CFI Notebook

Reference notes for the private, instrument, and commercial pilot candidate and instructor

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For Zoë, Sebastian, and Malcolm, who hopefully find
as much inspiration from me as I do from them.
I hope they learn to fly one day too.

Introduction

DISCLAIMER: As of this writing, the author is NOT an FAA-certified ground or flight instructor. This book must be used for reference purposes, only. For the purpose of ground or flight instruction, the reader is directed to consult a ground instructor, certificated flight instructor (CFI) or certificated flight instrument instructor (CFII).

This book represents José's draft CFI notebook. One day, I hope to use this collection of notes to help me remember everything I learned, and how I learned it, so that I might share this wisdom with my students.

There are some training materials that are directed at a motivated 17 year old. They gloss over details and speak in platitudes. They are helpful, but I would argue they are a good start. I would argue they do not assume enough of their audience.

There are some training materials that are extremely thorough, Denker [2] comes to mind. They are fantastic. They also assume a pretty rigorous grounding in physics. I love these training materials - as *references*.

So, where does this work lie? It's somewhere in between.

As an engineer, I perceive the world - including aviation - in a rigorous, quantitative fashion. Sure, when flying, I make subjective, sometimes spontaneous decisions, based on experience. But, when learning, I find that the basics are enough. I need rigor. I need quantification. The added information is most immediately useful as a memory aid, providing another mental structure (in addition to time in the aircraft) to scaffold everything we learn.

I'll take lazy eights as an example here. The author's command on this commercial pilot maneuver took a quantum leap once some key observations were made.

Join me as we take to the skies.

Acknowledgements

It takes a village to keep a small airplane in the air, and to make a pilot.

Most immediately, I must call out John Grieger, Brent Kelley and Tim Stahla, my partners (as of this writing) in our shared ownership of N36262, our 1978 Piper Lance II. With their help I have learned more about what it means to be the owner and operator of an aircraft than I could have hoped to otherwise. Our hangar flying sessions have made us all better pilots. I appreciate Martyn Atterton for selling me his share of the airplane when he decided it was time to hang up his wings.

Due credit also goes to the superstar mechanics who have helped to keep the Lance in the air. They are Bob Gloris, Mike LaPlant and John Lach. We are also grateful for the efforts of many other mechanics and technicians who help with all manner of aircraft issues.

My thanks go to the crew of phenomenal flight instructors with whom I have had the pleasure of flying throughout my aviation career. In reverse chronological order of last flight, these are: Cole Turner, Eric Lenk, Steve Jennings, Lawrence Spinetta, Mark Kobelin, Stephen Pitts, and Tim Stingle. Thanks, too, to my checkride examiners: David Goll, Felix Chiota. Each has brought their own unique perspective of flight and instruction to the table. All have helped me to shape and refine my own instructional style. With them together, I feel like I've gotten the best combination of military flight instruction, airline flight instruction, aeronautical university instruction, and homegrown Part 61 instruction that I could have possibly gotten as a low hour pilot.

I would also like to thank the fantastic crew of safety pilots who have flown with me through the years, regardless of who was in which seat. These would be Karthik Shivashankar, Leland Freeman, David Kindley, Geoffrey Blake, Robert Curtis, David Loia, and Jeff Chern. It is somewhat refreshing to know that all pilots, regardless of their seniority, are still students and are still humans.

Due credit goes to Joe Locasto, the old man at KSQL airport who gave me the final push to get into flying in 2011. When I lamented that flying was too expensive, he responded: "well, it's never going to be cheaper, so what are you waiting for?"

My eternal thanks go to my wife Jane, for supporting (or at least tolerating) many late nights spent putting the airplane away. When I propose a new adventure, this wonder woman never says “no”, only, “how?”.

Contents

Chapter 1

Performance and Limitations

It is important to know the capabilities of the airplane. It is also important to note how they change.

The Lance in particular has a huge variation in operating weight and center of gravity. A nose loaded, light Lance is practically a different airplane from a tail loaded, heavy Lance. It's important to explore the envelope of the plane in flight. But first, it's important to understand the envelope on the ground.

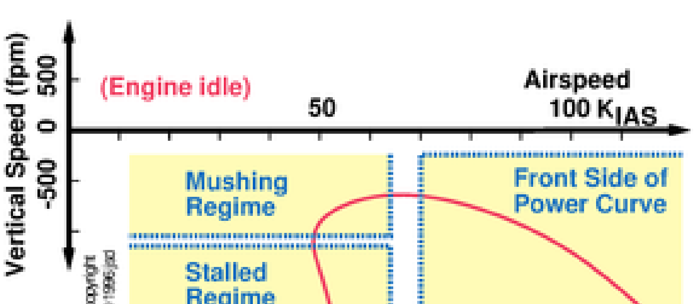
This chapter references the Lance's POH heavily. It is here: https://tinyurl.com/n36262poh.

1.1 The Power Curve

We're engineers! We want a rigorous definition of all of the above speeds and their variation.

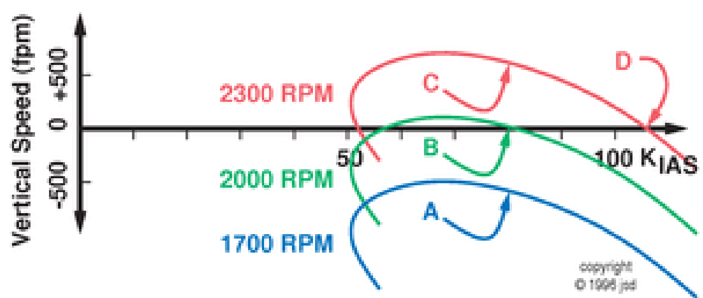
John S. Denker in "See How It Flies" has the most beautiful power curve diagram I've seen. It ties together the three major regimes of flight - normal, slow, and stalled - in one simple diagram. To me it is more clear than the classic diagram that plots lift, drag, and their ratio.

Here is Denker's power curve at idle power.



We plot airspeed on the X axis and vertical speed on the Y axis. The curve is decidedly not a function: it doubles back on itself. But we can piecewise define it as three functions. We draw a vertical tangent line on the left edge and a horizontal tangent line at the top edge. We'll talk about those tangent points later, they're important. But they define the limits of our three regimes of interest: normal, slow, and stalled. Or as Denker calls them, front side, mushing, and stalled.

Of course, this is at idle power. Since power makes us climb, but the power curve represents a fixed relationship between adjacent speeds that is always the same shape for the airplane, setting power moves the curve up or down. Denker wrote this for a fixed pitch prop, we can instead imagine 55, 65, and 75 percent power.



The one gotcha with this explanation of the power curve is that it doesn't really explain what the flaps do directly. But we can derive it. Flaps change the shape of the airfoil and give us more lift in exchange for more drag. Low flap settings give us mostly more lift, high flap settings give us mostly more drag. More lift means moving the curve up. More drag meand moving the curve to the left.

1.2 Speed Definitions

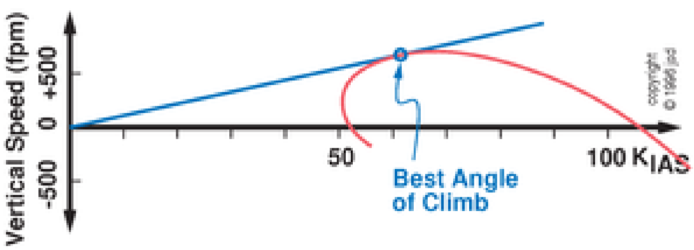
Now that we've built a rigorous framework for describing airplane behavior using the power curve mode, we can go ahead and define some speeds. The following speeds are appropriate for a complex single engine airplane. We do quote the Lance's POH here heavily but I find the POH definitions sorely lacking.

V_S or V_{S0} are the stalling speeds in the cruise or clean configuration: gear up, flaps up. This is the left-most point on the power curve, the barrier between the stalled and mushing regimes. From the Lance's POH: "stalling speed, or the minimum steady flight speed at which the airplane is controllable."

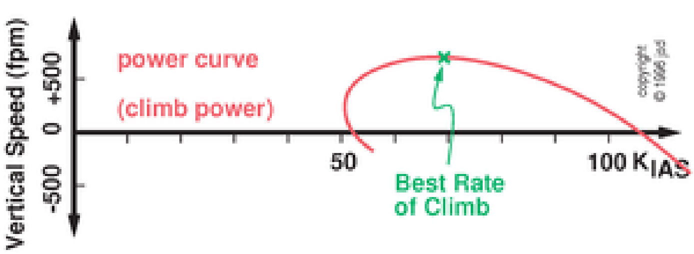
V_{S1} is the stalling speed in the landing or dirty configuration: gear down, flaps down. Since extending the flaps moves the power curve to the left, stalling speed is lowered.

V_R is the rotation speed. Denker suggests a few knots below V_Y unless specifically doing a short or soft field takeoff. In those cases I'd lift off right at or around V_X.

V_X is the best *angle* of climb speed, which we use to clear an obstacle. Denker draws a tangent from the origin of his performance curve axes to the power curve, the point of intersection is V_X. That speed will get slower if the power curve moves up (more lift) or to the left (more drag).



V_Y is the best *rate* of climb speed, which we use to gain altitude quickly. It corresponds to the maximum lift over drag speed, meaning, the most efficient point of operation. The maximum endurance speed is usually not far from this value. Denker draws this at the top of the power curve, or rather, where a horizontal line would be tangent to the curve. This does change with weight but as Denker points out the power curve is pretty flat here.



V_G is the best glide speed. V_Y is a reasonable guess.

V_{FO} is the flap operation speed. We don't have a specific one for the Lance.

V_{FE} is the flap extension speed. This is the speed at which the flaps may be extended. From the POH: "the highest speed permissible with wing flaps in a prescribed extended position."

V_A is the maneuvering speed. It is "the maximum speed at which application of full available aerodynamic control will not overstress the airplane." I talk about V_A in a later chapter, but realize that it depends on weight, and tests *a single control's full deflection at once*. Putting multiple controls to full deflection may overstress the airframe.

V_{LO} is the landing gear operation (retraction) speed. This is the maximum speed at which the landing gear may be safely extended or retracted.

V_{LE} is the landing gear extended speed. It is "the maximum speed at which an aircraft can be safely flown with the landing gear extended."

V_{NO} is the "normal operating" speed. "Maximum Structural Cruising Speed is the speed that should not be exceeded except in smooth air and then only with caution."

V_{NE} is the never exceed speed. Operations past this speed are likely to cause structural damage to the aircraft.

1.3 Lift and Weight

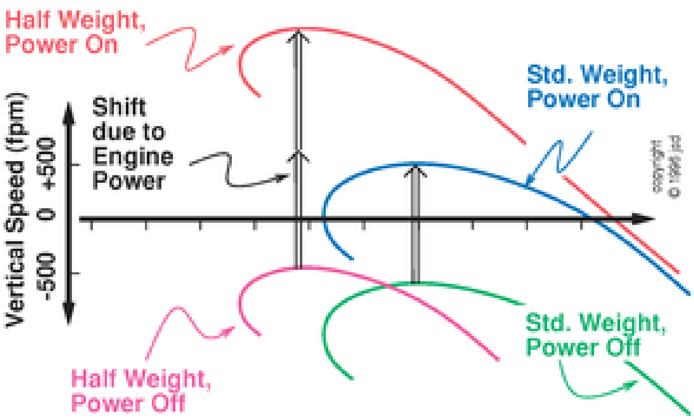
Recall the lift equation:

$$L = \frac{1}{2}\rho V^2 C_L S \tag{1.1}$$

, where ρ is the density of the air, V is velocity, C_L is the coefficient of lift and S is the surface area of the airfoil.

That V^2 term is key, Lift is proportional to the *square* of velocity. So what happens if we halve the weight, and thus, the needed lift? Well, it would drop by the square root of a half, which happens to be $\frac{\sqrt{2}}{2} \approx 0.707\ldots$ which is about 29 percent. At three-quarters weight, it drops by the square root of three quarters, which is $\frac{\sqrt{3}}{2} \approx 0.866\ldots$ which is about 13 percent.

Denker points out that the entire power curve shifts up and to the right, with both power off and power on. He even points out a Cherokee Six as a specific example of this - how interesting!



The procedure to derive this curve is as follows:

1. Scale the entire standard weight, power off curve by the reduction factor. It will move up (since vertical speeds are chopped - a light airplane doesn't sink as much) and to the left (since airspeeds go down - a light airplane has a lower stalling speed).
2. Shift the curve up for power. Realize that, since the airplane is lighter, the curve will shift by a greater amount.

1.4 Center of Gravity and Performance

There are some truths that the private pilot is expected to know about not only how the weight of the airplane affects performance, but also how the center of gravity affects performance.

First we can build some intuition. Fold a paper airplane (technically an "origami glider"). Go ahead, I'll wait. Now fly it. Observe how it flies. No wrong or right here, just observe the behavior. We'll use this as a baseline.

Now take a paper clip and clip it to the nose. Fly it again. What changes? It's a bit more stable - it wants to fly where we throw it. But it wants to nose down and stops flying at a lower speed. We can make it fly further by bending some tabs in the back.

Now take the paper clip, remove it from the nose, and clip it to the tail. Fly it a third time. What happens? Does it even fly at all? Probably not.

These are the extremes. If we flew a real airplane this nose or tail heavy it would be bad news indeed. But the same truths apply.

A nose heavy airplane is more stable. Why? For the same reason a tightrope walker is more stable holding a stabilizing rod: distribution of weight. The larger arm between the center of gravity (or center of mass - we use the terms equivalently) and the center of pressure means that the weight can act in a more nuanced fashion. The elevator (on a normal airplane with a normal empennage, not some Burt Rutan designed contraption) has to fly heavier to counteract the nose heaviness, which means it has more authority.

With the nose being heavy, the nose wants to keep falling over. We eat into our angle of attack budget because we need to fight to keep the nose up with elevator trim and angle of attack - just like we saw on our paper glider earlier.

The thing about flying with a higher angle of attack is that it increases our drag in all regimes. It increases our induced drag because the plane has to generate more lift at lower speeds. It increases our parasite drag because the frontal area of a wing at a higher angle of attack is greater.

If we take a look at the usual form of the lift/drag diagram - the one out of the testing supplement - some truths about stalling speed and cruise speed become pretty obvious. (But it took ten years for me to think of it this way...)

Compare power available and power required (sum total of induced and parasite drag).

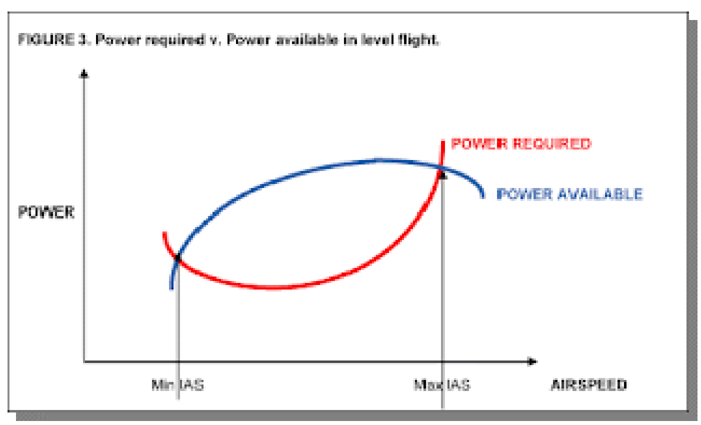


FIGURE 3. Power required v. Power available in level flight.

Image borrowed from http://airsoc.com/articles/view/id/59acd2623d2d2ebb7e8b4567/behind-the-power-curve until I make a better one.

This is a different view of the power curve. This form is nice because the stalling and cruising speed of the airplane fall out nicely. They are the places where the red and blue curves intersect. The intersection point on the left is the stalling speed. The intersection point on the right is max cruise.

So what does the higher angle of attack required for a nose heavy airplane do? It moves the red curve UP. What happens to the points? They move *closer together*.

A nose heavy airplane has a *higher* stall speed and a *lower* cruise speed. It is more stable.

Now. What happens to V_Y, our best climb speed? It so happens this speed is at L/D_{max}, the maximum lift over drag speed. Translating a curve up or down doesn't change that point. So V_Y is *unchanged*.

The converse is true for an aft heavy airplane: lower stall speed (!), higher cruise speed, lower angle of attack, less stable. The red curve moves DOWN.

If we look at the sort of spiral shaped view of the power curve we'd been looking at, a really high angle of attack from a nose heavy airplane would compress the curve about its best rate of climb. So what does this do to V_X? Well, recall that we had this clever tangent line definition of V_X erarlier. If we compress the curve, that tangent point *necessarily* moves to the left - as does *every* point on the "back of the power curve"! So V_X will increase. Slightly.

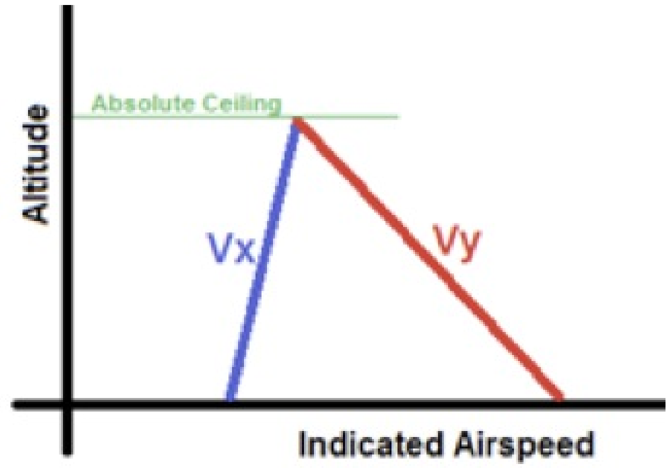
1.5 Altitude and Performance

For this let's consider a naturally aspirated engine. Turbocharged, supercharged, and turbine engines have different properties.

As the airplane climbs the engine becomes starved for air. The power curve moves down.

What happens to V_X? Well we defined it earlier as a tangent point along that power curve. As the curve comes down, the tangent point moves to the right. V_X increases.

How about V_Y? We have less excess power at any given airspeed. The curve shrinks a little bit. V_Y slowly increases with altitude because we have less and less excess power.



See https://www.advancedpilot.com/articles.php?action=article&articleid=1842. Or for yet another take on this see https://azpilots.org/news/17-safety/50333-climb-speeds.

