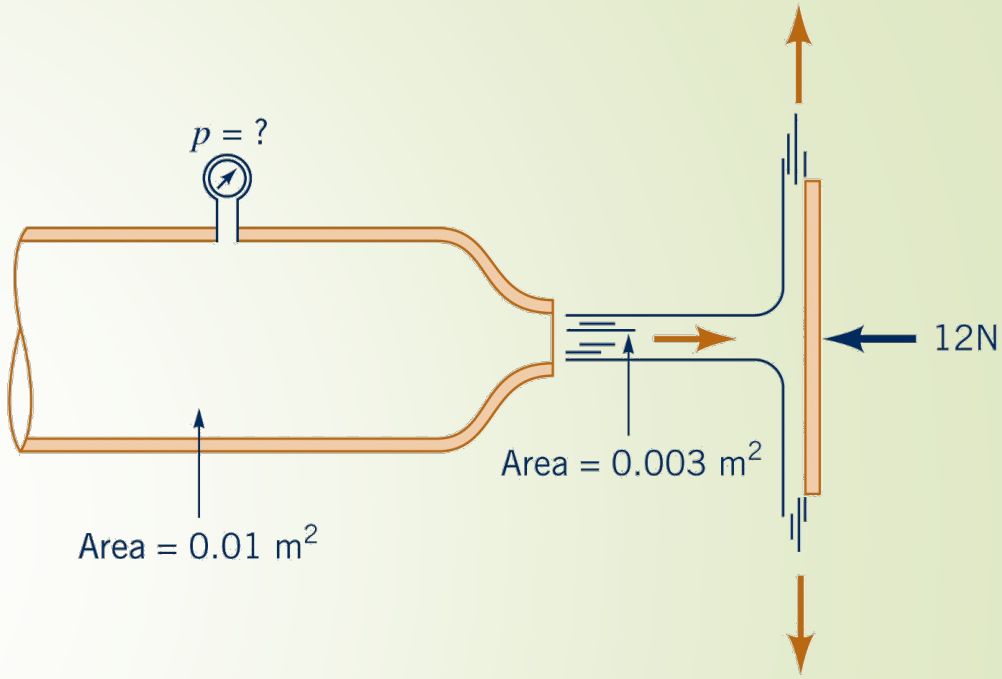

Figure P5.57

MECH-322 Fluid Mechanics

1

Study Aid

Momentum Conservation

Parametric Model

- Determine parametric model for gauge Pressure and Velocity as a function of external force to hold plate.
- **STEP 1:** Identify key points
- **STEP 2:** Identify Momentum Control Volume #1 for fluid around plate
- **KEY Fundamentals**
  - Mass Conservation
  - Energy Conservation
  - Momentum Conservation

