Speeds frequently used in General Aviation

\( V_A \)
design **maneuvering speed** (stalling speed at the maximum legal G-force, and hence the maximum speed at which abrupt, full deflection, elevator control input will not cause the aircraft to exceed its G-force limit). The aircraft will stall prior to any structural damage occurring. Maneuvering speed is adjusted based on the weight of the aircraft. As the weight increases, Maneuvering speed increases. This is because the aircraft is less subject to rapid acceleration at the higher weight.

\( V_{FE} \)
maximum **flap** extended speed (a different maximum speed may be specified for partial flap extension).

\( V_{LE} \)
maximum **landing gear** extended speed. The maximum speed at which the aircraft may be flown with the landing gear extended. \( V_{LE} \) is typically higher than \( V_{LO} \)

\( V_{LO} \)
maximum landing gear operating speed. The maximum speed at which the aircraft may be flying while raising or lowering the gear. Although \( V_{LO} \) is designated as one speed, in most cases it will have both an extension and retraction speed. Many aircraft can extend the gear at \( V_{LE} \), but (because of possible G-loading in climbout) must retract the gear at a lower speed. For example the Piper Seminole can extend the gear at its \( V_{LE} \) of 140 but must be below 109 to retract the gear, thus \( V_{LO} \) is read as 109,140 instead of a single airspeed. Another factor to consider is the direction of drop of the nose-wheel. In aircraft where the nosewheel retracts forward into the fuselage, the \( V_{LE} \) can actually be higher than \( V_{LO} \). \( V_{LO} \) can be approximated by 1.1 times \( V_{stall} \).

\( V_{MC} \) or \( V_{MCA} \)
minimum control speed with the **critical engine** inoperative. The speed below which control will be lost, normally due to roll or yaw divergence. In initial aircraft type testing and certification, this is tested at a safe height above ground and, when established, is factored in to \( V_2 \) (refer below) that by regulation has a set margin over \( V_{MCA} \) and also over \( Vs \).

\( V_{NE} \)
The \( V_{NE} \), or never exceed speed, is the V speed which refers to the velocity that should never be exceeded because of the risk of structural failure, due for example to wing or tail deformation, or **aeroelastic flutter**. On many airspeed indicators the \( V_{NE} \) is marked with a red line. This speed is specific to each aircraft model, and represents the edge of its performance envelope in terms of speed.

\( V_{NO} \)
The \( V_{NO} \) of an aircraft is known as the maximum structural cruising speed (the maximum speed to be used in turbulent conditions) or can refer to the **velocity of normal operation**. \( V_{NO} \) is specified as the upper limit of the green arc on many airspeed indicators. This speed is specific to the aircraft model. The range above \( V_{NO} \) is marked on the **airspeed indicator** as a yellow arc from \( V_{NO} \) to the \( V_{NE} \).

\( V_R \)
rotation speed. The speed of an **aircraft** at which the pilot initiates rotation to obtain the scheduled takeoff performance. It must be greater or equal to the \( V_\text{j speed} \).
**V**<sub>REF</sub> reference landing approach speed; speed (in calm air) at the landing screen height of 50 ft. Often used by pilots as a base from which to calculate speeds to be used during landing, and calculated as a margin over the stall speed - usually 1.3×**V**<sub>S0</sub>.

**V**<sub>S</sub> the stalling speed or the minimum steady flight speed at which the aircraft is controllable. Usually synonymous with **V**<sub>S1</sub>. This speed is specific to the aircraft model and depends upon the weight and balance of the aircraft. The true stall speed increases as atmospheric pressure decreases. (i.e. as temperature increases and/or as altitude increases.) The indicated stall speed, i.e. the speed indicated by the airspeed indicator, remains essentially unchanged with air pressure.

**V**<sub>S0</sub> the stalling speed or the minimum steady flight speed in the landing configuration.

**V**<sub>S1</sub> the stalling speed or the minimum steady flight speed obtained in a specific configuration (usually a "clean" configuration without flaps, landing gear and other sources of drag).

