Private Pilot (ASEL) Ground School Course

Lesson 11 | Aircraft Performance

Lesson Overview

Lesson Objectives:

- Develop a knowledge of aircraft performance.
- Develop an understanding aircraft performance and factors limiting outcomes.
- Skill to correctly determine expected aircraft performance.

Lesson Completion Standards:

- Student demonstrates satisfactory knowledge of aircraft performance by answering questions and actively participating in classroom discussions.
- Correctly calculates multiple performance problems.

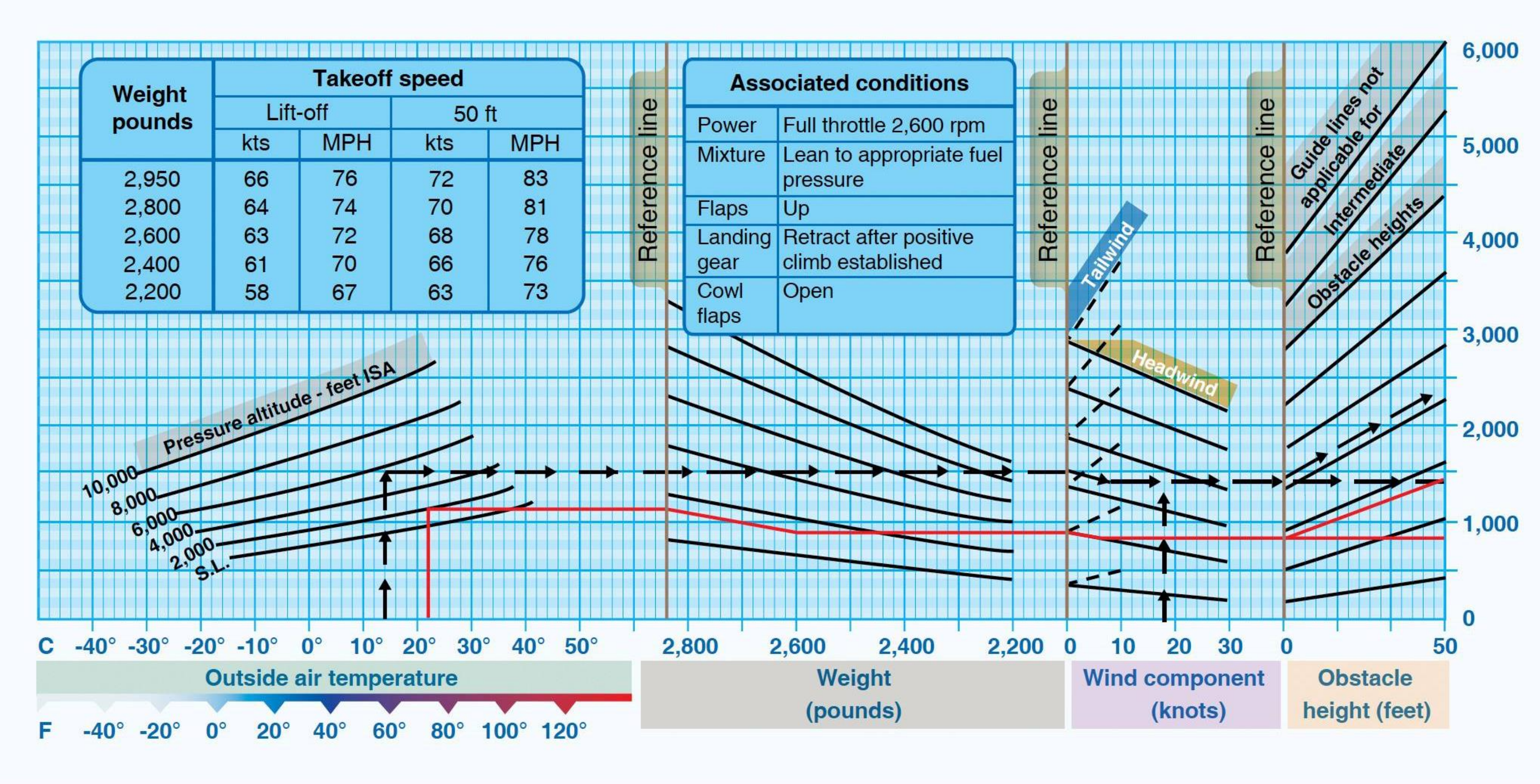
Questions …

- *What factors determine your density altitude?*
- *What is your V_X and V_Y?*
- *What TAS do you use for cross country?*
- *What RPM do you select for cross country cruise?*
- *What fuel burn do you flight plan?*
- *What is the difference between Range and Endurance?*
- *What factors affect takeoff and landing performance?*
- *Are you within your landing crosswind limit?*

Atmospheric Considerations

Aircraft Performance

Aircraft Performance …
Why vs. How



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Results of Ignoring Aircraft Performance

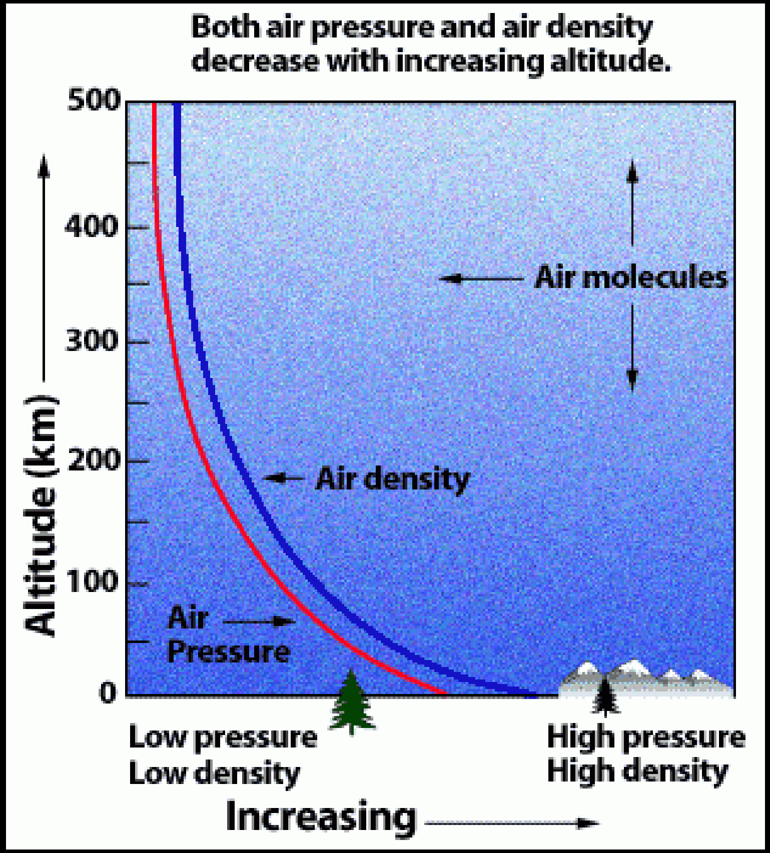
- https://www.youtube.com/watch?v=OVM3RRd1vf0
- https://www.youtube.com/watch?v=jjRPY4_XKy0

Performance Section of AFM/POH

- Contains the operating data for the aircraft
- This data pertains to takeoff, climb, range, endurance, descent, and landing
- Manufacturers' information and data furnished in the AFM/POH is *not* standardized
- Some provide the data in tabular form, while others use graphs
- Performance data may be presented based on standard atmospheric conditions, pressure altitude, or density altitude

Air Density

- Airplanes experience decreased performance in less-dense air
- The more air molecules flowing over the airplane's wing, the greater the lift developed
- Anything that thins the air reduces the wings' ability to generate lift

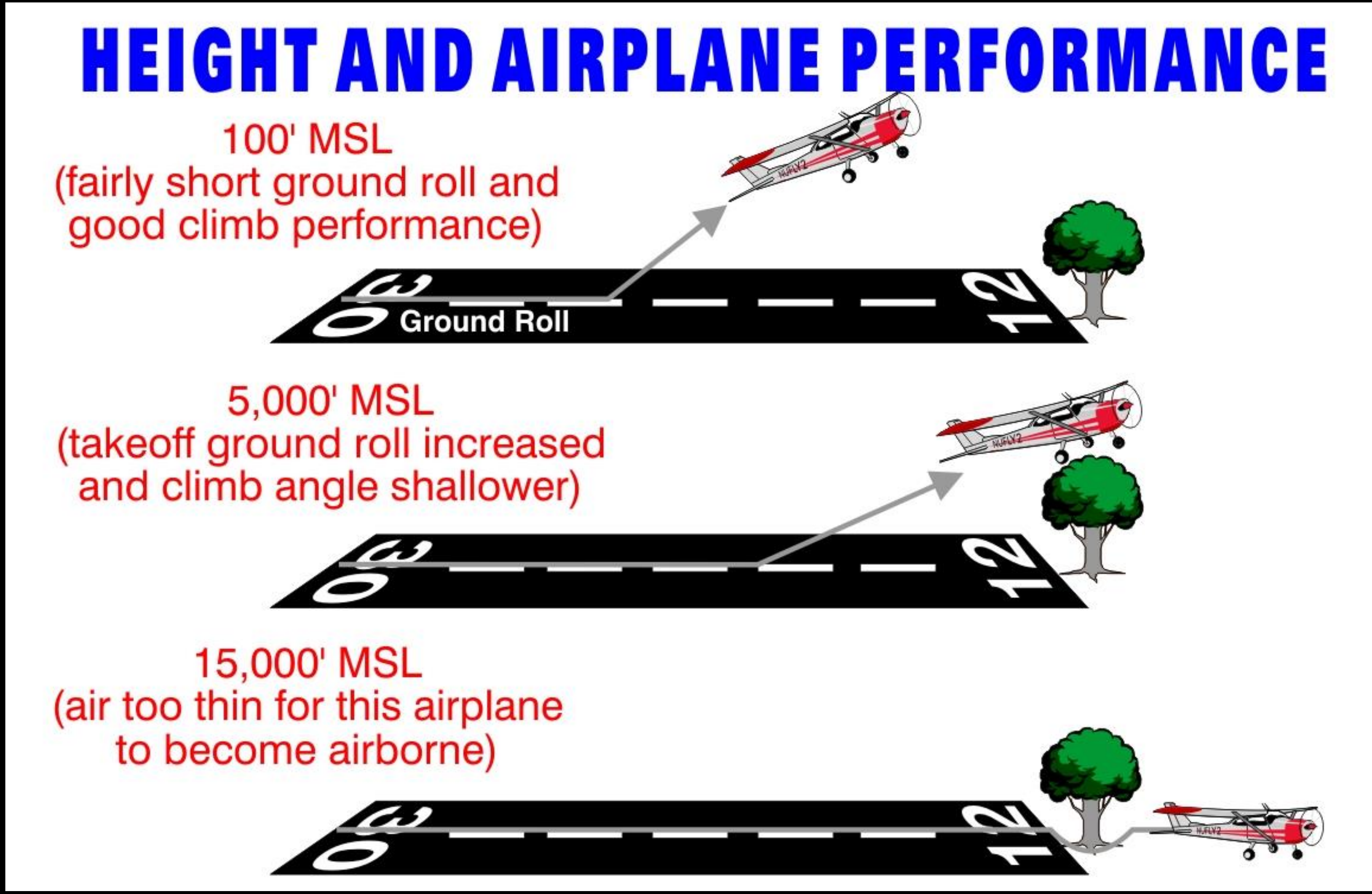


Air Density

- Airplane engine performance is affected in the same way
- Anything reducing the amount of air the engine intakes diminishes its power output
- Propeller efficiency is also decreased
- Less power = Less performance

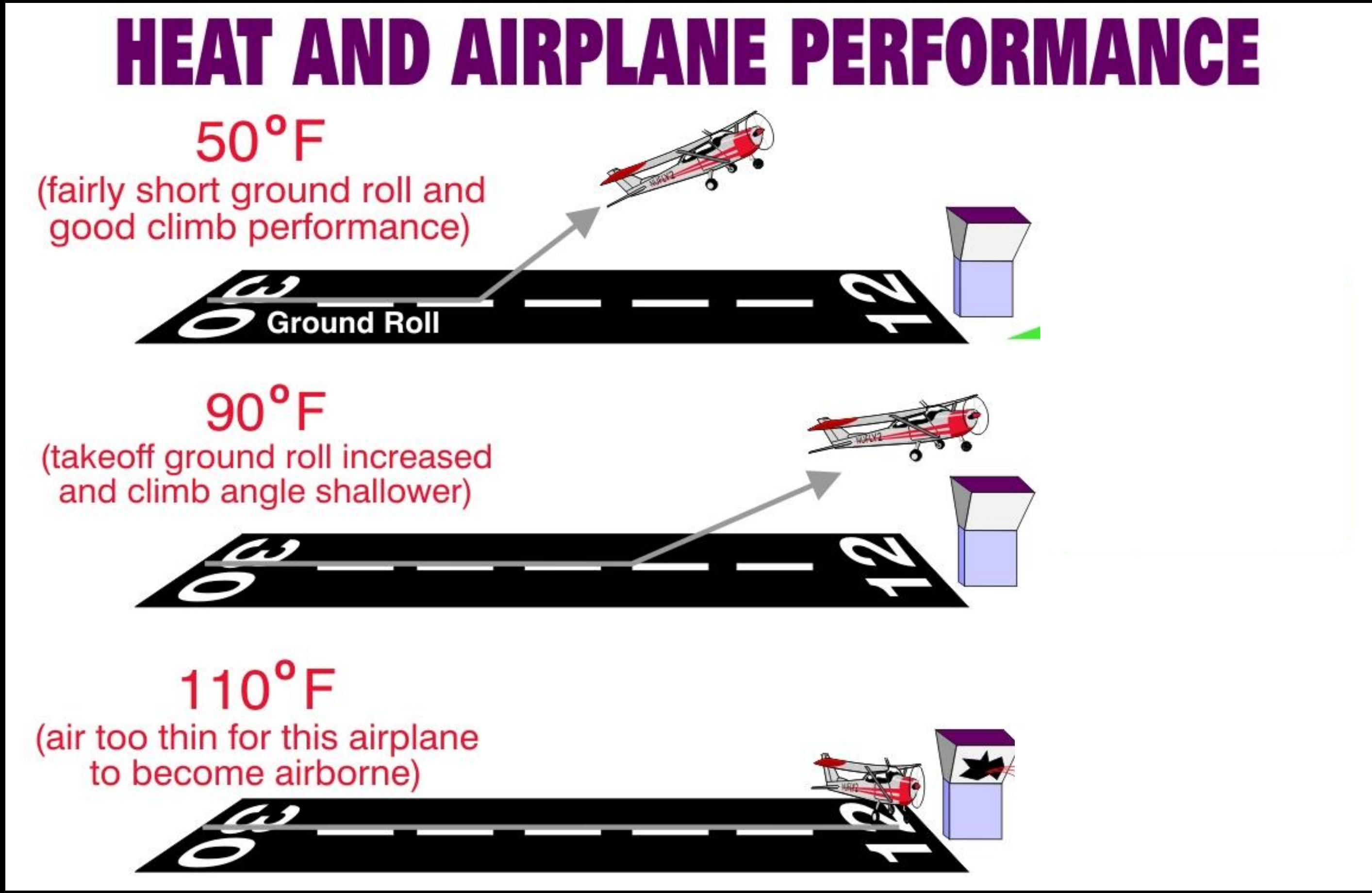
Height (Altitude)

- The higher you go, the less frequently the airplane's wing will run into air molecules, because they are fewer and farther between with increasing altitude
- Air density is less
- Fewer air molecules are available to move past the wing, so lift is reduced and performance is decreased
- Higher altitudes to result in slower acceleration, longer ground runs, and shallower climb profiles



Heat (Temperature)

- Heat reduces the performance of airplanes
- Heated air is much less dense than colder air
- Expect slower acceleration, longer takeoff runs, and shallower climb profiles on hot days



Humidity

- High humidity reduces airplane performance by thinning the air
- Moist air is lighter (thus less dense) because water molecules are lighter than air molecules
- Most performance charts (or E6B) make <u>no</u> correction for humidity
- Most ASOS/AWOS stations do

ISA International Standard Atmosphere

- Standard temperature at sea level is 59°F/15°C
- Standard pressure at sea level is 29.92” Hg
- Pressure decreases approximately 1” Hg/1,000 feet
- Standard lapse rate is a decrease of 3.5°F/2°C per thousand-foot altitude gain

Density Altitude

- Pressure altitude corrected for nonstandard temperature

Density Altitude

- Taking off at an airport near sea level usually results in good acceleration and climb performance
- The elevation has no effect on performance, temperatures are usually moderate, and the humidity is not too high

Density Altitude

- Suppose it's a very hot day at our sea level airport
- The airplane will not perform as well as at SL
- Because of the high temperature, the air might have a density equivalent to an altitude around 3,000 feet
- The term density altitude describes how dense the air feels to the airplane, regardless of the airplane's present height above SL
- Even though the airplane was physically at SL, in terms of airplane performance the airport has a density altitude of 3,000 feet

Performance Baseline

- Pressure altitude is the reference to which airplane engineers calibrate their performance charts
- Pressure altitude is what the altimeter indicates when 29.92 inches Hg is set in the altimeter's Kollsman window
- Engineers also calibrate performance charts to a standard temperature of 59°F (15°C) at sea level
- Standard temperature and pressure conditions are a reference point where a baseline of performance is established

Density Altitude

- If standard conditions existed at sea level all the time, we wouldn't have to worry about changes in air density and its effects on airplane performance

ISA Temperature Decrease

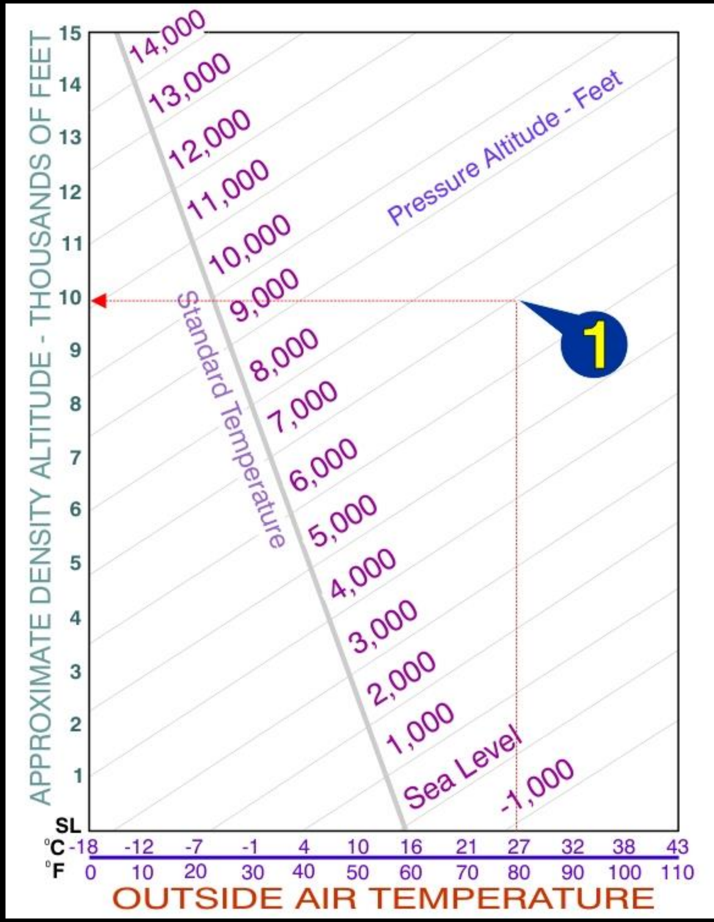
- Assume you’re at an airport at 4,000 foot MSL and *standard* conditions exist at SL (59°F)
- Also assume that temperatures decreases at 3.5°F per 1,000 feet
- Temperature drop from SL to 4,000 feet: 4 x 3.5°F = 14°F
- Temperature at 4,000 feet: 59°F - 14°F = 45°F

Effect Of Higher Temperature

- Suppose it's 100°F at 4,000 feet
- The airplane will not perform like it normally would at 4,000 feet
- It will perform more like it's at 7,500 feet
- Because of the higher than normal temperature, the air has a density altitude (performance altitude) of approximately 7,500 feet
- Increasing density altitude decreases airplane performance; decreasing density altitude increases performance

Density Altitude

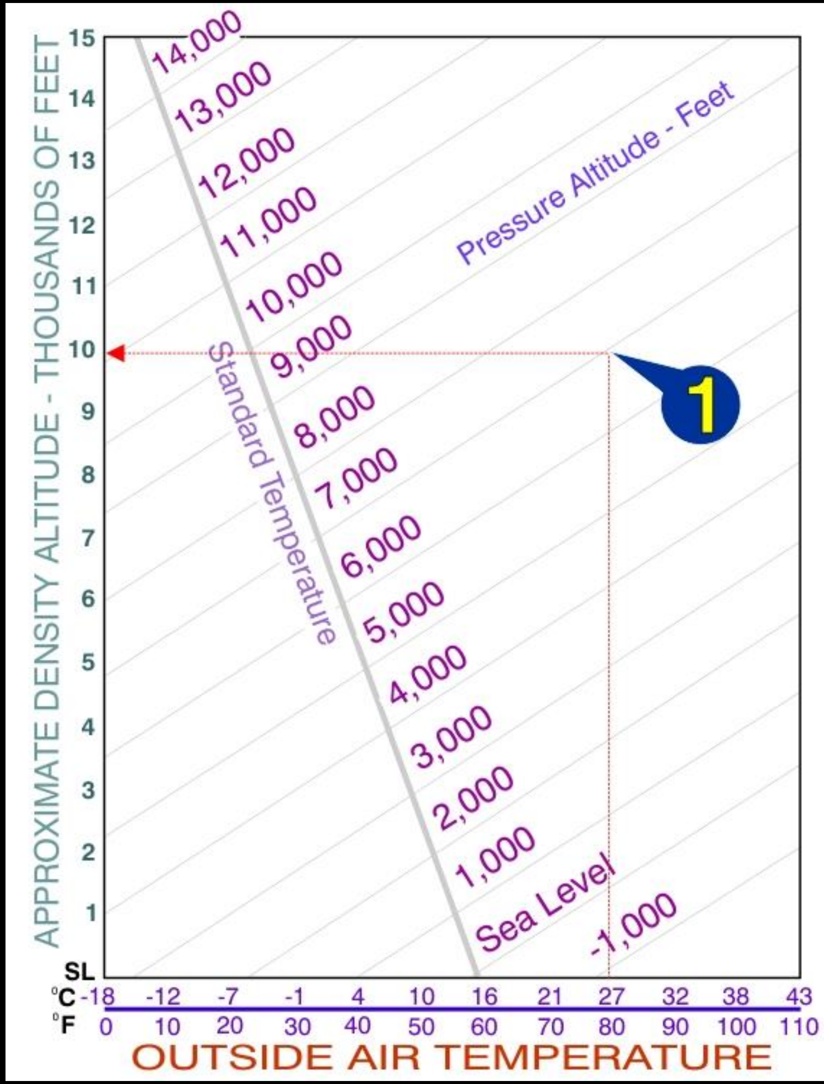
- Along the bottom (horizontal) axis is a temperature scale with Fahrenheit and Celsius markings
- Rising diagonally upward from left to right are pressure altitude lines
- On the left side of the chart is the density altitude reading along the vertical scale
- If you know the pressure altitude and air temperature for your location, you can find the density altitude



DENSITY ALTITUDE CHART

Altimeter Setting (" Hg)	Pressure Altitude Conversion Factor	Altimeter Setting (" Hg)	Pressure Altitude Conversion Factor
28.0	1,824	29.6	298
28.1	1,727	29.7	205
28.2	1,630	29.8	112
28.3	1,533	29.9	20
28.4	1,436	29.92	0
28.5	1,340	30.0	-73
28.6	1,244	30.1	-165
28.7	1,148	30.2	-257
28.8	1,053	30.3	-348
28.9	957	30.4	-440
29.0	863	30.5	-531
29.1	768	30.6	-622
29.2	673	30.7	-712
29.3	579	30.8	-803
29.4	485	30.9	-893
29.5	392	31.0	-983

Example #1



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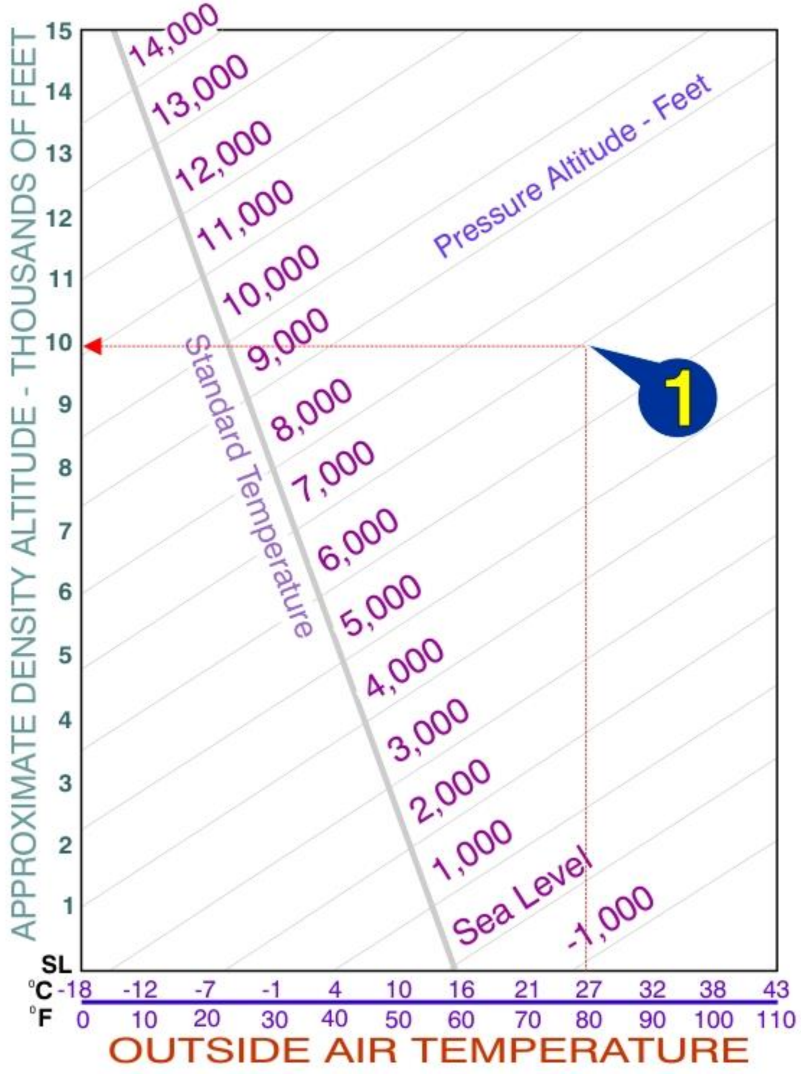
15-3

- *OAT: 80°F*
  PA: 7,000'
- Find 80°F on horizontal scale
- Move up until reaching 7,000 foot pressure altitude line
- Mark this point and move horizontally to the left
- Number on the left hand vertical scale (10,000 feet) is the density altitude

Example #2



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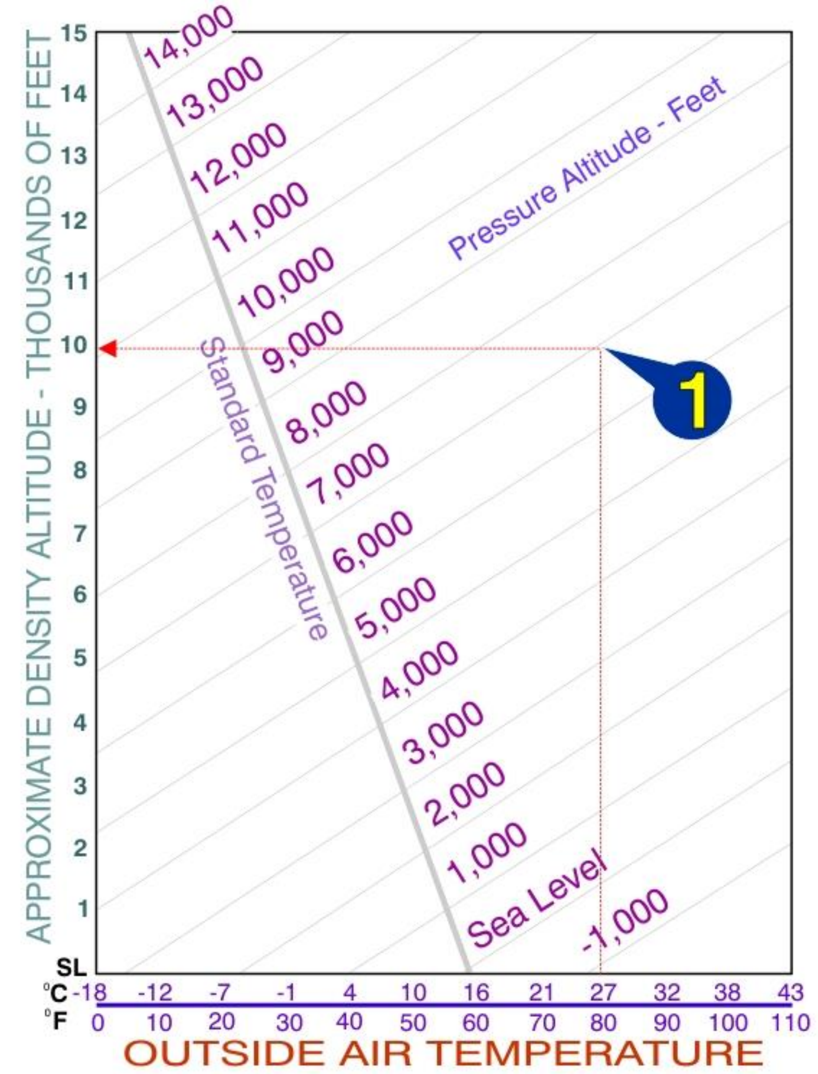
15-3

- OAT: 75°F
  PA: 3,257'
- First locate the PA between the diagonal lines

Example #2



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15-3

- OAT: 75°F
  PA: 3,257
- Move up 75°F line until reaching the PA line of 3,250
- Go across to the left to find a density altitude value of approximately 5,000 feet

Pressure Altitude Conversion Factor

- To find pressure altitude in the airplane place 29.92 in the altimeter's Kollsman window and read the pressure altitude
- How do you compute density altitude for an airport if you aren't there to set the altimeter to 29.92 or read the temperature?
- If you have the METAR for an airport and know the temperature ***and*** altimeter setting, you can find its density altitude

