Piper Archer

Single-engine Guide

MIDDLE GEORGIA STATE UNIVERSITY

Table of Contents

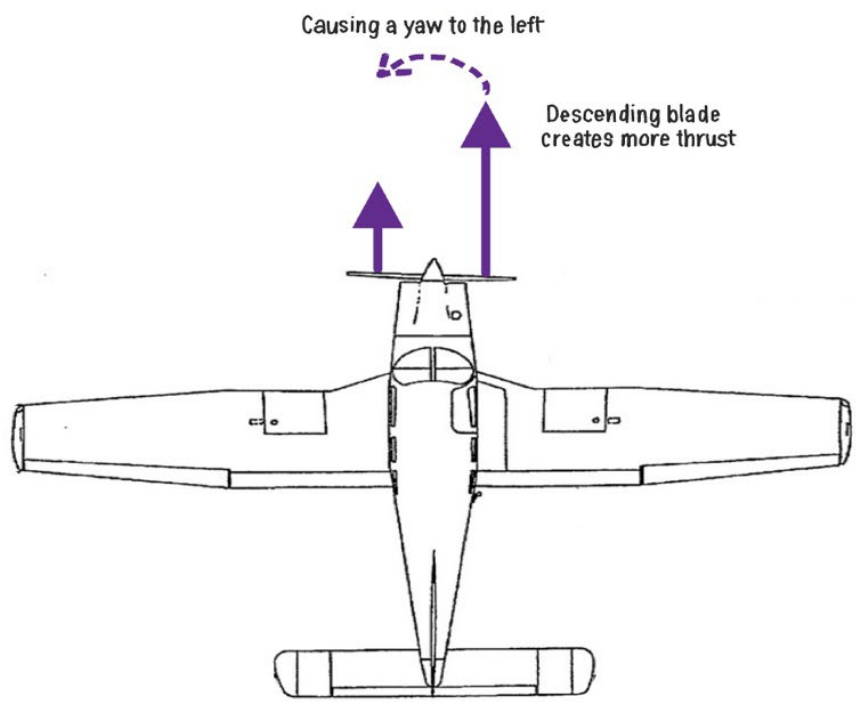
Section I: Single-engine Aerodynamics

Left-Turning Tendencies

Each blade of a propeller is fundamentally a rotating airfoil. The propeller produces a force called thrust, which pushes or pulls the aircraft through the air. Due to this force, there are four left-turning tendencies that you might experience during flight.

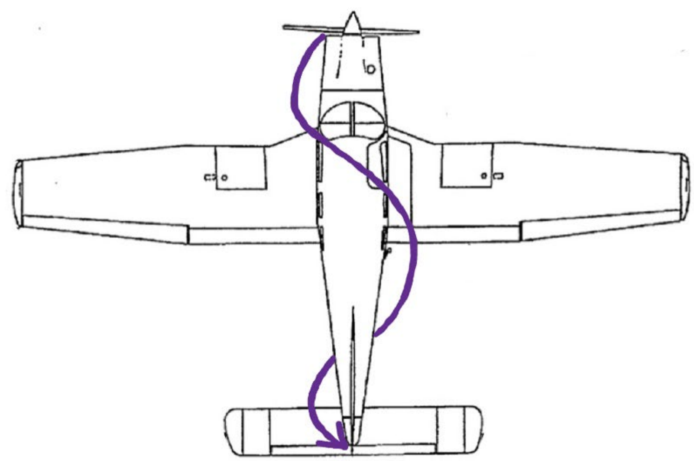
<u>P-Factor</u>

- P-factor, also known as asymmetric propeller loading, occurs when the descending blade of the propeller takes a bigger "bite" of air than the ascending blade. When the aircraft is flying at a greater angle of attack, the descending blade moves at a higher velocity. When the velocity of the airfoil increases, lift increases. Therefore, the descending blade produces more lift, or thrust, causing the aircraft to yaw to the left.