**V**<sub>X</sub> speed for best angle of climb. This provides the best altitude gain per unit of horizontal distance, and is usually used for clearing obstacles during takeoff.

**V**<sub>Y</sub> speed for best rate of climb. This provides the best altitude gain per unit of time.

### Other reference speeds

**V**<sub>B</sub> design speed for maximum gust intensity.

**V**<sub>C</sub> The **V**<sub>C</sub> of an aircraft is the **V** speed which refers to the velocity of cruising. **V**<sub>C</sub> is within the green arc on many airspeed indicators. This speed is different for each aircraft model. **V**<sub>C</sub> is also called the design cruising speed or the optimum cruise speed – the latter being the speed giving the most velocity (i.e. greatest distance/time) from a litre of fuel, usually utilising 75% power at Maximum Take-Off Weight (MTOW) and about 1.3 times the maximum lift-to-drag ratio (L/D) speed – Vbr above. The speed and power required decrease as the aircraft weight decreases from MTOW.

For normal category aircraft FAR Part 23 specifies a minimum design cruising speed (in knots) based on the wing loading of (weight in pounds divided by wing area in square feet). For the utility category, the minimum design cruising speed is . Many ultralight aeroplanes are unable to comply with the FAR part 23 requirement for a minimum design cruising speed.

**V**<sub>D</sub> design diving speed. Usually 1.4×**V**<sub>NO</sub>.

**V**<sub>DF</sub>/M<sub>DF</sub> demonstrated flight diving speed.

**V**<sub>EF</sub> the speed at which the critical engine is assumed to fail during takeoff.

**V**<sub>F</sub> design flap speed.
\( V_{FC}/M_{FC} \)
maximum speed for stability characteristics.

\( V_{FTO} \)
final takeoff speed

\( V_H \)
maximum speed in level flight with maximum continuous power.

\( V_{LOF} \)
lift-off speed.

\( V_{MO}/M_{MO} \)
maximum operating limit speed.

\( V_{MU} \)
minimum unstick speed.

\( V_{SR} \)
reference stall speed.

\( V_{SR0} \)
reference stall speed in the landing configuration.

\( V_{SR1} \)
reference stall speed in a specific configuration.

\( V_{SW} \)
speed at which onset of natural or artificial stall warning occurs.

\( V_{TOSS} \)
takeoff safety speed for Category A rotorcraft.

\( V_{WW} \)
maximum speed for windshield wiper operation.

\( V_1 \)
Takeoff decision speed. \( V_1 \) is the minimum speed in the takeoff, following a failure of the critical engine at \( V_{EF} \), at which the pilot can continue the takeoff with only the remaining engines. Any problems after \( V_1 \) are treated as in-flight emergencies. In the case of a balanced field takeoff, \( V_1 \) is the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the aircraft within the accelerate-stop distance and the minimum speed at which the takeoff can be continued and achieve the required height above the takeoff surface within the takeoff distance. In this context, \( V_1 \) is the takeoff decision speed.

\( V_2 \)
the minimum safe speed in the second segment of a climb following an engine failure. Also called takeoff screen speed and sometimes, takeoff safety speed, although as the second climb segment indicates, \( V_2 \) is an after takeoff speed frequently achieved shortly after rotate (\( V_r \)) as the aircraft accelerates. The engine failure case that is taken in the calculation of \( V_2 \) is that of the "most adverse engine" because the effects of different engines when failed, differ. The calculation of \( V_2 \) also includes set margins over the stall and other safety factors are built in as well.

\( V_{2min} \)
minimum safe speed in the second segment of a climb following an engine failure.
Non-regulatory speeds
These values are not defined by FAA regulations.

- **V\(_{\text{BE}}\)**: best endurance speed; the speed that gives the greatest airborne time for fuel consumed. This may be used when there is reason to remain aloft for an extended period, such as waiting for a forecast improvement in weather on the ground.

- **V\(_{\text{BG}}\)**: best power-off glide speed; the speed that provides maximum lift-to-drag ratio and thus the greatest gliding distance available.

