Situation 1 – Water flows through a 100 mm diameter pipe at a velocity of 4 m/s. Compute for the ff:

a. Volume flow rate in m^3/s and L/s
b. Mass flow rate in kg/s
c. Weight flow rate in N/s

Given:

Diameter (d) = 100 mm

Velocity (v) = 4 m/s

Required:

Volume flow rate (Q)

Mass flow rate (M)

Weight flow rate (W)

Solution:

a. $Q\ =\ Av$
$=\ \frac{\pi}{4}(0.1\ m)(4\ m/s)$

$Q\ =\ 0.031416\ m^3/s$

$\boldsymbol{Q\ =\ 31.416\ L/s}$

$\boldsymbol{Q\ =\ 0.031\ m^3/s}$

b. $M\ =\ \rho Q$
$= 1000\left(0.031\right)$
$\mathbf{M\ =\ 31\ kg/s}$

c. $W\ =\ \delta Q$
$= 9810\left(0.031\right)$
$\mathbf{W = 304.11\ N/s}$

Situation 2 – Neglecting air resistance, determine to what height a vertical jet of water could rise if projected with a velocity of 32 $\mathrm{m/s}$?

Given:

Velocity (v) = 32 $\mathrm{m/s}$

Required:

Height (H)

Solution:

$$H\ =\ \frac{v^2}{2g}$$

$$=\ \frac{(32\ m/s)^2}{2(9.81\ m/s^2)}$$

$$\boldsymbol{H}\ =\ \mathbf{52.192}\ \boldsymbol{m}$$

Situation 3 – If a jet is inclined upward 30° from the horizontal, what must be its velocity to reach over a 4 m wall at a horizontal distance of 25 m. Neglect friction.

Given:

Angle θ = 30°

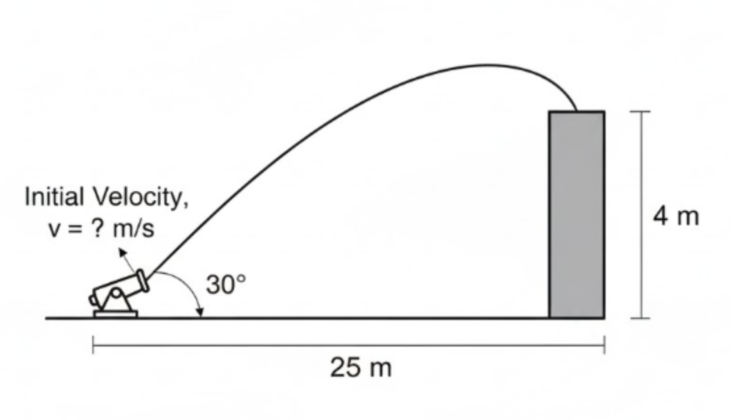
Vertical distance (y) = 4 m

Horizontal distance (x) = 25 m

Required:

Velocity (v)

Solution:



$$y = x\tan\theta - \frac{gx^2}{2v^2(\cos\theta)^2}$$

$$4\ m = 25\ m[\tan(30)] - \frac{9.81\ m/s^2\ (25\ m)^2}{2v^2\ [\cos(30)^2]}$$

$$\boldsymbol{v = 19.793\ m/s}$$

Situation 4 – Air is moving through a square 500 mm by 500 mm duct at 200 m^3/min. What is its mean velocity?

Given:

Base (b) & height (h) = 500 mm

Flow rate (Q) = 200 m^3/min

Required:

Velocity (v)

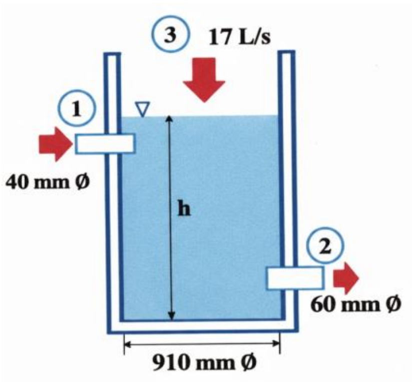
Solution:

$$Q = Av$$

$$200\ m^3/\min\ \left(\frac{1\ min}{60\ s}\right) = (0.5\ m)^2(v)$$

$$\boldsymbol{v} = \mathbf{13.333}\ \boldsymbol{m}/\boldsymbol{s}$$

Situation 5 – The water tank in the figure is being filled through section 1 at 7 m/s and through section 3 at 17 L/s. If water level h is constant, determine the exit velocity.



