PERFORMANCE AND LIMITATIONS

Lesson Outline

LESSON OBJECTIVE

To determine that the student exhibits instructional knowledge of the elements related to performance and limitations by describing the elements on the following slide.

LESSON SOURCE(S)

Pilot's Handbook of Aeronautical Knowledge
FAA-H-8083-25

Pilot Operating Handbook

Lesson Outline

LESSON ELEMENTS	TIMEFRAME	EQUIPMENT/TOOLS
Types of Altitude Types of Airspeed Use of Performance Charts Effects of Exceeding Limitations Effects of Atmospheric Conditions on Performance	40 Minutes *approximately* Discuss Objectives Present and Review Material Student Questions Conclusion and Quiz	Lesson Presentation Whiteboard and Markers FAA Sources and References

Lesson Outline

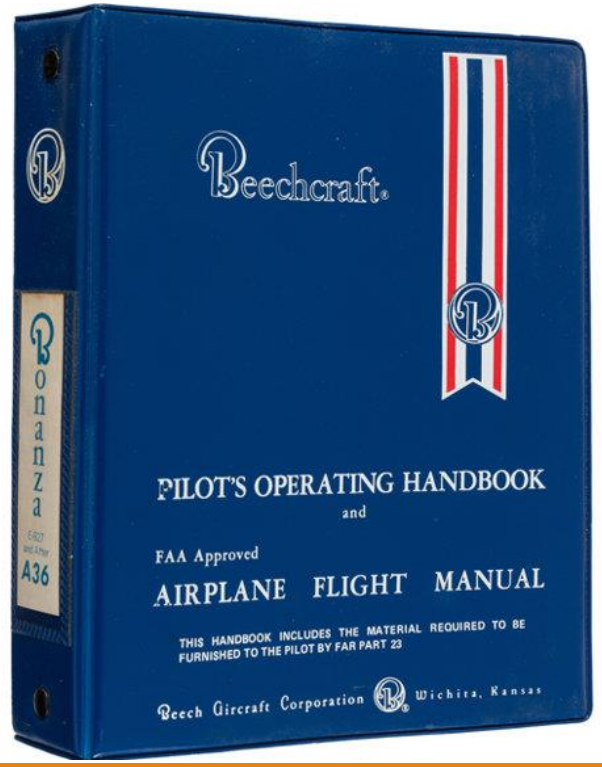
INSTRUCTOR ACTIONS	STUDENT ACTIONS	COMPLETION STANDARDS
Present Objectives and Standards Teach Lesson from Presentation Ask and Answer Student Questions Assign Homework Check Student's Post Lesson Quiz	Participate in Lesson Take Notes Ask and Respond to Questions Pass the Post Lesson Quiz	Student is able to understand and differentiate between the different lesson elements. Student is further able to apply this acquired knowledge in flight training/flight operation scenarios effectively and appropriately.

Performance and Limitations

The pilot should be familiar with the performance capabilities of their aircraft and how to properly and accurately run the performance data charts found in the airplane's POH or AFM.

POH/AFM

The performance or operational information section of the Aircraft Flight Manual/Pilot's Operating Handbook (AFM/ POH) contains the operating data for the aircraft; that is, the data pertaining to takeoff, climb, range, endurance, descent, and landing. The use of this data in flying operations is mandatory for safe and efficient operation.



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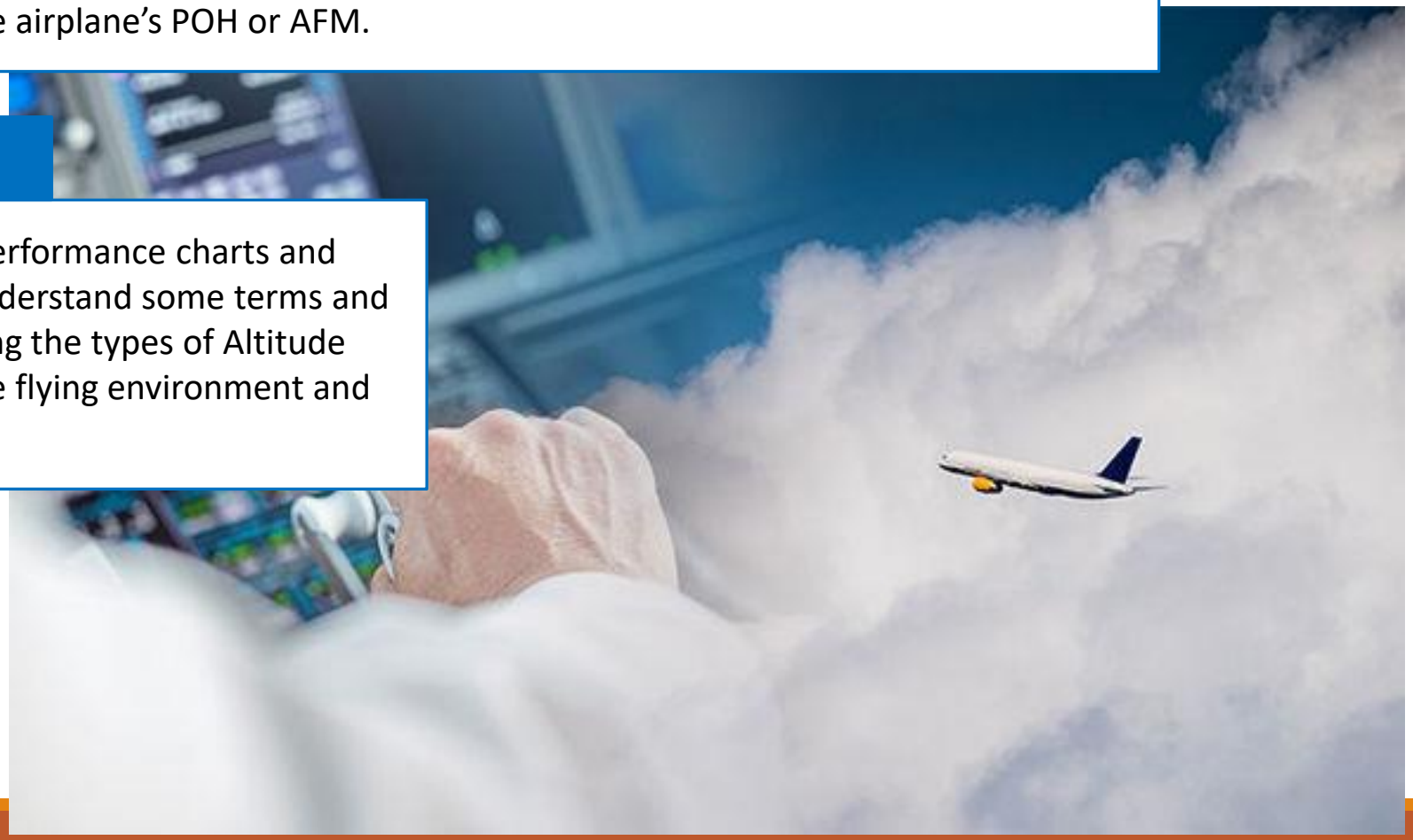

Effects of Atmospheric Conditions

Before we jump into our discussion on the performance charts and calculating performance data, we need to understand some terms and definitions. We are going to start by discussing the types of Altitude and the types of Airspeed encountered in the flying environment and their impact on aircraft performance.

