



FluidMech^{Power}

Your 24/7 Tutor for
Fluid Mechanics

Actus Potentia, Inc.

www.actuspotentia.com/Fluid.shtml

What will it do for Students

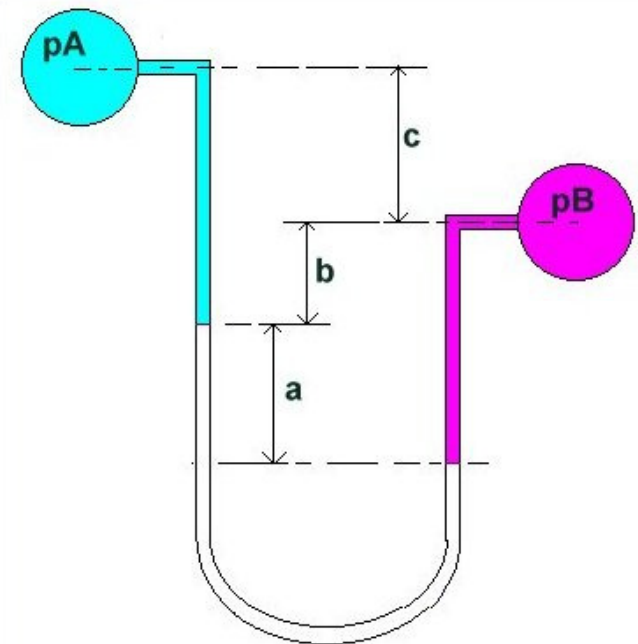
- ▶ You will get a strong foundation through guided problem solving
- ▶ You will know where to start and where to go from the step-by-step instructions
- ▶ You will get immediate feedback so that you can fix your mistakes
- ▶ You will finish your homework in a fraction of the time
- ▶ You will improve test scores and grade
- ▶ You can learn at your own pace at your own time

Manometer

Start at p_A ,
walk through
manometer
to p_B

$$p_A + \gamma_1 H_1 + \gamma_2 H_2 - \gamma_3 H_3 = p_B$$

NEW



Force on Plane Area

Triangle

Find Area

$$A = \frac{bh}{2}$$

Locate Centroid C, draw x_c
Find 2nd Moment of Area

$$I(x_c) = \frac{bh^3}{36}$$

Find d

$$d = a + \frac{2h}{3}$$

Find Force

$$F = \gamma d A \sin \theta$$

Find Location

$$p = \frac{I(x_c)}{dA} + d$$

Force on Plane Area

Semicircle

Find Area

$$A = \frac{\pi r^2}{2}$$

Locate Centroid C, draw x_c
Find 2nd Moment of Area

$$I(x_c) = \left(\frac{\pi}{8} - \frac{8}{9\pi}\right)r^4 = 0.109757r^4$$

Find d

$$d = a + r - \frac{4r}{3\pi}$$

Find Force

$$F = \gamma d A \sin \theta$$

Find Location

$$p = \frac{I(x_c)}{dA} + d$$

Force on Plane Area *help*

Force on Composite Plane Areas

Problem-1

The gate of Figure-1 is immersed in a fluid as shown in Figure-2. This gate is analyzed as a composite area consisting of two flat, rectangular gates.

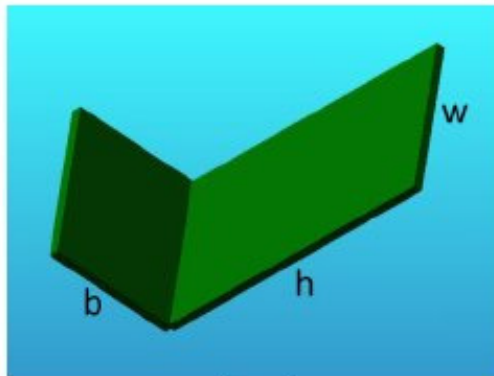


Figure-1

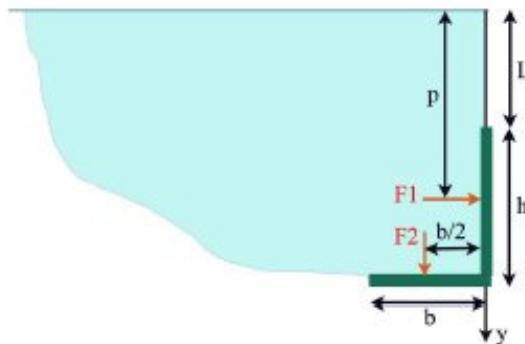


Figure-2

Force on Plane Area *help*

Problem-2

The gate of Figure-3 is immersed in a fluid. This gate is analyzed as a composite area consisting of one rectangular gate and a semi-circular gate.

