MECH-322 Fluids Study Aid

Dr. K. J. Berry

NO SUCCESS WITHOUT PRACTICE

FIND "Δh".

ROAD MAP

Identify and label various elevation levels associated with different fluids and understanding Pascal's Law.

Identify Starting Point and Ending Point.

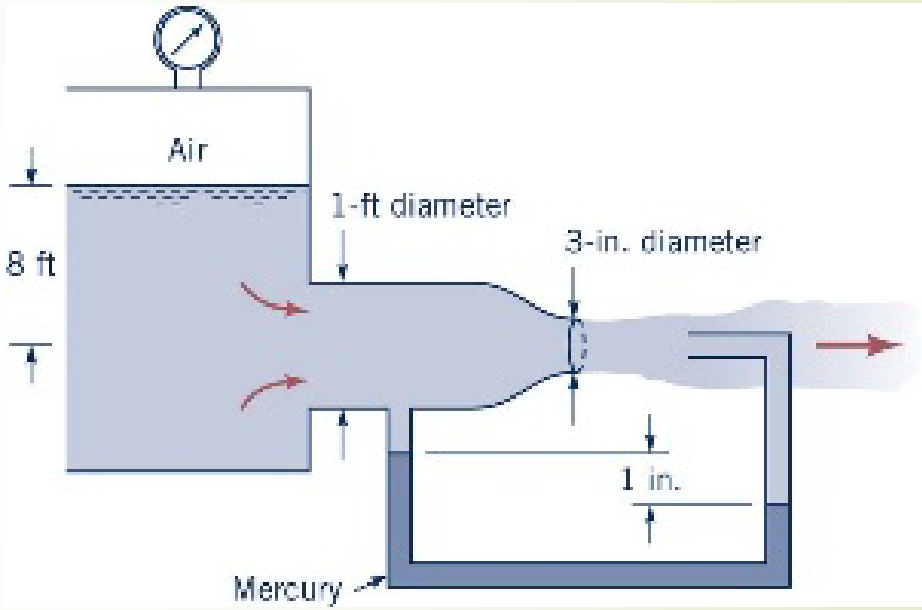
Identify any "MISSING" dimensions from Start Point to End Point, ΔS.

Transverse circuit from Start Point and Apply POINT-TO-POINT method for Law of Hydrostatics

Solve for unknown.