Performance and Limitations

The pilot should be familiar with the performance capabilities of their aircraft and how to properly and accurately run the performance data charts found in the airplane's POH or AFM.

Types of Altitude

We will begin by discussing the 5 types of Altitude, which are: Indicated Altitude, True Altitude, Absolute Altitude, Pressure Altitude, and Density Altitude.

Indicated Altitude

This is the altitude read off the Altimeter in flight calibrated in feet above Mean Sea Level (MSL).

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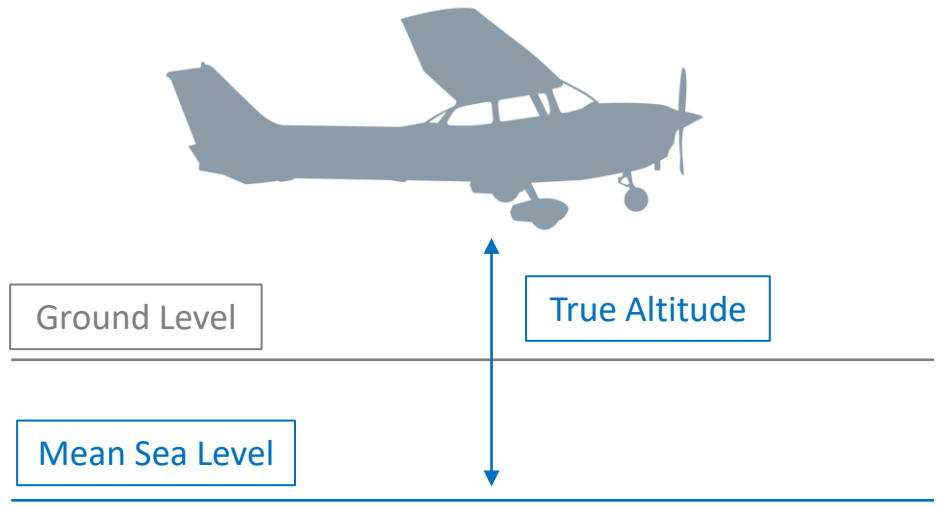
True Altitude

This is the height of the aircraft above Mean Sea Level (MSL).



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Types of Altitude

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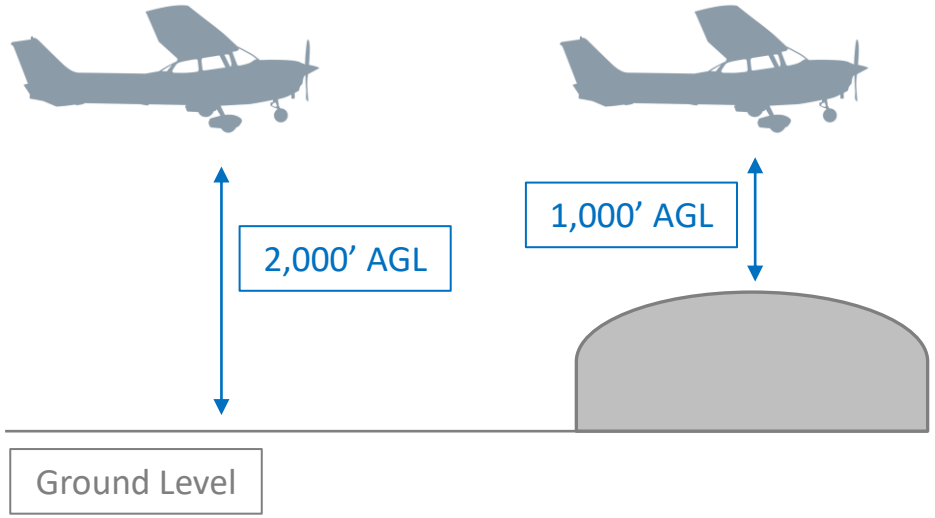
Absolute Altitude

This is the height of the aircraft Above Ground Level (AGL).



Performance and Limitations

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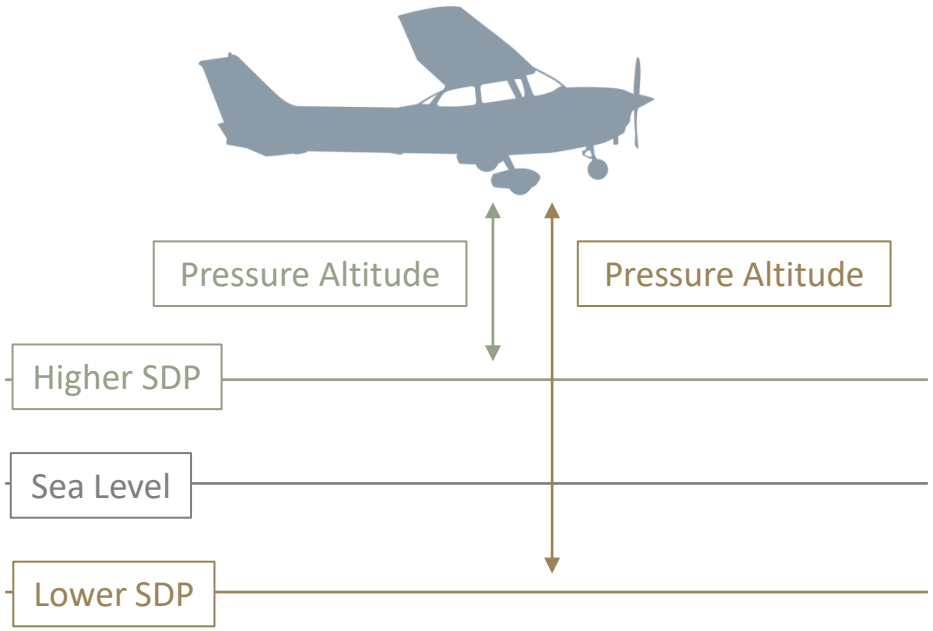
Pressure Altitude

Pressure altitude is the height above the standard datum plane (SDP). The aircraft altimeter is essentially a sensitive barometer calibrated to indicate altitude in the standard atmosphere. If the altimeter is set for 29.92 "Hg SDP, the altitude indicated is the pressure altitude. The SDP is a theoretical level at which the pressure of the atmosphere is 29.92 "Hg and the weight of air is 14.7 psi. As atmospheric pressure changes, the SDP may be below, at, or above sea level.



