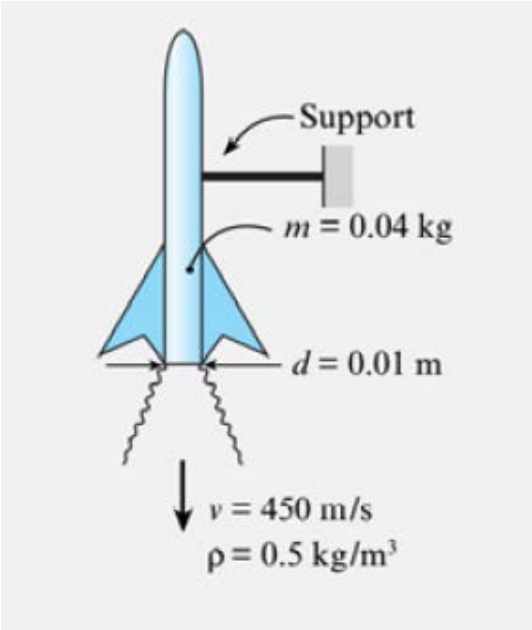
Example Problem 6.1

The following sketch shows a 40 g rocket, of the type used for model rocketry, being fired on a test stand to evaluate thrust. The exhaust jet from the rocket motor has a diameter of $d = 1$ cm, a speed of $v = 450$ m/s, and a density of $\rho = 0.5$ kg/m^3. Assume the pressure in the exhaust jet equals ambient pressure. Find the force F_s acting on the support that holds the rocket stationary.



Momentum Equation

$$\sum \vec{F}_{ext} = \sum \dot{m}_{out} \vec{V}_{out} - \sum \dot{m}_{in} \vec{V}_{in}$$

$$\sum F_{ext,x} = \sum \dot{m}_{out} V_{out,x} - \sum \dot{m}_{in} V_{in,x}$$

$$\sum F_{ext,y} = \sum \dot{m}_{out} V_{out,y} - \sum \dot{m}_{in} V_{in,y}$$

$$\sum F_{ext,z} = \sum \dot{m}_{out} V_{out,z} - \sum \dot{m}_{in} V_{in,z}$$

Example Problem 6.2

As shown in the sketch, concrete flows into a cart sitting on a scale. The stream of concrete has a density of $\rho = 150$ lbm/ft^3, an area of $A = 1$ ft^2, and a speed of $v = 10$ ft/s. At the instant shown, the weight of the cart plus the concrete is 800 lbf. Determine the tension in the cable and the weight recorded by the scale. Assume steady flow.

