



Commercial Pilot Ground School

Day 11

Weight and Balance, Performance Factors, Performance Charts



Agenda

- Weight and Balance
- Performance Factors
 - Density Altitude
 - Surface Winds
 - Weight
 - Runway Condition
- Performance Charts
 - Takeoff
 - Climb Performance
 - Cruise Performance
 - Descend
 - Landing
 - Glide Distance
 - Stall Speeds

Weight and Balance

The aircraft's weight and balance data is important information for a pilot that must be frequently reevaluated. Although the aircraft was weighed during the certification process, this information is not valid indefinitely. Equipment changes or modifications affect the weight and balance data. Too often pilots reduce the aircraft weight and balance into a rule of thumb, such as: "If I have three passengers, I can load only 100 gallons of fuel; four passengers, 70 gallons."



Weight and Balance

Weight and balance computations should be part of every preflight briefing. Never assume three passengers are always of equal weight. Instead, do a full computation of all items to be loaded on the aircraft, including baggage, as well as the pilot and passenger. It is recommended that all bags be weighed to make a precise computation of how the aircraft CG is positioned.



Weight and Balance

Weight and balance are critical components in the utilization of an aircraft to its fullest potential. The pilot must know how much fuel can be loaded onto the aircraft without violating CG limits, as well as weight limits to conduct long or short flights with or without a full complement of allowable passengers. For example, an aircraft has four seats and can carry 60 gallons of fuel. How many passengers can the aircraft safely carry? Can all those seats be occupied at all times with the varying fuel loads?



Weight and Balance

Four people who each weigh 150 pounds leads to a different weight and balance computation than four people who each weigh 200 pounds. The second scenario loads an additional 200 pounds onto the aircraft and is equal to about 30 gallons of fuel.

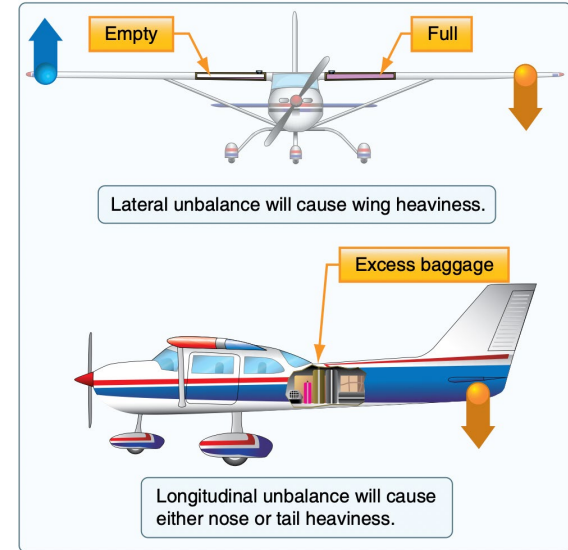
The additional weight may or may not place the CG outside of the CG envelope, but the maximum gross weight could be exceeded. The excess weight can overstress the aircraft and degrade the performance.



Weight and Balance

Balance refers to the location of the CG of an aircraft, and is important to stability and safety in flight. The CG is a point at which the aircraft would balance if it were suspended at that point.

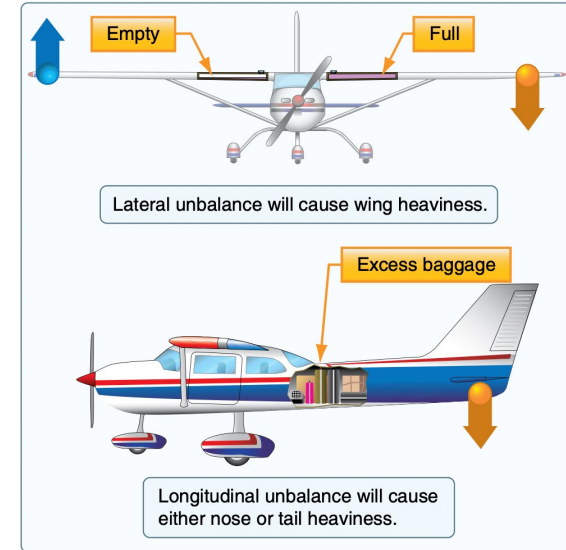
The primary concern in balancing an aircraft is the forward and aft location of the CG along the longitudinal axis. The CG is not a fixed point. It depends on the distribution of weight in the aircraft. As variable load items are shifted or expended, there is a resultant shift in CG location. The distance between the forward and back limits is certified for an aircraft by the manufacturer.



Weight and Balance

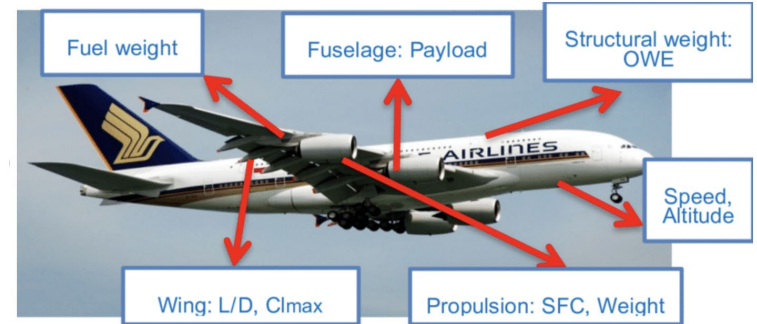
The pilot should realize that if the CG is displaced too far forward on the longitudinal axis, a nose-heavy condition will result, and vice versa. It is possible that the pilot would not be able to control the aircraft if the CG location is out of bounds.

Location of the CG with reference to the lateral axis is also important. The position of the lateral CG is not computed in all aircraft, but the pilot must be aware that adverse effects arise as a result of a laterally unbalanced condition.



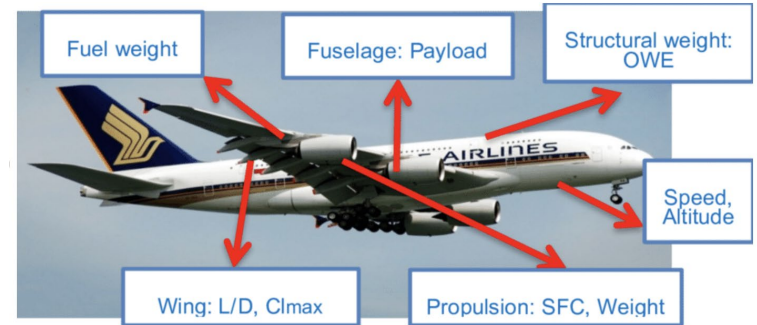
Performance

Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes. For example, the ability of an aircraft to land and take off in a very short distance is an important factor to the pilot who operates in and out of short, unimproved airfields. The ability to carry heavy loads, fly at high altitudes at fast speeds, and/or travel long distances is essential for the performance of airline and executive type aircraft.



Performance

The primary factors most affected by performance are the takeoff and landing distance, rate of climb, ceiling, payload, range, speed, maneuverability, stability, and fuel economy. Some of these factors are often directly opposed: for example, high speed versus short landing distance, long range versus great payload, and high rate of climb versus fuel economy. It is the preeminence of one or more of these factors that dictates differences between aircraft and explains the high degree of specialization found in modern aircraft.



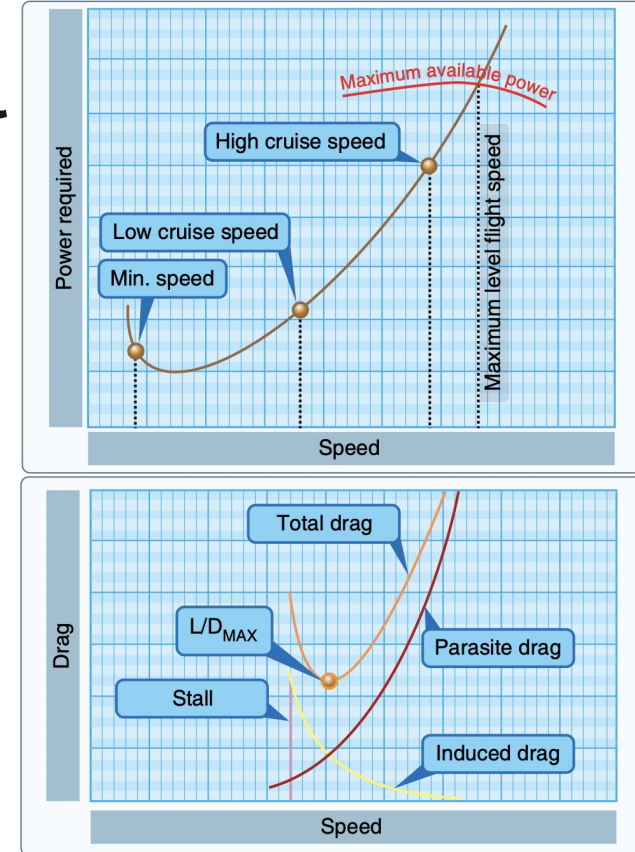
Factors Affecting Performance



Performance - Straight and Level

All of the principal components of flight performance involve steady-state flight conditions and equilibrium of the aircraft. For the aircraft to remain in steady, level flight, equilibrium must be obtained by a lift equal to the aircraft weight and a powerplant thrust equal to the aircraft drag. Thus, the aircraft drag defines the thrust required to maintain steady, level flight.