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Figuring Pressure Altitude #1

Get in the airplane and set the altimeter (in the Kollsman Window) to 29.92. The altitude read off the altimeter is the Pressure Altitude.

Performance and Limitations

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Figuring Pressure Altitude #2

You can figure the Pressure Altitude at your destination without needing access to an operating altimeter by following the mathematical equation below:

1. 29.92 – Current Altimeter Setting = "X"
2. Multiple "X" by 1,000 = "Y"
3. Add "Y" to the Field Elevation

Example: Altimeter Setting = 30.12, Field Elevation = 4,473'

1. 29.92 – 30.12 = -0.20
2. -0.20 x 1,000 = -200
3. -200 + 4,473 = 4,273' Pressure Altitude

Performance and Limitations

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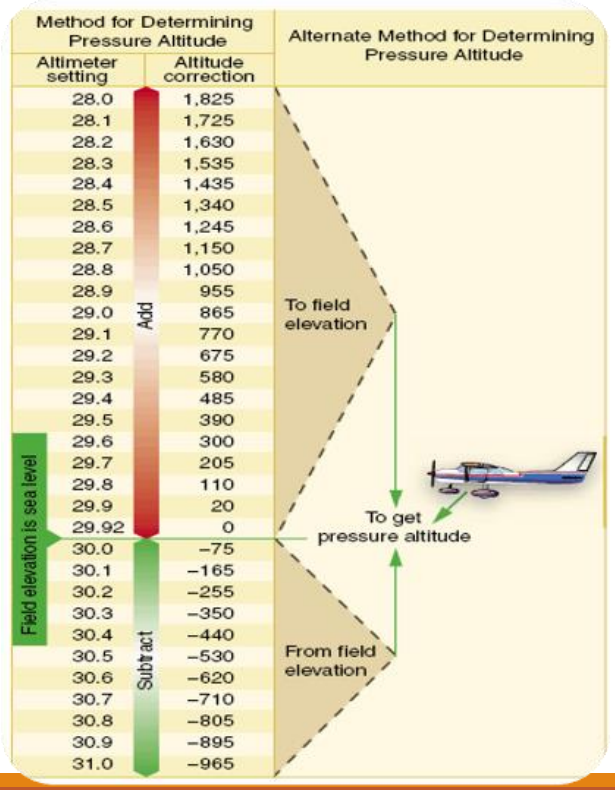
Figuring Pressure Altitude #3

Use the Pressure Altitude Chart.



Performance and Limitations

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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.

Actual Altitude: 6,000' MSL

Density Altitude: 3,000' MSL

This means more dense air. Hence, the airplane will have Better Performance.

Low Density Altitude = Increased Performance

Actual Altitude: 6,000' MSL

Density Altitude: 8,000' MSL

This means less dense air. Hence, the airplane will have Worse Performance.

High Density Altitude = Decreased Performance

Performance and Limitations

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Density Altitude

Anything that increases the density of air will decrease the Density Altitude and Increase Aircraft Performance.

Conversely, anything that decreases the density of air will increase the Density Altitude and Decrease Aircraft Performance.

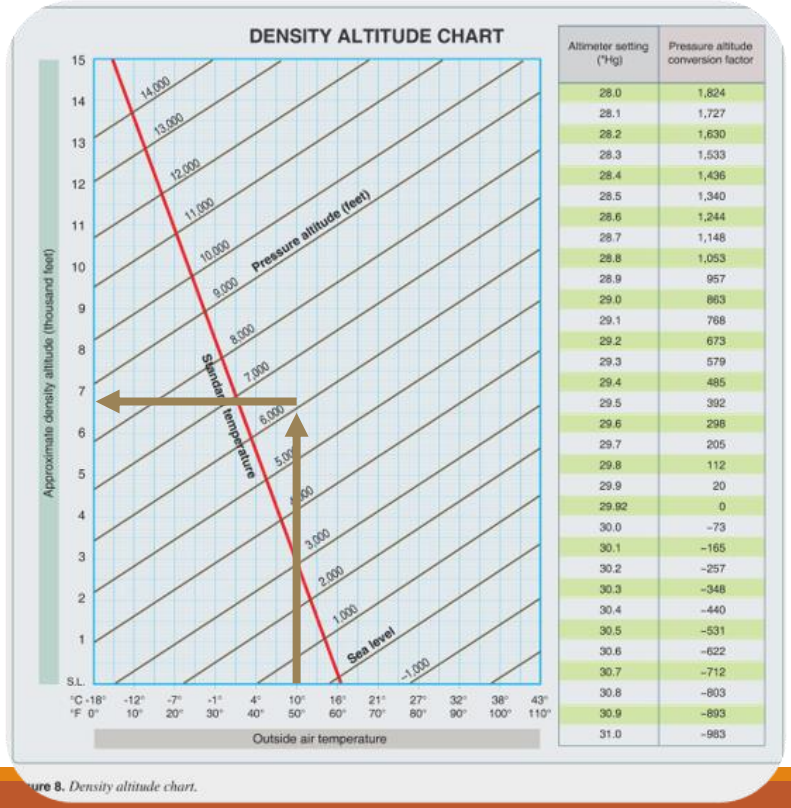
Factors that increase Density Altitude include: hotter temperatures, increased water vapor, and decreased atmospheric pressure.

Chart Example

What is the DA at 10C and 6,000'?

Answer

6,800'



ure 8. *Density altitude chart.*

Performance and Limitations

The pilot should be familiar with the performance capabilities of their aircraft and how to properly and accurately run the performance data charts found in the airplane's POH or AFM.

Types of Airspeed

Next, we need to discuss the 4 types of Airspeed, which are: Indicated Airspeed, Calibrated Airspeed, True Airspeed, and Ground Speed.