Find Pressure Altitude on Density Altitude Chart

- Chart has a vertical column showing altimeter settings vs. pressure altitude conversion factors

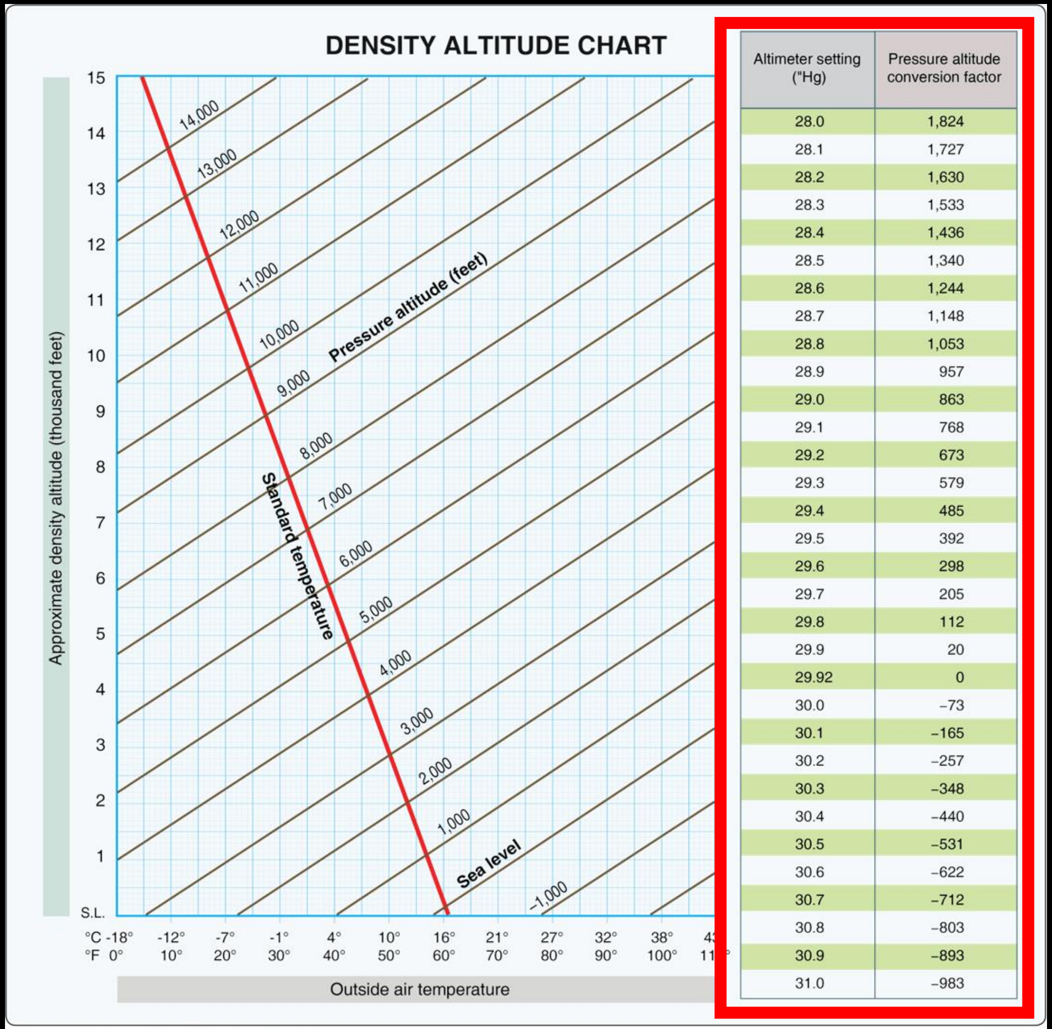

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Figure 8. Density Altitude Chart ©ASA

Find Pressure Altitude on Density Altitude Chart

- When the altimeter setting is greater than standard, pressure is higher and density altitude decreases
- When the altimeter setting is lower than standard, pressure is lower and density altitude increases

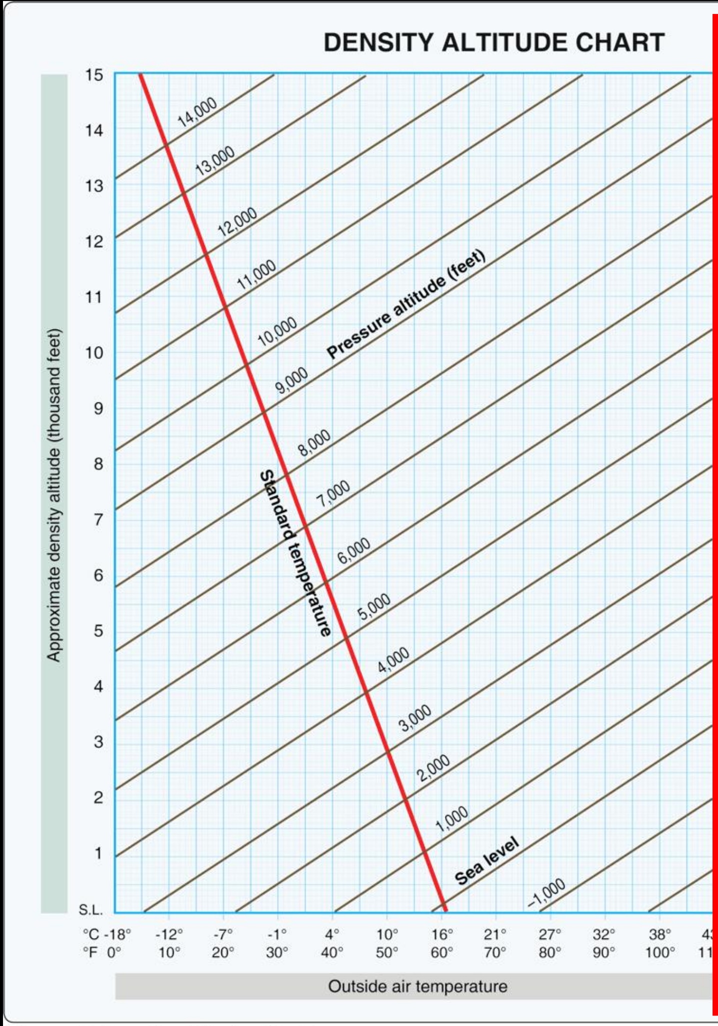

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Figure 8. Density Altitude Chart

Find Pressure Altitude on Density Altitude Chart

- Find the airport's current altimeter in the altimeter setting column to see what conversion factor must be applied to the altimeter reading to find pressure altitude

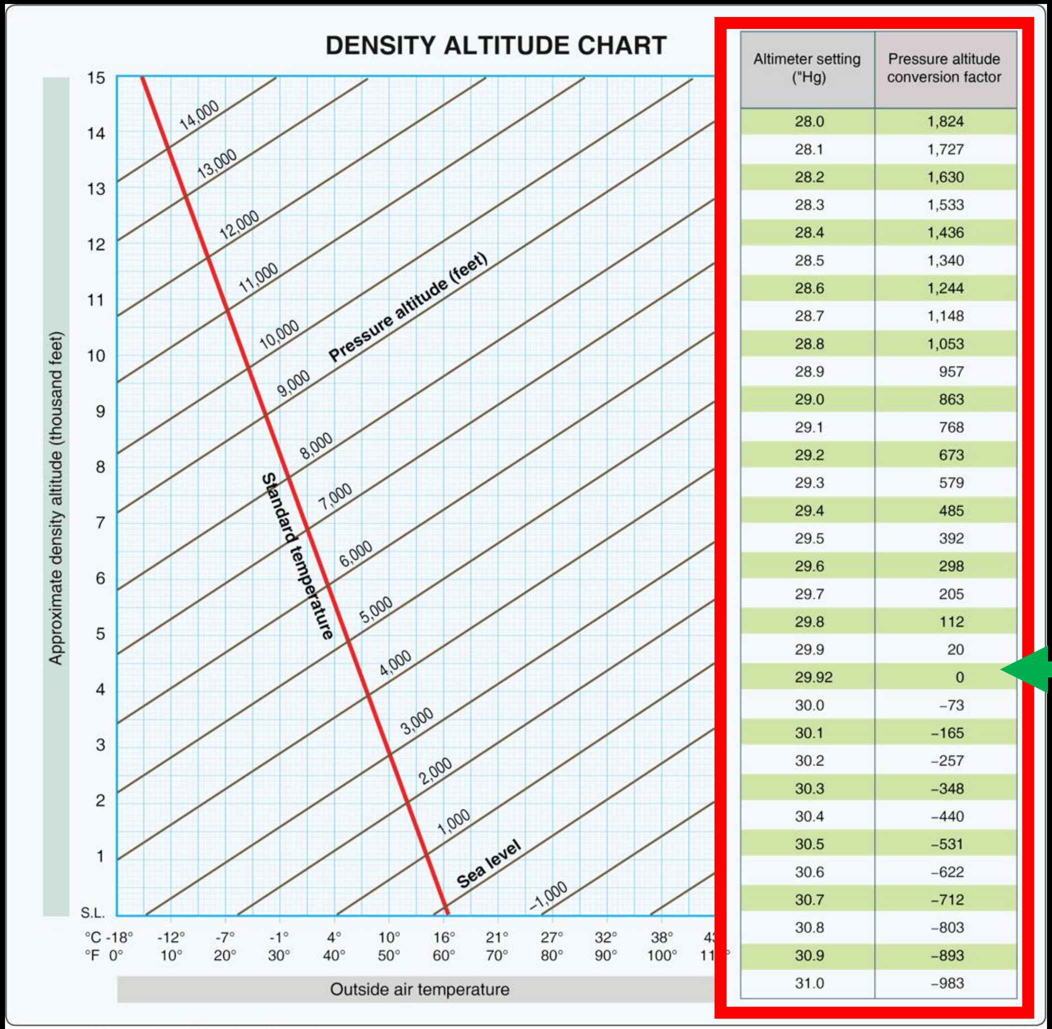

Figure 8. Density Altitude Chart

Example #3

- *Find Density altitude for the following conditions:*
  Field elevation: 7,257 feet MSL
  Altimeter: 30.20
  OAT: 80°F
- The altimeter should read the field elevation of 7,257 feet MSL with 30.20 set in the Kollsman window
- Moving the window's numbers down to 29.92 would move the hands downward
- The conversion factor specifies how much the hands would move downward

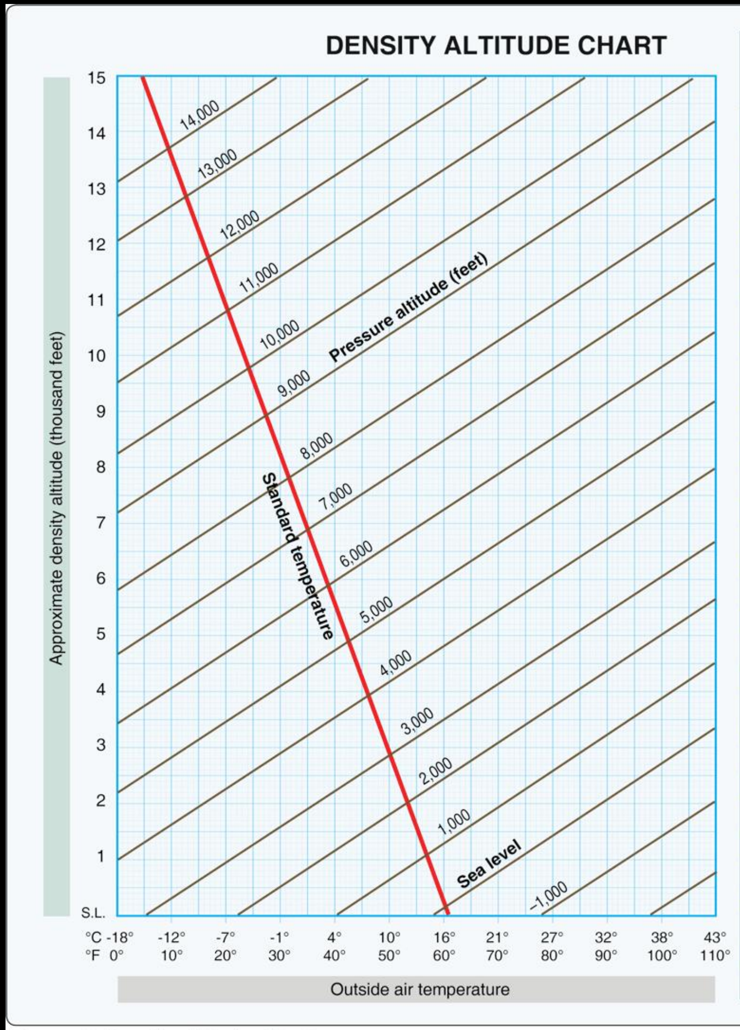

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Figure 8. Density Altitude Chart

Example #3

- *Find Density altitude for the following conditions:*
  Field elevation: 7,257 feet MSL
  Altimeter: 30.20
  OAT: 80°F
- Conversion factor for altimeter setting of 30.20 is -257 feet
- Subtract conversion factor from field elevation to find PA
- 7,257 - 257 = 7,000 PA
- Use OAT of 80°F and PA of 7,000 feet
- Density altitude is 9,750 feet

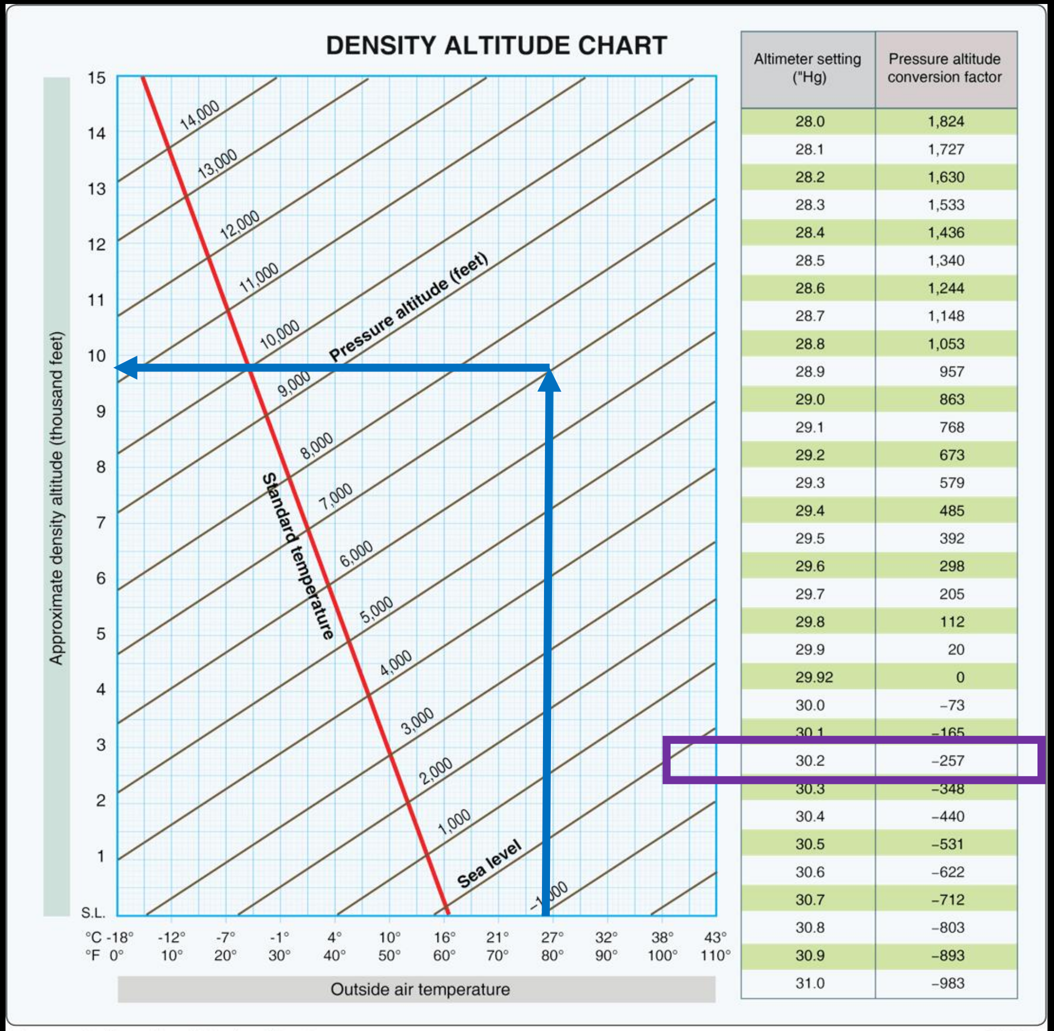
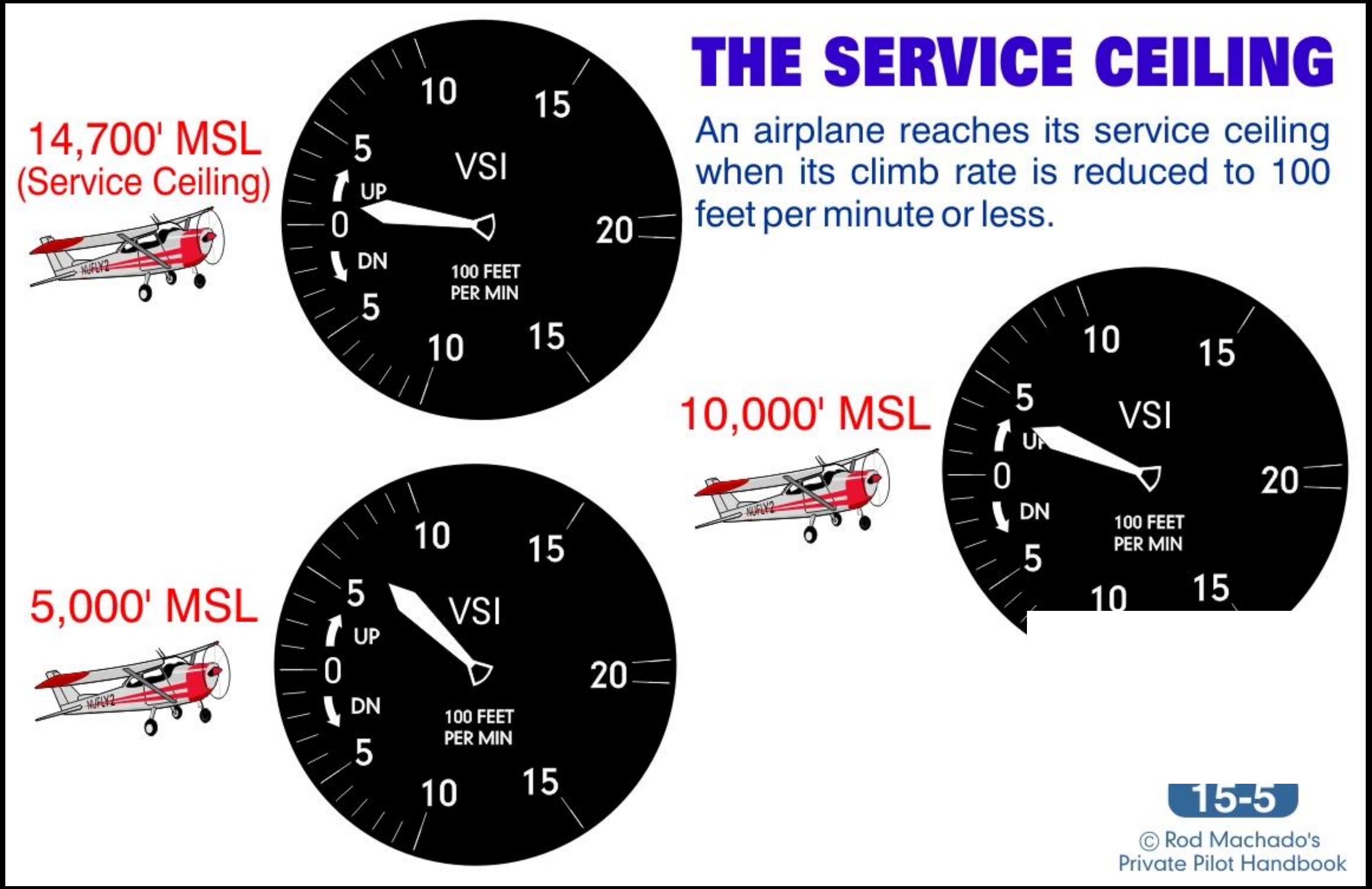


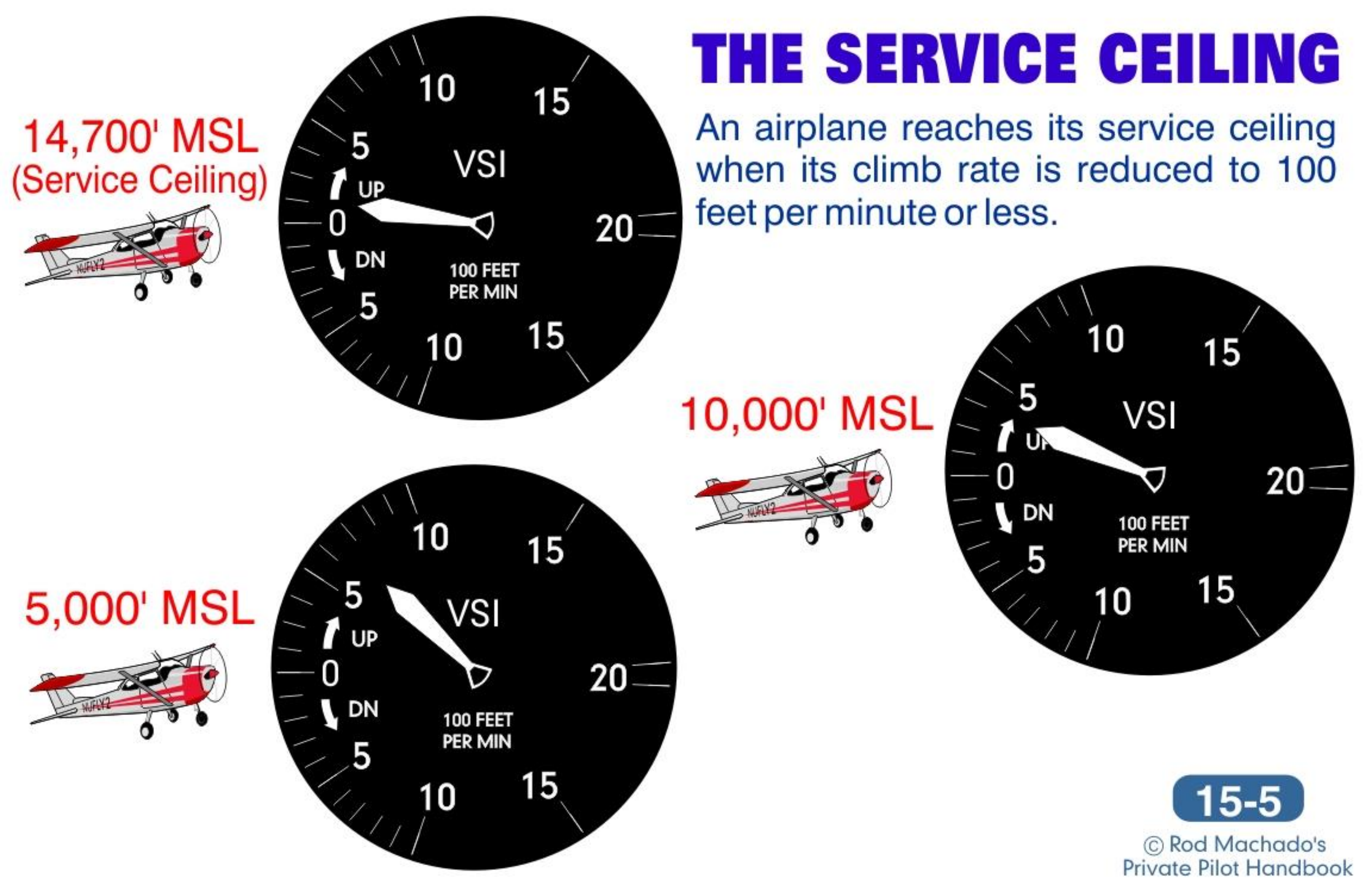
Figure 8. Density Altitude Chart ©ASA

Service Ceiling Definition

- POHs for individual airplanes list of the maximum height the airplane can be flown to before it ceases climbing
- Service ceiling is the altitude at which the climb rate drops to 100 feet per minute



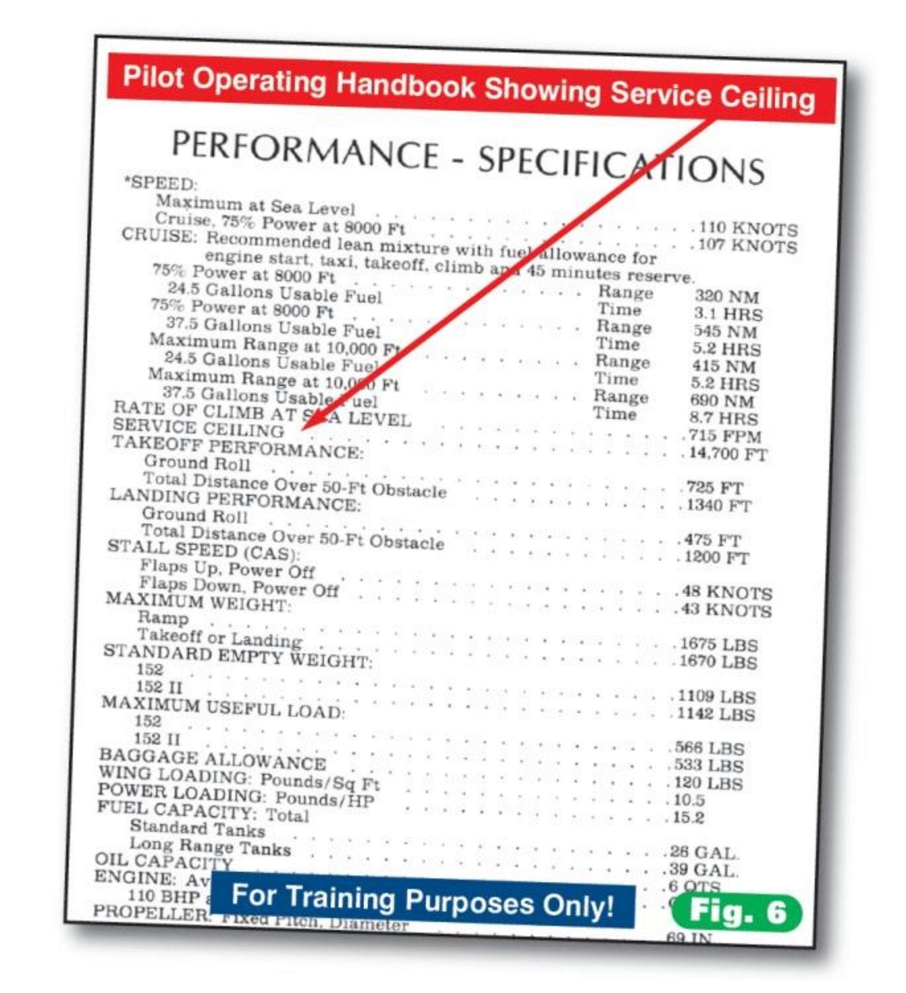
Service Ceiling Definition



- The service ceiling applies to a brand new airplane with a new engine
- Older airplanes will have service ceilings less than the POH
- Note: Absolute ceiling occurs when ROC is zero FPM

Cessna 152 POH Service Ceiling

- Cessna 152 service ceiling is 14,700 feet
- This is under ***Standard*** atmospheric conditions
- If the density altitude is close to or equal to that of the 14,700’ service ceiling, the airplane will only climb at 100 feet per minute or less


Pilot Operating Handbook Showing Service Ceiling

PERFORMANCE - SPECIFICATIONS

*SPEED:
Maximum at Sea Level
Cruise, 75% Power at 8000 Ft . . . . . 110 KNOTS
CRUISE: Recommended lean mixture with fuel allowance for . . . . . 107 KNOTS
engine start, taxi, takeoff, climb and 45 minutes reserve.
75% Power at 8000 Ft
24.5 Gallons Usable Fuel . . . . . Range 320 NM
75% Power at 8000 Ft Time 3.1 HRS
37.5 Gallons Usable Fuel . . . . . Range 545 NM
Maximum Range at 10,000 Ft Time 5.2 HRS
24.5 Gallons Usable Fuel . . . . . Range 415 NM
Maximum Range at 10,000 Ft Time 5.2 HRS
37.5 Gallons Usable Fuel . . . . . Range 690 NM
RATE OF CLIMB AT SEA LEVEL Time 8.7 HRS
SERVICE CEILING . . . . . 715 FPM
TAKEOFF PERFORMANCE: . . . . . 14,700 FT
Ground Roll
Total Distance Over 50-Ft Obstacle . . . . . 725 FT
LANDING PERFORMANCE: . . . . . 1340 FT
Ground Roll
Total Distance Over 50-Ft Obstacle . . . . . 475 FT
STALL SPEED (CAS): . . . . . 1200 FT
Flaps Up, Power Off
Flaps Down, Power Off . . . . . 48 KNOTS
MAXIMUM WEIGHT: . . . . . 43 KNOTS
Ramp
Takeoff or Landing . . . . . 1675 LBS
STANDARD EMPTY WEIGHT: . . . . . 1670 LBS
152
152 II . . . . . 1109 LBS
MAXIMUM USEFUL LOAD: . . . . . 1142 LBS
152
152 II . . . . . 566 LBS
BAGGAGE ALLOWANCE . . . . . 533 LBS
WING LOADING: Pounds/Sq Ft . . . . . 120 LBS
POWER LOADING: Pounds/HP 10.5
FUEL CAPACITY: Total 15.2
Standard Tanks
Long Range Tanks . . . . . 26 GAL.
OIL CAPACITY . . . . . 39 GAL.
ENGINE: Av . . . . . 6 QTS
110 BHP
PROPELLER: Fixed Pitch, Diameter
69 IN

For Training Purposes Only!

