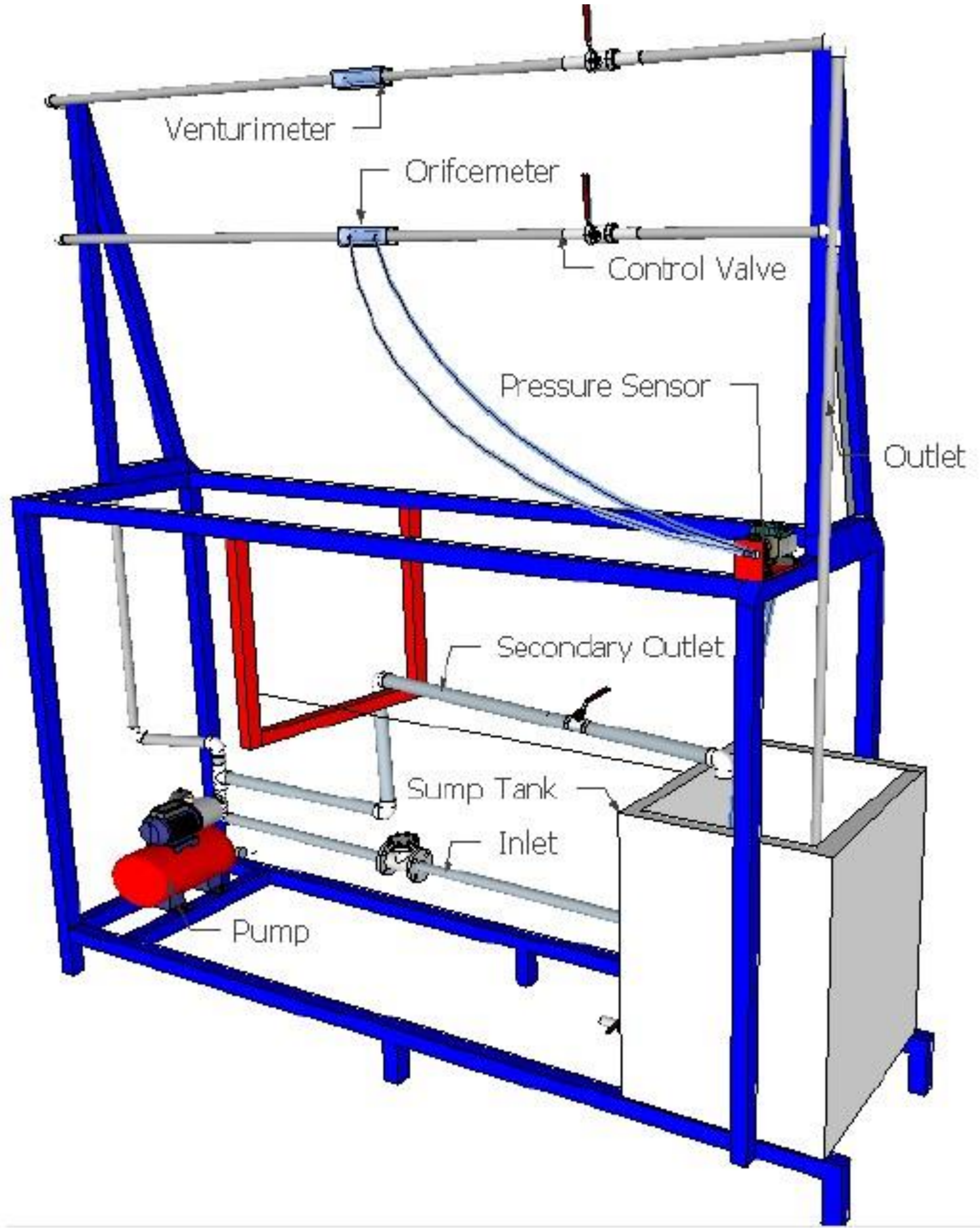

# Design Methodology

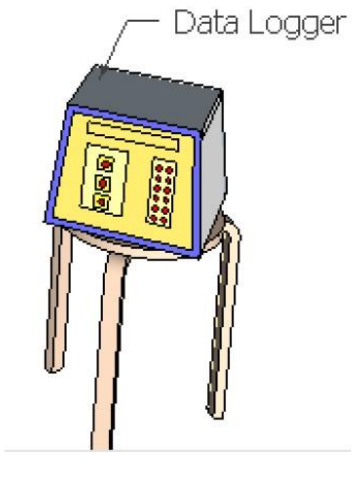
1. Requirements:

- Electricity Supply Single Phase, 220V AC, 50 Hz, 5-15 Amp, Combined socket with earthing.
- Water Supply (Initial Fill).
- Flood Drain Required.
- Floor Area Required 1.5 m x 0.75 m.
- Computer System: i3 processor with DVD drive. Windows 7/8, MS-office preloaded, One USB slot required in PC for DATA ACQUISITION CARD.

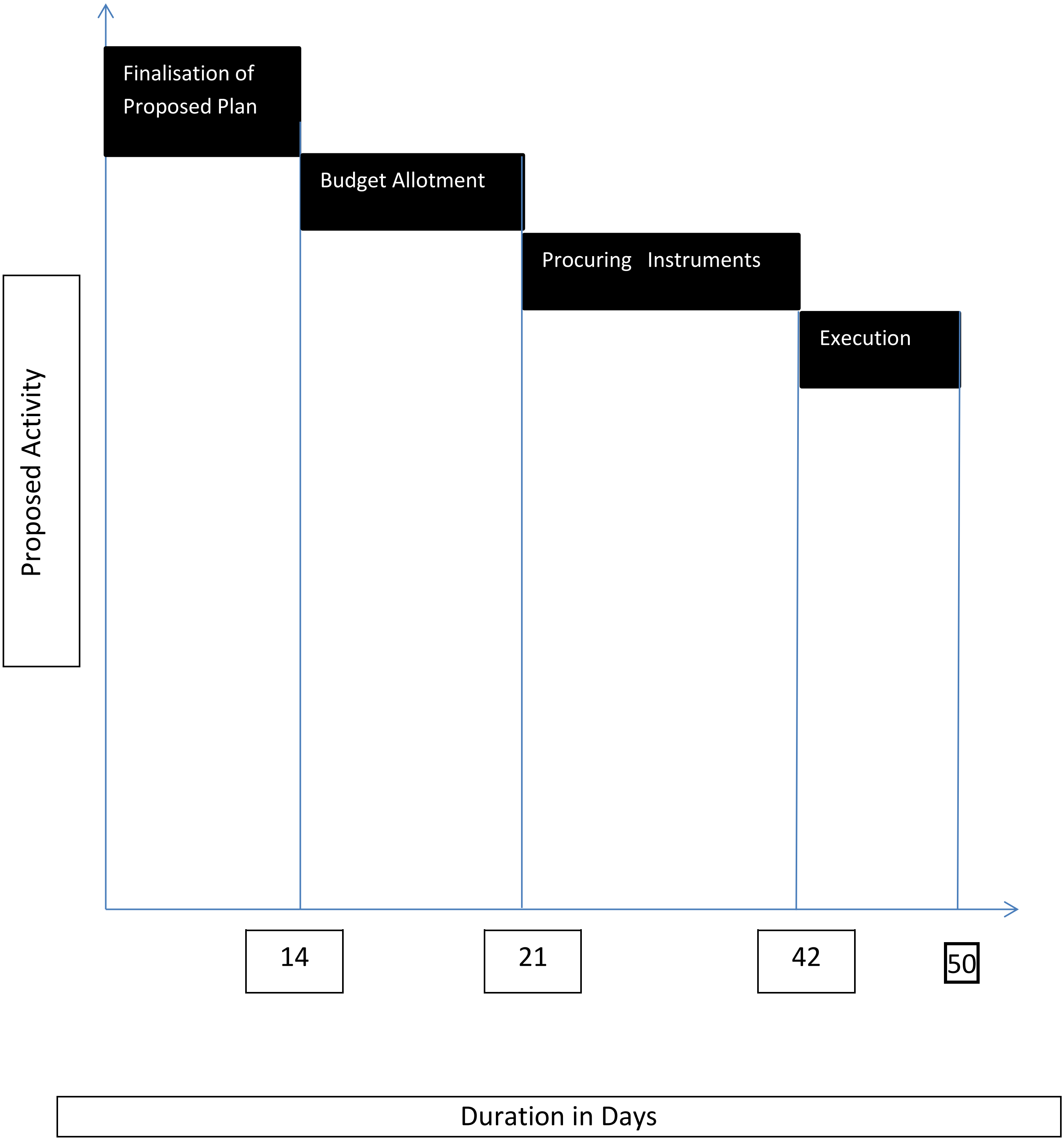
2. The apparatus shall look something like this(schematic made via sketch-up software) and would consist of:  Venturi meter

