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Take-off and Landing Formulas

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List of 20 Take-off and Landing Formulas

Take-off and Landing

Landing

1) Landing ground roll distance

Open Calculator

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

ex

$$1.448838\text{m} = 1.69 \cdot \left((60.5\text{N})^2\right) \cdot \left(\frac{1}{[g] \cdot 1.225\text{kg/m}^3 \cdot 5.08\text{m}^2 \cdot 0.000885} \right) \cdot \left(\frac{}{\left(0.5 \cdot 1.225\text{kg/m}^3 \cdot \left((0.7 \cdot 193\text{m}\right.\right.\right.$$

2) Landing Ground Run

Open Calculator

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

ex

$$2042.175\text{m} = (0.3\text{N} \cdot 23\text{m/s}) + \left(\frac{2000\text{kg}}{2 \cdot [g]} \right) \cdot \int \left(\frac{2 \cdot 292\text{m/s}}{600\text{N} + 65\text{N} + 0.004 \cdot (2000\text{kg} - 7\text{N})}, x, 0, 23\text{m/s} \right)$$

3) Stall velocity for given touchdown velocity

Open Calculator

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

ex

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

4) Touchdown velocity

Open Calculator

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

ex

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

5) Touchdown velocity for given stall velocity

Open Calculator

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

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

Take-Off

6) Coefficient of rolling friction during ground roll

Open Calculator

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

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

7) Drag during ground effect

Open Calculator

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

$$71977.67\text{N} = \left(4.5 + \frac{(5.5)^2 \cdot 0.4}{\pi \cdot 0.5 \cdot 4}\right) \cdot \left(0.5 \cdot 1.225\text{kg/m}^3 \cdot (60\text{m/s})^2 \cdot 5.08\text{m}^2\right)$$

8) Ground effect factor

Open Calculator

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

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

9) Lift acting on aircraft during ground roll

Open Calculator

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

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

10) Liftoff distance

Open Calculator

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

$$523.2758\text{m} = 1.44 \cdot \frac{(60.5\text{N})^2}{[g] \cdot 1.225\text{kg/m}^3 \cdot 5.08\text{m}^2 \cdot 0.000885 \cdot 186.5\text{N}}$$

11) Liftoff velocity for given stall velocity

Open Calculator

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

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

12) Liftoff velocity for given weight

Open Calculator

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

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

13) Maximum Lift coefficient for given liftoff velocity

Open Calculator

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

$$0.000888 = 2.88 \cdot \frac{60.5\text{N}}{1.225\text{kg/m}^3 \cdot 5.08\text{m}^2 \cdot \left((177.6\text{m/s})^2\right)}$$

14) Maximum Lift coefficient for given stall velocity

Open Calculator

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

$$0.000888 = 2 \cdot \frac{60.5\text{N}}{1.225\text{kg/m}^3 \cdot 5.08\text{m}^2 \cdot \left((148\text{m/s})^2\right)}$$

15) Resistance force during ground roll

Open Calculator

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

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

16) Stall velocity for given liftoff velocity

Open Calculator

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

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

17) Stall velocity for given weight

Open Calculator

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

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

18) Take Off Ground Run

Open Calculator

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

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

19) Thrust for given liftoff distance

Open Calculator

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

$$186.5984\text{N} = 1.44 \cdot \frac{(60.5\text{N})^2}{[g] \cdot 1.225\text{kg/m}^3 \cdot 5.08\text{m}^2 \cdot 0.000885 \cdot 523\text{m}}$$

20) Weight of aircraft during ground roll

Open Calculator

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

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

Variables Used

- **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

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Constant: **[g]**, 9.80665
  Gravitational acceleration on Earth
- Function: **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.
- Function: **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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