Fig. 6

Density Altitude Problem #3

- Suppose you're flying a new Cessna 152 from an airport where the pressure altitude is 10,000 feet and the OAT is 95°F
- What is the density altitude at that airport? Over 14,000 feet!
- The airplane, if it gets off the runway at all, will barely climb 100 feet per minute

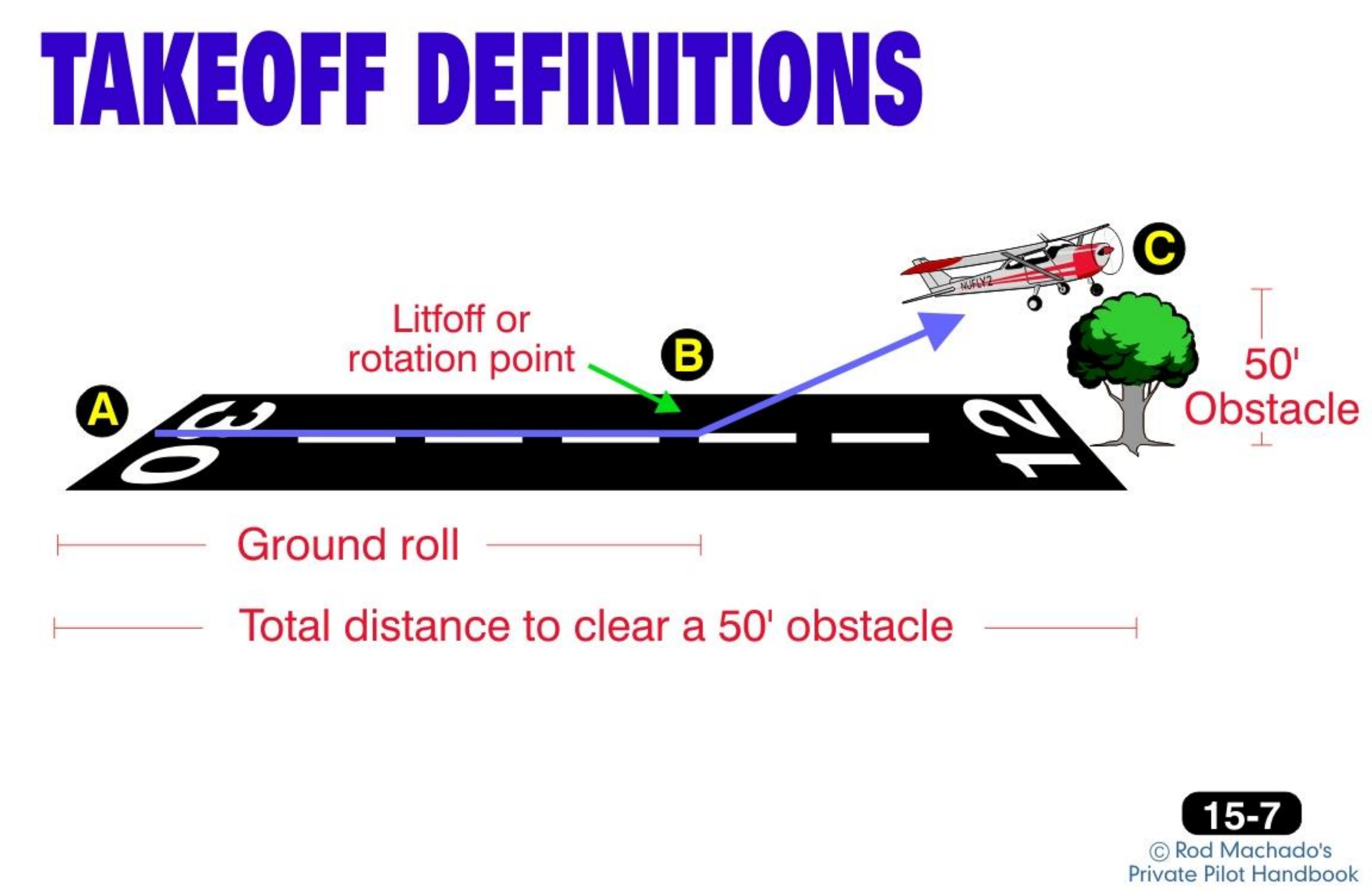
Density Altitude Factors

- High Density Altitude
- *High elevations*
- *Low atmospheric pressures*
- *High temperatures*
- *High humidity*

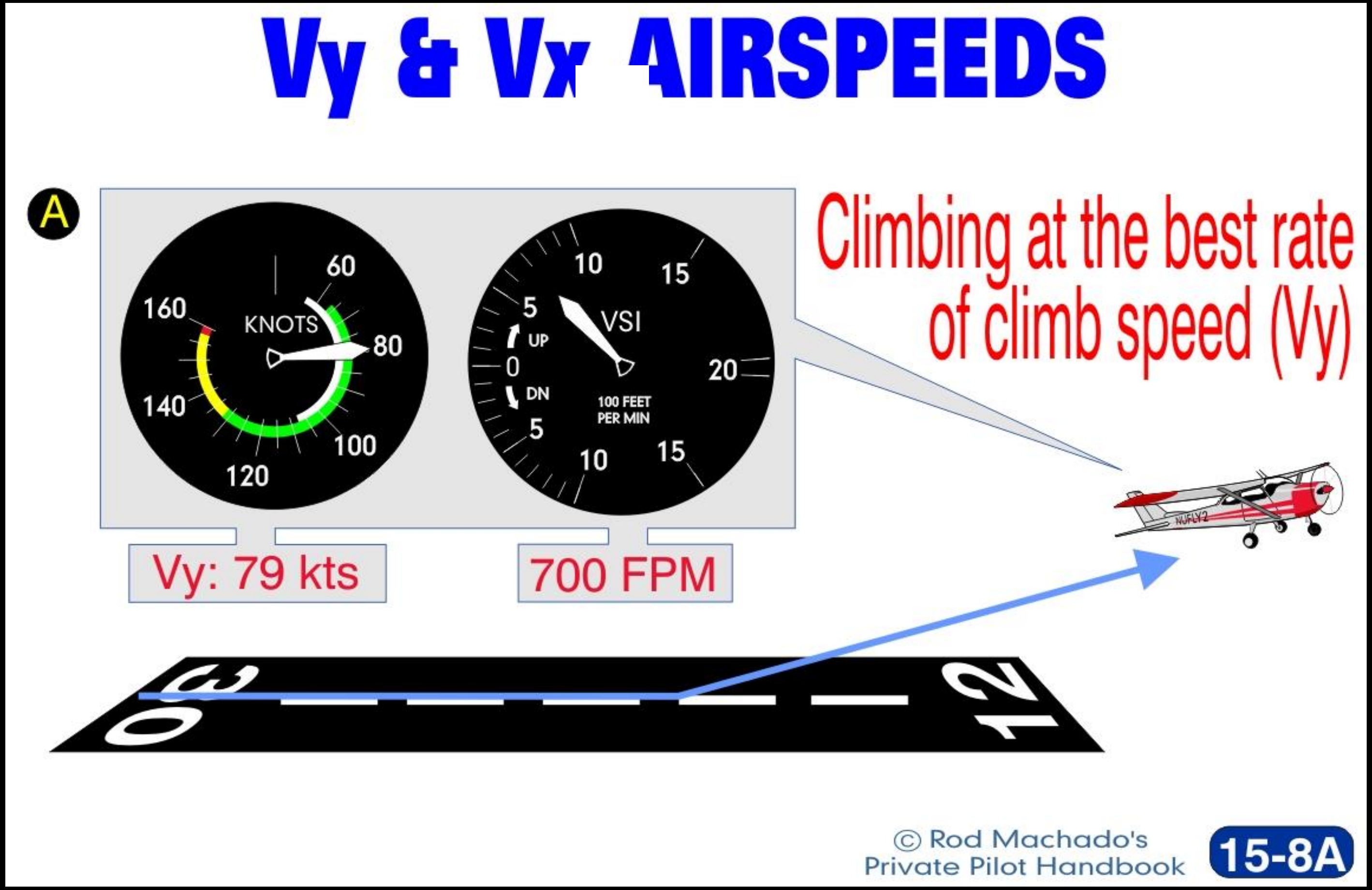
- Low Density Altitude
- *Lower elevations*
- *High atmospheric pressure*
- *Low temperatures*
- *Low humidity*

Takeoff Definitions

- Ground roll is the total distance required for the airplane to become airborne
- Point where the airplane reaches 50 feet above the runway is the total distance required for the airplane to clear a 50-foot obstacle



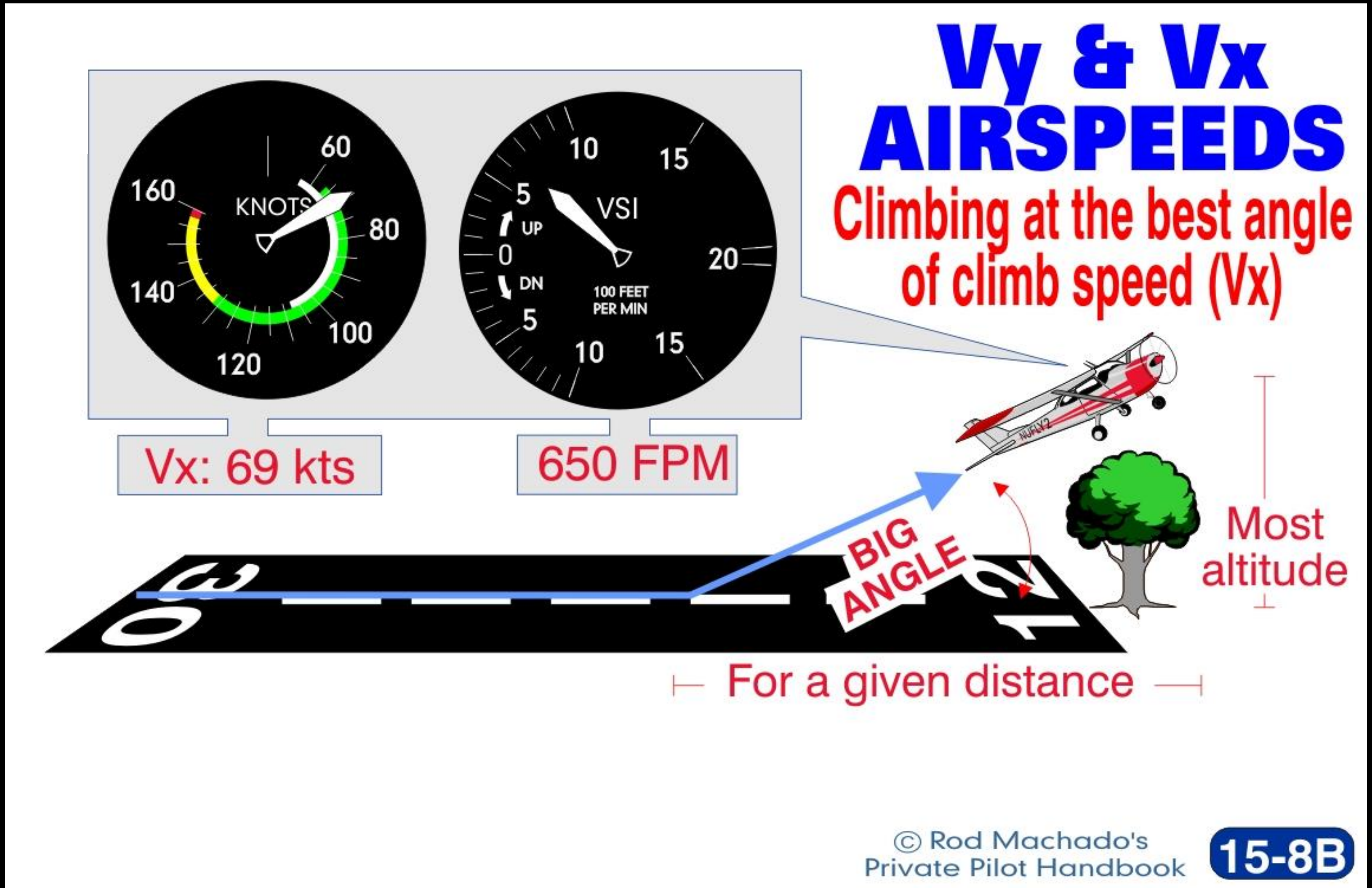
Best *Rate* Of Climb Speed V_Y



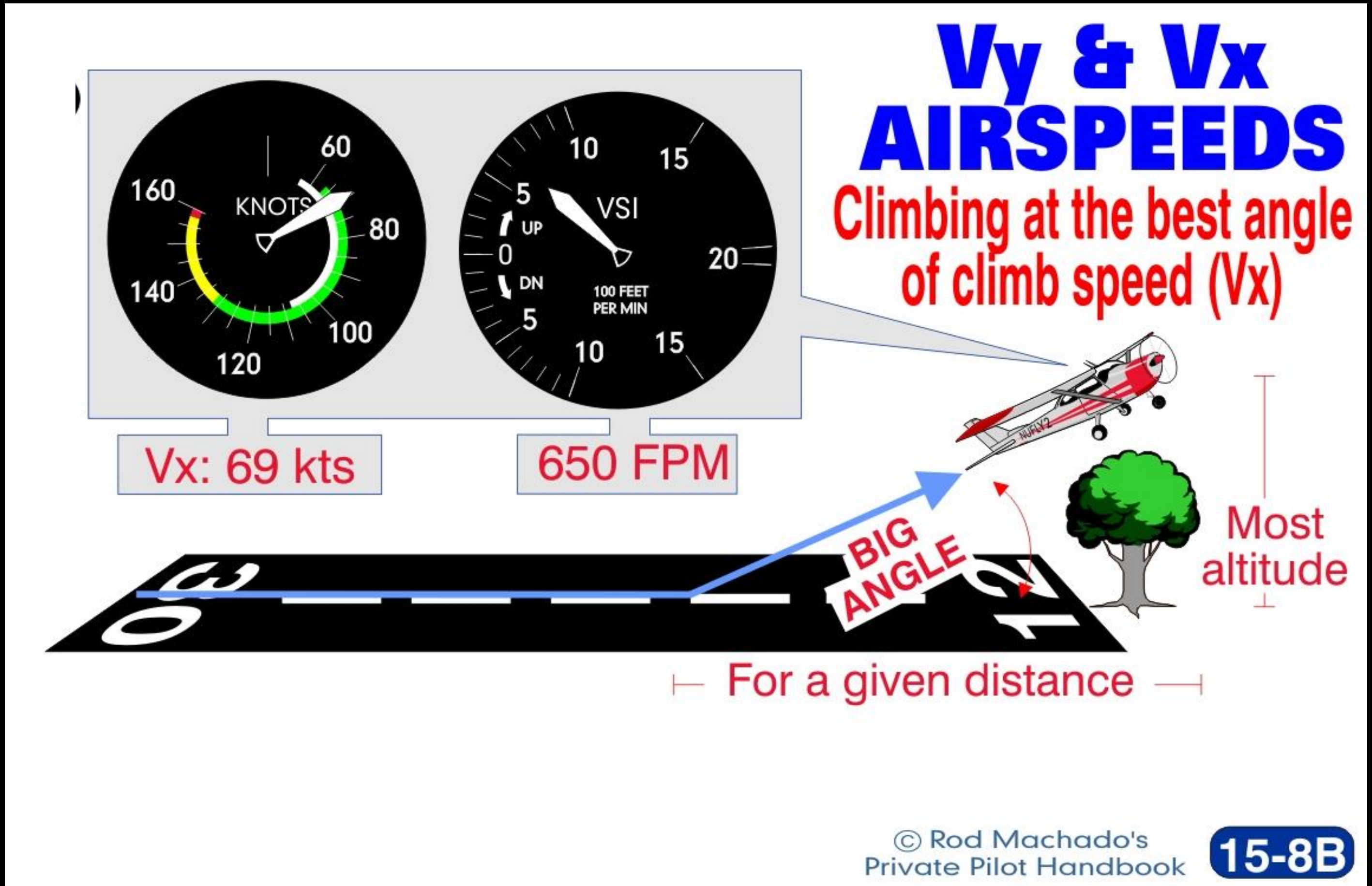
- Best rate of climb speed (Vy) gives you the greatest altitude gain for a given amount of time
- Gives you the largest deflection on the VSI

Best *Angle* Of Climb Speed V_X

- Best angle of climb speed (Vx) gives you the greatest altitude gain for a given distance over the ground
- Gives you the largest climb angle possible
- Altitude gain for a given distance over the ground is a concern with an obstacle at the departure end
- Used for short field takeoffs



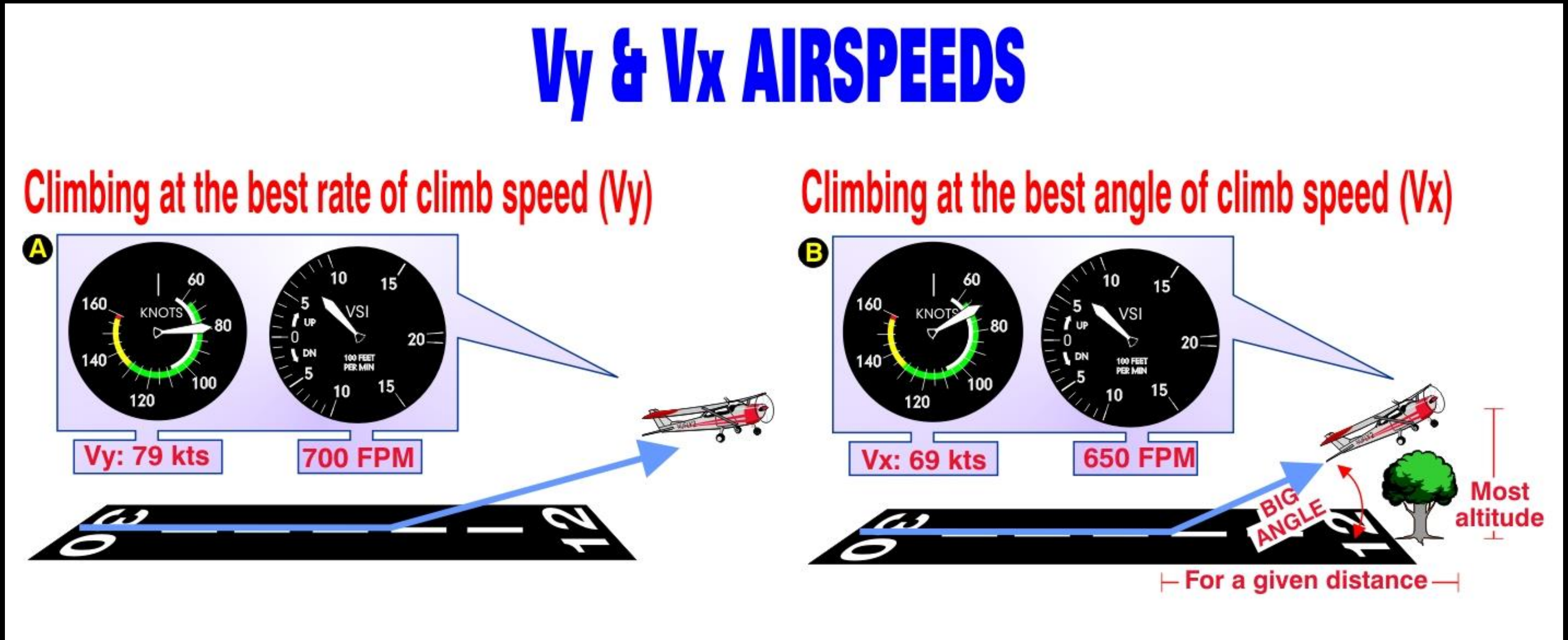
Best *Angle* Of Climb Speed V_X



- Airplane climbs at a larger angle because Vx is slower than Vy
- With a slower forward speed, it gains more altitude per foot of forward distance
- Some POHs recommend small flap settings to facilitate a short-field climb over an obstacle

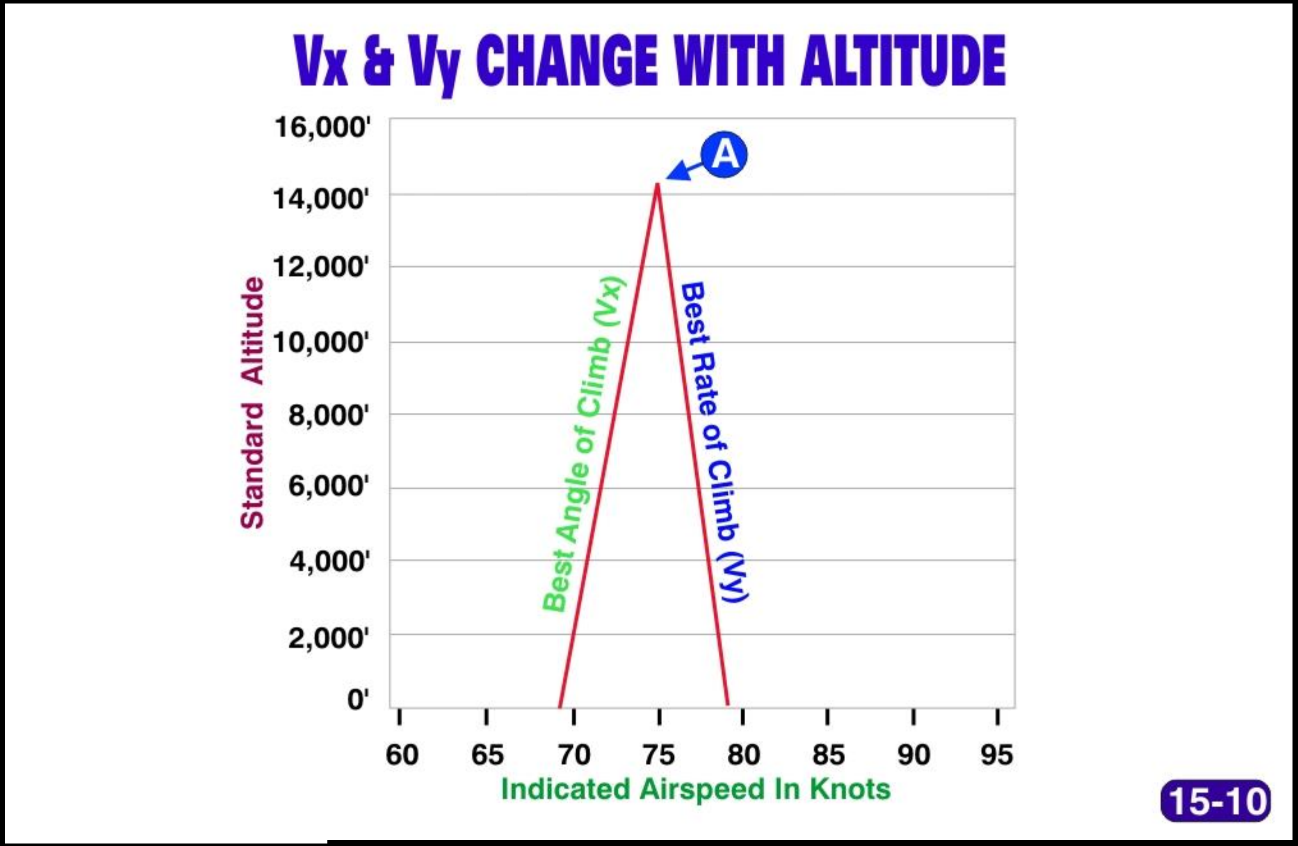
V_X and V_Y Climb Rates

- V_X is slower than V_Y
- Even though the nose attitude is generally higher at Vx, the airplane won't have as large a rate of climb deflection on the VSI as it would at Vy

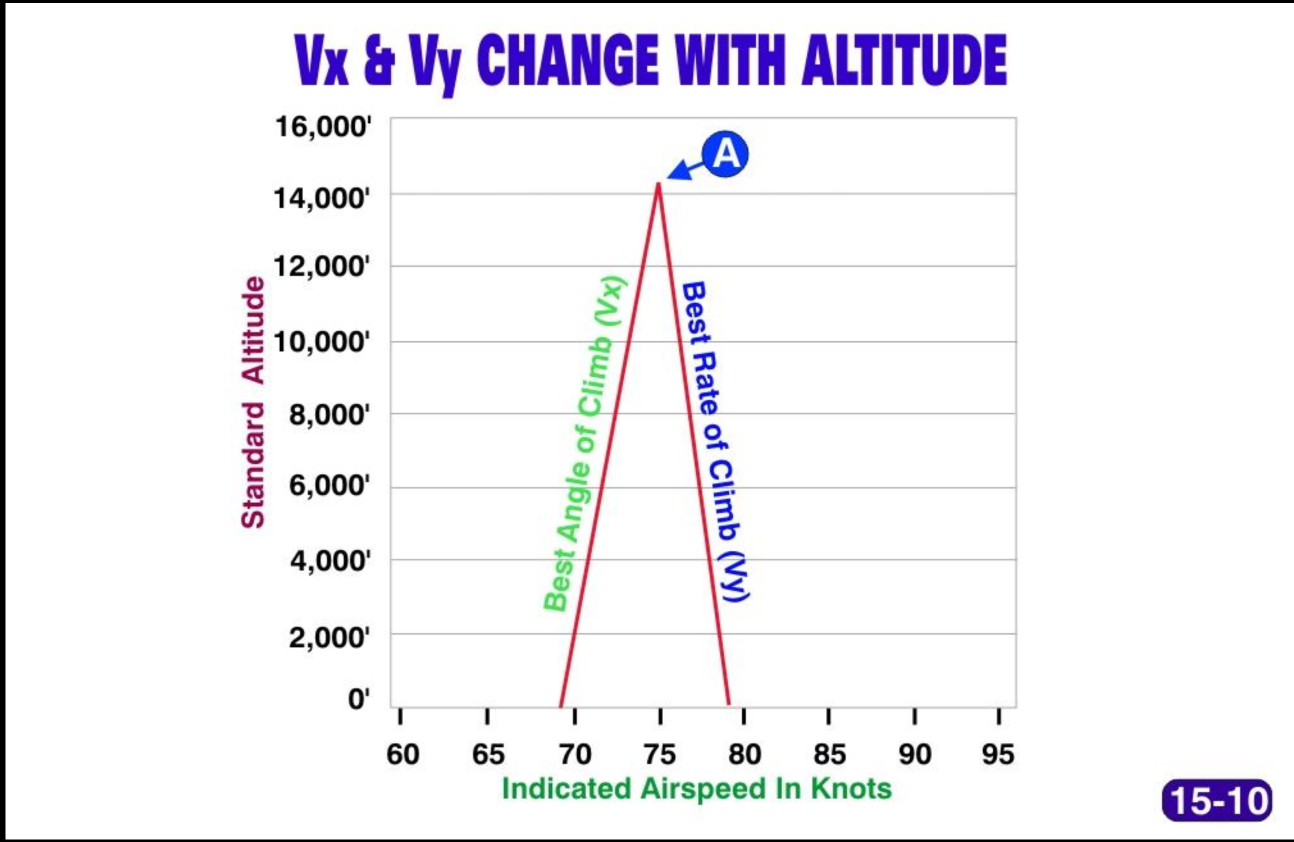


Vx and Vy Change With Altitude

- Best angle and best rate of climb speeds change slightly with altitude and weight
- The airplane's ability to climb is predicated on excess thrust (power)
- Changing altitude or weight changes the amount of excess thrust (power) available for a climb
- This affects the speeds at which Vx and Vy occur



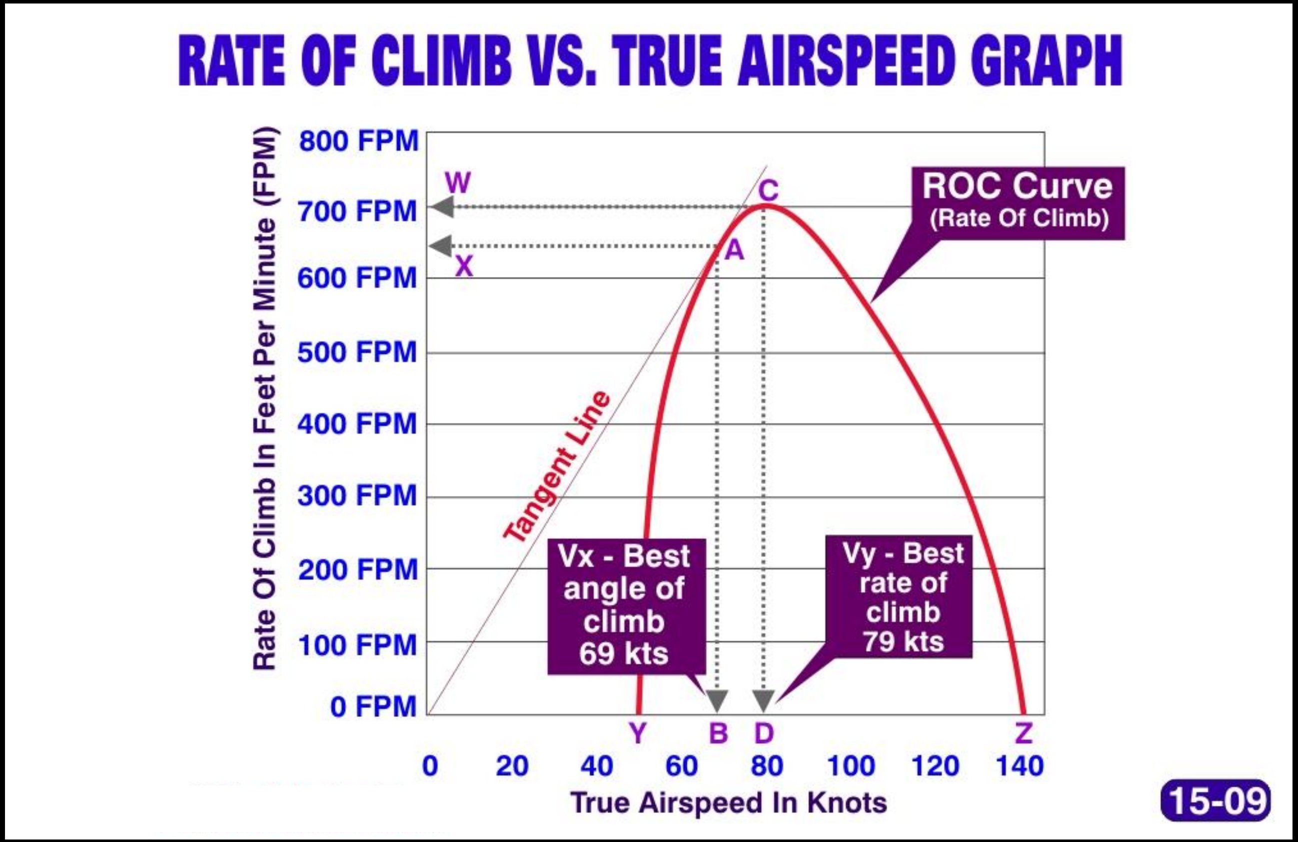
Vx and Vy Change With Altitude



- IAS for Vx increases with an increase in altitude
- IAS for Vy decreases with altitude
- The point where they meet is the altitude where the airplane can no longer climb
- This is known as the absolute ceiling

