Important Aircraft Runway Length Estimation Formulas PDF

Formulas
Examples
with Units

List of 25
Important Aircraft Runway Length Estimation Formulas

1) Desired Take off Weight Formula

Evaluate Formula

Formula

$$D = PYL + OEW + FW$$

Example with Units

$$36.1\,\text{t} = 25\,\text{t} + 10\,\text{t} + 1.1\,\text{t}$$

2) Fuel Weight to be Carried given Desired Takeoff Weight Formula

Evaluate Formula

Formula

$$FW = D - PYL - OEW$$

Example with Units

$$1.1\,\text{t} = 36.1\,\text{t} - 25\,\text{t} - 10\,\text{t}$$

3) Lift Coefficient for Lifting Force Provided by Wing Body of Vehicle Formula

Evaluate Formula

Formula

$$C_l = \frac{L_{Aircraft}}{0.5 \cdot \rho \cdot \left(V^2\right) \cdot S}$$

Example with Units

$$0.0011 = \frac{1072.39\,\text{kN}}{0.5 \cdot 1.21\,\text{kg/m}^3 \cdot \left(268\,\text{km/h}^2\right) \cdot 23\,\text{m}^2}$$

4) Lifting Force given Friction Force due to Rolling Resistance Formula

Evaluate Formula

Formula

$$L_{Aircraft} = \left(\left(\left(M_{Aircraft} \cdot [g] \cdot \cos\left(\Phi\right)\right) - \left(\frac{F_{Friction}}{\mu_r}\right)\right)\right)$$

Example with Units

$$1588.7886\,\text{kN} = \left(\left(\left(50000\,\text{kg} \cdot 9.8066\,\text{m/s}^2 \cdot \cos\left(5\right)\right) - \left(\frac{4125\,\text{kN}}{0.03}\right)\right)\right)$$

5) Lifting Force Provided by Wing Body of Vehicle Formula

Evaluate Formula

Formula

$$L_{Aircraft} = 0.5 \cdot \rho \cdot V^2 \cdot S \cdot C_l$$

Example with Units

$$999.431\,\text{kN} = 0.5 \cdot 1.21\,\text{kg/m}^3 \cdot 268\,\text{km/h}^2 \cdot 23\,\text{m}^2 \cdot 0.001$$

6) Operating Empty Weight when Desired Take-off Weight is considered Formula

Evaluate Formula

Formula

$$OEW = D - PYL - FW$$

Example with Units

$$10\,\text{t} = 36.1\,\text{t} - 25\,\text{t} - 1.1\,\text{t}$$

7) Payload carried when desired take-off weight is considered Formula

Evaluate Formula

Formula

$$PYL = D - OEW - FW$$

Example with Units

$$25\,\text{t} = 36.1\,\text{t} - 10\,\text{t} - 1.1\,\text{t}$$

8) Speed of Sound (Mach number) Formula

Evaluate Formula

Formula

$$c = \frac{V_{TAS}}{M_{True}}$$

Example with Units

$$47.5\,\text{km/h} = \frac{190\,\text{km/h}}{4}$$

9) True Aircraft Speed (Mach number) Formula

Evaluate Formula

Formula

$$V_{TAS} = c \cdot M_{True}$$

Example with Units

$$190\,\text{km/h} = 47.5\,\text{km/h} \cdot 4$$

10) True Mach number when true aircraft speed Formula

Evaluate Formula

Formula

$$M_{True} = \frac{V_{TAS}}{c}$$

Example with Units

$$4 = \frac{190\,\text{km/h}}{47.5\,\text{km/h}}$$

11) Vehicle Speed for Lifting Force Provided by Wing Body of Vehicle Formula

Evaluate Formula

Formula

$$V = \sqrt{\left(\frac{L_{Aircraft}}{0.5 \cdot \rho \cdot S \cdot C_l}\right)}$$

Example with Units

$$277.6098\,\text{km/h} = \sqrt{\left(\frac{1072.39\,\text{kN}}{0.5 \cdot 1.21\,\text{kg/m}^3 \cdot 23\,\text{m}^2 \cdot 0.001}\right)}$$

12) Aerodrome Reference Temperature Formulas

12.1) Aerodrome Reference Temperature Formula

Evaluate Formula

Formula

$$ART = T_a + \left(\frac{T_m - T_a}{3}\right)$$

Example with Units

$$34.8267\,\text{K} = 49.5\,\text{K} + \left(\frac{5.48\,\text{K} - 49.5\,\text{K}}{3}\right)$$

