Important Orifices and Mouthpieces Formulas PDF

Formulas
Examples
with Units

List of 33
Important Orifices and Mouthpieces Formulas

1) Flow Head Formulas

1.1) Absolute pressure head at constant head and atmospheric pressure head Formula

Evaluate Formula

Formula

$$H_{AP} = H_a + H_c - \left(\left(\left(\frac{V_o}{0.62}\right)^2\right)\cdot\left(\frac{1}{2\cdot 9.81}\right)\right)$$

Example with Units

$$13.4891\,\text{m} = 7\,\text{m} + 10.5\,\text{m} - \left(\left(\left(\frac{5.5\,\text{m/s}}{0.62}\right)^2\right)\cdot\left(\frac{1}{2\cdot 9.81}\right)\right)$$

1.2) Atmospheric pressure head at constant head and absolute pressure head Formula

Evaluate Formula

Formula

$$H_a = H_{AP} - H_c + \left(\left(\left(\frac{V_o}{0.62}\right)^2\right)\cdot\left(\frac{1}{2\cdot 9.81}\right)\right)$$

Example with Units

$$7.5109\,\text{m} = 14\,\text{m} - 10.5\,\text{m} + \left(\left(\left(\frac{5.5\,\text{m/s}}{0.62}\right)^2\right)\cdot\left(\frac{1}{2\cdot 9.81}\right)\right)$$

1.3) Head of Liquid above Centre of Orifice Formula

Evaluate Formula

Formula

$$H = \frac{V_{th}^2}{2\cdot 9.81}$$

Example with Units

$$4.1284\,\text{m} = \frac{9\,\text{m/s}^2}{2\cdot 9.81}$$

1.4) Head of liquid for head loss and coefficient of velocity Formula

Evaluate Formula

Formula

$$H = \frac{h_f}{1 - \left(C_v^2\right)}$$

Example with Units

$$7.8125\,\text{m} = \frac{1.2\,\text{m}}{1 - \left(0.92^2\right)}$$

1.5) Loss of head due to fluid resistance Formula

Evaluate Formula

Formula

$$h_f = H\cdot\left(1 - \left(C_v^2\right)\right)$$

Example with Units

$$0.768\,\text{m} = 5\,\text{m}\cdot\left(1 - \left(0.92^2\right)\right)$$

1.6) Loss of head due to sudden enlargement Formula

Evaluate Formula

Formula

$$h_L = \frac{\left(V_i - V_o\right)^2}{2\cdot 9.81}$$

Example with Units

$$0.3716\,\text{m} = \frac{\left(8.2\,\text{m/s} - 5.5\,\text{m/s}\right)^2}{2\cdot 9.81}$$

2) Flow Rate Formulas

2.1) Coefficient of discharge Formula

Evaluate Formula

Formula

$$C_d = \frac{Q_a}{Q_{th}}$$

Example with Units

$$0.875 = \frac{0.7\,\text{m}^3\text{/s}}{0.8\,\text{m}^3\text{/s}}$$

2.2) Coefficient of discharge for area and velocity Formula

Evaluate Formula

Formula

$$C_d = \frac{v_a \cdot A_a}{V_{th} \cdot A_t}$$

Example with Units

$$0.8205 = \frac{8\,\text{m/s} \cdot 4.80\,\text{m}^2}{9\,\text{m/s} \cdot 5.2\,\text{m}^2}$$

2.3) Coefficient of Discharge given Time for Emptying Tank Formula

Evaluate Formula

Formula

$$C_d = \frac{2 \cdot A_T \cdot \left(\left(\sqrt{H_i}\right) - \left(\sqrt{H_f}\right)\right)}{t_{total} \cdot a \cdot \sqrt{2 \cdot 9.81}}$$

Example with Units

$$0.7865 = \frac{2 \cdot 1144\,\text{m}^2 \cdot \left(\left(\sqrt{24\,\text{m}}\right) - \left(\sqrt{20.1\,\text{m}}\right)\right)}{30\,\text{s} \cdot 9.1\,\text{m}^2 \cdot \sqrt{2 \cdot 9.81}}$$

2.4) Coefficient of Discharge given Time of Emptying Circular Horizontal Tank Formula

Evaluate Formula

Formula

$$C_d = \frac{4 \cdot L \cdot \left(\left(\left(\left(2 \cdot r_1\right) - H_f\right)^{\frac{3}{2}}\right) - \left(\left(2 \cdot r_1\right) - H_i\right)^{\frac{3}{2}}\right)}{3 \cdot t_{total} \cdot a \cdot \left(\sqrt{2 \cdot 9.81}\right)}$$