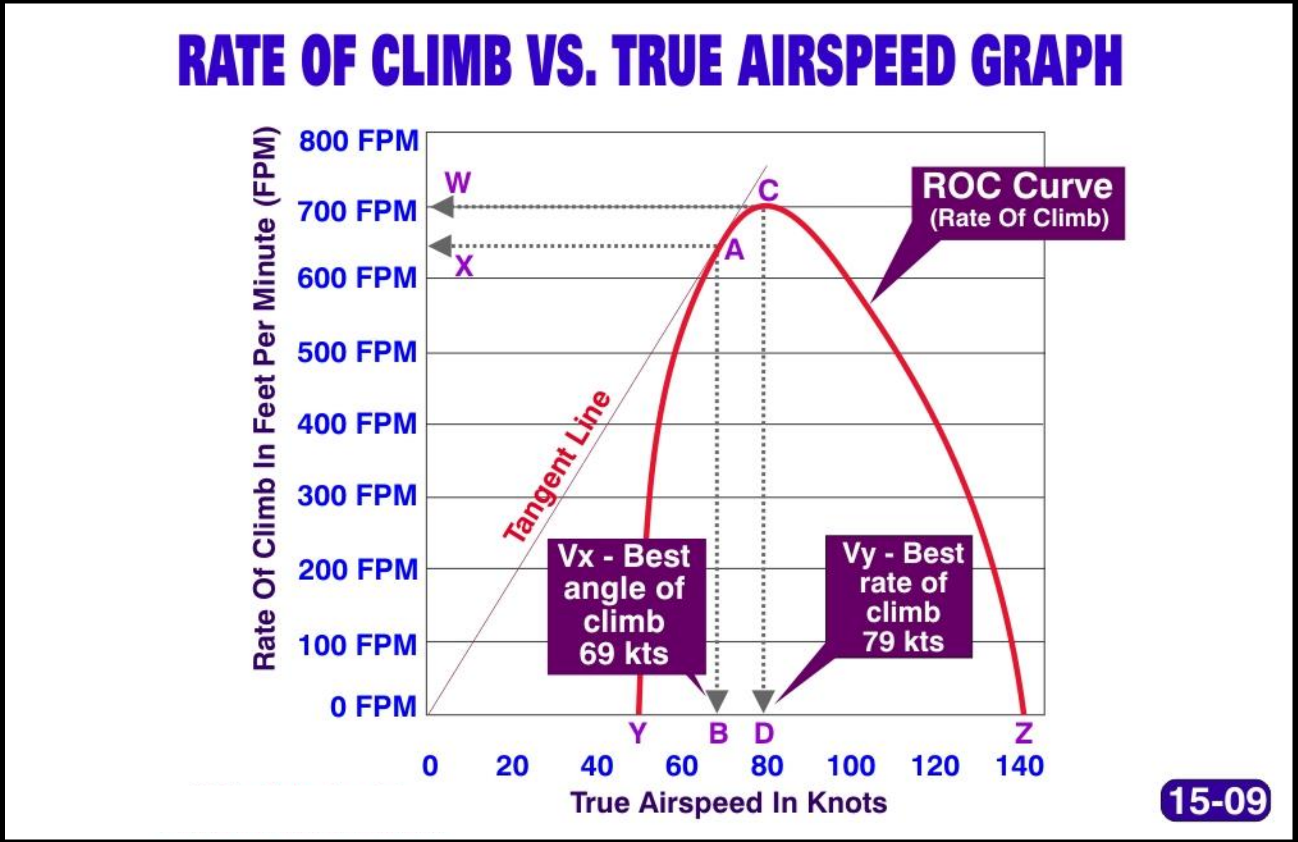
ROC vs. TAS

- Graph shows ROC for different airspeeds at a specific altitude at full throttle
- No ROC at Z since all the airplane's power is used to achieve maximum forward speed
- Slowing to C, parasite drag decreases and the excess thrust (thrust not used to overcome drag) has been converted into a ROC



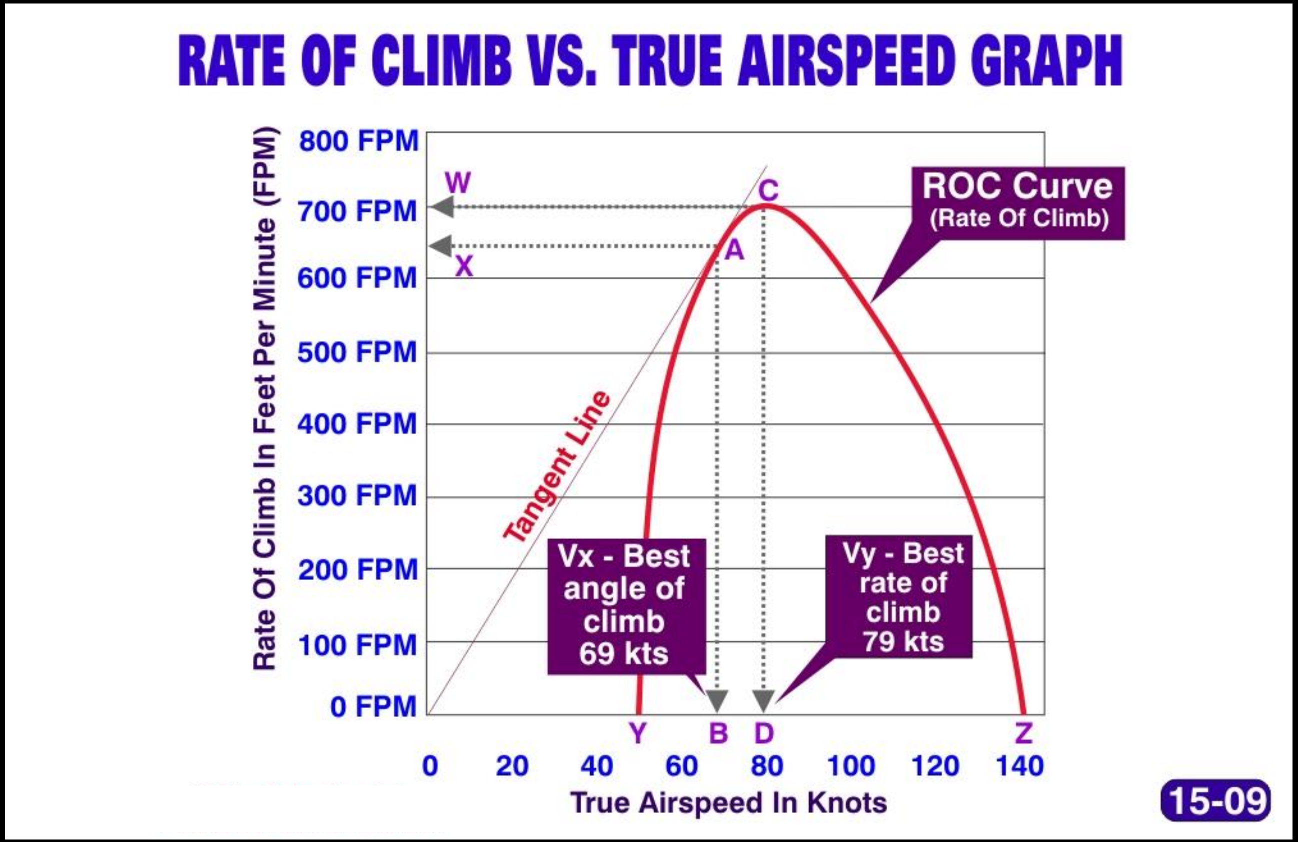
ROC vs. TAS

- Continued slowing further reduces the ROC because of the increasing induced drag
- At Y the airplane has no ROC since all the airplane's power is used in overcoming an enormous amount of induced drag (operating behind the power curve)



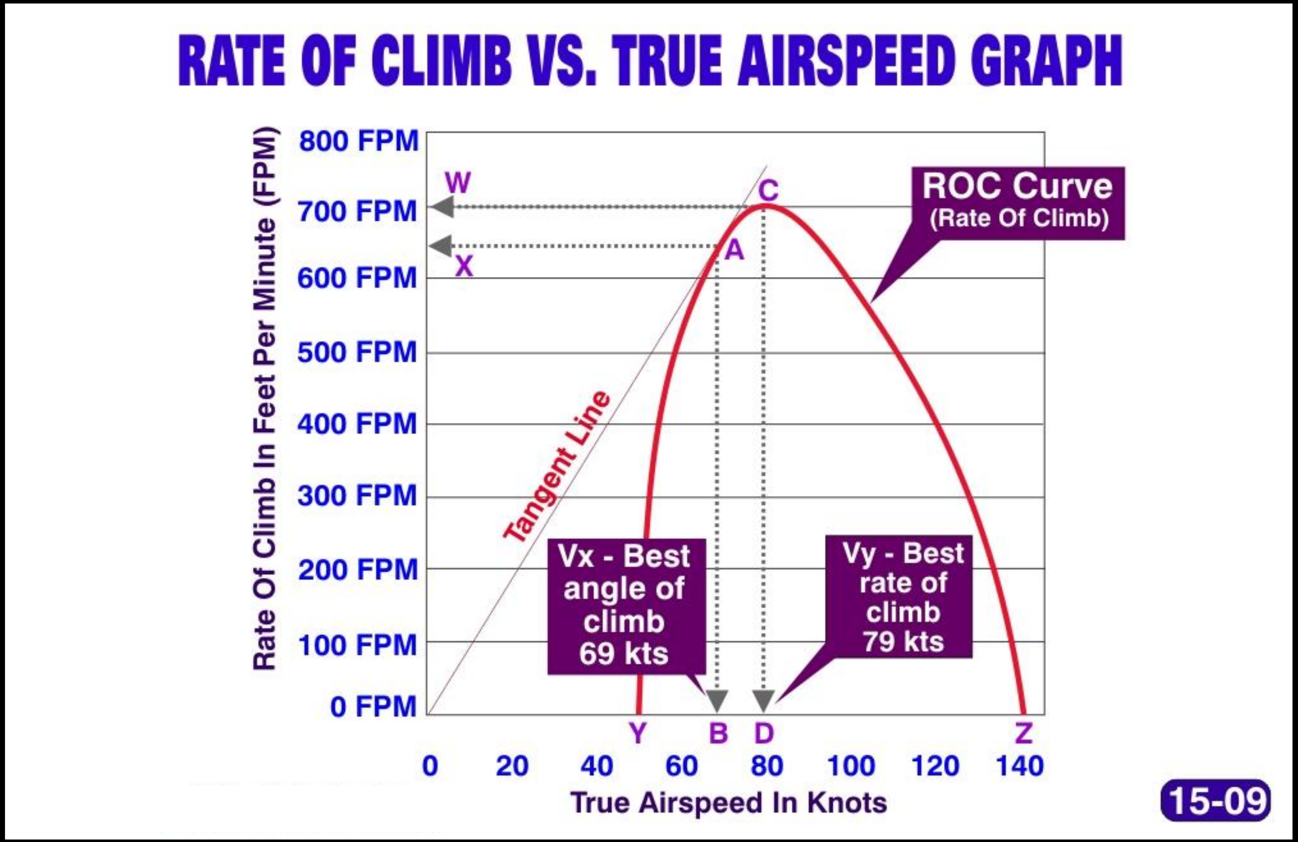
ROC vs. TAS

- The sea level, best rate of climb is found at point C
- Dropping directly down to point D identifies the Vy speed for this airplane



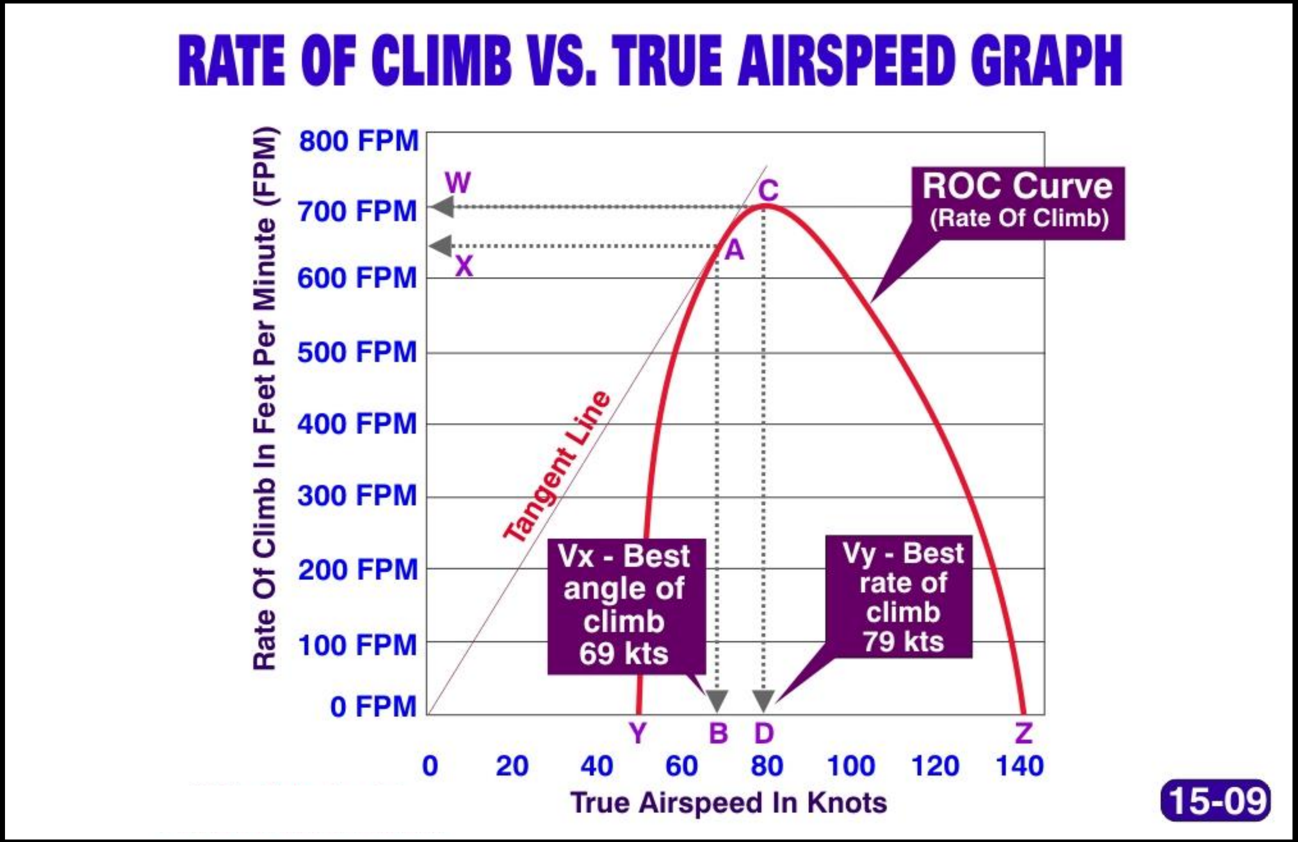
ROC vs. TAS

- The tangent line has the steepest slope (largest angle upward) where it contacts the ROC curve at point A
- At this point, the airplane experiences its best angle of climb
- Dropping downward from point A to point B identifies the airplane's speed for Vx



ROC vs. TAS

- Most of the time it's preferable to climb at some speed slightly above Vy
- This is called a cruise-climb speed and provides you better forward visibility during the climb
- On hot days it also keeps the engine cooler, preventing overheating and possible detonation



Maximum ROC Chart

- ROC decreases with an increase in PA
- Vy is found at a slower indicated airspeed (KIAS) at higher altitudes
- Under the ROC column are several temperature columns with variable climb rates
- ROC varies with temperature.

SECTION 5
PERFORMANCE

CESSNA
MODEL 152

RATE OF CLIMB

MAXIMUM

CONDITIONS:
Flaps Up
Full Throttle

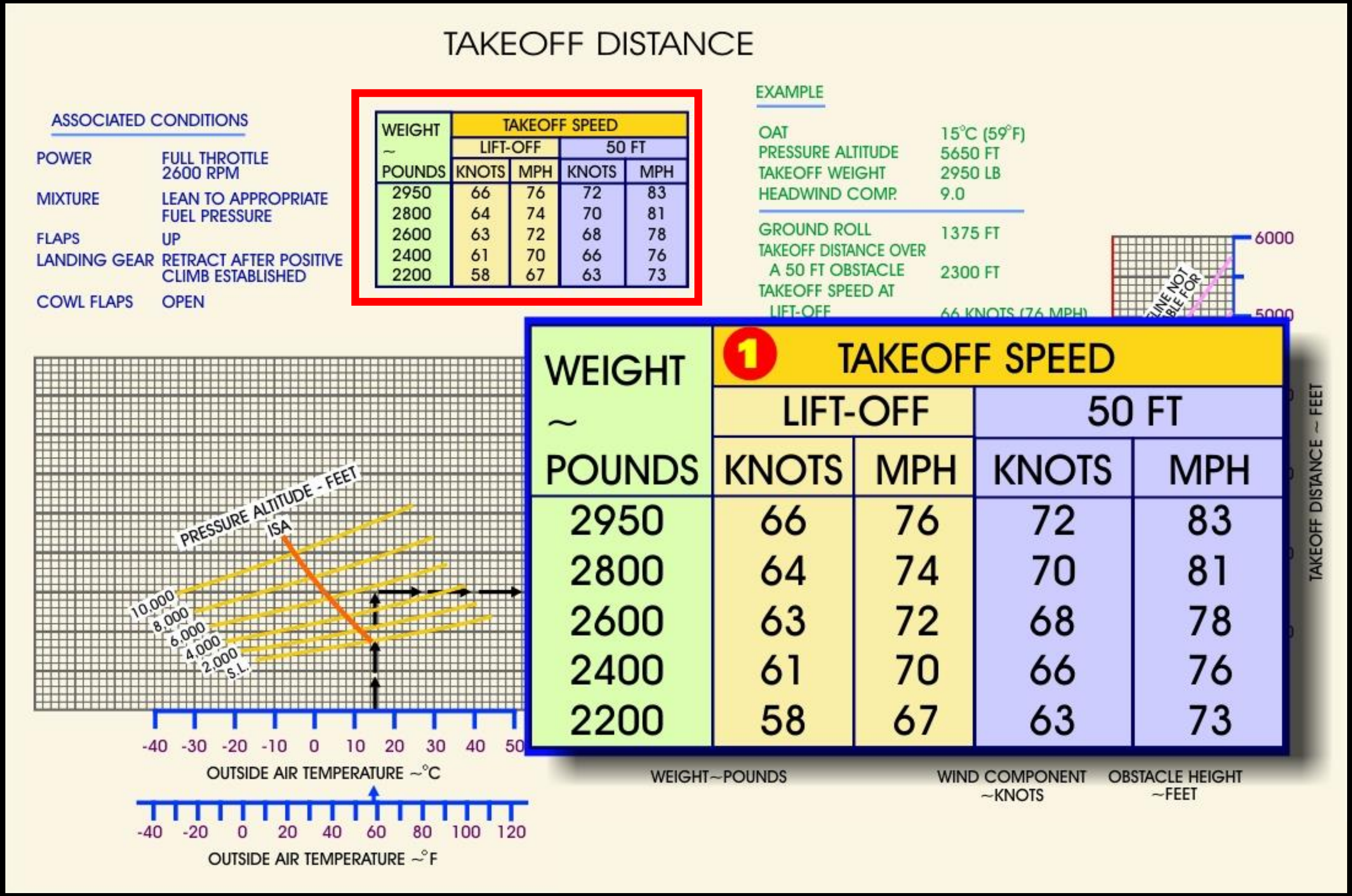
NOTE:
Mixture leaned above 3000 feet for maximum RPM.

WEIGHT LBS	PRESS ALT FT	CLIMB SPEED KIAS	RATE OF CLIMB - FPM			
			-20°C	0°C	20°C	40°C
1670	S.L.	67	835	765	700	630
	2000	66	735	670	600	535
	4000	65	635	570	505	445
	6000	63	535	475	415	355
	8000	62	440	380	320	265
	10,000	61	340	285	230	175
	12,000	60	245	190	135	85

Figure 5-5. Rate of Climb

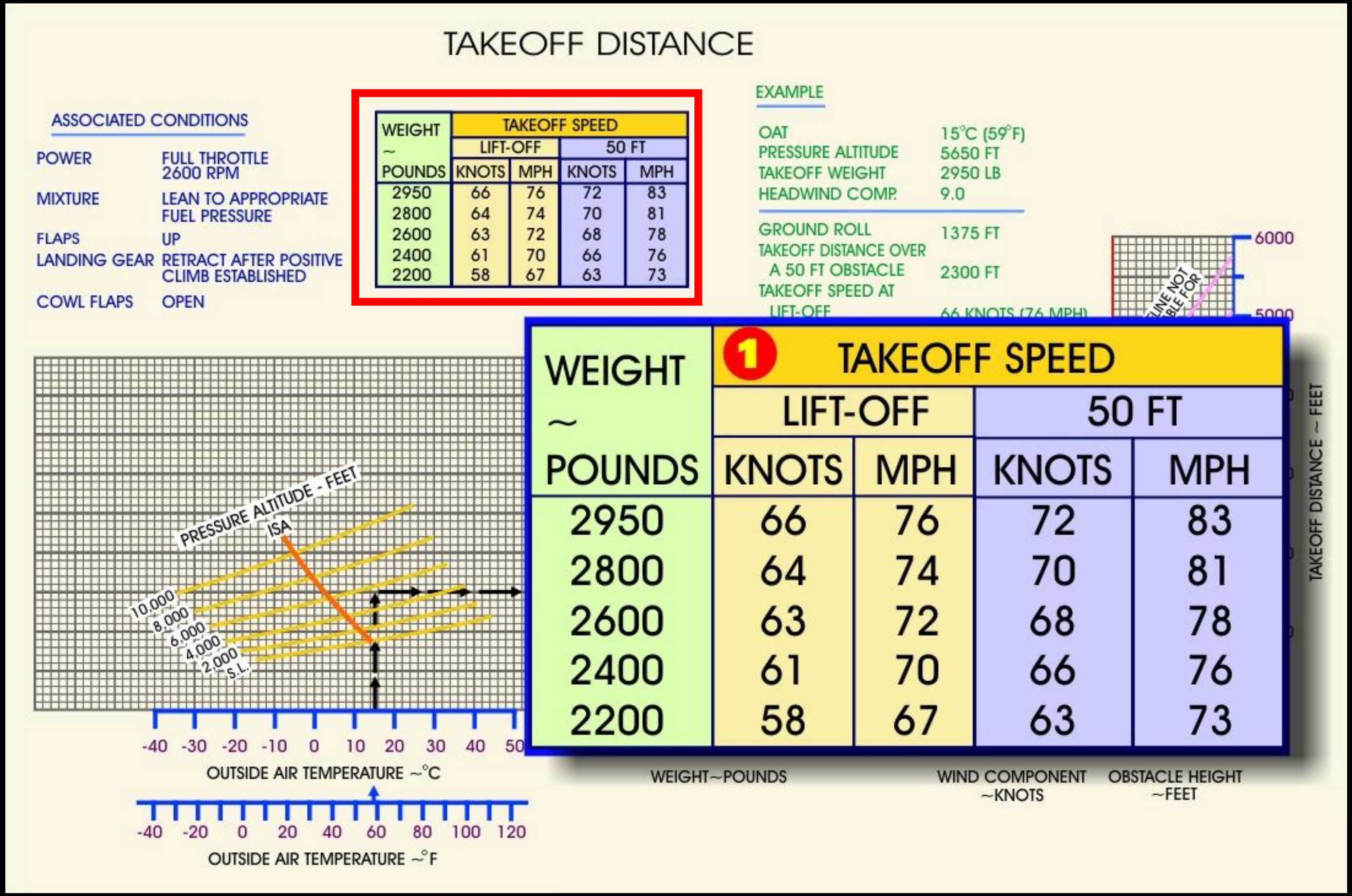
Variable Vx Speeds

- Many POHs don't show the slight increase in the IAS for Vx with an increase in altitude because the increase is small
- They do often show the change in Vx with a change in airplane weight
- This takeoff distance chart shows the variable Vx speeds under the 50 FT column
- These speeds decrease with a decrease in airplane weight (Vy also decreases with a weight decrease)



Variable Vx Speeds

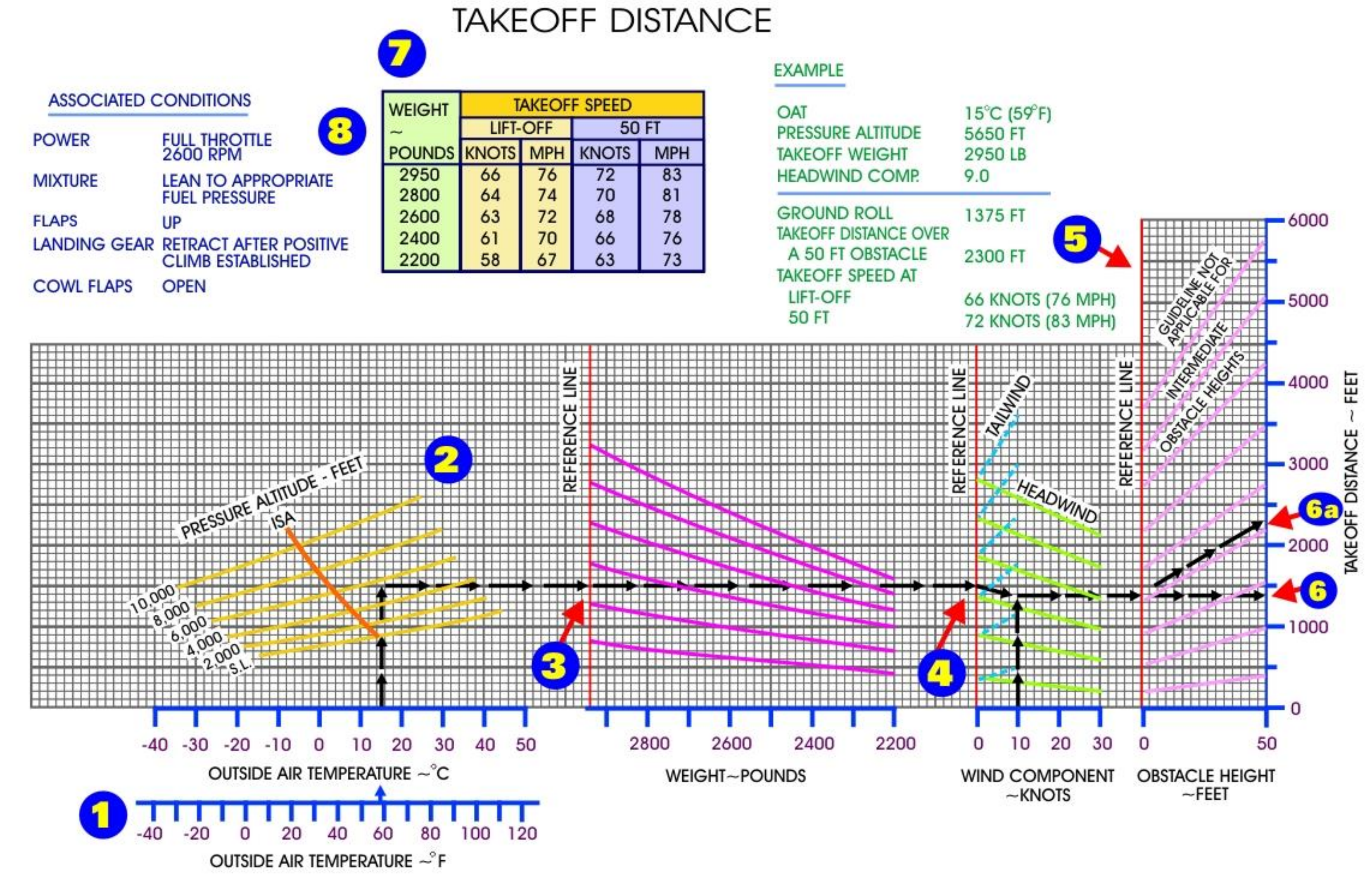
- An airplane will climb at less of a rate or angle with the gear down
- On retractable gear airplanes, retract the gear as soon as it's safe after departure
- Flaps are sometimes used for takeoff when suggested by the POH
- They should be retracted after liftoff when the airplane has accelerated to the recommended climb speed



Takeoff and Landing Performance

Takeoff Distance Chart

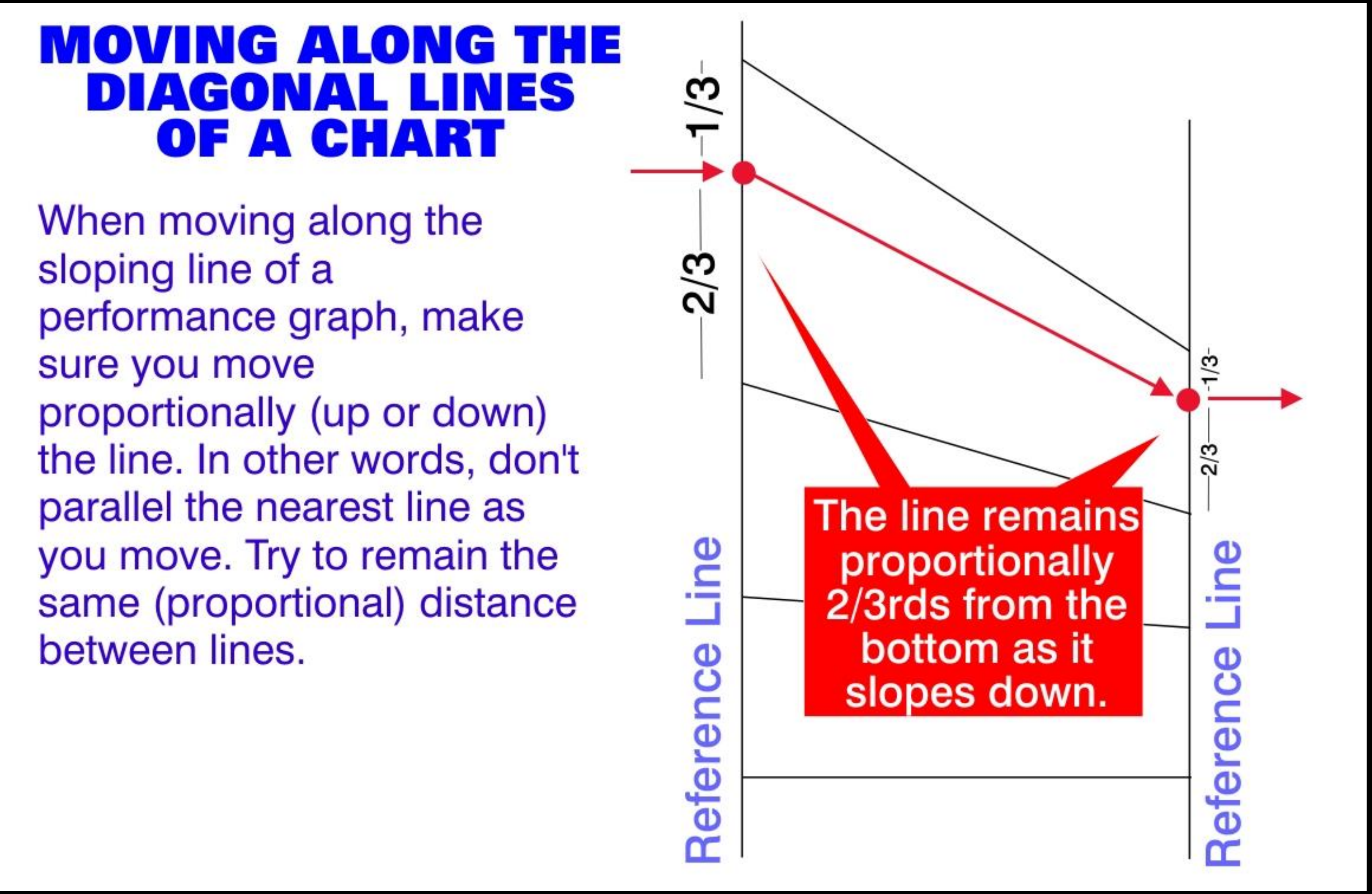
- Provides the takeoff ground roll under variable airplane and airport conditions: Temperature Pressure Altitude Weight Headwind/Tailwind Obstacle
- Also provides the best angle of climb speeds based on various weight conditions