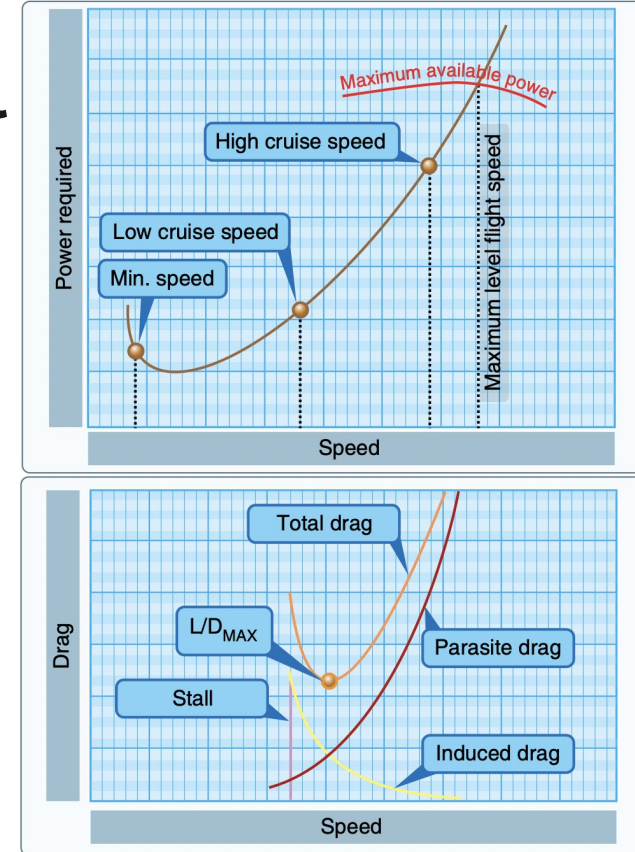
While parasite drag predominates at high speed, induced drag predominates at low speed. For example, if an aircraft in a steady flight condition at 100 knots is then accelerated to 200 knots, the parasite drag becomes four times as great, but the power required to overcome that drag is eight times the original value.



Performance - Straight and Level

Conversely, when the aircraft is operated in steady, level flight at twice as great a speed, the induced drag is one-fourth the original value, and the power required to overcome that drag is only one-half the original value.

The maximum level flight speed for the aircraft is obtained when the power or thrust required equals the maximum power or thrust available from the powerplant.



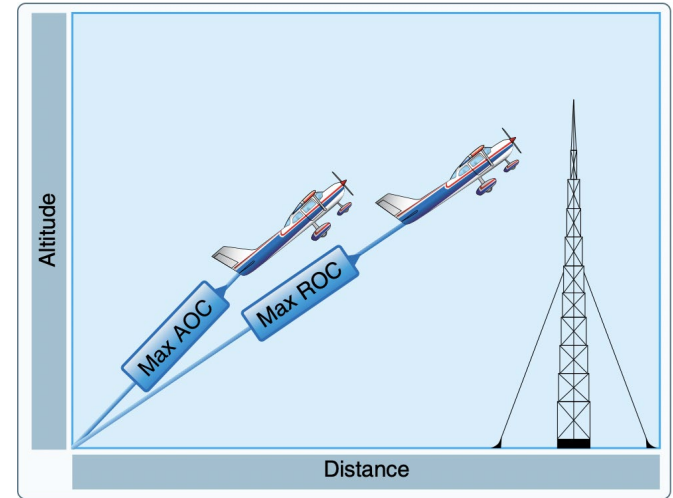
Performance - Climb

There are two primary reasons to evaluate climb performance. First, aircraft must climb over obstacles to avoid hitting them. Second, climbing to higher altitudes can provide better weather, fuel economy, and other benefits. Maximum Angle of Climb (AOC), obtained at V_X , may provide climb performance to ensure an aircraft will clear obstacles. Maximum Rate of Climb (ROC), obtained at V_Y , provides climb performance to achieve the greatest altitude gain over time. Maximum ROC may not be sufficient to avoid obstacles in some situations, while maximum AOC may be sufficient to avoid the same obstacles.



Climb - Angle of Climb (AOC) and Rate of Climb (ROC)

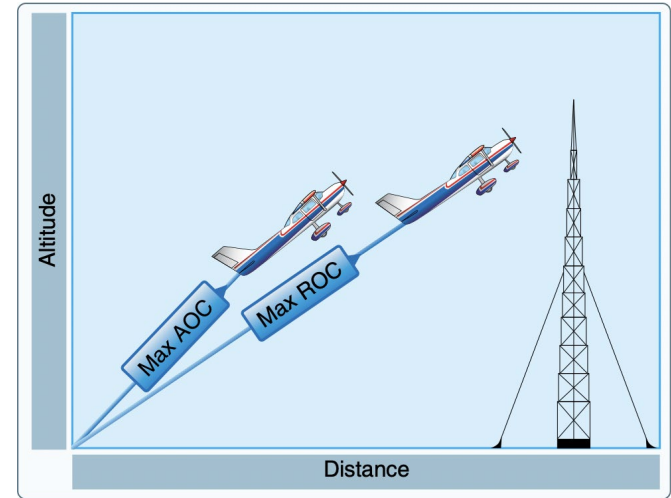
AOC is a comparison of altitude gained relative to distance traveled. AOC is the inclination (angle) of the flight path. For maximum AOC performance, a pilot flies the aircraft at V_X so as to achieve maximum altitude increase with minimum horizontal travel over the ground. A good use of maximum AOC is when taking off from a short airfield surrounded by high obstacles, such as trees or power lines. The objective is to gain sufficient altitude to clear the obstacle while traveling the least horizontal distance over the surface.



Climb - Angle of Climb (AOC) and Rate of Climb (ROC)

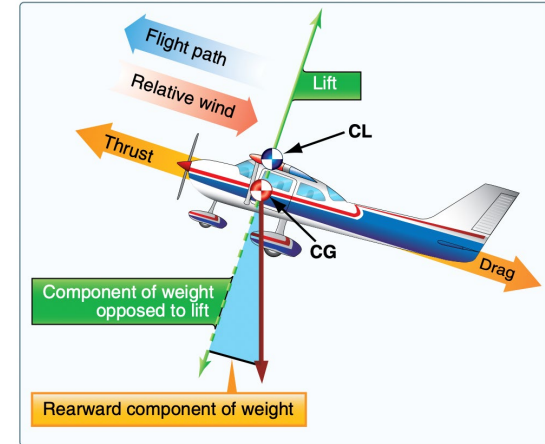
ROC is a comparison of altitude gained relative to the time needed to reach that altitude. ROC is simply the vertical component of the aircraft's flight path velocity vector. For maximum ROC performance, a pilot flies the aircraft at VY so as to achieve a maximum gain in altitude over a given period of time.

Maximum ROC expedites a climb to an assigned altitude. This gains the greatest vertical distance over a period of time. For example, in a maximum AOC profile, a certain aircraft takes 30 seconds to reach 1,000 feet AGL, but covers only 3,000 feet over the ground. By comparison, using its maximum ROC profile, the same aircraft climbs to 1,500 feet in 30 seconds but covers 6,000 feet across the ground.



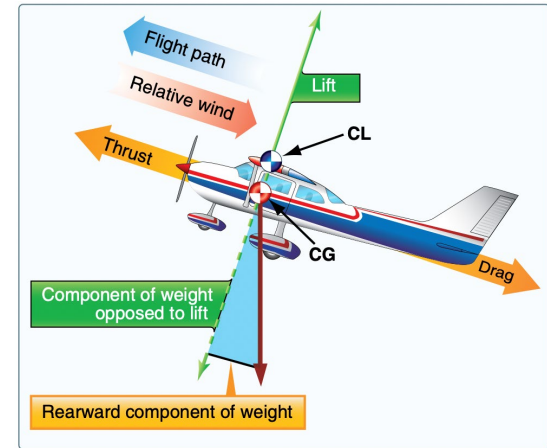
Climb Performance Factors

Weight has a very pronounced effect on aircraft performance. If weight is added to an aircraft, it must fly at a higher AOA to maintain a given altitude and speed. This increases the induced drag of the wings, as well as the parasite drag of the aircraft. Increased drag means that additional thrust is needed to overcome it, which in turn means that less reserve thrust is available for climbing. Aircraft designers go to great lengths to minimize the weight, since it has such a marked effect on the factors pertaining to performance.