12.2) Monthly Mean of Average Daily Temperature for given ART Formula

Evaluate Formula

Formula

$$T_a = \left(\frac{(3 \cdot ART) - T_m}{2}\right)$$

Example with Units

$$50\,\text{K} = \left(\frac{(3 \cdot 35.16\,\text{K}) - 5.48\,\text{K}}{2}\right)$$

12.3) Monthly mean of maximum daily temperature for hottest month of year Formula

Evaluate Formula

Formula

$$T_m = 3 \cdot \left(ART - T_a \right) + T_a$$

Example with Units

$$6.48\,\text{K} = 3 \cdot \left(35.16\,\text{K} - 49.5\,\text{K} \right) + 49.5\,\text{K}$$

13) Aircraft Gross Wing Formulas

13.1) Aircraft Gross Wing Area for Lifting Force Provided by Wing Body of Vehicle Formula

Evaluate Formula

Formula

$$S = \frac{L_{Aircraft}}{0.5 \cdot \rho \cdot V^2 \cdot C_l}$$

Example with Units

$$24.679\,\text{m}^2 = \frac{1072.39\,\text{kN}}{0.5 \cdot 1.21\,\text{kg/m}^3 \cdot 268\,\text{km/h}^2 \cdot 0.001}$$

13.2) Aircraft Gross Wing Area given Vehicle Speed under Steady Flight Conditions Formula

Evaluate Formula

Formula

$$S = 2 \cdot M_{Aircraft} \cdot \frac{[g]}{\rho \cdot C_l \cdot V^2}$$

Example with Units

$$11284.0686\,\text{m}^2 = 2 \cdot 50000\,\text{kg} \cdot \frac{9.8066\,\text{m/s}^2}{1.21\,\text{kg/m}^3 \cdot 0.001 \cdot 268\,\text{km/h}^2}$$

13.3) Aircraft Gross Wing Area given Vehicle Stalling Speed Formula

Evaluate Formula

Formula

$$S = 2 \cdot M_{Aircraft} \cdot \frac{[g]}{V^2 \cdot \rho \cdot C_{L,max}}$$

Example with Units

$$12.8228\,\text{m}^2 = 2 \cdot 50000\,\text{kg} \cdot \frac{9.8066\,\text{m/s}^2}{268\,\text{km/h}^2 \cdot 1.21\,\text{kg/m}^3 \cdot 0.88}$$

13.4) Maximum Attainable Lift Coefficient given Vehicle Stalling Speed Formula

Evaluate Formula

Formula

$$C_{L,max} = 2 \cdot M_{Aircraft} \cdot \frac{[g]}{\rho \cdot S \cdot V^2}$$

Example with Units

$$0.4906 = 2 \cdot 50000\,\text{kg} \cdot \frac{9.8066\,\text{m/s}^2}{1.21\,\text{kg/m}^3 \cdot 23\,\text{m}^2 \cdot 268\,\text{km/h}^2}$$

13.5) Vehicle Stalling Speed given Maximum Attainable Lift Coefficient Formula

Evaluate Formula

Formula

$$V = \sqrt{\frac{2 \cdot M_{Aircraft} \cdot [g]}{\rho \cdot S \cdot C_{L,max}}}$$

Example with Units

$$200.1071\,\text{km/h} = \sqrt{\frac{2 \cdot 50000\,\text{kg} \cdot 9.8066\,\text{m/s}^2}{1.21\,\text{kg/m}^3 \cdot 23\,\text{m}^2 \cdot 0.88}}$$

14) Runway Takeoff Length Formulas

14.1) Aerodrome Reference Temperature given Corrected Take off Length Formula

Evaluate Formula

Formula

$$ART = \left(\frac{TOR_{Corrected} - T_c}{T_c \cdot 0.01}\right) + T_s$$

Example with Units

$$35.1586\,\text{K} = \left(\frac{4038\,\text{m} - 3360\,\text{m}}{3360\,\text{m} \cdot 0.01}\right) + 14.98\,\text{K}$$

14.2) Runway Elevation given Runway Take off Length Corrected for Elevation Formula