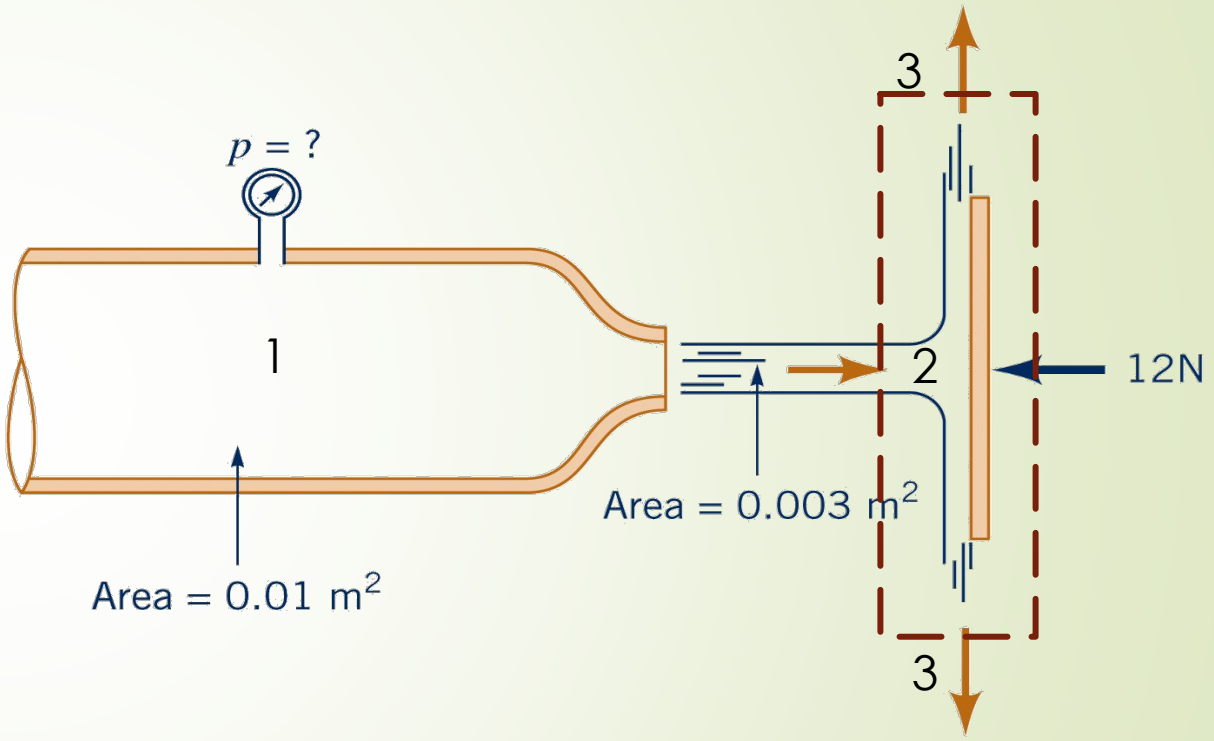

Figure P5.57

Energy/Mass Conservation

MASS CONSERVATION (Change in Area)

1-2

$$A_1 V_1 = A_2 V_2$$

$$V_1 = \frac{A_2 V_2}{A_1}$$

ENERGY CONSERVATION (BERNOULLI)