As altitude increases, our V_X increases and our V_Y decreases until they converge. At this point we have zero climb performance and one - only and exactly one - point on our power curve produces a nonnegative climb rate. That's our absolute ceiling.

If we're in a pinch and need to find V_Y we can put on our test pilot hats and do so empirically. Set a speed and watch the VSI. Knock 5 knots off (one line on the airspeed indicator). Trim for it and hold it. Are we climbing at a faster or slower rate?

Remember, too, that V_Y cannot go up, unless we swap engines.

1.6 V Speeds for the Lance

The Lance's POH defines a number of speeds. These speeds are commonly defined for single engine airplanes.

In this section, we explore the Lance's V speeds. For each V speed, we consider the definition of the speed, what it means operationally, and how it varies with respect to aircraft weight, aircraft loading (nose or tail heavy), density altitude, aircraft configuration (flaps, landing gear), and aircrat attitude.

The beginning of Section 4 of the POH provides many of these figures.

Recall the weights and speeds variation formula, which we can derive from two different values of the lift for-

V Speed	Value (KIAS)	Marking
V_{SO}	52	Bottom of White Arc
V_S	53	Bottom of Green Arc
V_R	87	None
V_X	68-87	None
V_Y	92	None
V_{FE}	109	Top of White Arc
V_A	132	Placard
V_{LO}	106	Placard
V_{LE}	129	Placard
V_{NO}	150	Bottom of Yellow Arc
V_{NE}	191	Red Line

Figure 1.1: V Speeds - P32T

Weight (pounds)	Stalling Speed (KIAS)
3600	53
3200	50
2800	47
2400	43
2151	41

Figure 1.2: Stalling Speed Weight Variance - P32T

mula. It is written here for stall speed but applies to many speeds in this section.

$$V_S' = V_S\sqrt{\frac{New\ Weight}{Old\ Weight}} \tag{1.2}$$

We can use this formula to calculate different speeds for a few different weights. I'll show values for 3600 lbs (max gross), 3200 lbs, 2800 lbs, 2400 lbs, and the airplane's minimum weight (with third row seats removed) of 2151 lbs as per the most recent POH.

Here is a cheat sheet with all the V speeds at max gross weight.

1.6.1 V_S - Stalling Speed

52-53 KIAS.

Variation Chart: see Figure 1.2.

- Markings: Bottom of green arc for flaps up. Bottom of white arc for flaps down.
- Weight: a heavier airplane will require a higher angle of attack to fly and thus will have a higher stalling speed. A lighter airplane will have a lower stalling speed.
- Loading: a nose heavy airplane will have a higher stalling speed due to the high angle of attack required to keep the nose flying. Conversely, an aft loaded airplane will have a lower stalling speed. But according to Denker the effect is relatively small, a few knots.
- Density Altitude: In thinner air, there is a greater discrepancy between indicated and calibrated airspeed. The airplane will stall at the same indicated airspeed but a higher true airspeed.
- Configuration: Changing the shape of the wings by deploying flaps changes the effective angle of attack. Deploying flaps will usually make the stall speed decrease.
- Attitude: Stalling speed increases in a turn since we are using a larger component of our lift vector to keep the airplane aloft. In turbulence, the angle of incidence may vary, leading to an earlier stall because the relocation of the relative wind causes us to exceed critical angle of attack earlier.

1.6.2 V_{NE} - Never Exceed Speed

191 KIAS or 189 KCAS

Variation Chart: None. This is an absolute value based on aerodynamic pressure, measured with the pitot tube. The wings and tail can crumple at any weight.

- Markings: Top of the yellow arc on the airspeed indicator. Red line on same indicator.
- Weight: No factor.
- Loading: No factor.
- Density Altitude: Will occur at a higher true airspeed, but same indicated airspeed, at high density altitude.
- Configuration: TODO
- Attitude: TODO

1.6.3 V_{NO} - Maximum Structural Cruising Speed

150 KIAS or 150 KCAS

Gross Weight (pounds)	Maneuvering Speed (KIAS)
3600	132
3400	129
3200	126
3000	123
2800	120
2600	117
2400	115
2151	112

Figure 1.3: Maneuvering Speed Weight Variance - P32T

Variation Chart: None. This is an absolute value based on aerodynamic pressure, measured with the pitot tube. The wings and tail can crumple at speeds beyond this in turbulence due to momentary increases in load factor. Operations in this region, including descents, are approved in smooth air. Proceed with caution!

- Markings: TODO
- Weight: TODO
- Loading: TODO
- Density Altitude: TODO
- Configuration: TODO
- Attitude: TODO

1.6.4 V_A - Design Maneuvering Speed

132 KIAS or KCAS at max gross weight. Also “Turbulent Air Operating Speed”.

Variation Chart: Per POH, use linear interpolation to get V_A at various weights. See Figure 1.3.

- Markings: Placarded for max gross weight.
- Weight: TODO
- Loading: TODO
- Density Altitude: TODO
- Configuration: TODO
- Attitude: TODO

1.6.5 V_{FE} - Maximum Flaps Extended Speed

109 KIAS or KCAS

Variation Chart: None. This is a structural limitation.

- Markings: TODO
- Weight: TODO
- Loading: TODO
- Density Altitude: TODO
- Configuration: TODO
- Attitude: TODO

1.6.6 Maximum Landing Gear Extension Speed

129 KIAS or 130 KCAS

Variation Chart: None. This is a structural limitation.

- Markings: TODO
- Weight: TODO
- Loading: TODO
- Density Altitude: TODO
- Configuration: TODO
- Attitude: TODO

1.6.7 Maximum Landing Gear Retraction Speed

106 KIAS or 109 KCAS

Variation Chart: None. This is a structural limitation.

- Markings: TODO
- Weight: TODO
- Loading: TODO
- Density Altitude: TODO
- Configuration: TODO
- Attitude: TODO

1.6.8 V_{LE} - Maximum Landing Gear Extended Speed

129 KIAS or 130 KCAS

Weight (pounds)	Speed (KIAS)
3600	92
3200	87
2800	81
2400	75
2151	71

Figure 1.4: Best Rate of Climb Speed Weight Variance, Clean - P32T

Weight (pounds)	Speed (KIAS)
3600	87
3200	82
2800	77
2400	71
2151	67

Figure 1.5: Best Rate of Climb Speed Weight Variance, Dirty - P32T

Variation Chart: None. This is a structural limitation.

- Markings: TODO
- Weight: TODO
- Loading: TODO
- Density Altitude: TODO
- Configuration: TODO
- Attitude: TODO

1.6.9 Caution Range - Yellow Arc

150 KIAS to 191 KIAS

Variation Chart: None. See prior discussion of V_{NO}.

- Markings: TODO
- Weight: TODO
- Loading: TODO
- Density Altitude: TODO
- Configuration: TODO
- Attitude: TODO

1.6.10 V_Y - Best Rate of Climb Speed

87 KIAS (gear down, flaps up) to 92 KIAS (gear up, flaps up)

Variation Chart: Yes. As this is a speed derived from the power curve, it is subject to translations and scalings of the power curve based on gross weight and configuration. See Figure 1.4 for the clean configuration and 1.5 for the dirty configuration. I consider these speeds to be optimistic and generally add 2-3 knots.

- Markings: TODO
- Weight: A higher weight causes a higher angle of attack and leaves less power available resulting in a higher best rate of climb speed. Variation Chart: TODO
- Loading: No variation. None! A nose heavy airplane will have higher induced drag and require more power to overcome this greater induced drag. The POH provides a hint concerning takeoff performance for nose heavy CGs forward of 85 inches. This increase is due to the gadded drag of the nose heavy airplane.
- Density Altitude: TODO
- Configuration: TODO
- Attitude: None. Attitude follows takeoff configuration, not the other way around. Fly coordinated now.

1.6.11 V_X - Best Angle of Climb Speed

68 KIAS (gear down, flaps up) to 87 KIAS (gear up, flaps up)

Variation Chart: Yes. As this is a speed derived from the power curve, it is subject to translations and scalings of the power curve based on gross weight and configuration. See Figure 1.6 for the clean configuration and 1.7 for the dirty configuration. I consider these speeds to be optimistic and generally add 2-3 knots.

- Markings: None.
- Weight: A lighter airplane has a lower V_X. A heavier airplane has a higher V_X. See previous discussion.
- Loading: A nose heavy airplane has a slightly higher V_X. See previous discussion.
- Density Altitude: TODO

Weight (pounds)	Speed (KIAS)
3600	87
3200	82
2800	77
2400	71
2151	67

Figure 1.6: Best Angle of Climb Speed Weight Variance, Clean - P32T

Weight (pounds)	Speed (KIAS)
3600	68
3200	64
2800	60
2400	56
2151	53

Figure 1.7: Best Angle of Climb Speed Weight Variance, Dirty - P32T

- Configuration: TODO
- Attitude: None. Attitude follows takeoff configuration, not the other way around. Fly coordinated now.

1.6.12 Landing Final Approach Speed, Full Flaps

75 KIAS

Variation Chart: TODO

- Markings: TODO
- Weight: TODO
- Loading: TODO
- Density Altitude: TODO
- Configuration: TODO
- Attitude: TODO

1.6.13 Maximum Demonstrated Crosswind Velocity

17 knots.

Variation Chart: None.

- Markings: TODO
- Weight: TODO
- Loading: TODO
- Density Altitude: TODO
- Configuration: TODO
- Attitude: TODO

1.7 Limitations

Along with performance, we need to understand the limitations of the aircraft. This section focuses on the Lance's limitations as mentioned in the POH, Section 2. It references the performance charts in the Lance's POH. We also need to cross-reference Section 9, the Supplements, for optional equipment. The writeup here focuses on things that the pilot can control or needs to know, and not things that are set on the ground (like the propeller diameter).

1.7.1 Airspeed

We discussed the airspeeds extensively in the previous section.

1.7.2 Engine

Maximum RPM: 2700.

Maximum oil temperature: 245 F (POH figure) or 118 C.

Oil pressure: minimum 25 PSI (red line), maximum 100 PSI (red line). We do exceed this briefly on the ground when oil is cold regularly by about 5 PSI.

Fuel pressure: minimum 12 PSI, maximum 40 PSI.

Fuel grade: 100/130 - Green. We use 100LL - Blue in the airplane all the time.

1.7.3 Weight Limits

Maximum weight of the airplane is 3600 lbs. Maximum baggage is 200 lbs, with 100 lbs in each of the fore and aft compartments.

1.7.4 Center of Gravity

At 3600 lbs: CG from 91.4 to 96.0 inches aft of datum.

At 3000 lbs: CG from 84.0 to 96.0 inches aft of datum.

At 2500 lbs: CG from 82.0 to 96.0 inches aft of datum.

1.7.5 Maneuvers

No acrobatics. No spins.

1.7.6 Flight Load Factors

Positive load factor to 3.8G - this is a "Normal" category airplane.

No inverted maneuvers approved.

1.7.7 Types of Operations

Day and Night VFR and IFR. Non icing.

1.7.8 Fuel Limitations

98 gallons total, of which 4 gallons are unusbale and 94 gallons are usable. These are totals, divide in half for each wing.

1.7.9 Rear Cabin Door Removal

Such operations are authorized. Max speed 144 KIAS. No smoking. Articles and lines must be tied down, stowed, and kept clear of controls and control surfaces. VFR only.

1.8 Performace

Performance and limitations go hand in hand. In this section we take a closer look at performance.

"Remember: to get chart performance, follow the chart procedures."

1.8.1 Airspeed System Calibration

Recall that calibrated airspeed is indicated airspeed corrected for installation and instrument errors.

The correspondence between KIAS and KCAS is largely linear. There is a slightly less linear region below max lift/drag speed.

Putting the flaps full down introduces about 2-3 knots of calibration error.

The reported calibration is at max gross weight.

There is no indication that calibrated airspeed varies with weight. Since we're simply concerned with the pressure differential in the pitot-static system, the weight should be no factor. If the airplane were infinitely heavy (tied down) the indications would be the same as if the airplane were neutrally buoyant (hovering just above the ground).

1.8.2 Stall Speed versus Angle of Bank

There is a well known correspondence between load factor and stall speed. This chart draws the correspondence between angle of bank, in degrees, and the stall speed with the flaps full down or the flaps full up.

Looking at the chart, we can tell that the airplane's stall speed with the flaps down is one knot lower.

The chart calls out maximum gross weight. As we know from earlier, the stall speed of the airplane varies with loading, which would cause the curve(s) to translate downward as stall speed lowers with reduced weight.

The chart does not provide stall speeds for bank angles beyond sixty degrees. Thus, we could take this to mean that a sixty degree bank is an operational limitation.

1.8.3 Flaps Second Notch Takeoff Performance and Ground Roll

This chart tells us our takeoff distance over a fifty foot barrier as a function of outside air temperature, pressure altitude, weight, and wind.

The chart numbers assume wide open throttle 2700 RPM, holding the brakes, and a paved, level, dry runway. They implicitly assume aft trim since the short field procedure calls this out.

We are cautioned that a nose heavy airplane has a harder time taking off. "Takeoff distance is increased by approximately 25% at CGs forward of 85 inches."

The chart is divided into three sections. The relations are decidedly nonlinear, but they are at least first and second order smooth.

In the first section we are in effect calculating the density altitude based on pressure altitude and outside air temperature. Lower temperatures result in shorter takeoff distances (air is more sense). Lower pressures also result in shorter takeoff distances.

In the second section we are correcting for airplane weight. A lighter airplane takes off in less distance (less lift required).

In the third section we are correcting for wind. A headwind reduces takeoff distance. A tailwind increases takeoff distance.

I do not believe the borders of this chart to be regulatory. Certainly we can launch an airplane into a greater than 15 knot headwind, or even a 5 knot tailwind (not something I would want to do without quite a lot of runway). We should be able to take off at pressure altitudes above 7000 feet as well. But doing something off the borders of the chart would certainly give me pause.

For the record, these numbers are extremely optimistic. The chart gives lift off speeds of 62-63 knots and obstacle clearing speeds of 62-65 knots, varying by weight in what now is the usual manner. But in my airplane we're not off until 73 knots at the earliest. That is a 15% discrepancy. So I make sure to pad these numbers by 15% in my own operations.

The ground roll chart is largely identical to the prior chart. All of the prior discussion applies, including the caveats. The main difference is that we are calculating ground roll instead of distance over an obstacle.

1.8.4 Flaps Up Takeoff Performance and Ground Roll

This chart is the bread and butter of our operations. Most of our takeoffs will be normal. The discussion from the flaps second notch charts applies here as well.

The liftoff speeds, once again, are optimistic. They say we will be off at 66-70 knots. I find that hilarious. N36262 doesn't want to fly until about 85 knots, you can't even pull it off the ground without some difficulty. That's a 25% discrepancy, and I would add a 25% "fudge factor" to these figures.

1.8.5 Gear Up and Gear Down Rate of Climb

This chart provides the climb performance of the airplane as a function of density altitude, engine fuel mixture, and airplane weight. The climb rate may be zero, or as great as 1700 feet per minute according tot his chart.

To achieve these numbers, the provided configuration is: gear up or down, flaps up, mixture as noted, wide open throttle, maximum RPM of 2700, and V_Y, which is once again 92 (gear up) or 87 (gear down) knots indicated.

These numbers are optimistic as well. They imply a 16,000 foot service ceiling for the airplane. That's very interesting as I saw a demonstrated service ceiling of 12,500 feet on an ISA+05 day, seeing about 50-100 feet per minute when we should have been seeing 200 according to this chart. So I would knock off 100 to 200 feet per minute - I would shift the entire right hand section of these charts over to the left a little bit.

1.8.6 Fuel, Distance, and Time to Climb

This chart estimates the fuel (in gallons), time (in minutes) and distance (in nautical miles) to achieve a particular density altitude. We collect data at the density altitude of takeoff, and of cruise, and take their difference to get our expected performance.

As usual, these numbers are so optimistic as to be objectionable.

The numbers are given in this configuration: gear up, flaps up, 2700 RPM, full throttle, 92 KIAS, 3600 lbs gross weight, no wind.

My procedure is to pull the engine back to 2500 RPM once we're at least 500 AGL. The primary reason for this is noise abatement. The secondary reason is to reduce wear and tear on the engine. The Cirrus derates the engine to 2500 RPM. That costs some performance.

But do leave the throttle alone. We don't need to pull it back. It's just one more thing to mess with in a critical phase of flight.

John Deakin talks about engine performance on takeoff here: `https://www.avweb.com/features/pelicans-perch-63where-should-i-run-my-engine-part-1/` and `https://www.avweb.com/features/pelicans-perch-64where-should-i-run-my-enginepart-2-the-climb/`. These are part of the truly excellent *Pelican's Perch* series of articles he wrote twenty years ago (!). [TODO: Add these articles to the bibliography, copy to the Takeoff section.]

As long as EGTs and CHTs are happy, with our GAMIjectors, we can lean to our heart's content. So I would pull the mixture back a little bit on climb out, and of course continue leaning as we climb into thinner air.

A 15-20% correction is what we've been using, so maybe that's appropriate here as well.

This chart does not provide any limitations.

1.8.7 Power Setting Table

This chart provides expected RPM and manifold pressure values for 45, 55, 65, and 75 percent engine performance at a number of pressure altitudes. In practice, the engine computer helps us with these values. Note that in a number of situations "over-square" valies are explicitly okay, further debunking the square myth.

We add 0.18 inches of manifold pressure for every 10 degree Fahrenheit variation above standard (since we need more air). We subtract for temperature below standard.

The implicit limits of this chart are wide open throttle or stalling the engine.

1.8.8 Cruise Performance

A handful of charts collectively describe speed, power, range, and endurance in a number of cruise configurations. The fuel flows are excessive, with our GAMIjectors we can achieve these numbers about two gallons per hour lower.

1.8.9 Fuel, Distance, and Time to Descend

Much of the discussion for the analogous Climb chart applies here. The configuration specified is: Gear up, flaps up, power as required, 150 KIAS, 500 FPM, 3600 lbs gross weight (which is impossible, we burned fuel to get to this altitude and we didn't refuel in flight), no wind.

1.8.10 Glide Range

The glide ratio is decidedly linear.

The chart gives this configuration for best glide: Gear up, flaps up, V_Y of 92 KIAS, power off, max gross weight (a lighter airplane glides further), propeller full decrease, no wind.