Given:

Section 1 velocity (v_1) = 7 m/s

Section 3 flow rate (Q_3) = 17 L/s

Required:

Section 2 velocity (v_2)

Solution:

$Q_1 + Q_3 = Q_2$

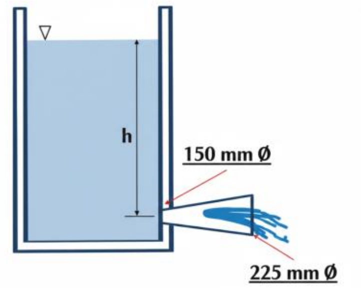
$A_1v_1 + Q_3 = A_2v_2$

$\frac{\pi}{4}(0.04\ \mathrm{m})^2(7\ \mathrm{m/s})\ +\ 17\ \mathrm{L/s}\ =\ \frac{\pi}{4}(0.06\ \mathrm{m})^2(v_2)$

$\boldsymbol{v}_\mathbf{2} = \mathbf{9.124}\ \boldsymbol{m}/\boldsymbol{s}$

Situation 6 – A diverging tube discharges water from a reservoir at a depth of *h* = 12 m below the water surface. The diameter of the tube gradually increases from 150 mm at the throat to 225 mm at the outlet. Neglecting friction, determine the ff:

1. Maximum possible rate of discharge through this tube
2. Corresponding possible pressure at the throat



Given:

Depth (h) = 12 m

Diameter of throat (D_2) = 150 mm

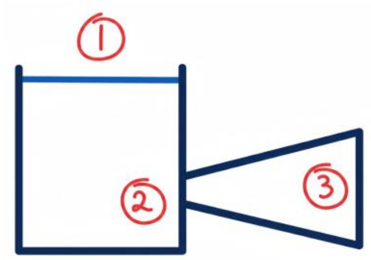
Diameter of outlet (D_3) = 225 mm

Required:

Discharge through the tube (Q)

Pressure at the throat (P_2)

Solution:



$$\boldsymbol{\frac{v^2}{2g}\rightarrow\frac{8Q^2}{\pi^2 gD^4}}$$

1. $E_1 = E_3$

   $\left(\frac{v^2}{2g} + \frac{P}{\delta} + z\right)_1 = \left(\frac{v^2}{2g} + \frac{P}{\delta} + z\right)_3$

   $0 + 0 + 12 = \frac{8Q^2}{\pi^2(9.81\ m/s^2){(0.225\ m)}^4} + 0 + 0$

   $\boldsymbol{Q = 0.61\ m^3/s}$

2. $E_2 = E_3$

   $\left(\frac{v^2}{2g} + \frac{P}{\delta} + z\right)_2 = \left(\frac{v^2}{2g} + \frac{P}{\delta} + z\right)_3$

   $\frac{8{(0.61\mathrm{m}^3/s)}^2}{\pi^2(9.81\mathrm{m}/s^2){(0.15\ \mathrm{m})}^4} + \frac{P}{9.81\ \mathrm{kN/m^3}} + 0 = \frac{\left[\frac{0.61\ m^3/s}{\frac{\pi}{4}(0.225\ m)^2}\right]^2}{2(9.81\ m/s^2)} + 0 + 0$

   $\boldsymbol{P_2 = 478.09\ kPa}$

Situation 7 – A horizontal pipe gradually changes from 350 mm diameter section to 125 mm diameter section. The pressure at the 350 mm section is 120 kPa and at the 125 mm section is 80 kPa. If the flow rate is 18 L/s of water, compute for the head lost between the two sections.

Given:

Diameter 1 (D_1) = 350 mm

Pressure 1 (P_1) = 120 kPa

Diameter 2 (D_2) = 125 mm

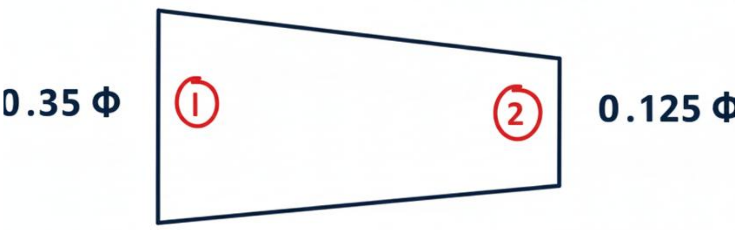
Pressure 2 (P_2) = 80 kPa

Flow rate (Q) = 18 L/s

Required:

Head loss (HL)

Solution:



$$\frac{v^2}{2g} \rightarrow \frac{8Q^2}{\pi^2 g D^4}$$

$$E_1 - \mathrm{HL} = E_2$$

$$\left(\frac{v^2}{2g} + \frac{P}{\delta} + z\right)_1 - \mathrm{HL} = \left(\frac{v^2}{2g} + \frac{P}{\delta} + z\right)_2$$

$$\frac{8(0.018\ m^3/s)^2}{\pi^2 (9.81\ m/s^2)(0.35\ m)^4} + \frac{120\ kPa}{9.81\ kN/m^3} + 0 - \mathrm{HL} = \frac{8(0.018\ m^3/s)^2}{\pi^2 (9.81\ m/s^2)(0.125\ m)^4} + \frac{80\ kPa}{9.81\ kN/m^3} + 0$$

$$\boldsymbol{HL = 3.97\ m}$$

Situation 8 – A liquid having a specific gravity of 1.665 is flowing in a 75 mm diameter pipe. The total head at a given point was found to be 18 Joule per Newton. The elevation of the pipe above the datum is 3.2 m and the pressure in the pipe is 70.6 kPa. Compute for the velocity of flow and the horsepower in the stream at that point.