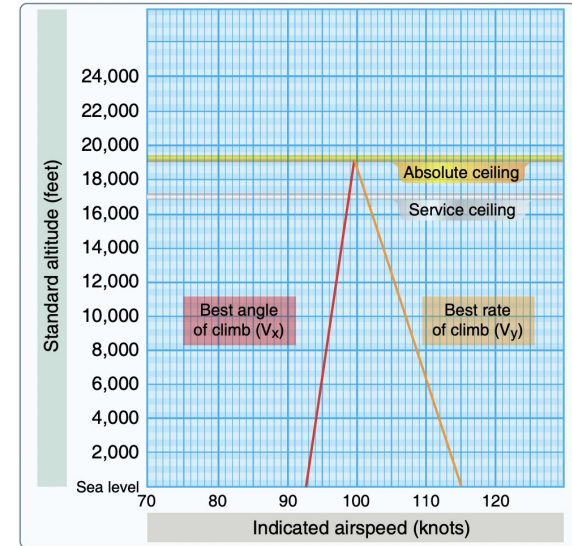
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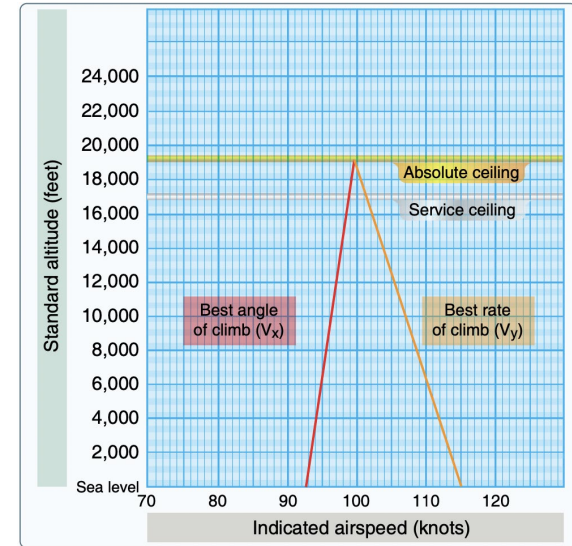
Climb Performance Factors

A change in an aircraft's weight produces a twofold effect on climb performance. First, a change in weight changes the drag and the power required. This alters the reserve power available, which in turn, affects both the climb angle and the climb rate. Secondly, an increase in weight reduces the maximum ROC, but the aircraft must be operated at a higher climb speed to achieve the smaller peak climb rate.



Climb Performance Factors

An increase in altitude also increases the power required and decreases the power available. Therefore, the climb performance of an aircraft diminishes with altitude. The speeds for maximum ROC, maximum AOC, and maximum and minimum level flight airspeeds vary with altitude. As altitude is increased, these various speeds finally converge at the absolute ceiling of the aircraft. At the absolute ceiling, there is no excess of power and only one speed allows steady, level flight. Consequently, the absolute ceiling of an aircraft produces zero ROC. The service ceiling is the altitude at which the aircraft is unable to climb at a rate greater than 100 feet per minute (fpm). Usually, these specific performance reference points are provided for the aircraft at a specific design configuration.





Performance - Range

The ability of an aircraft to convert fuel energy into flying distance is one of the most important items of aircraft performance. In flying operations, the problem of efficient range operation of an aircraft appears in two general forms:

1. To extract the maximum flying distance from a given fuel load
2. To fly a specified distance with a minimum expenditure of fuel

$$\text{specific endurance} = \frac{\text{flight hours}}{\text{pounds of fuel}}$$

or

$$\text{specific endurance} = \frac{\text{flight hours/hour}}{\text{pounds of fuel/hour}}$$

or

$$\text{specific endurance} = \frac{1}{\text{fuel flow}}$$



Performance - Range

A common element for each of these operating problems is the specific range; that is, nautical miles (NM) of flying distance versus the amount of fuel consumed. Range must be clearly distinguished from the item of endurance. Range involves consideration of flying distance, while endurance involves consideration of flying time. Thus, it is appropriate to define a separate term, specific endurance.

$$\text{specific endurance} = \frac{\text{flight hours}}{\text{pounds of fuel}}$$

or

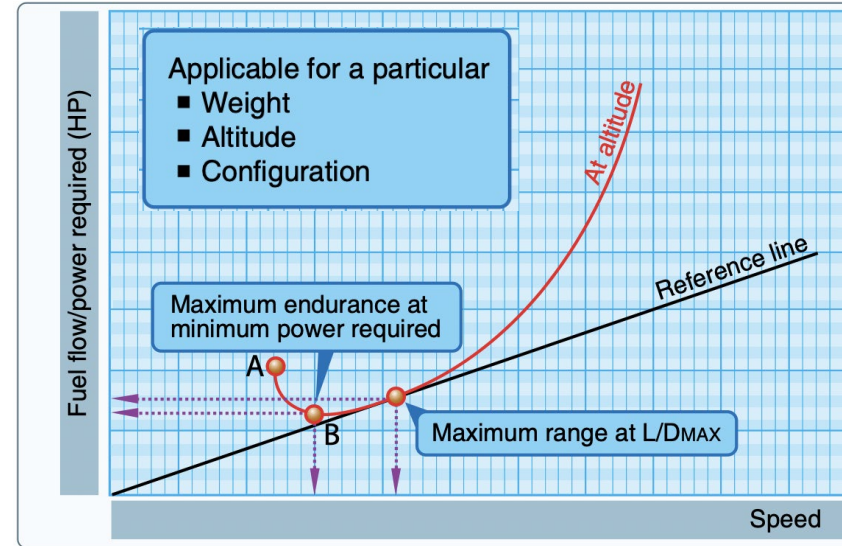
$$\text{specific endurance} = \frac{\text{flight hours/hour}}{\text{pounds of fuel/hour}}$$

or

$$\text{specific endurance} = \frac{1}{\text{fuel flow}}$$

Performance - Range

Fuel flow can be defined in either pounds or gallons. If maximum endurance is desired, the flight condition must provide a minimum fuel flow. In the table, at point A, the airspeed is low and fuel flow is high. This would occur during ground operations or when taking off and climbing. As airspeed is increased, power requirements decrease due to aerodynamic factors, and fuel flow decreases to point B. This is the point of maximum endurance. Beyond this point, increases in airspeed come at a cost. Airspeed increases require additional power and fuel flow increases with additional power.





Performance - Range

Cruise flight operations for maximum range should be conducted so that the aircraft obtains maximum specific range throughout the flight. The specific range can be defined by the following relationship.

If maximum specific range is desired, the flight condition must provide a maximum of speed per fuel flow. While the peak value of specific range would provide maximum range operation, long-range cruise operation is generally recommended at a slightly higher airspeed. Most long-range cruise operations are conducted at the flight condition that provides 99 percent of the absolute maximum specific range.

$$\text{specific range} = \frac{\text{NM}}{\text{pounds of fuel}}$$

or

$$\text{specific range} = \frac{\text{NM/hour}}{\text{pounds of fuel/hour}}$$

or

$$\text{specific range} = \frac{\text{knots}}{\text{fuel flow}}$$



Performance - Range

The advantage of such operation is that one percent of range is traded for three to five percent higher cruise speed. Since the higher cruise speed has a great number of advantages, the small sacrifice of range is a fair bargain. The values of specific range versus speed are affected by three principal variables:

1. Aircraft gross weight
2. Altitude
3. The external aerodynamic configuration of the aircraft.

$$\text{specific range} = \frac{\text{NM}}{\text{pounds of fuel}}$$

or

$$\text{specific range} = \frac{\text{NM/hour}}{\text{pounds of fuel/hour}}$$

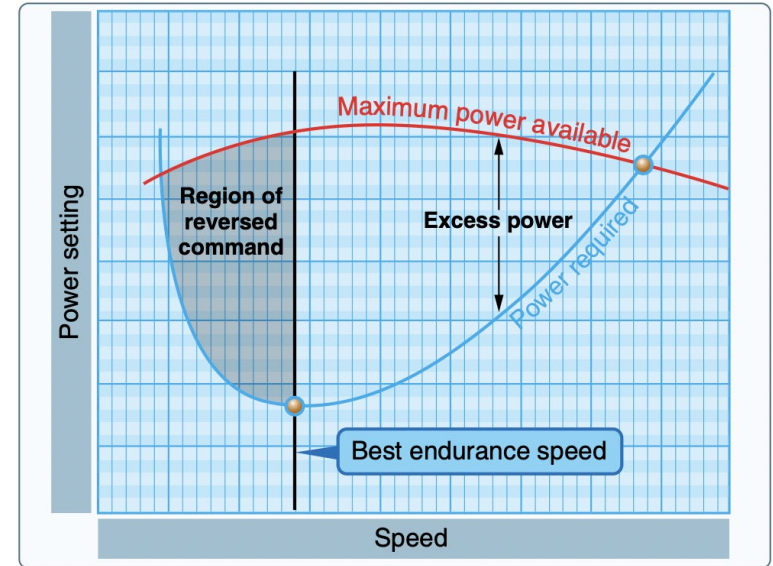
or

$$\text{specific range} = \frac{\text{knots}}{\text{fuel flow}}$$

Region of Reverse Command

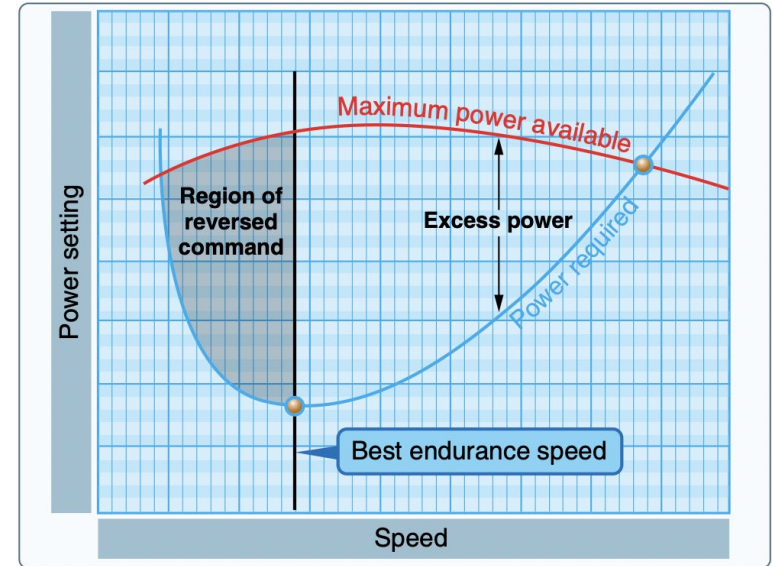
Flight in the region of normal command means that while holding a constant altitude, a higher airspeed requires a higher power setting and a lower airspeed requires a lower power setting. The majority of aircraft flying (climb, cruise, and maneuvers) is conducted in the region of normal command.

Flight in the region of reversed command means flight in which a higher airspeed requires a lower power setting and a lower airspeed requires a higher power setting to hold altitude. It does not imply that a decrease in power produces lower airspeed.



Region of Reverse Command

The region of reversed command is encountered in the low speed phases of flight. Flight speeds below the speed for maximum endurance (lowest point on the power curve) require higher power settings with a decrease in airspeed. Since the need to increase the required power setting with decreased speed is contrary to the normal command of flight, the regime of flight speeds between the speed for minimum required power setting and the stall speed (or minimum control speed) is termed the region of reversed command. In the region of reversed command, a decrease in airspeed must be accompanied by an increased power setting in order to maintain steady flight.



Region of Reverse Command

An airplane performing a low airspeed, high pitch attitude power approach for a short-field landing is an example of operating in the region of reversed command. If an unacceptably high sink rate should develop, it may be possible for the pilot to reduce or stop the descent by applying power. But without further use of power, the airplane would probably stall or be incapable of flaring for the landing. Merely lowering the nose of the airplane to regain flying speed in this situation, without the use of power, would result in a rapid sink rate and corresponding loss of altitude.



Region of Reverse Command

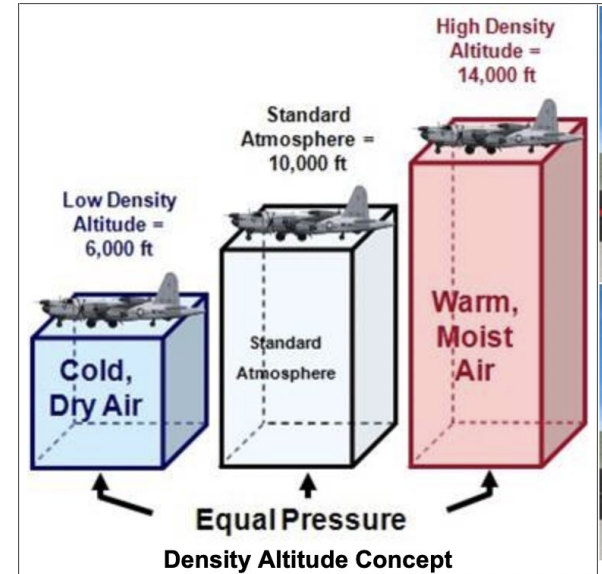
If during a soft-field takeoff and climb, for example, the pilot attempts to climb out of ground effect without first attaining normal climb pitch attitude and airspeed, the airplane may inadvertently enter the region of reversed command at a dangerously low altitude. Even with full power, the airplane may be incapable of climbing or even maintaining altitude. The pilot's only recourse in this situation is to lower the pitch attitude in order to increase airspeed, which inevitably results in a loss of altitude.



Predicting Performance - Density Altitude

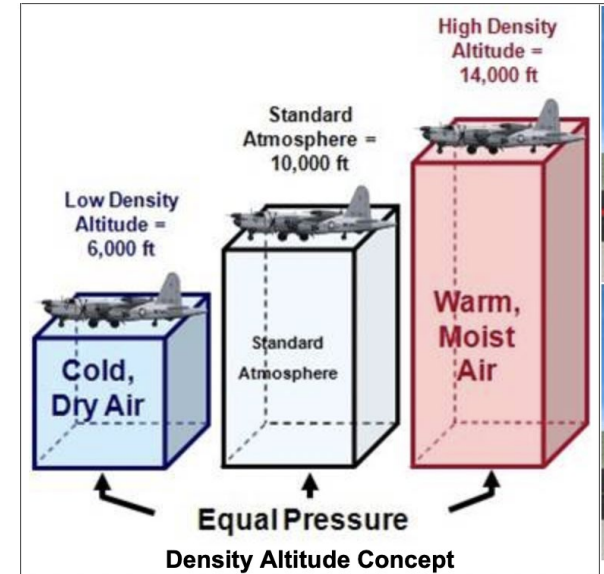
The more appropriate term for correlating aerodynamic performance in the nonstandard atmosphere is density altitude—the altitude in the standard atmosphere corresponding to a particular value of air density.

Density altitude is pressure altitude corrected for nonstandard temperature. As the density of the air increases (lower density altitude), aircraft performance increases. Conversely, as air density decreases (higher density altitude), aircraft performance decreases. A decrease in air density means a high density altitude; an increase in air density means a lower density altitude.



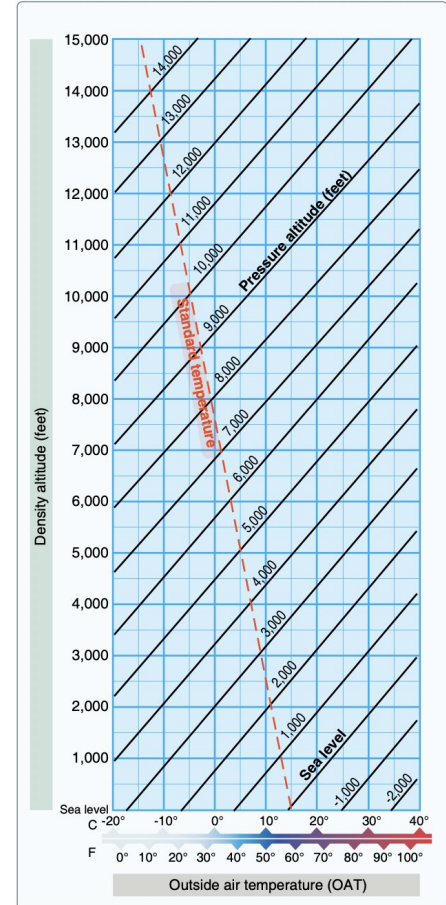
Predicting Performance - Density Altitude

Density altitude is used in calculating aircraft performance. Under standard atmospheric condition, air at each level in the atmosphere has a specific density; under standard conditions, pressure altitude and density altitude identify the same level. Density altitude, then, is the vertical distance above sea level in the standard atmosphere at which a given density is to be found.