Example with Units

$$0.8928 = \frac{4 \cdot 31\,\text{m} \cdot \left(\left(\left(\left(2 \cdot 21\,\text{m}\right) - 20.1\,\text{m}\right)^{\frac{3}{2}}\right) - \left(\left(2 \cdot 21\,\text{m}\right) - 24\,\text{m}\right)^{\frac{3}{2}}\right)}{3 \cdot 30\,\text{s} \cdot 9.1\,\text{m}^2 \cdot \left(\sqrt{2 \cdot 9.81}\right)}$$

2.5) Coefficient of Discharge given Time of Emptying Hemispherical Tank Formula

Evaluate Formula

Formula

$$C_d = \frac{\pi \cdot \left(\left(\left(\frac{4}{3}\right) \cdot R_t \cdot \left(\left(H_i^{\frac{3}{2}}\right) - \left(H_f^{\frac{3}{2}}\right)\right)\right) - \left(\left(\frac{2}{5}\right) \cdot \left(\left(H_i^{\frac{5}{2}}\right) - \left(H_f\right)^{\frac{5}{2}}\right)\right)\right)}{t_{total} \cdot a \cdot \left(\sqrt{2 \cdot 9.81}\right)}$$

Example with Units

$$0.3768 = \frac{3.1416 \cdot \left(\left(\left(\frac{4}{3}\right) \cdot 15\,\text{m} \cdot \left(\left(24\,\text{m}^{\frac{3}{2}}\right) - \left(20.1\,\text{m}^{\frac{3}{2}}\right)\right)\right) - \left(\left(\frac{2}{5}\right) \cdot \left(\left(24\,\text{m}^{\frac{5}{2}}\right) - \left(20.1\,\text{m}\right)^{\frac{5}{2}}\right)\right)\right)}{30\,\text{s} \cdot 9.1\,\text{m}^2 \cdot \left(\sqrt{2 \cdot 9.81}\right)}$$

2.6) Discharge in Borda's Mouthpiece Running Free Formula

Evaluate Formula

Formula

$$Q_M = 0.5 \cdot A \cdot \sqrt{2 \cdot 9.81 \cdot H_c}$$

Example with Units

$$36.6003\,\text{m}^3/\text{s} = 0.5 \cdot 5.1\,\text{m}^2 \cdot \sqrt{2 \cdot 9.81 \cdot 10.5\,\text{m}}$$

2.7) Discharge in Borda's Mouthpiece Running Full Formula

Evaluate Formula

Formula

$$Q_M = 0.707 \cdot A \cdot \sqrt{2 \cdot 9.81 \cdot H_c}$$

Example with Units

$$51.7528\,\text{m}^3/\text{s} = 0.707 \cdot 5.1\,\text{m}^2 \cdot \sqrt{2 \cdot 9.81 \cdot 10.5\,\text{m}}$$

2.8) Discharge in Convergent-Divergent Mouthpiece Formula

Evaluate Formula

Formula

$$Q_M = a_c \cdot \sqrt{2 \cdot 9.81 \cdot H_c}$$

Example with Units

$$30.1414\,\text{m}^3/\text{s} = 2.1\,\text{m}^2 \cdot \sqrt{2 \cdot 9.81 \cdot 10.5\,\text{m}}$$

2.9) Discharge through fully sub-merged orifice Formula

Evaluate Formula

Formula

$$Q_O = C_d \cdot w \cdot \left(H_b - H_{top} \right) \cdot \left(\sqrt{2 \cdot 9.81 \cdot H_L} \right)$$

Example with Units

$$19.0744\,\text{m}^3/\text{s} = 0.87 \cdot 3.5\,\text{m} \cdot \left(20\,\text{m} - 19.9\,\text{m} \right) \cdot \left(\sqrt{2 \cdot 9.81 \cdot 200\,\text{m}} \right)$$

2.10) Discharge through large rectangular orifice Formula

Evaluate Formula

Formula

$$Q_O = \left(\frac{2}{3} \right) \cdot C_d \cdot b \cdot \left(\sqrt{2 \cdot 9.81} \right) \cdot \left(\left(H_b^{1.5} \right) - \left(H_{top}^{1.5} \right) \right)$$