In real life, if the engine quits, you're losing oil pressure and thus governor authority not long after. In a single, the prop defaults to high RPM and acts as an air brake.

1.8.11 Landing Performance and Ground Roll

These charts are similar to the takeoff charts. But, since they assume a power off configuration, they omit a power section.

The associated conditions are: power off approach, full flaps, max gross weight (a lighter airplane stops in less distance), landing gear extended, 75 KIAS approach speed (appropriate for short field technique), full stall touchdown, maximum braking, paved level dry runway.

Performance charts are provided for the "Optional Landing Gear Heavy Duty Group No. 1". According to the equipment list, N36262 *DOES* have these installed. These include a Cleveland Aircraft Products 40-120 wheel assembly, 30-82 brake assembly, and Type III tires with eight plies. With stronger brakes, we can reduce the ground roll some.

As usual, I like a 10-20% margin here.

Chapter 2

Emergency Procedures

Dealing with emergencies is a crucial part of operating any aircraft. As a commercial pilot, operations that push the comfort zones and limits of both the pilot and the aircraft will become that much more common. Further, abiding by the law of large numbers, accidents are more likely to happen with more hours in the aircraft. Thus it is critical to be familiar with general emergency procedures, as well as the specific procedures for the airplane. Like the rest of this book, this chapter focuses on the Piper Lance II, P32T.

Systems knowledge, and systems familiarity, play a large role in emergency procedures. Not every emergency will have a dedicated checklist or flow. Sometimes, the pilot may be required to think, slow down, and understand the situation.

The heart of all emergency procedures comes down to this list, provided by Mr. Roger Sharp:

1. What can go wrong?
2. How would I know?
3. How do I fix it?
4. If I can't fix it, how do I minimize impact?

The first question involves some knowledge of aircraft systems. Thus, unlike the procedures in the POH, this chapter will focus more heavily on systems knowledge as it relates to emergency procedures.

The second question involves knowledge of general aerodynamics as well as the systems and quirks of the particular aircraft.

The third question involves following book procedure.

The fourth question involves aeronautical decision making, or ADM.

2.1 Landing Gear

2.1.1 System Overview

For starters, we begin reading about the landing gear in Chapter 7 of the POH. "The Lance II is equipped with a retractable tricycle landing gear, which is hydraulically actuated by an electrically powered reversible pump. The pump is controlled by a selector switch on the instrument panel."

The Landing Gear Electrical Schematic (Figure 7-5) provided an overview of the electrical systems connected to the gear. The landing gear actuator circuit breaker is a 25 amp circuit breaker which regulated the hydraulic pump motor, which is connected via relays to the actuator handle. The Gear Unsafe lamp is wired to the gear actuator and the up limit switches on each gear. The left, nose, and right bulbs are wired directly to the down lock switches.

Though not called out as such in the POH, the "three greens" pull right out of the instrument panel in case we need to swap them during emergency operations.

We do have a checklist for the landing gear in Section 3, Emergency Procedures. However, the title of the checklist, "Emergency Landing Gear Extension", is something of a misnomer. I would rename it to "Landing Gear Malfunctions".

Our airplane, thankfully, has the landing gear auto-extension system deleted. It is safe to ignore any sections of the POH that mention it. I confirmed this explicitly with Piper.

2.1.2 Landing Gear Malfunctions - Checklist

Prior to emergency extension procedure:

- Master Switch: Check ON.

- Circuit Breakers: Check.
- Radio Lights: Off (in daytime).
- Gear Indicator Bulbs: Check.

If landing gear does not check down and locked:

- Airspeed: Below 87 KIAS.
- Landing Gear Selector: Down.
- Emergency Gear Lever: Override Engaged (while fishtailing airplane).

If landing gear still does not check down and locked:

- Emergency Gear Lever: Override Engaged (while fishtailing airplane).

If all electrical power has been lost, the landing gear must be extended using the above procedures. The gear position indicator lights will not illuminate.

2.1.3 Landing Gear Malfunctions Discussion

The POH, Section 3.27, provides a short discussion of the above checklist I find this discussion insufficient. So, I will expand upon it here.

The first part of the checklist involves dealing with electrical issues. After all, the hydraulic gear system has an electrical pump that actuates it. Maybe the master switch is off. Maybe the pump burned out.

On this airplane, the radio dimmers also dim the three greens of the landing lights. The suggestion to turn the radio lights off makes certain that the bulbs will be as bright as possible.

The POH says to "check the landing gear indicators for faulty bulbs". But it doesn't dare describe *how* to do this. Fro crying out loud. They pull right out of the panel, and can be swapped. Note, from the electrical diagram, that the lights do offer some modicum of redundancy.

Has the airplane been flying in icing conditions? It's possible that the landing gear is frozen into place. Check the outside air temperature gage and fly into an area that has temperatures warm enough to melt the ice if able.

The recommendation to slow down - interestingly, to V_Y in the dirty configuration (it would be helpful if they mentioned that in the POH) - is to pull aerodynamic drag off a weak mechanism.

The recommendation to fishtail the airplane is to help swing a faulty landing gear into place to lock it. But this will only work with the main gears. With the nose gear, some nose dives and recoveries may help to snap the gear into place.

If none of these procedures work, it's helpful to get some eyes on the ground to have a look. Phone a friend, call the tower, or go somewhere else. If it's night time - go to a big airport, maybe they have search lights. A big airport will have more runways and more emergency services. You did bring a 45 minute reserve, did you not?

At this point, it's time to consider a forced landing. Gear up or gear down? That is the question. With two wheels down out of three we can attempt a landing. Try to use aileron or elevator to keep pressure off of the "bad" tire for as long as possible, and expect a severe yawing or pitching moment when it finally does catch. Try to turn the engine off to minimize damage.

The POH does not give any specific guidance for a partial gear landing. It DOES give guidance for whether to attempt a power off landing with gear down or gear up. But it doesn't tell us to look there, now does it? The guidance in both cases is the same: lowest possible airspeed with full flaps, ignition off, master switch off, fuel selector off, mixture idle cutoff. Tighten seat belts and shoulder harnesses. I would also open the door and prop it with a jacket, and be ready to evacuate immediately. If there is time, I would prep the fire extinguisher.

Chapter 3

High Altitude Operations

In this chapter, we introduce high altitude operations.

Before we dive in, we must answer a couple of questions.

What are high altitude operations? Simply put, these are operations far outside the "normal" environment you might expect to find on a Standard Day at sea level. We're talking about altitudes that are not terribly comfortable for humans, and possibly altitudes that are so high above MSL that we won't find any terrain there at all. There are enough aeromedical factors and enough changes to aircraft performance that we need to consider these operations carefully.

Why do we care about high altitude operations? We might need to get high enough to cross some mountains and stay above terrain. But there is also the desire for speed. I'm not just talking about the speed limit of 250 knots below 10,000 feet - if we wish to go faster, we need to go higher. I'm talking about the fact that *thinner air provides less drag*, which permits us to fly through the air more efficiently.

Mother Nature, of course, exists outside the realm of aviation. The challenges of high altitudes were present well before the first powered flights - just ask anyone who tried to climb Mount Everest in the 1800s. So, first, we must have a look at the atmosphere itself.

3.1 The Atmosphere and Its Layers

Recalling the basics from aviation weather, we know that the atmosphere is divided into several layers. Starting from the ground and going on up, we have the troposphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere. All weather - and most of the earth's air! - reside in the troposphere. Flight operations rarely venture into the stratosphere (even more rarely now that Concorde is no longer flying).

So, when we say "high altitude", we mean "higher than a short cross country flight but lower than Concorde". We're talking altitudes below about 45,000 feet. If you ever manage to get above that, please let me know. (I'm looking at you, astronaut friends... you know who you are!)

3.2 Density and Altitude

In order to better talk about the atmosphere, can we all agree on a make believe, consistent, common, daresay, *standard* atmosphere?

Well, apparently, we can. Aviators are all too familiar with the International Standard Atmosphere. This aviator only recently learned that when we say standard, we mean Standard, namely, International Standard (ISO) 2533 from 1975, which is identical to the ICAO Standard Atmosphere from -2 to 32 km, or up to about 100,000 feet.

Assuming you've paid the 198 CHF fee, or can otherwise access the standard, you would see an interesting thing happening. You would see the value of p, the pressure, and ρ, the density of the atmosphere, decrease as altitude increases - and rapidly at that. At sea level (zero elevation), pressure is the all too familiar 1013.25 hectopascals. At 3,000 meters or about 10,000 feet, we're down to 701.21 hectopascals - only 69% of the pressure at sea level! That means 69% as much air, 69% as much oxygen available for breathing or combustion, 69% as much drag.

Up at 10,000 meters or about 33,000 feet - typical airliner altitudes - we're down to 262 hectopascals. That's just over 25% of the pressure at sea level.

This is a huge change! It's enough that we need to pay special attention to how we are powering our airplanes, how we are providing our bodies with oxygen, and how we are constructing our airplanes. It's enough that we need to take into account certain operational considerations.

3.3 Propulsion

One of the problems with high altitude flight is that the air is so thin, there may not be enough oxygen for the (internal combustion) engine to run properly.

Recall that a normally aspirated aircraft with a piston engine has a service ceiling. That ceiling is defined as the altitude at which the airplane's climb rate slows to 100 feet per minute [4]. That exact altitude will vary based on aircraft loading and how the conditions compare to a standard day. Famously, Concorde would continue to climb while underway, going higher as it got lighter. But the fact remains: for a piston airplane, we can only go so high.

Since the limitation is oxygen, and not fuel, there are a few ways that we could gain power at a higher altitude.

What if we had an electric aircraft? That would be great - it doesn't need oxygen at all. Today, in 2022, battery technology isn't quite there, nor are solar cells, outside from a very few research aircraft.

What if we simply had supplemental oxygen on board? Certainly, if we carried oxygen tanks, we could supplement the oxygen in ambient air to gain more power. Operationally, this is not a great idea, since we now have to deal with the added weight, complexity, and risk of an oxygen system, and it will not last very long. But air-breathing rockets do exactly this, so it's not a bad idea per se, simply not the right one.

What if we could grab more air from the atmosphere, possibly by compressing the air before it gets to the engine intake manifold? Now we're on the right track.

The first approach we might take is simply inserting a compressor between the outside air intake and the engine's intake manifold. That compressor could be a piston pump, similar to the vacuum pum in the airplane. But that's not terribly efficient: it generates a fair amount of waste heat. For this application, a turbine is a better idea. We could power this compressor with the aircraft's engine, most likely with a belt or a gear drive off the engine crankshaft. Such a contraption has a name: supercharger. It requires more power from the engine, and there are some losses due to the belt or gear drive mechanism, but it is a new positive up to a point: we can shove more oxygen into the engine, and raise our service ceiling.

Some clever person (who?) looked elsewhere on the engine and found another possible source of energy for driving this compressor. They realized that the exhaust gasses coming out of the engine were quite warm and under a decent amount of pressure. What if this energy could be captured? We can add a *second* turbine in line with the exhaust pipe, and use the torque generated by that turbine to drive our intake compressor! As it turns out, this works better than a supercharger. We call this a "turbocharger". Sometimes we have more than one.

(some diagrams should go here)

Operating a supercharged or turbocharged engine has some key differences from operating a normally aspirated engine. One, we need to re-calibrate our manifold pressures. By this I mean, in normal operation, a piston engine's intake manifold would achieve a pressure no higher than ambient pressure, likely no more than 32 inches of mercury. But, a turbocharged (or supercharged) engine may be able to go above this. I say "may" because some turbos simply give sea-level pressure at higher altitudes (turbonormalized), whereas others can go well above sea level pressure. Regardless, the turbo lets the engine run harder than it could otherwise, which means increased heat and risk of engine damaged. There are often limitations on how long an engine may run on a particular power setting as a result.

The turbocharger (or supercharger) turbines are themselves metal parts that are subject to fatigue and thermal stresses. After flights, we want to give the turbines some time to cool down, lest we shut them off entirely and subject them to thermal shock.

Recall that, when we compress air, it gets quite warm. This is unfortunate, since we recall from the application of carburetor heat that warm air will lean our mixture. What if there were a way to compress the air, and then cool it to get it as dense as possible? There is: it is called an "intercooler". But, as this requires even more heat to be dissipated from the aircraft, the intercooler must be carefully placed so that it can dissipate heat effectively.

With a turbocharged engine in particular, the concept of “exhaust gas temperature” takes on a new meeting. Where are we measuring: before the exhaust turbine, or after? It makes more sense to measure before, and we call this the “turbine inlet temperature” or TIT. We need to manage this temperature carefully: we want the TIT to be as high as possible for efficient leaning of the engine, but if it is too high, it could melt the exhaust turbine.

These turbines need to spin quite fast - think 100,000 RPM - in order to be effective. It is challenging and expensive to create machinery that can operate at this speed.

All of this seems awfully complicated for a little bit of extra power. What if there was a better way?

There is. It's called the jet engine.

The jet engine is, at is simplest, a single turbine. It ingests air and compresses it. We inject fuel into the compressed air and ignite it, causing it to heat and expand. The exhaust heats and expands so much that it exerts a force on a turbine, which serves as thrust for the airplane. Much like the turbocharger, the jet engine grabs some energy from the exhaust system to power the input compression phase.

More specifically, this single arrangement is called a "turbojet". It is simple, powerful, and reliable. So long as fuel usage and noise are of no concern, this is the best powerplant. The military often doesn't care about fuel or noise so we see turbojets on plenty of military aircraft. If we care more about efficiency and noise than (potentially supersonic) speed, we can also attach a really fast-spinning propeller to this, and capture the propeller's thrust in a duct for maximum efficiency. This combination of a turbojet with a ducted fan is called a "turbofan" and is the most popular way of powering large aircraft.

Of course, the propulsion system allows the aircraft to operate at a higher altitude. But what about the pilot, flight crew, and passengers? Do we need to do anything special for them if we are flying at high altitudes?

3.4 Aeromedical Factors

Much like the airplane's engine, the human body needs a certain amount of oxygen to perform.

3.4.1 Impairment

Different symptoms for every person. Going into a hypobaric chamber is recommended experience.

3.4.2 Hypoxia

Hypoxic Hypoxia

If we want to get really specific about this, the real problem is that the “partial pressure” of the oxygen in the air is not enough to cross into the blood stream. So the problem we need to solve, one way or another, is making sure that there is enough oxygen in the air, that it has enough pressure to cross into the blood stream.

The oxygen isn't there.

Hypemic Hypoxia

The oxygen is there but we can't get it through the lungs into the blood. COVID, smoking.

Stagnant Hypoxia

The blood is oxygenated but it can't get to the destination due to poor blood flow.

Histotoxic Hypoxia

We can't pull the oxygen off the red blood cells at the destination.

3.4.3 Time of Useful Consciousness

Table in PHAK. 30 minutes at 20,000 feet. 1-2 minutes at 30,000 feet. 9-15 seconds at 45,000 feet.

3.4.4 Diving and Flight

12h if a controlled ascent was not required or up to 8k feet.

24h if controlled ascent was required or above 8k feet.

My personal minimums: 24h for all passengers.

3.4.5 Humidity

Dehydration is a secondary risk with dry air.

3.5 Oxygen Systems

At this point we are well convinced that we need more oxygen. It will keep the crew able to do their job and the passengers happy. The next natural question is, where should we get it? We have two options: do a better job of pulling it out of the air, or, carry it with us.

3.5.1 Pressurization

One way of getting more oxygen into the cabin is to grab more oxygen from the air around the airplane. At typical airliner altitudes, there is not enough oxygen to sustain human life. But, there is enough that, if we had some way of compressing air and keeping it in the airplane, we could manage.

So, to be pedantic (a theme in this book, in case you have not noticed), the problems of "getting more oxygen" and "keeping it around" are separate, but must work together to provide more oxygen to the humans and other living creatures aboard the aircraft.

We've already talked about some solutions to the "getting more oxygen" problem. They include superchargers, turbochargers, and turbine compressor sections. These are already pressurizing the air for the sake of the engine. Is getting more oxygen really as simple as siphoning off a bit of pressurized air from these compression systems, maybe filtering it, and breathing it in? In short, yes.

What if we don't have a turbo or a turbine? Do we have other options? Sure, but they are not terribly common. One is to simply use a pump. Using a combination of ram air pressure and a pump, we could compress air in much the same way a turbocharger would. To power this pump, we could use an electrical source, a belt or gear off the engine, or maybe even a ram air turbine driving an electrical, pneumatic or hydraulic system. There are enough different types of systems in airplanes that we cannot enumerate them all in this brief survey.

We might also use an oxygen concentrator. We're just beginning to see these applied to the world of aviation. Oxygen concentrators are effectively reverse-osmosis machines for air. They grab air from the atmosphere and push it through an extremely fine filter (a porous solid). The filter is sized to allow oxygen moleculed through but nothing much larger. On the other side, we find a higher concentration of oxygen (and nitrogen!) than we might otherwise find.

But, now that we have the extra oxygen, where do we keep it? One option is to pressurize the entire aircraft, blowing it up ever so slightly like a giant aluminum (or carbon fiber) balloon. One option is to keep it in a tank. One option is to just put it in a pipe and send it directly to a human, discarding any excess.

The most popular method is pressurization. We inflate the entire aircraft. In designing the aircraft, we take great care to pressurize only as much of the airframe as necessary, and select materials, openings, and structures that will permit the airframe to withstand not only an overpressure compared to the outside world, but also repeated cycles. (The early de Havilland DH.106 Comet airliner is a famous example of a plane designed without understanding of the stresses of pressurization cycles.)

With a pressurized aircraft, there are some essential design and operational considerations.

First off, let's say we pressurize the aircraft once. Are we done? Can we simply seal off the aircraft once this is done? The answer is no: in doing so, the occupants of the aircraft would slowly, but surely, convert all the oxygen in the cabin to carbon dioxide, leading to the eventual suffocation of all on board. (Plus, depending on what everyone had for dinner, it would smell pretty awful in the cabin, if you take my meaning. I can hear my children giggling at the prospect.)

So, we need not only pressurization, but also a constant flow of fresh air through the cabin. We have a source of air, likely bleed air from a turbine or a jet. So what about exhaust air? We can lose air through a controlled leak in the aircraft. We're familiar with controlled leaks: the vertical speed indicator famously uses a controlled leak to operate.

