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Orifices and Mouthpieces Formulas

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List of 33 Orifices and Mouthpieces Formulas

Orifices and Mouthpieces

Flow Head

1) Absolute pressure head at constant head and atmospheric pressure head

Open Calculator

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

ex $$13.48909\text{m} = 7\text{m} + 10.5\text{m} - \left(\left(\left(\frac{5.5\text{m/s}}{0.62}\right)^2\right) \cdot \left(\frac{1}{2 \cdot 9.81}\right)\right)$$

2) Atmospheric pressure head at constant head and absolute pressure head

Open Calculator

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

ex $$7.510911\text{m} = 14\text{m} - 10.5\text{m} + \left(\left(\left(\frac{5.5\text{m/s}}{0.62}\right)^2\right) \cdot \left(\frac{1}{2 \cdot 9.81}\right)\right)$$

3) Head of Liquid above Centre of Orifice

Open Calculator

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

ex $$4.12844\text{m} = \frac{(9\text{m/s})^2}{2 \cdot 9.81}$$

4) Head of liquid for head loss and coefficient of velocity

Open Calculator

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

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

5) Loss of head due to fluid resistance

Open Calculator

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

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

6) Loss of head due to sudden enlargement

Open Calculator

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

$$0.37156\text{m} = \frac{\left(8.2\text{m/s} - 5.5\text{m/s}\right)^2}{2 \cdot 9.81}$$

Flow Rate

7) Coefficient of discharge

Open Calculator

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

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

8) Coefficient of discharge for area and velocity

Open Calculator

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

$$0.820513 = \frac{8\text{m/s} \cdot 4.80\text{m}^2}{9\text{m/s} \cdot 5.2\text{m}^2}$$

9) Coefficient of Discharge given Time for Emptying Tank

Open Calculator

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

$$0.786502 = \frac{2 \cdot 1144\text{m}^2 \cdot \left(\left(\sqrt{24\text{m}}\right) - \left(\sqrt{20.1\text{m}}\right)\right)}{30\text{s} \cdot 9.1\text{m}^2 \cdot \sqrt{2 \cdot 9.81}}$$

10) Coefficient of Discharge given Time of Emptying Circular Horizontal Tank

Open Calculator

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

$$0.892776 = \frac{4 \cdot 31\text{m} \cdot \left(\left(\left((2 \cdot 21\text{m}) - 20.1\text{m}\right)^{\frac{3}{2}}\right) - \left((2 \cdot 21\text{m}) - 24\text{m}\right)^{\frac{3}{2}}\right)}{3 \cdot 30\text{s} \cdot 9.1\text{m}^2 \cdot \left(\sqrt{2 \cdot 9.81}\right)}$$

11) Coefficient of Discharge given Time of Emptying Hemispherical Tank

Open Calculator

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

$$0.376754 = \frac{\pi \cdot \left(\left(\left(\frac{4}{3}\right) \cdot 15\text{m} \cdot \left(\left((24\text{m})^{\frac{3}{2}}\right) - \left((20.1\text{m})^{\frac{3}{2}}\right)\right)\right) - \left(\left(\frac{2}{5}\right) \cdot \left(\left((24\text{m})^{\frac{5}{2}}\right) - (20.1\text{m})^{\frac{5}{2}}\right)\right)\right)}{30\text{s} \cdot 9.1\text{m}^2 \cdot \left(\sqrt{2 \cdot 9.81}\right)}$$

12) Discharge in Borda's Mouthpiece Running Free

Open Calculator

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

$$36.60027\text{m}^3/\text{s} = 0.5 \cdot 5.1\text{m}^2 \cdot \sqrt{2 \cdot 9.81 \cdot 10.5\text{m}}$$

13) Discharge in Borda's Mouthpiece Running Full

Open Calculator

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

$$51.75279\text{m}^3/\text{s} = 0.707 \cdot 5.1\text{m}^2 \cdot \sqrt{2 \cdot 9.81 \cdot 10.5\text{m}}$$

14) Discharge in Convergent-Divergent Mouthpiece

Open Calculator

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

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

15) Discharge through fully sub-merged orifice

Open Calculator

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

$$19.07444\text{m}^3/\text{s} = 0.87 \cdot 3.5\text{m} \cdot (20\text{m} - 19.9\text{m}) \cdot \left(\sqrt{2 \cdot 9.81 \cdot 200\text{m}}\right)$$

16) Discharge through large rectangular orifice

Open Calculator

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

$$20.65482\text{m}^3/\text{s} = \left(\frac{2}{3}\right) \cdot 0.87 \cdot 12\text{m} \cdot \left(\sqrt{2 \cdot 9.81}\right) \cdot \left(\left((20\text{m})^{1.5}\right) - \left((19.9\text{m})^{1.5}\right)\right)$$

17) Discharge through partially sub-merged orifice

Open Calculator

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

$$50126.68\text{m}^3/\text{s} = \left(0.87 \cdot 3.5\text{m} \cdot (20\text{m} - 200\text{m}) \cdot \left(\sqrt{2 \cdot 9.81 \cdot 200\text{m}}\right)\right) + \left(\left(\frac{2}{3}\right) \cdot 0.87 \cdot 12\text{m} \cdot \left(\sqrt{2 \cdot 9.81}\right) \cdot \left(\left(\right.\right.\right.$$

