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Fundamentals of Inviscid and Incompressible Flow Formulas

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List of 16 Fundamentals of Inviscid and Incompressible Flow Formulas

Fundamentals of Inviscid and Incompressible Flow

Aerodynamic Measurements and Wind Tunnel Testing

1) Airspeed Measurement by Pitot Tube

$$\text{fx } V_1 = \sqrt{\frac{2 \cdot (P_0 - P_{1 \text{ static}})}{\rho_0}}$$

[Open Calculator !\[\]\(de95854c7ee024cfadc48187bbb781b2_img.jpg\)](#)

$$\text{ex } 0.316703\text{m/s} = \sqrt{\frac{2 \cdot (61710\text{Pa} - 61660\text{Pa})}{997\text{kg/m}^3}}$$


2) Airspeed Measurement by Venturi

$$\text{fx } V_1 = \sqrt{\frac{2 \cdot (P_1 - P_2)}{\rho_0 \cdot (A_{\text{lift}}^2 - 1)}}$$

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa_img.jpg\)](#)

$$\text{ex } 0.315672\text{m/s} = \sqrt{\frac{2 \cdot (9800\text{Pa} - 9630.609\text{Pa})}{997\text{kg/m}^3 \cdot ((2.1)^2 - 1)}}$$




3) Dynamic Pressure in Incompressible Flow 

$$fx \quad q_1 = P_0 - P_{1 \text{ static}}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)


$$ex \quad 50Pa = 61710Pa - 61660Pa$$

4) Height Difference of Manometric Fluid for given Pressure Difference 

$$fx \quad \Delta h = \frac{\delta P}{w}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)


$$ex \quad 0.1044m = \frac{0.2088Pa}{2N/m^3}$$

5) Surface Pressure on Body using Pressure Coefficient 

$$fx \quad P = p_\infty + q_\infty \cdot C_p$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 61646Pa = 29900Pa + 39000Pa \cdot 0.814$$

6) Test Section Velocity by Manometric Height for Wind Tunnel 

$$fx \quad V_T = \sqrt{\frac{2 \cdot w \cdot \Delta h}{\rho_0 \cdot \left(1 - \frac{1}{A_{\text{lift}}^2}\right)}}$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754_img.jpg\)](#)

$$ex \quad 0.022778m/s = \sqrt{\frac{2 \cdot 2N/m^3 \cdot 0.1m}{997kg/m^3 \cdot \left(1 - \frac{1}{(2.1)^2}\right)}}$$




7) Total Pressure in Incompressible Flow 

$$fx \quad P_0 = P_{1 \text{ static}} + q_1$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95_img.jpg\)](#)

$$ex \quad 61710\text{Pa} = 61660\text{Pa} + 50\text{Pa}$$

8) Wind Tunnel Pressure Difference by Manometer 

$$fx \quad \delta P = w \cdot \Delta h$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2_img.jpg\)](#)

$$ex \quad 0.2\text{Pa} = 2\text{N/m}^3 \cdot 0.1\text{m}$$

9) Wind Tunnel Pressure Difference with Test Speed 

$$fx \quad \delta P = 0.5 \cdot \rho_{\text{air}} \cdot V_2^2 \cdot \left(1 - \frac{1}{A_{\text{lift}}^2} \right)$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7_img.jpg\)](#)

$$ex \quad 0.208813\text{Pa} = 0.5 \cdot 1.225\text{kg/m}^3 \cdot (0.664\text{m/s})^2 \cdot \left(1 - \frac{1}{(2.1)^2} \right)$$

10) Wind Tunnel Test Section Velocity 

$$fx \quad V_2 = \sqrt{\frac{2 \cdot (P_1 - P_2)}{\rho_0 \cdot \left(1 - \frac{1}{A_{\text{lift}}^2} \right)}}$$

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b_img.jpg\)](#)

$$ex \quad 0.66291\text{m/s} = \sqrt{\frac{2 \cdot (9800\text{Pa} - 9630.609\text{Pa})}{997\text{kg/m}^3 \cdot \left(1 - \frac{1}{(2.1)^2} \right)}}$$



