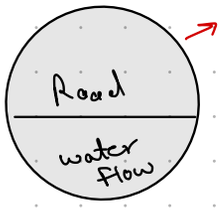
13 Jan 2022

* Water will always flow through 'Gravity'

Main diff. ←
→ In channel flow, there is atmospheric pressure acting.
→ In pipes, the pressure is never atmospheric pressure.



tunnel.

→ Is this an open channel or a pipe flow?

Ans→ Open channel.

→ Even though the Cross-sectn is closed ○, the water is not completely filling the tunnel. So the pressure is atmospheric.

Differences :-

	Open Channel Flow	Pipe Flow
1	*Open Channel Flow is a type of fluid flow in a conduit with a free surface open to the atmosphere.*	The pipe flow is a type of flow within a closed conduit.
2	Open Channel Flow has a free surface	There is no Free surface in pipe flow
3	The pressure at the free surface remains constant	Pressure in the pipe is not constant
4	Flow Driven by Gravity	Flow Driven by Pressure
5	The maximum velocity occurs at a little distance below the water surface	The maximum velocity occurs at the center of the pipe.
6	Surface roughness varies with depth of flow	Surface roughness varies with the type of pipe material
7	HGL(Hydraulic Gradient Line) coincides with the water surface line.	HGL(Hydraulic Gradient Line) do not coincide top surface of the water
8	The Cross-section of an open channel can be trapezoidal, triangular, rectangular, circular, etc.	The Cross-section of a pipe generally circular.

Types of open channels:

1) Natural channel → Stream or River
2) Man Made channel

→ ∴ Flume - is the channel made of wood, metal, Conc. or masonry usually supported on or above to carry out water across a depressic

→ Chute - A chute is a channel having steep slopes.

→ Drop - similar to chute but short distance.

→ Culvert - Installed to Drain water through highways.
∴ you can get confused in bridges and culverts.

∴ Man made channels are generally made for agricultural uses.
And are trapezoidal in shape (usualy)

Types of open channels (geometry.) and Types of Flow in Open channel.

17/1/22

→ types of fluid flow or water flow.

1) Prismatic and Non-prismatic channel.
→ A channel in which the cross-sectional shape, size and bottom slope are constant.

→ All natural channels have generaly varying Cross-sectional and are consequently called as Non-prismatic.

∴ Man-Made channels can be Prismatic channels.
∴ Natural channels are usually Non-prismatic channels.

∴ We are going to work with 'Flume' in lab.

Prismatic channel → generally have fixed shapes

2] Mobile boundry channel

→ when the flow of fluid erodes the water bed like stones and side materials through the flow, it is called Rigid boundry channel.

eg → flows through himalayan Regions.

The water is flowing through steap turns and takes/erodes the boundries and take mud or water bed with it.

→ when the boundry of the channel is mobile, and flow carries considerable amounts of sediment through suspension and is in contact with bed. Such channels are classified as mobile channels.

* In the mobile channel, not only depth of flow, but also bed width, longitudinal slope of channel may undergo changes with space and time depending on type of flow.

* The resistance of flow, quantity of sediment transported and channel geometry all depends on interaction of flow with channel boundries.

3] Rigid Boundry Channel. → opposite to Mobile boundry. (Nothing flows through the flow from boundry)

⇒ Rigid channels are those in which the boundry is not deformable, the shape and Roughness magnitudes are not functions of flow parameters.

→ In Rigid channels the flow velocity and shear stress distribution will be such that no major scouring, erosion or deposition will take place in the channel and the channel geometry and Roughness are essentialy constant with respect to time.

Related to time

Flow types.

Flow Regimes

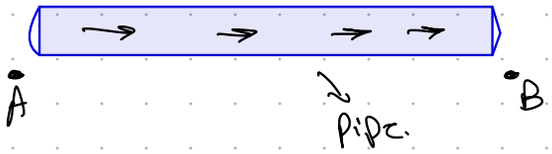
— Steady and Unsteady

— Uniform and Non-uniform

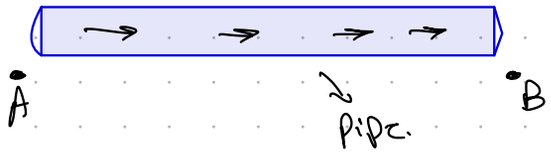
Related to Space.

— Gradually varies Flow and Rapidly varies Flow.

— Spadilly varied flows.



∴ If velocity is same at point A and B. then it is called as uniform flow.