Example with Units

$$20.6548\,\text{m}^3/\text{s} = \left(\frac{2}{3} \right) \cdot 0.87 \cdot 12\,\text{m} \cdot \left(\sqrt{2 \cdot 9.81} \right) \cdot \left(\left(20\,\text{m}^{1.5} \right) - \left(19.9\,\text{m}^{1.5} \right) \right)$$

2.11) Discharge through partially sub-merged orifice Formula

Evaluate Formula

Formula

$$Q_O = \left(C_d \cdot w \cdot \left(H_b - H_L \right) \cdot \left(\sqrt{2 \cdot 9.81 \cdot H_L} \right) \right) + \left(\left(\frac{2}{3} \right) \cdot C_d \cdot b \cdot \left(\sqrt{2 \cdot 9.81} \right) \cdot \left(\left(H_L^{1.5} \right) - \left(H_{top}^{1.5} \right) \right) \right)$$

Example with Units

$$50126.6776\,\text{m}^3/\text{s} = \left(0.87 \cdot 3.5\,\text{m} \cdot \left(20\,\text{m} - 200\,\text{m} \right) \cdot \left(\sqrt{2 \cdot 9.81 \cdot 200\,\text{m}} \right) \right) + \left(\left(\frac{2}{3} \right) \cdot 0.87 \cdot 12\,\text{m} \cdot \left(\sqrt{2 \cdot 9.81} \right) \cdot \left(\left(200\,\text{m}^{1.5} \right) - \left(19.9\,\text{m}^{1.5} \right) \right) \right)$$

3) Geometric Dimensions Formulas

3.1) Area at vena contracta for discharge and constant head Formula

Evaluate Formula

Formula

$$a_c = \frac{Q_M}{\sqrt{2 \cdot 9.81 \cdot H_c}}$$

Example with Units

$$2.1041\,\text{m}^2 = \frac{30.2\,\text{m}^3/\text{s}}{\sqrt{2 \cdot 9.81 \cdot 10.5\,\text{m}}}$$

3.2) Area of Mouthpiece in Borda's Mouthpiece Running Free Formula

Evaluate Formula

Formula

$$A = \frac{Q_M}{0.5 \cdot \sqrt{2 \cdot 9.81 \cdot H_c}}$$

Example with Units

$$4.2082\,\text{m}^2 = \frac{30.2\,\text{m}^3/\text{s}}{0.5 \cdot \sqrt{2 \cdot 9.81 \cdot 10.5\,\text{m}}}$$

3.3) Area of Mouthpiece in Borda's Mouthpiece Running Full Formula

Evaluate Formula

Formula

$$A = \frac{Q_M}{0.707 \cdot \sqrt{2 \cdot 9.81 \cdot H_c}}$$

Example with Units

$$2.9761\,\text{m}^2 = \frac{30.2\,\text{m}^3/\text{s}}{0.707 \cdot \sqrt{2 \cdot 9.81 \cdot 10.5\,\text{m}}}$$

3.4) Area of Orifice given Time of Emptying Hemispherical Tank Formula

Evaluate Formula

Formula

$$a = \frac{\pi \cdot \left(\left(\left(\frac{4}{3} \right) \cdot R_t \cdot \left(\left(H_i^{\frac{3}{2}} \right) - \left(H_f^{\frac{3}{2}} \right) \right) \right) - \left(\left(\frac{2}{5} \right) \cdot \left(\left(H_i^{\frac{5}{2}} \right) - \left(H_f \right)^{\frac{5}{2}} \right) \right) \right)}{t_{total} \cdot C_d \cdot \left(\sqrt{2 \cdot 9.81} \right)}$$

Example with Units

$$3.9408\,\text{m}^2 = \frac{3.1416 \cdot \left(\left(\left(\frac{4}{3} \right) \cdot 15\,\text{m} \cdot \left(\left(24\,\text{m}^{\frac{3}{2}} \right) - \left(20.1\,\text{m}^{\frac{3}{2}} \right) \right) \right) - \left(\left(\frac{2}{5} \right) \cdot \left(\left(24\,\text{m}^{\frac{5}{2}} \right) - \left(20.1\,\text{m} \right)^{\frac{5}{2}} \right) \right) \right)}{30\,\text{s} \cdot 0.87 \cdot \left(\sqrt{2 \cdot 9.81} \right)}$$