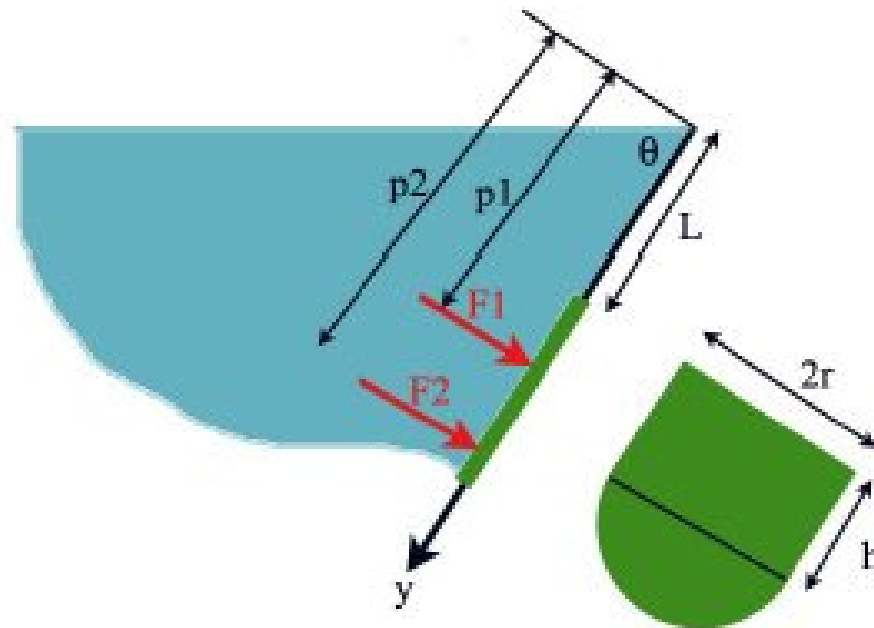
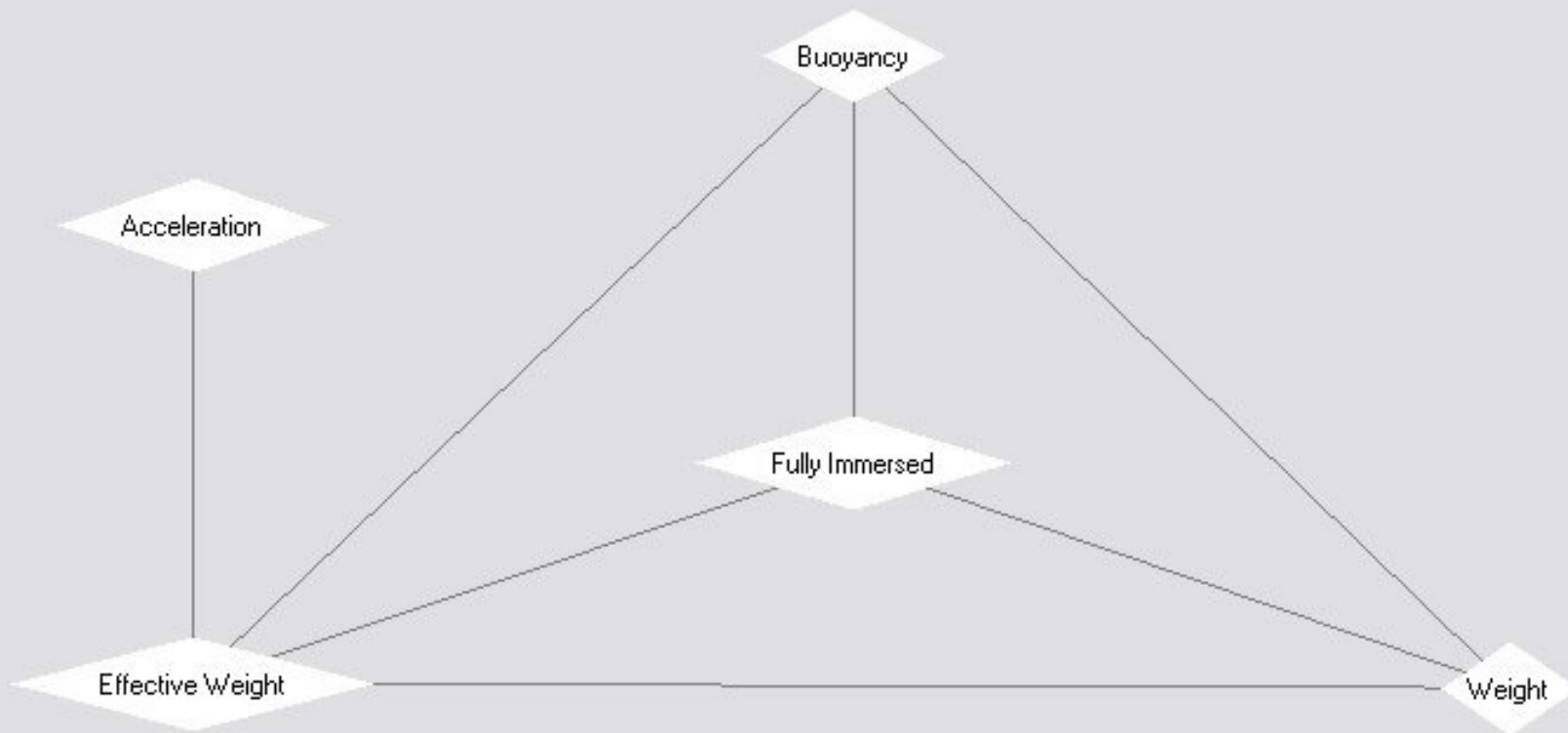