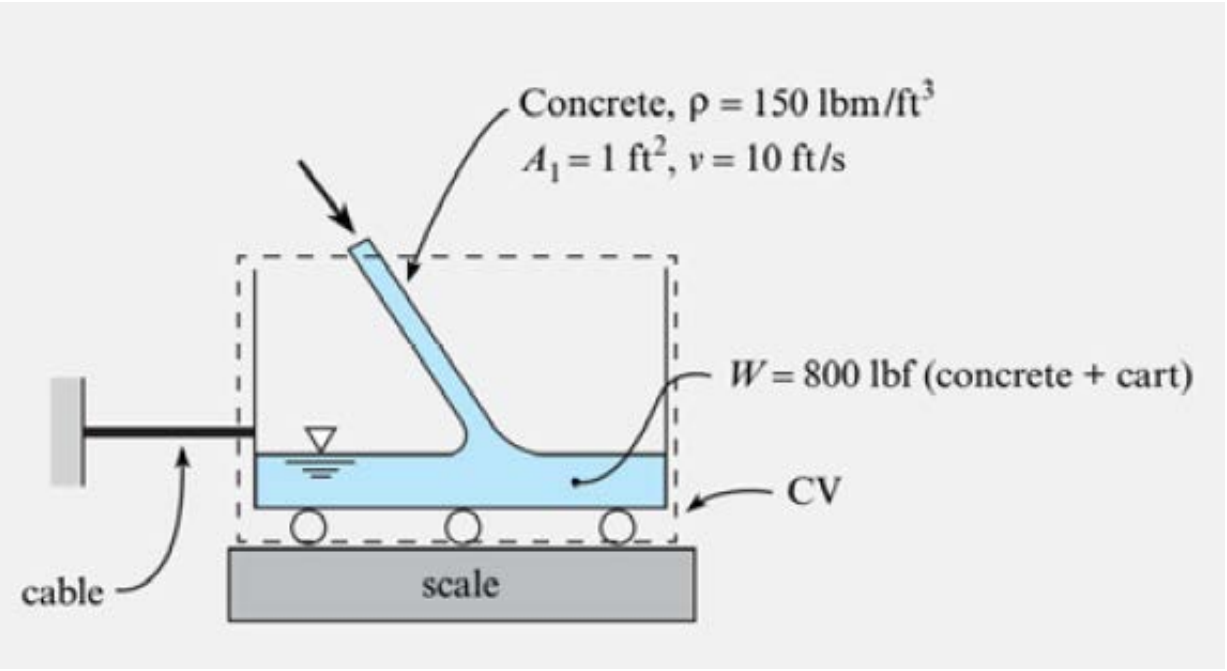
Momentum Equation

$$\sum \vec{F}_{ext} = \sum \dot{m}_{out} \vec{V}_{out} - \sum \dot{m}_{in} \vec{V}_{in}$$

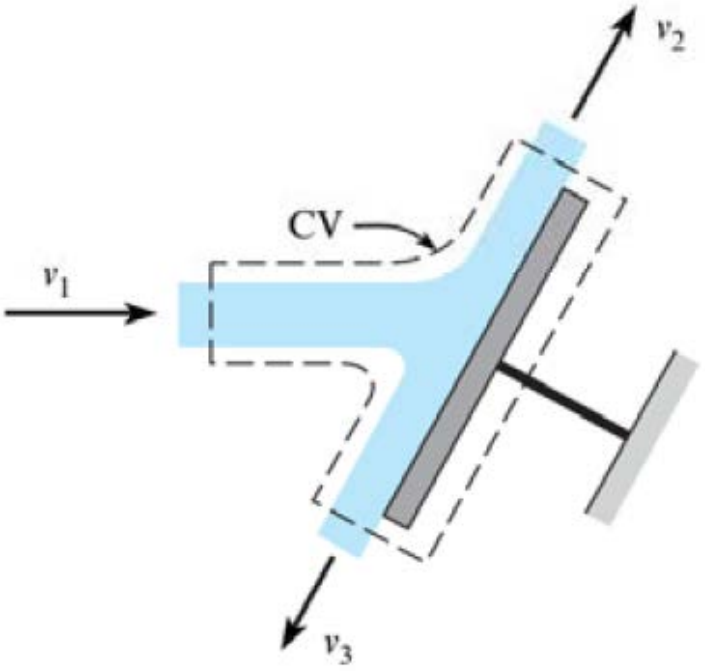
$$\sum F_{ext,x} = \sum \dot{m}_{out} V_{out,x} - \sum \dot{m}_{in} V_{in,x}$$

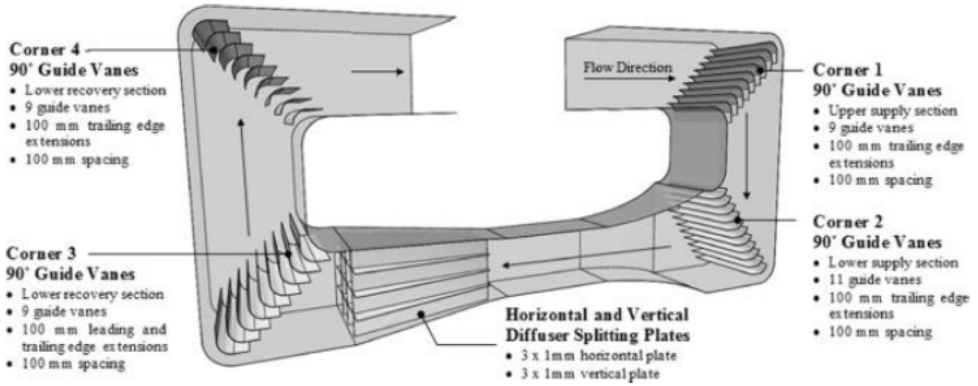
$$\sum F_{ext,y} = \sum \dot{m}_{out} V_{out,y} - \sum \dot{m}_{in} V_{in,y}$$

$$\sum F_{ext,z} = \sum \dot{m}_{out} V_{out,z} - \sum \dot{m}_{in} V_{in,z}$$



Vanes


v_2
CV
v_1
v_3


Corner 4
90° Guide Vanes
• Lower recovery section
• 9 guide vanes
• 100 mm trailing edge extensions
• 100 mm spacing
Flow Direction
Corner 1
90° Guide Vanes
• Upper supply section
• 9 guide vanes
• 100 mm trailing edge extensions
• 100 mm spacing
Corner 2
90° Guide Vanes
• Lower supply section
• 11 guide vanes
• 100 mm trailing edge extensions
• 100 mm spacing
Corner 3
90° Guide Vanes
• Lower recovery section
• 9 guide vanes
• 100 mm leading and trailing edge extensions
• 100 mm spacing
Horizontal and Vertical Diffuser Splitting Plates
• 3 x 1mm horizontal plate
• 3 x 1mm vertical plate

Example Problem 6.3 (on vanes)

A water jet ($\rho = 1.94$ slug/ft^3) is deflected 60° by a stationary vane as shown in the figure. The incoming jet has a speed of 100 ft/s and a diameter of 1 in. Find the force exerted by the jet on the vane.