WEIGHT ~ POUNDS	TAKEOFF SPEED			
	LIFT-OFF		50 FT	
	KNOTS	MPH	KNOTS	MPH
2950	66	76	72	83
2800	64	74	70	81
2600	63	72	68	78
2400	61	70	66	76
2200	58	67	63	73

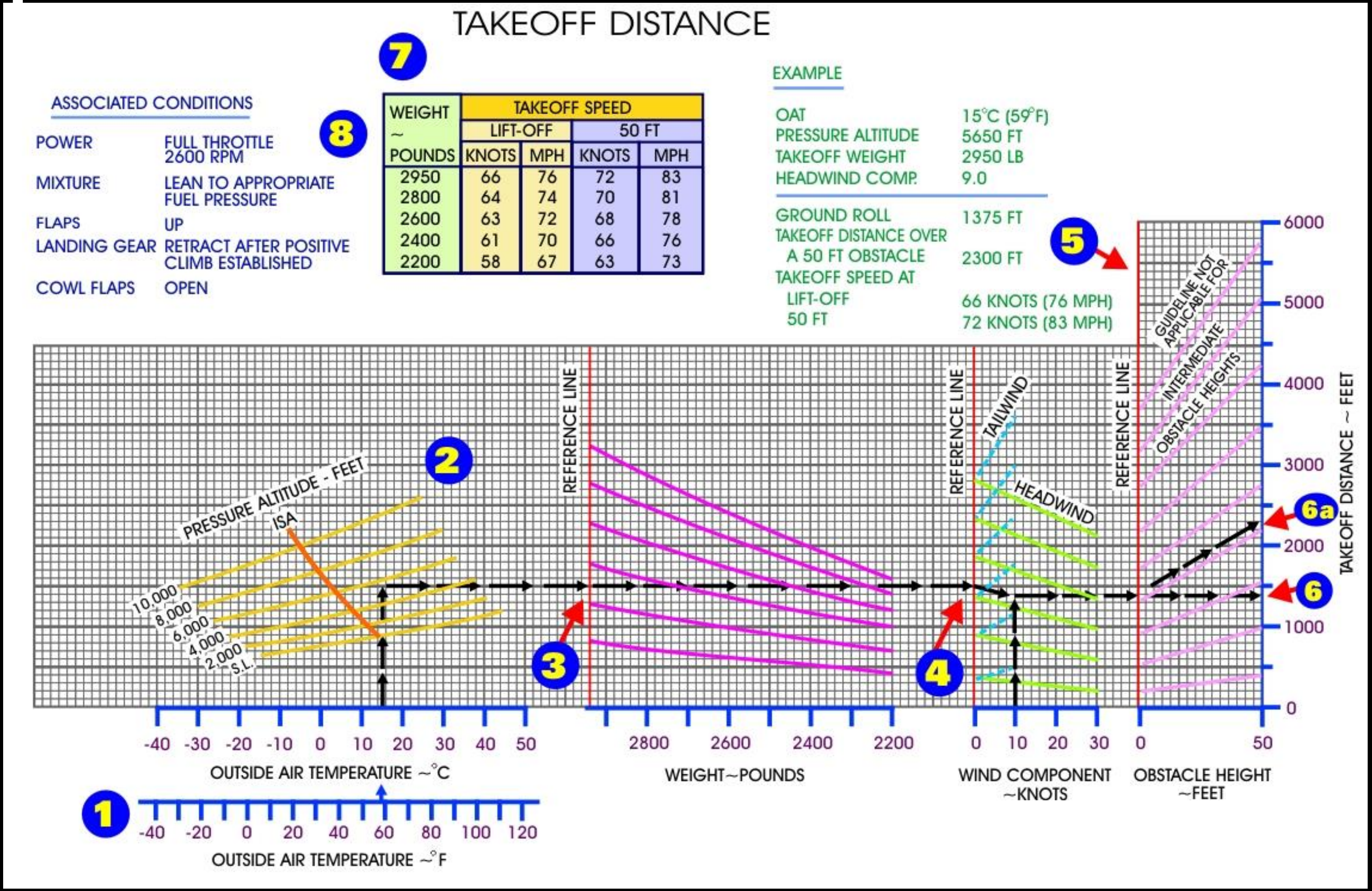
Movement Along the Diagonal Lines on Chart

- Movement along these lines should be proportional, not parallel
- Remain the same proportional distance between lines



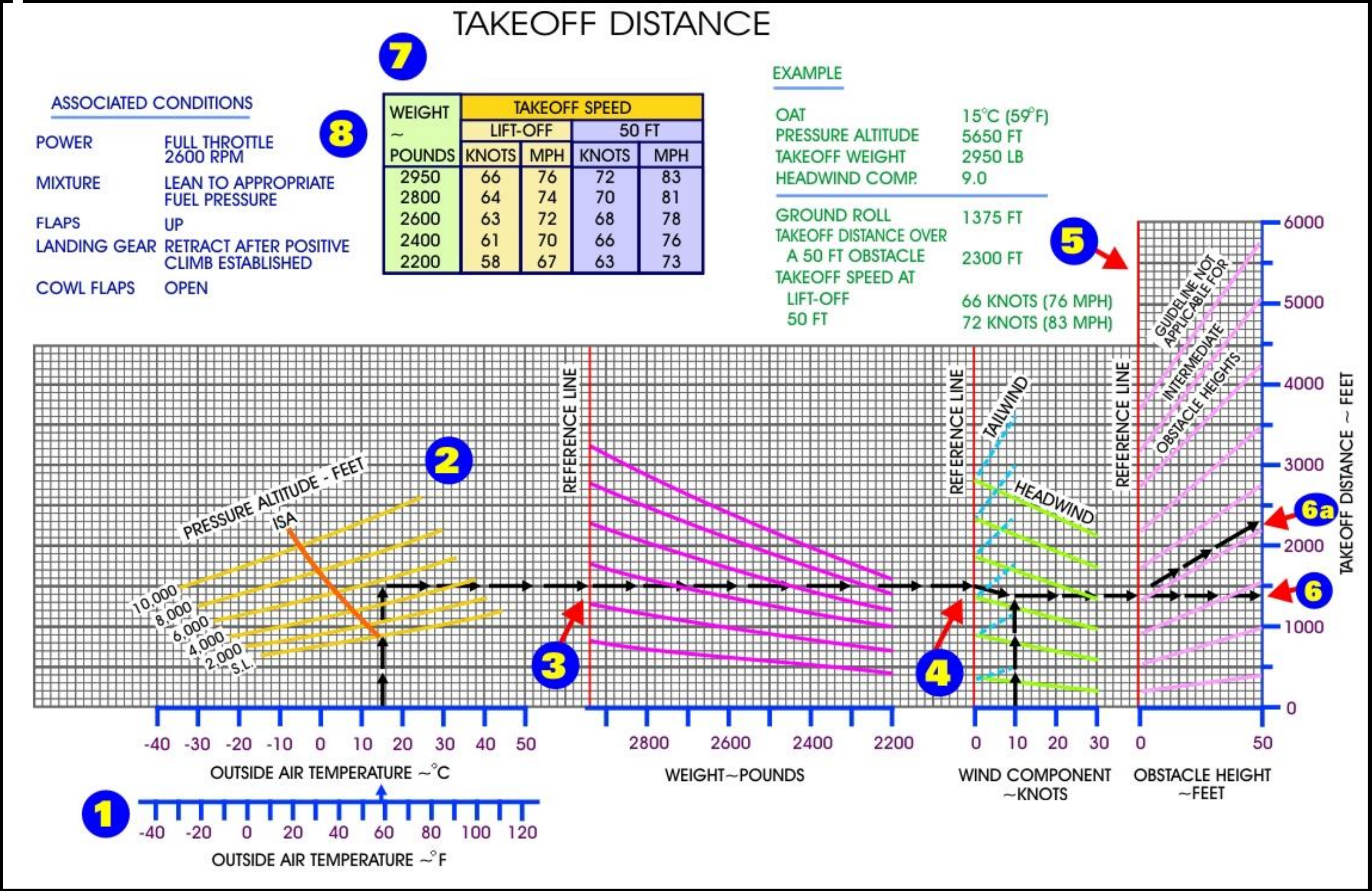
Example #1

- *Find ground roll and distance to clear a 50-foot obstacle:*
  OAT: 59F (15C)
  PA: 5,650 feet
  Takeoff weight: 2,950 pounds
  Headwind component: 9 knots
- Find 59F (15C) on bottom of chart (1)
- Move directly up to the 5,650' PA line (2)
- The 5,650' PA line is a little above a point halfway between the 5,000 and 6,000 foot lines



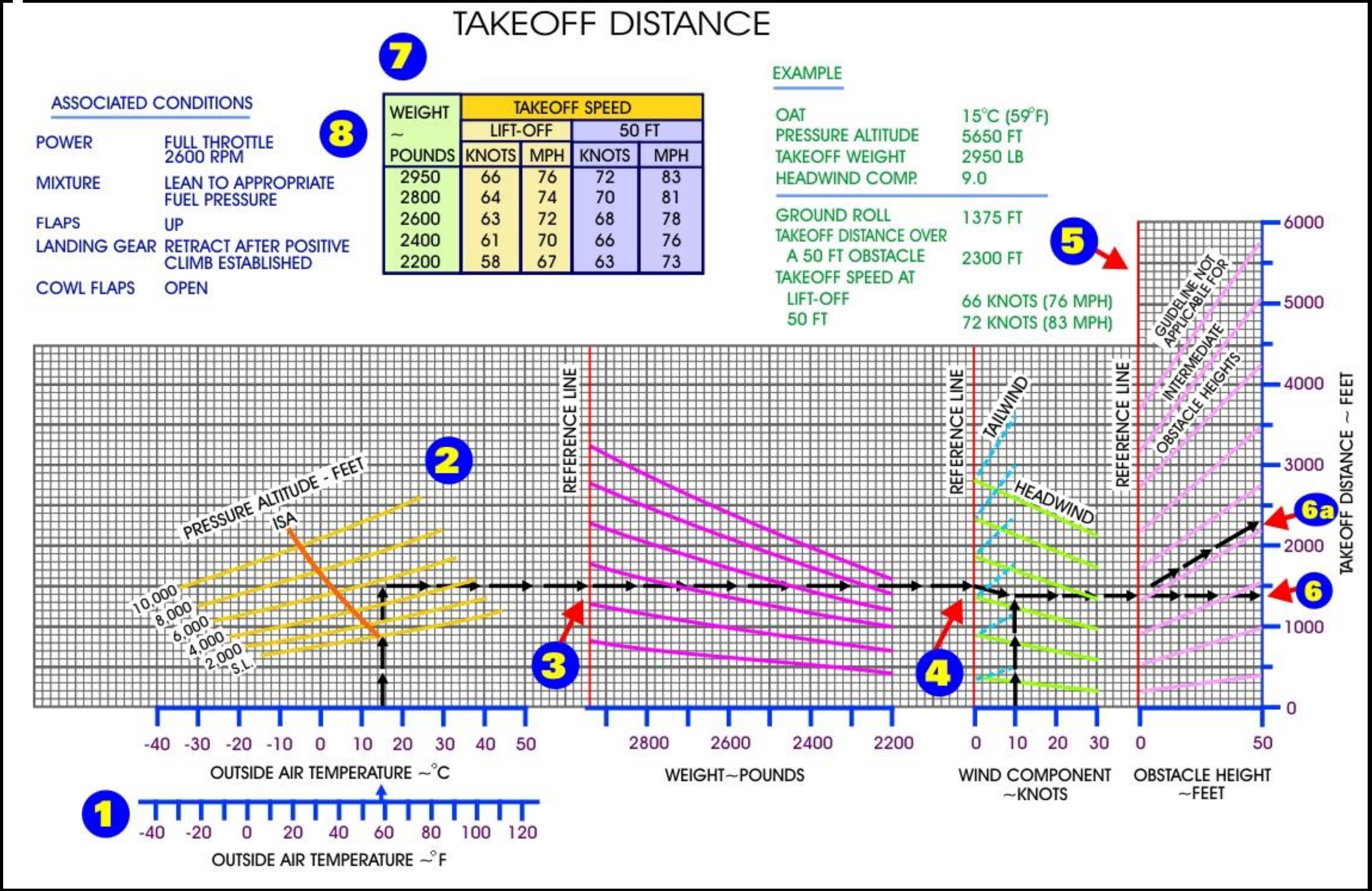
Example #1

- *Find ground roll and distance to clear a 50-foot obstacle:*
  OAT: 59F (15C)
  PA: 5,650 feet
  Takeoff weight: 2,950 pounds
  Headwind component: 9 knots
- Move horizontally to the right, directly over to the vertical reference line (3).
- Section 3 corrects for weight
- Our weight is 2,950 pounds, and this is what the reference line rests on, no correction is necessary



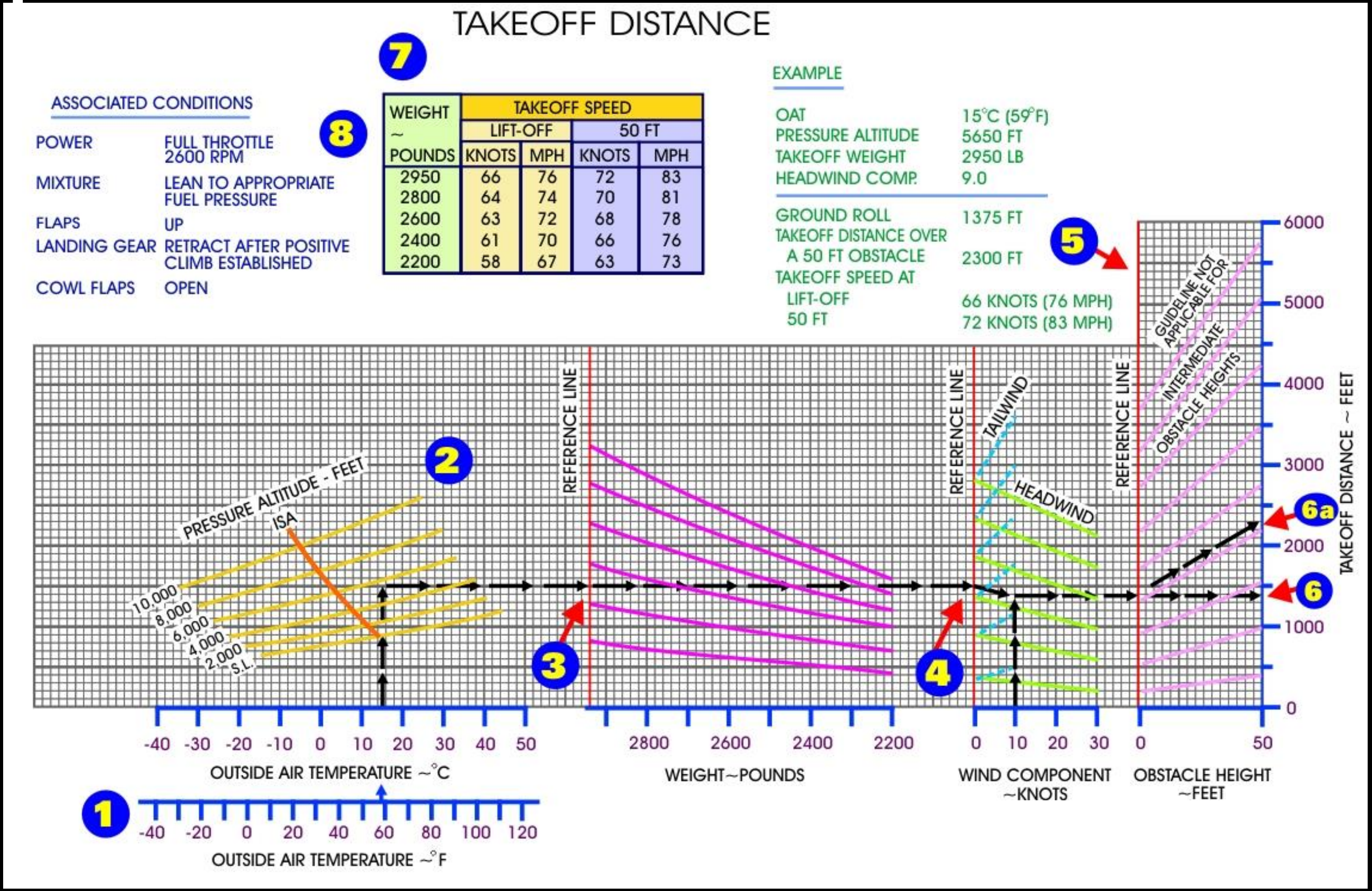
Example #1

- *Find ground roll and distance to clear a 50-foot obstacle:*
  OAT: 59F (15C)
  PA: 5,650 feet
  Takeoff weight: 2,950 pounds
  Headwind component: 9 knots
- Move right, horizontally, to the next reference line (4)
- If we had a weight different from 2,950 pounds, we'd move proportionally to the diagonal lines until reaching our takeoff weight on the bottom scale in section 3
- Then we'd move right, horizontally, to the reference line in section 4



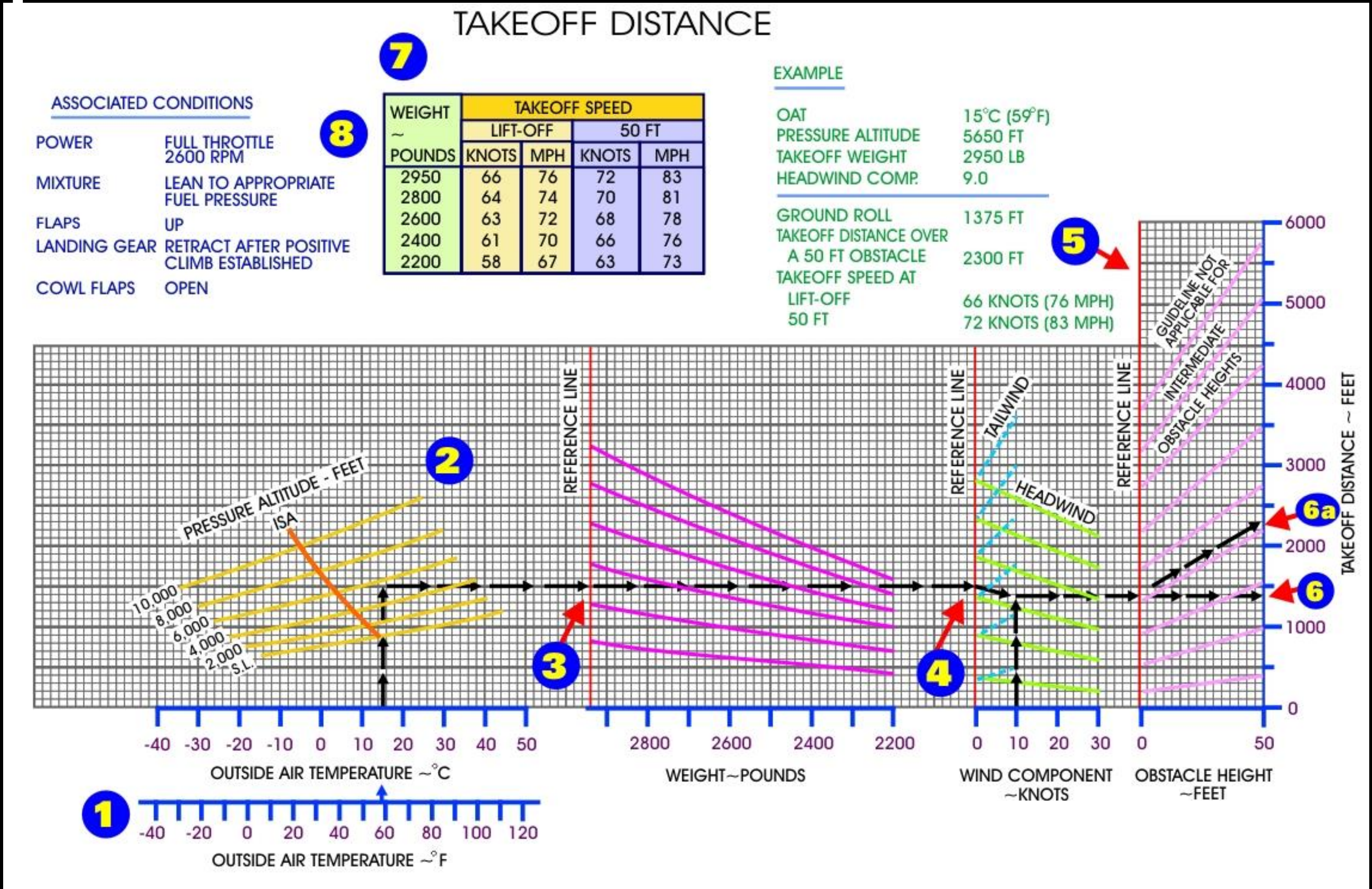
Example #1

- *Find ground roll and distance to clear a 50-foot obstacle:*
  OAT: 59F (15C)
  PA: 5,650 feet
  Takeoff weight: 2,950 pounds
  Headwind component: 9 knots
- Move down proportionally to the nearest diagonal line until reaching a 9-knot wind component value
- From this point move horizontally right toward the next reference line (5)



Example #1

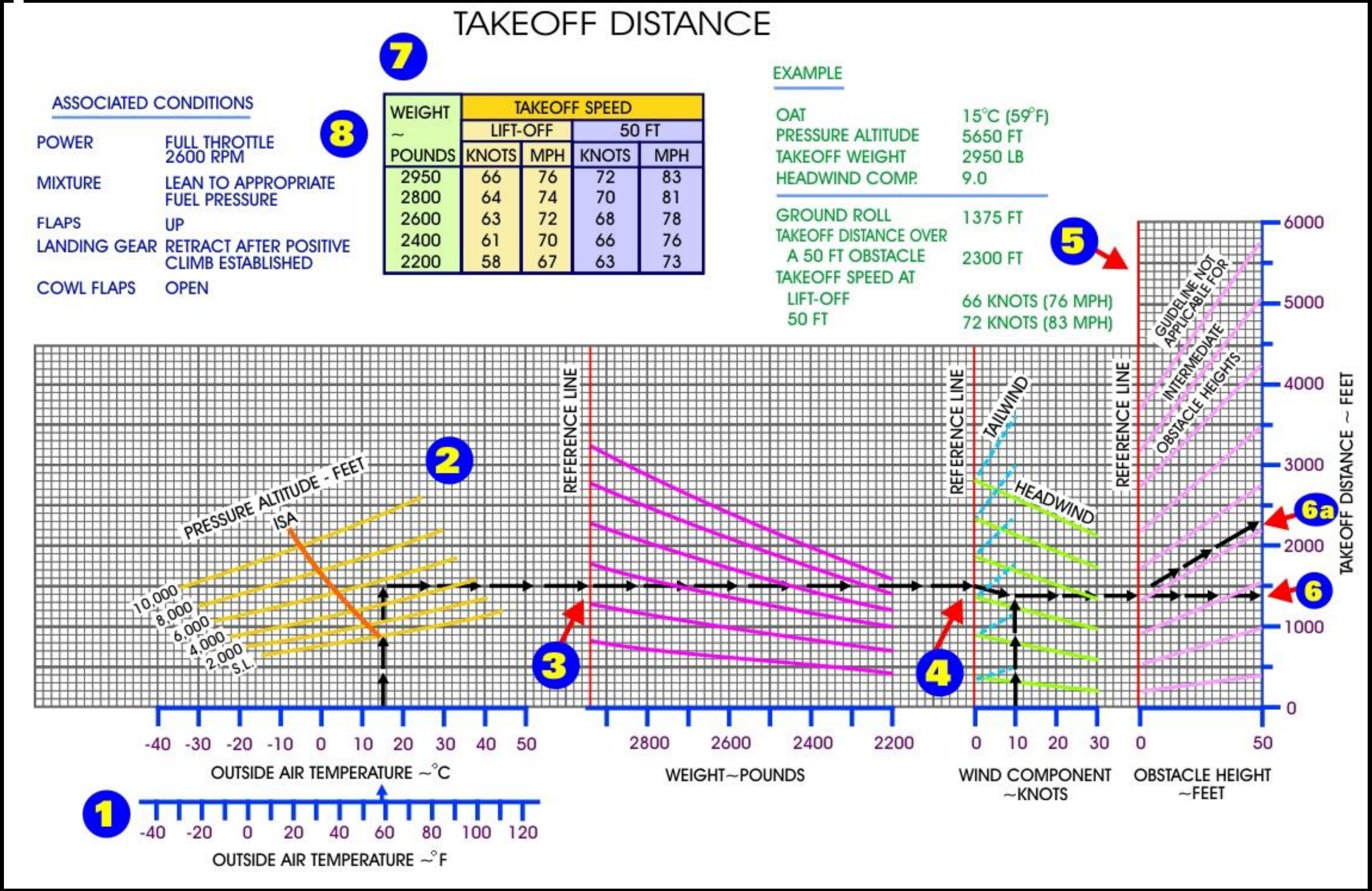
- *Find ground roll and distance to clear a 50-foot obstacle:*
  OAT: 59F (15C)
  PA: 5,650 feet
  Takeoff weight: 2,950 pounds
  Headwind component: 9 knots
- For a 50' obstacle move up proportionally to the diagonal line nearest (5) until reaching the 50' height mark on the bottom scale
- 2,300 feet of horizontal distance is required to clear that obstacle (6a)



WEIGHT ~ POUNDS	TAKEOFF SPEED LIFT-OFF KNOTS	LIFT-OFF MPH	50 FT KNOTS	50 FT MPH
2950	66	76	72	83
2800	64	74	70	81
2600	63	72	68	78
2400	61	70	66	76
2200	58	67	63	73

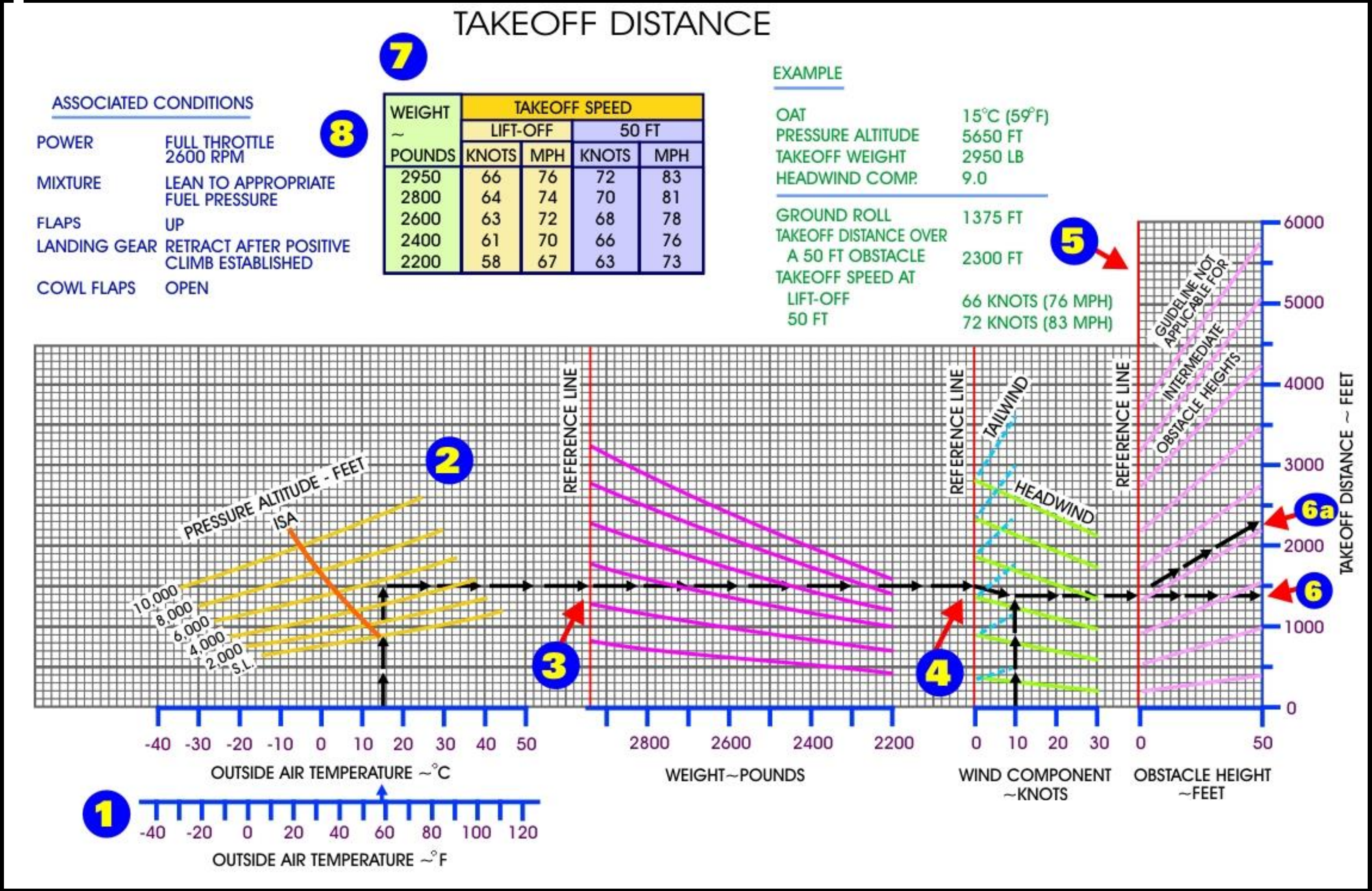
Example #1

- At (7) is a list of takeoff speeds for different weights
- At 2,950 pounds lift off speed is 66 knots
- For an obstacle at the end of the runway climb at a speed of 72 knots for that weight
- Variable weights require different liftoff and obstacle climb speeds.