3.5) Area of Tank given Time for Emptying Tank Formula

Evaluate Formula

Formula

$$A_T = \frac{t_{total} \cdot C_d \cdot a \cdot \left(\sqrt{2 \cdot 9.81}\right)}{2 \cdot \left(\left(\sqrt{H_i}\right) - \left(\sqrt{H_f}\right)\right)}$$

Example with Units

$$1265.4508\,\text{m}^2 = \frac{30\,\text{s} \cdot 0.87 \cdot 9.1\,\text{m}^2 \cdot \left(\sqrt{2 \cdot 9.81}\right)}{2 \cdot \left(\left(\sqrt{24\,\text{m}}\right) - \left(\sqrt{20.1\,\text{m}}\right)\right)}$$

3.6) Coefficient of Contraction given Area of Orifice Formula

Evaluate Formula

Formula

$$C_c = \frac{A_c}{a}$$

Example with Units

$$0.5549 = \frac{5.05\,\text{m}^2}{9.1\,\text{m}^2}$$

3.7) Horizontal distance for coefficient of velocity and vertical distance Formula

Evaluate Formula

Formula

$$R = C_v \cdot \left(\sqrt{4 \cdot V \cdot H}\right)$$

Example with Units

$$8.2287\,\text{m} = 0.92 \cdot \left(\sqrt{4 \cdot 4\,\text{m} \cdot 5\,\text{m}}\right)$$

3.8) Vertical distance for coefficient of velocity and horizontal distance Formula

Evaluate Formula

Formula

$$V = \frac{R^2}{4 \cdot \left(C_v^2\right) \cdot H}$$

Example with Units

$$31.25\,\text{m} = \frac{23\,\text{m}^2}{4 \cdot \left(0.92^2\right) \cdot 5\,\text{m}}$$

4) Velocity and Time Formulas

4.1) Coefficient of velocity Formula

Evaluate Formula

Formula

$$C_v = \frac{v_a}{V_{th}}$$

Example with Units

$$0.8889 = \frac{8\,\text{m/s}}{9\,\text{m/s}}$$

4.2) Coefficient of velocity for horizontal and vertical distance Formula

Evaluate Formula

Formula

$$C_v = \frac{R}{\sqrt{4 \cdot V \cdot H}}$$

Example with Units

$$2.5715 = \frac{23\,\text{m}}{\sqrt{4 \cdot 4\,\text{m} \cdot 5\,\text{m}}}$$

4.3) Coefficient of Velocity given Head Loss Formula

Evaluate Formula

Formula

$$C_v = \sqrt{1 - \left(\frac{h_f}{H}\right)}$$

Example with Units

$$0.8718 = \sqrt{1 - \left(\frac{1.2\,\text{m}}{5\,\text{m}}\right)}$$

4.4) Theoretical velocity Formula

Evaluate Formula

Formula

$$v = \sqrt{2 \cdot 9.81 \cdot H_p}$$

Example with Units

$$28.7061\,\text{m/s} = \sqrt{2 \cdot 9.81 \cdot 42\,\text{m}}$$

4.5) Time of Emptying Circular Horizontal Tank Formula

Evaluate Formula

Formula

$$t_{total} = \frac{4 \cdot L \cdot \left(\left(\left(\left(2 \cdot r_1 \right) - H_f \right)^{\frac{3}{2}} \right) - \left(\left(2 \cdot r_1 \right) - H_i \right)^{\frac{3}{2}} \right)}{3 \cdot C_d \cdot a \cdot \left(\sqrt{2 \cdot 9.81} \right)}$$

Example with Units

$$30.7854\,s = \frac{4 \cdot 31\,m \cdot \left(\left(\left(2 \cdot 21\,m \right) - 20.1\,m \right)^{\frac{3}{2}} \right) - \left(\left(2 \cdot 21\,m \right) - 24\,m \right)^{\frac{3}{2}} \right)}{3 \cdot 0.87 \cdot 9.1\,m^2 \cdot \left(\sqrt{2 \cdot 9.81} \right)}$$

4.6) Time of Emptying Hemispherical Tank Formula

Evaluate Formula

Formula

$$t_{total} = \frac{\pi \cdot \left(\left(\left(\frac{4}{3} \right) \cdot R_t \cdot \left(\left(H_i^{1.5} \right) - \left(H_f^{1.5} \right) \right) \right) - \left(0.4 \cdot \left(\left(H_i^{\frac{5}{2}} \right) - \left(H_f \right)^{\frac{5}{2}} \right) \right) \right)}{C_d \cdot a \cdot \left(\sqrt{2 \cdot 9.81} \right)}$$