How much should we pressurize the airplane? This is a complicated choice. We can refer to our Standard Atmosphere table as a reference. Keeping the pressurization level as close as possible to sea level will keep our passengers and crew as comfy as can be. But, this results in the highest overpressure and the most stress on the airframe. We know from the FARs that above 12,500 feet, the crew need oxygen (after 30 minutes), and above 15,000 feet, we must offer oxygen to our passengers. Presumably this is because the pilots need to be alert, whereas the passengers mostly need to stay seated and are free to doze off. So, if I had to venture a guess, I'd interpolate: take the best case (sea level) and the worst case (15,000 feet) and take the average. Pressurize to 7,500 feet? As it turns out, yes, airliners often pressurize to about 8,000 feet, so this isn't a bad guess after all.

Airframe designers aren't thinking in terms of altitude, they're thinking in terms of pressure, and specifically, differential pressure: the difference between the pressure inside the airplane and the pressure outside. They're designing for a particular pressure differential, taking the airplane's operating altitudes into consideration. A hypothetical airliner with a cabin pressure altitude of 10,000 feet flying at a ceiling of 20,000 feet, has to deal with a much lower pressure differential than another airliner with a cabin pressure altitude of 6,000 feet (hello, Dreamliner!) operating at 40,000 feet.

Now that we know what pressure we need, and how to maintain it (with a controlled leak), how do we get there? Can we just start pumping air into the cabin? Not exactly. Humans (and other animals...) have fairly sensitive respiratory systems. Pressurizing too fast can wreak havoc on ear drums and sinuses - especially if one is congested. So, pressurization systems need to have a rate control mechanism. This can be manual or automated.

With the rate considered, we can have three kinds of pressure: too much, not enough, and just right. (Terminology is my own.)

What if we have too much pressure? Well, the aircraft has a structural limitation. Too much pressure will start blowing out windows, blowing rivets, etc. If the calibrated drain of which we spoke earlier were to become clogged, this could be a possibility. This does not make for a great passenger experience. So, we need some sort of emergency pressure dump.

What if we have not enough pressure? Those FARs we talked about are regulatory. So if we don't have enough pressure - maybe the aircraft's intake was cracked, or we lost a window, or some other horrible catastrophe - we'd need to get the plane down to a lower altitude to be legal. The pilots and the passengers have supplemental oxygen in most cases (we'll talk about that in a moment...) but they only last for so long. In this case, an emergency descent down to an appropriate altitude is in order.

Those design considerations aside, pressurizing the cabin works great. Airliners do it all the time. Even Concorde did it up at 60,000 feet. Once we start getting much higher than that, it is difficult to impossible to get enough air to pressurize a large volume. Pressure suits are smaller than an entire cabin, which is why SR-71, U-2, and other high altitude pilots utilized them. True spacecraft don't have the opportunity to scavenge oxygen from the air, since there is no air!

With that said, it's high time to talk about ways that we can make our own luck, so to say, and carry oxygen with us.

3.5.2 Supplemental Oxygen Sources

Different from compressing outside air.

Oxygen tanks.

Aviator's breathing oxygen, 99.5% water free, so it doesn't freeze in lines. Mounted to aircraft or portable system.

Chemical oxygen generators - need to be stored/secured correctly.

Any source only lasts for so long.

3.5.3 Oxygen Delivery

Pressure suit?

Much of this information is straight out of the PHAK.

Mask. Fitted to face. May contain microphone. Usually oronasal - mouth and nose. Clean regularly.

Cannula. Nose only.

Diluter-demand: oxygen supplied only when user inhales. Mixes cabin air and oxygen.

Pressure-demand: similar to diluter-demand but oxygen comes in at positive pressure for higher altitudes above 40,000 feet. Requires a tight seal - no beard.

Continuous-flow: oxygen collects in a bag, which may not inflate fully, and is mixed with cabin air when inhaled.

Electrical pulse-demand: detects user breathing and only provides oxygen at start of breath, 50-85 percent more efficient.

Rebreather?

Pulse oximeter is a cheap and easy way to measure serum oxygen.

3.6 Operational Considerations

Loss of pressurization: get the mask on immediately (time of useful consciousness). Emergency dive down to 15,000 feet.

Overpressure: operation of dump valves.

Rate limitation error: manual override or no flight, see aircraft procedures.

Hyperventilation.

Chapter 4

Commercial Pilot Training

So you want to become a commercial pilot? What are the privileges and limitations for such a pilot? What does that even mean?

One thing is for certain: the private pilot checkride is NOT simply a "glorified commercial pilot checkride". The expectations - and risks - for a commercial pilot are much higher.

Think of it this way. The private pilot checkride represents your first flight with a passenger (albeit a fairly picky one at that). The commercial pilot checkride is meant to simulate your first *job interview* as a pilot. It's all about professionalism, polish, and positive control.

The private pilot checkride is your change to demonstrate competence. The commercial pilot checkride demonstrates fluency, professionalism, experience, and finesse. Of course, the ATP checkride takes this to another level, but we'll talk about that another day.

The PHAK [7] is a great reference. So is the AFH [5]. It's good for commercial pilots to be familiar with hazardous attitudes [1] as well.

4.1 Training

The Commercial Pilot is held to a higher standard than the Private Pilot. Many of the maneuvers on the private pilot checkride make an appearance on the commercial pilot checkride as well. Quantitatively, the commercial pilot has less margin: tighter limits for airspeed, altitde, heading, bank, landing distance, etc. Qualitatively, the checkride examiner wants to see that the commercial pilot candidate is the clear master of the aircraft. They are looking for positive control, smoothness, rudder coordination (and cross-coordination when appropriate!), and appropriate use of trim or checklists.

With the private pilot we ask, would I trust the candidate to take my spouse or child flying? With the commercial pilot we ask, would I trust the candidate to take my entire family flying? Are they the clear master of the aircraft? Can they explain the aircraft's, as Doug De Muro would say, quirks and features? Do they make the airplane do what they want it to do, when they want it, for reasons they can clearly explain?

For the author, the process of commercial pilot training was humbling. I already had about 100 hours in my airplane, was already instrument rated, and felt like a safe, competent pilot. How hard could it possibly be? I thought I could knock out the training in about five hours of dual instruction (in addition to all the other requirements in 14 CFR 61.129 of course). I thought wrong.

Commercial pilot training forced me to be a student pilot again. It was frustrating. It was humbling. I was practicing many of the same things that I had already demonstrated as a private pilot, but in a larger, faster airplane that was not a Cessna 172. (The author feels that there is an implicit bias toward the Cessna 172 in pilot training materials.) I was being forced to look outside - after learning to fly as an instrument pilot. I was being asked to put G forces on my body and airplane that were not necessarily comfortable, and would be extremely concerning in an instrument environment. Not only was I having to re-learn things that I had previously learned in a different airplane with a different instructor, but I was also being held to a higher standard. That standard, of course, is the Commercial Pilot ACS [6].

The "good news", at least for me, was that I was not immediately dependent on passing my checkride to gain any new privileges. I didn't have an airline job lined up. I could still fly myself and my family around if I wanted to. After some initial frustration, I learned to re-embrace the learning process, and that it's okay to postpone a checkride once, twice, or even more times. Cancellations are free, but disqualifications will cost you.

If I were to go back in time, and talk to myself when beginning, I would offer the following pieces of advice:

- This is going to take longer than you expect.
- This is VFR training with an instructor. Schedules, airplane maintenance, and weather all need to align. Often times they won't.
- For every hour in the air, spend three hours on the ground, split evenly between debriefing the previous flight and preparing for the next flight.
- Try to remember to have fun with this! Flight training is an incredible privilege that not everyone is able to do.
- Just because examiners book a month out doesn't mean you need to book immediately. A concrete date can be a good thing (motivation) and a bad thing (an unnecessary stressor).
- The difficulty of commercial pilot training is a direct function of competency at the end of the private pilot checkride. If soft and short field operations, steep turns, and emergency descents remained regular operations, things will go easier. If, however, it has been two years since the words "steep turns" came out of your mouth, this might take a little while.

Ultimately, my own goals include being a flight instructor (for which the commercial rating is a prerequisite) and being competent in my airplane (commercial training certainly explores the flight envelope).

4.2 Ground Operations

TODO. Spend some time talking here about what makes a commercial pilot more senior than a private pilot on the ground. Do so in ACS order. Talk about airworthiness requirements, weather information, cross country flight planning, the National Airspace System, Performance and Limitations, Operation of Systems, Human Factors, Preflight Assessment, Flight Deck Management. This ends up reading like a checkride cheatsheet.

4.2.1 Engine Starting

At the commercial pilot we kick everything up a notch, even something as humdrum as starting the engine. Surely we've started an ending before?! But now, we should be able to talk a little more about what's going on.

TODO: talk about how in starting the engine, the prime makes the fuel mixture rich, and cranking makes the mixture progressively leaner until we catch.

TODO: talk about gear driven starters and how to not damage them.

TODO: discuss whether or not to leave the alternator on while starting. Depends on POH. Belt vs gear driven alternators.

TODO: discuss importance of ground lean.

4.2.2 Taxiing

On the checkride, make sure to use an appropriately slow taxi speed. Rushing on the ground will only make the checkride end faster by getting you disqualified. 10 knots is a good ground speed. Feet off the brakes and minimal RPM for this. Don't forget crosswind controls.

4.2.3 Before Takeoff Check

Follow the checklist.

What would you do if the engine ran rough?

Takeoff briefing. Describe what we would do if there were an obstruction on the runway. What kind of takeoff is this? Where do we expect to be airborne? What do we do if our engine quits on the ground roll? On rotation? At 100 AGL? At 500 AGL? Making a 360 is a bad idea. Making a 180 might be a good idea. Using a crosswind runway is an option. Maybe scope out landing sites just off the departure end of the runway ahead of time.

The Lance has an STC for GAMIjectors, which explicitly allow us to lean the mixture to peak EGT for takeoff. I use this as my justification for leaning the mixture to get the RPM drop in the mag check to where I need it to be. At this point, in the Lance, I might point out that the D in Lycoming IO-540-K1G5D stands for "dual magneto", meaning both magnetos are driven by a single gear. This is a single point of failure for the magnetos, which is an unfortunate design.

4.3 Flight Operations

The Commercial Pilot ACS [6] is the bible for the Commercial Pilot checkride. We refer to it frequently in this section.

The author has, as of this writing, spent the most time in the P32T type, a T-tailed Piper Lance II. The detailed procedures here implicitly refer to the Lance, and its airspeeds and quirks. Some details will differ based upon the particular aircraft.

The Lance has a wide range of flight envelopes. It flies very differently when nose loaded with a forward center of gravity (CG), as opposed to when aft loaded with a rear CG. The numbers and profiles in this section assume a "checkride profile". This includes a pilot and an observer in the front seat totaling 440 lbs, 50 gallons of fuel in the tanks, 20 lbs of baggage in the nose, 40 lbs of bags on the second row seats, and 50 lbs of baggage in the tail. This should give a CG station of about 86 inches. When practicing maneuvers for the checkride, it's important to get the plane set up almost the same every time. For me, this meant flying with a number of safety pilots, who were more than happy to provide ballast in the front right seat.

I did these maneuvers in Texas winter and early spring weather. This generally meant field elevations of 1000 AGL and density altitudes of about 1500 AGL when landing. I've found the Lance to be extremely sensitive to density altitude, particularly when landing. At density altitudes approaching sea level, the Lance wants to float on the runway, and it may be necessary to cut power four or more hundred feet early to make a mark. Conversely, at high density altitudes, the Lance becomes even more of a flying brick and wants to sink through ground effect.

Airplane loading makes a huge difference in how this airplane flies. I got a stall warning doing a short field takeoff with my usual procedure with full tanks and a safety pilot when I wouldn't with half tanks. If that happens just push the nose over a little bit and gain airspeed. The stall warning on this plane comes on at about 70 knots.

On checkride day I would recommend doing the maneuvers that day to see what the airplane wants to do.

But first a thought. Why do we even do these maneuvers? Doing a chandelle or steep turns with paying passengers who don't expect those maneuvers is not a great idea. The lazy eights and eights on pylons have almost no practical application. The best rationale I can come up with is this: they demonstrate mastery of a complex, albeit fairly arbitrary, maneuver. As a commercial pilot you won't do these maneuvers. But you could be doing crop dusting. Or, you could be doing aerial surveillance, which requires flying back and forth along the ground. Or, you could be flying an aerial photographer around, who needs to keep a photographic subject in one place. Thinking of it as a job interview, the mastery of these maneuvers gives a potential employer a *baseline* of performance. It's sort of like inverting a binary tree on a programming interview: you'll never do it in practice, but you show it to the interviewer to demonstrate mastery.

For consistency, I will explore these topics in the same order in which they appear in the Commercial Pilot ACS in the subsections that follow.

4.3.1 Maneuvering Speed

Read `https://www.planeandpilotmag.com/article/understanding-maneuvering-speed/`.

Read `https://www.federalregister.gov/documents/2010/08/16/2010-20195/maneuvering-speed-limitation-statement`. Even if this applies primarily to transport category airplanes, the same rules of physics govern our normal category single engine airplane. The discussion is relevant.

Maneuvering speed is defined at the speed at which a full control deflection will cause the airplane to stall before it breaks. Since it incorporates the airplane's intertia, a lighter airplane will have a lower maneuvering speed than a heavier airplane.

Naïvely, we expect that the maneuvering speed varies with weight. But, since there is a regulatory aspect to this, we need to check the POH. In the Lance, somewhat confusingly, we're told to just linearly interpolate.

Maneuvering speed is a maximum, not a minimum.

It's possible that the placarded maneuvering speed for the Lance - 132 knots at max gross - is an optimistic number determined by a test pilot with a new airplane in ideal, controlled conditions. For the reasons described in those articles linked above, this may not be realistic.

In flight, the airplane can respond, with feedback, on how smoothly it handles.

I've foind that, in the aforementioned "checkride profile", a maneuvering speed of 120 knots is safe for the airplane and occupants, is in keeping with all available maneuvering speed guidance, and allows us to fly the commercial pilot maneuvers adequately. So, that's the speed we'll use for the rest of the chapter.

4.3.2 Traffic Patterns

By now, traffic patterns should be old hat. But there are still some improvements I made along the way.

I sometimes had a tendency to fly tight traffic patterns. While this is fine for a long succession of take offs and landings for currency, it's not ideal and reinforces bad habits. The traffic pattern should not be a racetrack. (Well, it should for the power off 180, but that's a topic for later.) It should have a clear crosswind, downwind, base, and final leg. The crosswind leg should be long enough so that the runway is off the Lance's wing tip, and so that the four legs of the traffic pattern hane a distinct ground track (since it's so easy to check with ForeFlight or FlightAware now).

A wider traffic pattern gives us more time to spot other aircraft and more time to get set up for short and soft field landings. The Lance has more energy than a 172 and doesn't want to slow down right away so we need to plan that out some.

The turn to base should be with the runway threshold 45 degrees behind.

Pay close attention to the wind. In the pattern, is the wind blowing you toward or away from the runway? Crosswind and base should have the same ground track distance. But, one will have a longer duration on account of winds.

Pay close attention to an RP on the sectional chart for a right hand traffic pattern. For the checkride, scope out potential right patterns ahead of time. Especially if much time has been spent doing left handed takeoffs, landings, and power off 180s, a right pattern could really cause a problem if they are unfamiliar!

A traffic pattern likely involves a landing. It may be a normal landing, a soft field landing, or a short field landing. Refer to the appropriate section for each landing.

4.3.3 Normal Takeoff and Climb

This one should be a gimme. We've taken off as many times as we've landed, and most of those have been normal take offs. So, instead of belaboring the basics, we'll jump to the gotchas.

Crosswind controls and left rudder application will be critical. The examiner will want to see that the airplane takes off smoothly and keeps going. No wing dip. No hunting for the center line. No getting blown off course.

We're looking for two callouts. "Airspeed alive" once the airspeed indicator is off the stops. "Engine good" to make sure the gages are in the green. It's okay for oil pressure to be momentarily high. The Lance uses Aeroshell W100 Plus, which has the consistency of treacle (molasses) at normal temperatures. Even if the oil temperature indicator is still in the green, the entire oil system is still coming up to temperature. We'll see oil pressure up to 107 PSI.

We'll also see the engine get up to 2720 RPM, 20 RPM over redline. This could be a governor or engine tweak that needs to be done or a slightly miscalibrated sensor. These are normal in the Lance.

The ground roll requires some special attention in the Lance. Both heading and altitude control down the runway require special attention.

With a 300 HP engine and directly connected front steering, maintaining directional control down the runway takes some forethought. We need to lead the airplane by about 1.5 seconds lest we fall behind and get ourselves into pilot-induced lateral oscillations. Yoke should be into the wind - that's particularly important in this airplane due to the large rudder and relatively light loading of the nose wheel. The takeoff roll will require an increasing amount of right rudder as we gain airspeed. For a new Lance pilot, it will take a number of takeoffs to execute a "binary search" and find the correct control pressure. Determine what is too much pressure, what is not enough, and iterate between the two until it's just right.

The relatively small horizontal stabilizer in the Lance doesn't really become aerodynamically active - doesn't start flying - in the neutral trim position until about 75-80 knots. It is a wing, and like any wing, it has an angle of attack, a stalling speed, and a stall characteristic. If we simply hold the yoke neutral and try to let the airplane fly itself off the runway - as we would in a Cessna 172 or a Bonanza or maybe even a conventional tail PA32 or P32T - the airplane will start bucking like a bronco. The reason for this is that, as we are accelerating through about 80 knots, we are in the critical lift regime of that horizontal stabilizer. It makes enough lift to rotate the airplane. The airplane rotates by 3-5 degreees and barely lifts the nose wheel off the ground (recall that the nose wheel is on a strut and extends downward as we unweigh it). The stabilizer stalls. The nose wheel comes back down. The stabilizer un-stalls and the cycle continues. It feels like the nose wheel is dancing on the runway and the plane can't make up its mind whether or not it wants to fly.

My technique for fighting this is to apply forward yoke, similar to what you might do in a tailwheel airplane. I hold the airplane down - gently! - through 85 knots. That's fast enough that rotation won't stall the horizontal stabilizer. Past that speed, I gently rotate. Done correctly, this will result in a gentle, airliner-style rotation.

