Lect #16

Energy Grade line:-

It is graphical representation of total energy head along the flow path is called energy grade line

→ The line joining the level of pizometer or static head called HGL.

→ The line joining the level of pitot tube or total head called EGL.

Hydraullic grade Line:-

It is graphical represent[illegible]d along the flow path, is c[illegible]

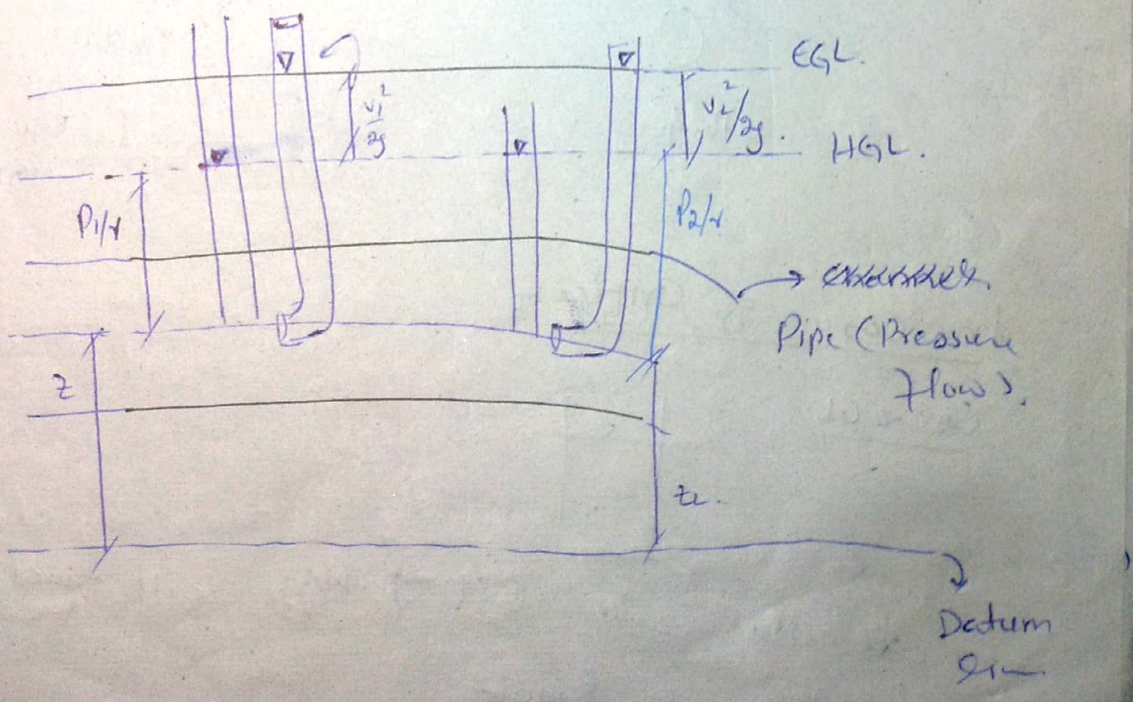
Note:-

Grade → slope → variation of energy along path.

