Important Lift Distribution Formulas PDF

Formulas
Examples
with Units

List of 30
Important Lift Distribution Formulas

1) Elliptical Lift Distribution Formulas

1.1) Aspect Ratio given Induced Angle of Attack Formula

Evaluate Formula

Formula

$$AR_{ELD} = \frac{C_{L,ELD}}{\pi \cdot \alpha_i}$$

Example with Units

$$2.4704 = \frac{1.49}{3.1416 \cdot 11^\circ}$$

1.2) Aspect Ratio given Induced Drag Coefficient Formula

Evaluate Formula

Formula

$$AR_{ELD} = \frac{C_{L,ELD}^2}{\pi \cdot C_{D,i,ELD}}$$

Example

$$2.4537 = \frac{1.49^2}{3.1416 \cdot 0.288}$$

1.3) Circulation at given Distance along Wingspan Formula

Evaluate Formula

Formula

$$\Gamma = \Gamma_o \cdot \sqrt{1 - \left(2 \cdot \frac{a}{b}\right)^2}$$

Example with Units

$$13.9986\,\text{m}^2/\text{s} = 14\,\text{m}^2/\text{s} \cdot \sqrt{1 - \left(2 \cdot \frac{16.4\,\text{mm}}{2340\,\text{mm}}\right)^2}$$

1.4) Circulation at Origin given Downwash Formula

Evaluate Formula

Formula

$$\Gamma_o = -2 \cdot w \cdot b$$

Example with Units

$$14.04\,\text{m}^2/\text{s} = -2 \cdot -3\,\text{m/s} \cdot 2340\,\text{mm}$$

1.5) Circulation at Origin given Induced Angle of Attack Formula

Evaluate Formula

Formula

$$\Gamma_o = 2 \cdot b \cdot \alpha_i \cdot V_\infty$$

Example with Units

$$13.9267\,\text{m}^2/\text{s} = 2 \cdot 2340\,\text{mm} \cdot 11^\circ \cdot 15.5\,\text{m/s}$$

1.6) Circulation at Origin given Lift of Wing Formula

Evaluate Formula

Formula

$$\Gamma_o = 4 \cdot \frac{F_L}{\rho_\infty \cdot V_\infty \cdot b \cdot \pi}$$

Example with Units

$$14.0074\,\text{m}^2/\text{s} = 4 \cdot \frac{488.8\,\text{N}}{1.225\,\text{kg/m}^3 \cdot 15.5\,\text{m/s} \cdot 2340\,\text{mm} \cdot 3.1416}$$

1.7) Circulation at Origin in Elliptical Lift Distribution Formula

Evaluate Formula

Formula

$$\Gamma_o = 2 \cdot V_\infty \cdot S_0 \cdot \frac{C_l}{\pi \cdot b}$$

Example with Units

$$13.9791\,\text{m}^2/\text{s} = 2 \cdot 15.5\,\text{m/s} \cdot 2.21\,\text{m}^2 \cdot \frac{1.5}{3.1416 \cdot 2340\,\text{mm}}$$

1.8) Coefficient of Lift given Circulation at Origin Formula

Evaluate Formula

Formula

$$C_{L,ELD} = \pi \cdot b \cdot \frac{\Gamma_o}{2 \cdot V_\infty \cdot S_0}$$

Example with Units

$$1.5022 = 3.1416 \cdot 2340\,\text{mm} \cdot \frac{14\,\text{m}^2/\text{s}}{2 \cdot 15.5\,\text{m/s} \cdot 2.21\,\text{m}^2}$$

1.9) Coefficient of Lift given Induced Angle of Attack Formula

Evaluate Formula

Formula

$$C_{L,ELD} = \pi \cdot \alpha_i \cdot AR_{ELD}$$

Example with Units

$$1.4958 = 3.1416 \cdot 11° \cdot 2.48$$

1.10) Coefficient of Lift given Induced Drag Coefficient Formula

Evaluate Formula

Formula

$$C_{L,ELD} = \sqrt{\pi \cdot AR_{ELD} \cdot C_{D,i,ELD}}$$

Example

$$1.4979 = \sqrt{3.1416 \cdot 2.48 \cdot 0.288}$$

1.11) Downwash in Elliptical Lift Distribution Formula

Evaluate Formula

Formula

$$w = -\frac{\Gamma_o}{2 \cdot b}$$

Example with Units

$$-2.9915\,\text{m/s} = -\frac{14\,\text{m}^2/\text{s}}{2 \cdot 2340\,\text{mm}}$$