Evaluate Formula

Formula

$$R_e = \left(\frac{T_c - TOR}{TOR \cdot 0.07}\right) \cdot 300$$

Example with Units

$$10.2284\,\text{m} = \left(\frac{3360\,\text{m} - 3352\,\text{m}}{3352\,\text{m} \cdot 0.07}\right) \cdot 300$$

14.3) Runway Slope about Take-off Length Corrected for Elevation, Temperature and Slope Formula

Evaluate Formula

Formula

$$S_{Slope} = \frac{TOR_C - TOR_{Corrected}}{TOR_{Corrected} \cdot 0.1}$$

Example with Units

$$0.0099 = \frac{4042\,\text{m} - 4038\,\text{m}}{4038\,\text{m} \cdot 0.1}$$

14.4) Runway Take off Length Corrected for Elevation Formula

Evaluate Formula

Formula

$$T_c = \left(TOR \cdot 0.07 \cdot \left(\frac{R_e}{300}\right)\right) + TOR$$

Example with Units

$$3361.3856\,\text{m} = \left(3352\,\text{m} \cdot 0.07 \cdot \left(\frac{12\,\text{m}}{300}\right)\right) + 3352\,\text{m}$$

14.5) Runway Take off Length Corrected for Elevation, Temperature and Slope Formula

Evaluate Formula

Formula

$$TOR_C = \left(TOR_{Corrected} \cdot S_{Slope} \cdot 0.1 \right) + TOR_{Corrected}$$

Example with Units

$$4042.038\,\text{m} = \left(4038\,\text{m} \cdot 0.01 \cdot 0.1 \right) + 4038\,\text{m}$$

14.6) Runway Takeoff Length Corrected for Elevation and Temperature Formula

Evaluate Formula

Formula

$$TOR_{Corrected} = \left(T_c \cdot \left(ART - T_s \right) \cdot 0.01 \right) + T_c$$

Example with Units

$$4038.048\,\text{m} = \left(3360\,\text{m} \cdot \left(35.16\,\text{K} - 14.98\,\text{K} \right) \cdot 0.01 \right) + 3360\,\text{m}$$

Variables used in list of Aircraft Runway Length Estimation Formulas above

- **ART** Aerodrome Reference Temperature *(Kelvin)*
- **c** Speed of Sound *(Kilometer per Hour)*
- C_l Lift Coefficient
- $C_{L,max}$ Maximum Lift Coefficient
- **D** Desired Takeoff Weight of Aircraft *(Tonne)*
- $F_{Friction}$ Force of Friction *(Kilonewton)*
- **FW** Fuel Weight to be carried *(Tonne)*
- $L_{Aircraft}$ Lifting Force of Aircraft *(Kilonewton)*
- $M_{Aircraft}$ Mass Aircraft *(Kilogram)*
- M_{True} True Mach Number
- **OEW** Operating Empty Weight *(Tonne)*
- **PYL** Payload Carried *(Tonne)*
- R_e Runway Elevation *(Meter)*
- **S** Aircraft Gross Wing Area *(Square Meter)*
- S_{Slope} Runway Slope
- T_a Monthly Mean of Average Daily Temperature *(Kelvin)*
- T_c Runway Take off Length Corrected *(Meter)*
- T_m Monthly Mean of Monthly Daily Temperature *(Kelvin)*
- T_s Standard Temperature *(Kelvin)*
- **TOR** Takeoff Run *(Meter)*
- TOR_C Corrected Runway Takeoff Length *(Meter)*
- $TOR_{Corrected}$ Corrected Takeoff Run *(Meter)*
- **V** Vehicle Speed *(Kilometer per Hour)*
- V_{TAS} True Aircraft Speed *(Kilometer per Hour)*
- μ_r Coefficient of Rolling Friction
- **ρ** Density Altitude for flying *(Kilogram per Cubic Meter)*
- **Φ** Angle between Runway and Horizontal Plane

Constants, Functions, Measurements used in list of Aircraft Runway Length Estimation Formulas above

- constant(s): **[g]**, 9.80665
  Gravitational acceleration on Earth
- Functions: **cos**, cos(Angle)
  Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- 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 Tonne (t), Kilogram (kg)
  Weight Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Speed** in Kilometer per Hour (km/h)
  Speed Unit Conversion
- Measurement: **Force** in Kilonewton (kN)
  Force Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³)
  Density Unit Conversion

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