Important Preliminary Aerodynamics Formulas PDF

Formulas
Examples
with Units

List of 17
Important Preliminary Aerodynamics Formulas

1) Aerodynamic Force Formula

Evaluate Formula

Formula

$$F_R = F_D + F_L$$

Example with Units

$$100.5\,\text{N} = 80.05\,\text{N} + 20.45\,\text{N}$$

2) Dynamic pressure aircraft Formula

Evaluate Formula

Formula

$$q = \frac{1}{2} \cdot \rho \cdot V_{fs}^{2}$$

Example with Units

$$70.5189\,\text{Pa} = \frac{1}{2} \cdot 1.225\,\text{kg/m}^3 \cdot 10.73\,\text{m/s}^{2}$$

3) Dynamic Pressure given Drag Coefficient Formula

Evaluate Formula

Formula

$$q = \frac{F_D}{C_D}$$

Example with Units

$$70.5908\,\text{Pa} = \frac{80.05\,\text{N}}{1.134}$$

4) Dynamic Pressure given Gas Constant Formula

Evaluate Formula

Formula

$$q = \frac{1}{2} \cdot \rho \cdot M_r^{2} \cdot cp \cdot R \cdot T$$

Example with Units

$$70.5135\,\text{Pa} = \frac{1}{2} \cdot 1.225\,\text{kg/m}^3 \cdot 7.67^{2} \cdot 0.003\,\text{J/(kg*K)} \cdot 4.1\,\text{J/(kg*K)} \cdot 159.1\,\text{K}$$

5) Dynamic Pressure given Induced Drag Formula

Evaluate Formula

Formula

$$q = \frac{F_L^{2}}{\pi \cdot D_i \cdot b_W^{2}}$$

Example with Units

$$70.5441\,\text{Pa} = \frac{20.45\,\text{N}^{2}}{3.1416 \cdot 1.2\,\text{N} \cdot 1.254\,\text{m}^{2}}$$

6) Dynamic Pressure given Lift Coefficient Formula

Evaluate Formula

Formula

$$q = \frac{F_L}{C_L}$$

Example with Units

$$70.5172\,\text{Pa} = \frac{20.45\,\text{N}}{0.29}$$

7) Dynamic Pressure given Mach Number Formula

Evaluate Formula

Formula

$$q = \frac{1}{2} \cdot \rho \cdot \left(M_r \cdot a \right)^2$$

Example with Units

$$70.5232\,\text{Pa} = \frac{1}{2} \cdot 1.225\,\text{kg/m}^3 \cdot \left(7.67 \cdot 1.399\,\text{m/s} \right)^2$$

8) Dynamic Pressure given Normal Pressure Formula

Evaluate Formula

Formula

$$q = \frac{1}{2} \cdot cp \cdot p \cdot M_r^2$$

Example with Units

$$70.5947\,\text{Pa} = \frac{1}{2} \cdot 0.003\,\text{J/(kg*K)} \cdot 800\,\text{Pa} \cdot 7.67^2$$

9) Flight Speed given Dynamic Pressure Formula

Evaluate Formula

Formula

$$V_{fs} = \sqrt{\frac{2 \cdot q}{\rho}}$$

Example with Units

$$10.7286\,\text{m/s} = \sqrt{\frac{2 \cdot 70.5\,\text{Pa}}{1.225\,\text{kg/m}^3}}$$

10) Mach Number of Moving Object Formula

Evaluate Formula

Formula

$$M_r = \frac{v}{c}$$

Example with Units

$$7.6793 = \frac{2634\,\text{m/s}}{343\,\text{m/s}}$$

11) Mach Number-2 Formula

Evaluate Formula

Formula

$$M = \sqrt{\left(\frac{\left(\left(Y - 1 \right) \cdot M_r^2 + 2 \right)}{2 \cdot Y \cdot M_r^2 - \left(Y - 1 \right)} \right)}$$

Example

$$0.3942 = \sqrt{\left(\frac{\left(\left(1.4 - 1 \right) \cdot 7.67^2 + 2 \right)}{2 \cdot 1.4 \cdot 7.67^2 - \left(1.4 - 1 \right)} \right)}$$

12) Power required at Altitude Formula

Evaluate Formula

Formula

$$P_{R,alt} = \sqrt{\frac{2 \cdot W_{body}^3 \cdot C_D^2}{\rho_0 \cdot S \cdot C_L^3}}$$

