Chapter (4)

Motion of Fluid Particles and Streams

Read all Theoretical subjects from (slides Dr.K.AlASTAL)

Patterns of Flow

Reynolds Number (R_e):

A dimensionless number used to identify the type of flow.

$$R_e = \frac{\text{Inertia Forces}}{\text{Viscous Forces}} = \frac{\rho \times V \times D}{\mu} = \frac{V \times D}{\nu}$$

$V = \text{mean velocity} \left(\frac{m}{s}\right)$, $D = \text{pipe diameter (m)}$

$\rho = \text{fluid density } (Kg/m^3)$

$\mu = \text{Dynamic viscosity (Pa.s)}$, $\nu = \text{kinematic viscosity } (m^2/s)$

For flow in pipe:

If $(R_e \leq 2000) \rightarrow\rightarrow$ The flow is laminar

If $(2000 < R_e \leq 4000) \rightarrow\rightarrow$ The flow is transitional

If $(R_e > 2000) \rightarrow\rightarrow$ The flow is turbulent

Read the two Examples (in slides)

Discharge and Mean Velocity:

Discharge: The total quantity of fluid flowing in unit time past any cross section of a stream is called the discharge or flow at that section **(flow rate)**.

Discharge can be measured by one of the following two methods:

1. In terms of mass (Mass Flow Rate,ṁ,):

$$\dot{m} = \frac{\text{Mass of fluid}}{\text{time taken to collect the fluid}} = \frac{dm}{dt} = \rho \times Q \ (Kg/s).$$

2. In terms of volume (Volume Flow Rate or discharge,Q,):

$$Q = \frac{\text{Volume of Fluid}}{\text{Time}} = \frac{V}{t} \ (m^3/s).$$

This method is the most commonly used method to represents discharge.

There is another important way to represents Q:

$$Q = \frac{V}{t} = \frac{\text{Area} \times L}{t} = \text{Area} \times \text{Speed} \rightarrow Q = A \times v \ (m^3/s).$$

Continuity of Flow

Matter cannot be created or destroyed (principle of conservation of mass)

Mass entering per unit time = Mass leaving per unit time + Increasing of mass in the control volume per unit time

If the flow is steady, no increase in the mass within the control volume. So,

Mass entering per unit time = Mass leaving per unit time

Continuity Equation for Steady Flow and Incompressible Flow:

$A_1 v_1 = A_2 v_2 = Q = \text{constant}$

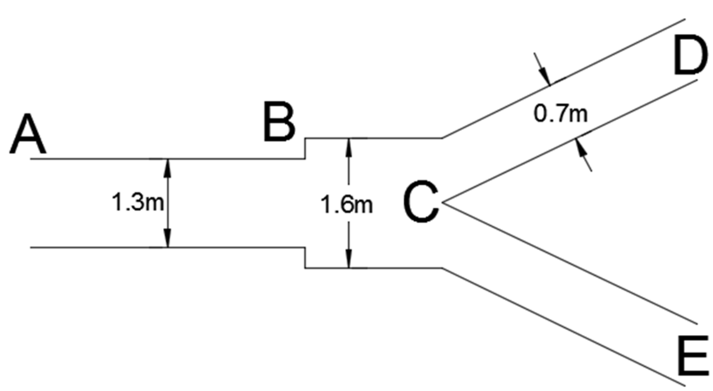
This equation is a very powerful tool in fluid mechanics and will be used repeatedly throughout the rest of this course.

The following problems clarify the concept of continuity of flow

Problems

1.

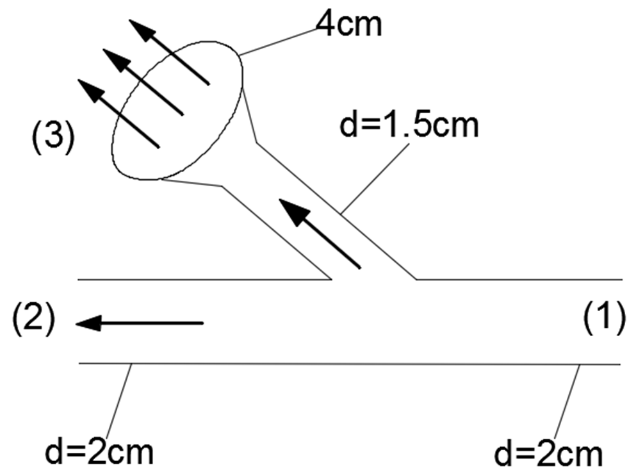
Water flows through pipe AB 1.3m diameter at speed of 3m/s and passes through a pipe BC of 1.6m diameter. At C the pipe branches. Branch CD is 0.7m in diameter and carries one third of the flow in AB. The velocity in branch CE is 2.7m/s. **Find** the flow rate in AB, the velocity in BC, the velocity in CD and the diameter of CE.