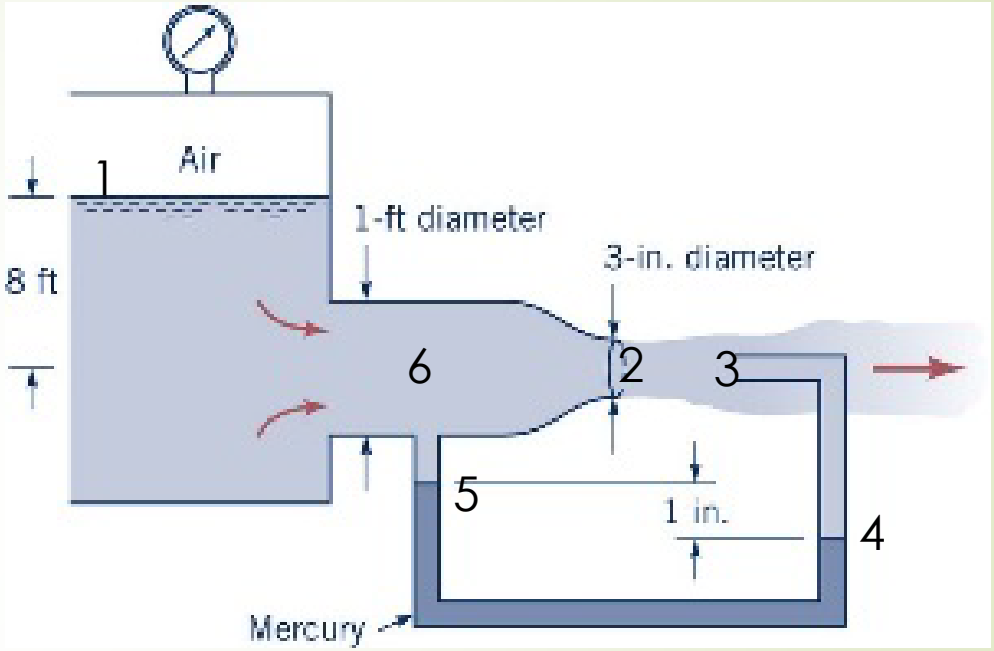
Study Aid: Bernoulli + Manometry

- **Water flows steadily from a large, closed tank as shown through nozzle. The deflection in the mercury manometer is 1" and viscous effects are small. Water exits as free jet from nozzle.**
  - **Determine the volume flow rate, Q.**
    - **Implies we must find VELOCITY.**
  - **Determine the air pressure in the space above the surface of the water in the tank.**



Identify Points & Considerations

- It is **CRITICAL** to identify and label points at inlet/exit points and fluid intersections.
- Identify important considerations and understand why:
  - Bernoulli
  - Manometry
    - Gives DELTA Pressure
  - Mass Conservation
  - Free Jets? (2)
  - Stagnation Pressure Taps? (3)
  - Static Pressure Taps? (6)
  - Manometer Fluid Interfaces (5,4)
  - Free Surfaces (1)



FIND "Δh".

ROAD MAP

Identify and label various elevation levels associated with different fluids and understanding Pascal's Law.

Identify Starting Point and Ending Point.

Identify any "MISSING" dimensions from Start Point to End Point, ΔS. (CRITICAL)

Transverse circuit from Start Point and Apply POINT-TO-POINT method for Law of Hydrostatics

Solve for unknown pressure differential ΔP, (or h).

APPLY BERNOULLI USING SAME POINT, or POINTS, w/ΔP

Creativity, the ability to make or otherwise bring into existence something new, whether a new solution to a problem, a new method or device, or a new artistic object or form.

Steve Wozniak and Steve Jobs
Steve Wozniak (left) and Steve Jobs holding an Apple I circuit board, c. 1976.
Courtesy of Apple Computer, Inc.

Creative CHAOS is the MAYHEM that occurs in creative teams when multiple assets, projects, and clients are being juggled — without the FRAMEWORK to ensure that people, skills, information, and tools are being used effectively. (CLICK)

Learning CHAOS occurs when equations are applied randomly to engineering problem solving without a FRAMEWORK for thinking, approach, and logical engineering judgement.

Dr. K. J. Berry, ASME FELLOW, c. 2024

2015

Apply Manometry (6-3)

