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Flow over Airfoils and Wings Formulas

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List of 26 Flow over Airfoils and Wings Formulas

Flow over Airfoils and Wings

Flow over Airfoils

1) Boundary Layer Thickness for Laminar Flow

Open Calculator

fx $$\delta_{\text{L}} = 5 \cdot \frac{\text{x}}{\sqrt{\text{Re}_{\text{L}}}}$$

ex $$0.247487\text{m} = 5 \cdot \frac{2.10\text{m}}{\sqrt{1800}}$$

2) Boundary Layer Thickness for Turbulent Flow

Open Calculator

fx $$\delta_{\text{T}} = 0.37 \cdot \frac{\text{x}}{\text{Re}_{\text{T}}^{\frac{1}{5}}}$$

ex $$0.151917\text{m} = 0.37 \cdot \frac{2.10\text{m}}{(3500)^{\frac{1}{5}}}$$

3) Center of Pressure Location for Cambered Airfoil

Open Calculator

fx $$x_{cp} = -\frac{C_{m,le} \cdot c}{C_L}$$

ex $$0.75\text{m} = -\frac{\text{-}0.3 \cdot 3\text{m}}{1.2}$$

4) Lift Coefficient for Cambered Airfoil

Open Calculator

fx $$C_{L,cam} = 2 \cdot \pi \cdot ((\alpha) - (\alpha_0))$$

ex $$1.41903 = 2 \cdot \pi \cdot ((10.94^\circ) - (\text{-}2^\circ))$$

5) Lift Coefficient for Symmetrical Airfoil by Thin Airfoil Theory

Open Calculator

fx $$C_L = 2 \cdot \pi \cdot \alpha$$

ex $$1.199705 = 2 \cdot \pi \cdot 10.94^\circ$$

6) Moment Coefficient about Leading-Edge for Symmetrical Airfoil by Thin Airfoil Theory

Open Calculator

fx $$C_{m,le} = -\frac{C_L}{4}$$

ex $$\text{-}0.3 = -\frac{1.2}{4}$$

7) Skin Friction Drag Coefficient for Flat Plate in Laminar Flow

Open Calculator

fx $$C_f = \frac{1.328}{\sqrt{Re_L}}$$

ex $$0.031301 = \frac{1.328}{\sqrt{1800}}$$

8) Skin Friction Drag Coefficient for Flat Plate in Turbulent Flow

Open Calculator

fx $$C_f = \frac{0.074}{Re_T^{\frac{1}{5}}}$$

ex $$0.014468 = \frac{0.074}{(3500)^{\frac{1}{5}}}$$

Flow over Wings

9) 2D Lift Curve Slope of Airfoil given Lift Slope of Elliptic Finite Wing

Open Calculator

fx $$a_0 = \frac{a_{C,l}}{1 - \frac{a_{C,l}}{\pi \cdot AR}}$$

ex $$6.278065\text{rad}^{-1} = \frac{5.54\text{rad}^{-1}}{1 - \frac{5.54\text{rad}^{-1}}{\pi \cdot 15}}$$

10) 2D Lift Curve Slope of Airfoil given Lift Slope of Finite Wing

Open Calculator

fx
$$a_0 = \frac{a_{C,l}}{1 - \frac{a_{C,l} \cdot (1+\tau)}{\pi \cdot AR}}$$

ex
$$6.324406\text{rad}^{-1} = \frac{5.54\text{rad}^{-1}}{1 - \frac{5.54\text{rad}^{-1} \cdot (1+0.055)}{\pi \cdot 15}}$$

11) Aspect Ratio given Span Efficiency Factor

Open Calculator

fx
$$AR = \frac{C_L^2}{\pi \cdot e_{span} \cdot C_{D,i}}$$

ex
$$15.03087 = \frac{(1.2)^2}{\pi \cdot 0.95 \cdot 0.0321}$$

12) Aspect Ratio of Wing given Lift Curve Slope of Elliptic Finite Wing

Open Calculator

fx
$$AR = \frac{a_0}{\pi \cdot \left(\frac{a_0}{a_{C,l}} - 1\right)}$$

ex
$$14.96538 = \frac{6.28\text{rad}^{-1}}{\pi \cdot \left(\frac{6.28\text{rad}^{-1}}{5.54\text{rad}^{-1}} - 1\right)}$$

13) Aspect Ratio of Wing given Lift Curve Slope of Finite Wing

Open Calculator

fx $$AR = \frac{a_0 \cdot (1 + \tau)}{\pi \cdot \left(\frac{a_0}{a_{C,l}} - 1\right)}$$

ex $$15.78848 = \frac{6.28\text{rad}^{-1} \cdot (1 + 0.055)}{\pi \cdot \left(\frac{6.28\text{rad}^{-1}}{5.54\text{rad}^{-1}} - 1\right)}$$

14) Effective Angle of Attack of Finite Wing

Open Calculator

fx $$\alpha_{eff} = \alpha_g - \alpha_i$$

ex $$8^\circ = 12^\circ - 4^\circ$$

15) Geometric Angle of Attack given Effective Angle of Attack

Open Calculator

fx $$\alpha_g = \alpha_{eff} + \alpha_i$$

ex $$12^\circ = 8^\circ + 4^\circ$$

16) Induced Angle of Attack given Effective Angle of Attack

Open Calculator

fx $$\alpha_i = \alpha_g - \alpha_{eff}$$

ex $$4^\circ = 12^\circ - 8^\circ$$

17) Lift Curve Slope for Elliptic Finite Wing

Open Calculator

fx
$$a_{C,l} = \frac{a_0}{1 + \frac{a_0}{\pi \cdot AR}}$$

ex
$$5.541507\text{rad}^{-1} = \frac{6.28\text{rad}^{-1}}{1 + \frac{6.28\text{rad}^{-1}}{\pi \cdot 15}}$$

