Important Design Process Formulas PDF

Formulas
Examples
with Units

List of 19
Important Design Process Formulas

1) Battery Weight Fraction Formula

Evaluate Formula

Formula

$$WBF = \left(\frac{R}{E_{battery} \cdot 3600 \cdot \eta \cdot \left(\frac{1}{[g]} \right) \cdot LDmax_{ratio}} \right)$$

Example with Units

$$0.054 = \left(\frac{10\,\text{km}}{21\,\text{J/kg} \cdot 3600 \cdot 0.80 \cdot \left(\frac{1}{9.8066\,\text{m/s}^2} \right) \cdot 30} \right)$$

2) Cost Index given Minimum Design Index Formula

Evaluate Formula

Formula

$$CI = \frac{\left(DI_{min} \cdot 100 \right) - \left(WI \cdot P_w \right) - \left(TI \cdot P_t \right)}{P_c}$$

Example

$$1327.9132 = \frac{\left(160 \cdot 100 \right) - \left(50.98 \cdot 15.1 \right) - \left(95 \cdot 19 \right)}{10.11}$$

3) Electric Power for Wind Turbine Formula

Evaluate Formula

Formula

$$P_e = W_{shaft} \cdot \eta_g \cdot \eta_{transmission}$$

Example with Units

$$0.192\,\text{kW} = 0.6\,\text{kW} \cdot 0.8 \cdot .4$$

4) Fuel Load Formula

Evaluate Formula

Formula

$$W_f = W_{misf} + W_{resf}$$

Example with Units

$$9499\,\text{kg} = 8761\,\text{kg} + 738\,\text{kg}$$

5) Induced Inflow Ratio in Hover Formula

Evaluate Formula

Formula

$$\lambda = \frac{v_i}{R_{rotor} \cdot \omega}$$

Example with Units

$$4.1429 = \frac{58\,\text{m/s}}{0.007\,\text{km} \cdot 2\,\text{rad/s}}$$

6) Maximum Payload Capability Formula

Evaluate Formula

Formula

$$W_{pay} = MTOW - W_{OE} - W_f$$

Example with Units

$$52370\,\text{kg} = 62322\,\text{kg} - 453\,\text{kg} - 9499\,\text{kg}$$

7) Minimum Design Index Formula

Evaluate Formula

Formula

$$DI_{min} = \frac{\left(CI \cdot P_c\right) + \left(WI \cdot P_w\right) + \left(TI \cdot P_t\right)}{100}$$

Example

$$160 = \frac{\left(1327.913 \cdot 10.11\right) + \left(50.98 \cdot 15.1\right) + \left(95 \cdot 19\right)}{100}$$

8) Mission Fuel Formula

Evaluate Formula

Formula

$$W_{misf} = W_f - W_{resf}$$

Example with Units

$$8761\,\text{kg} = 9499\,\text{kg} - 738\,\text{kg}$$

9) Period of Design Index given Minimum Design Index Formula

Evaluate Formula

Formula

$$TI = \frac{\left(DI_{min} \cdot 100\right) - \left(WI \cdot P_w\right) - \left(CI \cdot P_c\right)}{P_t}$$

Example

$$95.0001 = \frac{\left(160 \cdot 100\right) - \left(50.98 \cdot 15.1\right) - \left(1327.913 \cdot 10.11\right)}{19}$$

10) Priority of Objective Cost in Design Process given Minimum Design Index Formula

Evaluate Formula

Formula

$$P_c = \frac{\left(DI_{min} \cdot 100\right) - \left(WI \cdot P_w\right) - \left(TI \cdot P_t\right)}{CI}$$

Example

$$10.11 = \frac{\left(160 \cdot 100\right) - \left(50.98 \cdot 15.1\right) - \left(95 \cdot 19\right)}{1327.913}$$

11) Priority of Objective Period of Design given Minimum Design Index Formula

Evaluate Formula

Formula

$$P_t = \frac{\left(DI_{min} \cdot 100\right) - \left(WI \cdot P_w\right) - \left(CI \cdot P_c\right)}{TI}$$

Example

$$19 = \frac{\left(160 \cdot 100\right) - \left(50.98 \cdot 15.1\right) - \left(1327.913 \cdot 10.11\right)}{95}$$

12) Priority of Objective Weight in Design Process given Minimum Design Index Formula

Evaluate Formula

Formula

$$P_w = \frac{\left(DI_{min} \cdot 100\right) - \left(CI \cdot P_c\right) - \left(TI \cdot P_t\right)}{WI}$$

Example

$$15.1 = \frac{\left(160 \cdot 100\right) - \left(1327.913 \cdot 10.11\right) - \left(95 \cdot 19\right)}{50.98}$$

13) Propulsion Net Thrust Formula

Evaluate Formula

Formula

$$Ft = m_{af} \cdot \left(V_J - V_f\right)$$

Example with Units

$$9.81\,\text{N} = 0.9\,\text{kg/s} \cdot \left(60.90\,\text{m/s} - 50\,\text{m/s}\right)$$

14) Range Increment of Aircraft Formula

Evaluate Formula

Formula

$$\Delta R = R_D - R_H$$

Example with Units

$$334\,\text{km} = 1220\,\text{km} - 886\,\text{km}$$

15) Reserve Fuel Formula

Evaluate Formula

Formula

$$W_{resf} = W_f - W_{misf}$$

Example with Units

$$738\,\text{kg} = 9499\,\text{kg} - 8761\,\text{kg}$$

16) Summation of Priorities of all Objectives that need to be Minimized Formula

Evaluate Formula

Formula

$$P_{min} = P_c + P_w + P_t$$

Example

$$44.21 = 10.11 + 15.1 + 19$$

17) Summations of Priorities of Objectives that need to be Maximized (Military planes) Formula