Example #1

- (8) lists all the associated conditions this chart is based on
- Always read all conditions listed in this section of a chart
- There are many variables affecting airplane performance listed in this section



WEIGHT ~ POUNDS	TAKEOFF SPEED			
	LIFT-OFF		50 FT	
	KNOTS	MPH	KNOTS	MPH
2950	66	76	72	83
2800	64	74	70	81
2600	63	72	68	78
2400	61	70	66	76
2200	58	67	63	73

Tabular Takeoff Distance Chart

- *Read all notes before starting any computations*
- Short field computations based on 10° of flaps, full throttle, then brake release, specific runway conditions, and zero wind
- Note #3 states distances should be decreased 10% for each 9 knots of headwind
- For tailwinds up to 10 knots, increase distances by 10% for each 2 knots

TAKEOFF DISTANCE
SHORT FIELD

CONDITIONS
Flaps 10 degrees
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 of headwind. For operations with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operations 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
1,670	50	54	S.L.	640	1190	695	1290	755	1390	810	1495	875	1605
			1000	705	1310	765	1420	825	1530	890	1645	960	1770
			2000	775	1445	840	1565	910	1690	980	1820	1055	1960
			3000	855	1600	925	1730	1000	1870	1080	2020	1165	2185
			4000	940	1775	1020	1920	1100	2080	1190	2250	1285	2440
			5000	1040	1970	1125	2140	1215	2320	1315	2525	1420	2750
			6000	1145	2200	1245	2395	1345	2610	1455	2855	1570	3125
			7000	1270	2470	1375	2705	1490	2960	1615	3255	1745	3590
			8000	1405	2800	1525	3080	1655	3395	1795	3765	1940	4195

15-16

Tabular Takeoff Distance Chart

- If taking off on a dry grass runway instead of a hard surface, increase distances by 15% of the ground roll
- Grass creates drag and prevents acceleration of the airplane
- There is no chart variation for different weights because a small two-place trainer doesn't have much variation in its payload

TAKEOFF DISTANCE
SHORT FIELD

CONDITIONS
Flaps 10 degrees
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 of headwind. For operations with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operations 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
1,670	50	54	S.L.	640	1190	695	1290	755	1390	810	1495	875	1605
			1000	705	1310	765	1420	825	1530	890	1645	960	1770
			2000	775	1445	840	1565	910	1690	980	1820	1055	1960
			3000	855	1600	925	1730	1000	1870	1080	2020	1165	2185
			4000	940	1775	1020	1920	1100	2080	1190	2250	1285	2440
			5000	1040	1970	1125	2140	1215	2320	1315	2525	1420	2750
			6000	1145	2200	1245	2395	1345	2610	1455	2855	1570	3125
			7000	1270	2470	1375	2705	1490	2960	1615	3255	1745	3590
			8000	1405	2800	1525	3080	1655	3395	1795	3765	1940	4195

15-16

Example #2

- *Determine takeoff ground roll and distance to clear a 50' obstacle based on the following conditions:*
  Pressure altitude: 3,000 feet
  Temperature: 20°C
  Tailwind component: 4 knots
- Without correcting for the tailwind, we obtain a ground roll of 1,000 feet and distance to clear 50' obstacle of 1,870 feet
- Note #3 states to increase distances by 10% for each 2 knots of tailwind
- Distances need to increase by 20%

TAKEOFF DISTANCE

SHORT FIELD

CONDITIONS
Flaps 10 degrees
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 of headwind. For operations with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operations 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
1,670	50	54	S.L.	640	1190	695	1290	755	1390	810	1495	875	1605
			1000	705	1310	765	1420	825	1530	890	1645	960	1770
			2000	775	1445	840	1565	910	1690	980	1820	1055	1960
			3000	855	1600	925	1730	1000	1870	1080	2020	1165	2185
			4000	940	1775	1020	1920	1100	2080	1190	2250	1285	2440
			5000	1040	1970	1125	2140	1215	2320	1315	2525	1420	2750
			6000	1145	2200	1245	2395	1345	2610	1455	2855	1570	3125
			7000	1270	2470	1375	2705	1490	2960	1615	3255	1745	3590
			8000	1405	2800	1525	3080	1655	3395	1795	3765	1940	4195

15-16

Example #3

- *Determine takeoff ground roll and distance to clear a 50' obstacle based on the following conditions:*
  Pressure altitude: 3,000 feet
  Temperature: 20°C
  Tailwind component: 4 knots
- Note #3 states to increase distances by 10% for each 2 knots of tailwind
- Distances need to increase by 20%
- Adjusting for a tailwind ground roll becomes 1,200' feet and the horizontal distance to clear a 50' obstacle becomes 2,244'

Takeoff Distance Chart
For Training Purposes Only!

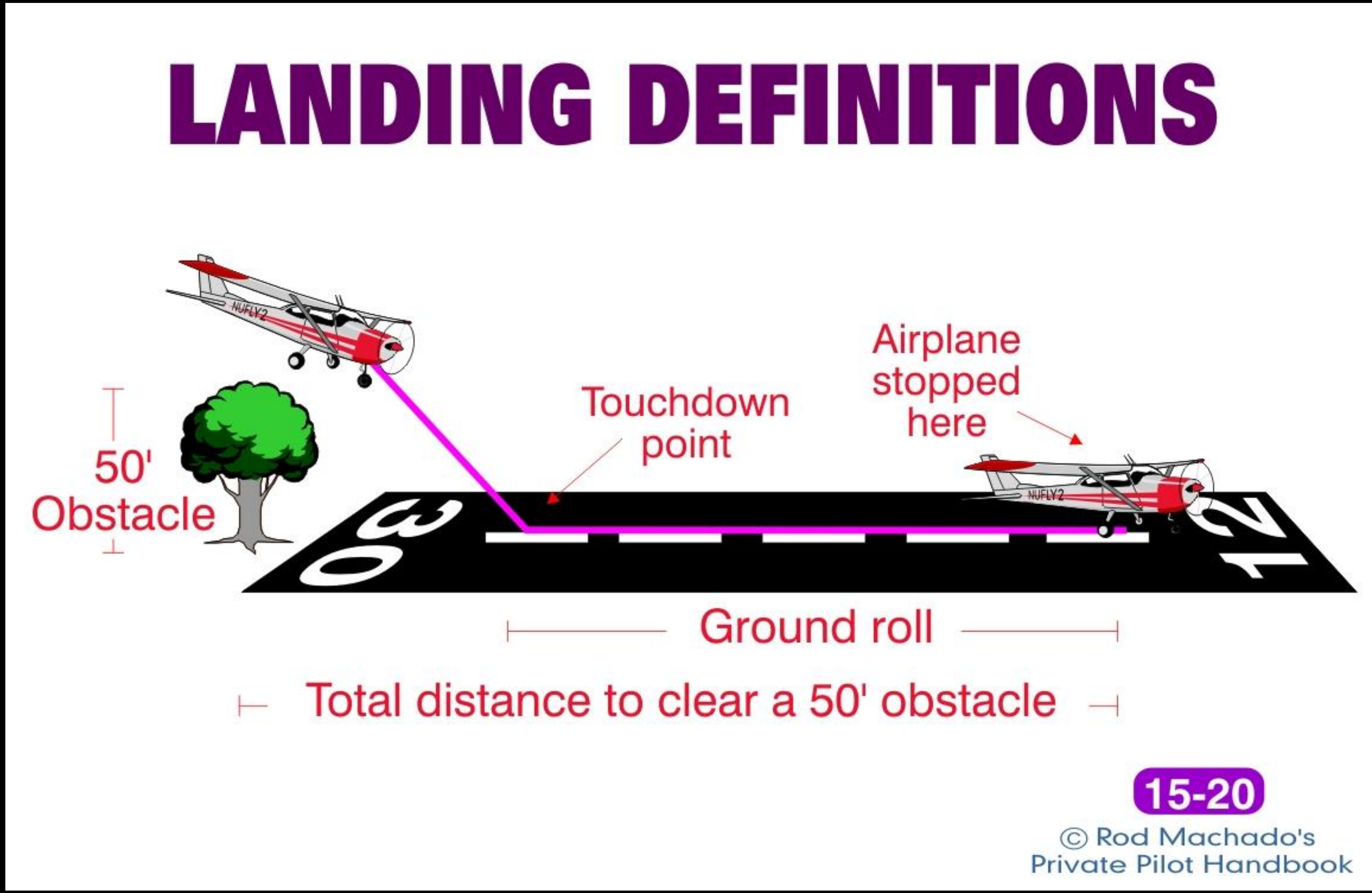
Takeoff Distance Problem #4 Answer:
20% of 1,000′ = (.20)x(1,000) = 200′
1,000′+200′ = 1,200′ Ground Roll
20% of 1,870′ = (.2)x(1,870′) = 374′
1,870′+374′ = 2,244′ to clear 50′ obstacle.

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
1,670	50	54	S.L.	640	1190	695	1290	755	1390	810	1495	875	1605
			1000	705	1310	765	1420	825	1530	890	1645	960	1770
			2000	775	1445	840	1565	910	1690	980	1820	1055	1960
			3000	855	1600	925	1730	1000	1870	1080	2020	1165	2185
			4000	940	1775	1020	1920	1100	2080	1190	2250	1285	2440
			5000	1040	1970	1125	2140	1215	2320	1315	2525	1420	2750
			6000	1145	2200	1245	2395	1345	2610	1455	2855	1570	3125
			7000	1270	2470	1375	2705	1490	2960	1615	3255	1745	3590
			8000	1405	2800	1525	3080	1655	3395	1795	3765	1940	4195

Fig. 17

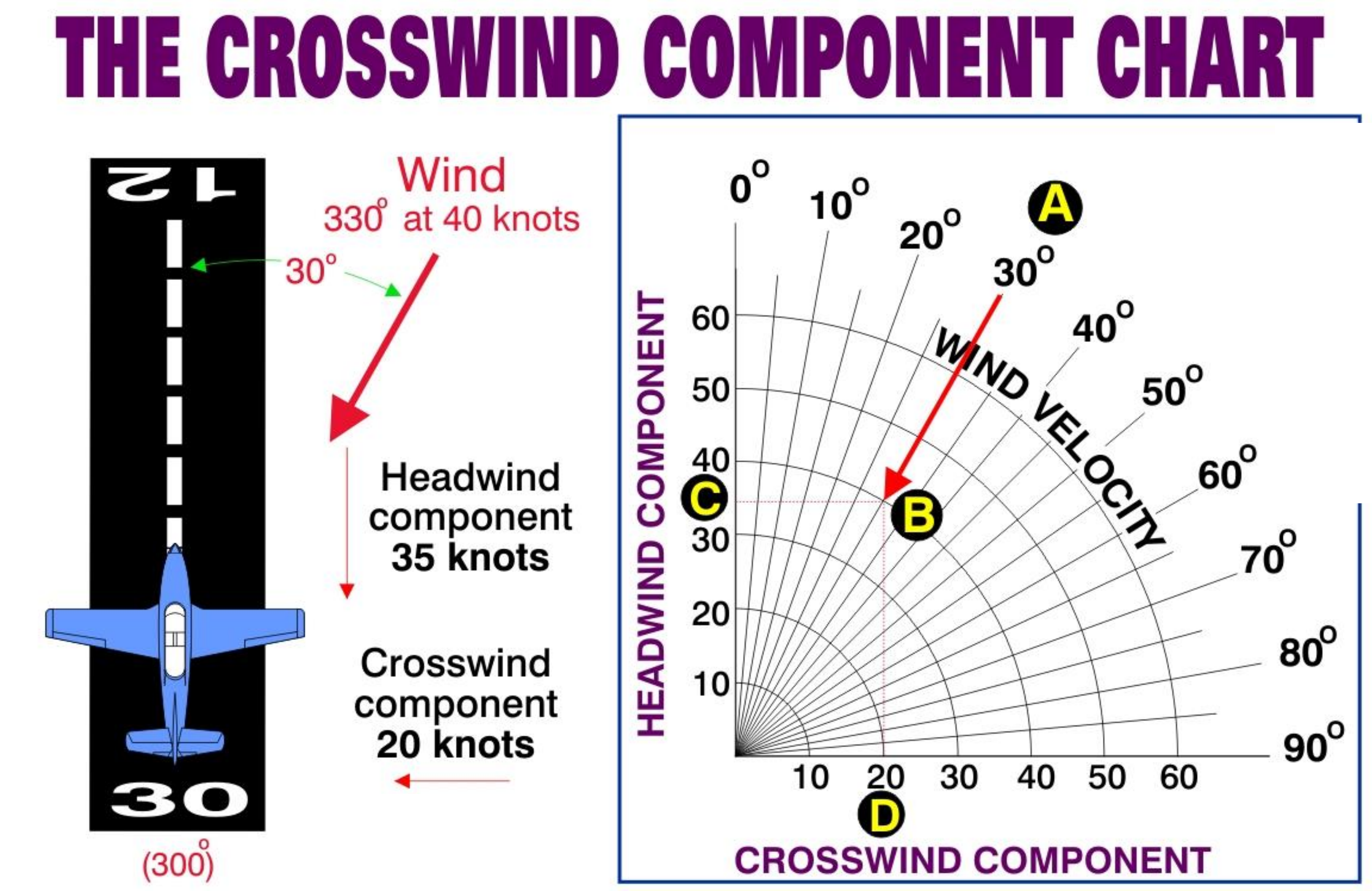
Landing Definitions

- Ground roll is the distance required to stop the airplane once the wheels have made contact with the runway
- The distance to land over a 50' obstacle is the total distance to cross over that obstacle, touchdown, and come to a stop



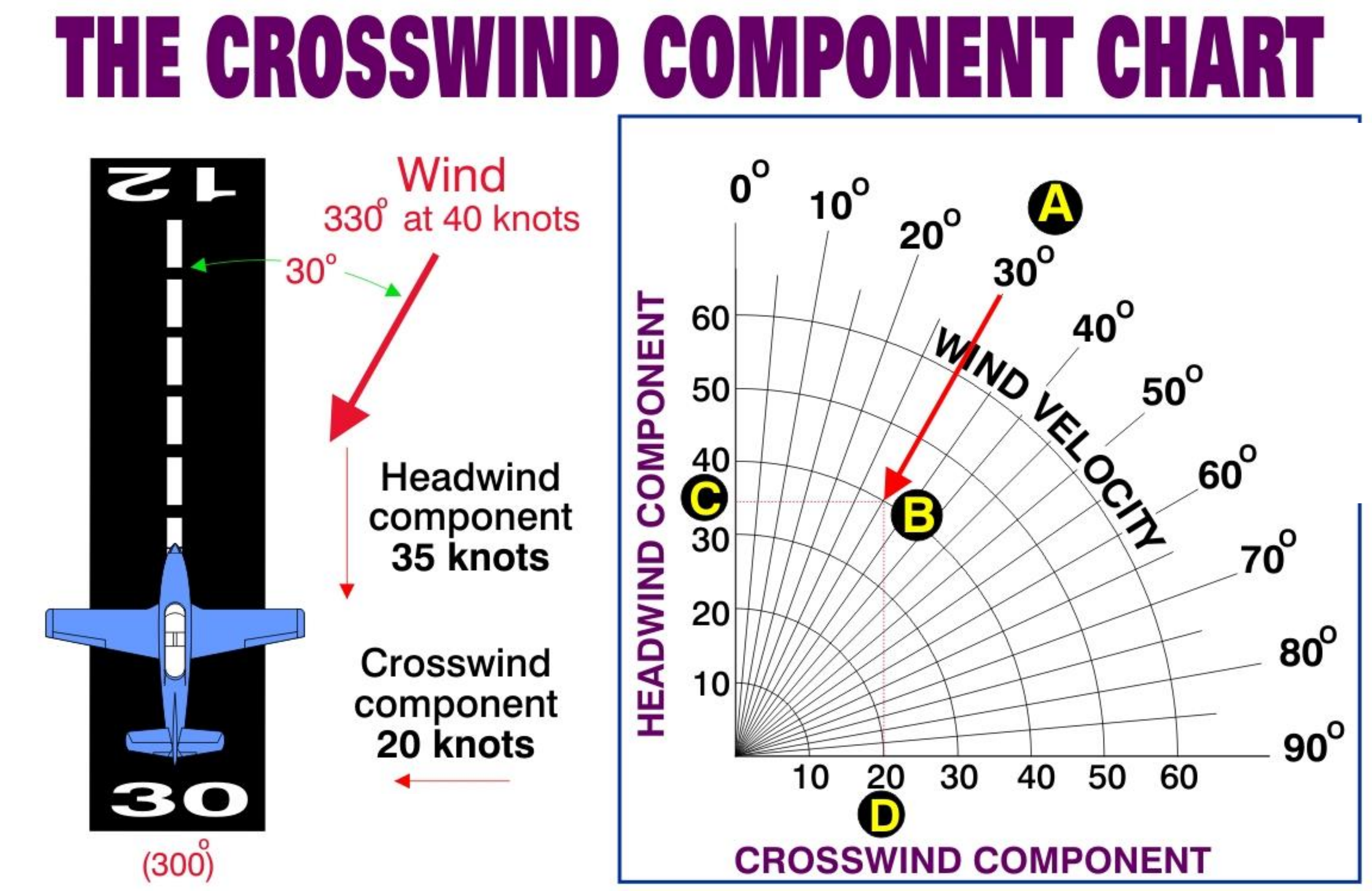
Crosswind Component

- Chart determines the headwind and crosswind components
- Several performance charts require the headwind or tailwind component in order to determine takeoff or landing distance
- POHs list the maximum crosswind component (max demonstrated)
- An average pilot should be able to handle without needing exceptional skill



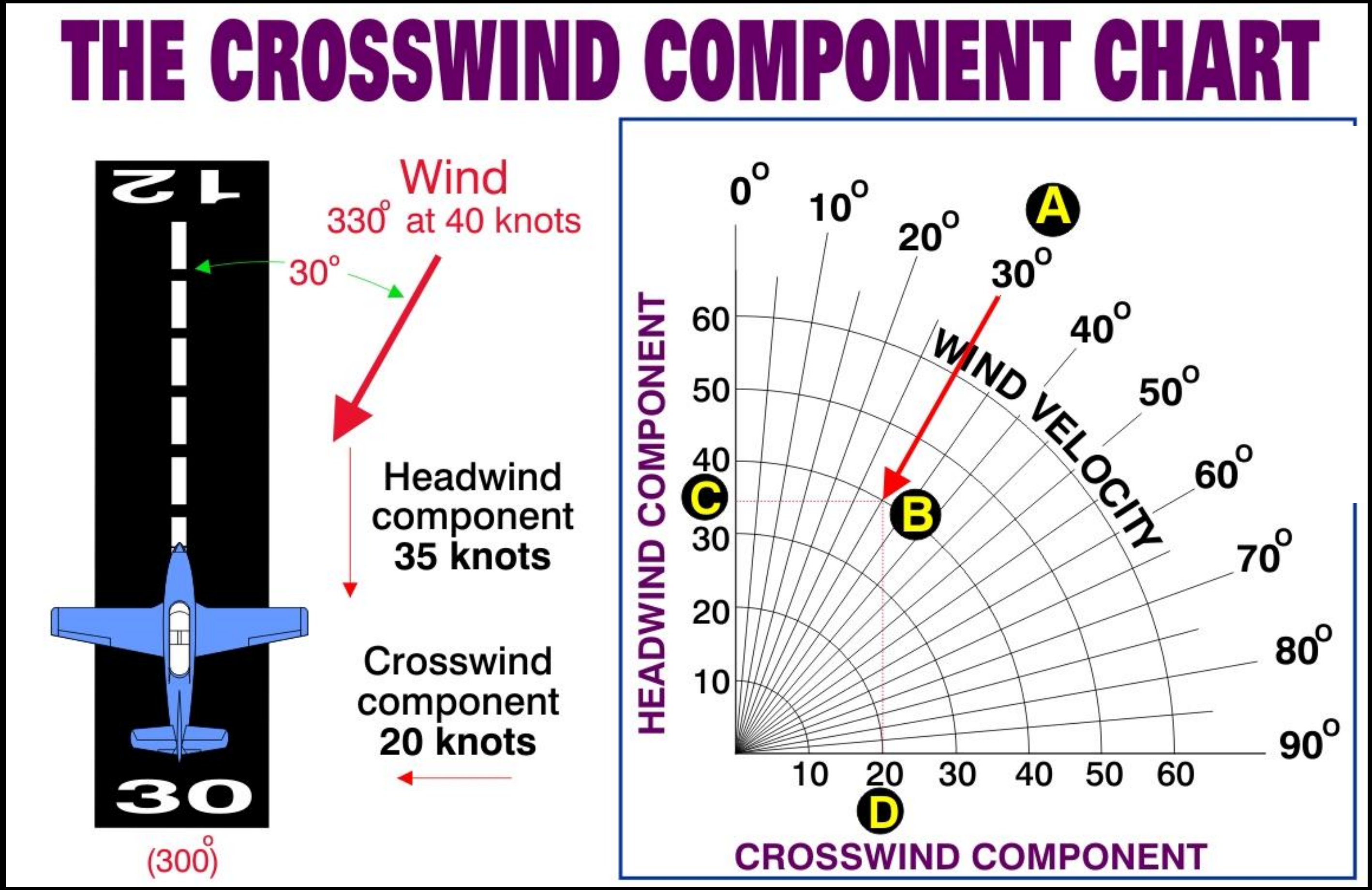
Crosswind Example #1

- Departing on Runway 30
- Tower reports wind from 330° at 40 knots
- What are the headwind and crosswind components associated with this wind?



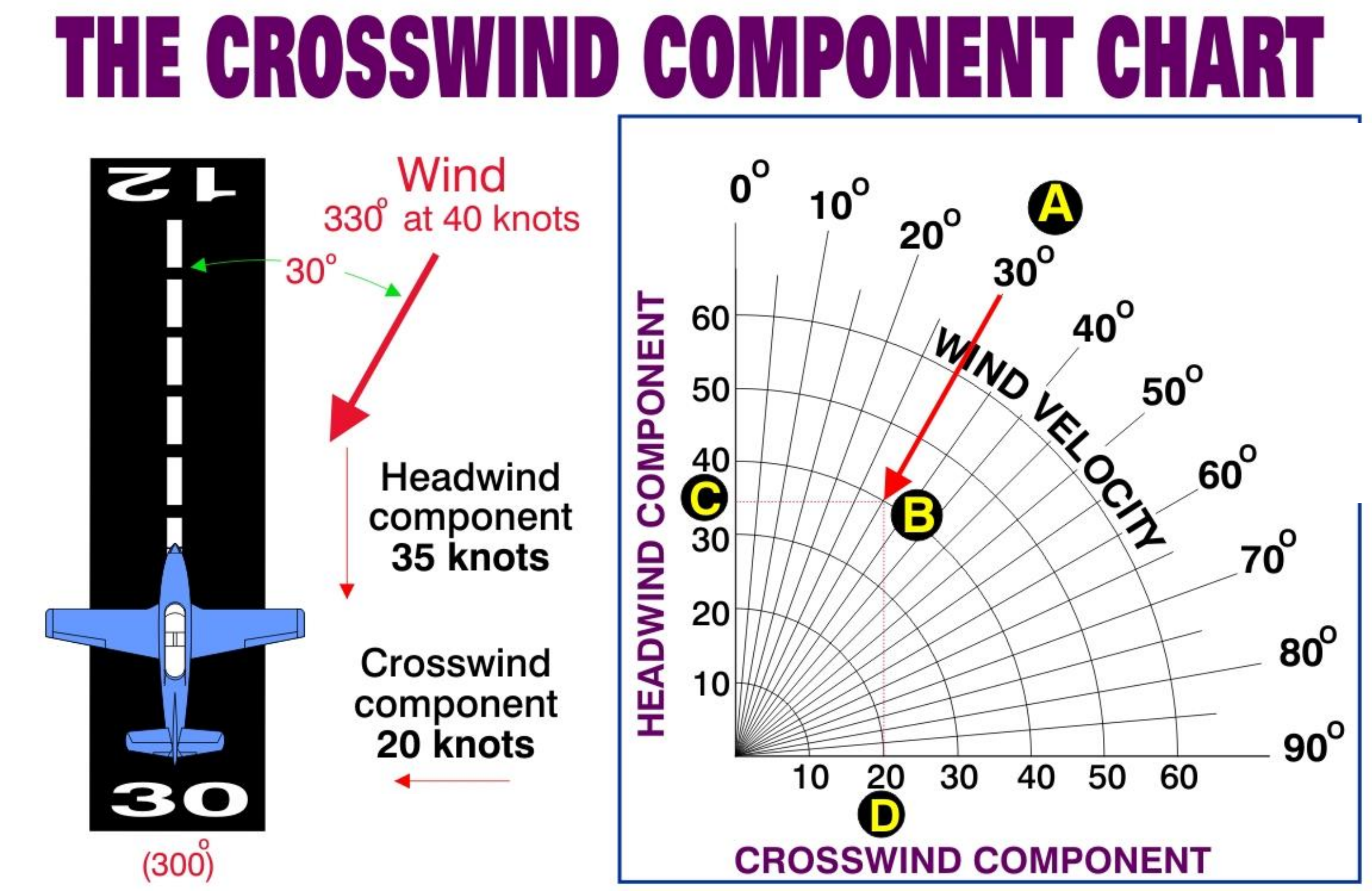
Crosswind Example #1

- Runway 30 is aligned in a direction of 300°
- Wind from 330° makes a 30° angle with the runway
- Some of this wind imparts a headwind component and some a crosswind component



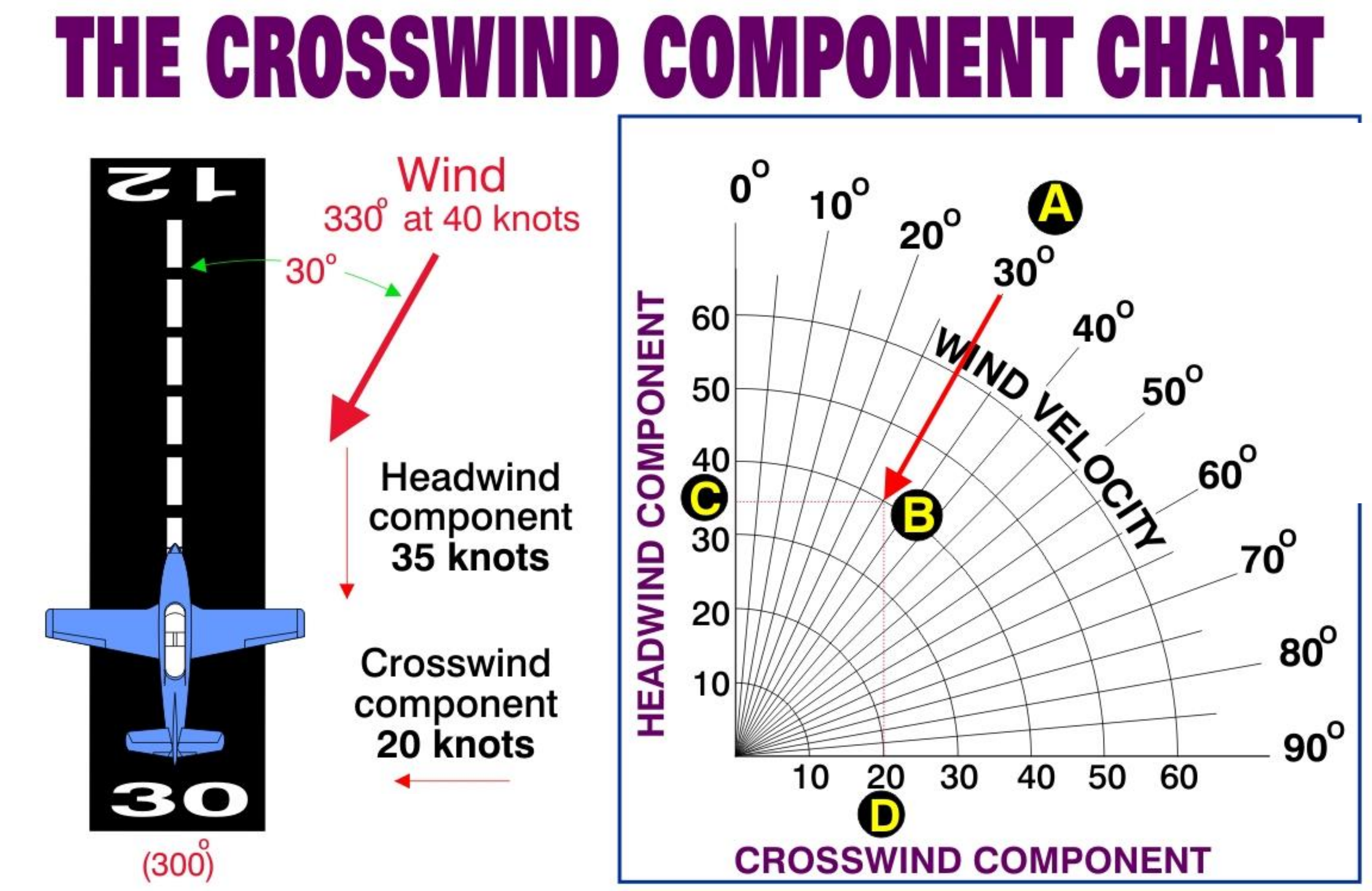
Crosswind Example #1

- Wind is 30° off the right of the nose
- The 0° mark represents the nose of the airplane
- Find the 30° diagonal line (A)
- This represents the angle the wind makes with the nose of the airplane