In a retract, we're looking for an extra callout. "Positive rate, no usable runway, gear up." Be familiar with the max landing gear retraction speed (109 knots in the Lance) and the maximum landing gear extended and extension speed (both are 129 knots in the Lance). When I take off in any airplane, I like to tap the brakes once a departure is assured. With a retract, there's no sense in storing spinning wheels, it just wears out the wheel brakes in the wheel wells. In any airplane, stopping the landing gear from spinning early on helps to avoid an unexpeted resonance through the landing gear mechanism. This was most prominent on a particular Cessna I used to fly: about ten seconds after takeoff, the aircraft would shake violently as an unbalanced wheel spinning down triggered a resonant mode in the fixed landing gear.

But! In the Lance we need a healthy dose of right rudder on takeoff. So, just before I reach for the gear knob, and with my right foot still on the rudder, I grab the parking brake to stop the wheels.

In the Lance, dirty configuration Vy is the same as clean configuration Vx: 87 knots.

Since the Lance is special I would make sure that the examiner is familiar with the quirks of a takeoff in the Lance. I would explain that the horizontal stabilizer, being small and out of the slipstream, doesn't become really active until about 80-85 knots.

My normal takeoff in the Lance involves keeping the plane on the ground (with neutral or slightly forward elevator) until 85, then smoothly rotating. At that point, even the tricky T-tail Lance can fly itself off the ground like a Cessna.

We don't need an excessive climb rate. Nose to the horizon or just above it in the Lance will give us a nice 500 to 1000 foot per minute climb. That's all we need.

As a personal minimum, I fly runway heading at Vy of 92 knots until we are 500' AGL.

In the Lance, we pull it back to 25-25 - meaning 25" of manifold pressure and 2500 RPM - once we're through 500' AGL. This is for noise abatement. There is some controversy as to how necessary this is for engine longevity, but I like to make things just a little quieter for passengers and for people on the ground. This does mean the black knob keeps coming forward as we get up to altitude. There is also some controversy about whether or not the throttle needs to come back at all. After all, the Cirrus is governor limited to 2500 RPM. It likely won't hurt the engine and would decrease workload to leave the throttle alone. Mike Busch has an opinion here, I may update this paragraph after I re-read his book.

Once we're 500' AGL, the fuel pump and landing light can come off. At night, I might keep the landing light on just a little longer if there is heavy traffic in the area. When switching the fuel pump off, watch the engine gages. If any substantial loss of power is indicated, get the fuel pump back on and consider a precautionary landing.

At this point, I either get ready to enter the traffic pattern, or establish a cruise climb. A good cruise climb in the Lance is 105 knots. That provides a good climb rate and plenty of airflow over the engine.

Yep. At least an entire page on just a normal takeoff. You can see how the rest of this section will go. Lots to think about as a professional pilot!

4.3.4 Normal Approach and Landing

A DPE friend once shared his thoughts on transitioning to a new airplane, such as a Cirrus. He said it would be better to do a hundred landings in the plane than fly it around for a bunch of hours.

I will start by saying that the Lance is a fairly difficult airplane to land. It's a little plane that flies like a big plane. It has high wing loading and relatively fast approach speeds for a single engine airplane. Unlike a Cessna, which will gladly float in ground effect for a long while, the Lance will gladly sink right through ground effect, depositing itself on the ground with an unwelcome thud.

At the commercial pilot level, we're all about precision. Even though the ACS gives us 100-200 feet of leeway for many of our landings, we want to practice being on the mark, every time. The 1000 foot markers are going to be our target for these and all other landings in this chapter.

Pundits on the Internet think that the Lance's landing quirks are due to that pesky T-tail, with a small horizontal stabilizor out of the wind. That may be somewhat true. I believe the relatively simple wing cross section and high wing loading are bigger factors.

Bigger airplanes - airliners - are flown "by the book" and "by the numbers". I've found, experimentally from flight, that the Lance has three landing profiles. Let's call them fast, medium, and slow. A normal landing is a medium landing profile.

Fast: We're coming down final at 105 knots. The airplane lands with a decent amount of energy and floating down the runway is somewhat inevitable. This is the instrument approach profile, and suitable for use at large airports with long runways and an abundance of fast, heavy traffic. If the pilot is successful in flying the airplane in ground effect - achieved by cutting the power and lifting the nose to the horizon or just above - the pilot will be rewarded with a gentle touchdown. The tradeoff is that we use a ton of runway - expect a 3000 foot ground roll on a standard day at 1000' MSL.

Since the Fast approach is the staple of the instrument approach, I'll relate it to an instrument approach here. At the initial approach fix (IAF) fly normally and become established on course and on glide slope. At the intermediate fix (IF) slow to 129 KIAS and get the landing gear down. At the final approach fix (FAF) complete a GUMPFSS check, which will include getting the first notch of flaps down and flying a stabilized approach at 105 KIAS. Put in the second notch of flaps at or by the decision point when the field is sighted (or go missed). Put in the third notch of flaps once close enough to the airfield that a landing is assured.

We probably won't see this one on a commercial checkride for a single engine airplane, since they don't make you fly an approach, but it will be a staple for the instrument checkride.

Medium: We're coming down final at 95 knots, slowing to 90 and then 85 knots as we round out. This is a typical VFR traffic pattern and visual approach. It's the approach the plane wants to fly without being too far on the backside of the power curve (recalling that L/D max in the Lance is 92 knots clean).

Let's walk through an entire normal approach and landing in the Lance.

The approach begins on the down wind leg. I like to give myself plenty of time to get set up for this correctly. This means I'm entering the traffic pattern well before the departure end of the runway of intended landing, already at altitude. My spacing is such that the runway is off and just past my wing tip. Wider approaches give us more room in the Lance. If challenged by an examiner, explain that the Lance is a bigger, heavier airplane than a Cessna and needs more time to bleed off energy. Airspeed should be gear extension speed at most.

Abeam the numbers, we are on airspeed (105-129 knots), on altitude (1000' AGL in most cases; this procedure may need to be scaled for airports that have nonstandard pattern altitudes like KPAO), on heading (reciprocal of runway heading plus wind correction), and at the correct spacing. A good landing begins with a good approach, and a good approach begins with a good set up.

Still abeam the numbers, we reduce the power and complete our GUMPFSS check. Gas - most full tank. Undercarriage - confirm 129 kias, gear comes down, plane starts slowing down. Mixture - full rich. Prop - forward for max speed. Flaps - confirm 109 kias, first notch of flaps comes down. Seatbelts and harnesses fastened. Fuel pump and landing lights on.

We should be established in a smooth 500-700 foot per minute descent at about 100-105 knots.

With the runway numbers 45 degrees behind us, it's time to turn from downwind to base. Make a smooth, coordinated turn, making sure to keep the descent and not exceeding 30 degrees of bank in the pattern. Once wings are level, put in the second notch of flaps. Still descending at 500-700 feet per minute, the airspeed should be right on 95 knots. Pitch for airspeed, power for altitude and sink rate. The power setting here varies wildly based on density altitude and airplane loading, it can be as low as 12 and as high as 20 inches.

When approaching the extended runway centerline, it's time to begin the turn to final. Maintain coordination and maintain the descent. Become aligned with the runway and establish a glide slope based on a VASI, PAPI, or visual estimation. (Be aware of airfields that have nonstandard PAPI angles. Runway 15 at KRYW is set up for a 4.0 degree glide slope. But the RNAV RWY 15 approach is configured for a three degree approach, so we can fly down at three degrees safely. Just be aware that you'll see all red lights when you do so.)

There will inevitably be a crosswind on final. It will probably be from the left (in the northern hemisphere). In the Lance, I strongly prefer to fly a crab angle as opposed to a forward slip. There are a few reasons for this. One, a crab angle is easier to stabilize - it is what I would use on a long instrument approach. Two, a crab angle doesn't require cross coordination of controls and is somewhat safer, especially as we have a more aft CG in the Lance. Three, a crab angle is naturally coordinated! I'll cross control closer to the ground, using yoke for left-right alighment on the runway centerline and rudder for rotational alignment of the nose with the runway. The Lance has enough adverse yaw that it takes less rudder than you might expect - still plenty, but not a ton. On the other hand, it does take slightly more yoke than I usually expect, and it needs to keep coming in as the airplane slows to a stop.

Once a landing is assured and the runway is made, put in the final notch of flaps. That last bit of flaps induces a decent amount of pitch-up moment. Be prepared for that. We should be slowing so that we're 90 knots across the runway threshold and 85 knots at wheels down. Confirm three greens here - the landing gear had better be down or else we're going around. A power adjustment may be necessary. Be careful not to get too slow.

Here's the secret to a perfect spot landing on the 1000 foot marks. Cut power 2-3 stripes before the marks. If we're on glideslope and on airspeed, this will work perfectly.

The roundout in the Lance for a normal landing involves bringing the nose to or a few degrees above the horizon and trying to keep the wheels off the runway as long as possible. Think about slow flight at 3' AGL with the engine out in the dirty configuration for as long as possible. Assuming we didn't allow ourselves to get super slow on final, the wheels will let down with light to moderate force and we can proceed to brake.

In the Lance, the flap selector and gear selector are very easy to tell apart. One is a small round knob. The other is a big long lever. Once we're on the ground, we can retract that flaps to get more weight on the wheels for braking.

I'll have more to say about go-arounds later, but for now, the procedure is: all three throttle controls forward, then in order: flaps, gear, flaps, flaps.

4.3.5 Soft-Field Takeoff and Climb

The soft field takeoff and climb demonstrates that the pilot is able to operate the aircraft safely on a dirt, grass, or other similar off-pavement airstrip. The constant theme is unweighting: keeping weight off of the tires, particularly the nosewheel. A secondary theme is smoothness.

We configure the aircraft with two notches of flaps and one or two turns of nose-up trim past the neutral point. Once we begin moving the aircraft, we continue to move until we are airborne or abort the landing. Back pressure on the yoke will transfer as much weight as possible from the nose wheel to the mains. The Lance has very little elevator authority at low speeds so this effect will be minimized.

Taxi smoothly and continuously onto the runway. Apply takeoff power, at perhaps half the rate as usual (taking 6-8 seconds to advance the throttles instead of 3-4) to help prevent kicking up debris. Holding firm backpressure, accelerate down the runway.

The Lance's V_x speed with gear down is only 68 knots. The Lance usually doesn't climb until 70 knots. So, in this aircraft, it may not be necessary to accelerate in ground effect, as we might with many other aircraft. The pilot must be mindful of this.

Once we are airborne at rotation speed above V_x, we hold that to clear a 50- or 100-foot obstacle. Then, once positive rate is confirmed and the obstacle is clear, we retract the gear, lower the flaps one notch at a time, and continue accelerate to our gear up V_x of 87 knots, which just so happens to be V_y with gear down and flaps up. After that, we continue to accelerate to a clean V_y of 92 knots, and continue to climb from there.

A soft-field takeoff is not necessarily a short-field takeoff as well. If it is we need best rate to clear an obstacle. If not, we don't. Best ti clarify this before beginning the maneuver.

Once airborne, the airspeed should be monotonically increasing. Don't sink! Don't stall! Don't let the stall warning go off. Keep the nose coming down and the airspeed and altitide coming up. Once 500' AGL, proceed as you would for a normal takeoff and departure.

Disqualifications might include: porpoising on the ground due to incorrect transition to ground effect flight (which we shouldn't need in the Lance), stopping once we begin the ground roll, inappropriate use of controls, incorrect airspeeds.

4.3.6 Soft-Field Approach and Landing

The soft field landing demonstrates that the pilot is able to manage the aircraft on a surface other than a paved runway. Much like the soft field take off, the goal of the maneuver is to keep as much weight off of the tires, particularly the nose tire, for as long as possible. Note that, by default, the soft field approach is NOT also a short field approach. However, the Lance's POH does not differentiate between them.

The landing begins as a typical short landing: wheels down at 75 knots, full flaps. In the Lance, a blip of throttle is needed to allow the main tires to gently set down on the ground as opposed to slamming down and potentially digging in. Then, we continue to hold back pressure and leave the flaps down to gently bring the nose down, doing so as late as able. We can lower the flaps to two notches as soon as able, and have the option of leaving them down as we taxi. We must not stop until we are clear of the active.

Another option is to do a power on approach and landing. This takes longer, but you can really take your time to grease the wheels onto the runway when doing so. This has become my preferred approach.

In the Lance, we typically do these maneuvers with half a tank of fuel and two front seat occupants pushing the station weight limit of 440 lbs. This leads to a fairly fore CG condition where the aircraft is nose heavy. When the aircraft is aft loaded, the nose becomes MUCH lighter, and it is possible to wheelie all the way down the runway unless we are very careful.

Note that the soft field landing has no aiming point specified. This is good, since a true grass strip won't have markings.

Disqualifications might include: bouncing, slamming the nose wheel, stopping on the runway.

4.3.7 Short-Field Takeoff and Maximum Performance Climb

In the short field takeoff, we are looking to use a minimum of runway, lifting off at the earliest spot possible, and to clear a 50 foot obstacle. To use the minimum runway, we position the aircraft as close to the very end of the runway as possible, using a displaced threshold to our advantage. In the Lance we use two notches of flaps. We hold the brakes, apply full power, lean if appropriate, and release the brakes. Seriously - feet off the brakes!

We recall that V_x in the Lance is a mere 68 knots in the dirty configuration. We're lucky if we are airborne at 70-75. Maintain that airspeed until clear. Then it's gear up and flaps up as we accelerate through V_x of 87 knots to V_y of 92 knots.

Disqualifications might include: forgetting to position the airplane as far as possible on the end of the runway, incorrect flap settings, forgetting to run up with brakes held, incorrect airspeeds.

4.3.8 Short-Field Approach and Landing

The Lance doesn't like to be slow as this maneuver reminds us.

The short field approach is an important practical maneuver. On a checkride, we usually have the examiner give us an aiming point, and it's usually the 1000 foot markers. In real life, that aiming point is the numbers as we're looking to truly use minimal runway.

In the Lance, we set up for a full flaps stabilized approach diung 75 knots over the numbers. The plane will want to sink quickly when we cut power so a small dose of throttle will set us up for success. However, it's imporant to be within 100 feet of the required spot, so a hard landing is better than a failed checkride. Recalling that the 1000 foot markers are 200 feet ling (source?), the goal is to be ON the markers.

Once down, retract flaps (easy in the Lance, lower the lever to the ground), apply full back pressure, and call out “maximum braking”. It’s not necessary to actually brake hard, we don’t need to leave tire marks on the runway.

Disqualifications - and there are many for this one - might include: improper configuration, missing the aiming point, bouncing so hard that we porpoise and have to go around, forget to call out “maximum braking”.

4.3.9 Power-Off 180° Accuracy Approach and Landing

This maneuver is probably responsible for more failed commercial pilot and CFI checkrides than all the others combined. It is unforgiving and requires a very high degree of precision, particularly to correct for winds. The candidate gets one shot at this one. If they land short, or land long, or have to go around, that’s a disqualification. It still makes sense to continue the checkride, but if this happens to you, expect to lick your wounds, spend an hour with a CFI for an additional signoff, and to take another shot in the coming weeks.

Recalling the old joke, “you are never too high or too fast in a Piper”, the power off 180 will be faster and steeper than it would on a Cessna. I’ve had some safety pilots get really quiet and nervous as we do this maneuver, thinking we’re going to crash and die, only to watch me put the plane down perfectly on the 1000 foot marks. I would be sure to brief the intricacies of this maneuver in the Lance prior to execution.

For this maneuver, we fly a traffic pattern with a closer than usual downwind leg ($\frac{1}{3}$ of the way up the Lance’s wing instead of just off the tip) and cut the power abeam our touchdown point, the 1000 foot markers. We immediately pitch for our best glide speed of 92 knots, turn a fairly tight pattern, put the gear down once the field is made, and execute a normal, possibly no flaps landing. This ends up being a fiarly aggressive, tight, rounded approach, with no real base leg, as downwind transitions smoothly to base and final.

DO NOT FORGET TO PUT THE GEAR DOWN. If you’re less than 50’ AGL and don’t see three greens, GO AROUND. This isn’t worth a new engine.

With respect to the aiming point, there are three possible outcomes:

- Too short. We’ve lost too much energy and have no hope of making the aiming point. Perhaps our pattern was too wide, we did not correct for wind, or we otherwise failed to manage energy. Identify and call out the situation, and immediately GO AROUND. Whether or not this is disqualifying, this is the correct course of action.
- On point. This is ideal. But getting it magically right by chance means we’re not really in control of the aircraft. So, even though this will pass the test, it’s not the best place to be.
- Too far. We have not lost enough energy. As long as we don’t have *such* an excess of energy that we cannot manage the airplane and the landing, this is fine. We have some tricks to get lower: cut the airspeed (down to 75 instead of 87-92), lower the flaps, slip with flaps extended (approved in the Lance!).

You’ve got 200 feet from the aiming point for this one. If the aiming point is the near side of the 1000 foot markers, the limit will be the end of them. You’ll know immediately when you’ve done this one correctly, and so will your examiner.

Assuming you do this correctly, this is arguably the hardest part of the checkride. So spend plenty of time practicing.

Setup is absolutely critical for this one. If the setup isn’t right, it’s technically not a go around if you do a 360 in the pattern for spacing. The examiner may frown on this. Make sure to allow plenty of time for a complete, stabilized downwind leg. Also, we don’t want to be *too* fast downwind. Best glide is 92. Being at about 105 is right. If we’re at 130, that’s all that much more extra energy that we need to manage.

Even the Lance will float a tiny bit in ground effect, so we’ve started aiming for two lines prior, flaring and floating to the marks.

In the Lance, the bank angles and sink rates may seem excessive. I’ve had at least one safety pilot / right seat CFI get nervous. So, with an examiner, make certain to brief this.

Disqualifications include: failing to make the aiming point (obviously), failing to go around when appropriate.

Slamming the plane on the ground on the marks isn’t great. Being off center line can be disqualifying. Failing to make a crosswind correction can be a huge problem. If the wind is blowing you toward the runway, consider a wider pattern. If there is a strong wind blowing away from the runway, consider an even tighter pattern. We've practiced these almost exclusively to the left, which is preferred with the airplane's left turning tendency (partially caused by even a windmilling propeller).

