Important Propeller-Driven Airplane Formulas PDF

Formulas
Examples
with Units

List of 22
Important Propeller-Driven Airplane Formulas

1) Cruise Weight Fraction for Prop-Driven Aircraft Formula

Evaluate Formula

Formula

$$FW_{cruise\ prop} = \exp\left(\frac{R_{prop} \cdot (-1) \cdot c}{LDmax_{ratio} \cdot \eta}\right)$$

Example with Units

$$0.7778 = \exp\left(\frac{7126.017\,\text{m} \cdot (-1) \cdot 0.6\,\text{kg/h/W}}{5.081527 \cdot 0.93}\right)$$

2) Endurance of Propeller-Driven Airplane Formula

Evaluate Formula

Formula

$$E_{prop} = \frac{\eta}{c} \cdot \frac{C_L^{1.5}}{C_D} \cdot \sqrt{2 \cdot \rho_\infty \cdot S} \cdot \left(\left(\frac{1}{W_1}\right)^{\frac{1}{2}} - \left(\frac{1}{W_0}\right)^{\frac{1}{2}}\right)$$

Example with Units

$$454.2055\,\text{s} = \frac{0.93}{0.6\,\text{kg/h/W}} \cdot \frac{5^{1.5}}{2} \cdot \sqrt{2 \cdot 1.225\,\text{kg/m}^3 \cdot 5.11\,\text{m}^2} \cdot \left(\left(\frac{1}{3000\,\text{kg}}\right)^{\frac{1}{2}} - \left(\frac{1}{5000\,\text{kg}}\right)^{\frac{1}{2}}\right)$$

3) Lift to Drag for Maximum Endurance given Preliminary Endurance for Prop-Driven Aircraft Formula

Evaluate Formula

Formula

$$LDEmax_{ratio\ prop} = \frac{E \cdot V_{Emax} \cdot c}{\eta \cdot \ln\left(\frac{W_{L,beg}}{W_{L,end}}\right)}$$

Example with Units

$$85.0491 = \frac{452.0581\,\text{s} \cdot 15.6\,\text{m/s} \cdot 0.6\,\text{kg/h/W}}{0.93 \cdot \ln\left(\frac{400\,\text{kg}}{394.1\,\text{kg}}\right)}$$

4) Lift to Drag Ratio for Maximum Endurance given Max Lift to Drag Ratio for Prop-Driven Aircraft Formula

Evaluate Formula

Formula

$$LDEmax_{ratio} = 0.866 \cdot LDmax_{ratio}$$

Example

$$4.4006 = 0.866 \cdot 5.081527$$

5) Lift-to-Drag ratio for given Range of Propeller-Driven Airplane Formula

Evaluate Formula

Formula

$$LD = c \cdot \frac{R_{prop}}{\eta \cdot \ln\left(\frac{W_0}{W_1}\right)}$$

Example with Units

$$2.5 = 0.6\,\text{kg/h/W} \cdot \frac{7126.017\,\text{m}}{0.93 \cdot \ln\left(\frac{5000\,\text{kg}}{3000\,\text{kg}}\right)}$$

6) Maximum Lift to Drag Ratio given Lift to Drag Ratio for Max Endurance of Prop-Driven Aircraft Formula

Evaluate Formula

Formula

$$LDmax_{ratio} = \frac{LDEmax_{ratio}}{0.866}$$

Example

$$5.0808 = \frac{4.40}{0.866}$$

7) Maximum Lift to Drag Ratio given Range for Prop-Driven Aircraft Formula

Evaluate Formula

Formula

$$LDmax_{ratio} = \frac{R_{prop} \cdot c}{\eta \cdot \ln\left(\frac{W_i}{W_f}\right)}$$

Example with Units

$$5.0815 = \frac{7126.017\,\text{m} \cdot 0.6\,\text{kg/h/W}}{0.93 \cdot \ln\left(\frac{450\,\text{kg}}{350\,\text{kg}}\right)}$$

8) Power Available for Reciprocating Engine-Propeller Combination Formula

Evaluate Formula

Formula

$$P_A = \eta \cdot BP$$

Example with Units

$$20.6553\,\text{W} = 0.93 \cdot 22.21\,\text{W}$$

9) Propeller Efficiency for given Endurance of Propeller-Driven Airplane Formula

Evaluate Formula

Formula

$$\eta = \frac{E}{\left(\frac{1}{c}\right) \cdot \left(\frac{C_L^{1.5}}{C_D}\right) \cdot \left(\sqrt{2 \cdot \rho_\infty \cdot S}\right) \cdot \left(\left(\left(\frac{1}{W_1}\right)^{\frac{1}{2}}\right) - \left(\left(\frac{1}{W_0}\right)^{\frac{1}{2}}\right)\right)}$$