Indicated Airspeed

This is the airspeed that is read off the Airspeed Indicator in flight. It is used for: speed limits and speed restrictions from ATC, and for the aircraft's V-Speeds.

Performance and Limitations

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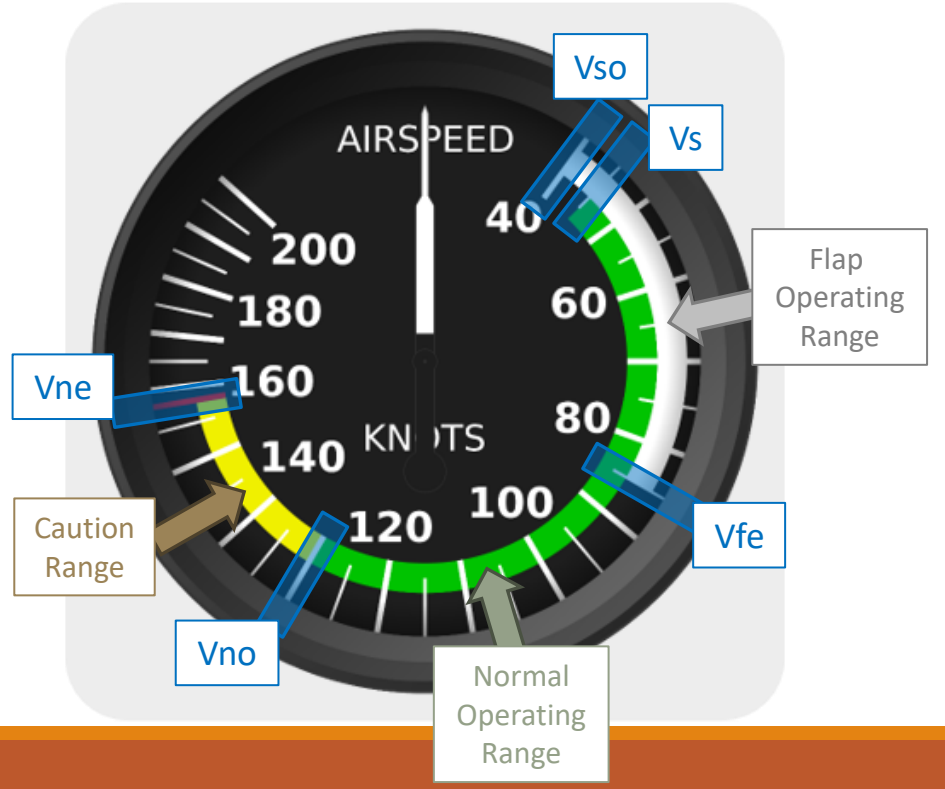
Airspeed Indicator Markings

- Vso = Stall Speed in the Landing Configuration
- Vs = Stall Speed in the Clean Configuration
- Vfe = Maximum Flap Extension Speed
- Vno = Normal Operating Range
- Vne = Never Exceed Speed

Additional V-Speeds

- Vx = Best Angle of Climb Speed
- Vy = Best Rate of Climb Speed
- Va = Design Maneuvering Speed



Performance and Limitations

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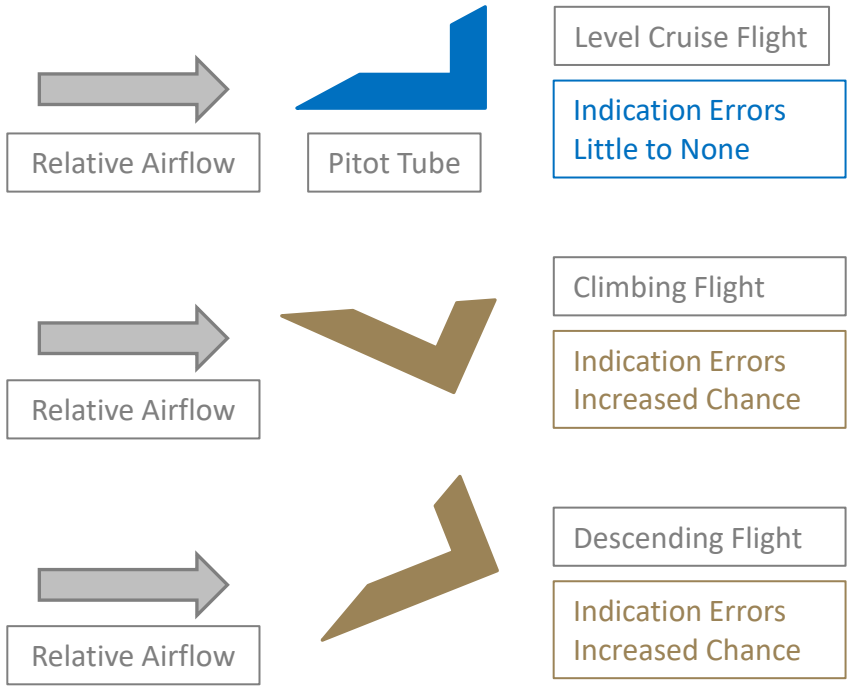
Calibrated Airspeed

Is Indicated Airspeed (IAS) corrected for pitot tube installation. Airspeed indications are most accurate when the pitot tube points directly into the airflow (cruise flight). However, at varying angle of attack, the pitot tubes position varies in relation to the relative airflow (climbs and descents). This causes small indication errors that are published by the manufacturer (in the POH) as Calibrated Airspeed.