Example with Units

$$12.9915\,s = \frac{3.1416 \cdot \left(\left(\left(\frac{4}{3} \right) \cdot 15\,m \cdot \left(\left(24\,m^{1.5} \right) - \left(20.1\,m^{1.5} \right) \right) \right) - \left(0.4 \cdot \left(\left(24\,m^{\frac{5}{2}} \right) - \left(20.1\,m \right)^{\frac{5}{2}} \right) \right) \right)}{0.87 \cdot 9.1\,m^2 \cdot \left(\sqrt{2 \cdot 9.81} \right)}$$

4.7) Time of Emptying Tank through Orifice at Bottom Formula

Evaluate Formula

Formula

$$t_{total} = \frac{2 \cdot A_T \cdot \left(\left(\sqrt{H_i} \right) - \left(\sqrt{H_f} \right) \right)}{C_d \cdot a \cdot \sqrt{2 \cdot 9.81}}$$

Example with Units

$$27.1208\,s = \frac{2 \cdot 1144\,m^2 \cdot \left(\left(\sqrt{24\,m} \right) - \left(\sqrt{20.1\,m} \right) \right)}{0.87 \cdot 9.1\,m^2 \cdot \sqrt{2 \cdot 9.81}}$$

4.8) Velocity of liquid at C-C for Hc, Ha, and H Formula

Evaluate Formula

Formula

$$V_i = \sqrt{2 \cdot 9.81 \cdot \left(H_a + H_c - H_{AP} \right)}$$

Example with Units

$$8.2867\,m/s = \sqrt{2 \cdot 9.81 \cdot \left(7\,m + 10.5\,m - 14\,m \right)}$$

Variables used in list of Orifices and Mouthpieces Formulas above

- **a** Area of Orifice *(Square Meter)*
- **A** Area *(Square Meter)*
- A_a Actual Area *(Square Meter)*
- a_c Area at Vena Contracta *(Square Meter)*
- A_c Area of Jet *(Square Meter)*
- A_t Theoretical Area *(Square Meter)*
- A_T Area of Tank *(Square Meter)*
- **b** Thickness of Dam *(Meter)*
- C_c Coefficient of Contraction
- C_d Coefficient of Discharge
- C_v Coefficient of Velocity
- **H** Head of the Liquid *(Meter)*
- H_a Atmospheric Pressure Head *(Meter)*
- H_{AP} Absolute Pressure Head *(Meter)*
- H_b Height of Liquid Bottom Edge *(Meter)*
- H_c Constant Head *(Meter)*
- h_f Head Loss *(Meter)*
- H_f Final Height of Liquid *(Meter)*
- H_i Initial Height of Liquid *(Meter)*
- h_L Loss of Head *(Meter)*
- H_L Difference in Liquid Level *(Meter)*
- H_p Pelton Head *(Meter)*
- H_{top} Height of Liquid Top Edge *(Meter)*
- **L** Length *(Meter)*
- Q_a Actual Discharge *(Cubic Meter per Second)*
- Q_M Discharge through Mouthpiece *(Cubic Meter per Second)*
- Q_O Discharge through Orifice *(Cubic Meter per Second)*
- Q_{th} Theoretical Discharge *(Cubic Meter per Second)*
- **R** Horizontal Distance *(Meter)*
- r_1 Radius *(Meter)*
- R_t Hemispherical Tank Radius *(Meter)*
- t_{total} Total Time Taken *(Second)*
- **v** Velocity *(Meter per Second)*
- **V** Vertical Distance *(Meter)*
- v_a Actual Velocity *(Meter per Second)*
- V_i Velocity of Liquid Inlet *(Meter per Second)*
- V_o Velocity of Liquid Outlet *(Meter per Second)*
- V_{th} Theoretical Velocity *(Meter per Second)*
- **w** Width *(Meter)*

Constants, Functions, Measurements used in list of Orifices and Mouthpieces Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **sqrt**, sqrt(Number) *A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.*
- Measurement: **Length** in Meter (m) *Length Unit Conversion*
- Measurement: **Time** in Second (s) *Time Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area Unit Conversion*
- Measurement: **Speed** in Meter per Second (m/s) *Speed Unit Conversion*
- Measurement: **Volumetric Flow Rate** in Cubic Meter per Second (m³/s) *Volumetric Flow Rate Unit Conversion*

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