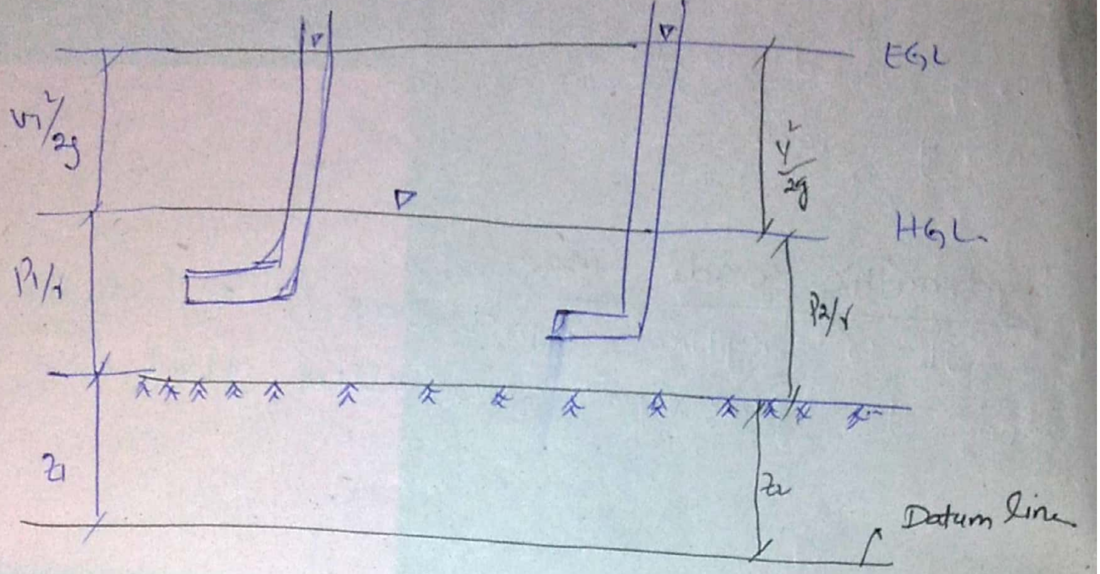
→ In case of pipe & channel, the nature of EGL & HGL will be different.

(*) For Ideal fluid the lines will be horizontal & for real fluid it will be tilted.

(*) Both pitot tube & pizometer will be at same level.



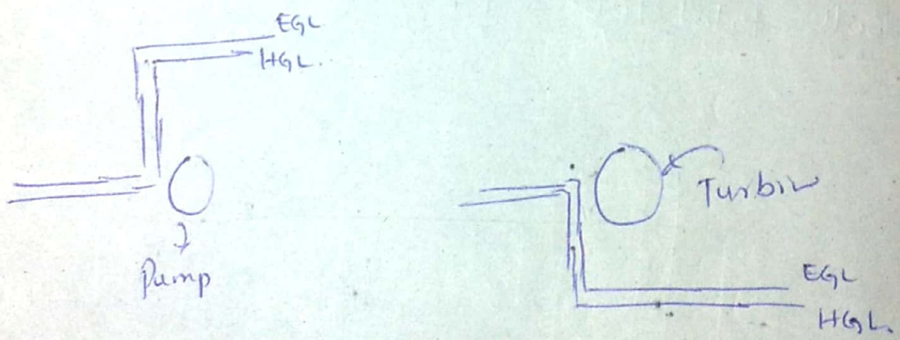
For Channel Flow:-



No need of piezometer which is alway

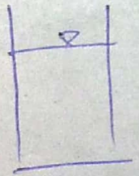
→ For pump, the EGL & HGL will move up.

→ For turbine, both will move down.



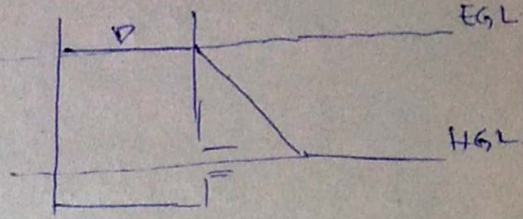
In case of Orifice:-

Case #01



As static so EGL & HGL will touch the surface of liquid.

EGL will be always above HGL.



For Inside tank

$P/\gamma + z_1 + P_{atm}$

when out through orifice

$\cancel{z}^{0} + \cancel{P/\gamma}^{0} + P_{atm} \rightarrow$

The slope is due to gradually decrease & we get such line.

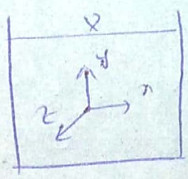
<u>Velocity & Acceleration:-</u>

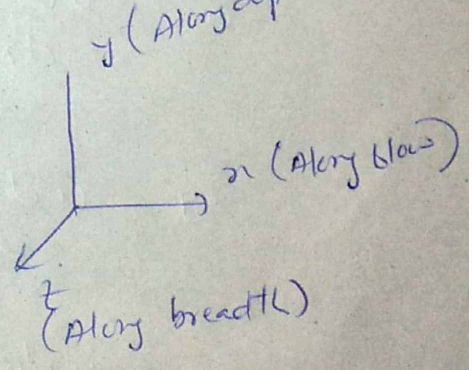
Velocity in field flow is represented by;

Velocity

$V(x, y, z)$

It is not unidirectional flow.