Example with Units

$$0.9256 = \frac{452.0581\,\text{s}}{\left(\frac{1}{0.6\,\text{kg/h/W}}\right) \cdot \left(\frac{5^{1.5}}{2}\right) \cdot \left(\sqrt{2 \cdot 1.225\,\text{kg/m}^3 \cdot 5.11\,\text{m}^2}\right) \cdot \left(\left(\left(\frac{1}{3000\,\text{kg}}\right)^{\frac{1}{2}}\right) - \left(\left(\frac{1}{5000\,\text{kg}}\right)^{\frac{1}{2}}\right)\right)}$$

10) Propeller Efficiency for given Range and Lift-to-Drag Ratio of Propeller-Driven Airplane Formula

Evaluate Formula

Formula

$$\eta = R_{prop} \cdot \frac{c}{LD \cdot \left(\ln\left(\frac{W_0}{W_1}\right)\right)}$$

Example with Units

$$0.93 = 7126.017\,\text{m} \cdot \frac{0.6\,\text{kg/h/W}}{2.50 \cdot \left(\ln\left(\frac{5000\,\text{kg}}{3000\,\text{kg}}\right)\right)}$$

11) Propeller Efficiency for given Range of Propeller-Driven Airplane Formula

Evaluate Formula

Formula

$$\eta = R_{prop} \cdot c \cdot \frac{C_D}{C_L \cdot \ln\left(\frac{W_0}{W_1}\right)}$$

Example with Units

$$0.93 = 7126.017\,\text{m} \cdot 0.6\,\text{kg/h/W} \cdot \frac{2}{5 \cdot \ln\left(\frac{5000\,\text{kg}}{3000\,\text{kg}}\right)}$$

12) Propeller Efficiency for Reciprocating Engine-Propeller Combination Formula

Evaluate Formula

Formula

$$\eta = \frac{P_A}{BP}$$

Example with Units

$$0.93 = \frac{20.656\,\text{W}}{22.21\,\text{W}}$$

13) Propeller Efficiency given Preliminary Endurance for Prop-Driven Aircraft Formula

Evaluate Formula

Formula

$$\eta = \frac{E_p \cdot V_{Emax} \cdot c}{LDEmax_{ratio} \cdot \ln\left(\frac{W_{L,beg}}{W_{L,end}}\right)}$$

Example with Units

$$0.9305 = \frac{23.4\,\text{s} \cdot 15.6\,\text{m/s} \cdot 0.6\,\text{kg/h/W}}{4.40 \cdot \ln\left(\frac{400\,\text{kg}}{394.1\,\text{kg}}\right)}$$

14) Propeller Efficiency given Range for Prop-Driven Aircraft Formula

Evaluate Formula

Formula

$$\eta = \frac{R_{prop} \cdot c}{LDmax_{ratio} \cdot \ln\left(\frac{W_i}{W_f}\right)}$$

Example with Units

$$0.93 = \frac{7126.017\,\text{m} \cdot 0.6\,\text{kg/h/W}}{5.081527 \cdot \ln\left(\frac{450\,\text{kg}}{350\,\text{kg}}\right)}$$

15) Range of Propeller-Driven Airplane Formula

Evaluate Formula

Formula

$$R_{prop} = \left(\frac{\eta}{c}\right) \cdot \left(\frac{C_L}{C_D}\right) \cdot \left(\ln\left(\frac{W_0}{W_1}\right)\right)$$

Example with Units

$$7126.0175\,\text{m} = \left(\frac{0.93}{0.6\,\text{kg/h/W}}\right) \cdot \left(\frac{5}{2}\right) \cdot \left(\ln\left(\frac{5000\,\text{kg}}{3000\,\text{kg}}\right)\right)$$

16) Range of Propeller-Driven Airplane for given lift-to-drag ratio Formula

Evaluate Formula

Formula

$$R_{prop} = \left(\frac{\eta}{c}\right) \cdot (LD) \cdot \left(\ln\left(\frac{W_0}{W_1}\right)\right)$$

Example with Units

$$7126.0175\,\text{m} = \left(\frac{0.93}{0.6\,\text{kg/h/W}}\right) \cdot (2.50) \cdot \left(\ln\left(\frac{5000\,\text{kg}}{3000\,\text{kg}}\right)\right)$$

17) Shaft Brake Power for Reciprocating Engine-Propeller Combination Formula

Evaluate Formula

Formula

$$BP = \frac{P_A}{\eta}$$

Example with Units

$$22.2108\,\text{W} = \frac{20.656\,\text{W}}{0.93}$$

18) Specific Fuel Consumption for given Endurance of Propeller-Driven Airplane Formula

Evaluate Formula

Formula

$$c = \frac{\eta}{E} \cdot \frac{C_L^{1.5}}{C_D} \cdot \sqrt{2 \cdot \rho_\infty \cdot S} \cdot \left(\left(\frac{1}{W_1}\right)^{\frac{1}{2}} - \left(\frac{1}{W_0}\right)^{\frac{1}{2}}\right)$$

