Important Take-off and Landing Formulas PDF

Formulas
Examples
with Units

List of 20
Important Take-off and Landing Formulas

1) Landing Formulas

1.1) Landing ground roll distance Formula

Evaluate Formula

Formula

$$s_L = 1.69 \cdot \left(W^2 \right) \cdot \left(\frac{1}{[g] \cdot \rho_\infty \cdot S \cdot C_{L,max}} \right) \cdot \left(\frac{1}{\left(0.5 \cdot \rho_\infty \cdot \left(\left(0.7 \cdot V_T \right)^2 \right) \cdot S \cdot \left(C_{D,0} + \left(\phi \cdot \frac{C_L^2}{\pi \cdot e \cdot AR} \right) \right) \right) + \left(\mu_r \cdot \left(W - \left(0.5 \cdot \rho_\infty \cdot \left(\left(0.7 \cdot V_T \right)^2 \right) \cdot S \cdot C_L \right) \right) \right)} \right)$$

Example with Units

$$1.4488\,\text{m} = 1.69 \cdot \left(60.5\,\text{N}^2 \right) \cdot \left(\frac{1}{9.8066\,\text{m/s}^2 \cdot 1.225\,\text{kg/m}^3 \cdot 5.08\,\text{m}^2 \cdot 0.000885} \right) \cdot \left(\frac{1}{\left(0.5 \cdot 1.225\,\text{kg/m}^3 \cdot \left(\left(0.7 \cdot 193\,\text{m/s} \right)^2 \right) \cdot 5.08\,\text{m}^2 \cdot \left(0.0161 + \left(0.4 \cdot \frac{5.5^2}{3.1416 \cdot 0.5 \cdot 4} \right) \right) \right) +} \right)$$

1.2) Landing Ground Run Formula

Evaluate Formula

Formula

$$Sg_l = \left(F_{normal} \cdot V_{TD} \right) + \left(\frac{W_{aircraft}}{2 \cdot [g]} \right) \cdot \int \left(\frac{2 \cdot V_\infty}{V_{TR} + D + \mu_{ref} \cdot \left(W_{aircraft} - L \right)}, x, 0, V_{TD} \right)$$

Example with Units

$$2042.1746\,\text{m} = \left(0.3\,\text{N} \cdot 23\,\text{m/s} \right) + \left(\frac{2000\,\text{kg}}{2 \cdot 9.8066\,\text{m/s}^2} \right) \cdot \int \left(\frac{2 \cdot 292\,\text{m/s}}{600\,\text{N} + 65\,\text{N} + 0.004 \cdot \left(2000\,\text{kg} - 7\,\text{N} \right)}, x, 0, 23\,\text{m/s} \right)$$

1.3) Stall velocity for given touchdown velocity Formula

Evaluate Formula

Formula

$$V_{stall} = \frac{V_T}{1.3}$$

Example with Units

$$148.4615\,\text{m/s} = \frac{193\,\text{m/s}}{1.3}$$

1.4) Touchdown velocity Formula

Evaluate Formula

Formula

$$V_T = 1.3 \cdot \left(\sqrt{2 \cdot \frac{W}{\rho_\infty \cdot S \cdot C_{L,max}}} \right)$$

Example with Units

$$192.6924\,\text{m/s} = 1.3 \cdot \left(\sqrt{2 \cdot \frac{60.5\,\text{N}}{1.225\,\text{kg/m}^3 \cdot 5.08\,\text{m}^2 \cdot 0.000885}} \right)$$

1.5) Touchdown velocity for given stall velocity Formula

Evaluate Formula

Formula

$$V_T = 1.3 \cdot V_{stall}$$

Example with Units

$$192.4\,\text{m/s} = 1.3 \cdot 148\,\text{m/s}$$

2) Take-Off Formulas

2.1) Coefficient of rolling friction during ground roll Formula

Evaluate Formula

Formula

$$\mu_r = \frac{R}{W - F_L}$$

Example with Units

$$0.1 = \frac{5\,\text{N}}{60.5\,\text{N} - 10.5\,\text{N}}$$

2.2) Drag during ground effect Formula

Evaluate Formula

Formula

$$F_D = \left(C_{D,e} + \frac{C_L^2 \cdot \phi}{\pi \cdot e \cdot AR} \right) \cdot \left(0.5 \cdot \rho_\infty \cdot V^2 \cdot S \right)$$