Bernoulli's Equation and Pressure Concepts

11) Pressure at Downstream Point by Bernoulli's Equation

$$\text{fx } P_2 = P_1 + 0.5 \cdot \rho_0 \cdot (V_1^2 - V_2^2)$$

[Open Calculator !\[\]\(74d4806277d7e73349d8e8c0897931e9_img.jpg\)](#)

$$\text{ex } 9630.212\text{Pa} = 9800\text{Pa} + 0.5 \cdot 997\text{kg/m}^3 \cdot \left((0.3167\text{m/s})^2 - (0.664\text{m/s})^2 \right)$$

12) Pressure at Upstream Point by Bernoulli's Equation

$$\text{fx } P_1 = P_2 - 0.5 \cdot \rho_0 \cdot (V_1^2 - V_2^2)$$

[Open Calculator !\[\]\(8bba887393ca45b761e5cb49e755e762_img.jpg\)](#)

$$\text{ex } 9800.397\text{Pa} = 9630.609\text{Pa} - 0.5 \cdot 997\text{kg/m}^3 \cdot \left((0.3167\text{m/s})^2 - (0.664\text{m/s})^2 \right)$$

13) Pressure Coefficient

$$\text{fx } C_p = \frac{P - p_\infty}{q_\infty}$$

[Open Calculator !\[\]\(0fb13ad0bfa3d86868cdd3883e5665b3_img.jpg\)](#)

$$\text{ex } 0.814615 = \frac{61670\text{Pa} - 29900\text{Pa}}{39000\text{Pa}}$$


14) Pressure Coefficient using Velocity Ratio

$$\text{fx } C_p = 1 - \left(\frac{V}{u_\infty} \right)^2$$

[Open Calculator !\[\]\(e50091943b385fe16d3277389202856f_img.jpg\)](#)

$$\text{ex } 0.817438 = 1 - \left(\frac{47\text{m/s}}{110\text{m/s}} \right)^2$$



15) Static Pressure in Incompressible Flow 

fx
$$P_{1 \text{ static}} = P_0 - q_1$$

[Open Calculator](#) 

ex
$$61660\text{Pa} = 61710\text{Pa} - 50\text{Pa}$$

16) Velocity at Point on Airfoil for given Pressure Coefficient and Free-Stream Velocity 

fx
$$V = \sqrt{u_\infty^2 \cdot (1 - C_p)}$$

[Open Calculator](#) 

ex
$$47.44049\text{m/s} = \sqrt{(110\text{m/s})^2 \cdot (1 - 0.814)}$$








Variables Used

- A_{lift} Contraction Ratio
- C_p Pressure Coefficient
- P Surface Pressure at Point (Pascal)
- P_0 Total Pressure (Pascal)
- P_1 static Static Pressure at Point 1 (Pascal)
- P_1 Pressure at Point 1 (Pascal)
- P_2 Pressure at Point 2 (Pascal)
- p_∞ Freestream Pressure (Pascal)
- q_1 Dynamic Pressure (Pascal)
- q_∞ Freestream Dynamic Pressure (Pascal)
- u_∞ Freestream Velocity (Meter per Second)
- V Velocity at a Point (Meter per Second)
- V_1 Velocity at Point 1 (Meter per Second)
- V_2 Velocity at Point 2 (Meter per Second)
- V_T Test Section Velocity (Meter per Second)
- Δh Height Difference of Manometric Fluid (Meter)
- δP Pressure Difference (Pascal)
- ρ_0 Density (Kilogram per Cubic Meter)
- ρ_{air} Air Density (Kilogram per Cubic Meter)
- w Specific Weight of Manometric Fluid (Newton per Cubic Meter)



Constants, Functions, Measurements used

- **Function:** **sqrt**, $\text{sqrt}(\text{Number})$
Square root function
- **Measurement:** **Length** in Meter (m)
Length Unit Conversion 
- **Measurement:** **Pressure** in Pascal (Pa)
Pressure Unit Conversion 
- **Measurement:** **Speed** in Meter per Second (m/s)
Speed Unit Conversion 
- **Measurement:** **Density** in Kilogram per Cubic Meter (kg/m^3)
Density Unit Conversion 
- **Measurement:** **Specific Weight** in Newton per Cubic Meter (N/m^3)
Specific Weight Unit Conversion 



Check other formula lists

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