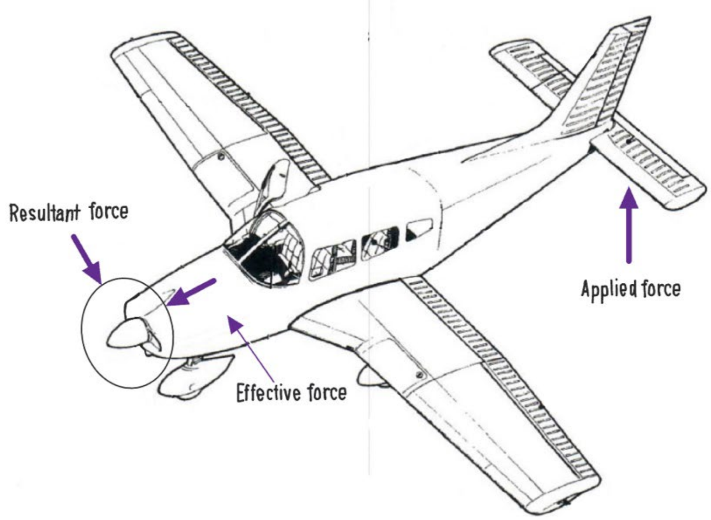
Spiraling Slipstream

- Spiraling slipstream occurs due to the high-speed rotation of the aircraft's propeller. The airflow coming from the propeller wraps around the fuselage of the aircraft, like a corkscrew. This normally occurs then the speed of the propeller is high, and the speed of the aircraft is slow (such as in takeoff configuration). When the airflow wraps around the plane, it strikes the tail of the aircraft, causing a yawing motion to the left.