Instructors and examiners get really nervous if you take your hand off the throttle for this one. Keep the hand on the throttle, ready to go around.

4.3.10 Go-Around/Rejected Landing

Flaps, gear, flaps, flaps.

Go-arounds in the Lance are, for the most part, a non-event. The airplane has plenty of reserve power at lowland altitudes and ample power at higher density altitudes.

All of the knobs come forward at once. Full power, high RPM or low pitch propeller, full mixture. If it's known to be a high density altitude the mixture can come back slightly. As part of the landing checklist we should have already set the propeller and the mixture so it's just the throttle that is moving smoothly forward. (Smoothly means, about 4 seconds from idle to full power. Don't slam it forward in half a second and risk de-tuning the engine counterweights.)

Offset from the runway as appropriate. I will offset if there is any traffic on the runway at all. For all I know, they are not talking on the radio and could decide to take off. I will offset on the side opposite the traffic pattern and maintain visual separation.

In the Lance, since that last notch of flaps gives us so very much induced drag and includes a pitching moment, the very first thing we do is to get the first notch of flaps out. We confirm a positive rate of climb, then bring in the first notch of flaps.

Then the landing gear comes up. Making sure we are below the landing gear extension speed of 109 knots, we confirm a positive rate of climb and bring the landing gear up.

Now, I bring back the remaining two notches of flaps, one at a time, confirming a positive rate of climb before and after each one.

While doing all of this, I'm devoting most of my attention outside the cockpit, looking for traffic.

I'll maintain Vy of 92 knots up to 500 AGL.

4.3.11 Steep Turns

First of our maneuvers.

Clearing turns are critical or else we fail. S turns or 360.

Maneuvering speed. Power comes in. Pick reference points.

50 degrees bank. Overbanking tendency.

Critical to maintain sight picture.

HEAVY backpressure in the Lance. Two hands! Hard to trim in time. Don't enter a dive, fight for it.

You know you've done well when you hit your own wake turbulence. Bump bump.

Once to the left, once to the right.

4.3.12 Steep Spiral

Old joke: "In a Piper, your best field is directly under you."

Not the same as emergency descent. This is a ground reference maneuver. Purpose: getting set up for an emergency landing from altitude.

Power comes to idle. Pitch and trim for best glide in the clean configuration.

Which way is the wind coming from?

Tip: clear engine into the wind to help correct wind drift.

Easy to bust altitude on this one. We lose about 1200' every 360 degrees.

Easy to lose track of how many turns we've done. Set the heading indicator. Keep track on a kneeboard if need be. We're looking for three turns. We're ending on a particular heading or pointed at a reference, without busting 1500' AGL.

This is not an emergency descent. We'll talk about that later.

4.3.13 Chandelles

Ah, the chandelle. That classic commercial pilot maneuver. I wonder how long it's been part of the ACS, the PTS, and whatever came before it. I wonder if my grandfather-in-law had to demonstrate one of these in the early 1940s.

At its core, the chandelle is a combination of a 180-degree turn and a maximum performance climb. Our goal is to enter the maneuver at maneuvering speed, and to end the maneuver with a blip of the stall horn pointed in the opposite direction.

Watch https://www.youtube.com/watch?v=Ml8YI7oj2Q8. The UND commercial pilot maneuvers are pretty good. They are close to how I would teach the maneuver. Of course, like many training materials, they are heavily biased toward the Cessna 172. In the rest of this section we'll add some refinements and take the quirks of the Lance into consideration.

Just like the standard traffic pattern, the key to success in the chandelle - and most any other maneuver - is to break it up into sections. This isn't a maneuver where we make one control input, wait a minute, and hope we got it right. This is a maneuver where we have some key reference points.

It helps me to break this maneuver into two independent axes: the pitch axis, and the roll axis. Let's analyze in turn what each of these are doing before bringing them back together. (I picked this order of axes intentionally.)

In the pitch axis, we're looking to climb as much as possible without stalling. We smoothly lift the nose to about 12-15 degrees of pitch in the Lance, come in with a little power, hold right rudder to maintain coordination, and hold that pitch angle until the stall warning horn goes off. As the climb progresses, more and more backpressure will be needed to keep the nose up, and more rudder will be needed, as the speed bleeds off. Once the stall warning goes off, we level off and maintain altitude, allowing the nose to continue falling without ballooning or losing altitude.

In the roll axis, this is somewhat more than a 180 degree turn. The airplane rolls immediately into a coordinated 30 degree turn. The complication here is that we cannot maintain a 30 degree bank angle the entire way through. If we were to do so, we would stall the airplane, since our pitch change is causing us to lose airspeed. Further, this would sharpen our turn rate, since turn rate increases for constant bank and decreasing airspeed. So, starting about halfway through the turn, we need to start rolling to wings level. Indeed, through the second half of the turn, we're chasing a corner of the flight envelope. As we get slower, we roll out slightly, which drops our stall speed and lets us fly a little slower still. As a result, the first 90 degrees of this maneuver will take much less time than the second 90 degrees.

The common instruction technique breaks this maneuver down into two 90 degree segments. I found, in my training, that this was not sufficiently granular for me to enjoy consistent success with this maneuver. So, we found 45 degree increments worked much better.

In the Lance, as usual, we enter this maneuver at 120 knots. Our exit speed is 70 knots. This is maybe a knot or two above (power-on, clean) stall speed and sufficient for giving us a little blip of the stall warning horn when the maneuver is complete. For power, we do not use full power for this maneuver. Unlike the Cessna 172, the high-performance Lance, with a 300 HP engine, would have a really difficult time finding a stall at full power. We could have full backpressure and just hang off the stall warning horn indefinitely. So instead, we do this maneuver at 65-75% power. That means, maybe adding 2-4 inches of manifold pressure. After that initial power adjustment, this is a constant power maneuver. I fly all of these maneuvers, including the chandelle, at 2400 RPM.

We usually enter this maneuver at 4500' MSL or about 3500' AGL in our area. We can gain 1000 feet in the maneuver. We normally do one to the left, and one to the right. Be warned, at 6500' MSL, the air is thinner and the Lance's performance suffers. So, if doing these for training, remember to descend between attempts.

Begin by flying straight and level trimmed for 120 knots at the desired altide on heading. I set my heading bug as a reminder. Pick visual reference points for 45, 90, and 135 degrees. An intersection of roads works well but make certain the roads are distinct. Don't forget about clearing turns or our GUMPFSS check. In particular, the clearing turns need to clear the airspace above and behind us as well, and in the Lance, the fuel pump needs to come on..

In the first 45 degrees, we immediately roll into 30 degrees of bank, then come in with power, and then start pitching up to 12-15 degrees. This will take quite a lot of backpressure with both hands in the Lance. Moreover, as the speed drops off, this will take more and more backpressure. It's not really worth trying to trim this out - we need both hands for pitch control.

45 degrees in, we're at maximum bank. We call this out. We may not be at maximum pitch yet, that's fine.

The second quarter of the maneuver, 45 to 90 degrees, goes by the most quickly. Make sure that the 90 degree visual reference point is in sight as we'll start doing something once we see it. Backpressure will be increasing as the aircraft slows.

At the 90 degree point, call out "90 degrees, max pitch, max bank, starting to roll out". Immediately release 10 degrees of bank, resulting in a 20 degree bank. The maneuver, in terms of time elapsed, is about one third done. This is where the fun begins.

Through the second half of the maneuver, we need to actually fly the airplane. The airspeed will continue to decrease until we're at 70 knots. The bank angle will continue to roll out from 20 degrees to zero. The heading will continue to come around until we've turned 180 degrees. The trick is to get to 70 knots, zero bank, and 180 degrees all at once, without hanging off the stall warning horn. During this time, the pitch remains constant (12-15 degrees of bank) and the altitude will do whatever it does.

It should take about twice as long to get from 90 to 135 degrees as it does from 135 to 180 degrees. Remember to keep the airplane coordinated. Proper coordination can help keep the nose coming around to the correct heading. I found that undershooting 180 degrees of turn was much more common than overshooting it.

The first 90 degrees of the maneuver is about speed and smoothness. The second 90 degrees are about slow flight and managing three variables (airspeed, bank angle, and heading) to converve.

The 135 degree point is a good checkpoint. Are we at about 10-15 degrees of bank? Are we about halfway between 70 knots and whatever our airspeed was at the 90 degree point?

That last quarter will feel like the longest. Fly the airplane. Look inside and outside. Pay attention to all the variables. I call this quarter "gaming it" because you're actually flying the airplane here, not just waiting for the maneuver to be over.

While doing all of this, it's more important to look outside the cockpit. Become familiar with the sight pictures throughout the maneuvers.

At the 180 degree point, keep the power in and push the nose over to stay on altitude. As we accelerate, power can start to come out. The Lance likes to balloon - don't let it.

It's common to do one chandelle in one direction, and another in the opposite direction. Give the plane time to get back up to maneuvering speed before attempting another or else the maneuver will come up short.

In the Lance, the chandelle's combination of high power setting, high bank angle, and low speed, results in CHTs getting as high as we ever see them: about 350 F. I would acknowledge this. If it's a particularly warm day, I would give the engine a chance to cool down before doing one in the other direction. Remember, on the checkride, you are the PIC. You can tell the instructor that the CHTs are too high to safely complete the maneuver, and fix this by flying straight and level for about a minute.

4.3.14 Lazy Eights

A lazy eight is a combination of a 180 degree turn, done at the same time as a shallow climb and descent. We turn one way, then turn the other. Its nearest living relative is the private pilot maneuver "S-turns across a road". The aerobatic maneuver "wingover" is a cousin.

The standard literature describes this as a "graceful" maneuver. It is supposed to be "beautiful". It is supposed to be "ballet in the air". It is supposed to demonstrate "mastery of the aircraft" or somesuch.

Such subjective descriptions are of zero use to the poor pilot who attempts this maneuver. We need some more rigor to derive and describe this maneuver.

The lazy eight is NOT a chandelle. It is a slow maneuver. The standard literature describes it as "lazy". Again, that's subjective. How slow? About 40 seconds for a Cessna 152, and about 60 seconds for the Lance. This largely comes down to how many knots of airspeed separate V_A and V_S0 on your aircraft. I suspect it has to do with the square of that since we're talking about energy that needs to be dissipated. I'll get back to that.

Before we go too much further, let's at least talk through the conventional way of teaching this maneuver. It's not a bad start, and for many student pilots more skilled at the controls than the author, it's often enough.

First, let's consider a skateboarder shredding a half pipe. If not familiar, have a look at this video: https://www.youtube.com/watch?v=FJfqcpnH6Ys. The half-pipe in this case is a U shaped channel, about twice as tall as the skateboarder and about 30 times as long as the skateboard. The skateboarder starts at the top of the pipe. They skate down the ramp, raching maximum speed at the bottom. They climb up the other side, going about as high as the top. Once they reach the top, they turn and go back down. As they go up the pipe, they convert kinetic for potential energy, slowing down as they climb. The minimum speed is at the top of the pipe, where they turn around and go back down.

Usually, to stay on the pipe, the skateboarder makes all their turns in the same direction - to the left or to the right. But, if the pipe were sufficiently long, the skateboarder could do one to the left, then one to the right, continuing on indefinitely down the half-pipe.

One thing. The half-pipe happens pretty quickly. What if the pipe were more shallow? Well, then we could slow it down, and take our time turning around at the top.

A lazy eight is similar to shredding half-pipes (in alternating directions) in the sky with the airplane, except we make it take longer to demonstrate that we can control the aircraft.

In the airplane, we start out by flying straight and level. We pitch up and start turning. The plane climbs. As the plane climbs, it slows down, and our rate of turn naturally increases. At some point about halfway through, we've reached our minimum speed. The plane noses over and starts descending. We end up flying straight and level in the opposite direction.

Seems easy enough. What's so tricky about it? A couple of things. If we do the maneuver too quickly, we risk stalling or spinning the aircraft. If we do it too slowly, it's not really a maneuver, so much as just flying the airplane. So we pick a time scale somewhere in the middle.

Another tricky thing is that it's easy to get disoriented. For this we need good visual references. Not terribly surprising since the commercial pilot certificate is a visual certificate. I'll come back to this.

Another challenge is consistency. We need to impose some order on the maneuver so we can reproduce it consistently. I group being on the correct airspeed and heading under consistency.

The final challenge for now is airspeed management and airframe protection. Too fast and we could rip the wings off the airplane. Too slow and we could stall and spin.

Once you put all those constraints together, you arrive at the following procedure, which is usually how lazy eights are taught.

The pilot selects a clear visual reference line on the ground. A major highway, river, railroad, right of way for a power line, or other sufficiently long, straight feature is suitable for this maneuver. The keys are that the reference line be visible from all angles, and be distinct enough from other things on the ground to avoid confusion, disorientation, and ultimately, maneuver failure. A short road is not great. A small road among many other small roads is not great. The edge of a field is not great. If necessary, scope this out ahead of time using a sectional chart, Google Earth, or any other available resource.

The pilot plans to enter the maneuver flying perpendicular to the ground reference line. To protect the airframe, we want to be flying no faster than V_A, the design maneuvering speed for the aircraft. We likely want to be flying slower since we're probably not at gross weight. In the Lance, we enter at 120 knots indicated.

While flying straight at the reference line, but before crossing it, the pilot selects some key reference points. One is at 45 degrees off the nose in the direction of the turn. This point will represent the one-quarter point through the turn. One is at 90 degrees. More than likely this will simply be the reference line itself. Alignment with the reference line will represent the halfway point through the turn. The last reference point is at 135 degrees, or 45 degrees behind the reference line. That point represents the three-quarter point through the turn. Since the turn in one direction will immediately be followed by a turn in the other direction, it would be a good idea to get 45 and 135 degree references on both sides. Try to pick something obvious: a quarry, a silo, a castle, a lake, a river bend. Clouds aren't the worst choice but they do move. A particular field surrounded by other similar fields is probably not a great choice.

We break the maneuver down into quarters. We begin execution once we cross the reference line. This is a constant power maneuver, so don't touch the throttle - 18" of manifold pressure and 2400 RPM in the Lance on a standard day at 4500' MSL is about perfect. We shouldn't need to touch the trim either. Let's assume calm winds for now. Here we go!

In the first quarter, we are, at the same time, entering a shallow turn of about 5 degrees, and beginning to increase our pitch. Control inputs smoothly increase. At the 45 degree point, we are at 10 degrees of pitch, representing maximum pitch, and at about 15 degrees of bank, representing half of our maximum bank. We've gained about 200 feet.

In the second quarter, we are starting to let the nose down while increasing bank to the maximum. Just before the 90 degree point - let's say ten degrees prior - an interesting thing starts to happen with the nose. We are approaching maximum turn rate and minimum speed. Our lift vector is no longer pointing straight up. The nose wants to nose over and slice through the horizon. Let it!

At the half way point, our airspeed is about 10 knots above stall speed, 80 knots in the Lance. Our pitch attitude is level since we've already let the nose start falling. Our bank momentarily reaches maximum bank of 30 degrees. We're thinking about *letting* the nose down and releasing the controls. We've gained about 200 more feet.

In the third quarter, we're rolling out from 30 degrees of bank and pitching down. Close to the three quarter point, we find that the Lance needs some nose-down help from the yoke, so we provide that. The airplane is accelerating and descending at this point. We need to manage that. At the three quarter point, we're back at 15 degrees of bank and whatever pitch is appropriate for our other goals - probably 5 or so degrees down.

In the fourth quarter, we're taking our time to make sure that we roll out on airspeed, and on heading.

We finish the maneuver at the same airspeed and altitude as our entry, but in the opposite direction, over the same reference line. Once we're there, we start a turn in the opposite direction. We can keep doing this indefinitely.

The hypothetical perfect VFR pilot can conduct this maneuver exclusively by looking at the airplane, so they say.

Simple enough, huh?

Well, the author didn't think so. Here are a few more tricks that the author found helpful.

First, watch this video: `https://www.youtube.com/watch?v=3Oxbr1PuoSQ`.

The video raises some important points.

First is that the lazy eight is an exercise in managing the overbanking tendencies of the aircraft. Past a few degrees of input, the airplane wants to keep turning. Or, as I see it, we tickle an unstable mode of the aircraft with this maneuver.

Second is the incredible importance of coordination. Sure, skidding or slipping is disqualifying on a checkride, but that's not the important or interesting part. The airplane has a left turning tendency, which we'll need to fight with right rudder. The Lance has a decent amount of adverse yaw that ends up helping us some here.

Third is an important reminder that this is a visual reference maneuver. In the video, the instructor has the panel covered with a sheet of paper. All he does is take a couple of quick peeks at the instruments to confirm altitude and airspeed.

Last is that we can complete the maneuver with fairly minimul control inputs. Well, at least, on a Cessna. But that's not true on the Lance. As my Navy test pilot friend points out, the Lance has *extreme* roll stability, so we have to help it along some.

In addition to the video, I'll add my own observations.

Thinking about the timing of the maneuver helped me to quantify what it means to "slow down". As someone who regularly deals with events that happen in the span of about 5 *milli*seconds at work, fifteen seconds feels like an eternity! But quantifying that helped tremendously. Each quarter should take about 20-30 seconds, and a complete turn should take about 90 seconds.

In particular, the first quarter will take a really long time. We use this quarter to try to gain some separation from our starting point. It helps us to fly a wider turn which gives us more options in the later segments. The second quarter sees the most control inputs. In the third quarter, it's important to get out of that 30 degrees of bank quickly or else the turn will be over too soon.

We sometimes had trouble with the aircraft not losing altitude fast enough in the third and fourth quarters. One instructor pointed out a "half ground, half sky" sight picture that served as a good reference.

I also thought more carefully about what the aircraft was doing in each of the yaw, pitch, and roll axes individually, and what the aircraft's stability was doing for us.

In yaw: the airplane is turning 180 degrees. The rate of yaw increases through the first half and decreases through the second half. It's probably close to a perfect cosine. The Lance is lightly stable in yaw and doesn't need much help here.

In pitch: We're nosing up, than descending. Yoke back, let the nose fall over, yoke forward. Since we didn't touch power or trim, the airplane *wants* to find its original airspeed and altitude. Zoom up, zoom down.