Figure-3

Buoyancy Concept Map



Buoyancy Concept Map - Variables

Displaying all variables in map

Accept Changes (Enter)

Discard Changes (Esc)

Add Other Variables

Basic

KNOWN variables

Check all the variables you know.

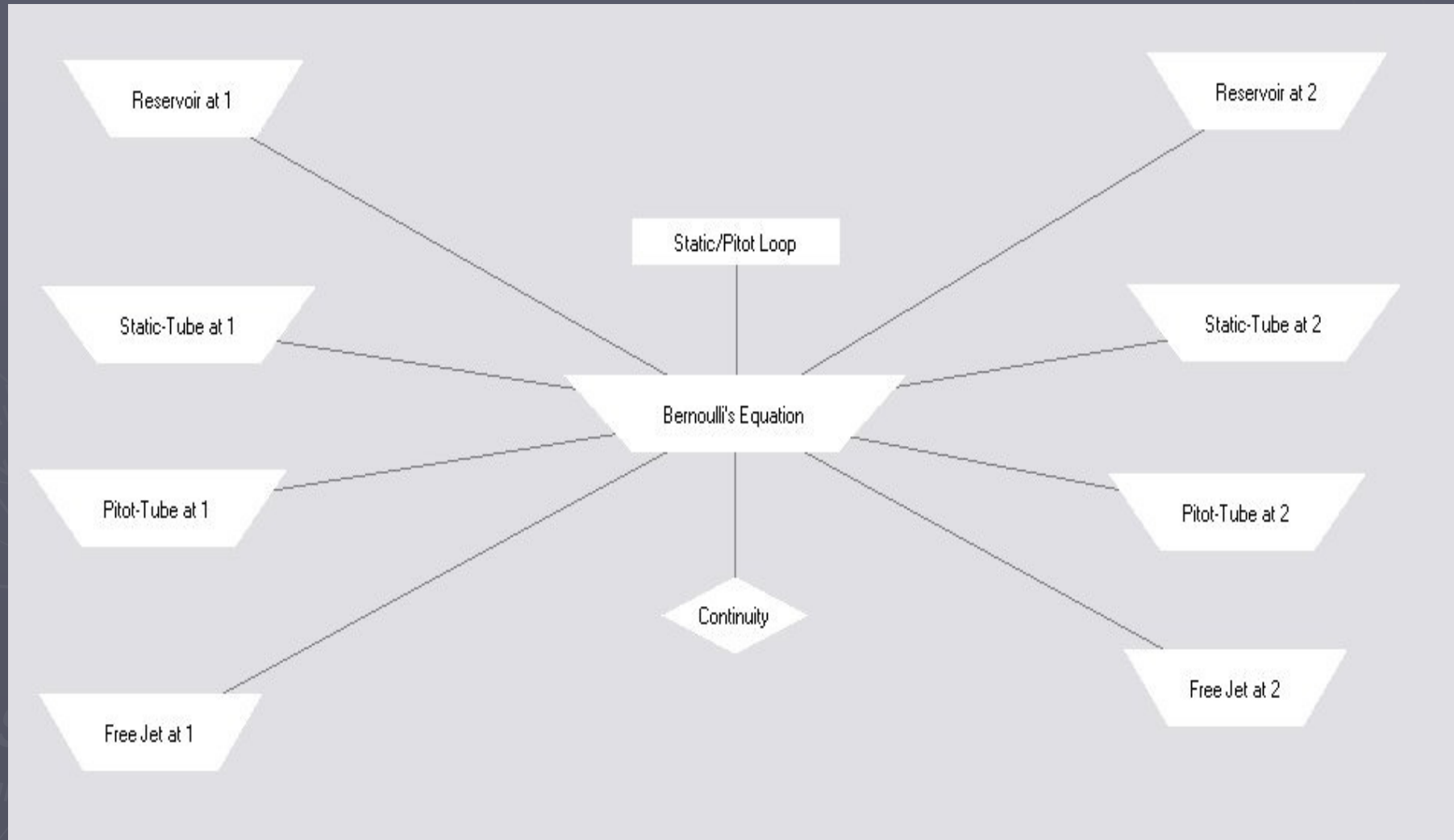
- Acceleration - a
- Acceleration Gravity - g
- Buoyancy Force - F_Buoy
- Sp. Weight Body - γ_{body}
- Sp. Weight Fluid - γ_{fluid}
- Vol. Body - V_{body}
- Vol. Displaced Fluid - V_{disp}
- Weight Body - W_{body}
- Weight Effective - W_{eff}