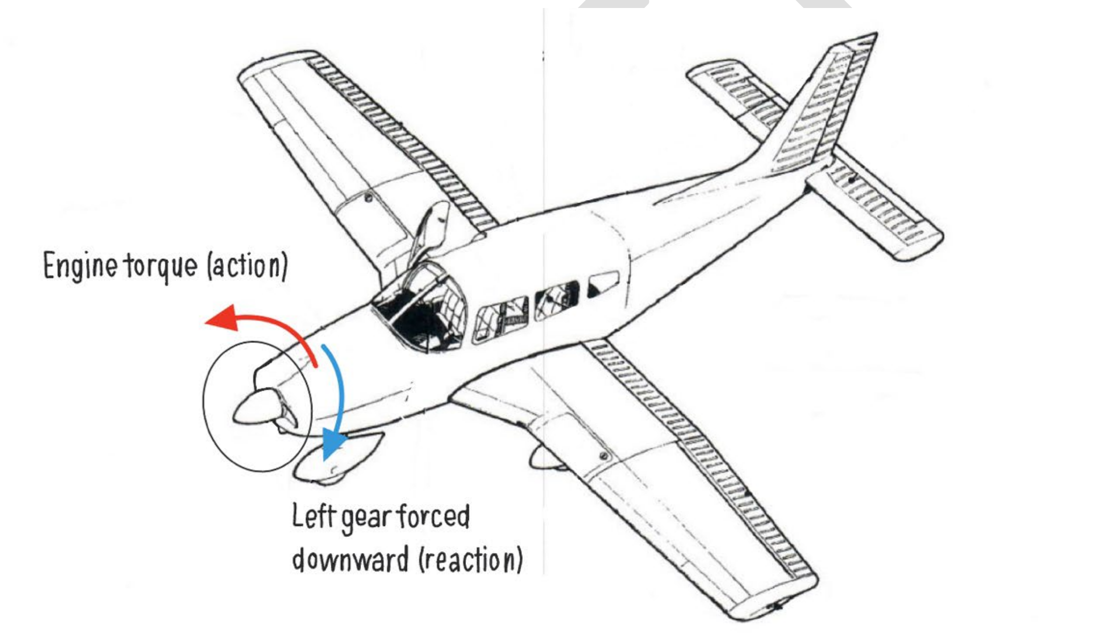
Gyroscopic Precession

- A gyroscope is a mounted wheel or disk that rapidly spins around an axis. On the airplane, the propeller acts as a gyroscope. There are two principles of gyroscopes: precession and rigidity in space. For this turning tendency, precession is the principle being considered. Precession is the resultant action when a force is applied to the spinning disk. When this force is applied, the resultant action (force) occurs 90 degrees later in the direction of rotation. This can cause a pitching motion, yawing motion, or both depending on where the force was first applied.