Example with Units

$$700.0602\,\text{W} = \sqrt{\frac{2 \cdot 750\,\text{N}^3 \cdot 1.134^2}{997\,\text{kg/m}^3 \cdot 91.05\,\text{m}^2 \cdot 0.29^3}}$$

13) Power required at Altitude given Power at sea-level Formula

Evaluate Formula

Formula

$$P_{R,alt} = P_{R,0} \cdot \sqrt{\frac{[\text{Std-Air-Density-Sea}]}{\rho_0}}$$

Example with Units

$$700.0894\,\text{W} = 19940\,\text{W} \cdot \sqrt{\frac{1.229}{997\,\text{kg/m}^3}}$$

14) Power required at sea-level conditions Formula

Evaluate Formula

Formula

$$P_{R,0} = \sqrt{\frac{2 \cdot W_{body}^{3} \cdot C_D^{2}}{[Std\text{-}Air\text{-}Density\text{-}Sea] \cdot S \cdot C_L^{3}}}$$

Example with Units

$$19939.1681\,W = \sqrt{\frac{2 \cdot 750\,N^{3} \cdot 1.134^{2}}{1.229 \cdot 91.05\,m^2 \cdot 0.29^{3}}}$$

15) Velocity at Altitude Formula

Evaluate Formula

Formula

$$V_{alt} = \sqrt{2 \cdot \frac{W_{body}}{\rho_0 \cdot S \cdot C_L}}$$

Example with Units

$$0.2387\,m/s = \sqrt{2 \cdot \frac{750\,N}{997\,kg/m^3 \cdot 91.05\,m^2 \cdot 0.29}}$$

16) Velocity at Altitude given Velocity at Sea-Level Formula

Evaluate Formula

Formula

$$V_{alt} = V_0 \cdot \sqrt{\frac{[Std\text{-}Air\text{-}Density\text{-}Sea]}{\rho_0}}$$

Example with Units

$$0.2352\,m/s = 6.7\,m/s \cdot \sqrt{\frac{1.229}{997\,kg/m^3}}$$

17) Velocity at Sea-Level given Lift Coefficient Formula

Evaluate Formula

Formula

$$V_0 = \sqrt{\frac{2 \cdot W_{body}}{[Std\text{-}Air\text{-}Density\text{-}Sea] \cdot S \cdot C_L}}$$

Example with Units

$$6.7988\,m/s = \sqrt{\frac{2 \cdot 750\,N}{1.229 \cdot 91.05\,m^2 \cdot 0.29}}$$

Variables used in list of Preliminary Aerodynamics Formulas above

- **a** Sonic Speed *(Meter per Second)*
- b_W Lateral Plane Span *(Meter)*
- **c** Speed of Sound *(Meter per Second)*
- C_D Drag Coefficient
- C_L Lift Coefficient
- **cp** Specific Heat of Air *(Joule per Kilogram per K)*
- D_i Induced Drag *(Newton)*
- F_D Drag Force *(Newton)*
- F_L Lift Force *(Newton)*
- F_R Aerodynamic Force *(Newton)*
- **M** Mach Number 2
- M_r Mach Number
- **p** Pressure *(Pascal)*
- $P_{R,0}$ Power Required at Sea-level *(Watt)*
- $P_{R,alt}$ Power Required at Altitude *(Watt)*
- **q** Dynamic Pressure *(Pascal)*
- **R** Gas Constant *(Joule per Kilogram per K)*
- **S** Reference Area *(Square Meter)*
- **T** Temperature *(Kelvin)*
- **v** Velocity *(Meter per Second)*
- V_0 Velocity at Sea-Level *(Meter per Second)*
- V_{alt} Velocity at an Altitude *(Meter per Second)*
- V_{fs} Flight Speed *(Meter per Second)*
- W_{body} Weight of Body *(Newton)*
- **Y** Heat Capacity Ratio
- **ρ** Ambient Air Density *(Kilogram per Cubic Meter)*
- ρ_0 Density *(Kilogram per Cubic Meter)*

Constants, Functions, Measurements used in list of Preliminary Aerodynamics Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **[Std-Air-Density-Sea]**, 1.229 *Standard air density at sea-level conditions*
- 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 Meter (m) *Length Unit Conversion*
- Measurement: **Temperature** in Kelvin (K) *Temperature 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: **Power** in Watt (W) *Power Unit Conversion*
- Measurement: **Force** in Newton (N) *Force Unit Conversion*
- Measurement: **Specific Heat Capacity** in Joule per Kilogram per K (J/(kg*K)) *Specific Heat Capacity Unit Conversion*
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³) *Density Unit Conversion*

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