18) Lift Curve Slope for Finite Wing

Open Calculator

fx
$$a_{C,l} = \frac{a_0}{1 + \frac{a_0 \cdot (1+\tau)}{\pi \cdot AR}}$$

ex
$$5.505897\text{rad}^{-1} = \frac{6.28\text{rad}^{-1}}{1 + \frac{6.28\text{rad}^{-1} \cdot (1+0.055)}{\pi \cdot 15}}$$

19) Oswald Efficiency Factor

Open Calculator

fx
$$e_{osw} = 1.78 \cdot \left(1 - 0.045 \cdot AR^{0.68}\right) - 0.64$$

ex
$$0.634903 = 1.78 \cdot \left(1 - 0.045 \cdot (15)^{0.68}\right) - 0.64$$

Induced Drag

20) Induced Drag Coefficient

Open Calculator

$$C_{D,i} = \frac{D_i}{q_\infty \cdot S}$$

$$0.039376 = \frac{101\text{N}}{450\text{Pa} \cdot 5.7\text{m}^2}$$

21) Induced Drag Coefficient given Total Drag Coefficient

Open Calculator

$$C_{D,i} = C_D - c_d$$

$$0.0321 = 0.0771 - 0.045$$

22) Profile Drag Coefficient

Open Calculator

$$c_d = \frac{F_{skin} + D_p}{q_\infty \cdot S}$$

$$0.045224 = \frac{100\text{N} + 16\text{N}}{450\text{Pa} \cdot 5.7\text{m}^2}$$

23) Profile Drag Coefficient given Total Drag Coefficient

Open Calculator

$$c_d = C_D - C_{D,i}$$

$$0.045 = 0.0771 - 0.0321$$

24) Total Drag Coefficient for Subsonic Finite Wing

Open Calculator

fx $C_D = c_d + C_{D,i}$

ex $0.0771 = 0.045 + 0.0321$

25) Velocity Induced at Point by Infinite Straight Vortex Filament

Open Calculator

fx $v_i = \frac{\gamma}{2 \cdot \pi \cdot h}$

ex $3.9038\text{m/s} = \frac{13\text{m}^2/\text{s}}{2 \cdot \pi \cdot 0.53\text{m}}$

26) Velocity Induced at Point by Semi-infinite Straight Vortex Filament

Open Calculator

fx $v_i = \frac{\gamma}{4 \cdot \pi \cdot h}$

ex $1.9519\text{m/s} = \frac{13\text{m}^2/\text{s}}{4 \cdot \pi \cdot 0.53\text{m}}$

Variables Used

- a_0 2D Lift Curve Slope *(1 per Radian)*
- $a_{C,l}$ Lift Curve Slope *(1 per Radian)*
- **AR** Wing Aspect Ratio
- **c** Chord *(Meter)*
- c_d Profile Drag Coefficient
- C_D Total Drag Coefficient
- $C_{D,i}$ Induced Drag Coefficient
- C_f Skin Friction Drag Coefficient
- C_L Lift Coefficient
- $C_{L,cam}$ Lift Coefficient for Cambered Airfoil
- $C_{m,le}$ Moment Coefficient about Leading Edge
- D_i Induced Drag *(Newton)*
- D_p Pressure Drag Force *(Newton)*
- e_{osw} Oswald Efficiency Factor
- e_{span} Span Efficiency Factor
- F_{skin} Skin Friction Drag Force *(Newton)*
- **h** Perpendicular Distance to Vortex *(Meter)*
- q_∞ Free Stream Dynamic Pressure *(Pascal)*
- Re_L Reynolds Number for Laminar Flow
- Re_T Reynolds Number for Turbulent Flow
- **S** Reference Area *(Square Meter)*

- v_i Induced Velocity *(Meter per Second)*
- x Distance on X-Axis *(Meter)*
- x_{cp} Center of Pressure *(Meter)*
- α Angle of Attack *(Degree)*
- α_0 Angle of Zero Lift *(Degree)*
- α_{eff} Effective Angle of Attack *(Degree)*
- α_g Geometric Angle of Attack *(Degree)*
- α_i Induced Angle of Attack *(Degree)*
- γ Vortex Strength *(Square Meter per Second)*
- δ_L Laminar Boundary Layer Thickness *(Meter)*
- δ_T Turbulent Boundary Layer Thickness *(Meter)*
- τ Induced Lift Slope Factor

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: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Pressure** in Pascal (Pa)
  Pressure Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Force** in Newton (N)
  Force Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Reciprocal Angle** in 1 per Radian (rad^{-1})
  Reciprocal Angle Unit Conversion
- Measurement: **Velocity Potential** in Square Meter per Second (m²/s)
  Velocity Potential Unit Conversion

Check other formula lists

- **Flow and Lift Distribution Formulas**
- **Flow over Airfoils and Wings Formulas**
- **Lift Distribution Formulas**

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