Given:

Specific gravity (sg) = 1.665

Diameter (D) = 75 mm

Total head (E) = 18 Joule per Newton

Datum (z) = 3.2 m

Pressure (P) = 70.6 kPa

Required:

Velocity (v)

Power (P)

Solution:

$$\mathrm{E} = \frac{v^2}{2g} + \frac{P}{\delta} + \mathrm{z}$$

$$18\ \mathrm{m}\ =\ \frac{v^2}{2\left(9.81 m/s^2\right)} + \frac{70.6\ kPa}{9.81\ kN/m^3} + 3.2\ \mathrm{m}$$

$$\boldsymbol{v} = \mathbf{14}.\mathbf{338}\ \boldsymbol{m}/\boldsymbol{s}$$

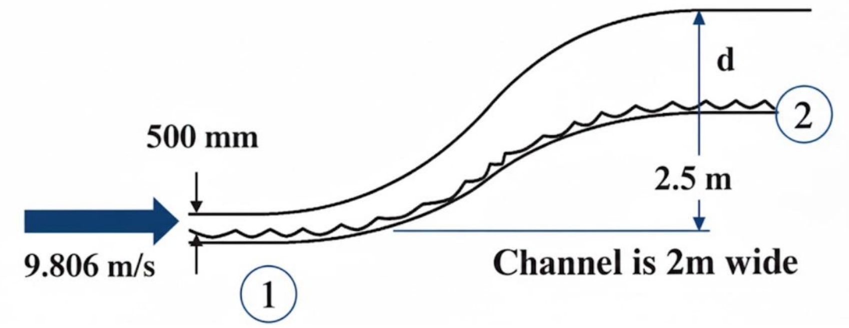
$$\mathrm{P} = \mathrm{Q}\delta E$$

$$=\ \frac{\pi}{4}(0.075\ \mathrm{m})^2(14.338\ \mathrm{m/s})[9810\ \mathrm{N}/m^3(1.665)](18\ m)$$

$$= \frac{18623.304\ watts}{746\ hp}$$

$$\boldsymbol{P} = \mathbf{24}.\mathbf{964}\ \boldsymbol{hp}$$

Situation 9 – High velocity water flows up an inclined plane as shown. What are the two possible depths of flow at section 2? Neglect losses.



Given:

Velocity (v) = 9.806 m/s

Depth at section 1 (d_1) = 500 mm

Datum (z) = 2.5 m

Channel width (w) = 2 m

Required:

Two possible depths at section 2 (d_2)

Solution:

$Q = Av$

$= 0.5\ m(2)(9.806\ m/s)$

$Q = 9.806\ m^3/s$

$E_1 = d_1 + \frac{v^2}{2g}$

$= 0.5\ m + \frac{(9.806\ m/s)^2}{2(9.81\ m/s^2)}$

$E_1 = 5.401\ m$

$E_2 = E_1 - z$

$= 5.401\ m - 2.5\ m$

$E_2 = 2.901\ m$

$E_2 = d_2 + \frac{v^2}{2g}$

$2.901\ m = d_2 + \frac{(\frac{9.806\ m^3/s}{2d_2})^2}{2(9.81\ m/s^2)}$

$\boldsymbol{d_2 = 2.738\ m\ or\ 0.756\ m}$

Situation 10 – A turbine is rated 900 hp when the flow of water through is 780 L/s. Assuming efficiency of 85%, compute for the head acting on the turbine.

Given:

Power output = 900 hp

Flow rate = 780 L/s

Efficiency = 85%

Required:

Head extracted (HE)

Solution:

$\text{Efficiency} = \frac{Output}{Input}(100)$

$0.85 = \frac{900\ hp}{Input}$

$P_I = 1058.824\ \text{hp}(764\ \text{watts})$

$P_I = 789882.353\ \text{watts}$

$\text{P} = \text{Q}\delta\text{HE}$

$789882.353\ \text{watts} = 0.78\ m^3/\text{s}(9810\ \text{N}/m^3)(\text{HE})$

$\boldsymbol{HE} = \mathbf{103}.\mathbf{228}\ \boldsymbol{m}$