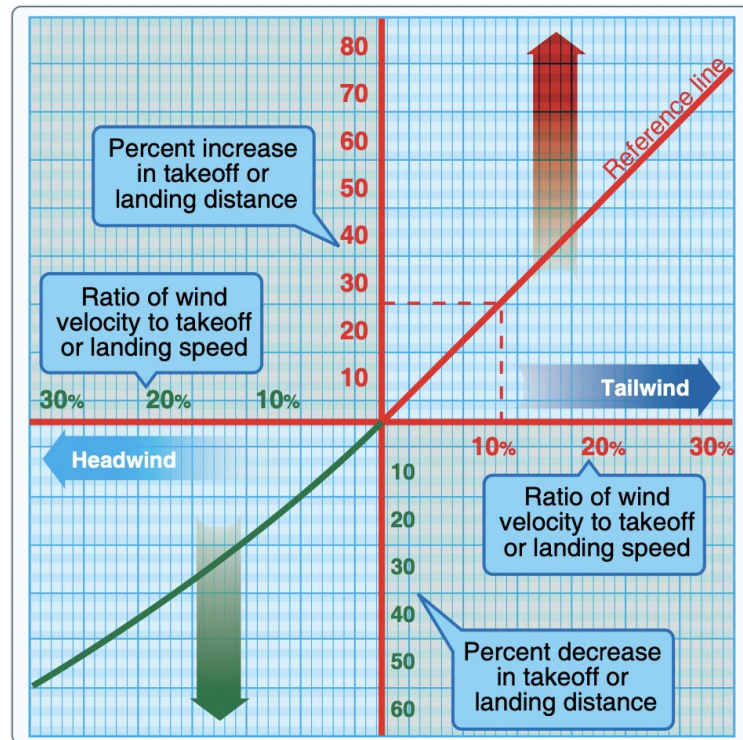
Predicting Performance - Density Altitude

Density altitude is determined by first finding pressure altitude and then correcting this altitude for nonstandard temperature variations. Since density varies directly with pressure, and inversely with temperature, a given pressure altitude may exist for a wide range of temperature by allowing the density to vary. However, a known density occurs for any one temperature and pressure altitude. The density of the air, of course, has a pronounced effect on aircraft and engine performance. Regardless of the actual altitude at which the aircraft is operating, it will perform as though it were operating at an altitude equal to the existing density altitude.



Effects of surface Winds

The effect of wind on landing distance is identical to its effect on takeoff distance. The general effect of wind by the percent change in takeoff or landing distance as a function of the ratio of wind velocity to takeoff or landing speed.



Performance - Runway Surface

Runway conditions affect takeoff and landing performance. Typically, performance chart information assumes paved, level, smooth, and dry runway surfaces. Since no two runways are alike, the runway surface differs from one runway to another, as does the runway gradient or slope.

Runway surfaces vary widely from one airport to another. The runway surface encountered may be concrete, asphalt, gravel, dirt, or grass. The runway surface for a specific airport is noted in the Chart Supplement. Any surface that is not hard and smooth increases the ground roll during takeoff. This is due to the inability of the tires to roll smoothly along the runway. Tires can sink into soft, grassy, or muddy runways. Potholes or other ruts in the pavement can be the cause of poor tire movement along the runway.



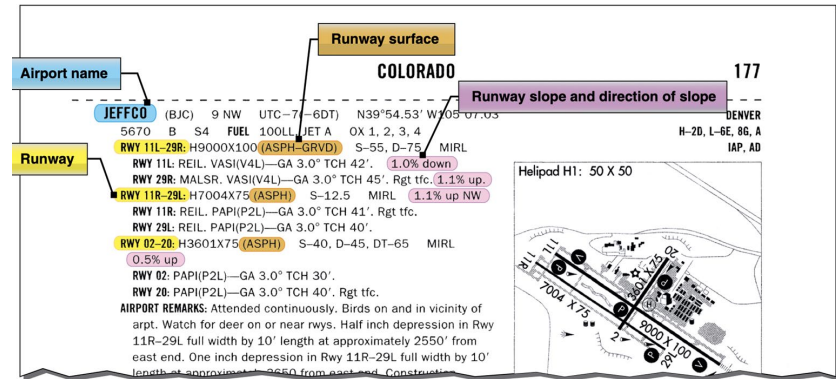
Performance - Runway Surface

Obstructions such as mud, snow, or standing water reduce the airplane's acceleration down the runway. Although muddy and wet surface conditions can reduce friction between the runway and the tires, they can also act as obstructions and reduce the landing distance. Braking effectiveness is another consideration when dealing with various runway types. The condition of the surface affects the braking ability of the aircraft.



Performance - Runway Surface

The gradient or slope of the runway is the amount of change in runway height over the length of the runway. The gradient is expressed as a percentage, such as a 3 percent gradient. This means that for every 100 feet of runway length, the runway height changes by 3 feet. A positive gradient indicates the runway height increases, and a negative gradient indicates the runway decreases in height. An upsloping runway impedes acceleration and results in a longer ground run during takeoff. However, landing on an upsloping runway typically reduces the landing roll. A downsloping runway aids in acceleration on takeoff resulting in shorter takeoff distances. The opposite is true when landing, as landing on a downsloping runway increases landing distances. Runway slope information is contained in the Chart Supplement U.S.



Performance - Runway Conditions

Water on the runways reduces the friction between the tires and the ground and can reduce braking effectiveness. The ability to brake can be completely lost when the tires are hydroplaning because a layer of water separates the tires from the runway surface. This is also true of braking effectiveness when runways are covered in ice.

When the runway is wet, the pilot may be confronted with dynamic hydroplaning. Dynamic hydroplaning is a condition in which the aircraft tires ride on a thin sheet of water rather than on the runway's surface. Because hydroplaning wheels are not touching the runway, braking and directional control are almost nil. To help minimize dynamic hydroplaning, some runways are grooved to help drain off water; most runways are not.



Performance - Runway Conditions

On wet runways, directional control can be maximized by landing into the wind. Abrupt control inputs should be avoided. When the runway is wet, anticipate braking problems well before landing and be prepared for hydroplaning. Opt for a suitable runway most aligned with the wind. Mechanical braking may be ineffective, so aerodynamic braking should be used to its fullest advantage.





Performance Charts

Performance charts allow a pilot to predict the takeoff, climb, cruise, and landing performance of an aircraft. These charts, provided by the manufacturer, are included in the AFM/POH. Information the manufacturer provides on these charts has been gathered from test flights conducted in a new aircraft, under normal operating conditions while using average piloting skills, and with the aircraft and engine in good working order.

CESSNA
MODEL 172S

INTRODUCT 



Cessna Aircraft Company

Model 172S

THIS MANUAL INCORPORATES INFORMATION ISSUED IN THE PILOT'S OPERATING HANDBOOK AND FAA APPROVED AIRPLANE FLIGHT MANUAL AT REVISION 5 DATED 19 JULY 2004 (PART NUMBER 172SPHUS05).



Performance Charts

By using these performance charts, a pilot can determine the runway length needed to take off and land, the amount of fuel to be used during flight, and the time required to arrive at the destination. It is important to remember that the data from the charts will not be accurate if the aircraft is not in good working order or when operating under adverse conditions. Always consider the necessity to compensate for the performance numbers if the aircraft is not in good working order or piloting skills are below average.

CESSNA
MODEL 172S

INTRODUCT 



Information Manual **SKYHAWK** **SP**



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Cessna Aircraft Company

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Performance Charts

Every chart is based on certain conditions and contains notes on how to adapt the information for flight conditions. It is important to read every chart and understand how to use it. Read the instructions provided by the manufacturer. For an explanation on how to use the charts, refer to the example provided by the manufacturer for that specific chart.

MAXIMUM RATE OF CLIMB

CONDITIONS:
Flaps Up
Gear Up
2600 RPM
Cowl Flaps Open
Standard Temperature

PRESS ALT	MP	PPH
S.L. TO 17,000	35	162
18,000	34	156
20,000	32	144
22,000	30	132
24,000	28	120

NOTES:

1. Add 16 pounds of fuel for engine start, taxi, and takeoff allowance.
2. Increase time, fuel, and distance by 10% for each 10 °C above standard temperature.
3. Distances shown are based on zero wind.

WEIGHT LBS	PRESS ALT FT	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
				TIME MIN	FUEL USED POUNDS	DISTANCE NM
4000	S.L.	100	930	0	0	0
	4000	100	890	4	12	7

Performance Charts

The information manufacturers furnish is not standardized. Information may be contained in a table format and other information may be contained in a graph format. Sometimes combined graphs incorporate two or more graphs into one chart to compensate for multiple conditions of flight. Combined graphs allow the pilot to predict aircraft performance for variations in density altitude, weight, and winds all on one chart. Because of the vast amount of information that can be extracted from this type of chart, it is important to be very accurate in reading the chart. A small error in the beginning can lead to a large error at the end.