∴ If you take velocity of Both points but with some time gap and if it is same, it is called as steady flow.

Steady and Un-steady Flow

→ Properties such as depth discharge at a section do not change with time

→ If the Depth or discharge change with time the flow is called as unsteady.

→ Flood flows in Rivers Rapidly varying Surges in Canals are some examples of unsteady flows.

Uniform and Non-uniform Flow :-

If the flow properties, say the depth of flow, in an open channel remain constant along the length of channel, the flow is uniform.

→ A flow in which the flow properties vary along the channel is termed as Non-uniform flow.

→ A prismatic channel carrying a certain discharge with a constant velocity is an example of uniform flow.

→ In uniform flow, the gravity force on the flowing liq balances the frictional force between the flowing fluid and inside surface of the channel, which is in contact with the fluid. In case of Non-uniform flow, the Friction and Force (gravity) are Not in balance

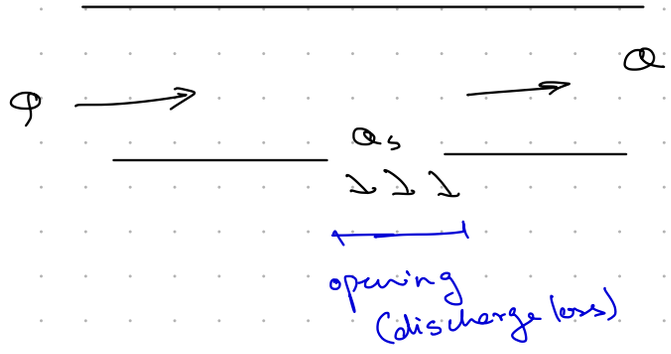
gravity and frictional force are equal to each other and are in opposite direct^{n} in uniform flow.

∴ gravitational and frictional force are not equal in Non-uniform flow.

∴ The Non-uniform flow can be classified as gradually varied flow (GVF) and rapidly varied flow (RVF)

∴ No additional water allowed or no additional water is removed in this system.

Spatially Varies Flow



Geometric Elements.

→ Top width 'T', of a channel is the width of channel section at the water surface.

→ The flow area, A, is the cross sectional area of flow normal to the direction of flow.

→ the wetted perimeter, P, is the length of the line of interface between the fluid and the channel boundary.

Basic Understanding → From youtube

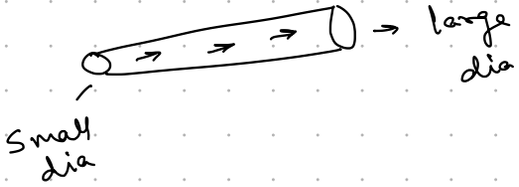
Steady Flow → Properties do not change with time like pressure, temperature and velocity.

unsteady flow → Properties will change with time.

Uniform Flow → If there is no change in velocity with respect to space cordinates in a flow.

∴ we only see at velocity in Uniform flow.

NOW - Uniform flow - properties can change with respect to space



Formulas :-

1) Hydraulic radius (R) = A/P

2) Hydraulic depth (D) = A/T

3) Section factor (Z) = $A\sqrt{D}$ = $A\sqrt{\frac{A}{T}}$ (It is used in Critical Flow calculations)

