Important Wing-Tail Contribution Formulas PDF

Formulas
Examples
with Units

List of 15
Important Wing-Tail Contribution Formulas

1) Angle of Attack at Tail Formula

Evaluate Formula

Formula

$$\alpha_t = \alpha_w - i_w - \varepsilon + i_t$$

Example with Units

$$0.77\,\text{rad} = 0.083\,\text{rad} - 0.078\,\text{rad} - 0.095\,\text{rad} + 0.86\,\text{rad}$$

2) Angle of Attack of Wing Formula

Evaluate Formula

Formula

$$\alpha_w = \alpha_t + i_w + \varepsilon - i_t$$

Example with Units

$$0.083\,\text{rad} = 0.77\,\text{rad} + 0.078\,\text{rad} + 0.095\,\text{rad} - 0.86\,\text{rad}$$

3) Angle of incidence of tail Formula

Evaluate Formula

Formula

$$i_t = \alpha_t - \alpha_w + i_w + \varepsilon$$

Example with Units

$$0.86\,\text{rad} = 0.77\,\text{rad} - 0.083\,\text{rad} + 0.078\,\text{rad} + 0.095\,\text{rad}$$

4) Angle of incidence of wing Formula

Evaluate Formula

Formula

$$i_w = \alpha_w - \alpha_t - \varepsilon + i_t$$

Example with Units

$$0.078\,\text{rad} = 0.083\,\text{rad} - 0.77\,\text{rad} - 0.095\,\text{rad} + 0.86\,\text{rad}$$

5) Downwash angle Formula

Evaluate Formula

Formula

$$\varepsilon = \alpha_w - i_w - \alpha_t + i_t$$

Example with Units

$$0.095\,\text{rad} = 0.083\,\text{rad} - 0.078\,\text{rad} - 0.77\,\text{rad} + 0.86\,\text{rad}$$

6) Lift due to Tail only Formula

Evaluate Formula

Formula

$$L_t = F_L - L_w$$

Example with Units

$$273.04\,\text{N} = 1073.04\,\text{N} - 800\,\text{N}$$

7) Lift due to Wing only Formula

Evaluate Formula

Formula

$$L_w = F_L - L_t$$

Example with Units

$$800\,\text{N} = 1073.04\,\text{N} - 273.04\,\text{N}$$

8) Tail area for given tail efficiency Formula

Evaluate Formula

Formula

$$S_t = S \cdot \frac{C_L - CW_{lift}}{CT_{lift} \cdot \eta}$$

Example with Units

$$1.8038\,m^2 = 5.08\,m^2 \cdot \frac{1.108 - 1.01}{0.3 \cdot 0.92}$$

9) Tail Efficiency for given lift coefficients Formula

Evaluate Formula

Formula

$$\eta = S \cdot \frac{C_L - CW_{lift}}{CT_{lift} \cdot S_t}$$

Example with Units

$$0.9219 = 5.08\,m^2 \cdot \frac{1.108 - 1.01}{0.3 \cdot 1.8\,m^2}$$

10) Tail Lift Coefficient for given Pitching Moment Formula

Evaluate Formula

Formula

$$CT_{lift} = -2 \cdot \frac{M_t}{l_t \cdot \rho_\infty \cdot V_{tail}^2 \cdot S_t}$$

Example with Units

$$0.3 = -2 \cdot \frac{-218.6644\,N*m}{0.801511\,m \cdot 1.225\,kg/m^3 \cdot 28.72\,m/s^2 \cdot 1.8\,m^2}$$

11) Tail Lift Coefficient for given Pitching Moment Coefficient Formula

Evaluate Formula

Formula

$$CT_{lift} = -\left(Cm_t \cdot S \cdot \frac{c_{ma}}{\eta \cdot S_t \cdot l_t}\right)$$

Example with Units

$$0.2985 = -\left(-0.39 \cdot 5.08\,m^2 \cdot \frac{0.2\,m}{0.92 \cdot 1.8\,m^2 \cdot 0.801511\,m}\right)$$

12) Tail Lift Coefficient of Wing-Tail Combination Formula

Evaluate Formula

Formula

$$CT_{lift} = S \cdot \frac{C_L - CW_{lift}}{\eta \cdot S_t}$$

Example with Units

$$0.3006 = 5.08\,m^2 \cdot \frac{1.108 - 1.01}{0.92 \cdot 1.8\,m^2}$$

13) Total Lift Coefficient of Wing-Tail Combination Formula

Evaluate Formula

Formula

$$C_L = CW_{lift} + \left(\eta \cdot S_t \cdot \frac{CT_{lift}}{S}\right)$$

Example with Units

$$1.1078 = 1.01 + \left(0.92 \cdot 1.8\,m^2 \cdot \frac{0.3}{5.08\,m^2}\right)$$

14) Total Lift of Wing-Tail Combination Formula

Evaluate Formula

Formula

$$F_L = L_w + L_t$$

Example with Units

$$1073.04\,\text{N} = 800\,\text{N} + 273.04\,\text{N}$$

15) Wing Lift Coefficient of wing-tail combination Formula

Evaluate Formula

Formula

$$CW_{lift} = C_L - \left(\eta \cdot S_t \cdot \frac{CT_{lift}}{S}\right)$$

Example with Units

$$1.0102 = 1.108 - \left(0.92 \cdot 1.8\,\text{m}^2 \cdot \frac{0.3}{5.08\,\text{m}^2}\right)$$

Variables used in list of Wing-Tail Contribution Formulas above

- C_L Lift Coefficient
- c_{ma} Mean Aerodynamic Chord *(Meter)*
- Cm_t Tail Pitching Moment Coefficient
- CT_{lift} Tail Lift Coefficient
- CW_{lift} Wing Lift Coefficient
- F_L Lift Force *(Newton)*
- L_t Lift due to Tail *(Newton)*
- L_w Lift due to Wing *(Newton)*
- M_t Pitching Moment due to Tail *(Newton Meter)*
- S Reference Area *(Square Meter)*
- S_t Horizontal Tail Area *(Square Meter)*
- V_{tail} Velocity Tail *(Meter per Second)*
- α_t Horizontal Tail Angle of Attack *(Radian)*
- α_w Wing Angle of Attack *(Radian)*
- ε Downwash Angle *(Radian)*
- η Tail Efficiency
- ρ_∞ Freestream Density *(Kilogram per Cubic Meter)*
- i_t Tail Incidence Angle *(Radian)*
- i_w Wing Incidence Angle *(Radian)*
- l_t Horizontal Tail Moment Arm *(Meter)*

Constants, Functions, Measurements used in list of Wing-Tail Contribution Formulas above

- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Area** in Square Meter (m^2)
  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 Radian (rad)
  Angle Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m^3)
  Density Unit Conversion
- Measurement: **Moment of Force** in Newton Meter (N*m)
  Moment of Force Unit Conversion

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7/8/2024 | 8:14:02 AM UTC