In roll: We start the plane rolling. We give it a bank angle and maybe a touch of momentum. The airplane wants to keep increasing the bank to some extent. But these things are happening at time constants that end up being faster than our maneuver. So we baby the airplane into, and out of, a gentle bank, not exceeding 30 degrees.

We haven't talked about crosswinds yet. Strictly speaking, this is not a ground reference maneuver. But if we don't correct for winds, we don't stay on our line. Instead, we start drifting. So, through the maneuver, just like in a traffic pattern, we can think about gaming the turn. If we're getting blown away from our reference line, maybe we want to hurry up the first quarter and start our turn sooner. If we're getting blown toward it, maybe we want to slow down through the first quarter and slow down the last quarter.

This maneuver comes back on the CFI checkride, where we might need to teach it. So approaching it with rigor up front pays dividends later.

For anyone who picked up this maneuver more easily, without all this rigor: I envy you.

If you're still stuck, have a look at https://www.av8n.com/how/htm/maneuver.html#sec-lazy-eight. I don't degree with teaching the attitude-centric or nose-centric view of that explanation, but it provides an interesting cross-check for what I've described above.

Anyway. All the quantification aside, this is supposed to be a *smooth* maneuver. We're not fighting the airplane on the controls or micro-managing it. We're making small, subtle control inputs.

4.3.15 Eights on Pylons

The commercial pilot maneuver "eights on pylons" has us turning about two ground reference points, about three-quarters of a mile apart. The idea is to fly around one, then head to the other and turn in the opposite direction. We enter the maneuver on the downwind, at our highest ground speed, and fly it at constant power.

When in the turn, the goal is to keep the wing pointed precisely at the pylon, so that it appears to be frozen in one spot looking out the window.

We recall that this is a constant power maneuver. So how can we keep the pylon in exactly one place? The answer is with altitude control.

As it turns out, to keep the wing pointed at a single reference, altitude and ground speed are closely coupled. I'll attempt to build some intuition for this before diving into a more formal proof.

If we are in a car driving along - at zero altitude - it is impossible to do this maneuver. There is no way to control where anything is in the window whizzing past us. If we were to climb (imagine an overpass), the ground would "slow down". Things tend to get behind us really quickly.

Conversely, if we were to find ourselves up in space, the ground would effectively appear to stand still at the sorts of speeds a single engined airplane could fly (assuming there is any air up there to hold us up). If we tried to turn, we would have to cover an incredibly long distance to keep a point in one place.

The intuition is as follows:

- Reference point moving behind the wing. We are too low! Climb!
- Reference point moving in front of the wing. We are too high! Descend!

So, there is a "sweet spot" of altitudes, and it happens to be around 1000 AGL.

Using some trigonometry, vector decomposition, and basic physics, we can prove that, for every ground speed, there is an altitude that allows us to turn with the wing pointed at a point on the ground. Curiously

Ground Speed (knots)	Absolute Altitude (feet)
60	320
65	375
70	435
75	500
80	565
85	640
90	715
95	800
100	885
105	975
110	1070
115	1170
120	1275
125	1385
130	1495
135	1615

Figure 4.1: Pivotal Altitude Chart

enough, radius and bank angle - through related to one another - have nothing to do with the pivotal altitude.

A really nice discussion of the proof is here: https://www.youtube.com/watch?v=oc9mqDadv_M.

The FAA's training materials focus exclusively on ground speed. But, the proof I just shared, also talks about air speed.

Using a spreadsheet, I was able to calculate this pivotal altitude chart, rounded to the nearest 5 feet for simplicity.

Have a good look at those altitudes. Remember we never want to be lower than 500 AGL if we can help it, especially on a checkride, which means we'll be flying this maneuver ideally at 75 knots at the slowest. Remember, we're turning through the maneuver, and going from a tailwind to a headwind, which means we'll be scrubbing a good deal of airspeed and altitude.

In the Lance, I like to enter this maneuver at about 120 knots, 2400 RPM, 20" to 22" of pressure, so that the speed doesn't get too low. With only 18" of manifold pressure on a standard day at 1500' MSL we were getting really slow.

The commercial pilot ACS wants us to not exceed a bank angle of 40 degrees. Recalling that bank angle is solely a function of horizontal distance to the pylon, we'll want to make sure we keep enough horizontal space from the pylon to enable this.

4.3.16 Maneuvering During Slow Flight and Stalls

Nothing too special about these except the very tight commercial pilot ACS limits: ± 50 feet for altitude, $\pm 10°$ heading, $+5/-0$ for airspeed (which in the Lance is usually 70), and $\pm 5°$ angle of bank. The examiner may want to see these in the clean configuration, or an approach configuration, which could be one notch of flaps, two notches of flaps and gear down, full flaps and gear down. The may ask you to fly straight and level, to turn (usually 15 degrees is about right), to climb or descend, or to do more than one at the same time. If we're doing these power off, of course we cannot maintain altitude, so allow plenty of margin for descending just above stall speed. If we're doing these power on, correct rudder application is paramount.

Remember: pitch (and quite a lot of nose up trim in the Lance) for airspeed, power for altitude.

Give plenty of space above the ground for these. KMDD airport sits at 2805.4 feet MSL. We could be entering these maneuvers at 5500-6000 feet MSL.

For the commercial pilot, stalls may be to first indication (BEEEP!) or a full stall (BEEEP!, heavy buffet, and a very tiny nose drop and excessive sink rate in the Lance).

The Lance doesn't want to fly slow. Full aft trim helps relieve control pressures in slow flight, in addition to dropping the gear and putting in two notches of flaps. Maintaining altitude is easy enough as long as we're cognizant of the fact that the plane will need continuing back pressure and trim to not sink. It takes a big dose of right rudder to maintain heading. I tend to fixate on altitude control and lose my heading. Picking a reference point is good, but since we could end up in a nose high attitude doing this maneuver, it may not be enough. Using the heading bug is good, but it also gives the examiner a concrete way to fail you, so be careful.

The Lance has very gentle, docile stall characteristics. The first indication of a stall is the stall warning horn, usually at about 70 knots. After that, we get pronounced aerodynamic buffeting as we approach the critical angle of attack. The actual stall simply results in the vertical speed indicator dropping down from zero to 500-1000 feet per minute down. The nose doesn't fall over, the pitch attitude of the airplane doesn't change, it just mushes down. Recovery is a go-around: all engine controls forward, push the nose forward to lower that angle of attack, and reduce drag with flaps-gear-flaps-flaps in succession.

If I'm really on top of it, I can recover the Lance from a power off stall in as little as 100 feet. About 200 feet is more typical.

Disqualifications include: getting below 1,500 AGL. Make that 2000 AGL. Stall recovery can be up to 550 feet in the Lance. Call that 3000 AGL. Forgetting to make clearing turns is disqualifying. Forgetting to stay coordinated could be as well.

4.3.17 Accelerated Stalls and Spin Awareness

Fortunately, these are harder to enter than they are to exit. Also fortunately, we don't have an altitude requirement for this one. Well, except for one: DO NOT get below 3000 feet AGL. If we're especially ham fisted, we'll enter a stall, which - shocker! - is disqualifying.

Set up the airplane for V_A, configure as requested, set power appropriately, and enter a coordinated 45 degree banking turn. Don't worry about altitude as long as we're high enough.

Now: PULL. It will take a HEAVY two handed pull in the Lance to get a stall warning.

Hear the BEEEP? Wings level and go around. Done.

4.3.18 Emergency Descent

Again, the old joke is that we're never too high or too fast in the Lance.

I like to do the emergency descent at 120 knots. That gives a little bit of margin below the maximum landing gear operation and extension speed of 129 KIAS.

We don't need flaps for this maneuver. The vertical speed indicator only goes to +- 2000 feet per minute. If the nail is pegged, we don't really know if we're sinking at 2000 feet per minute or more. 2000 is plenty.

When we start the maneuver we need to pick an altitude for leveling off. We'll want to come in with the power about 300 feet early to make sure we don't sink through it.

Clear the area. Then, slow to 120 knots. Get the gear down and bring the power to idle. Enter a controlled spiraling descent - ideally to the left - and maintain 30 to 45 degrees of bank to keep a positive load factor on the wings.

The commercial pilot ACS says we need to be between 30 and 45 degrees of bank, appropriate airspeed +0/-10 knots (so 120-129 is perfect), and that we have +-100 feet of altitude for our recovery. A heading is not specified.

4.3.19 Emergency Approach and Landing

In a Lance, the best field is usually directly beneath you. It's better to overshoot than undershoot with a dead engine since you can forward slip or put in flaps to get down.

We're looking for the ABCDE checklist, emergency checklists, radio communications, dividing time inside and outside the cockpit, and setting up for a base to final for an off airport landing. The engine may or may not be "working" based on the scenario. If the engine isn't working, pitch and trim for 92 knots best glide, and only put the gear down when the field is made. Otherwise, keep one hand on the throttles at all times.

Not much new here from the private pilot days.

4.3.20 Systems and Equipment Malfunctions

A big part of the scenario that the examiner selects will be the emergency. There are a few popular ones. They could easily include:

- Engine stoppage due to loss of fuel. We could have a simulated loss of fuel flow due to a ruptured fuel line, an inoperative fuel pump, or a missing gas cap, which would cause all the fuel to evaporate out of the tanks in short order.
- Carbon monoxide in the airplane due to a simulated exhaust manifold leak.
- In flight fire due to fuel system issue.
- Loss of oil pressure or excessive engine temperature in flight.
- Loss of alternator due to broken alternator belt.
- Door opening in flight.

- Governor failure in flight leading to propeller overspeed.
- Sick passenger in need of immediate medical attention.
- Failure of pitot-static system due to simulated pitot tube ice.

I can't give a complete listing of every possible simulated emergency that could arise. It's important to be familiar with the POH, the emergency procedures, and the systems of the airplane. Take the time to establish flows. Practice.

4.4 Maneuver Checklists

These checklists are specifically NOT presented in ACS order. Instead, they are presented in the order that makes sense for a typical training sortie.

GUMPFSS Landing Check used on maneuvers in this section:

- G - Gas: On the most full tank. Switch on fuel pump before changing tanks.
- U - Undercarraige: Extend if below 129 KIAS on the Lance. Leave up for upper air maneuvers or power off 180s.
- M - Mixture: Full rich. Lean the mixture if full rich causes a marked reduction in power. Leave alone for constant power upper air maneuvers.
- P - Propeller. Leave alone for upper air work, push forward for landings.
- F - Flaps. As needed.
- S - Seatbelts and Shoulder Harnesses. Must be fastened.
- S - Switches. Landing light as needed. Fuel pump: switch ON.

STEEP TURNS

- CLEAR THE AREA + GUMPFSS
- Pick reference point on horizon.
- Set heading indicator.
- Roll right to 50
- Power comes in
- Substantial back pressure – both hands.
- Keep reference point on horizon. Reference point is oil port on top cowling left of nose.
- In left turns the nose is above the horizon.
- In right turns nose is below horizon.
- Lead roll out of turn by 25 degrees.
- Our standard is +-50 feet altitude.

CHANDELLE

- CLEAR THE AREA + GUMPFSS
- 18"/2400 RPM or whatever speed is needed for 120 KIAS
- Pick a reference point and two side reference points.
- Roll to 30 degrees, power comes in.
- Pitch right up to 12-15 degrees nose up.
- Substantial back pressure – both hands.
- At the 45: Call out: Max Bank
- 45-90: Back pressure continues to increase.
- 90: Call out: Max Pitch. Reduce roll to 20. Keep the back pressure. Maneuver is about a third done.
- 90-135: make sure turn rate and loss of speed are not excessive.
- 135-180: game it so you're right at 70 KIAS at 180 degrees.
- 180 degrees: BEEEEP on heading. Level off.
- Watch the nose. Don't balloon or sink. Forward pressure as we accelerate.

ENGINE FAILURE

- A – Airfield. Probably under you or close to it.
- B – Best Glide.
- C – Checklist. Touch anything related to fuel, oil, mixture, or outside air. GUMPFSS check.
- D – Declare emergency. Squawk 7700. 121.5 MAYDAY x 3
- E - Execute.

POWER OFF SPIRAL aka STEEP SPIRAL (not an "Emergency Descent").

- CLEAR THE AREA if able + GUMPFSS
- Pick a point below. Pick a heading reference.
- Heading bug.
- Straight to 92 KIAS clean. NOT an emergency descent. Trim for it.
- Where is wind blowing? Clear engine into it.
- Vary bank to keep point where it needs to be. No more than 60 degrees.
- Start high up enough for three turns.
- 1500 AGL plus 1200/turn is 5100 AGL MINIMUM.
- Smooth recovery after three turns.

LAZY EIGHTS

- CLEAR THE AREA + GUMPFSS
- 18"/2400 RPM or whatever speed is needed for 120 KIAS (sometimes 19 works better")
- Pick a road.
- Slow slow slow.
- Roll to 15 degrees.
- Pitch up.
- Don't touch the power.
- 0-45: pitching up. Slow slow slow.
- 45: Call out. "Maximum pitch".
- 45-80 work up to max pitch and max bank. You'll gain 400-600 feet.
- 80-100 nose slices through horizon.
- 90: Call out. "Maximum bank".
- 100-135 baby the nose down, back to 120 KIAS.
- 135-180 keep pushing that nose down.
- Finish on altitude and on heading.
- Do it again.

EIGHTS ON PYLONS

- CLEAR THE AREA + GUMPFSS
- 18"/2400 RPM or whatever speed is needed for 120 KIAS
- Pivotal altitude is about 800-1200 AGL.
- Pick points a mile apart. Wind blowing between them. Enter on a downwind and turn left first.
- Think about wind correction. Xs should be symmetrical.
- Don't touch power.
- Spot ahead of the wing? DIVE.
- Spot is usually ahead.
- Spot behind the wing? CLIMB.
- You're slowing up in the turn.

POWER OFF 180

- Traffic pattern, runway 1/3 up wing.
- Cut power abeam numbers.
- 92 KIAS - GUMPFSS
- Rounded short approach
- GEAR DOWN when field is made
- HAND ON THROTTLE
- Touch down on 1000 foot markers
- GO AROUND if it's not assured.
- FLAPS if needed.

Chapter 5

Commercial Pilot Checkride

This chapter contains a hodge-podge of material that I prepared for checkride day.

5.1 Requirements

The applicability for a commercial pilot candidate comes from 14 CFR 61.121 and thereafter.

- 18 years of age
- English language
- Knowledge test
- Instructor endorsement
- Aeronautical experience
- Pass the checkride
- Private pilot or better
- Category and class requirements

You also need a medical. 3rd Class (or Basic Med) just to take the checkride, 2nd Class to exercise the privileges.

5.1.1 Aeronautical Experience

For further details please see 14 CFR 61.129. Since this is written with the Piper Lance II in mind, this subsection focuses on Airplane Single Engine Land (ASEL) requirements.

- 250 hours total flight time
- 100 hours powered, of which 50 in airplanes
- 100 hours PIC time
  - 50 hours in airplanes
  - 50 hours cross country (greater than 50 nmi), of which 10 hours in airplanes
- 20 hours of training
  - 10 hours instrument training using view limiting device - not IMC! 5 must be in a single.
  - 10 hours in a complex (retract, constant speed prop, flaps), turbine, or TAA (moving map, 2 axis autopilot)
  - 2 hour cross country, daytime, with a 100 nmi leg
  - 2 hour cross country, night, with a 100 nmi leg
  - 3 hours checkride prep with CFI in preceding two calendar months.
- 10 hours of solo time to include
  - Long cross country: at least 300nmi, one 250nmi leg, at least three landings.
  - 5 hours VFR night with 10 takeoffs, traffic patterns, and landings at a towered airport
- The 10 hours may be flown with an instructor (e.g. "supervised solo") but you cannot mix and match. See the Grannis Interpretation.

5.2 Commercial Operations

There are more formal definitions of these terms. These are my informal working definitions of them in my own words.

Commercial Operator - the person or entity that makes the airplane available for a commercial operation. Being a commercial operator is a Big Deal and often involves a bunch of legal entanglement. An individual cannot legally serve as a commercial operator without a whole mess of paperwork (think Part 121 or Part 135 operations).

Holding Out - advertising! Posting to social media, putting up a flyer at the airport, or even word of mouth can serve as advertising. Don't do it!

Common Carriage - the transport of a member of the public by airplane. Generally not someone you know personally. Can't do this with my basic commercial certificate.

Private Carriage - the transport of a familiar person, such as a friend, family member, coworker, etc. It can also include serving as someone's personal pilot for some period of time. There is a spectrum here: if you're engaging in a different "private carriage" operating several times a week with people you barely know, that could be construed as common carriage.

So what can you do with a commercial pilot certificate? You can be paid for flying an airplane. But you don't get to be a commercial operator or engage in common carriage unless you work for a commercial operator. An instrument rating in the same category and class is required for operations in excess of 50 miles from the home base, or at night.

Things you may do: flight instruction, banner towing, aerial surveillance and photography, crop dusting, ferry flights, sightseeing flights within 25 nmi, glider towing.

14 CFR 61.133, 14 CFR 119.1, Advisory Circular 120-12A - Private Carriage Versus Common Carriage of Persons or Property.

5.3 Aeronautical Knowledge

5.3.1 Hydroplaning

The New Oxford English Dictionary offers this definition of the verb hydroplane: "(of a vehicle) slide uncontrollably on the wet surface of a road".

The examiner may ask about the different kinds of hydroplaning. They are:

Dynamic hydroplaning. The airplane landing on a water soaked surface will build a wedge of water in front of the wheel. The wedge does not compress and lifts the wheel off the ground, causing a marked reduction in traction.

Viscous hydroplaning. The airplane landing on a water coated surface will compress a thin film of water which will lift the contact patch of the tire. A very small amount of water is necessary for this phenomenon. The key is that the surface needs to be extremely smooth with nowhere for water to go.

Reverted rubber hydroplaning. The airplane's tire locks trapping some water underneath the contact patch. The water absorbs energy and turns to superheated steam, lifting the tire and de-vulcanizing or "reverting" the rubber on the tire.

The NASA report Phenomena of Pneumatic Tire Hydroplaning [3] is the primary source for this material from the late 1960s. Fairly early on that source introduces the hydroplaning equation, $V_P = 9\sqrt{p}$, where V_P is the hydroplaning speed in knots, p is the tire pressure in PSI, and 9 is a unitless conversion factor for knots. To get V_P in miles per hour this conversion factor is instead 10.35.