DESIRED variables

Check the one variable you need.

- Acceleration - a
- Acceleration Gravity - g
- Buoyancy Force - F_Buoy
- Sp. Weight Body - γ_{body}
- Sp. Weight Fluid - γ_{fluid}
- Vol. Body - V_{body}
- Vol. Displaced Fluid - V_{disp}
- Weight Body - W_{body}
- Weight Effective - W_{eff}

Bernoulli Eqn. Concept Map



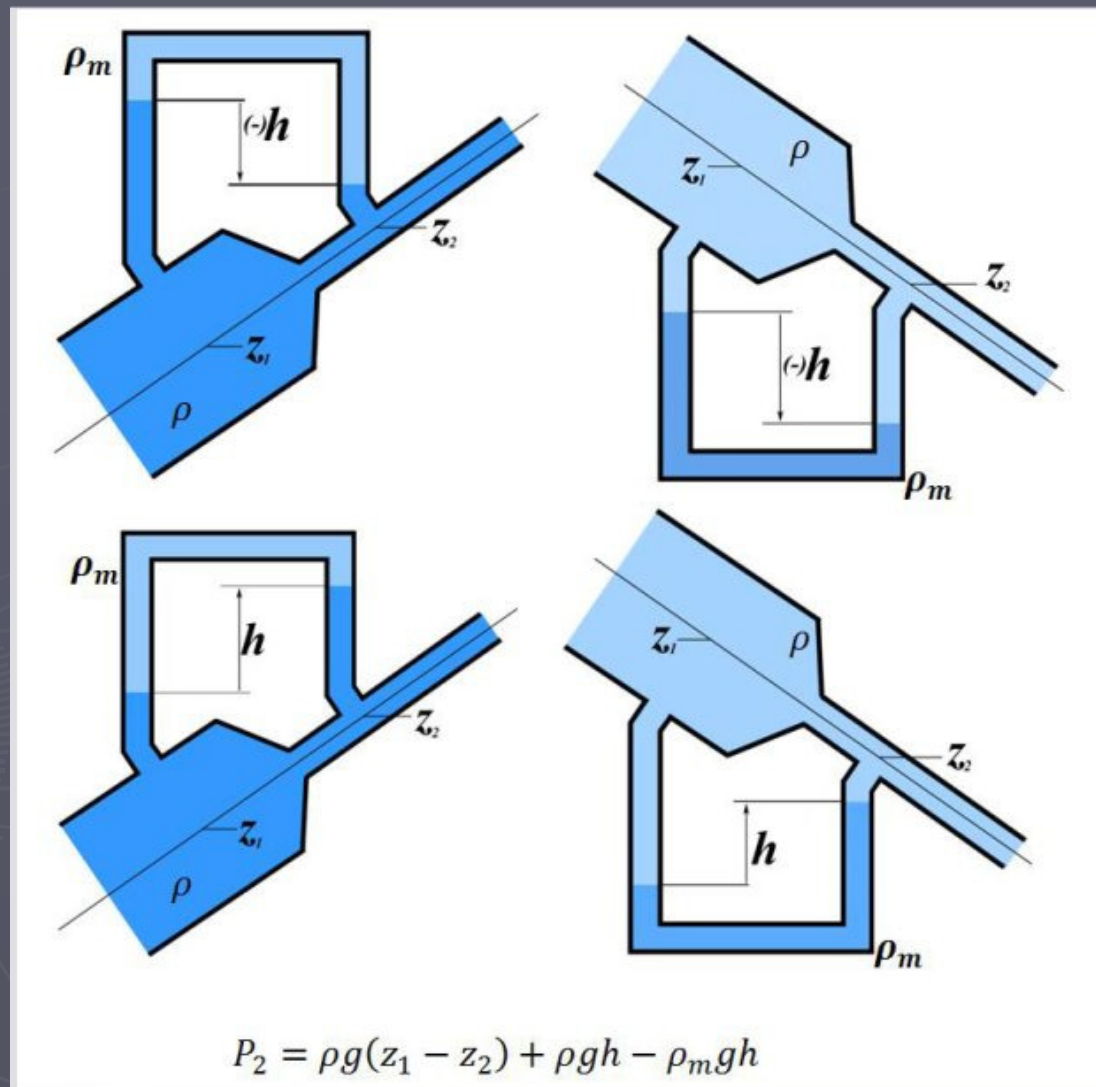
Bernoulli Concept Map - Variables

Displaying all variables in map

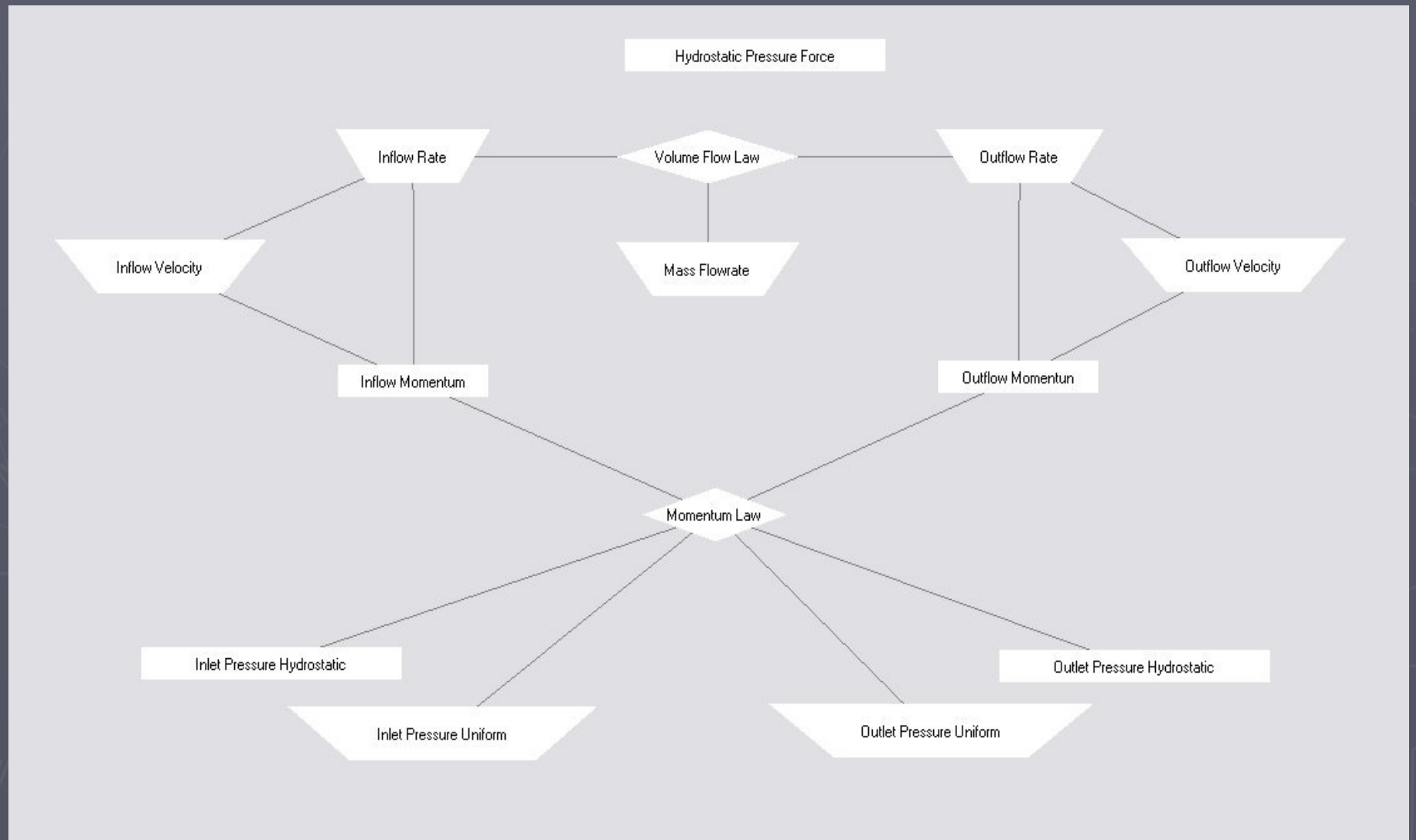
Accept Changes (Enter) Discard Changes (Esc) Add Other Variables Basic ▾