Velocity is not only change with time but also change with position.

Velocities in x, y & z direction can be written as.

$u = x/t$.

$v = y/t$

$w = z/t$

∴ In actual field we deal with bulk of water so we consider acc in just x-direct

so, acceleration is;

$$\vec{a} = \frac{dv}{dt}(x, y, z, t).$$

where v is function of x, y, z & t.
so used chain rule

$$\vec{a} = \frac{dv}{dx} \cdot \frac{dx}{dt} + \frac{dv}{dy}\frac{dy}{dt} + \frac{dv}{dz} \cdot \frac{dz}{dt}$$

$$= \frac{dv}{dx}u + \frac{dv}{dy}v + \frac{dv}{dz} \cdot w$$

Eqn of acc for total velocity.

For <u>simplification</u>:-

$$\vec{a}_x = u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz} + \frac{du}{dt}$$

$$\bar{a}_y = u\frac{dv}{dx} + v\frac{dv}{dy} + w\frac{dv}{dz} + \frac{dv}{dt}$$

$$a_z = u\frac{dw}{dx} + v\frac{dw}{dy} + w\frac{dw}{dz} + \frac{dw}{dt}.$$

- The acceleration which is cause by change in velocity with ~~time~~ position called convective acceleration.

where as the accelration, which is caused by velocity with time called local acc.

On the basis of these acc we decide whether the flow is steady, uniform or both cros

Flow	Convective Acc	Local Acc.	
i) Steady & uniform	0	0.	Constant flow
ii) Steady & non uniform.	Non zero	0	Constant flow
iii) Unsteady & uniform.	0	Non zero	Variable flow
iv) Unsteady & ununiform	Non zero	Non zero	Variable flow

∴ In real life steady flow is not possible.

Example:- A flow field defined by.

$u = 3x + 2t, \quad v = y + t, \quad w = z + 2t.$

what will be acc at $P(3, 1, 1, 5)$.

Sol:- Analyze:-
Velocity in x, y & z direction is non zero so it is 3-D flow.
+ It's function of time & position so flow is unsteady & non uniform

so there is Convective & local acc

As $a = \sqrt{a_x^2 + a_y^2 + a_z^2} \longrightarrow (1)$.

$a_x = u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz} + \frac{du}{dt}$

$\frac{du}{dx} = -3$, $\frac{du}{dy} = 0$, $\frac{du}{dz} = 0$, $\frac{du}{dt} = 2$.

So; $a_x = u(3) + 2 = (3x+2t)3+2$.

$= (3(3) + 6(5)) + 2 = 59\ L/T^2$

$a_y = u\frac{dv}{dx} + v\frac{dv}{dy} + w\frac{dv}{dz} + \frac{dv}{dt}$.

$\frac{dv}{dx} = 0$, $\frac{dv}{dy} = 1$, $\frac{dv}{dz} = 0$, $\frac{dv}{dt} = 1$.

$a_y = v(1) + 1 = (y+t) + 1 = 1+5+1 = 7\ L/T^2$

$a_z = u\frac{dw}{dx} + v\frac{dw}{dy} + w\frac{dw}{dz} + \frac{dw}{dt}$.

$\frac{dw}{dx} = 0$, $\frac{dw}{dy} = 0$, $\frac{dw}{dz} = 1$, $\frac{dw}{dt} = 2$.

$a_z = w(1) + 2 = (z+2t) + 2$.

$= (1+10) + 2 = 13\ L/T^2$

in (1) ⇒ By putting values

$a = \sqrt{(59)^2 + (7)^2 + (13)^2}$.

$\boxed{a = 60.6\ L/T^2}$ Ans 2