Example with Units

$$71977.674\,\text{N} = \left(4.5 + \frac{5.5^2 \cdot 0.4}{3.1416 \cdot 0.5 \cdot 4} \right) \cdot \left(0.5 \cdot 1.225\,\text{kg/m}^3 \cdot 60\,\text{m/s}^2 \cdot 5.08\,\text{m}^2 \right)$$

2.3) Ground effect factor Formula

Evaluate Formula

Formula

$$\phi = \frac{\left(16 \cdot \frac{h}{b}\right)^2}{1 + \left(16 \cdot \frac{h}{b}\right)^2}$$

Example with Units

$$0.4796 = \frac{\left(16 \cdot \frac{3\,\text{m}}{50\,\text{m}}\right)^2}{1 + \left(16 \cdot \frac{3\,\text{m}}{50\,\text{m}}\right)^2}$$

2.4) Lift acting on aircraft during ground roll Formula

Evaluate Formula

Formula

$$F_L = W - \left(\frac{R}{\mu_r}\right)$$

Example with Units

$$10.5\,\text{N} = 60.5\,\text{N} - \left(\frac{5\,\text{N}}{0.1}\right)$$

2.5) Liftoff distance Formula

Evaluate Formula

Formula

$$s_{LO} = 1.44 \cdot \frac{W^2}{[g] \cdot \rho_\infty \cdot S \cdot C_{L,max} \cdot T}$$

Example with Units

$$523.2758\,\text{m} = 1.44 \cdot \frac{60.5\,\text{N}^2}{9.8066\,\text{m/s}^2 \cdot 1.225\,\text{kg/m}^3 \cdot 5.08\,\text{m}^2 \cdot 0.000885 \cdot 186.5\,\text{N}}$$

2.6) Liftoff velocity for given stall velocity Formula

Evaluate Formula

Formula

$$V_{LO} = 1.2 \cdot V_{stall}$$

Example with Units

$$177.6\,\text{m/s} = 1.2 \cdot 148\,\text{m/s}$$

2.7) Liftoff velocity for given weight Formula

Evaluate Formula

Formula

$$V_{LO} = 1.2 \cdot \left(\sqrt{\frac{2 \cdot W}{\rho_\infty \cdot S \cdot C_{L,max}}}\right)$$

Example with Units

$$177.8699\,\text{m/s} = 1.2 \cdot \left(\sqrt{\frac{2 \cdot 60.5\,\text{N}}{1.225\,\text{kg/m}^3 \cdot 5.08\,\text{m}^2 \cdot 0.000885}}\right)$$

2.8) Maximum Lift coefficient for given liftoff velocity Formula

Evaluate Formula

Formula

$$C_{L,max} = 2.88 \cdot \frac{W}{\rho_\infty \cdot S \cdot \left(V_{LO}^2\right)}$$

Example with Units

$$0.0009 = 2.88 \cdot \frac{60.5\,\text{N}}{1.225\,\text{kg/m}^3 \cdot 5.08\,\text{m}^2 \cdot \left(177.6\,\text{m/s}^2\right)}$$

2.9) Maximum Lift coefficient for given stall velocity Formula

Evaluate Formula

Formula

$$C_{L,max} = 2 \cdot \frac{W}{\rho_\infty \cdot S \cdot \left(V_{stall}^2\right)}$$

Example with Units

$$0.0009 = 2 \cdot \frac{60.5\,\text{N}}{1.225\,\text{kg/m}^3 \cdot 5.08\,\text{m}^2 \cdot \left(148\,\text{m/s}^2\right)}$$

2.10) Resistance force during ground roll Formula

Evaluate Formula

Formula

$$R = \mu_r \cdot \left(W - F_L\right)$$

Example with Units

$$5\,\text{N} = 0.1 \cdot \left(60.5\,\text{N} - 10.5\,\text{N}\right)$$

2.11) Stall velocity for given liftoff velocity Formula

Evaluate Formula

Formula

$$V_{stall} = \frac{V_{LO}}{1.2}$$

Example with Units

$$148\,\text{m/s} = \frac{177.6\,\text{m/s}}{1.2}$$

2.12) Stall velocity for given weight Formula

Evaluate Formula

Formula

$$V_{stall} = \sqrt{\frac{2 \cdot W}{\rho_\infty \cdot S \cdot C_{L,max}}}$$

Example with Units

$$148.2249\,\text{m/s} = \sqrt{\frac{2 \cdot 60.5\,\text{N}}{1.225\,\text{kg/m}^3 \cdot 5.08\,\text{m}^2 \cdot 0.000885}}$$