KNOWN variables	DESIRED variables
Check all the variables you know.	Check the one variable you need.
<input type="checkbox"/> Altitude-1 - Alt1	<input type="radio"/> Altitude-1 - Alt1
<input type="checkbox"/> Altitude-2 - Alt2	<input type="radio"/> Altitude-2 - Alt2
<input type="checkbox"/> Area-1 - A1	<input type="radio"/> Area-1 - A1
<input type="checkbox"/> Area2 - A2	<input type="radio"/> Area2 - A2
<input type="checkbox"/> Density - rho	<input type="radio"/> Density - rho
<input type="checkbox"/> Gravity - g	<input type="radio"/> Gravity - g
<input type="checkbox"/> manometer deflection - H_man	<input type="radio"/> manometer deflection - H_man
<input type="checkbox"/> manometer density - rho_m	<input type="radio"/> manometer density - rho_m
<input type="checkbox"/> Pressure-1 - Pr1	<input type="radio"/> Pressure-1 - Pr1
<input type="checkbox"/> Pressure-2 - Pr2	<input type="radio"/> Pressure-2 - Pr2
<input type="checkbox"/> Total Head -1 - H1	<input type="radio"/> Total Head -1 - H1
<input type="checkbox"/> Total Head-2 - H2	<input type="radio"/> Total Head-2 - H2
<input type="checkbox"/> Velocity-1 - Vel1	<input type="radio"/> Velocity-1 - Vel1
<input type="checkbox"/> Velocity-2 - Vel2	<input type="radio"/> Velocity-2 - Vel2

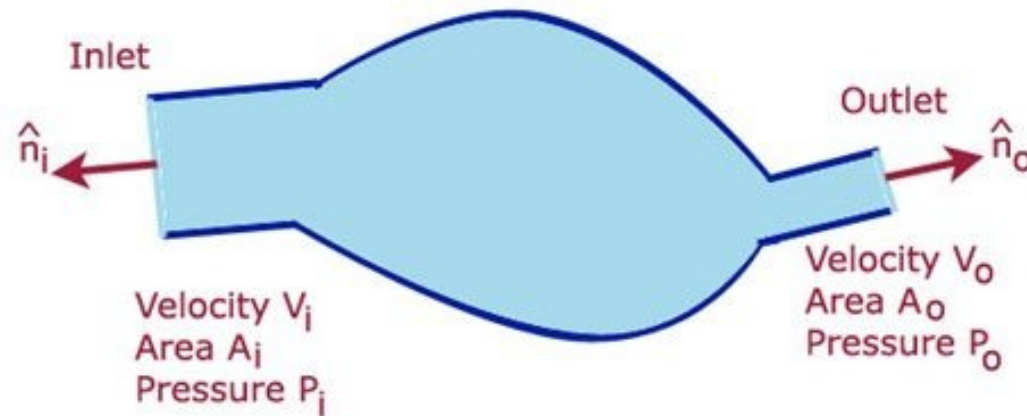
Bernoulli Concept Map - *help*



Momentum – Concept Map



Momentum Concept Map *help*



Weight of fluid = $\vec{W} = W_x \hat{x} + W_y \hat{y}$

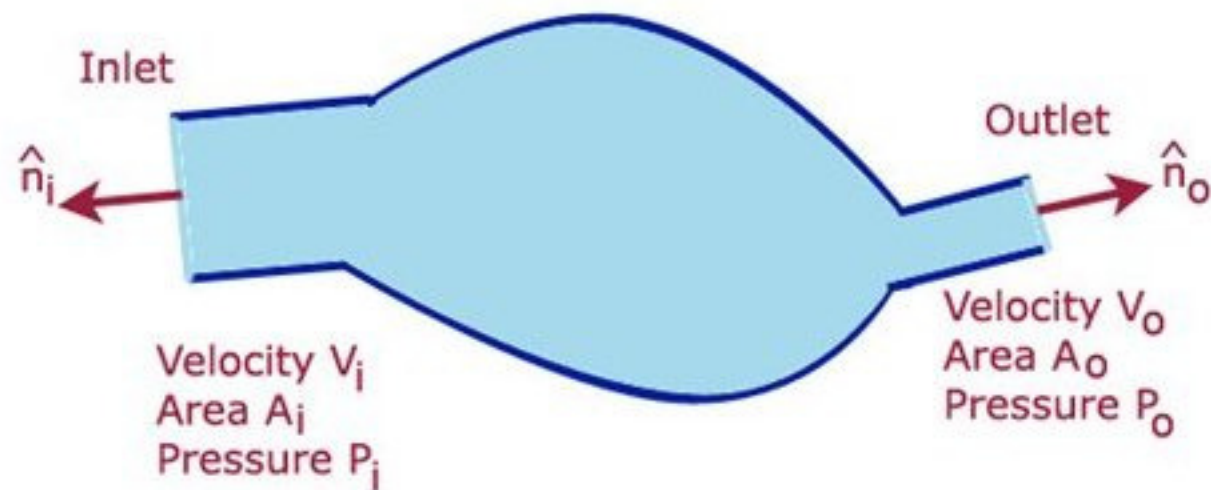
Force from pipes, walls, surfaces in contact with the fluid =