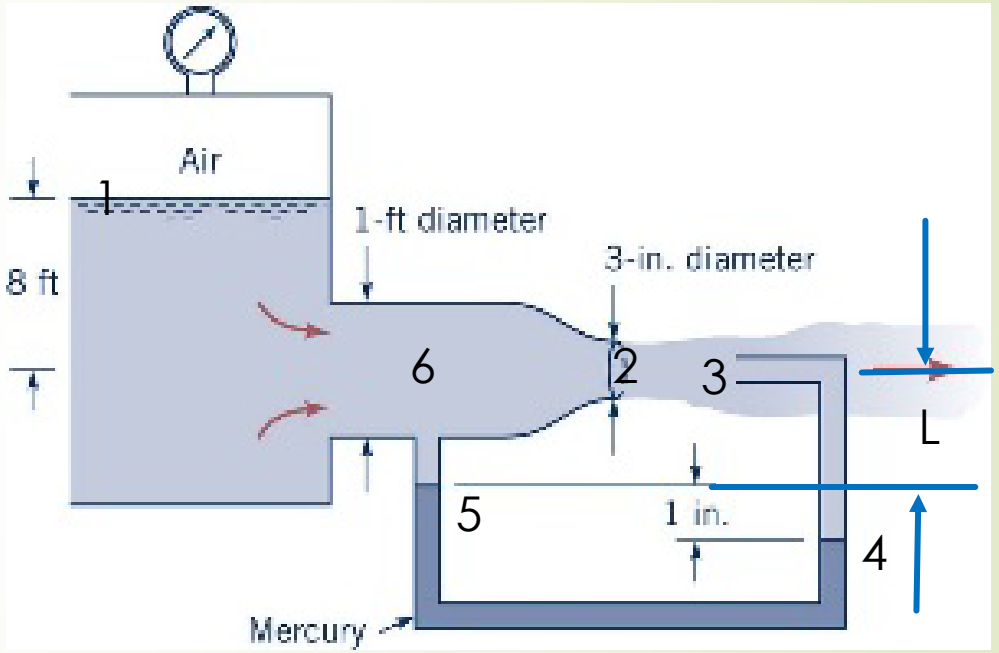
- **IDENTIFY UNKNOWN DIMENSIONS (L)**

Apply Manometry 6-3

$$P_6 + \cancel{\gamma_f L} + \gamma_m \frac{1}{12} - \gamma_f \left(\frac{1}{12} + \cancel{L}\right) = P_3$$

$$\frac{P_3 - P_6}{\gamma_f} = \frac{1}{12}\left(\frac{\gamma_m}{\gamma_f} - 1.0\right)$$

Combine with Bernoulli



Manometry Gives a Pressure Differential

Apply Bernoulli (maybe multiple times)

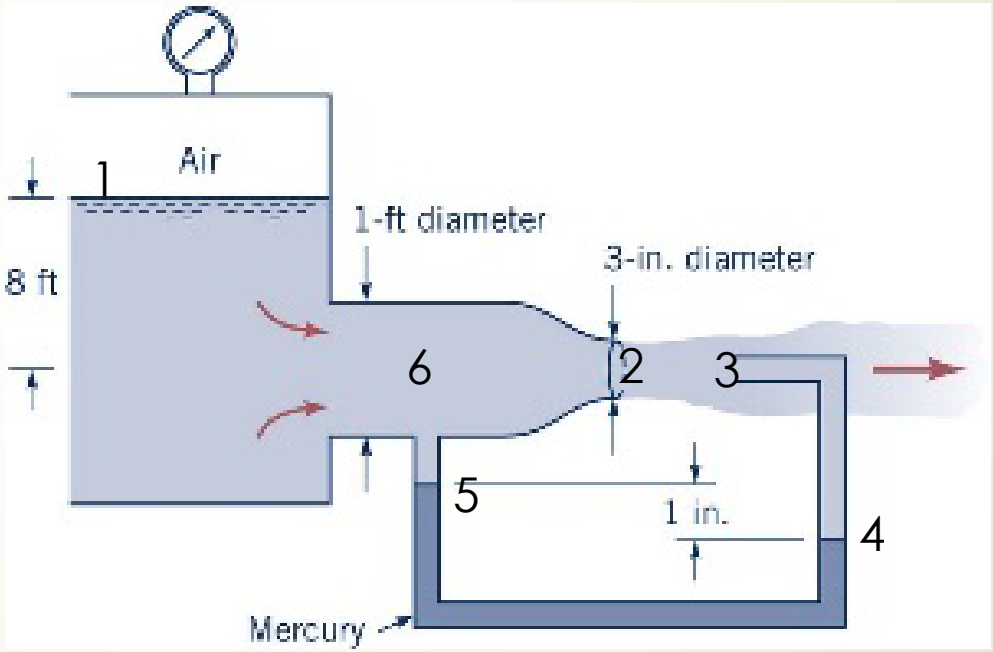
- **USE point involve with MANOMETER static pressure. Consider which two points have the most known information?**