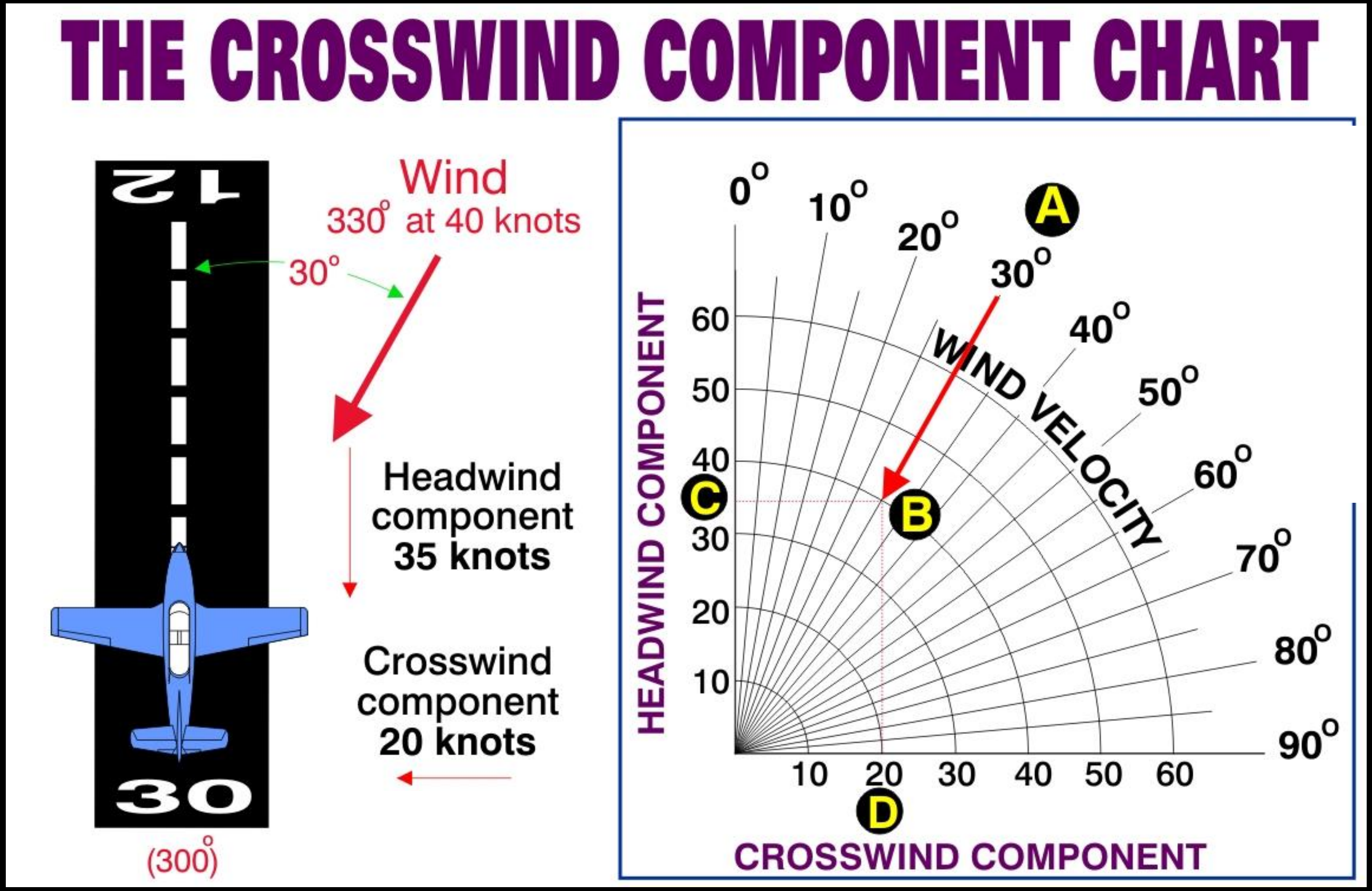
Crosswind Example #1

- Slide down this 30° line until reaching the 40 knot wind velocity arc (B)
- Drop straight down to point D to determine the amount of crosswind
- Right crosswind component of 20 knots

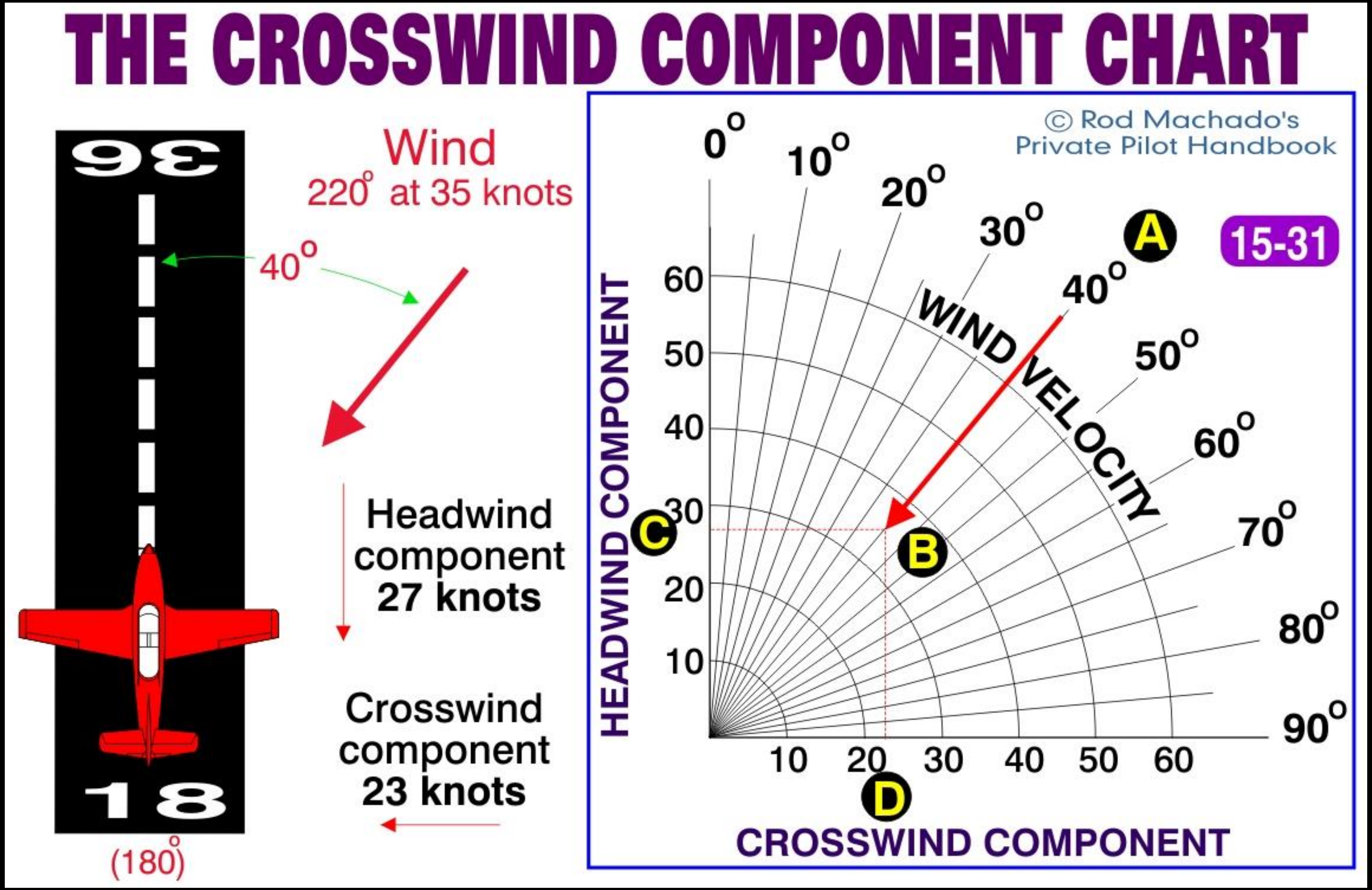


Crosswind Example #1

- To find the headwind component move left horizontally to (C)
- Headwind component is 35 knots
- This headwind value is used for any takeoff or landing performance computation

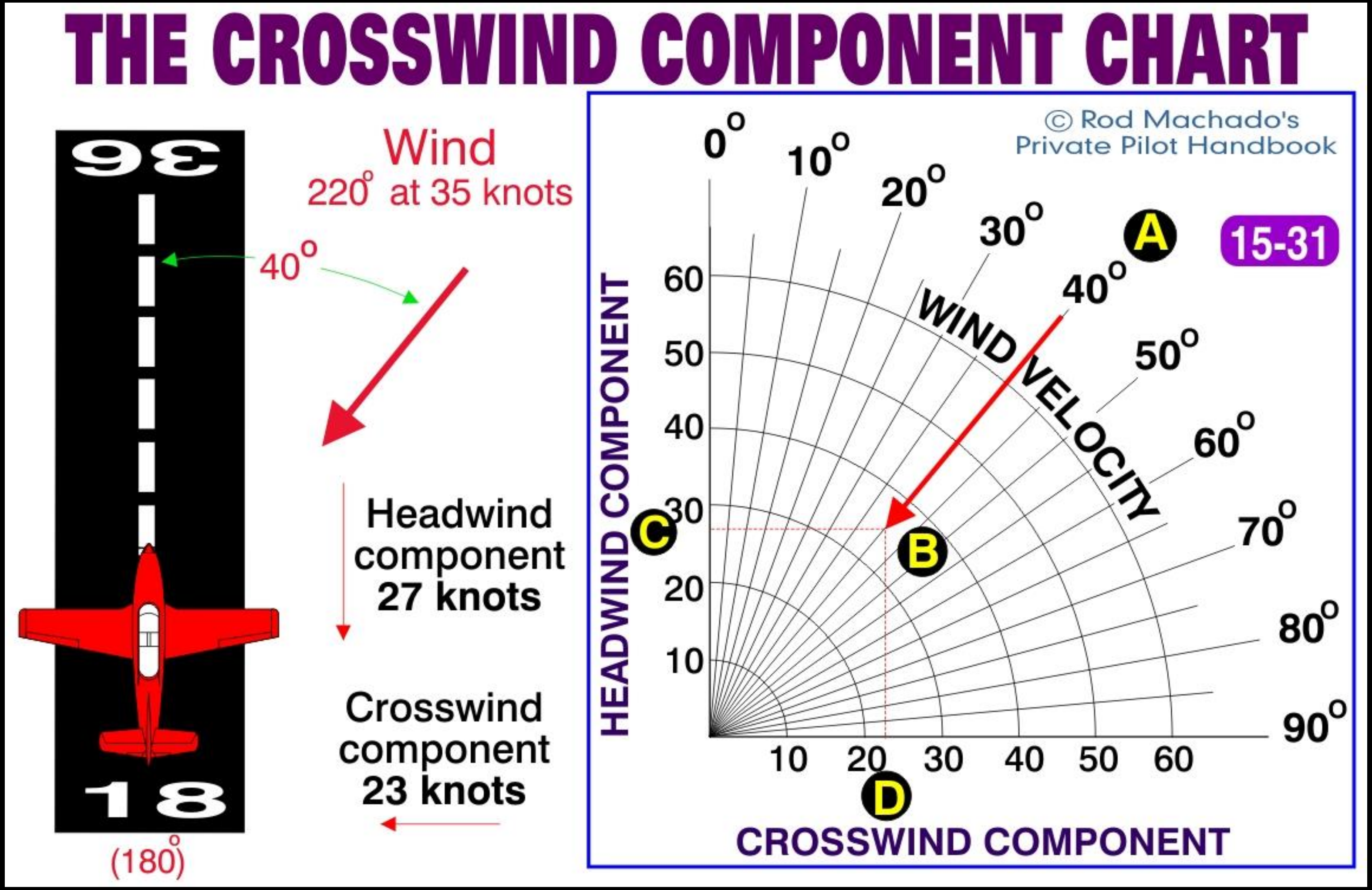


Crosswind Example #2



- What is the crosswind component if landing on Runway 18 with the tower reporting wind of 220° at 35 knots?
- Find the angle between the wind and the nose
- 220° minus 180° is 40°

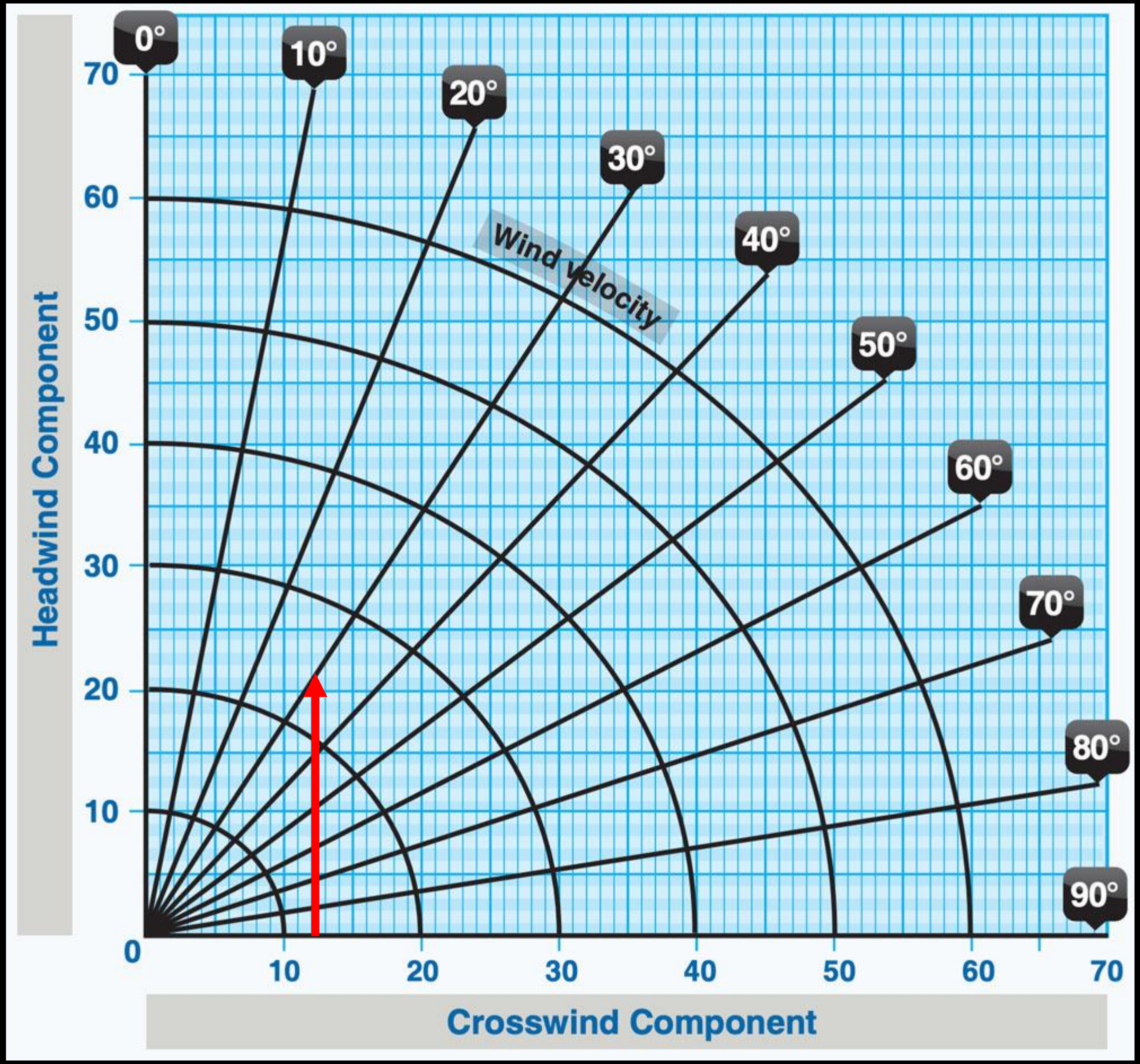
Crosswind Example #2



- Find the 40° diagonal line (A) and slide down until reaching the 35 knot wind arc (B)
- Dropping straight down gives a crosswind component of 23 knots (D)
- A headwind component of 27 knots exists at point C
- This component exceeds the limit for an airplane certified for a maximum crosswind component of 20 knots

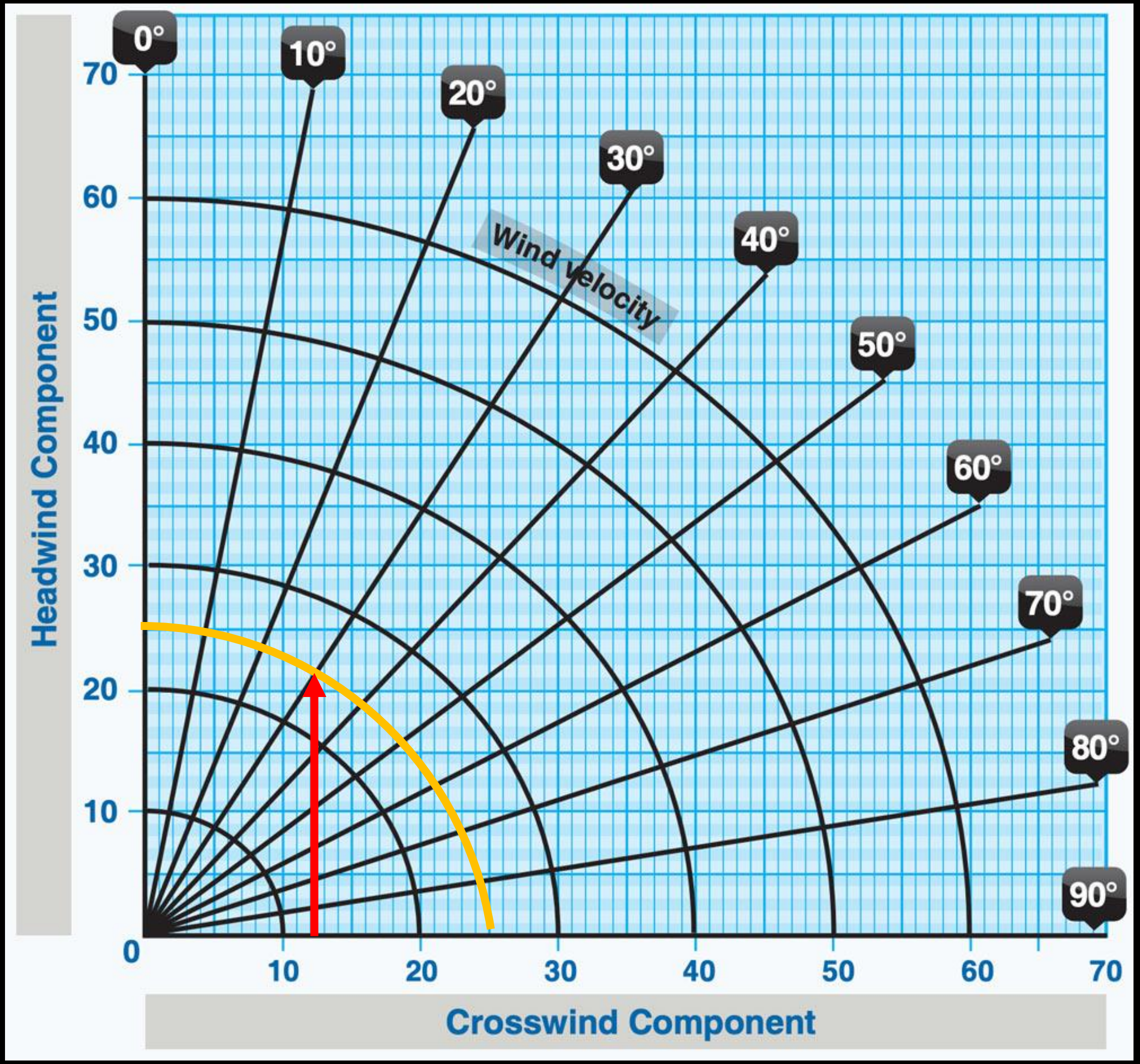
Crosswind #3

- ***Determine the maximum wind velocity for a 30° crosswind if the maximum crosswind component for the airplane is 12 knots***
- This problem requires us to work backwards
- The airplane has a maximum crosswind component of 12 knots
- Find this position along the bottom of the crosswind chart (X)
- Move straight up until reaching the 30° diagonal line (Y)



Crosswind #3

- ***Determine the maximum wind velocity for a 30° crosswind if the maximum crosswind component for the airplane is 12 knots***
- What wind arc you would be resting on if smaller wind-arc calibrations existed?
- Parallel this arc around to the end of the scale (either direction)
- The maximum wind velocity is 24 knots



Enroute Performance

Time, Fuel, and Distance To Climb

- *Columns provide:*
  Climb speed (Vy)
  Expected rate of climb
  Time it to altitude
  Fuel used
  Distance covered (zero wind)
- Chart shows how Vy decreases with increase in altitude

Time, Fuel & Distance to Climb

Maximum Rate of Climb

WEIGHT LBS	PRESSURE ALTITUDE FT	TEMP °C	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
					TIME MIN	FUEL USED GALLONS	DISTANCE NM
1,670	S.L.	15.	67	715	0	0	0
	1000	13	66	675	1	0.2	2
	2000	11	66	630	3	0.4	3
	3000	9	65	590	5	0.7	5
	4000	7	65	550	6	0.9	7
	5000	5	64	505	8	1.2	9
	6000	3	63	465	10	1.4	12
	7000	1	63	425	13	1.7	14
	8000	-1	62	380	15	2.0	17
	9000	-3	62	340	18	2.3	21
	10,000	-5	61	300	21	2.6	25
	11,000	-7	61	255	25	3.0	29
				215	29	3.4	34

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

MAXIMUM RATE OF CLIMB

NOTES:
1. Add 0.8 of a gallon of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10 C above standard tem
4. Distances shown are based on zero wind.

Time, Fuel, and Distance To Climb

Time, Fuel & Distance to Climb

Maximum Rate of Climb

WEIGHT LBS	PRESSURE ALTITUDE FT	TEMP °C	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL TIME MIN	FROM SEA LEVEL FUEL USED GALLONS	FROM SEA LEVEL DISTANCE NM
1,670	S.L.	15.	67	715	0	0	0
	1000	13	66	675	1	0.2	2
	2000	11	66	630	3	0.4	3
	3000	9	65	590	5	0.7	5
	4000	7	65	550	6	0.9	7
	5000	5	64	505	8	1.2	9
	6000	3	63	465	10	1.4	12
	7000	1	63	425	13	1.7	14
	8000	-1	62	380	15	2.0	17
	9000	-3	62	340	18	2.3	21
	10,000	-5	61	300	21	2.6	25
	[illegible]	[illegible]	[illegible]	255	25	3.0	29
	[illegible]	[illegible]	[illegible]	215	29	3.4	34

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

MAXIMUM RATE OF CLIMB

NOTES:
1. Add 0.8 of a gallon of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10 C above standard temperature.
4. Distances shown are based on zero wind.

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- *Read <u>all</u> notes before using the chart*

Climb Example #1

- ***Estimate time and fuel consumed to climb from SL to 5,000 feet PA under standard temperature conditions***
- Find fuel used and distance values for the 5,000 foot PA row
- Time = 8 minutes
- Fuel Used = 1.2 gallons
- Per Note 1 add 0.8 gallon of fuel
- Total Fuel: 1.2 + 0.8 = 2.0 gallons

Time, Fuel & Distance to Climb

Maximum Rate of Climb

WEIGHT LBS	PRESSURE ALTITUDE FT	TEMP °C	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
					TIME MIN	FUEL USED GALLONS	DISTANCE NM
1,670	S.L.	15.	67	715	0	0	0
	1000	13	66	675	1	0.2	2
	2000	11	66	630	3	0.4	3
	3000	9	65	590	5	0.7	5
	4000	7	65	550	6	0.9	7
	5000	5	64	505	8	1.2	9
	6000	3	63	465	10	1.4	12
	7000	1	63	425	13	1.7	14
	8000	-1	62	380	15	2.0	17
	9000	-3	62	340	18	2.3	21
	10,000	-5	61	300	21	2.6	25
	11,000	-7	61	255	25	3.0	29
				215	29	3.4	34

MAXIMUM RATE OF CLIMB

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

NOTES:
1. Add 0.8 of a gallon of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10 C above standard temperature.
4. Distances shown are based on zero wind.

Climb #2

Time, Fuel & Distance to Climb

Maximum Rate of Climb

WEIGHT LBS	PRESSURE ALTITUDE FT	TEMP °C	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
					TIME MIN	FUEL USED GALLONS	DISTANCE NM
1,670	S.L.	15.	67	715	0	0	0
	1000	13	66	675	1	0.2	2
	2000	11	66	630	3	0.4	3
	3000	9	65	590	5	0.7	5
	4000	7	65	550	6	0.9	7
	5000	5	64	505	8	1.2	9
	6000	3	63	465	10	1.4	12
	7000	1	63	425	13	1.7	14
	8000	-1	62	380	15	2.0	17
	9000	-3	62	340	18	2.3	21
	10,000	-5	61	300	21	2.6	25
	11,000	-7	61	255	25	3.0	29
				215	29	3.4	34

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

MAXIMUM RATE OF CLIMB

NOTES:
1. Add 0.8 of a gallon of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10 C above standard temperature.
4. Distances shown are based on zero wind.

- Find time and fuel used to take off and climb from an airport with a PA of 2,000 feet to 6,000 feet PA; airport temperature is 21°C
- Must subtract the difference in time and fuel consumed from 6,000' to 2,000'
- Time to climb to 6,000 PA: 10 min
- Time to climb to 2,000 PA: 3 min
- Time to climb from 2,000 to 6,000 feet is 10 - 3 = 7 minutes

Climb #2

Time, Fuel & Distance to Climb

Maximum Rate of Climb

WEIGHT LBS	PRESSURE ALTITUDE FT	TEMP °C	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
					TIME MIN	FUEL USED GALLONS	DISTANCE NM
1,670	S.L.	15.	67	715	0	0	0
	1000	13	66	675	1	0.2	2
	2000	11	66	630	3	0.4	3
	3000	9	65	590	5	0.7	5
	4000	7	65	550	6	0.9	7
	5000	5	64	505	8	1.2	9
	6000	3	63	465	10	1.4	12
	7000	1	63	425	13	1.7	14
	8000	-1	62	380	15	2.0	17
	9000	-3	62	340	18	2.3	21
	10,000	-5	61	300	21	2.6	25
	11,000	-7	61	255	25	3.0	29
				215	29	3.4	34

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

MAXIMUM RATE OF CLIMB

NOTES:
1. Add 0.8 of a gallon of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10 C above standard temperature.
4. Distances shown are based on zero wind.

- Fuel to 6,000: 1.4 gallons
- Fuel to 2,000: 0.4 gallon
- Fuel to climb from 2,000 to 6,000:
- 1.4 - 0.4 = 1 gallon

Climb #2

Time, Fuel & Distance to Climb

Maximum Rate of Climb

WEIGHT LBS	PRESSURE ALTITUDE FT	TEMP °C	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
					TIME MIN	FUEL USED GALLONS	DISTANCE NM
1,670	S.L.	15.	67	715	0	0	0
	1000	13	66	675	1	0.2	2
	2000	11	66	630	3	0.4	3
	3000	9	65	590	5	0.7	5
	4000	7	65	550	6	0.9	7
	5000	5	64	505	8	1.2	9
	6000	3	63	465	10	1.4	12
	7000	1	63	425	13	1.7	14
	8000	-1	62	380	15	2.0	17
	9000	-3	62	340	18	2.3	21
	10,000	-5	61	300	21	2.6	25
	11,000	-7	61	255	25	3.0	29
				215	29	3.4	34

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

MAXIMUM RATE OF CLIMB

NOTES:
1. Add 0.8 of a gallon of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10 C above standard temperature.
4. Distances shown are based on zero wind.

- Time to climb: 7 minutes
  Fuel to climb: 1 gallon
  Airport temperature: 21°C
- Correct for the nonstandard temperature
- 21°C at 2,000 feet is 10°C above standard temperature for that altitude
- Per note #3 increase both these values by 10%

Climb #2

Time, Fuel & Distance to Climb

Maximum Rate of Climb

WEIGHT LBS	PRESSURE ALTITUDE FT	TEMP °C	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
					TIME MIN	FUEL USED GALLONS	DISTANCE NM
1,670	S.L.	15.	67	715	0	0	0
	1000	13	66	675	1	0.2	2
	2000	11	66	630	3	0.4	3
	3000	9	65	590	5	0.7	5
	4000	7	65	550	6	0.9	7
	5000	5	64	505	8	1.2	9
	6000	3	63	465	10	1.4	12
	7000	1	63	425	13	1.7	14
	8000	-1	62	380	15	2.0	17
	9000	-3	62	340	18	2.3	21
	10,000	-5	61	300	21	2.6	25
	11,000	-7	61	255	25	3.0	29
				215	29	3.4	34

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

MAXIMUM RATE OF CLIMB

NOTES:
1. Add 0.8 of a gallon of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10 C above standard temperature.
4. Distances shown are based on zero wind.

- Time to climb: 7 minutes
  Fuel to climb: 1 gallon
  Airport temperature: 21°C
- Time to climb is 7 + (1.1 x 7) = 7.7 minutes
- Fuel used is 1 + (1.1 x 1) = 1.1 gallons
- Per Note #1 add 0.8 gallon for engine start, taxi, and takeoff
- Total fuel consumption is 1.1 + 0.8 = 1.9 gallons

Cruise Performance Chart

- Chart determines enroute fuel consumption and expected true airspeed
- Always read the notes before using the chart
- Note at the top of the chart assumes the engine operates at 65% maximum continuous power or full throttle, based on the RPM and manifold pressure settings provided in the chart

Cruise Power Settings

CRUISE POWER SETTINGS

65% MAXIMUM CONTINUOUS POWER (OR FULL THROTTLE)
2800 POUNDS

	ISA - 20 °C (-36 °F)								STANDARD DAY (ISA)								ISA + 20 °C (+36 °F)							
PRESS ALT.	IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS	
FEET	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH
S.L.	27	-3	2450	20.9	6.6	11.5	147	169	63	17	2450	21.2	6.6	11.5	150	173	99	37	2450	21.8	6.6	11.5	153	176
2000	19	-7	2450	20.4	6.6	11.5	149	171	55	13	2450	21.0	6.6	11.5	153	176	91	33	2450	21.5	6.6	11.5	156	180
4000	12	-11	2450	20.1	6.6	11.5	152	175	48	9	2450	20.7	6.6	11.5	156	180	84	29	2450	21.3	6.6	11.5	159	183
6000	5	-15	2450	19.8	6.6	11.5	155	178	41	5	2450	20.4	6.6	11.5	158	182	79	26	2450	21.0	6.6	11.5	161	185
8000	-2	-19	2450	19.5	6.6	11.5	157	181	36	2	2450	20.2	6.6	11.5	161	185	72	22	2450	20.8	6.6	11.5	164	189
10,000	-8	-22	2450	19.2	6.6	11.5	160	184	28	-2	2450	19.9	6.6	11.5	163	188	64	18	2450	20.3	6.5	11.4	166	191
12,000	-15	-26	2450	18.8	6.4	11.3	162	186	21	-6	2450	18.8	6.1	10.9	163	188	57	14	2450	18.8	5.9	10.6	163	188
14,000	-22	-30	2450	17.4	5.8	10.5	159	183	14	-10	2450	17.4	5.6	10.1	160	184	50	10	2450	17.4	5.4	9.8	160	184
16,000	-29	-34	2450	16.1	5.3	9.7	156	180	7	-14	2450	16.1	5.1	9.4	156	180	43	6	2450	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.