MAXIMUM RATE OF CLIMB

CONDITIONS:
Flaps Up
Gear Up
2600 RPM
Cowl Flaps Open
Standard Temperature

PRESS ALT	MP	PPH
S.L. TO 17,000	35	162
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				TIME MIN	FUEL USED POUNDS	DISTANCE NM
4000	S.L.	100	930	0	0	0
	4000	100	890	4	12	7

Performance Charts - Interpolation

Not all of the information on the charts is easily extracted. Some charts require interpolation to find the information for specific flight conditions. Interpolating information means that by taking the known information, a pilot can compute intermediate information. However, pilots sometimes round off values from charts to a more conservative figure.

Using values that reflect slightly more adverse conditions provides a reasonable estimate of performance information and gives a slight margin of safety. The following illustration is an example of interpolating information from a takeoff distance chart.

Conditions	Flaps 10° Full throttle prior to brake release Paved level runway Zero wind			TAKEOFF DISTANCE MAXIMUM WEIGHT 2,400 LB						
	Weight (lb)	Takeoff speed KIAS		Press ALT (ft)	0 °C		10 °C		20 °C	
		Lift off	AT 50 ft		Grnd roll (ft)	Total feet to clear 50 ft OBS	Grnd roll (ft)	Total feet to clear 50 ft OBS	Grnd roll (ft)	Total feet to clear 50 ft OBS
	2,400	51	56	S.L.	795	1,460	860	1,570	925	1,685
				1,000	875	1,605	940	1,725	1,015	1,860
				2,000	960	1,770	1,035	1,910	1,115	2,060
				3,000	1,055	1,960	1,140	2,120	1,230	2,295
				4,000	1,165	2,185	1,260	2,365	1,355	2,570
				5,000	1,285	2,445	1,390	2,660	1,500	2,895
				6,000	1,425	2,755	1,540	3,015	1,665	3,300
				7,000	1,580	3,140	1,710	3,450	1,850	3,805
				8,000	1,755	3,615	1,905	4,015	2,060	4,480

To find the takeoff distance for a pressure altitude of 2,500 feet at 20 °C, average the ground roll for 2,000 feet and 3,000 feet.

$$\frac{1,115 + 1,230}{2} = 1,173 \text{ feet}$$



Takeoff Charts

Takeoff charts are typically provided in several forms and allow a pilot to compute the takeoff distance of the aircraft with no flaps or with a specific flap configuration. A pilot can also compute distances for a no flap takeoff over a 50 foot obstacle scenario, as well as with flaps over a 50 foot obstacle. The takeoff distance chart provides for various aircraft weights, altitudes, temperatures, winds, and obstacle heights.

Sample Problem

Pressure Altitude.....2,000 feet

OAT.....22 °C

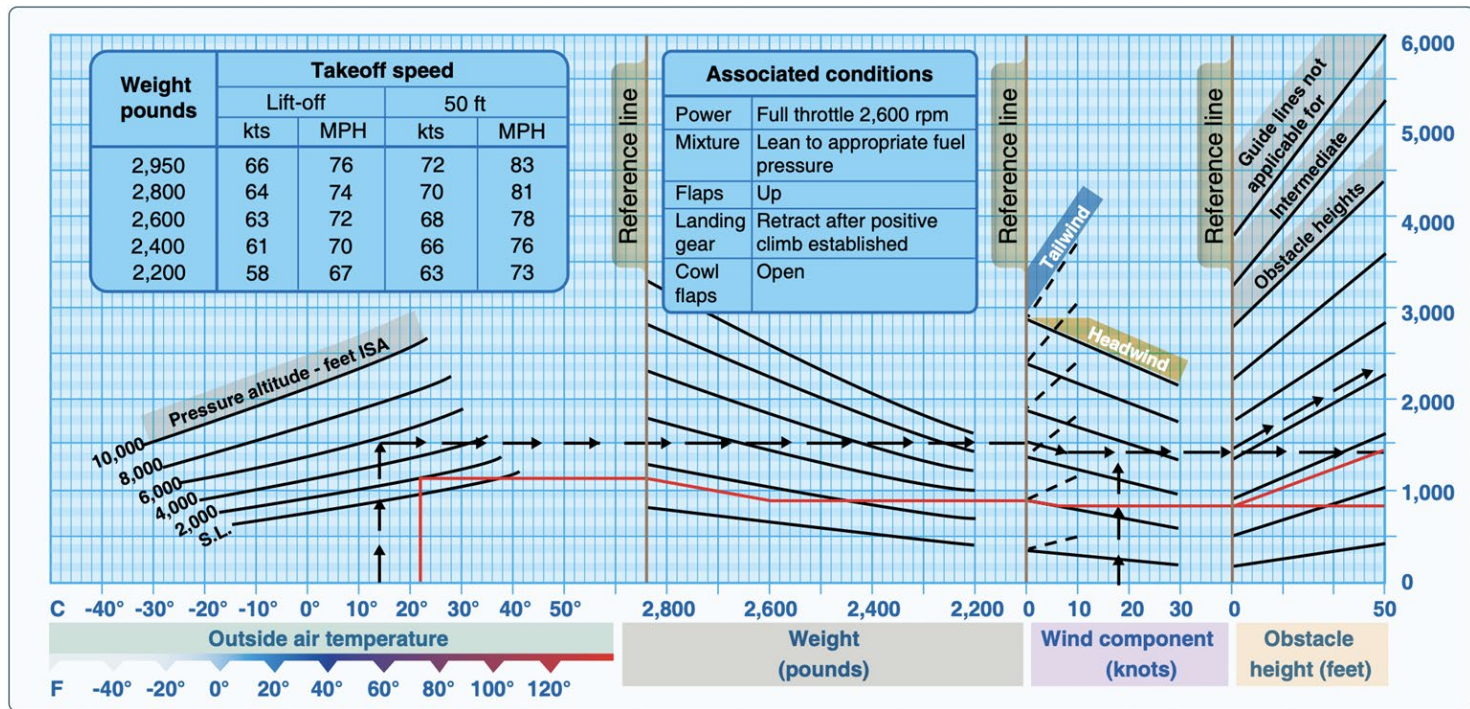
Takeoff Weight.....2,600 pounds

Headwind.....6 knots

Obstacle Height.....50 foot obstacle

(Chart on the next page)

Takeoff Charts





Takeoff Charts

Sample Problem

Pressure Altitude.....3,000 feet

OAT.....30 °C

Takeoff Weight.....2,400 pounds

Headwind.....18 knots

(Chart on the next page)

Takeoff Charts

Conditions	Flaps 10° Full throttle prior to brake release Paved level runway Zero wind			TAKEOFF DISTANCE MAXIMUM WEIGHT 2,400 LB SHORT FIELD										
	Notes													
1. Prior to takeoff from fields above 3,000 feet elevation, the mixture should be leaned to give maximum rpm in a full throttle, static runup. 2. Decrease distances 10% for each 9 knots headwind. For operation with tailwind up to 10 knots, increase distances by 10% for each 2 knots. 3. For operation on a dry, grass runway, increase distances by 15% of the "ground roll" figure.														
Weight (lb)	Takeoff speed KIAS		Press ALT (ft)	0 °C		10 °C		20 °C		30 °C		40 °C		
	Lift off	AT 50 ft		Grnd roll (ft)	Total feet to clear 50 ft OBS	Grnd roll (ft)	Total feet to clear 50 ft OBS	Grnd roll (ft)	Total feet to clear 50 ft OBS	Grnd roll (ft)	Total feet to clear 50 ft OBS	Grnd roll (ft)	Total feet to clear 50 ft OBS	
2,400	51	56	S.L.	795	1,460	860	1,570	925	1,685	995	1,810	1,065	1,945	
			1,000	875	1,605	940	1,725	1,015	1,860	1,090	2,000	1,170	2,155	
			2,000	960	1,770	1,035	1,910	1,115	2,060	1,200	2,220	1,290	2,395	
			3,000	1,055	1,960	1,140	2,120	1,230	2,295	1,325	2,480	1,425	2,685	
			4,000	1,165	2,185	1,260	2,365	1,355	2,570	1,465	2,790	1,575	3,030	
			5,000	1,285	2,445	1,390	2,660	1,500	2,895	1,620	3,160	1,745	3,455	
			6,000	1,425	2,755	1,540	3,015	1,665	3,300	1,800	3,620	1,940	3,990	
			7,000	1,580	3,140	1,710	3,450	1,850	3,805	2,000	4,220	---	---	
			8,000	1,755	3,615	1,905	4,015	2,060	4,480	---	---	---	---	



Climb and Cruise Charts

Climb and cruise chart information is based on actual flight tests conducted in an aircraft of the same type. This information is extremely useful when planning a cross-country flight to predict the performance and fuel consumption of the aircraft. Manufacturers produce several different charts for climb and cruise performance. These charts include everything from fuel, time, and distance to climb to best power setting during cruise to cruise range performance.



