CHEN.3030 Fluid Mechanics

VI. Linear Momentum Equation + Applications…

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See Chapter 6 (only sections 1–3) in your text by Hibbeler

For Steady Uniform Flows

$$\sum_{\text{outlets}} \dot{m}\,\vec{v}_r \;-\; \sum_{\text{inlets}} \dot{m}\,\vec{v}_r \;=\; \sum \vec{F}$$

Linear Momentum Equation

where $\dot{m} = \rho A v_r$ is the mass flow rate (a scalar)

and $\vec{v}_r = \vec{v}_f - \vec{v}_{cs}$ is the fluid relative velocity (a vector)

with v_f and v_{cs} representing the fluid velocity and the velocity of the control surface relative to a fixed observer

For a fixed control volume, $v_{cs} = 0$, and v_r becomes v_f and these are usually replaced simply by $v = v_r = v_f$ (for $v_{cs} = 0$).

Let's do some examples…

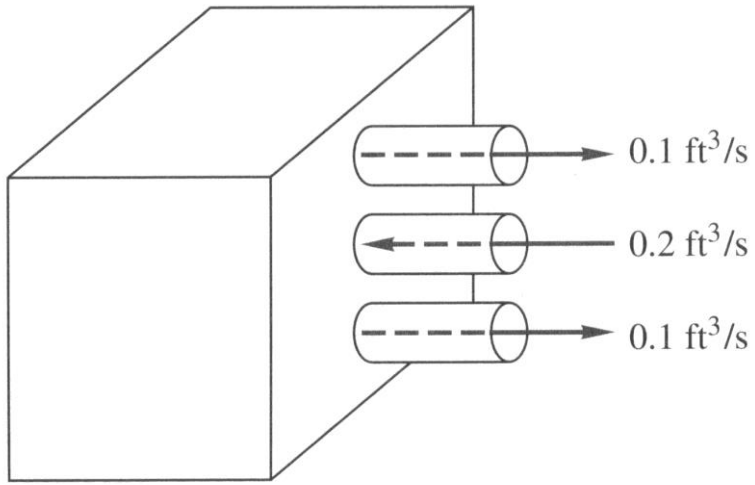
Ex. #1 -- focus on signs…

The box shown has three 0.5 in holes.

The volume flow rates are shown.

Assume that the inlet and exit streams of water are free jets. (use ρ = 62.4 lbm/ft^3)

Compute the net force, if any, which this flow situation causes on the box.



Ex. #2 -- focus on pressure forces…

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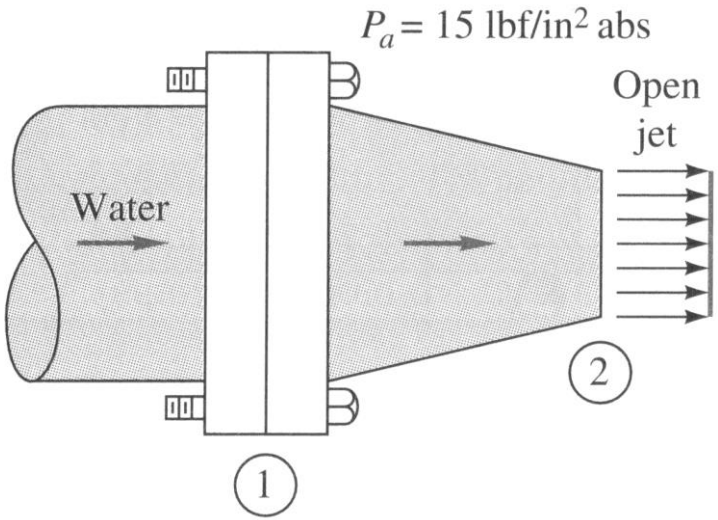
The horizontal nozzle has $D_1 = 12''$ and $D_2 = 6''$.

The inlet pressure is $P_1 = 38$ psia and the exit speed is $v_2 = 56$ ft/s.

Compute the horizontal force provided by the flange bolts to hold the nozzle fixed.

Use a water density of $\rho = 62.4$ lbm/ft^3.