4) Section factor used in uniform flow Calculations = $Z = AR^{(2/3)}$

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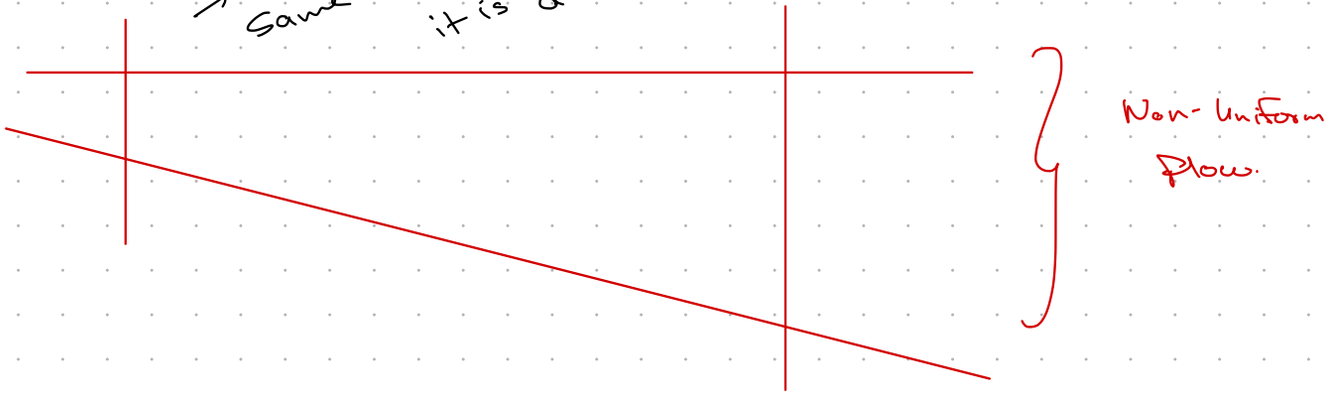
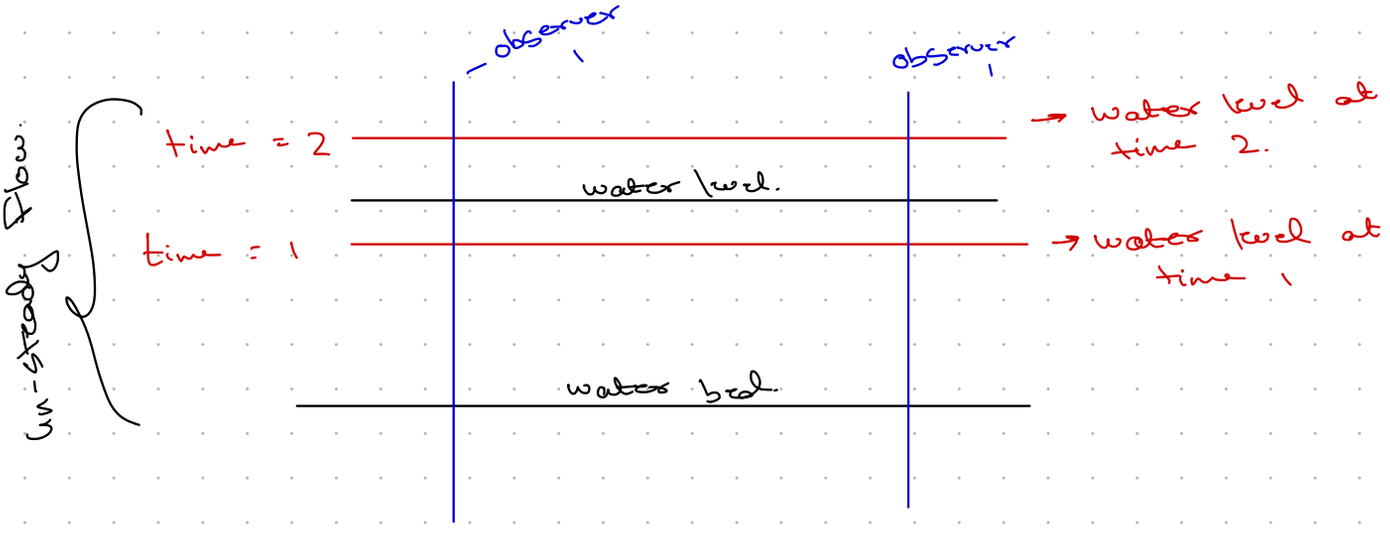
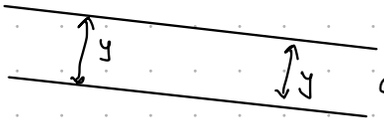
→ If the flow remains same after 10-15 mins, it is a steady flow





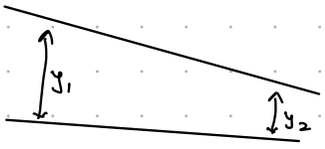
Types / classification of open channel flows.

a. Uniform flow



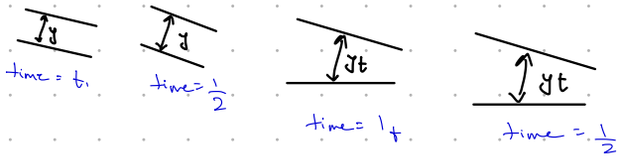
Constant water depth.