Solution

2.

Pipe flow steadily through the piping junction (as shown in the figure) entering section (1) at a flow rate of 4.5m^3/hr. The average velocity at section (2) is 2.5 m/s. A portion of the flow is diverted through the showerhead 100 holes of 1-mm diameter. Assuming uniform shower flow, estimate the exit velocity from the showerhead holes.



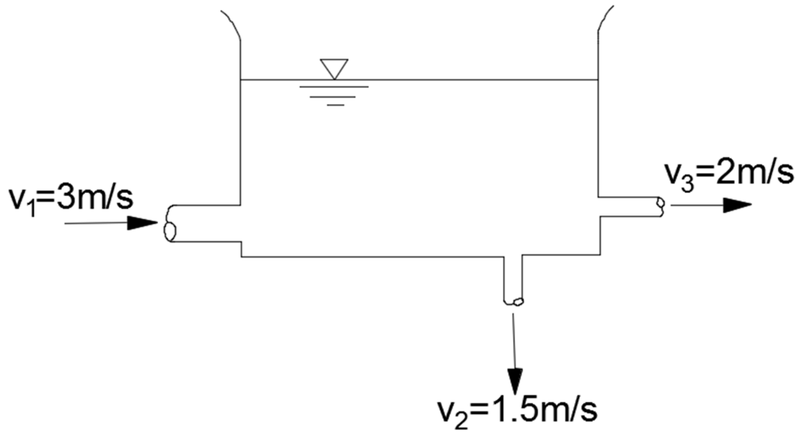
Solution

3.

For the shown tank, if the inlet pipe is 40 cm in diameter and the outlet pipes are 20 cm in diameter.

A. Is the tank filling or emptying and at what rate?

B. What should be the velocity of water at the inlet pipe to keep the water level in the tank constant?

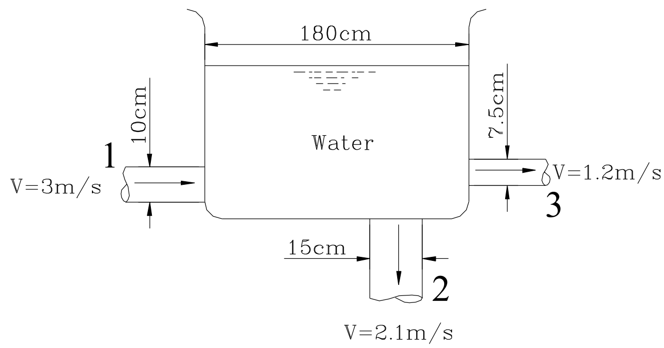


Solution

4.

In the figure shown is the tank filling or emptying?

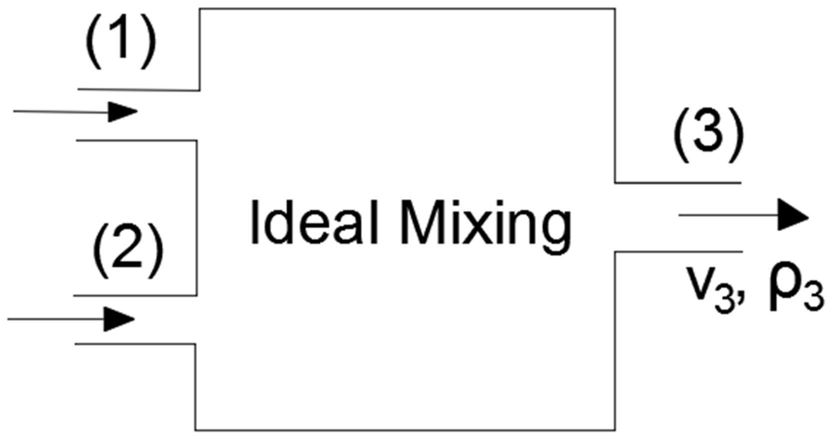
At what velocity is the water level rising or falling in this circular tank?



Solution

5.

In the figure shown below, the diameter of pipes (1) and (2) is 3cm and the diameter of pipe (3) is 4cm. Alcohol (SG = 0.8) enters section (1) at 6m/s while water enters section (2) at 10 m/s. Assuming ideal mixing of incompressible fluids, **compute** the exist velocity and the density of the mixture in section (3).



Solution