Performance and Limitations

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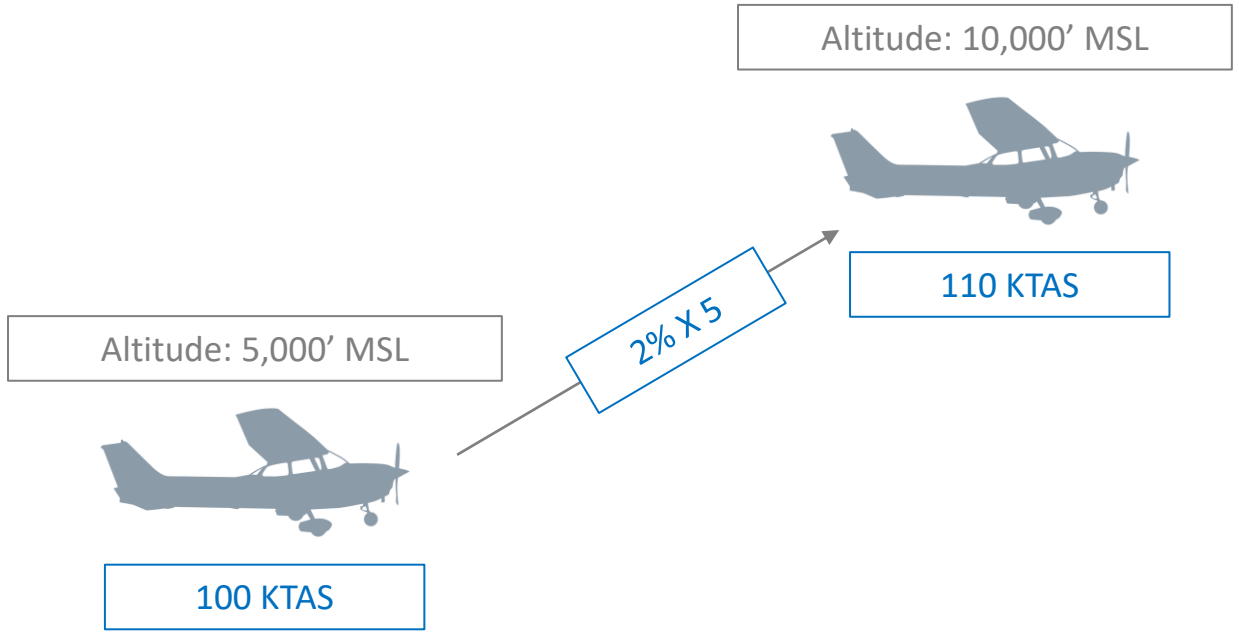
True Airspeed

Is the airspeed of the airplane relative to the airmass in which it is flying. Airspeed increases approximately 2% per thousand feet of altitude gain.

Even though the engine is producing less power at higher altitudes, the aircraft is also experiencing less drag due to decreased air density. For this reason, the True Airspeed will increase with increasing altitude.



Performance and Limitations

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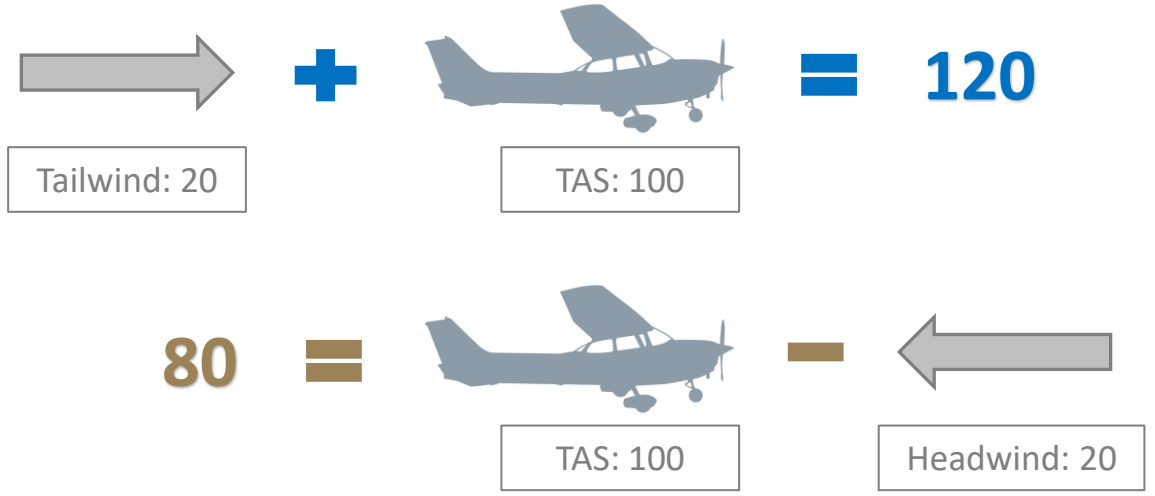
Groundspeed

This is the speed the aircraft is travelling across the surface of the Earth. It is True Airspeed corrected for wind direction and velocity. Tailwinds will increase an airplane's Groundspeed while Headwinds will decrease the Groundspeed.

Groundspeeds are used for time and distance calculations in flight planning and can be found using the "back side" of the E6B.



Performance Chart Examples

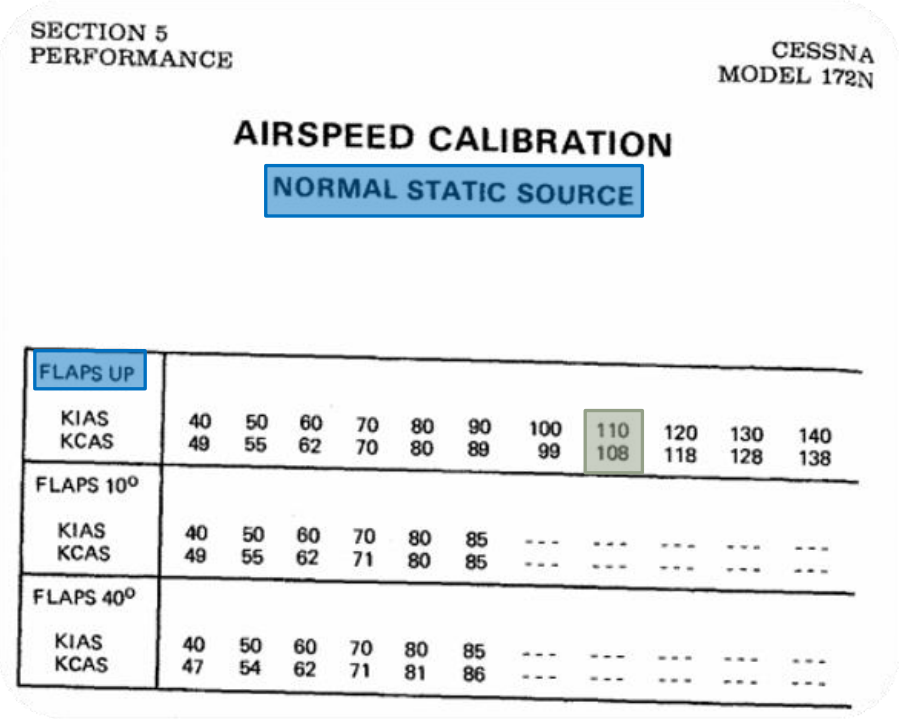
Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes.