b. Non-uniform flow

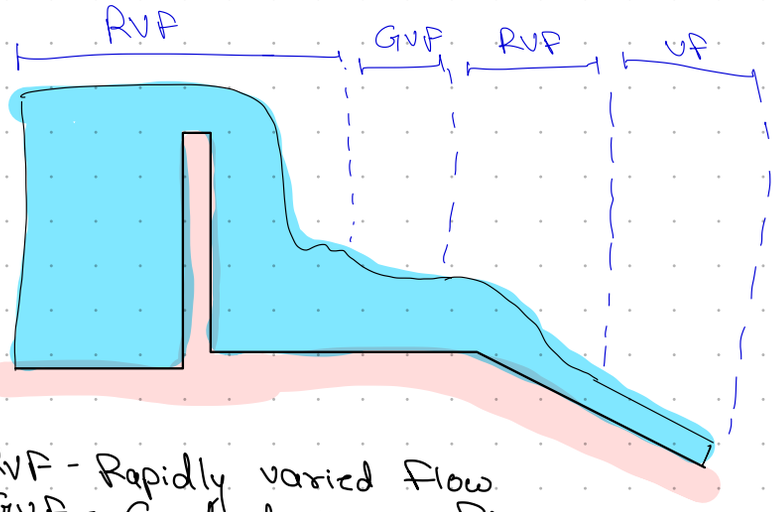


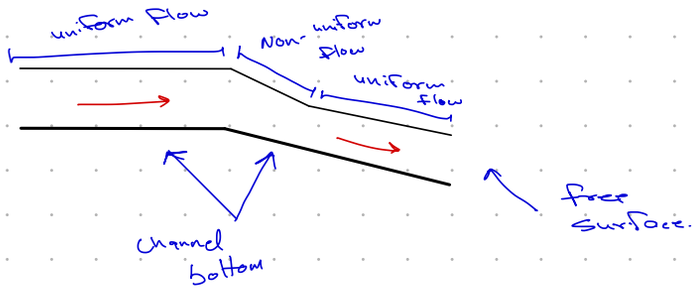
Depth changes along the channel.

c. Steady flow



d. Unsteady flow.





RVF - Rapidly varied flow
GVF - Gradually varied flow
UF - Uniform flow.

Open channel flow :

(time is criterion)

- Steady flow
  - Uniform flow
  - Varied flow
    - GVF
    - RVF
- Unsteady flow.

(Space is the criterion)

- Uniform flow
- Varied flow
  - GVF
  - RVF

Problems :-

1) A 5m wide rectangular channel is laid at a longitudinal slope of 1 in 4000 and carries water at a uniform flow depth 1.5m. Find the hydraulic radius and the avg boundary shear stress.

→ Area (A)
$= b \times H$
$= 5 \times 1.5$
$= 7.5\ m$

Perimeter (weighted) $P = b + 2H$
$= 5 + 2 \times 1.5$
$= 8\ m^2$

Hydraulic Radius $R = \frac{A}{P} = \frac{7.5}{8} = 0.9375$

$\tau = \rho g R S_o = 1000 \times 9.81 \times 0.9375 \times (1/4000) = 2.3\ N/m^2$

(sp. wt. of water; gravity; Hydraulic Radius; slope)

Resistance Equations Chezy's equation.

Resistance offered by the boundry of channel to the flowing water.

$$V = \sqrt{\frac{8gRS_0}{f}} = C\sqrt{RS_0}$$

f → Friction factor.

where $C\sqrt{\frac{8g}{f}}$ is chezy's coefficient

It is empirical equation

$C = 40$ to 80 $\sqrt{m}/s$ Range of C

unit.

Maning's eqn :-

$$V = \frac{1}{n} R^{2/3} S_0^{1/2}$$

} universaly accepted.

Goes back to 17th Century.

manning's Coefficient.

Examples

1) From Ex 1 (Q1 of Problem) the boundry is made up of Concrete Assume flow to be rough the friction factor = 0.0145.

Find chezy's Constant and Manning's

$R = 0.9375$

$C = \sqrt{\frac{8g}{f}}$

$\Rightarrow C = \sqrt{\frac{8 \times 9.81}{0.0145}} = 73.56 \sqrt{m}/sec$

$n = R^{1/6}/C$

$n = \frac{0.9375^{1/6}}{73.56} = 0.0134$

$V = ?$

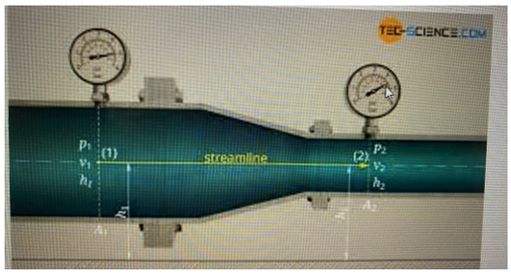
$\therefore V = C\sqrt{RS_0}$

$\therefore \frac{1}{n} R^{2/3} S_0^{1/2}$ or $C\sqrt{RS_0}$ $= 73.56\sqrt{0.9375 \times (1/4000)}$

$= 1.1261$ m/sec

Pipe Flow.