Apply Bernoulli: $6 \rightarrow 3$

$$\frac{P_6}{\gamma_f}+\frac{V_6^2}{2g}+z_6=\frac{P_3}{\gamma_f}+\frac{V_3^2}{2g}+z_3, \rightarrow z_6=z_3$$

$$\frac{P_6}{\gamma_f}-\frac{P_3}{\gamma_f}=\frac{V_3^2}{2g}-\frac{V_6^2}{2g}$$

$$V_6=\sqrt{\left(\frac{P_3}{\gamma_f}-\frac{P_6}{\gamma_f}\right)2g}\text{; and } V_3=0 \text{ (WHY ?)}$$



V3=0, STAGNATION POINT

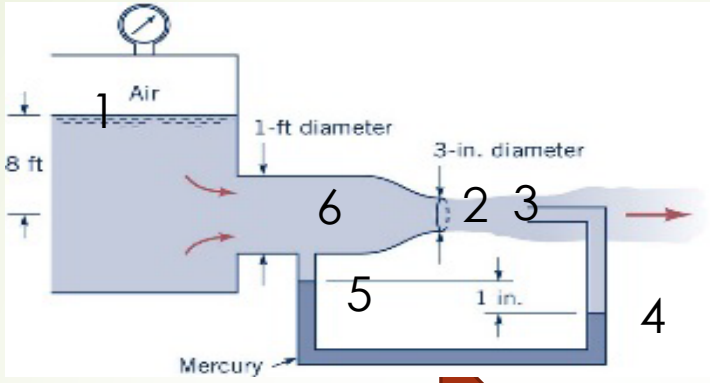
Combine Bernoulli and Manometry

Apply Manometry 6-3

$$P_6 + \cancel{\gamma_f L} + \gamma_m \frac{1}{12} - \gamma_f \left(\frac{1}{12} + \cancel{L}\right) = P_3$$

$$\frac{P_3 - P_6}{\gamma_f} = \frac{1}{12}\left(\frac{\gamma_m}{\gamma_f} - 1.0\right)$$

Combine with Bernoulli



Apply Bernoulli: $6 \rightarrow 3$

$$\frac{P_6}{\gamma_f} + \frac{V_6^2}{2g} + z_6 = \frac{P_3}{\gamma_f} + \frac{V_3^2}{2g} + z_3, \rightarrow z_6 = z_3$$

$$\frac{P_6}{\gamma_f} - \frac{P_3}{\gamma_f} = \frac{V_3^2}{2g} - \frac{V_6^2}{2g}$$

$$V_6 = \sqrt{\left(\frac{P_3}{\gamma_f} - \frac{P_6}{\gamma_f}\right) 2g}; \text{ and } V_3 = 0 \text{ (WHY ?)}$$

$$V_6 = \sqrt{\left(\frac{P_3}{\gamma_f} - \frac{P_6}{\gamma_f}\right) 2g}$$

$$\frac{P_3 - P_6}{\gamma_f} = \frac{1}{12}\left(\frac{\gamma_m}{\gamma_f} - 1.0\right)$$

$$V_6 = \sqrt{\frac{1}{12}\left(\frac{\gamma_m}{\gamma_f} - 1.0\right) 2g}$$

$$V_6 = \sqrt{\frac{1}{12} ft \bullet (13.55 - 1.0) \bullet 2 \bullet 32.2 \frac{ft}{s^2}}$$

$$V_6 = 8.2\, ft / s$$

$$Q = VA = V_6 A_6 = V_2 A_2$$

$$Q = 8.2\, ft/s \bullet \pi \frac{D_6^2}{4} = 8.2\, ft/s \bullet \frac{\pi}{4}(1)^2\ ft^2$$

$$Q = 6.44 \frac{ft^3}{s}$$

$$V_2 = \frac{Q}{A_2} = \frac{6.44 \frac{ft^3}{s}}{\pi \frac{D_2^2\, ft^2}{4}} = 131.2\, ft/s$$