Airspeed Calibration Chart

What is the CAS (Calibrated Airspeed) if the IAS (Indicated Airspeed) is 110 with flaps up?

Answer

108 KCAS.



SECTION 5
PERFORMANCE

CESSNA
MODEL 172N

AIRSPEED CALIBRATION

NORMAL STATIC SOURCE

FLAPS UP											
KIAS	40	50	60	70	80	90	100	110	120	130	140
KCAS	49	55	62	70	80	89	99	108	118	128	138
FLAPS 10°											
KIAS	40	50	60	70	80	85	---	---	---	---	---
KCAS	49	55	62	71	80	85	---	---	---	---	---
FLAPS 40°											
KIAS	40	50	60	70	80	85	---	---	---	---	---
KCAS	47	54	62	71	81	86	---	---	---	---	---

Performance Chart Examples

Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes.

Stall Speed Chart

At what IAS will the airplane stall with 10 degrees of flaps and at a bank angle of 30 degrees?

Answer

40 KIAS.

STALL SPEEDS

CONDITIONS:
Power Off

NOTES:
1. Maximum altitude loss during a stall recovery may be as much as 180 feet.
2. KIAS values are approximate.

MOST REARWARD CENTER OF GRAVITY

WEIGHT LBS	FLAP DEFLECTION	ANGLE OF BANK							
		0°		30°		45°		60°	
		KIAS	KCAS	KIAS	KCAS	KIAS	KCAS	KIAS	KCAS
2300	UP	42	50	45	54	50	59	59	71
	10°	38	47	40	51	45	56	54	66
	40°	36	44	38	47	43	52	51	62

Performance Chart Examples

Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes.

Takeoff Distance Chart

What is our takeoff distance to clear a 50’ obstacle at 4,000’ Pressure Altitude and a temperature of 20C?

Answer

2,175’.

TAKEOFF DISTANCE

MAXIMUM WEIGHT 2300 LBS

SHORT FIELD

CONDITIONS:
Flaps Up
Full Throttle Prior to Brake Release
Paved, Level, Dry Runway
Zero Wind

NOTES:
1. Short field technique as specified in Section 4.
2. Prior to takeoff from fields above 3000 feet elevation, the mixture should be leaned to give maximum RPM in a full throttle, static runup.
3. Decrease distances 10% for each 9 knots headwind. For operation with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operation on a dry, grass runway, increase distances by 15% of the “ground roll” figure.

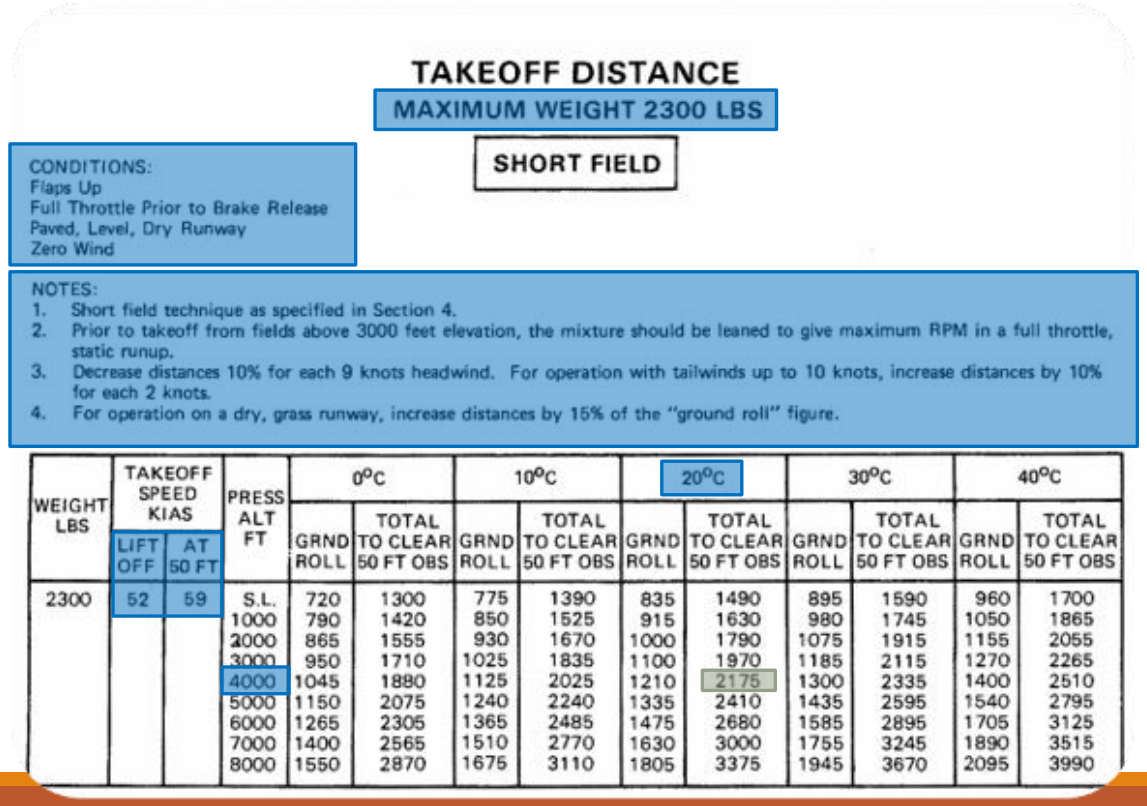
WEIGHT LBS	TAKEOFF SPEED KIAS		PRESS ALT FT	0°C		10°C		20°C		30°C		40°C	
	LIFT OFF	AT 50 FT		GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS
2300	52	59	S.L.	720	1300	775	1390	835	1490	895	1590	960	1700
			1000	790	1420	850	1525	915	1630	980	1745	1050	1865
			2000	865	1555	930	1670	1000	1790	1075	1915	1155	2055
			3000	950	1710	1025	1835	1100	1970	1185	2115	1270	2265
			4000	1045	1880	1125	2025	1210	2175	1300	2335	1400	2510
			5000	1150	2075	1240	2240	1335	2410	1435	2595	1540	2795
			6000	1265	2305	1365	2485	1475	2680	1585	2895	1705	3125
			7000	1400	2565	1510	2770	1630	3000	1755	3245	1890	3515
			8000	1550	2870	1675	3110	1805	3375	1945	3670	2095	3990

Performance Chart Examples

Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes.

Takeoff Distance Chart

All of the takeoff, landing, rate of climb, and time/fuel/distance to climb charts are run in the same manner as this chart.