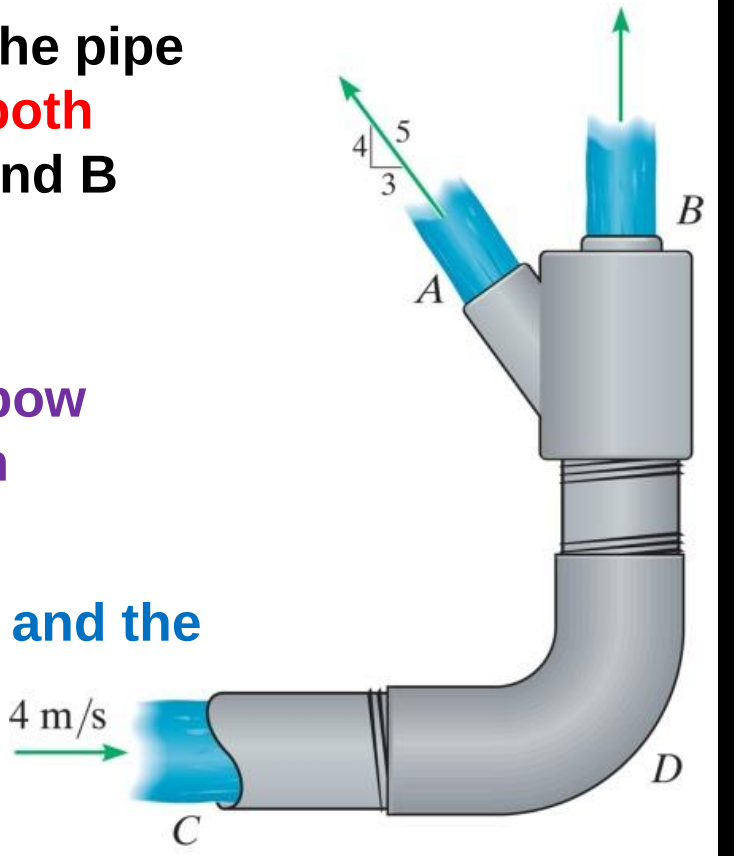


Ex. #3 -- angles, others eqns. …

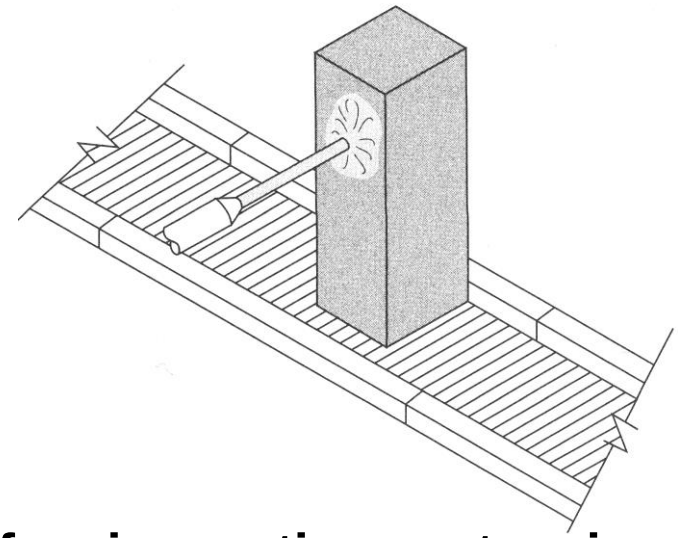
Water flows through pipe C at 4 m/s. The pipe diameter at C is 6 cm and, at A and B, both diameters are 2 cm. The streams at A and B are free jets.

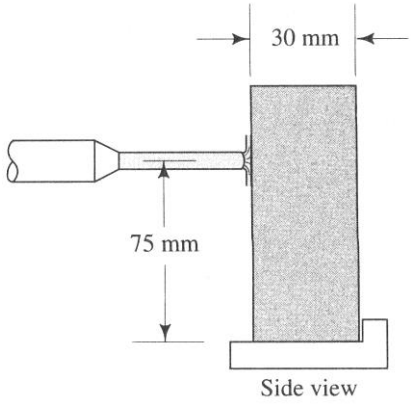
Determine the horizontal and vertical components of force exerted by the elbow necessary to hold the pipe assembly in equilibrium.

Neglect the size and weight of the pipe and the water within…



Ex. #4 -- Tip the Carton…





One part of an inspection system in a packaging operation uses a jet of air to remove imperfect cartons from a conveyor line.

The carton tips over a small ledge on the side of the conveyor as shown.

The carton has a mass of 0.10 kg, the air jet has a diameter of 0.01 m, and the air has a density of 1.2 kg/m^3.

Determine the velocity of air needed to tip the carton off the conveyor.

Ex. #5 -- CV has constant speed…

The truck is traveling at 5 m/s shoveling liquid slush.

The slush is 0.25 m deep and its density is $\rho = 125\ kg/m^3$ and $\theta = 60^o$. The plow is 3 m wide (into the page).

Determine the traction force needed to maintain the given motion.