    - Orifice meter
    - Control Valves
    - Pressure Sensors
    - Outlet
    - Secondary Outlet
    - Sump Tank
    - Inlet
    - Pump
    - Data Logger


Venturimeter
Orifcemeter
Control Valve
Pressure Sensor
Outlet
Secondary Outlet
Sump Tank
Inlet
Pump


Data Logger

# Project Plan



# Proposed Budget

| Requirement | Approximate Cost (in AED) |
|---|---|
| Venturi meter | 1500 |
| Orifice meter | 1000 |
| Control Valves | 250 |
| Pressure Sensors | 1200 |
| Various Control Devices and Pipes | 1000 |
| Sump Tank | 150 |
| Pump | 750 |
| Data Logger | 1500 |
| **Total:** | **7350** |

# Project Deliverables

The project deliverables include calculating and finding out the following at first for both the devices:

| Nomenclature | Column Headings | Units | Type |
|---|---|---|---|
| $A_1$ | Area at inlet of Venturimeter and Orficemeter | $m^2$ | Calculated |
| $A_2$ | Area at throat of Venturimeter and Area of orifice | $m^2$ | Calculated |
| $C_d$ | Coefficient of Discharge | Unit-less | Calculated |
| $D_1$ | Dia at inlet of Venturimeter and Orficemeter | $m$ | Given |
| $D_2$ | Dia at throat of Venturimeter and dia of orifice | $m$ | Given |
| $F$ | Flow rate of water | $LPH$ | Measured |
| $g$ | Acceleration due to gravity | $m/s^2$ | Given |
| $h$ | Differential pressure transmitter reading | $mm$ of WC | Measured |
| $H$ | Loss of Head | $m$ | Calculated |
| $Q_a$ | Actual Discharge | $m^3/s$ | Calculated |
| $Q_t$ | Theoretical Discharge | $m^3/s$ | Calculated |

Further calculations will involve the following formulae:

$$H = \frac{h}{1000}\ (m) \tag{1}$$

$$A_1 = \frac{\pi}{4} \times {D_1}^2\ (m^2) \tag{2}$$

$$A_2 = \frac{\pi}{4} \times {D_2}^2\ (m^2) \tag{3}$$

$$Q_a = \frac{F}{1000 \times 3600}\ (m^3/s) \tag{4}$$

$$Q_t = \frac{A_1 A_2 \sqrt{2gH}}{\sqrt{A_1^2 - A_2^2}}\ (m^3/s) \tag{5}$$

$$C_d = \frac{Q_a}{Q_t} \tag{6}$$

Further error analysis will also be conducted which includes:

$$\%\ Error = \left| \frac{Q_{experimental} - Q_{theoretical}}{Q_{theoretical}} \times 100 \right| \tag{7}$$

In this way we will be able to determine the coefficient of discharge for both venturi meter and orifice meter. This will further help us to find out the actual flow in pipelines.

# Conclusions

The expected observations and learnings from the project are as follows:

- Firstly, we are expected to observe that the Coefficient of Discharge for both the cases i.e. both for the Venturi meter and Orifice meter is less than 1, which will meet our expectations as there are certain amount of losses involved. Cd for both the cases should have been less than 1, given that the instrument set-up is less erroneous.
- This deviation of the discharge coefficient from the value of unity comes from the deficiency of either the flow model (mass flux through the valve as a function of density and pressure) or the fluid model (density as a function of pressure), or both.
- Secondly, we will observe that the Cd values for the Venturi meter and Orifice meter are quite different i.e. coefficient of discharge for venturi meter is expected to be a higher value than the orifice meter, which indicates the advantages and disadvantages of the two instruments over each other.
- Also the pressure recovery is limited for an orifice plate and the permanent pressure loss depends primarily on the area ratio, whereas high pressure and energy recovery makes the venturi meter suitable where only small pressure heads are available.

# References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