1.12) Freestream Velocity given Circulation at Origin Formula

Evaluate Formula

Formula

$$V_\infty = \pi \cdot b \cdot \frac{\Gamma_o}{2 \cdot S_0 \cdot C_{L,ELD}}$$

Example with Units

$$15.6273\,\text{m/s} = 3.1416 \cdot 2340\,\text{mm} \cdot \frac{14\,\text{m}^2/\text{s}}{2 \cdot 2.21\,\text{m}^2 \cdot 1.49}$$

1.13) Freestream Velocity given Induced Angle of Attack Formula

Evaluate Formula

Formula

$$V_\infty = \frac{\Gamma_o}{2 \cdot b \cdot \alpha_i}$$

Example with Units

$$15.5816\,\text{m/s} = \frac{14\,\text{m}^2/\text{s}}{2 \cdot 2340\,\text{mm} \cdot 11°}$$

1.14) Induced Angle of Attack given Aspect Ratio Formula

Evaluate Formula

Formula

$$\alpha_i = \frac{C_l}{\pi \cdot AR_{ELD}}$$

Example with Units

$$11.0309° = \frac{1.5}{3.1416 \cdot 2.48}$$

1.15) Induced Angle of Attack given Circulation at Origin Formula

Evaluate Formula

Formula

$$\alpha_i = \frac{\Gamma_o}{2 \cdot b \cdot V_\infty}$$

Example with Units

$$11.0579° = \frac{14\,m^2/s}{2 \cdot 2340\,mm \cdot 15.5\,m/s}$$

1.16) Induced Angle of Attack given Coefficient of Lift Formula

Evaluate Formula

Formula

$$\alpha_i = S_0 \cdot \frac{C_l}{\pi \cdot b^2}$$

Example with Units

$$11.0414° = 2.21\,m^2 \cdot \frac{1.5}{3.1416 \cdot 2340\,mm^2}$$

1.17) Induced Angle of Attack given Downwash Formula

Evaluate Formula

Formula

$$\alpha_i = -\left(\frac{w}{V_\infty}\right)$$

Example with Units

$$11.0895° = -\left(\frac{-3\,m/s}{15.5\,m/s}\right)$$

1.18) Induced Drag Coefficient given Aspect Ratio Formula

Evaluate Formula

Formula

$$C_{D,i,ELD} = \frac{C_{L,ELD}^2}{\pi \cdot AR_{ELD}}$$

Example

$$0.285 = \frac{1.49^2}{3.1416 \cdot 2.48}$$

1.19) Lift at given Distance along Wingspan Formula

Evaluate Formula

Formula

$$L = \rho_\infty \cdot V_\infty \cdot \Gamma_o \cdot \sqrt{1 - \left(2 \cdot \frac{a}{b}\right)^2}$$

Example with Units

$$265.7989\,N = 1.225\,kg/m^3 \cdot 15.5\,m/s \cdot 14\,m^2/s \cdot \sqrt{1 - \left(2 \cdot \frac{16.4\,mm}{2340\,mm}\right)^2}$$

1.20) Lift of Wing given Circulation at Origin Formula

Evaluate Formula

Formula

$$F_L = \frac{\pi \cdot \rho_\infty \cdot V_\infty \cdot b \cdot \Gamma_o}{4}$$

Example with Units

$$488.5416\,N = \frac{3.1416 \cdot 1.225\,kg/m^3 \cdot 15.5\,m/s \cdot 2340\,mm \cdot 14\,m^2/s}{4}$$