1-2

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 ; z_1 = z_2, p_2 = 0$$

$$p_1 = \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right) \gamma$$

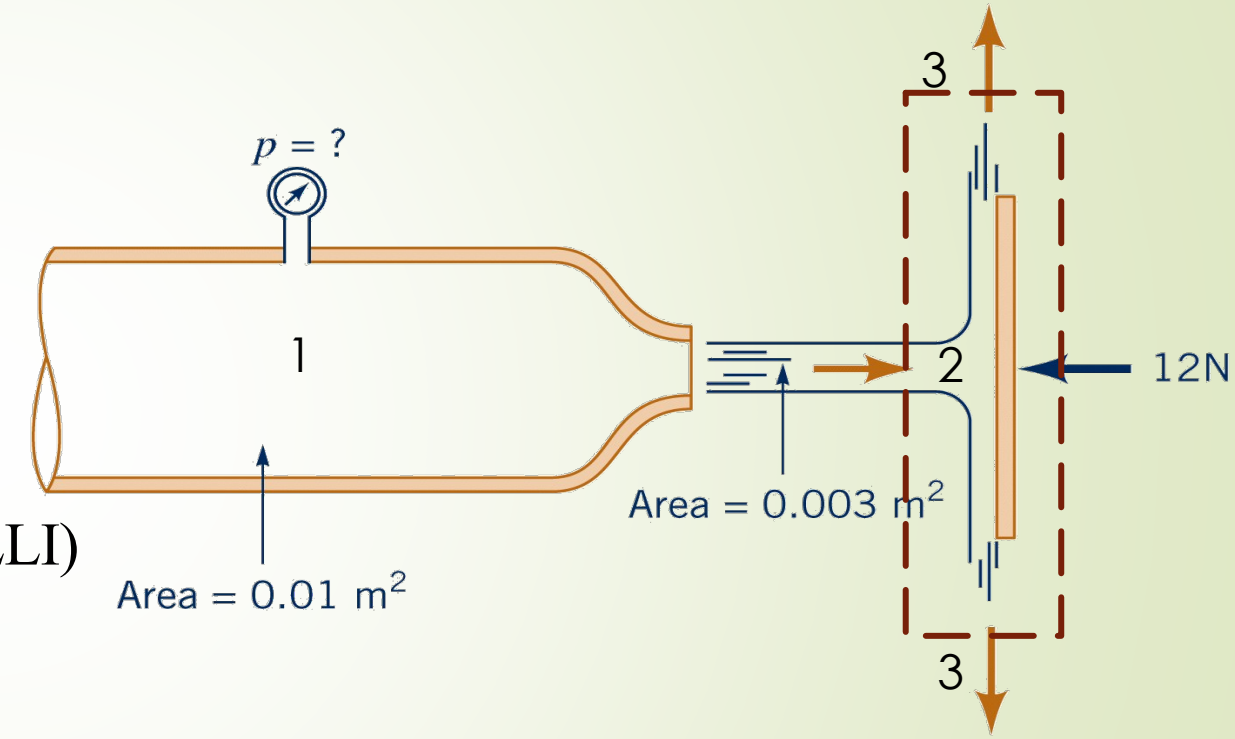

Figure P5.57

COMBINE ENERGY & MASS CONSERVATION

$$p_1 = \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right) \gamma$$

$$V_1 = \frac{A_2 V_2}{A_1}$$

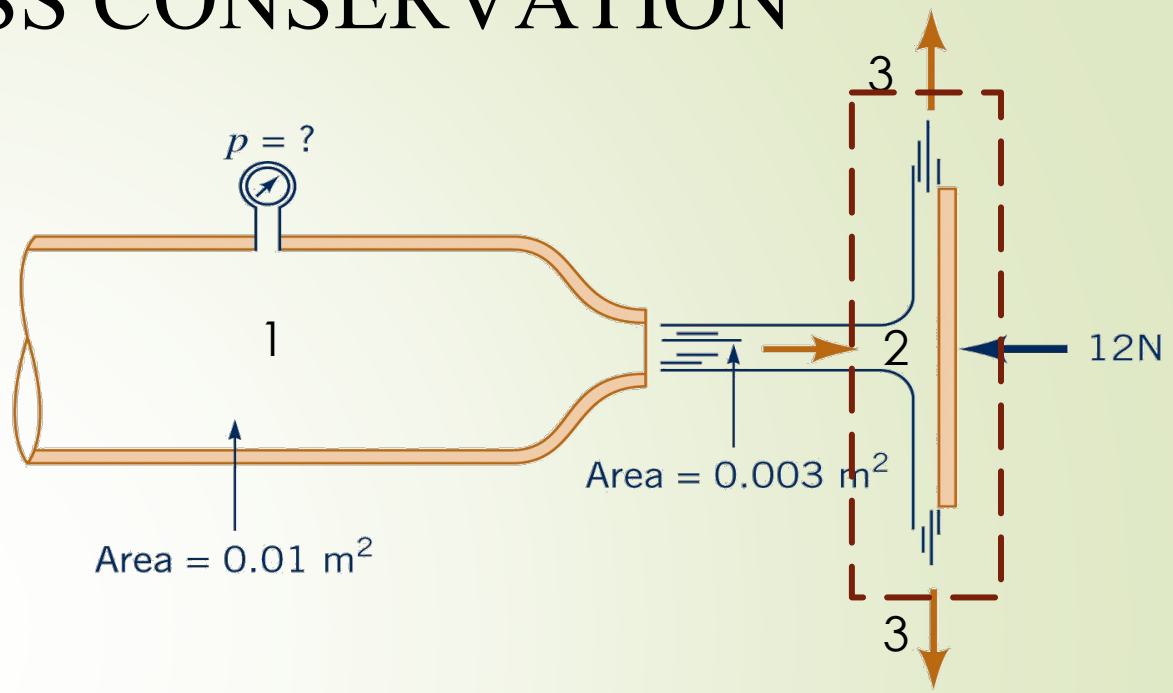

Figure P5.57
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$$p_1(V_2, \frac{A_2}{A_1}) = \left(\frac{V_2^2}{2g} - \frac{\left(\frac{A_2 V_2}{A_1} \right)^2}{2g} \right) \gamma = \frac{V_2^2}{2g} \left[1 - \left(\frac{A_2}{A_1} \right)^2 \right] \gamma$$