$\vec{F} = F_x \hat{x} + F_y \hat{y}$

Momentum Equation:

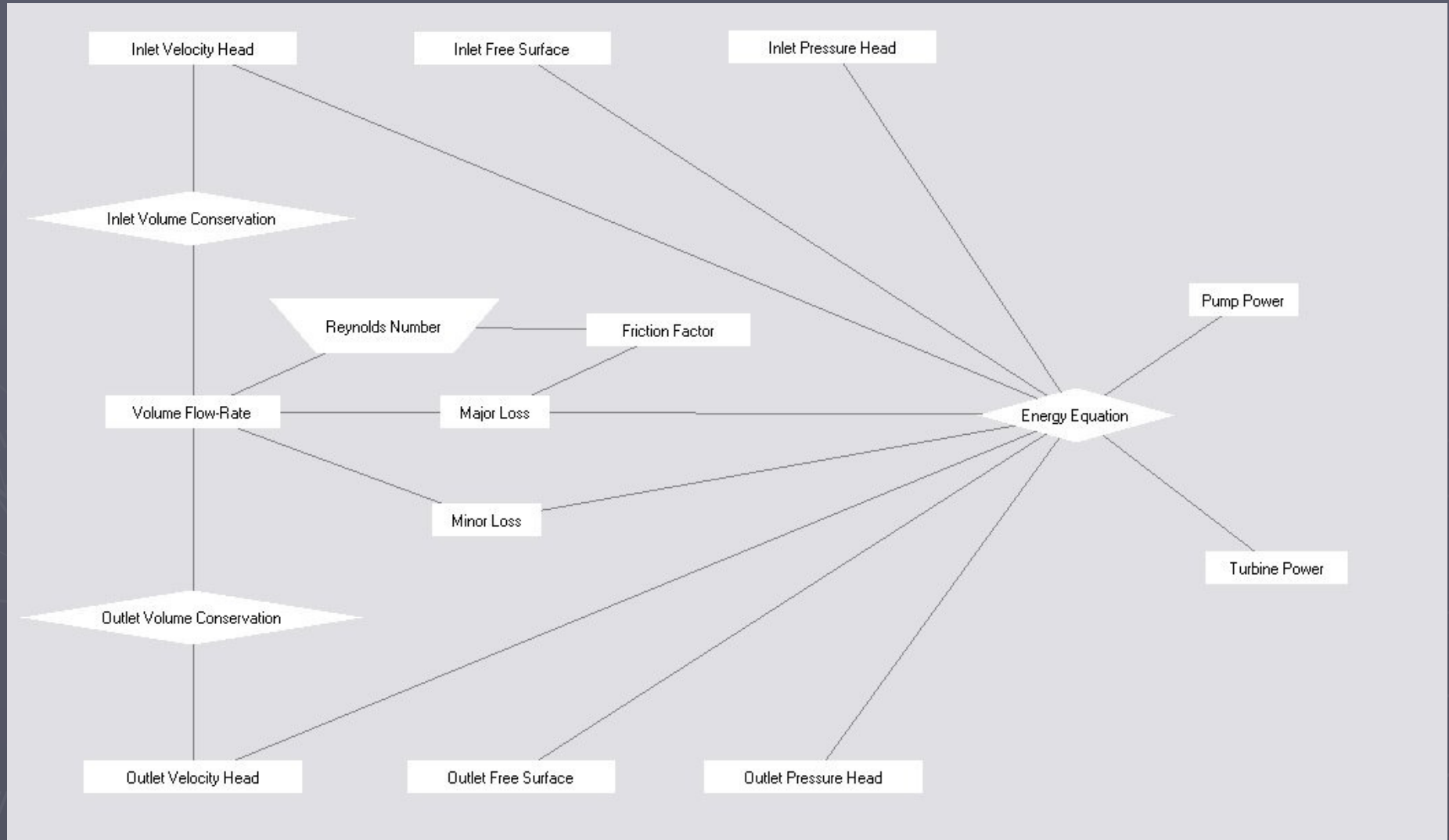
$$\vec{M}_i + \vec{P}_i + \vec{P}_o + \vec{W} + \vec{F} = \vec{M}_o$$