2.13) Take Off Ground Run Formula

Evaluate Formula

Formula

$$S_g = \frac{W_{aircraft}}{2 \cdot [g]} \cdot \int \left(\frac{2 \cdot V_\infty}{N - D - \mu_{ref} \cdot \left(W_{aircraft} - L \right)}, x, 0, V_{LOS} \right)$$

Example with Units

$$239.4067\,\text{m} = \frac{2000\,\text{kg}}{2 \cdot 9.8066\,\text{m/s}^2} \cdot \int \left(\frac{2 \cdot 292\,\text{m/s}}{20000\,\text{N} - 65\,\text{N} - 0.004 \cdot \left(2000\,\text{kg} - 7\,\text{N} \right)}, x, 0, 80.11\,\text{m/s} \right)$$

2.14) Thrust for given liftoff distance Formula

Evaluate Formula

Formula

$$T = 1.44 \cdot \frac{W^2}{[g] \cdot \rho_\infty \cdot S \cdot C_{L,max} \cdot s_{LO}}$$

Example with Units

$$186.5984\,\text{N} = 1.44 \cdot \frac{60.5\,\text{N}^2}{9.8066\,\text{m/s}^2 \cdot 1.225\,\text{kg/m}^3 \cdot 5.08\,\text{m}^2 \cdot 0.000885 \cdot 523\,\text{m}}$$

2.15) Weight of aircraft during ground roll Formula

Evaluate Formula

Formula

$$W = \left(\frac{R}{\mu_r} \right) + F_L$$

Example with Units

$$60.5\,\text{N} = \left(\frac{5\,\text{N}}{0.1} \right) + 10.5\,\text{N}$$

Variables used in list of Take-off and Landing Formulas above

- **AR** Aspect Ratio of a Wing
- **b** Wingspan *(Meter)*
- $C_{D,0}$ Zero-Lift Drag Coefficient
- $C_{D,e}$ Parasite Drag Coefficient
- C_L Lift Coefficient
- $C_{L,max}$ Maximum Lift Coefficient
- **D** Drag Force *(Newton)*
- **e** Oswald Efficiency Factor
- F_D Drag *(Newton)*
- F_L Lift *(Newton)*
- F_{normal} Normal Force *(Newton)*
- **h** Height from Ground *(Meter)*
- **L** Lift Force *(Newton)*
- **N** Thrust Force *(Newton)*
- **R** Rolling Resistance *(Newton)*
- **S** Reference Area *(Square Meter)*
- S_g Takeoff Ground Run *(Meter)*
- s_L Landing Roll *(Meter)*
- s_{LO} Liftoff Distance *(Meter)*
- Sg_l Landing Ground Run *(Meter)*
- **T** Aircraft Thrust *(Newton)*
- **V** Flight Velocity *(Meter per Second)*
- V_∞ Velocity of Aircraft *(Meter per Second)*
- V_{LO} Liftoff velocity *(Meter per Second)*
- V_{LOS} Aircraft Lift Off Speed *(Meter per Second)*
- V_{stall} Stall Velocity *(Meter per Second)*
- V_T Touchdown Velocity *(Meter per Second)*
- V_{TD} Velocity at Touchdown Point *(Meter per Second)*
- V_{TR} Reverse Thrust *(Newton)*
- **W** Weight *(Newton)*
- $W_{aircraft}$ Weight Of Aircraft *(Kilogram)*
- μ_r Coefficient of Rolling Friction
- μ_{ref} Reference Of Rolling Resistance Coefficient
- ρ_∞ Freestream Density *(Kilogram per Cubic Meter)*
- ϕ Ground Effect Factor

Constants, Functions, Measurements used in list of Take-off and Landing Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- constant(s): **[g]**, 9.80665
  Gravitational acceleration on Earth
- Functions: **int**, int(expr, arg, from, to)
  The definite integral can be used to calculate net signed area, which is the area above the x -axis minus the area below the x -axis.
- 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: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Force** in Newton (N)
  Force Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³)
  Density Unit Conversion

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