Climb and Cruise Charts

The first chart to check for climb performance is a fuel, time, and distance-to-climb chart.

This chart gives the fuel amount used during the climb, the time it takes to accomplish the climb, and the ground distance that is covered during the climb. To use this chart, obtain the information for the departing airport and for the cruise altitude. Using the table below, calculate the fuel, time, and distance to climb based on the information provided.



Climb and Cruise Charts

Sample Problem

Departing Airport Pressure Altitude.....6,000 feet

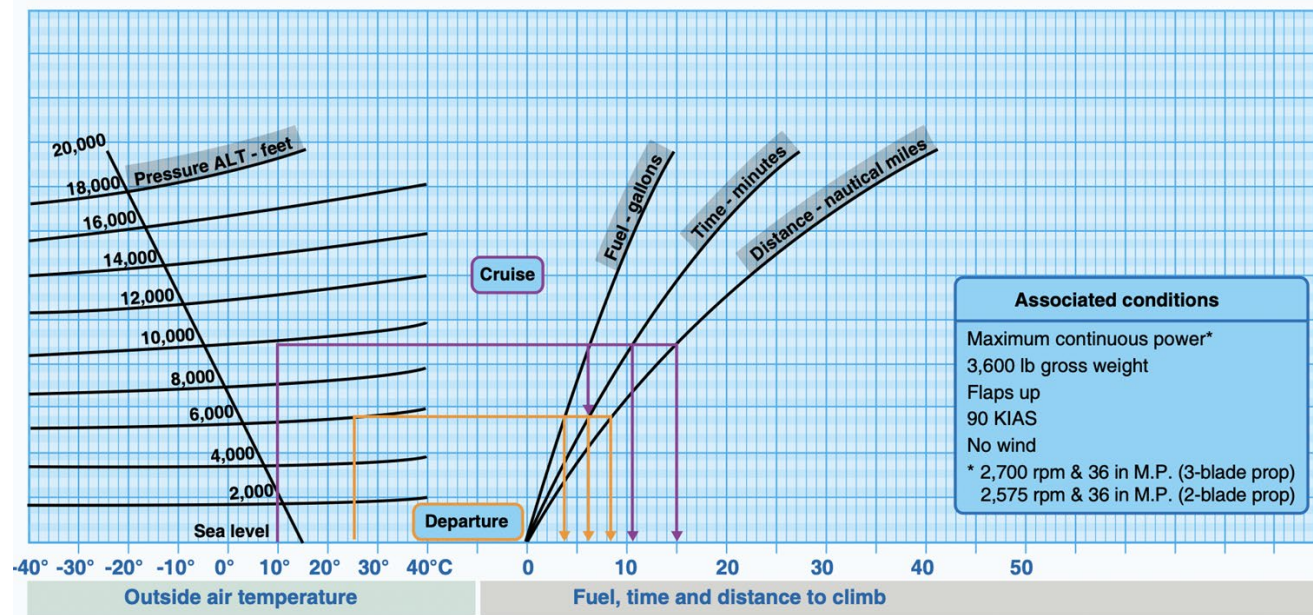
Departing Airport OAT.....25 °C

Cruise Pressure Altitude.....10,000 feet

Cruise OAT.....10 °C

(Chart on the next page)

Climb and Cruise Charts



Fuel, time and distance to climb

Sample Problem

Departing Airport Pressure Altitude.....Sea level

Departing Airport OAT.....22 °C

Cruise Pressure Altitude.....8,000 feet

Takeoff Weight.....3,400 pounds

Conditions	NORMAL CLIMB 110 KIAS				
	Flaps up Gear up 2,500 rpm 30 "Hg 120 PPH fuel flow Cowl flaps open Standard temperature				
Notes	1. Add 16 pounds of fuel for engine start, taxi, and takeoff allowance. 2. Increase time, fuel, and distance by 10% for each 7 °C above standard temperature. 3. Distances shown are based on zero wind.				
Weight (pounds)	Press ALT (feet)	Rate of climb fpm	From sea level		
			Time (minutes)	Fuel used (pounds)	Distance (nautical miles)
4,000	S.L.	605	0	0	0
	4,000	570	7	14	13
	8,000	530	14	28	27
	12,000	485	22	44	43
	16,000	430	31	62	63
	20,000	365	41	82	87
3,700	S.L.	700	0	0	0
	4,000	665	6	12	11
	8,000	625	12	24	23
	12,000	580	19	37	37
	16,000	525	26	52	53
	20,000	460	34	68	72
3,400	S.L.	810	0	0	0
	4,000	775	5	10	9
	8,000	735	10	21	20
	12,000	690	16	32	31
	16,000	635	22	44	45
	20,000	565	29	57	61

Cruise and Range Performance

Sample Problem

Pressure Altitude.....5,000 feet

RPM.....2,400 rpm

Fuel Carrying Capacity.....38 gallons, no reserve

Notes	Conditions							
	Gross weight—2,300 lb. Standard conditions Zero wind Lean mixture							
	Maximum cruise is normally limited to 75% power.							
ALT	RPM	% BHP	TAS MPH	GAL/ Hour	38 gal (no reserve)		48 gal (no reserve)	
					Endr. hours	Range miles	Endr. hours	Range miles
2,500	2,700	86	134	9.7	3.9	525	4.9	660
	2,600	79	129	8.6	4.4	570	5.6	720
	2,500	72	123	7.8	4.9	600	6.2	760
	2,400	65	117	7.2	5.3	620	6.7	780
	2,300	58	111	6.7	5.7	630	7.2	795
	2,200	52	103	6.3	6.1	625	7.7	790
5,000	2,700	82	134	9.0	4.2	565	5.3	710
	2,600	75	128	8.1	4.7	600	5.9	760
	2,500	68	122	7.4	5.1	625	6.4	790
	2,400	61	116	6.9	5.5	635	6.9	805
	2,300	55	108	6.5	5.9	635	7.4	805
	2,200	49	100	6.0	6.3	630	7.9	795
7,500	2,700	78	133	8.4	4.5	600	5.7	755
	2,600	71	127	7.7	4.9	625	6.2	790
	2,500	64	121	7.1	5.3	645	6.7	810
	2,400	58	113	6.7	5.7	645	7.2	820
	2,300	52	105	6.2	6.1	640	7.7	810
10,000	2,650	70	129	7.6	5.0	640	6.3	810
	2,600	67	125	7.3	5.2	650	6.5	820
	2,500	61	118	6.9	5.5	655	7.0	830
	2,400	55	110	6.4	5.9	650	7.5	825
	2,300	49	100	6.0	6.3	635	8.0	800



Cruise Power Setting

Sample Problem

Pressure Altitude at

Cruise.....6,000 feet

OAT.....36 °F above
standard

(Chart on the next page)

CRUISE POWER SETTING																									
65% MAXIMUM CONTINUOUS POWER (OR FULL THROTTLE)																									
2,800 POUNDS																									
Press ALT	ISA -20° (-36 °F)								Standard day (ISA)								ISA +20° (+36 °F)								
	IOAT		Engine speed	Man. press	Fuel flow per engine		TAS		IOAT		Engine speed	Man. press	Fuel flow per engine		TAS		IOAT		Engine speed	Man. press	Fuel flow per engine		TAS		
	°F	°C	RPM	"HG	PSI	GPH	kts	MPH	°F	°C	RPM	"HG	PSI	GPH	kts	MPH	°F	°C	RPM	"HG	PSI	GPH	kts	MPH	
S.L.	27	-3	2,450	20.7	6.6	11.5	147	169	63	17	2,450	21.2	6.6	11.5	150	173	99	37	2,450	21.8	6.6	11.5	153	176	
2,000	19	-7	2,450	20.4	6.6	11.5	149	171	55	13	2,450	21.0	6.6	11.5	153	176	91	33	2,450	21.5	6.6	11.5	156	180	
4,000	12	-11	2,450	20.1	6.6	11.5	152	175	48	9	2,450	20.7	6.6	11.5	156	180	84	29	2,450	21.3	6.6	11.5	159	183	
6,000	5	-15	2,450	19.8	6.6	11.5	155	178	41	5	2,450	20.4	6.6	11.5	158	182	79	26	2,450	21.0	6.6	11.5	161	185	
8,000	-2	-19	2,450	19.5	6.6	11.5	157	181	36	2	2,450	20.2	6.6	11.5	161	185	72	22	2,450	20.8	6.6	11.5	164	189	
10,000	-8	-22	2,450	19.2	6.6	11.5	160	184	28	-2	2,450	19.9	6.6	11.5	163	188	64	18	2,450	20.3	6.5	11.4	166	191	
12,000	-15	-26	2,450	18.8	6.4	11.3	162	186	21	-6	2,450	18.8	6.1	10.9	163	188	57	14	2,450	18.8	5.9	10.6	163	188	
14,000	-22	-30	2,450	17.4	5.8	10.5	159	183	14	-10	2,450	17.4	5.6	10.1	160	184	50	10	2,450	17.4	5.4	9.8	160	184	
16,000	-29	-34	2,450	16.1	5.3	9.7	156	180	7	-14	2,450	16.1	5.1	9.4	156	180	43	6	2,450	16.1	4.9	9.1	155	178	
Notes	1. Full throttle manifold pressure settings are approximate. 2. Shaded area represents operation with full throttle.																								