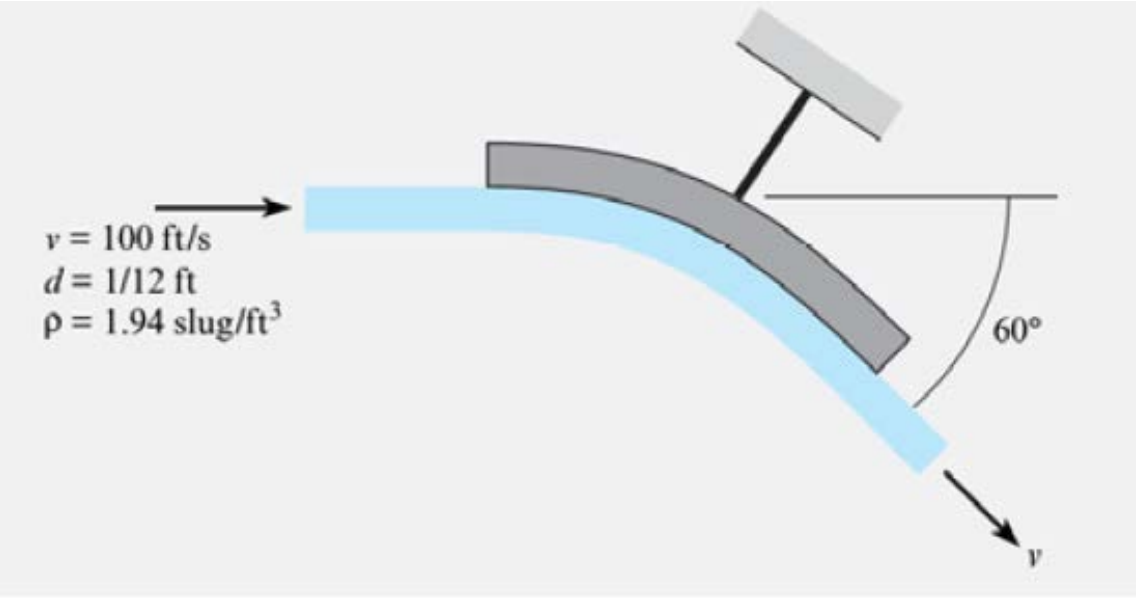
Momentum Equation

$$\sum \vec{F}_{ext} = \sum \dot{m}_{out} \vec{V}_{out} - \sum \dot{m}_{in} \vec{V}_{in}$$

$$\sum F_{ext,x} = \sum \dot{m}_{out} V_{out,x} - \sum \dot{m}_{in} V_{in,x}$$

$$\sum F_{ext,y} = \sum \dot{m}_{out} V_{out,y} - \sum \dot{m}_{in} V_{in,y}$$

$$\sum F_{ext,z} = \sum \dot{m}_{out} V_{out,z} - \sum \dot{m}_{in} V_{in,z}$$



Example Problem 6.4 (on nozzles)

The sketch shows air flowing through a nozzle. The inlet pressure is $p_1 = 105$ kPa abs, and the air exhausts into the atmosphere, where the pressure is 101.3 kPa abs. The nozzle has an inlet diameter of 60 mm and an exit diameter of 10 mm, and the nozzle is connected to the supply pipe by flanges. Find the force required to hold the nozzle stationary. Assume the air has a constant density of 1.22 kg/m^3. Neglect the weight of the nozzle.