Air Pressure

- Apply Bernoulli 1-2

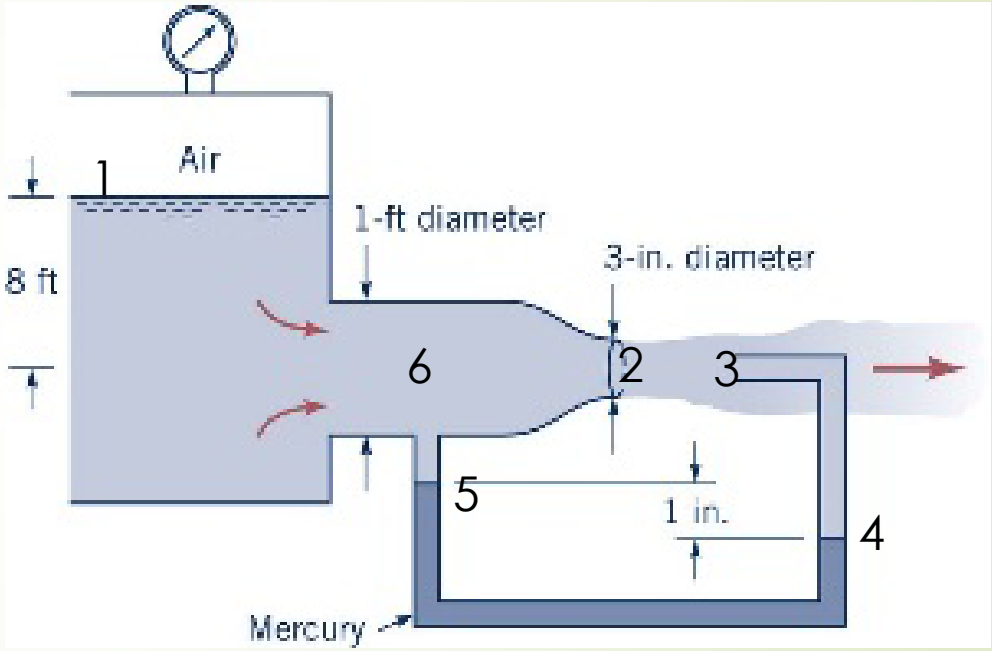
$$\frac{P_1}{\gamma_f}+\frac{V_1^2}{2g}+z_1=\frac{P_2}{\gamma_f}+\frac{V_2^2}{2g}+z_2;\rightarrow z_1=8',z_2=0,V_1=0,P_2=0$$

$$P_1=\left(\frac{V_2^2}{2g}-z_1\right)\gamma_f$$

$$P_1=\left(\frac{131.2^2\,ft^2/s^2}{2\bullet 32.2\,ft/s^2}-8ft\right)\bullet 62.4\frac{lbf}{ft^3}$$

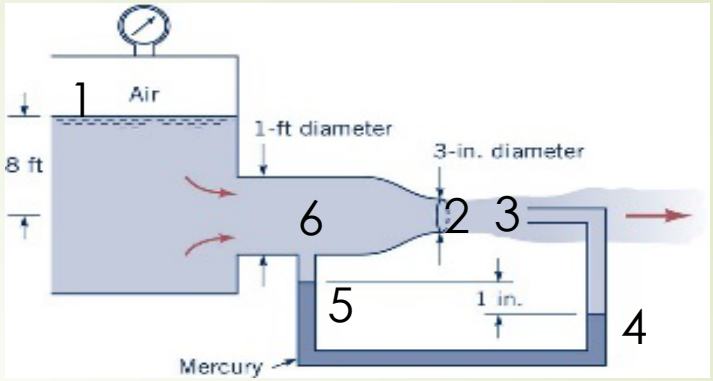
$$P_1=16{,}180\frac{lbf}{ft^2}$$

$$P_1=112.4PSI$$



Nozzle Inlet Pressure

- Note affect due to velocity



ApplyBernoulli, 1-6

$$P_6 = \left(\frac{P_1}{\gamma_f} + z_1 - \frac{V_6^2}{2g} \right) \gamma_f \rightarrow or \Delta P = \gamma_f (\Delta z - \frac{V_6^2}{2g})$$

COMMENT:

Observe that hydrostatic pressure is reduced by Velocity HEAD ($\frac{V_6^2}{2g}$) at point.