Cruise Performance Chart

- Three temperature sections exist on the chart
- Middle column is for standard temperature (ISA)
- Left and right columns are sections for temperatures below and above standard conditions
- Within each section is an individual temperature column (IOAT - indicated outside air temperature) for variable temperature conditions enroute

Cruise Power Settings

CRUISE POWER SETTINGS

65% MAXIMUM CONTINUOUS POWER (OR FULL THROTTLE)
2800 POUNDS

	ISA - 20 °C (-36 °F)								STANDARD DAY (ISA)								ISA + 20 °C (+36 °F)							
PRESS ALT.	IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS	
FEET	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH
S.L.	27	-3	2450	20.9	6.6	11.5	147	169	63	17	2450	21.2	6.6	11.5	150	173	99	37	2450	21.8	6.6	11.5	153	176
2000	19	-7	2450	20.4	6.6	11.5	149	171	55	13	2450	21.0	6.6	11.5	153	176	91	33	2450	21.5	6.6	11.5	156	180
4000	12	-11	2450	20.1	6.6	11.5	152	175	48	9	2450	20.7	6.6	11.5	156	180	84	29	2450	21.3	6.6	11.5	159	183
6000	5	-15	2450	19.8	6.6	11.5	155	178	41	5	2450	20.4	6.6	11.5	158	182	79	26	2450	21.0	6.6	11.5	161	185
8000	-2	-19	2450	19.5	6.6	11.5	157	181	36	2	2450	20.2	6.6	11.5	161	185	72	22	2450	20.8	6.6	11.5	164	189
10,000	-8	-22	2450	19.2	6.6	11.5	160	184	28	-2	2450	19.9	6.6	11.5	163	188	64	18	2450	20.3	6.5	11.4	166	191
12,000	-15	-26	2450	18.8	6.4	11.3	162	186	21	-6	2450	18.8	6.1	10.9	163	188	57	14	2450	18.8	5.9	10.6	163	188
14,000	-22	-30	2450	17.4	5.8	10.5	159	183	14	-10	2450	17.4	5.6	10.1	160	184	50	10	2450	17.4	5.4	9.8	160	184
16,000	-29	-34	2450	16.1	5.3	9.7	156	180	7	-14	2450	16.1	5.1	9.4	156	180	43	6	2450	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.

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Cruise Performance Chart

- When given a PA and temperature, find the PA on the far left column
- Proceed to the right until you are near a temperature similar to that for your cruise altitude
- Chart shows the RPM and manifold pressure settings required to develop 65% power with the associated fuel flow and TAS for those settings

Cruise Power Settings

CRUISE POWER SETTINGS

65% MAXIMUM CONTINUOUS POWER (OR FULL THROTTLE)
2800 POUNDS

	ISA - 20 °C (-36 °F)								STANDARD DAY (ISA)								ISA + 20 °C (+36 °F)							
PRESS ALT.	IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS	
FEET	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH
S.L.	27	-3	2450	20.9	6.6	11.5	147	169	63	17	2450	21.2	6.6	11.5	150	173	99	37	2450	21.8	6.6	11.5	153	176
2000	19	-7	2450	20.4	6.6	11.5	149	171	55	13	2450	21.0	6.6	11.5	153	176	91	33	2450	21.5	6.6	11.5	156	180
4000	12	-11	2450	20.1	6.6	11.5	152	175	48	9	2450	20.7	6.6	11.5	156	180	84	29	2450	21.3	6.6	11.5	159	183
6000	5	-15	2450	19.8	6.6	11.5	155	178	41	5	2450	20.4	6.6	11.5	158	182	79	26	2450	21.0	6.6	11.5	161	185
8000	-2	-19	2450	19.5	6.6	11.5	157	181	36	2	2450	20.2	6.6	11.5	161	185	72	22	2450	20.8	6.6	11.5	164	189
10,000	-8	-22	2450	19.2	6.6	11.5	160	184	28	-2	2450	19.9	6.6	11.5	163	188	64	18	2450	20.3	6.5	11.4	166	191
12,000	-15	-26	2450	18.8	6.4	11.3	162	186	21	-6	2450	18.8	6.1	10.9	163	188	57	14	2450	18.8	5.9	10.6	163	188
14,000	-22	-30	2450	17.4	5.8	10.5	159	183	14	-10	2450	17.4	5.6	10.1	160	184	50	10	2450	17.4	5.4	9.8	160	184
16,000	-29	-34	2450	16.1	5.3	9.7	156	180	7	-14	2450	16.1	5.1	9.4	156	180	43	6	2450	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.

Cruise Example #1

- ***Find fuel consumption and TAS under the following conditions:***
  PA: 8,000 feet
  Temperature: +22°C
  Manifold pressure: 20.8 in Hg
  Wind: Calm

Cruise Power Settings

CRUISE POWER SETTINGS

65% MAXIMUM CONTINUOUS POWER (OR FULL THROTTLE)
2800 POUNDS

	ISA - 20 °C (-36 °F)								STANDARD DAY (ISA)								ISA + 20 °C (+36 °F)							
PRESS ALT.	IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS	
FEET	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH
S.L.	27	-3	2450	20.9	6.6	11.5	147	169	63	17	2450	21.2	6.6	11.5	150	173	99	37	2450	21.8	6.6	11.5	153	176
2000	19	-7	2450	20.4	6.6	11.5	149	171	55	13	2450	21.0	6.6	11.5	153	176	91	33	2450	21.5	6.6	11.5	156	180
4000	12	-11	2450	20.1	6.6	11.5	152	175	48	9	2450	20.7	6.6	11.5	156	180	84	29	2450	21.3	6.6	11.5	159	183
6000	5	-15	2450	19.8	6.6	11.5	155	178	41	5	2450	20.4	6.6	11.5	158	182	79	26	2450	21.0	6.6	11.5	161	185
8000	-2	-19	2450	19.5	6.6	11.5	157	181	36	2	2450	20.2	6.6	11.5	161	185	72	22	2450	20.8	6.6	11.5	164	189
10,000	-8	-22	2450	19.2	6.6	11.5	160	184	28	-2	2450	19.9	6.6	11.5	163	188	64	18	2450	20.3	6.5	11.4	166	191
12,000	-15	-26	2450	18.8	6.4	11.3	162	186	21	-6	2450	18.8	6.1	10.9	163	188	57	14	2450	18.8	5.9	10.6	163	188
14,000	-22	-30	2450	17.4	5.8	10.5	159	183	14	-10	2450	17.4	5.6	10.1	160	184	50	10	2450	17.4	5.4	9.8	160	184
16,000	-29	-34	2450	16.1	5.3	9.7	156	180	7	-14	2450	16.1	5.1	9.4	156	180	43	6	2450	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.

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Cruise Example #1

- *Find fuel consumption and TAS under the following conditions:*
  PA: 8,000 feet
  Temperature: +22°C
  Manifold pressure: 20.8 in Hg
  Wind: Calm
- Find 8,000-foot PA line
- Follow across until reaching a temperature of or near +22°C
- To produce 65% power an engine RPM of 2450 and a MP of 20.8 in of Hg are necessary
- Fuel flow is 11.5 GPH
  Estimated TAS is 164 knots

Cruise Power Settings

CRUISE POWER SETTINGS

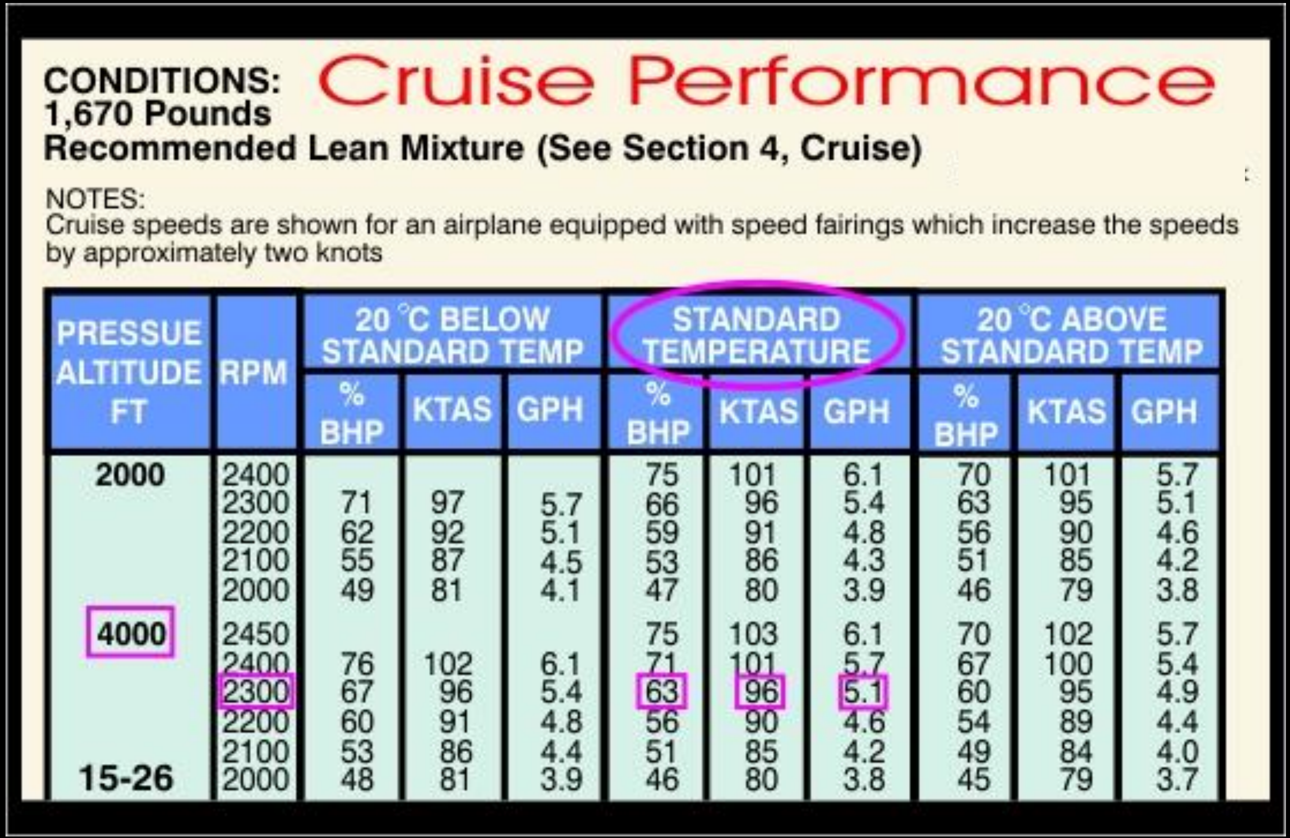
65% MAXIMUM CONTINUOUS POWER (OR FULL THROTTLE)
2800 POUNDS

PRESS ALT.	ISA - 20 °C (-36 °F)								STANDARD DAY (ISA)								ISA + 20 °C (+36 °F)							
	IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS		IOAT		ENGINE SPEED	MAN. PRESS	FUEL FLOW		TAS	
FEET	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH	°F	°C	RPM	IN HG	PSI	GPH	KTS	MPH
S.L.	27	-3	2450	20.9	6.6	11.5	147	169	63	17	2450	21.2	6.6	11.5	150	173	99	37	2450	21.8	6.6	11.5	153	176
2000	19	-7	2450	20.4	6.6	11.5	149	171	55	13	2450	21.0	6.6	11.5	153	176	91	33	2450	21.5	6.6	11.5	156	180
4000	12	-11	2450	20.1	6.6	11.5	152	175	48	9	2450	20.7	6.6	11.5	156	180	84	29	2450	21.3	6.6	11.5	159	183
6000	5	-15	2450	19.8	6.6	11.5	155	178	41	5	2450	20.4	6.6	11.5	158	182	79	26	2450	21.0	6.6	11.5	161	185
8000	-2	-19	2450	19.5	6.6	11.5	157	181	36	2	2450	20.2	6.6	11.5	161	185	72	22	2450	20.8	6.6	11.5	164	189
10,000	-8	-22	2450	19.2	6.6	11.5	160	184	28	-2	2450	19.9	6.6	11.5	163	188	64	18	2450	20.3	6.5	11.4	166	191
12,000	-15	-26	2450	18.8	6.4	11.3	162	186	21	-6	2450	18.8	6.1	10.9	163	188	57	14	2450	18.8	5.9	10.6	163	188
14,000	-22	-30	2450	17.4	5.8	10.5	159	183	14	-10	2450	17.4	5.6	10.1	160	184	50	10	2450	17.4	5.4	9.8	160	184
16,000	-29	-34	2450	16.1	5.3	9.7	156	180	7	-14	2450	16.1	5.1	9.4	156	180	43	6	2450	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.

Cruise Performance

- Chart is for an airplane with a fixed pitch propeller
- PA found on the left side of the chart with variable RPM settings for variable power conditions
- Shows various percentage selections of BHP to operate
- If the airplane has a 100 HP engine, chart shows what percentage of the 100 is being used
- Chart has three temperature columns



CONDITIONS: 1,670 Pounds
Recommended Lean Mixture (See Section 4, Cruise)

Cruise Performance

NOTES:
Cruise speeds are shown for an airplane equipped with speed fairings which increase the speeds by approximately two knots

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	2400				75	101	6.1	70	101	5.7
	2300	71	97	5.7	66	96	5.4	63	95	5.1
	2200	62	92	5.1	59	91	4.8	56	90	4.6
	2100	55	87	4.5	53	86	4.3	51	85	4.2
	2000	49	81	4.1	47	80	3.9	46	79	3.8
4000	2450				75	103	6.1	70	102	5.7
	2400	76	102	6.1	71	101	5.7	67	100	5.4
	2300	67	96	5.4	63	96	5.1	60	95	4.9
	2200	60	91	4.8	56	90	4.6	54	89	4.4
	2100	53	86	4.4	51	85	4.2	49	84	4.0
	2000	48	81	3.9	46	80	3.8	45	79	3.7

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Cruise Example #2

- ***Find fuel consumption and TAS at PA of 4,000' feet, 2,300 RPM, STD conditions***
- Locate the 4,000' PA column, then move to 2,300 RPM value
- TAS is 96 knots
  Fuel consumption is 5.1 GPH
  Power output is 63%

CONDITIONS: Cruise Performance
1,670 Pounds
Recommended Lean Mixture (See Section 4, Cruise)

NOTES:
Cruise speeds are shown for an airplane equipped with speed fairings which increase the speeds by approximately two knots

PRESSUE 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	2400				75	101	6.1	70	101	5.7
	2300	71	97	5.7	66	96	5.4	63	95	5.1
	2200	62	92	5.1	59	91	4.8	56	90	4.6
	2100	55	87	4.5	53	86	4.3	51	85	4.2
	2000	49	81	4.1	47	80	3.9	46	79	3.8
4000	2450				75	103	6.1	70	102	5.7
	2400	76	102	6.1	71	101	5.7	67	100	5.4
	2300	67	96	5.4	63	96	5.1	60	95	4.9
	2200	60	91	4.8	56	90	4.6	54	89	4.4
	2100	53	86	4.4	51	85	4.2	49	84	4.0
	2000	48	81	3.9	46	80	3.8	45	79	3.7

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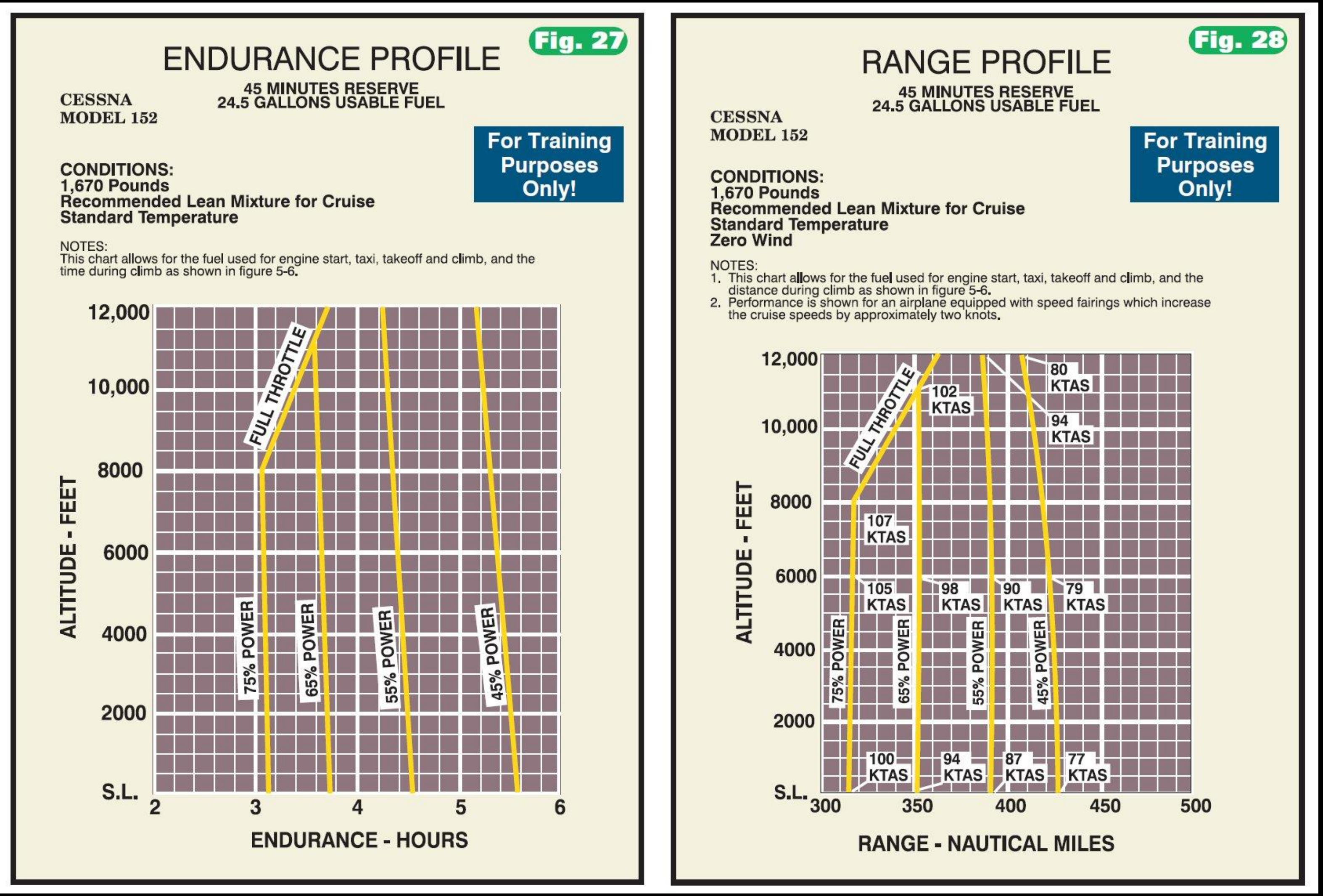
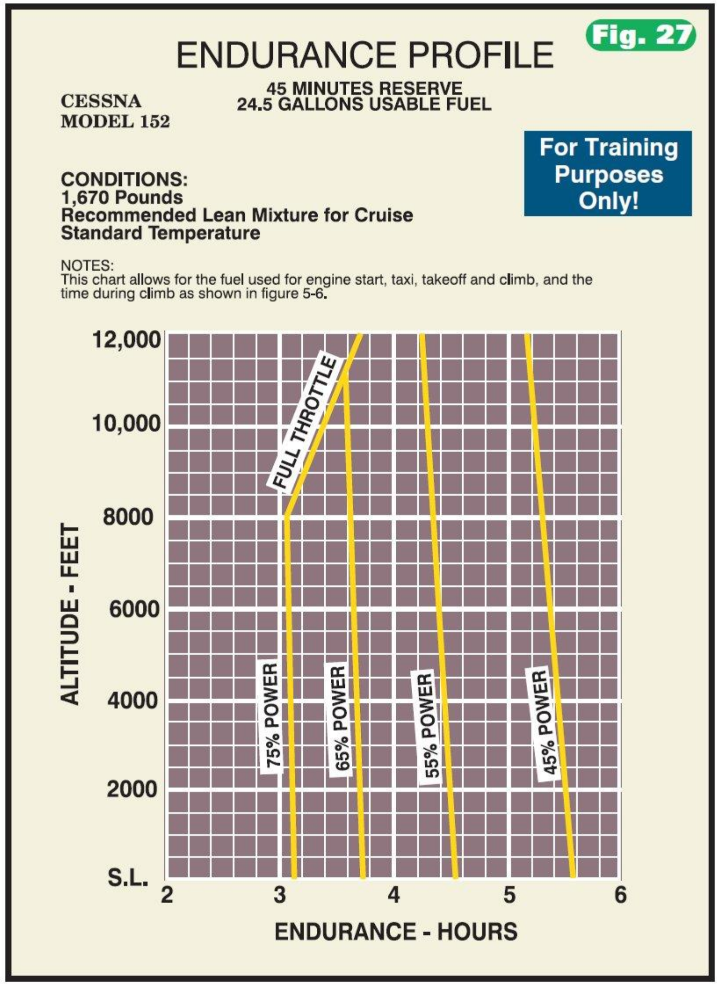
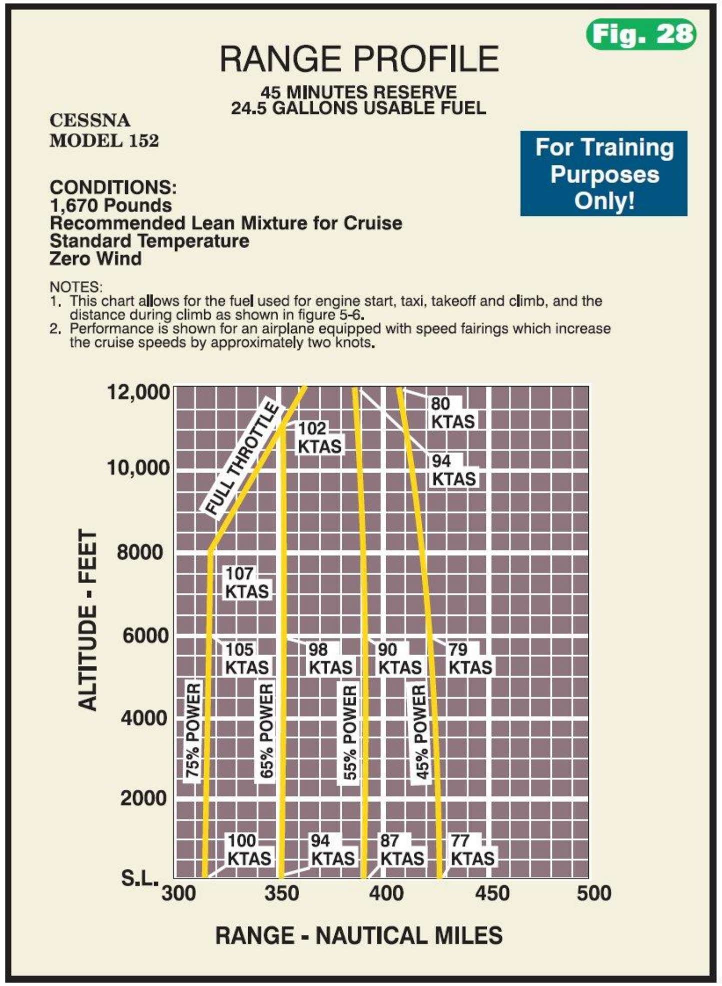
Endurance and Range Profile Charts

- Left is a best-endurance chart
- Right is a best-range chart
- To use either chart you must know the percentage of power developed by the engine
- Percent power is found in the previous cruise performance charts



Endurance

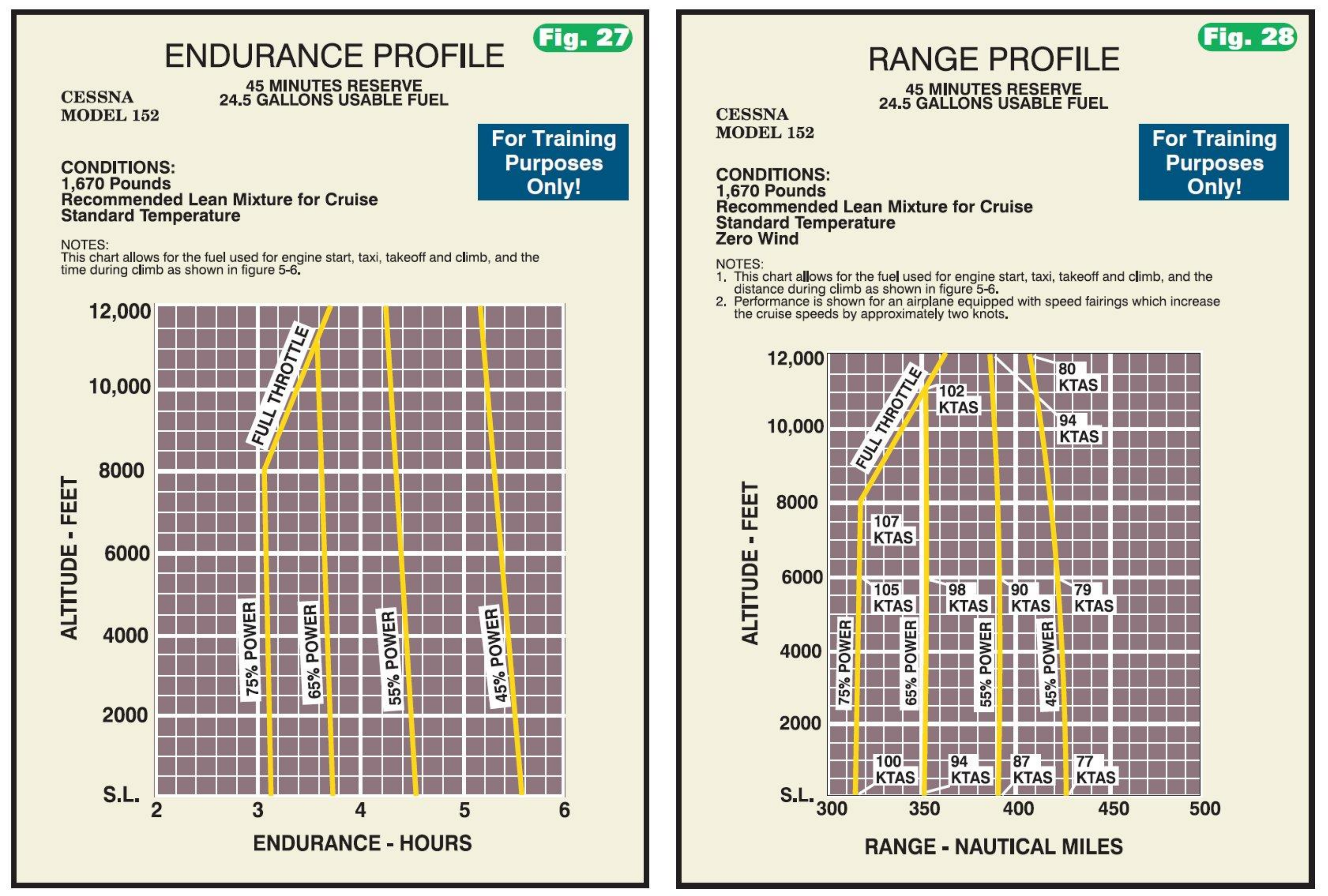




- ***What would endurance be at 8,000 feet if using 65% power?***
- Find 8,000 feet and move across to the 65% power line
- Drop straight down and find an endurance of 3 hours and 36 minutes

Range

- At 65% power and 8,000 feet range is approximately 354 nautical miles
- Range is based on no wind
- Both Range and Endurance charts yield numbers that include a 45 minute fuel reserve



Practice Problems

Tips

- *Read all chart notes first*
- *If data is given in °C and chart uses °F, convert data to °F*
- *Do the same with MPH vs. Knots*

Considerations

Discussion

- How can the following effect aircraft performance?

- Weight and Balance
- Pilot Technique
- Airframe Limitations

Knowledge Check

What speed will give you the greatest altitude gain over a given distance?

A. V_{SO}
B. V_Y
C. V_{MC}
D. V_X

Knowledge Check

What speed will give you the greatest altitude gain over a given distance?

~~A. V_{SO}~~
~~B. V_Y~~
~~C. V_{MC}~~
D. V_X

Knowledge Check

Which of the following factors do not influence takeoff performance?

A. Weather conditions
B. Pilot Technique
C. Winds Aloft
D. Weight and Balance

Knowledge Check

Which of the following factors do not influence takeoff performance?

A. ~~Weather conditions~~
B. ~~Pilot Technique~~
C. Winds Aloft
D. ~~Weight and Balance~~

Knowledge Check

Which section of the POH will describe how a short-field effort Takeoff or Landing is expected to be performed?

A. Section Three
B. Section Five
C. Section Nine
D. Section Four

Knowledge Check

Which section of the POH will describe how a short-field effort Takeoff or Landing is expected to be performed?

A. ~~Section Three~~
B. ~~Section Five~~
C. ~~Section Nine~~
D. Section Four

Knowledge Check

What is the definition of “Service Ceiling”?

A. The altitude at which the climb rate drops to 100 feet per minute
B. The altitude at which the climb rate drops to 1,000 feet per minute
C. The altitude at which the climb rate drops to 500 feet per minute
D. The altitude at which the climb rate drops to 0 feet per minute

Knowledge Check

What is the detention of "Service Celling"?

A. The altitude at which the climb rate drops to 100 feet per minute

~~B. The altitude at which the climb rate drops to 1,000 feet per minute~~

~~C. The altitude at which the climb rate drops to 500 feet per minute~~

~~D. The altitude at which the climb rate drops to 0 feet per minute~~

Knowledge Check

Which of the following factors does not affect Density Altitude?

A. High elevations
B. Short runway
C. High temperatures
D. High humidity

Knowledge Check

Which of the following factors does not affect Density Altitude?

A. ~~High elevations~~
B. Short runway
C. ~~High temperatures~~
D. ~~High humidity~~