Evaluate Formula

Formula

$$P_{max} = P_p + P_f + P_b + P_m + P_r + P_d + P_s$$

Example

$$76 = 11 + 14 + 10.5 + 6 + 13 + 12 + 9.5$$

18) Thrust-to-Weight Ratio given Vertical Velocity Formula

Evaluate Formula

Formula

$$TW = \left(\left(\frac{V_v}{V_a}\right) + \left(\left(\frac{P_{dynamic}}{W_S}\right) \cdot \left(C_{Dmin}\right)\right) + \left(\left(\frac{k}{P_{dynamic}}\right) \cdot \left(W_S\right)\right)\right)$$

Example with Units

$$17.9671 = \left(\left(\frac{54\,\text{m/s}}{206\,\text{m/s}}\right) + \left(\left(\frac{8\,\text{Pa}}{5\,\text{Pa}}\right) \cdot \left(1.3\right)\right) + \left(\left(\frac{25}{8\,\text{Pa}}\right) \cdot \left(5\,\text{Pa}\right)\right)\right)$$

19) Weight Index given Minimum Design Index Formula

Evaluate Formula

Formula

$$WI = \frac{\left(DI_{min} \cdot 100\right) - \left(CI \cdot P_c\right) - \left(TI \cdot P_t\right)}{P_w}$$

Example

$$50.9801 = \frac{\left(160 \cdot 100\right) - \left(1327.913 \cdot 10.11\right) - \left(95 \cdot 19\right)}{15.1}$$

Variables used in list of Design Process Formulas above

- C_{Dmin} Minimum Drag Coefficient
- **CI** Cost Index
- DI_{min} Minimum Design Index
- $E_{battery}$ Battery Specific Energy Capacity *(Joule per Kilogram)*
- **Ft** Thrust Force *(Newton)*
- **k** Lift Induced Drag Constant
- $LDmax_{ratio}$ Maximum Lift to Drag Ratio of Aircraft
- m_{af} Air Mass Flow Rate *(Kilogram per Second)*
- **MTOW** Maximum Take Off Weight *(Kilogram)*
- P_b Scariness Priority (%)
- P_c Cost Priority (%)
- P_d Disposability Priority (%)
- $P_{dynamic}$ Dynamic Pressure *(Pascal)*
- P_e Electric Power of Wind Turbine *(Kilowatt)*
- P_f Flight Quality Priority (%)
- P_m Maintainability Priority (%)
- P_{max} Priority Sum of Objectives to be Maximized (%)
- P_{min} Priority Sum of Objectives to be Minimized(%)
- P_p Performance Priority (%)
- P_r Producibility Priority (%)
- P_s Stealth Priority (%)
- P_t Period Priority (%)
- P_w Weight Priority (%)
- **R** Range of Aircraft *(Kilometer)*
- R_D Design Range *(Kilometer)*
- R_H Harmonic Range *(Kilometer)*
- R_{rotor} Rotor Radius *(Kilometer)*
- **TI** Period Index
- **TW** Thrust-to-Weight Ratio

Constants, Functions, Measurements used in list of Design Process Formulas above

- constant(s): **[g]**, 9.80665
  Gravitational acceleration on Earth
- Measurement: **Length** in Kilometer (km)
  Length Unit Conversion
- Measurement: **Weight** in Kilogram (kg)
  Weight Unit Conversion
- Measurement: **Pressure** in Pascal (Pa)
  Pressure Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Power** in Kilowatt (kW)
  Power Unit Conversion
- Measurement: **Force** in Newton (N)
  Force Unit Conversion
- Measurement: **Mass Flow Rate** in Kilogram per Second (kg/s)
  Mass Flow Rate Unit Conversion
- Measurement: **Angular Velocity** in Radian per Second (rad/s)
  Angular Velocity Unit Conversion
- Measurement: **Specific Energy** in Joule per Kilogram (J/kg)
  Specific Energy Unit Conversion

- V_a Aircraft Velocity *(Meter per Second)*
- V_f Flight Velocity *(Meter per Second)*
- v_i Induced Velocity *(Meter per Second)*
- V_J Velocity of Jet *(Meter per Second)*
- V_v Vertical Airspeed *(Meter per Second)*
- W_f Fuel Load *(Kilogram)*
- W_{misf} Mission Fuel *(Kilogram)*
- W_{OE} Operating Empty Weight *(Kilogram)*
- W_{pay} Payload *(Kilogram)*
- W_{resf} Reserve Fuel *(Kilogram)*
- W_S Wing Loading *(Pascal)*
- W_{shaft} Shaft Power *(Kilowatt)*
- **WBF** Battery Weight Fraction
- **WI** Weight Index
- ΔR Range Increment of Aircraft *(Kilometer)*
- η Efficiency
- η_g Efficiency of Generator
- $\eta_{transmission}$ Efficiency of Transmission
- λ Inflow Ratio
- ω Angular Velocity *(Radian per Second)*

Download other Important Conceptual Design PDFs

- Important Aerodynamic Design Formulas
- Important Design Process Formulas
- Important Structural Design Formulas
- Important Weight Estimation Formulas

Try our Unique Visual Calculators

- Percentage error
- LCM of three numbers
- Subtract fraction

Please SHARE this PDF with someone who needs it!

This PDF can be downloaded in these languages

English Spanish French German Russian Italian Portuguese Polish Dutch

7/9/2024 | 6:03:14 AM UTC