Landing Charts

Landing performance is affected by variables similar to those affecting takeoff performance. It is necessary to compensate for differences in density altitude, weight of the airplane, and headwinds. Like takeoff performance charts, landing distance information is available as normal landing information, as well as landing distance over a 50 foot obstacle. As usual, read the associated conditions and notes in order to ascertain the basis of the chart information. Remember, when calculating landing distance that the landing weight is not the same as the takeoff weight. The weight must be recalculated to compensate for the fuel that was used during the flight.

Sample Problem

Pressure Altitude.....1,250 feet

Temperature.....Standard

Conditions	Flaps lowered to 40° Power off Hard surface runway Zero wind		LANDING DISTANCE							
			At sea level & 59 °F		At 2,500 ft & 50 °F		At 5,000 ft & 41 °F		At 7,500 ft & 32 °F	
Gross weight lb	Approach speed IAS, MPH	Ground roll	Total to clear 50 ft OBS	Ground roll	Total to clear 50 ft OBS	Ground roll	Total to clear 50 ft OBS	Ground roll	Total to clear 50 ft OBS	
1,600	60	445	1,075	470	1,135	495	1,195	520	1,255	
Note	1. Decrease the distances shown by 10% for each 4 knots of headwind. 2. Increase the distance by 10% for each 60 °F temperature increase above standard. 3. For operation on a dry, grass runway, increase distances (both "ground roll" and "total to clear 50 ft obstacle") by 20% of the "total to clear 50 ft obstacle" figure.									



Landing Charts

Sample Problem

OA T..... 57 °F

Pressure Altitude..... 4,000 feet

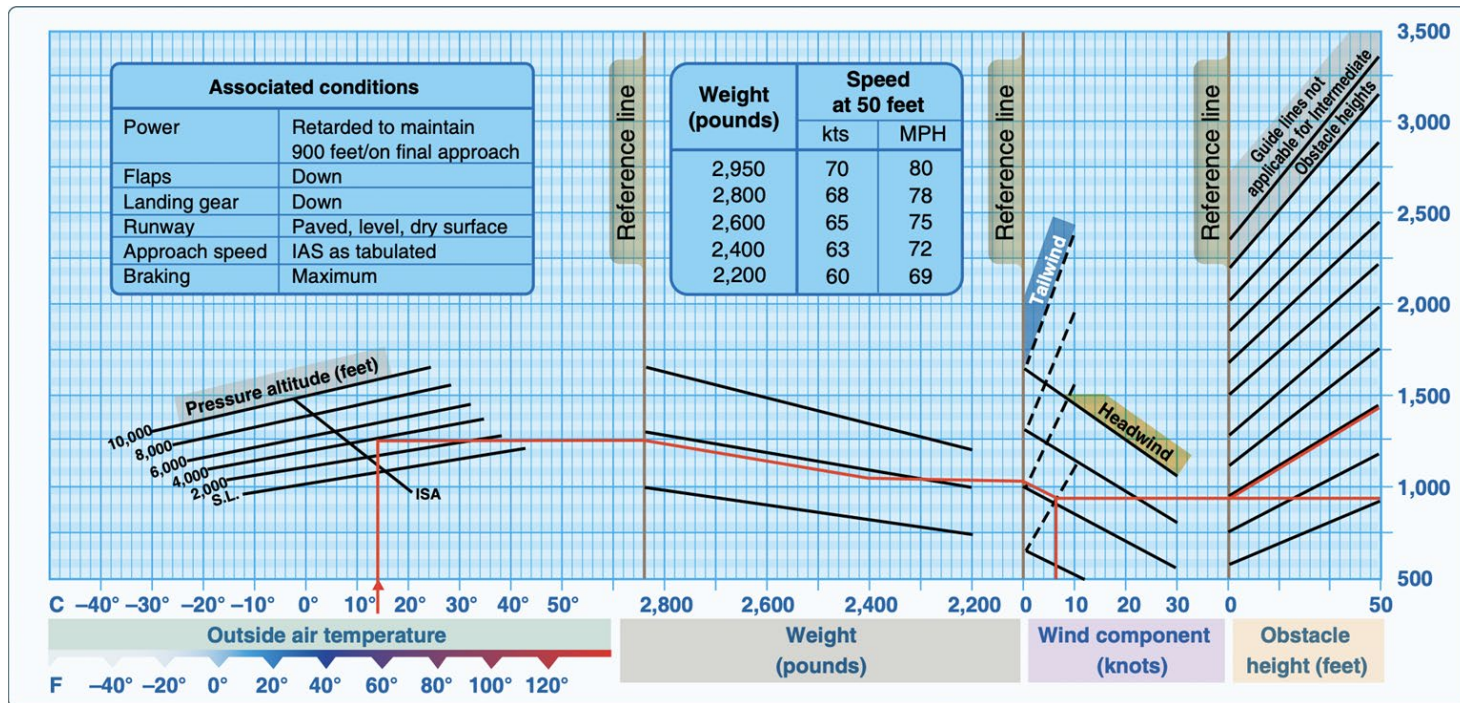
Landing Weight.....2,400 pounds

Headwind..... 6 knots

Obstacle Height..... 50 feet

(Chart on the next page)

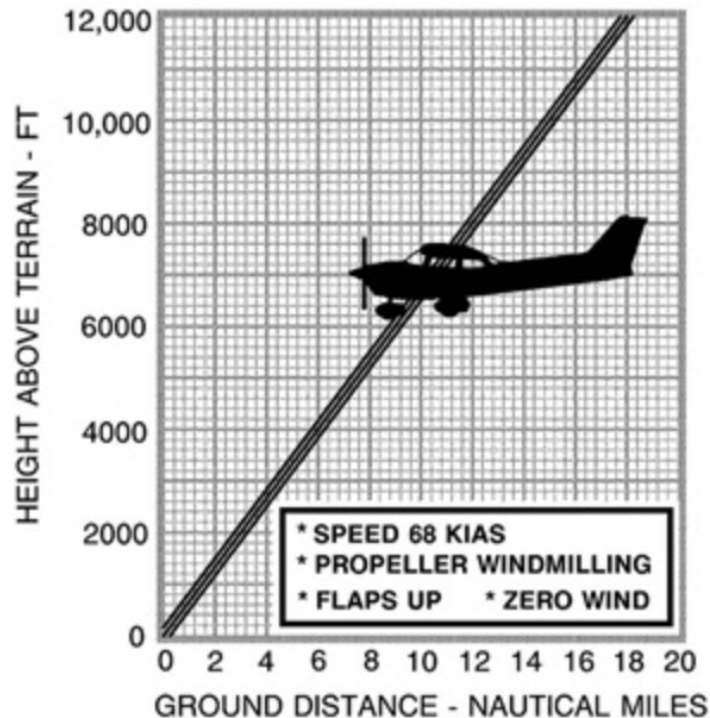
Landing Charts



Glide Chart

The Glide Distance Chart is a very important tool to use in case of an engine failure. It tells us, with certain conditions depicted on it, the loss of altitude for every distance moving forward.

The pilot has to remember, that this chart was done in perfect lab conditions, and it should be used as an aid.



Stall Speed Chart

Stall speed performance charts are designed to give an understanding of the speed at which the aircraft stalls in a given configuration. This type of chart typically takes into account the angle of bank, the position of the gear and flaps, and the throttle position. Use the table and the accompanying conditions to find the speed at which the airplane stalls.

Sample Problem

Power..... OFF
Flaps..... Down
Gear..... Down
Angle of Bank..... 45°

Gross weight 2,750 lb			Angle of bank			
			Level	30°	45°	60°
			Gear and flaps up			
Power	On	MPH	62	67	74	88
		knots	54	58	64	76
	Off	MPH	75	81	89	106
		knots	65	70	77	92
			Gear and flaps down			
Power	On	MPH	54	58	64	76
		knots	47	50	56	66
	Off	MPH	66	71	78	93
		knots	57	62	68	81