TAKEOFF DISTANCE

MAXIMUM WEIGHT 2300 LBS

SHORT FIELD

CONDITIONS:
Flaps Up
Full Throttle Prior to Brake Release
Paved, Level, Dry Runway
Zero Wind

NOTES:
1. Short field technique as specified in Section 4.
2. Prior to takeoff from fields above 3000 feet elevation, the mixture should be leaned to give maximum RPM in a full throttle, static runup.
3. Decrease distances 10% for each 9 knots headwind. For operation with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operation on a dry, grass runway, increase distances by 15% of the "ground roll" figure.

WEIGHT LBS	TAKEOFF SPEED KIAS		PRESS ALT FT	0°C		10°C		20°C		30°C		40°C	
	LIFT OFF	AT 50 FT		GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS
2300	52	59	S.L.	720	1300	775	1390	835	1490	895	1590	960	1700
			1000	790	1420	850	1525	915	1630	980	1745	1050	1865
			2000	865	1555	930	1670	1000	1790	1075	1915	1155	2055
			3000	950	1710	1025	1835	1100	1970	1185	2115	1270	2265
			4000	1045	1880	1125	2025	1210	2175	1300	2335	1400	2510
			5000	1150	2075	1240	2240	1335	2410	1435	2595	1540	2795
			6000	1265	2305	1365	2485	1475	2680	1585	2895	1705	3125
			7000	1400	2565	1510	2770	1630	3000	1755	3245	1890	3515
			8000	1550	2870	1675	3110	1805	3375	1945	3670	2095	3990

Performance Chart Examples

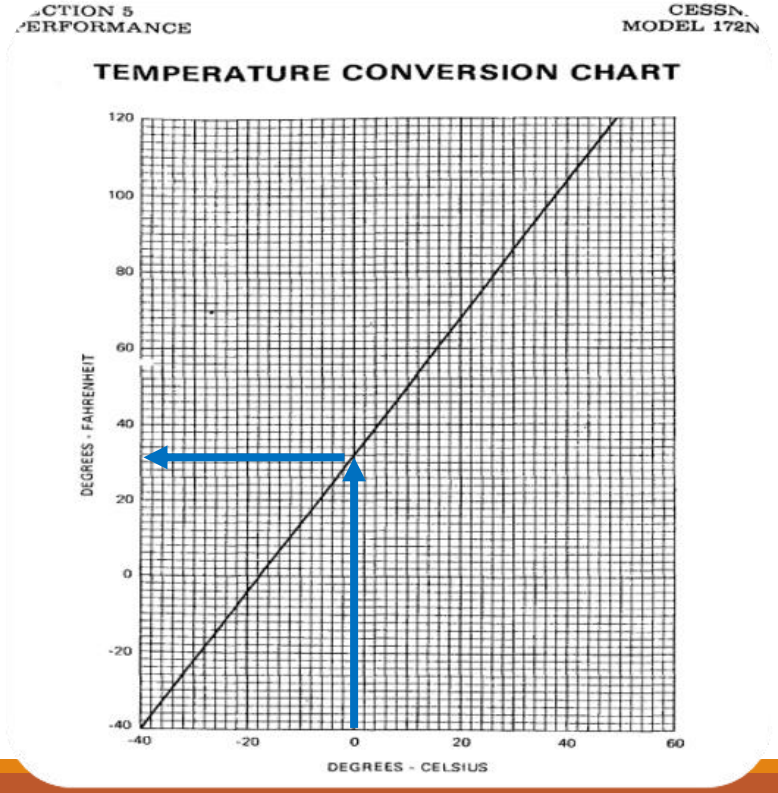
Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes.

Temperature Conversion Chart

This chart helps us to easily convert temperature in Celsius to Fahrenheit or vice-versa. What is 0C in Fahrenheit?

Answer

32F.



Performance Chart Examples

Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes.

Cruise Performance Chart

What is our airplane's TAS and Fuel Burn at 6,000' with an RPM setting of 2400 at Standard Temperature?

Answer

TAS = 109, Fuel Burn = 6.8 GPH.

CRUISE PERFORMANCE

CONDITIONS:
2300 Pounds
Recommended Lean Mixture

PRESSURE ALTITUDE FT	RPM	20°C BELOW STANDARD TEMP			STANDARD TEMPERATURE			20°C ABOVE STANDARD TEMP		
		% BHP	KTAS	GPH	% BHP	KTAS	GPH	% BHP	KTAS	GPH
2000	2500	- - -	- - -	- - -	75	116	8.4	71	115	7.9
	2400	72	111	8.0	67	111	7.5	63	110	7.1
	2300	64	106	7.1	60	105	6.7	56	105	6.3
	2200	56	101	6.3	53	100	6.1	50	99	5.8
	2100	50	95	5.8	47	94	5.6	45	93	5.4
4000	2550	- - -	- - -	- - -	75	118	8.4	71	118	7.9
	2500	76	116	8.5	71	115	8.0	67	115	7.5
	2400	68	111	7.6	64	110	7.1	60	109	6.7
	2300	60	105	6.8	57	105	6.4	54	104	6.1
	2200	54	100	6.1	51	99	5.9	48	98	5.7
	2100	48	94	5.6	46	93	5.5	44	92	5.3
6000	2600	- - -	- - -	- - -	75	120	8.4	71	120	7.9
	2500	72	116	8.1	67	115	7.6	64	114	7.1
	2400	64	110	7.2	60	109	6.8	57	109	6.4
	2300	57	105	6.5	54	104	6.2	52	103	5.9
	2200	51	99	5.9	49	98	5.7	47	97	5.5
	2100	46	93	5.5	44	92	5.4	42	91	5.2