Momentum Concept Map *help*



$$\text{Momentum inflow} = \vec{M}_i = \dot{m} \vec{V}_i = \rho Q_i \vec{V}_i$$

Energy Concept Map



Energy Concept Map *help*

Inlet velocity head = H_{Vi}

Inlet pressure head = H_{Pi}

Inlet altitude = H_i

Major Head Loss = H_{Major}

Minor Head Loss = H_{Minor}

Pump Head = H_{Pump}

Turbine Heed = H_{Turb}

Outlet velocity head = H_{Vo}

Outlet pressure head = H_{Po}

Outlet altitude = H_o

Energy Equation:

$$H_{Vi} + H_{Pi} + H_i - H_{Major} - H_{Minor} + H_{Pump} - H_{Turb} \\ = H_{Vo} + H_{Po} + H_o$$

Pipe Flow – Iterative Solution

Pipe-Flow: Diameter Unknown

Pipe-Flow: Diameter unknown problems

Density Length of pipe Gravity

Viscosity Volume flowrate Major Head-Loss

Begin calculation with a guessed friction factor = 0.02

Find D

$$D = \left(\frac{8fLQ^2}{\pi^2 gH_{major}} \right)^{1/5}$$

Find Velocity

$$V = \frac{4Q}{\pi D^2}$$

Iterate in loop until convergence.

Find Friction Factor

$$f = \frac{0.25}{[0.758912 - 0.9 \log_{10}(Re)]^2}$$

Find Reynolds Number

$$Re = \frac{\rho V D}{\mu}$$

Pipe Flow – Iterative Solution

Pipe-Flow: Diameter Unknown

Pipe-Flow: Flowrate unknown problems

Density Length of pipe Gravity

Viscosity Diameter Major Head-Loss

Begin calculation with a guessed friction factor = 0.02

Find Q

$$Q = \left(\frac{\pi^2 g H_{major} D^5}{8 f L} \right)^{1/2}$$

Find Velocity

$$V = \frac{4Q}{\pi D^2}$$

Iterate in loop until convergence.

Find Friction Factor

$$f = \frac{0.25}{[0.758912 - 0.9 \log_{10}(Re)]^2}$$

Find Reynolds Number

$$Re = \frac{\rho V D}{\mu}$$

Dimensional Analysis

Buckingham PI - Theorem

BUCKINGHAM PI-THEOREM

M-L-T F-L-T

How many variables?
Less than or equal to 7 and greater than 3

M/F - Check
Does M appear in ANY of the variables?
 Yes No


L - Check
Does L appear in ANY of the variables?
 Yes No

T - Check
Does T appear in ANY of the variables?
 Yes No

	M	L	T
Repeat - 1	<input type="text"/>	<input type="text"/>	<input type="text"/>
Repeat - 2	<input type="text"/>	<input type="text"/>	<input type="text"/>
Repeat - 3	<input type="text"/>	<input type="text"/>	<input type="text"/>

Repeating Variables
Enter dimensions of the repeating variables.

Repeat
YOU NEED 3 REPEATING VARIABLES
YOU WILL GET 2 PI - VARIABLES



Dimensional Analysis *help*

Why Some Combinations of Repeating Variables Do Not Work

A set of repeating variables cannot be used to non-dimensionalize other variables when – two or more variables in the set can form non-dimensional groups among themselves.

Example-1

A set of repeating variables contain a length (D), an angular velocity (ω), and a velocity (V).

$$\begin{aligned}D &:= [L] \\ \omega &:= [T^{-1}] \\ V &:= [LT^{-1}]\end{aligned}$$

These three variables can be combined into a dimensionless group

$$\Pi = D\omega / V$$

Therefore, the set (D , ω , V) is unsuitable as a set of repeating variables.

Example-2

A set of repeating variables contain a pressure (p), a density (ρ), and a velocity (V).

$$\begin{aligned}p &:= [ML^{-1} T^{-2}] \\ \rho &:= [ML^{-3}] \\ V &:= [LT^{-1}]\end{aligned}$$

These three variables can be combined into a dimensionless group

$$\Pi = \rho V^2 / p$$

Therefore, the set (p , ρ , V) is unsuitable as a set of repeating variables.