- **V\(_{\text{XSE}}\)**: speed for best angle climb with the critical engine inoperative.

- **V\(_{\text{YSE}}\)**: speed for best rate of climb with the critical engine inoperative.

- **V\(_2\)**: t/o safety speed

- **V\(_3\)**: steady initial climb speed with all engines operating

- **V\(_4\)**: steady climb speed with all engines operating to be achieved by 400 ft gross height

- **V\(_{\text{a}}\)**: design maneuvering speed

- **V\(_c\)**: design cruising speed.

- **V\(_{\text{clmax}}\)**: max coefficient of lift speed.

- **V\(_{\text{d}}\)**: design diving speed

- **V\(_{\text{dmin}}\)**: minimum drag

- **V\(_{\text{df}}\)**: demonstrated flight diving speed

- **V\(_{\text{ef}}\)**: the CAS at which the critical engine is assumed to fail

- **V\(_f\)**: design flap speed

- **V\(_{\text{fe}}\)**: max flap extended speed

- **V\(_{\text{fto}}\)**: final t/o speed

- **V\(_{\text{imd}}\)**: minimum drag

- **V\(_{\text{imp}}\)**: minimum power

- **V\(_h\)**: max speed in level flight with max continuous power.
\( V_{le} \) max landing gear extended speed
\( V_{lo} \) max landing gear operating speed
\( V_{lof} \) lift-off speed
\( V_{mbe} \) max brake energy speed
\( V_{md} \) minimum drag
\( V_{mc} \) minimum control speed with critical engine inoperative
\( V_{mca} \) minimum control speed, air
Air minimum control speed is the minimum flight speed at which the aircraft is directionally controllable as determined in accordance with applicable aviation regulations. Aircraft certification conditions include one engine becoming inoperative and windmilling, not more than a 5 degree bank towards the operative engine, takeoff power on the operative engine, landing gear up, flaps in takeoff position, and most rearward C of G.
\( V_{mcg} \) minimum control speed, ground, with nose wheel steering assumed inoperative
\( V_{mcl} \) minimum control speed, approach and landing
\( V_{me} \) max endurance
\( V_{mini} \) minimum IFR speed for helicopters
\( V_{mo} \) max operating limit speed
\( V_{mp} \) minimum power
\( V_{mr} \) max range
\( V_{mu} \) minimum unstick speed
\( V_{nd} \) max structural cruising speed
\( V_{p} \) aquaplaning speed.
\( V_{ra} \) rough air speed
\( V_{ref} \) reference landing speed
\( V_{s} \) V-stall
\( V_{sl0} \) stall speed in landing configuration
\( V_{s1} \)  
  stall speed in a specified configuration

\( V_{s1g} \)  
  one g stall speed

\( V_{sr} \)  
  reference stall speed

\( V_{sse} \)  
  safe single engine speed

\( V_t \)  
  threshold speed

\( V_{t\text{max}} \)  
  max threshold speed

\( V_x \)  
  best angle of climb

\( V_{xe} \)  
  best angle of climb, single engine

\( V_y \)  
  best rate of climb

\( V_{yse} \)  
  best rate of climb single engine
### Speeds indicated on Airspeed Indicator

Several V speeds are denoted on the color-coded Airspeed Indicator, to give pilots an immediate reference, as follows:

- **$V_{S0}$**
  Least speed of white arc

- **$V_{S1}$**
  Least speed of green arc

- **$V_{FE}$**
  Greatest speed of white arc.

- **$V_{NO}$**
  Intersection of green and yellow arcs. The yellow arc is a caution, as speeds in this region may add dangerous stress to the aircraft, and are only to be used in smooth air when no turbulence or abrupt control inputs are expected.

- **$V_{NE}$**
  red line and greatest speed of yellow arc.

- In addition, on light multi-engine aircraft, $V_{YSR}$ is indicated by a blue line, and $V_{MC}$ is indicated by a red line near the least speed of the green arc.