5.4 Weight Shift Formula

$$\frac{weight\ of\ object}{Weight\ of\ aircraft} = \frac{Distance\ CG\ moves}{distance\ between\ stations} \tag{5.1}$$

5.5 NTSB

Accident - death, serious injury, substantial damage, from first passenger boarding to last passenger deboarding

Incident - not an accident but affects safety

Immediate notification: accident, flight control system, unable to perform duties, turblne failure, in flight fire, release of propeller blade, mid air collision, 25k of damage, complete loss of information more than fifty percent of EFIS, overdue airplane believed to be in accident

Serious injury - fracture, hemmhorage, internal organ, 2nd or 3rd degree burn, hospitalization 48 hours within 7 days

Serious damage - affects safety, requires repair or replacement

5.6 Checkride Flight Planning - Take One

For my checkride I was posed with this problem:

1. Plan a VFR cross-country as follows: HOME AIRPORT-KAEX (GPS navigation will be unavailable to you in the airplane). (We clarified that KACT, the checkride airport, is the "home airport" here.)
2. Have your cross-country navigation logs (winds, estimated times en-route, etc.) and flight plan forms completed prior to your arrival for the practical test. Also bring with you a weather briefing packet for the trip. You can either call the F.S.S. or use FAA approved on-line resources. You don't have to print out everything, only the information that is pertinent to the trip.
3. When you select check points for flight, try to find points that are not too far apart, preferably no more than 10-20 nm. apart. Doing so will shorten the cross-country portion of the flight.
4. I weigh 210 lbs. We will take 5 lbs. of luggage as well. Please compute weight and balance, take-off and landing distance data for our flight. Determine your aircraft's maximum range using the cruise altitude, and other conditions for the first leg.
5. Be able to locate your aircraft's current Weight and Balance and Equipment List, supplements, and the other required aircraft documents (AROW).
6. Review the current Commercial Pilot ACS in its entirety (available on www.faa.gov). Also take time to review the Appendices in the ACS, including Stall/Spin Awareness/Avoidance, and Runway Incursion Avoidance (Hot Spots), etc.
7. *Information on fees and payment intentionally omitted.*

Lots to talk about here.

5.6.1 Cross Country Planning

We're going form KACT to KAEX. This is an interesting routing for a few reasons. There is no obvious direct route. There is no single highway, railroad, or power line we can follow. There are a bunch of airports and VORs in the area. There really aren't any useful radio aids to navigation on the direct route. There are also some MOAs along the way.

With passengers on board, I would avoid MOAs, assuming they are generally active. I could check the sectional chart for more information on those.

If I had a GPS and were going VFR I'd go direct to 3R4 or to the Natchitoches (OOC) NDB and then direct to KAEX. But we're no GPS.

My first thought is to go IFR without GPS. Off airways we could go KACT ACT LOA LFK AEX KAEX. This is 261.3 nmi where direct is 240.8. If we had to stick to airways we could go KACT ACT V15 CLL V565 LFK V212 AEX KAEX. Radar and VOR services should be good in this flat land area so those would be reasonably safe. Who knows, ATC might just give me vectors the entire way.

But we should expect to do this VFR. This is the VFR route that I've picked. It comes to a hair under 250 nmi. I would do this with flight following for sure.

1. Take off from KACT having announced "VFR to the southeast". Fly a heading of 116 for about 7 nmi.
2. Fly over or south of the Baylor stadium. Watch for game related TFRs! Flying south of the stadium avoids KCNW's airspace.
3. Fly heading 086 for 8nmi to a small lake, Tradinghouse Creek Reservoir, as a visual reference point.
4. Fly heading 075 for 23 nmi to overfly Mexia KLXY airport. Top of climb should be in here somewhere as well.
5. Fly heading 072 for 19 nmi to overfly the town of Fairfield, passing two small airfields and crossing a railroad line and a highway along the way.
6. Fly heading 079 for 23 nmi to overfly Palestine KPSN airport.
7. Fly heading 100 for 33 nmi to overfly the town of Alto, which is on Highway 69.
8. Fly heading 102 for 19 nmi to overfly Nacogdoches KOCH airport.
9. Fly heading 093 for 28 nmi to overfly San Augustine 78R airport, just before a highway, a power line, a railroad line, and the town of San Augustine.
10. Fly heading 088 for 35 nmi to overfly Hart 3R4 airport. Along the way overfly Ammons private airport, which is on a prominent peninsula.

11. Fly heading 079 for 23 nmi to intercept Highway 49 and the rail line well south of the Natchitoches town, airport, and NDB.

12. Following Highway 49 south, fly a general heading of 130 for 21 nmi to overfly Lake Rodemacher. Establish two way radio communication with KAEX no later than the Lake.

13. From the lake, I would expect to be vectored in, but flying a heading of 108 for 10 nmi would take me straight to the airport.

I chose this route for a few reasons. Flying down to LFK and overflying the MOA would not be great flying VFR. There are plenty of airports along the way which provide opportune places to divert if needed. Early on, the waypoints are close together. Since it's a checkride I'd expect a diversion pretty early on.

If I were routed to fly through KCNW's airspace to avoid town, I could just follow Highway 84 to the west. Instead of the stadium and the lake, I would fly over KCNW, then proceed on a heading of 087 for 15 nmi until crossing an abandoned military airfield. Another 14 nmi on that same heading would get me to KLXY where I could resume the previous plan. But a transition through KCNW is not guaranteed, and I couldn't get to 3000' to overfly it in time.

Altitude selection is based on winds aloft and the hemispherical altitude rule. Being instrument rated, if I were flying at night, I would want to climb higher, 9000' IFR or 9500' VFR, to have options in case of an engine failure. With the Lance's 7.8:1 glide ratio, at 9500 feet, I would have, in theory, up to 14 statuate miles or 12 nmi of glide distance. Chances are pretty good that I would be able to make an airport along my route. Otherwise, during the day, I would probably select 5500' VFR to get high enough to give my passengers cool air, but keep them low enough that there is plenty of oxygen to breathe. 7500' and 9500' do offer better cruise performance, I might select those altitudes if I wanted to make better time. Terrain is pretty much no factor on this lowland route.

5.6.2 Navigation Logs, Flight Plan Forms, Weather Briefing

I would calculate these with ForeFlight and print backups the day before.

Make sure to look at winds aloft for several altitudes since these will come into play for the maneuvers section of the checkride.

5.6.3 Cross Country Planning Cross-Check: Waypoint Distances

The points I selected are generally about 10-20 nmi apart. Again, I'm expecting an early diversion to KPWG, which is an examiner favorite, but KCNW and KLXY are possibilities as well.

Pilotage, dead reckoning, fuel, emergency equipment, briefings, etc.

5.6.4 Weight and Balance

The examiner is 210 lbs and I am 230 lbs. Together that puts us at the station limit of 440 lbs for the front seats. The examiner's 5 lb bag can go on the second row seat. I plan on my own 15 lbs bag, 20 lbs of nose cargo and 50 lbs of aft cargo. We carry about 50 gallons of fuel because I like the way the airplane handles. We burn about 14 an hour at 145 knots so 50 gallons gives 3.5 hours of endurance or about 507 nmi of range. That's plenty for this flight of 250 nmi with IFR reserves of cruise to alternate (let's say KMKV) plus 45 minutes.

I would do all of this on ForeFlight.

5.6.5 Aircraft Documents

On the Lance, the airworthiness certificate, registration certificate, and radio certificate are on the wing spar bulkhead immediately aft of the pilot's seat. The owner's manual, supplements, and weight and balance are beind the copilot's seat. I'll take photos of all of these on my phone for ease of demonstration.

5.6.6 Commercial Pilot ACS Review

...still reviewing...

I didn't see a notice in the current Commercial Pilot ACS (DATE) for Stall/Spin Awareness/Avoidance, Runway Incursion Avoidance, Hot Spots, etc. I think he meant the "Special Emphasis Areas" from the PTS of days of old. The FAA seems to think that, instead of calling them out separately, they should just be inline with certain ACS items. However I find the combined presentation useful and still relevant. I was able to find a copy at http://sethlake.aero/FAA_SpecialEmphasisAreas.pdf.

5.6.7 Compensation for the DPE

In the past I've had DPEs accept electronic payment - Venmo or Zelle - for checkrides. Venmo was fine. Zelle had a transaction limit that left me scrambling for the ATM at the last minute.

Cash works.

DPEs sometimes complain about big wads of cash. Do them - and yourself - a favor and get big bills from the bank. Yes it's old school but it works. Don't forget cash for a re-examination fee. Better to have it and not need it than need it and not have it.

A sealed security envelope works nicely for the examiner's fee.

5.7 Checkride Flight Planning - Take Two

My examiner finally texted me at 9:45am that he would not be able to make a 9am scheduled checkride. That's unacceptable. So I fired him.

I changed to a different examiner who gave me a different problem. I was asked to plan a cross-country from KHYI to KVCT, with a 225 pound passenger. This is arguably an easier problem than the one I had earlier. I used a combination of SkyVector.com and ForeFlight to perform my route planning. I obtained airspace information from a digital edition of the San Antonio sectional chart.

5.7.1 The Route

KHYI to KVCT is a fairly short cross-country at 81.9 miles. It is above 50 miles in length, so to fly it legally as a commercial pilot with passengers I would need to be instrument rated.

My first inclination is always to fly it IFR. Without looking further I might expect a routing of radar vectors, direct to the VCT VOR, then direct. Indeed, a quick peek at ForeFlight shows that to be a popular route. I would select an altitude of 5000 feet (IFR) or 5500 feet (VFR). KVCT even has two VOR approaches (and an ILS into 13) that would serve us well if we lost GPS. (We could figure our position using the CWK, SAT, and VCT VORs if we did get lost.)

Of course, I expect that I won't have GPS at all, and I'll fly it VFR. This is the route I would select. Distances in nautical miles.

1. Depart KHYI from the current runway and expect radar vectors to the south.
2. Fly a nominal heading of 145 for 9 miles to pass over Fentress Airpark.
3. Fly heading 126 for 9 miles to pass over the Town of Luling.
4. Fly heading 129 for 13 miles to pass over Dreyer Memorial (T20) airport. We've been mostly following the San Marcos River until now.
5. Fly heading 155 for 29 miles to pass over Cuero Muni (T71) and the Town of Cuero, where a number of roads and railroads converge near a prison.
6. Fly heading 120 for 13 miles to pass a closed airfield. From here we should be looking straight down Runway 13 at KVCT. This is a good place to start our descent if we have not already, and to establish radio contact with KVCT tower.
7. Fly heading 128 for 10 miles to KVCT.

5.7.2 Airspace Analysis

Departure from KHYI, a Class D towered airport with ceilings up to 2700 feet. It reverts to Class E when the tower is closed. Traffic pattern for me in the Lance is 1600 AGL. We exit the airport airspace into Class E airspace.

Near Fentress Airpark we transition from Class E airspace with a 700 foot base to Class E with a 1200 foot base. We also have warnings of parachute activity in the vicinity.

Near Luling we cross Victor aitrways V198. That is Class E airspace too, but we are already in it.

Near T20 we cross two military training route: IR148 and VR1120. IR148 will see high speed military IFR traffic above 1500 feet AGL (three digits). VR1120 will see military traffic operating at VFR below 1500 feet AGL (four digits).

We pass underneath the Randolph 1A MOA (8000 to 17999 feet, SR-SS Mon-Fri), Alert Area A-632E (6000 to but not including 9000 feet, SR-2400 Mon-Fri, 1400-2400 Sun, or by DOD NOTAM), and the Kingsville 5 MOA (9000 to 17999 feet, SR-2400 Mon-Fri, 1400-2400 Sun). Those are listed in ForeFlight as well as in the margin of the VFR Sectional Chart.

KVCT is a towered Class D airport with ceilings up to 2600 feet. It reverts to Class E when the tower is closed. Pattern altitude for me in a light aircraft is 1100 AGL.

An altitude of 4000-4500 feet northbound and 5000-5500 feet southbound is appropriate for cruise without needing to deal with the MOAs or Alert Area.

It should be no factor, but I would stay far away from R-6312, which is designated for "high altitude release bomb training". Yikes. https://www.federalregister.gov/documents/2001/10/29/01-27159/modification-of-restricted-area-r-6312-cotulla-tx

5.7.3 Weather Considerations

Victoria is far enough inland that we should be shielded from advection fog and other coastal weather phenomena. I would expect winds from the southeast.

For an IFR alternate, I would be looking for something a bit further inland and towered. There isn't much, so we might be going back where we came. I'd select KSAT to give my passengers the greatest number of options possible, or offer to take them back to KHYI. Depending on their mission and the weather, we could select another nearby field.

5.7.4 Weight and Balance

Much of the previous discussion applies. 50 gallons of fuel is plenty to fly all the way to VCT, go missed, fly back to SAT and have ample reserves.

Chapter 6

Alphabet Soup

This chapter contains a number of useful memory items for us to know.

6.1 Required Equipment - VFR Day/Night

A TOMATO FLAMES (F) + FLAPS from 14 CFR 91.205.

- A - Altimeter
- T - Tachometer
- O - Oil Pressure Gage
- M - Magnetic Compass
- A - Airspeed Indicator
- T - Temperature Gauge (liquid cooled engines)
- O - Oil Temperature (air cooled engines)
- F - Fuel Gauge
- L - Landing Gear Position Indication
- A - Anti Collision Lights (after Mar 11 1996)
- M - Manifold Pressure Gauge
- E - Emergency Locator Transmitter (ELT)
- S - Seat Belts and Shoulder Harnesses
- F - Floatation Equipment (Commercial)
- F - Fuses
- L - Landing Lights
- A - Anti Collision Lights
- P - Position Lights
- S - Source of electrical power

6.2 Required Equipment - IFR

GRAB CARD + required equipment for VFR day and night.

- G - Generators or Alternators
- R - Radio
- A - Altimeter
- B - Ball (Turn Coordinator)
- C - Clock
- A - Attitude Indicator
- R - Rate of Turn
- D - Directional Gyro

6.3 Airworthiness - Required Paperwork

ARROW

- A - Airworthiness Certificate
- R - Registration
- R - Radio Station Certificate (International)
- O - Operating limitations, including owner's manual and placards.
- W - Weight and Balance

6.4 Airworthiness - Required Inspections

AVIATES

- A - Airworthiness Directives
- V - VOR Check (30 days)

- I - Inspections (100 hour, annual)
- A - Altimeter (24 mos)
- T - Transponder (24 mos)
- E - ELT (12 mos)
- S - Static System (24 mos)

6.5 Landing Checklist

GUMPS + FS or GUMPFSS

- G - Gas or fuel selector
- U - Undercarriage
- M - Mixture
- P - Propeller
- F - Flaps
- S - Seat belts and harnesses
- S - Switches: fuel pump, landing light, etc.

6.6 Lost Communications Procedure - IFR

AVE F MEA or "Avenue F M.E.A.".

6.7 Aircraft Registrations

Every three (3) years. Nullification: 30 FT DUC or "thirty foot duck".

- 30 - 30 days after death.
- F - Foreign registry
- T - Transfer of ownership
- D - Destroyed
- U - US citizenship lost or revoked
- C - Canceled

6.8 Special Use Airspaces

MC PRAWN

- M - Military Operations Area
- C - Controlled Firing Area
- P - Prohibited
- R - Restricted
- A - Alert
- W - Warning
- N - National Security or TFR

6.9 Kinds of Class E Airspace

SET VODA

- S - Surface (an airport)
- E - Extension
- T - Transition
- V - Victor Airways
- O - Offshore
- D - Domestic Enroute
- A - Above 14,500' MSL

6.10 Aeronautical Decision Making

There are a whole bunch of these, let's group them together...

6.10.1 Aeromedical Factors

I'M SAFE - Self Assessment

- I - Illness
- M - Medication
- S - Stress
- A - Alcohol
- F - Fatigue
- E - Eating, Emotion

6.10.2 Mission Factors

PAVE

- P - Pilot
- A - Aircraft
- V - enVironment
- E - External Pressures

6.10.3 Single Pilot Resource Management

Five P's

- P - Plan
- P - Plane
- P - Pilot
- P - Passengers
- P - Programming

6.10.4 Hazardous Attitudes

MARII - like "Mary" with two I's.

- M - Macho
- A - Anti Authority
- R - Resignation
- I - Impulsivity
- I - Invulnerability

6.10.5 Problem Solving

DECIDE

- D - Detect
- E - Estimate
- C - Choose
- I - Identify
- D - Do
- E - Evaluate

6.10.6 Emergency

ABCDE

- A - Airspeed - pitch for best glide
- B - Best field - select landing site
- C - Checklist - fuel flows, flow checklist, memory items
- D - Declare - squawk 7700, MAYDAY x 3 on 121.5
- E - Execute

6.11 Spatial Disorientations

ICE FLAGGS

- I - Inversion Illusion (climb to straight and level - tumbling backwards)
- C - Coriolis Illusion (look down pick up a pen)
- E - Elevator Illusion (abrupt updrafts or down-drafts)
- F - False Horizon (clouds, stars)
- L - The Leans
- A - Autokinesis (things seem to be moving)
- G - Graveyard Spin
- G - Graveyard Spiral (tightening spiral)
- S - Somatogravic Illusion (throttle acceleration)

6.12 Kinds of Fog

Toyota SUPRA

- S - Steam
- U - Upslope
- P - Precipitation Induced
- R - Radiation
- A - Advection (light breeze)

6.13 AIRMETs

- S - Sierra - like The Sierras - mountain obscuration
- T - Tango - Turbulence
- Z - Zulu - Zamboni - Icing

6.14 Spin Recovery

PARE (or whatever your POH says - if it's a Cirrus, that means the chute)

- P - Power to idle
- A - Ailerons neutral
- R - Rudder opposite
- E - Elevator to push nose forward and break stall

6.15 Compass Errors

6.15.1 Turning Errors

UNOS

- UN - Undershoot North
- OS - Overshoot South

6.15.2 Acceleration Errors

ANDS

- AN - Accelerate North
- DS - Decelerate South

6.16 Lost Procedures

The three C's.

- C - Climb. More altitude affords more options.
- C - Conserve. Slow to maximum range speed.
- C - Confess. Ask for help!

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