X:MOMENTUM:CV#1

$$\sum_x \vec{F} = \left(\frac{dM_x}{dt}\right)_{CV} + \sum_x (u_{out} \pm)\dot{m}_{out} - \sum_x (u_{in} \pm)\dot{m}_{in}$$

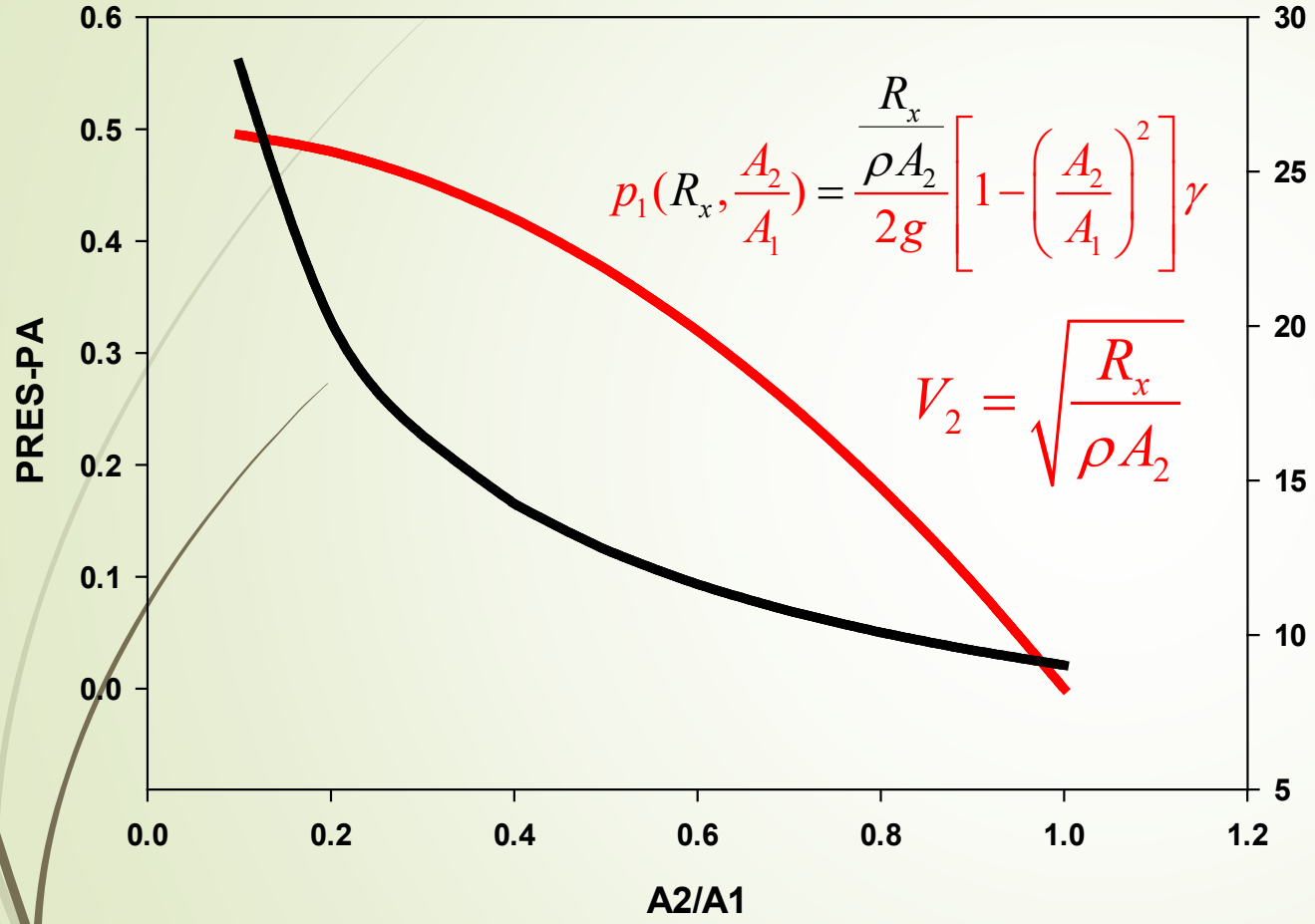
$$-R_x = 0 + 0 - V_2 \dot{m}_{in} = -V_2^2 \rho A_2$$