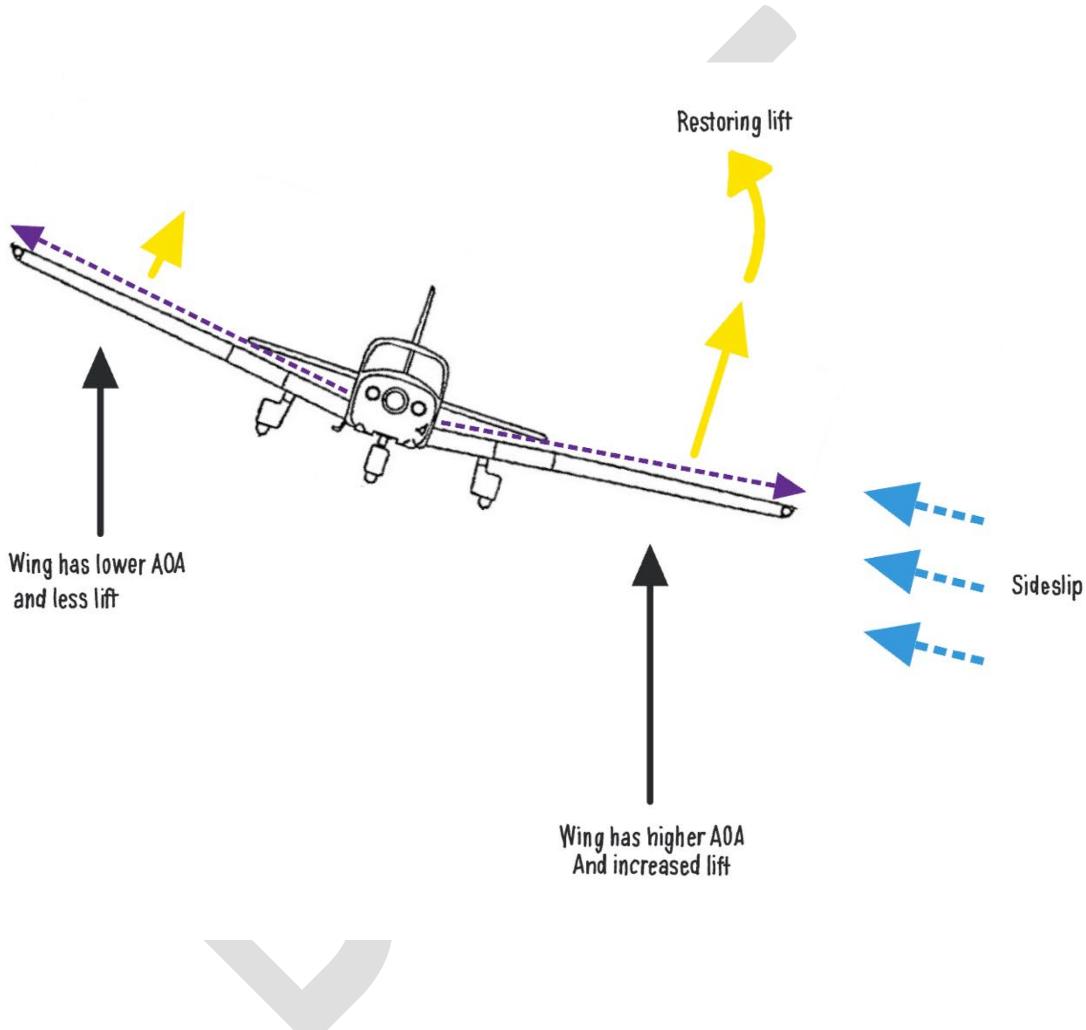
Torque

- The principle of torque is based on Newton's Third Law that states "every action has an equal and opposite reaction". The clockwise rotation of the engine and propeller to the right (the action) forces the left landing gear of the aircraft to push down on the ground (the reaction).



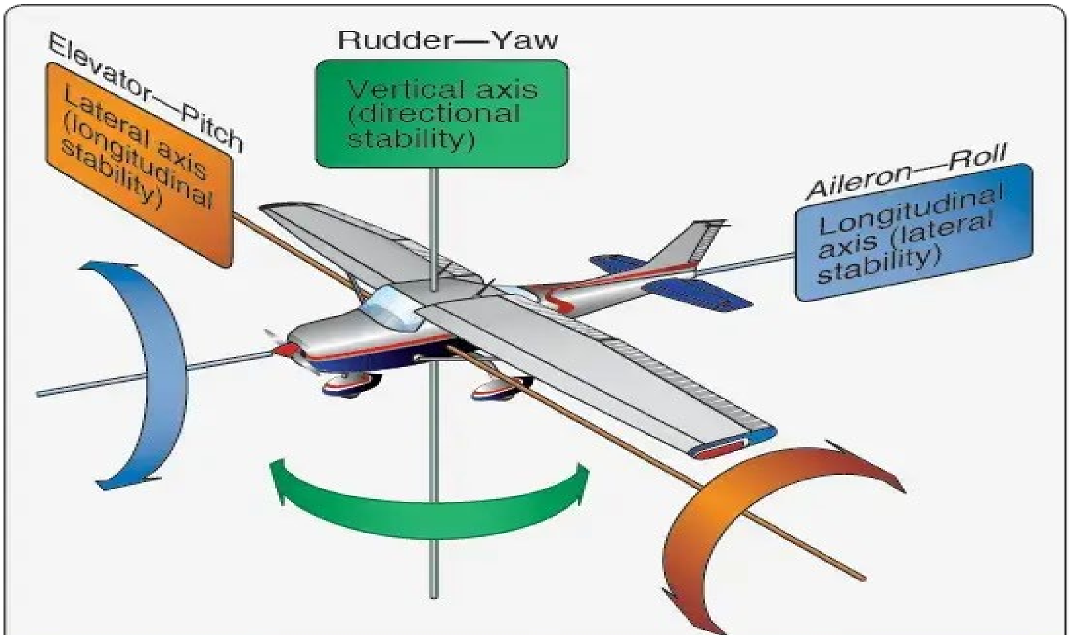
Dihedral Wings

Dihedral wings are when the aircraft's wing tip is at a higher angle than the wing's root. Dihedral wings make the aircraft more laterally stable, meaning the aircraft is more stable in a bank. in certain conditions, wind can cause the aircraft to roll into a sideslip. The sideslip changes where the relative wind is coming from, therefore changing the AOA and lift of the wing. With the lower wing having a higher AOA, it also has increased lift. The relative wind strikes under the wing that is lowered, which pushes it back up towards the level position.