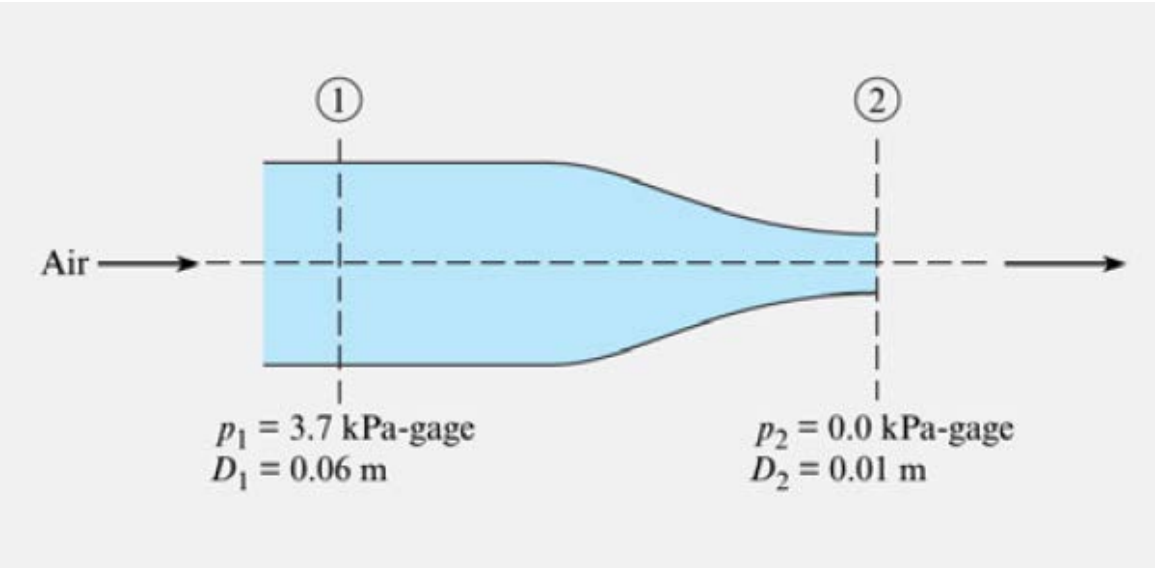
Momentum Equation

$$\sum \vec{F}_{ext} = \sum \dot{m}_{out} \vec{V}_{out} - \sum \dot{m}_{in} \vec{V}_{in}$$

$$\sum F_{ext,x} = \sum \dot{m}_{out} V_{out,x} - \sum \dot{m}_{in} V_{in,x}$$

$$\sum F_{ext,y} = \sum \dot{m}_{out} V_{out,y} - \sum \dot{m}_{in} V_{in,y}$$

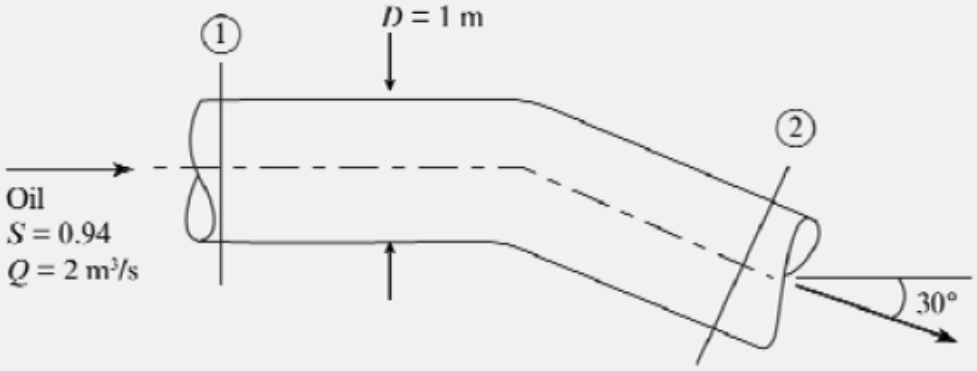
$$\sum F_{ext,z} = \sum \dot{m}_{out} V_{out,z} - \sum \dot{m}_{in} V_{in,z}$$



Example Problem 6.5 (on bends)

Find force to keep a (horizontal) bend in place

- The bend lies in a horizontal plane.
- $\forall_{oil} = 1.2\ m^3$ = volume of oil in bend.
- $W_{bend} = 4000\ N$ = empty weight of bend.
- $p = 75$ kPa-gage = pressure along the centerline.



Momentum Equation

$$\sum \vec{F}_{ext} = \sum \dot{m}_{out} \vec{V}_{out} - \sum \dot{m}_{in} \vec{V}_{in}$$

$$\sum F_{ext,x} = \sum \dot{m}_{out} V_{out,x} - \sum \dot{m}_{in} V_{in,x}$$

$$\sum F_{ext,y} = \sum \dot{m}_{out} V_{out,y} - \sum \dot{m}_{in} V_{in,y}$$

$$\sum F_{ext,z} = \sum \dot{m}_{out} V_{out,z} - \sum \dot{m}_{in} V_{in,z}$$