2) General Lift Distribution Formulas

2.1) Aspect Ratio given Induced Drag Factor Formula

Evaluate Formula

Formula

$$AR_{GLD} = \frac{(1+\delta)\cdot C_{L,GLD}^{2}}{\pi \cdot C_{D,i,GLD}}$$

Example

$$15.0464 = \frac{(1+0.05)\cdot 1.47^{2}}{3.1416\cdot 0.048}$$

2.2) Induced Drag Coefficient given Induced Drag Factor Formula

Evaluate Formula

Formula

$$C_{D,i,GLD} = \frac{(1+\delta)\cdot C_{L,GLD}^{2}}{\pi \cdot AR_{GLD}}$$

Example

$$0.0481 = \frac{(1+0.05)\cdot 1.47^{2}}{3.1416\cdot 15}$$

2.3) Induced Drag Coefficient given Span Efficiency Factor Formula

Evaluate Formula

Formula

$$C_{D,i,GLD} = \frac{C_{L,GLD}^{2}}{\pi \cdot e_{span} \cdot AR_{GLD}}$$

Example

$$0.0483 = \frac{1.47^{2}}{3.1416\cdot 0.95\cdot 15}$$

2.4) Induced Drag Factor given Induced Drag Coefficient Formula

Evaluate Formula

Formula

$$\delta = \frac{\pi \cdot AR_{GLD}\cdot C_{D,i,GLD}}{C_{L,GLD}^{2}} - 1$$

Example

$$0.0468 = \frac{3.1416\cdot 15\cdot 0.048}{1.47^{2}} - 1$$

2.5) Induced Drag Factor given Span Efficiency Factor Formula

Evaluate Formula

Formula

$$\delta = e_{span}^{-1} - 1$$

Example

$$0.0526 = 0.95^{-1} - 1$$

2.6) Induced Lift Slope Factor given Lift Curve Slope of Finite Wing Formula

Evaluate Formula

Formula

$$\tau_{FW} = \frac{\pi \cdot AR_{GLD}\cdot\left(\frac{a_0}{a_{C,l}} - 1\right)}{a_0} - 1$$

Example with Units

$$0.0023 = \frac{3.1416\cdot 15\cdot\left(\frac{6.28\,\text{rad}^{-1}}{5.54\,\text{rad}^{-1}} - 1\right)}{6.28\,\text{rad}^{-1}} - 1$$

2.7) Lift Coefficient given Induced Drag Factor Formula

Evaluate Formula

Formula

$$C_{L,GLD} = \sqrt{\frac{\pi \cdot AR_{GLD}\cdot C_{D,i,GLD}}{1+\delta}}$$

Example

$$1.4677 = \sqrt{\frac{3.1416\cdot 15\cdot 0.048}{1+0.05}}$$

2.8) Lift Coefficient given Span Efficiency Factor Formula

Evaluate Formula

Formula

$$C_{L,GLD} = \sqrt{\pi \cdot e_{span} \cdot AR_{GLD} \cdot C_{D,i,GLD}}$$

Example

$$1.4659 = \sqrt{3.1416 \cdot 0.95 \cdot 15 \cdot 0.048}$$

2.9) Span Efficiency Factor Formula

Evaluate Formula

Formula

$$e_{span} = \left(1 + \delta\right)^{-1}$$

Example

$$0.9524 = \left(1 + 0.05\right)^{-1}$$

2.10) Span Efficiency Factor given Induced Drag Coefficient Formula

Evaluate Formula

Formula

$$e_{span} = \frac{C_{L,GLD}^{2}}{\pi \cdot AR_{GLD} \cdot C_{D,i,GLD}}$$

Example

$$0.9553 = \frac{1.47^{2}}{3.1416 \cdot 15 \cdot 0.048}$$

Variables used in list of Lift Distribution Formulas above

- **a** Distance from Center to Point *(Millimeter)*
- a_0 2D Lift Curve Slope *(1 per Radian)*
- $a_{C,l}$ Lift Curve Slope *(1 per Radian)*
- AR_{ELD} Wing Aspect Ratio ELD
- AR_{GLD} Wing Aspect Ratio GLD
- **b** Wingspan *(Millimeter)*
- $C_{D,i,ELD}$ Induced Drag Coefficient ELD
- $C_{D,i,GLD}$ Induced Drag Coefficient GLD
- C_l Lift Coefficient Origin
- $C_{L,ELD}$ Lift Coefficient ELD
- $C_{L,GLD}$ Lift Coefficient GLD
- e_{span} Span Efficiency Factor
- F_L Lift Force *(Newton)*
- **L** Lift at Distance *(Newton)*
- S_0 Reference Area Origin *(Square Meter)*
- V_∞ Freestream Velocity *(Meter per Second)*
- **w** Downwash *(Meter per Second)*
- α_i Induced Angle of Attack *(Degree)*
- Γ Circulation *(Square Meter per Second)*
- Γ_o Circulation at Origin *(Square Meter per Second)*
- δ Induced Drag Factor
- ρ_∞ Freestream Density *(Kilogram per Cubic Meter)*
- τ_{FW} Induced Lift Slope Factor of Finite Wing

Constants, Functions, Measurements used in list of Lift Distribution 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 Millimeter (mm) *Length Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area 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: **Density** in Kilogram per Cubic Meter (kg/m³) *Density Unit Conversion*
- Measurement: **Momentum Diffusivity** in Square Meter per Second (m²/s) *Momentum Diffusivity Unit Conversion*
- Measurement: **Reciprocal Angle** in 1 per Radian (rad^{-1}) *Reciprocal Angle Unit Conversion*

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