$$V_2 = \sqrt{\frac{R_x}{\rho A_2}}; \sqrt{\frac{N}{\frac{kg}{m^3} m^2}} = \sqrt{\frac{\cancel{kg} - m/s^2}{\frac{\cancel{kg}}{m^3} m^2}} = \sqrt{\frac{m^2}{s^2}} = m/s$$

COMBINE WITH ENERGY

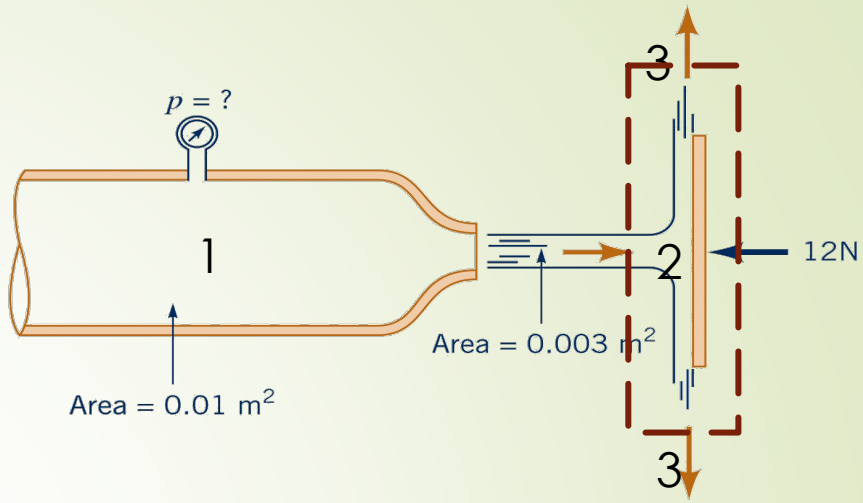
$$p_1(R_x, \frac{A_2}{A_1}) = \frac{\frac{R_x}{\rho A_2}}{2g}\left[1 - \left(\frac{A_2}{A_1}\right)^2\right]\gamma = \frac{\frac{N}{\frac{kg}{\cancel{m^3}} m^2}}{\frac{m}{s^2}} \frac{N}{\cancel{m^3}} = \frac{N}{m^2} = Pa$$

Nozzle Expansion
A1=0.01m, Rx=100N



$$p_1(R_x, \frac{A_2}{A_1}) = \frac{\frac{R_x}{\rho A_2}}{2g}\left[1-\left(\frac{A_2}{A_1}\right)^2\right]\gamma$$

$$V_2 = \sqrt{\frac{R_x}{\rho A_2}}$$



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Density	Gamma	Rx	A1
kg/m3	N/m3	N	m2
1.23	12.0663	100	0.01
	A2	P	V2
A2/A1	m	PA	m/s
0.1	0.001	0.495	28.5133
0.2	0.002	0.48	20.16195
0.3	0.003	0.455	16.46216
0.4	0.004	0.42	14.25665
0.5	0.005	0.375	12.75153
0.6	0.006	0.32	11.6405
0.7	0.007	0.255	10.77701
0.8	0.008	0.18	10.08097
0.9	0.009	0.095	9.504432
1	0.01	1.11E-16	9.016696