27-1-22
Lecture 9.



V_2 has greater velocity. ∴ Cross sectional area is inversely proportional to velocity.

where is the pressure more?

Bernoulli Eqn.

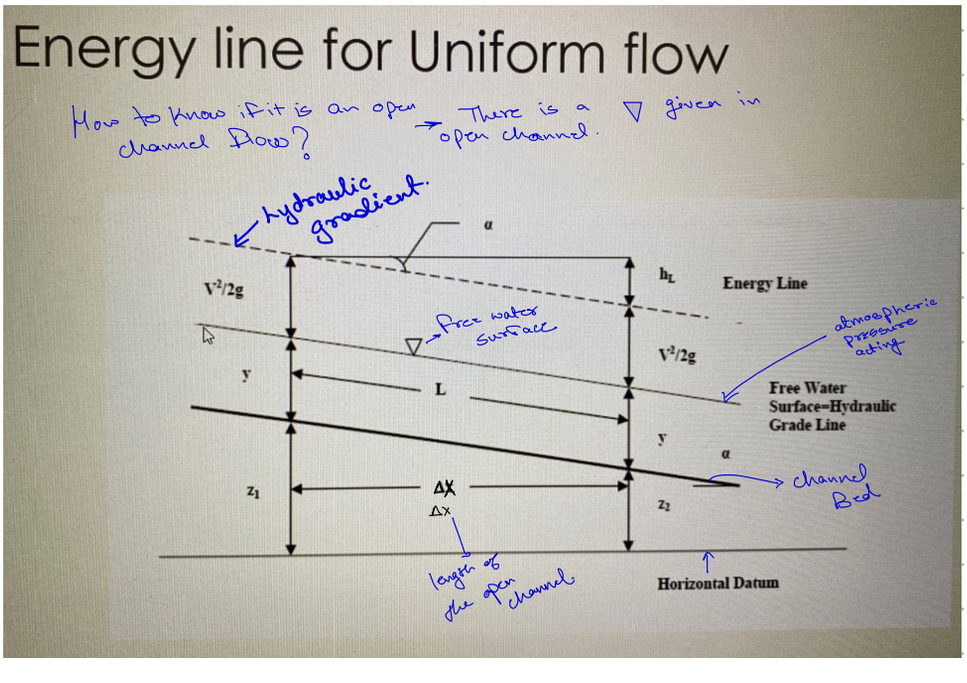
$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + H_L$$

∴ z_1 and z_2 gets Cancelled.

as we know V_2 is greater than V_1, So to satisfy the equation P_1 has to be greater than P_2.

Difference between open channel and pipe :-

open channel has atmospheric pressure.



This is an uniform flow because the depth of channel stays constant throughout.

How energy and Depth are Connected ?

Head loss:

The head (energy) loss bet^n cross-sect^n 1 and 2.

$$z_1 + \frac{P_1}{\gamma} + \frac{v_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + h_L$$

$$\frac{P_1}{\gamma} = \frac{P_2}{\gamma} = y$$

$$v_1 = v_2 = v$$

$$h_L = z_1 - z_2.$$

Head loss per unit length

The head loss for unit length of channel length is energy line (hydraulic) slope.

$$S_{ener} = \frac{h_L}{L} = \frac{z_1 - z_2}{L} = \sin\alpha.$$

Since in open channel flows the channel slope is generally a small value

$$\alpha < 5° - 10°$$

$$\sin\alpha \simeq \tan\alpha$$

$$\tan\alpha = \frac{h_L}{\Delta x} = S_0 \rightarrow (\text{channel bottom slope})$$

$$S_{ener} = S_0$$

Uniform flow Conclusion.

Hydraulic grade line coincides with water surface slope in every kind of open channel flow. Since the velocity will remain constant in every cross section at uniform flows. Energy line slope, hydraulic grade line slope (water surface slope) and channel bottom slope are equal to each other and will be parallel as well.

$$S = S_0 = S_{ener}$$

where S is the water surface slope

Lecture 9 31st Jan

Applying Bernoulli eqn at any location along the channel gives sum of the vertical distance measured from a horizontal datum 'z', the depth of flow 'y' and the kinetic energy '$V_{av}^2/2g$'. That sum defines the energy grade line and is termed the total energy, H.

$$H = z + y + \frac{V_{av}^2}{2g}$$