Example with Units

$$0.6029\,\text{kg/h/W} = \frac{0.93}{452.0581\,\text{s}} \cdot \frac{5^{1.5}}{2} \cdot \sqrt{2 \cdot 1.225\,\text{kg/m}^3 \cdot 5.11\,\text{m}^2} \cdot \left(\left(\frac{1}{3000\,\text{kg}}\right)^{\frac{1}{2}} - \left(\frac{1}{5000\,\text{kg}}\right)^{\frac{1}{2}}\right)$$

19) Specific Fuel Consumption for given Range and Lift-to-Drag Ratio of Propeller-Driven Airplane Formula

Evaluate Formula

Formula

$$c = \left(\frac{\eta}{R_{prop}}\right) \cdot (LD) \cdot \left(\ln\left(\frac{W_0}{W_1}\right)\right)$$

Example with Units

$$0.6\,\text{kg/h/W} = \left(\frac{0.93}{7126.017\,\text{m}}\right) \cdot (2.50) \cdot \left(\ln\left(\frac{5000\,\text{kg}}{3000\,\text{kg}}\right)\right)$$

20) Specific Fuel Consumption for given Range of Propeller-Driven Airplane Formula

Evaluate Formula

Formula

$$c = \left(\frac{\eta}{R_{prop}}\right) \cdot \left(\frac{C_L}{C_D}\right) \cdot \left(\ln\left(\frac{W_0}{W_1}\right)\right)$$

Example with Units

$$0.6\,\text{kg/h/W} = \left(\frac{0.93}{7126.017\,\text{m}}\right) \cdot \left(\frac{5}{2}\right) \cdot \left(\ln\left(\frac{5000\,\text{kg}}{3000\,\text{kg}}\right)\right)$$

21) Specific Fuel Consumption given Preliminary Endurance for Prop-Driven Aircraft Formula

Evaluate Formula

Formula

$$c = \frac{LDEmax_{ratio\ prop} \cdot \eta \cdot \ln\left(\frac{W_{L,beg}}{W_{L,end}}\right)}{E \cdot V_{Emax}}$$

Example with Units

$$0.6\,\text{kg/h/W} = \frac{85.04913 \cdot 0.93 \cdot \ln\left(\frac{400\,\text{kg}}{394.1\,\text{kg}}\right)}{452.0581\,\text{s} \cdot 15.6\,\text{m/s}}$$

22) Specific Fuel Consumption given Range for Prop-Driven Aircraft Formula

Evaluate Formula

Formula

$$c = \frac{\eta \cdot LDmax_{ratio} \cdot \ln\left(\frac{W_i}{W_f}\right)}{R_{prop}}$$

Example with Units

$$0.6\,\text{kg/h/W} = \frac{0.93 \cdot 5.081527 \cdot \ln\left(\frac{450\,\text{kg}}{350\,\text{kg}}\right)}{7126.017\,\text{m}}$$

Variables used in list of Propeller-Driven Airplane Formulas above

- **BP** Brake Power *(Watt)*
- **c** Specific Fuel Consumption *(Kilogram per Hour per Watt)*
- C_D Drag Coefficient
- C_L Lift Coefficient
- **E** Endurance of Aircraft *(Second)*
- E_p Preliminary Endurance of Aircraft *(Second)*
- E_{prop} Endurance of Propeller Aircraft *(Second)*
- $FW_{cruise\ prop}$ Cruise Weight Fraction Propeller Aircraft
- **LD** Lift-to-Drag Ratio
- $LDEmax_{ratio\ prop}$ Lift to Drag Ratio at Maximum Endurance Prop
- $LDEmax_{ratio}$ Lift to Drag Ratio at Maximum Endurance
- $LDmax_{ratio}$ Maximum Lift-to-Drag Ratio
- P_A Available Power *(Watt)*
- R_{prop} Range of Propeller Aircraft *(Meter)*
- **S** Reference Area *(Square Meter)*
- V_{Emax} Velocity for Maximum Endurance *(Meter per Second)*
- W_0 Gross Weight *(Kilogram)*
- W_1 Weight without Fuel *(Kilogram)*
- W_f Weight at End of Cruise Phase *(Kilogram)*
- W_i Weight at Start of Cruise Phase *(Kilogram)*
- $W_{L,beg}$ Weight at Start of Loiter Phase *(Kilogram)*
- $W_{L,end}$ Weight at End of Loiter Phase *(Kilogram)*
- η Propeller Efficiency
- ρ_∞ Freestream Density *(Kilogram per Cubic Meter)*

Constants, Functions, Measurements used in list of Propeller-Driven Airplane Formulas above

- Functions: **exp**, exp(Number)
  n an exponential function, the value of the function changes by a constant factor for every unit change in the independent variable.
- Functions: **ln**, ln(Number)
  The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.
- 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: **Weight** in Kilogram (kg)
  Weight Unit Conversion
- Measurement: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Area** in Square Meter (m^2)
  Area Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Power** in Watt (W)
  Power Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m^3)
  Density Unit Conversion
- Measurement: **Specific Fuel Consumption** in Kilogram per Hour per Watt (kg/h/W)
  Specific Fuel Consumption Unit Conversion

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