Performance Chart Examples

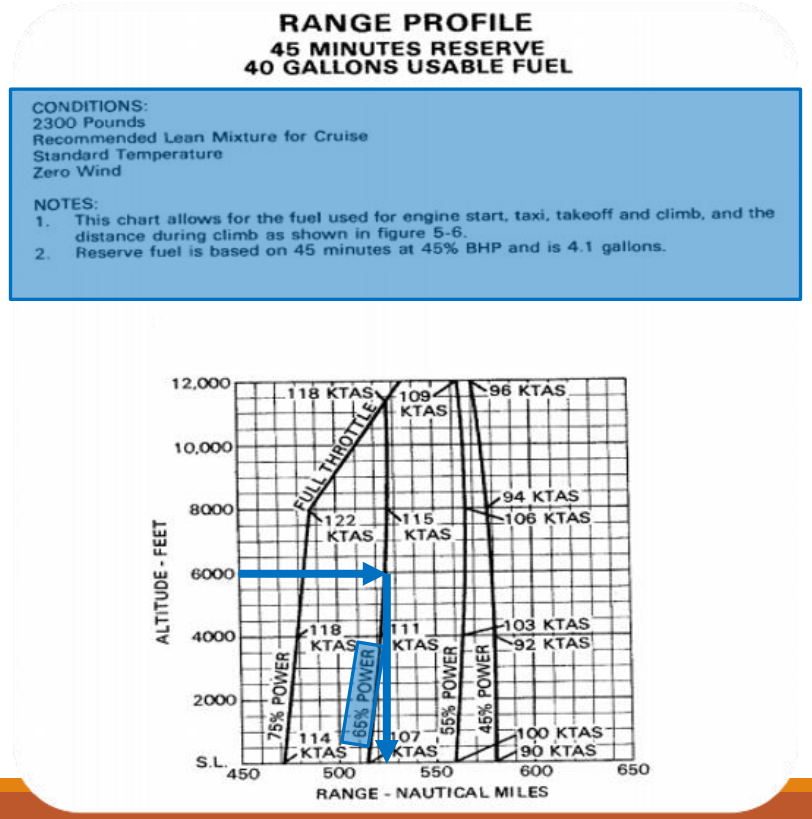
Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes.

Range Profile Chart

How many Nautical Miles could we fly at 6,000’ and a at Cruise Performance of 65% BHP?

Answer

525 NM.

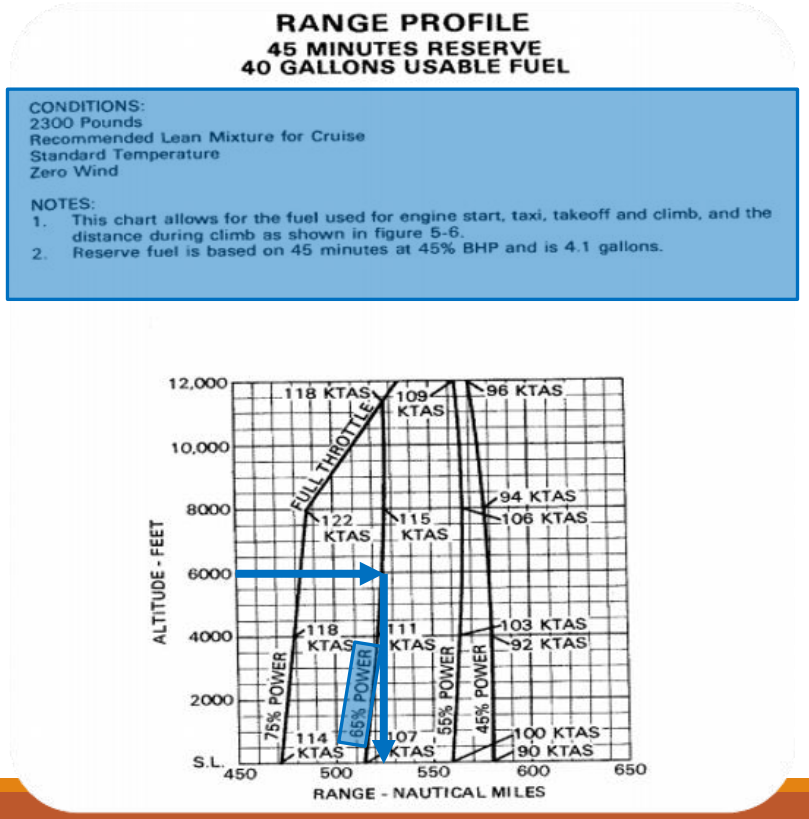


Performance Chart Examples

Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes.

Range Profile Chart

The Endurance Profile Chart is run in the same manner as this chart. Instead of a NM range, the Endurance Chart gives us distances that can be flow in hours (time).



Performance Chart Examples

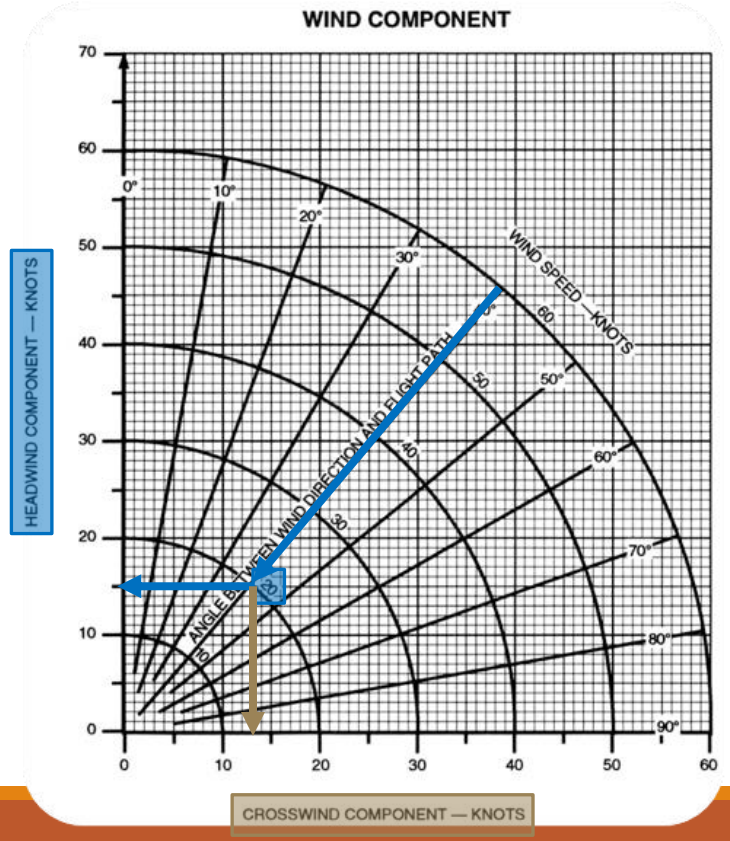
Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes.

Crosswind Component Chart

What would the Crosswind and Headwind components be if the wind direction was 250, wind velocity was 20 knots, and taking off on runway 210?

Answer

Crosswind = 13, Headwind = 15.



Lesson Summary

In this lesson we discussed various performance definitions, types of airspeed and altitude, and how to run example performance charts from the Pilot Operating Handbook (POH).