Geometric Dimensions

18) Area at vena contracta for discharge and constant head

Open Calculator

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

$$2.104083\text{m}^2 = \frac{30.2\text{m}^3/\text{s}}{\sqrt{2 \cdot 9.81 \cdot 10.5\text{m}}}$$

19) Area of Mouthpiece in Borda's Mouthpiece Running Free

Open Calculator

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

$$4.208165\text{m}^2 = \frac{30.2\text{m}^3/\text{s}}{0.5 \cdot \sqrt{2 \cdot 9.81 \cdot 10.5\text{m}}}$$

20) Area of Mouthpiece in Borda's Mouthpiece Running Full

Open Calculator

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

$$2.976072\text{m}^2 = \frac{30.2\text{m}^3/\text{s}}{0.707 \cdot \sqrt{2 \cdot 9.81 \cdot 10.5\text{m}}}$$

21) Area of Orifice given Time of Emptying Hemispherical Tank

Open Calculator

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

$$3.940758\text{m}^2 = \frac{\pi \cdot \left(\left(\left(\frac{4}{3}\right) \cdot 15\text{m} \cdot \left(\left((24\text{m})^{\frac{3}{2}}\right) - \left((20.1\text{m})^{\frac{3}{2}}\right)\right)\right) - \left(\left(\frac{2}{5}\right) \cdot \left(\left((24\text{m})^{\frac{5}{2}}\right) - (20.1\text{m})^{\frac{5}{2}}\right)\right)\right)}{30\text{s} \cdot 0.87 \cdot \left(\sqrt{2 \cdot 9.81}\right)}$$

22) Area of Tank given Time for Emptying Tank

Open Calculator

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

$$1265.451\text{m}^2 = \frac{30\text{s} \cdot 0.87 \cdot 9.1\text{m}^2 \cdot \left(\sqrt{2 \cdot 9.81}\right)}{2 \cdot \left(\left(\sqrt{24\text{m}}\right) - \left(\sqrt{20.1\text{m}}\right)\right)}$$

23) Coefficient of Contraction given Area of Orifice

Open Calculator

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

$$0.554945 = \frac{5.05\text{m}^2}{9.1\text{m}^2}$$

24) Horizontal distance for coefficient of velocity and vertical distance

Open Calculator

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

$$8.22873\text{m} = 0.92 \cdot \left(\sqrt{4 \cdot 4\text{m} \cdot 5\text{m}}\right)$$

25) Vertical distance for coefficient of velocity and horizontal distance

Open Calculator

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

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

Velocity and Time

26) Coefficient of velocity

Open Calculator

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

$$0.888889 = \frac{8\text{m/s}}{9\text{m/s}}$$

27) Coefficient of velocity for horizontal and vertical distance

Open Calculator

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

$$2.571478 = \frac{23\text{m}}{\sqrt{4 \cdot 4\text{m} \cdot 5\text{m}}}$$

28) Coefficient of Velocity given Head Loss

Open Calculator

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

$$0.87178 = \sqrt{1 - \left(\frac{1.2\text{m}}{5\text{m}}\right)}$$

29) Theoretical velocity

Open Calculator

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

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

30) Time of Emptying Circular Horizontal Tank

Open Calculator

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

$$30.78537\text{s} = \frac{4 \cdot 31\text{m} \cdot \left(\left(\left((2 \cdot 21\text{m}) - 20.1\text{m}\right)^{\frac{3}{2}}\right) - \left((2 \cdot 21\text{m}) - 24\text{m}\right)^{\frac{3}{2}}\right)}{3 \cdot 0.87 \cdot 9.1\text{m}^2 \cdot \left(\sqrt{2 \cdot 9.81}\right)}$$

31) Time of Emptying Hemispherical Tank

Open Calculator

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

$$12.99151\text{s} = \frac{\pi \cdot \left(\left(\left(\frac{4}{3}\right) \cdot 15\text{m} \cdot \left(\left((24\text{m})^{1.5}\right) - \left((20.1\text{m})^{1.5}\right)\right)\right) - \left(0.4 \cdot \left(\left((24\text{m})^{\frac{5}{2}}\right) - (20.1\text{m})^{\frac{5}{2}}\right)\right)\right)}{0.87 \cdot 9.1\text{m}^2 \cdot \left(\sqrt{2 \cdot 9.81}\right)}$$

32) Time of Emptying Tank through Orifice at Bottom

Open Calculator

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

$$27.12077\text{s} = \frac{2 \cdot 1144\text{m}^2 \cdot \left(\left(\sqrt{24\text{m}}\right) - \left(\sqrt{20.1\text{m}}\right)\right)}{0.87 \cdot 9.1\text{m}^2 \cdot \sqrt{2 \cdot 9.81}}$$

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

Open Calculator

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

$$8.286736\text{m/s} = \sqrt{2 \cdot 9.81 \cdot (7\text{m} + 10.5\text{m} - 14\text{m})}$$

Variables Used

- **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

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Function: **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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- **Notches and Weirs Formulas**
- **Orifices and Mouthpieces Formulas**

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