Make-up lecture, 11/30/00
Thanks to Logan for taking the notes.

don't know yet

$F_p = P_1 A_1 - P_2 A_2 \qquad B = M_g \qquad T = F$

oday | We wrote down momentum balance 11/29/00

total momentum in control volume

momentum flow terms, one for each inflow or outflow

$$\frac{\partial}{\partial t}\int \rho \vec{u}\, dV = \rho_1 \langle u_1^2 \rangle \vec{A_1} - \rho_2 \langle u_2^2 \rangle \vec{A_2}$$

Pressure terms act on fluid areas in specific directions.

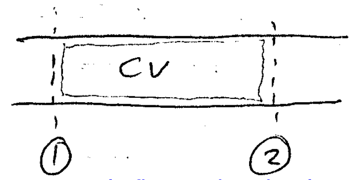
$$+ P_1 \vec{A_1} - P_2 \vec{A_2} - \vec{F} + m\vec{g}$$

"F" is force on fluid by a solid surface in specified direction. Body force is total force on the fluid in CV by body forces

- vector eqn. – need to apply in specific directions
  → 1 component at a time (groan)

ce fluid * F is shear, non-specified normal force (both) – possibly from solid surfaces

- flow in a pipe (turbulent) (assume control volume cv)



- Apply momentum balance / What will it tell us?

Apply first to the simplest problem to see what the equation will tell us. We are not asking a specific question.

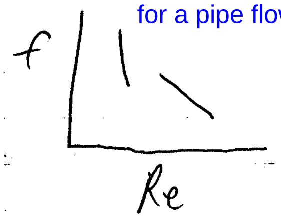
$\rho_1 = \rho_2, \quad A_1 = A_2, \quad \frac{\partial}{\partial t} = \text{const}$

$$0 = \rho u_1^2 A_1 - \rho u_2^2 A_2 + P_1 A_1 - P_2 A_2 - F$$

- F is shear stress here
- Simplifies to $\boxed{F = (P_1 - P_2) A}$

ressure drop $\frac{P_1 - P_2}{L} = \frac{F/L}{A}$ find walls' shear stress

We can always get the pressure drop
for a pipe flow from f-Re plot



$$f \equiv \frac{\Delta P}{L} R \Big/ \rho u^2$$

and $\frac{F}{L} = \frac{\Delta P A}{L}$

Substitute for delta-p in
terms of
the friction factor

$$\frac{F}{L} = \frac{\rho U^2 f A}{R} = \frac{\rho u^2 f \pi R^2}{R} = \rho U^2 f \pi R$$

$$F = \Delta P A = \left(\frac{f \rho u^2}{2}\right) 2\pi R L$$

Area of pipe inside

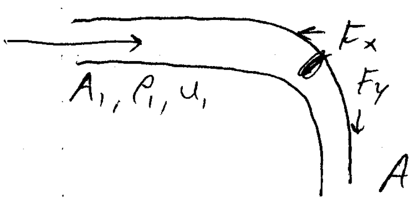
$\left(\frac{f \rho u^2}{2}\right) \rightarrow = \tau_{wall}$

Use momentum balance to get forces on things

Ultimately $-\underbrace{\Delta P A}_{\text{x section}} = \tau_{wall} A$ ← *Area of pipe wall*

We can tell how much
tangential force it will take
to keep the straight pipe in

Force on a pipe bend - how much force to keep it in place?



"F" are forces on the fluid
caused by the solid
surfaces.

hafta do one direction at a time

x direction $0 = \rho u_1^2 A_1 - 0 + P_1 A_1 - F_x$ (flow in) (no flow out in x direction)

y direction $0 = -\rho u_2^2 A_2 - P_2 A_2 + F_y$ (out) no flow in, in the y direction

e for
, F_y:

$$F_x = \rho u_1^2 A_1 + P_1 A_1$$
$$F_y = \rho u_2^2 A_2 - P_2 A_2$$

We can solve for both
directions

cheg rules
Finance drools

review What have we learned?

Forces ⟶ need momentum balance
- 1 direction at a time

Summary of lecture:

Make sure that you know what the terms mean. You will get a better understanding by using the equation in problems.

If the question asks for the force on something, you need the momentum equation.

Remember that momentum is a vector quantity. Thus we need to be careful about direction and we will use the balance 1 direction at a time.

Questions about "pumping power" or pressure drop in complex pipe networks are not easily answered by the mometum balance. You will use the Bernoulli equation.