Stability

Stability is the inherent quality of an airplane to correct for conditions that disturb equilibrium and return to its original state or flight path. There are 3 different types of stability around each of the axes of rotation:

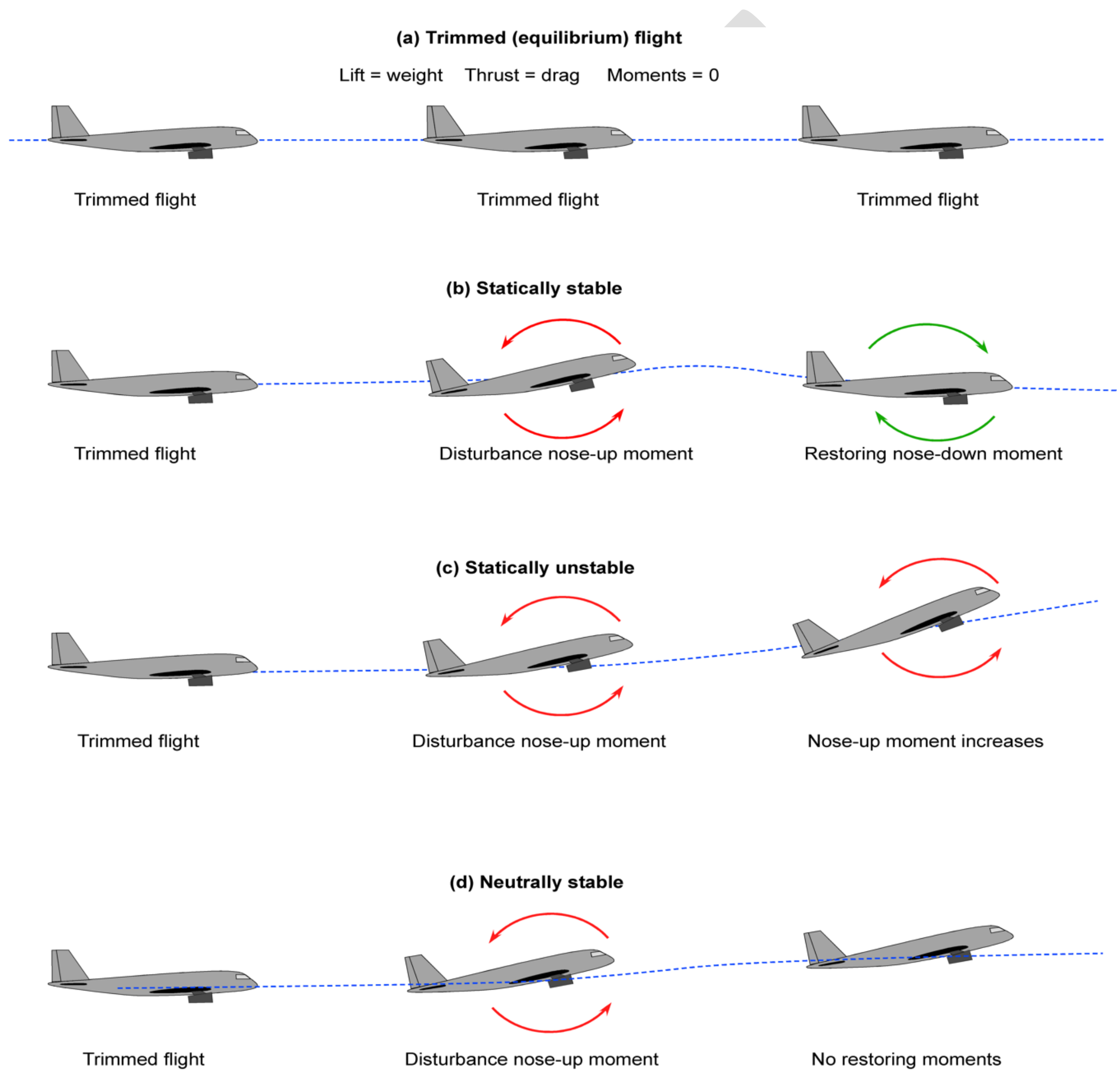


Primary Control Surface	Airplane Movement	Axes of Rotation	Type of Stability
Aileron	Roll	Longitudinal	Lateral
Elevator/ Stabilator	Pitch	Lateral	Longitudinal
Rudder	Yaw	Vertical	Directional

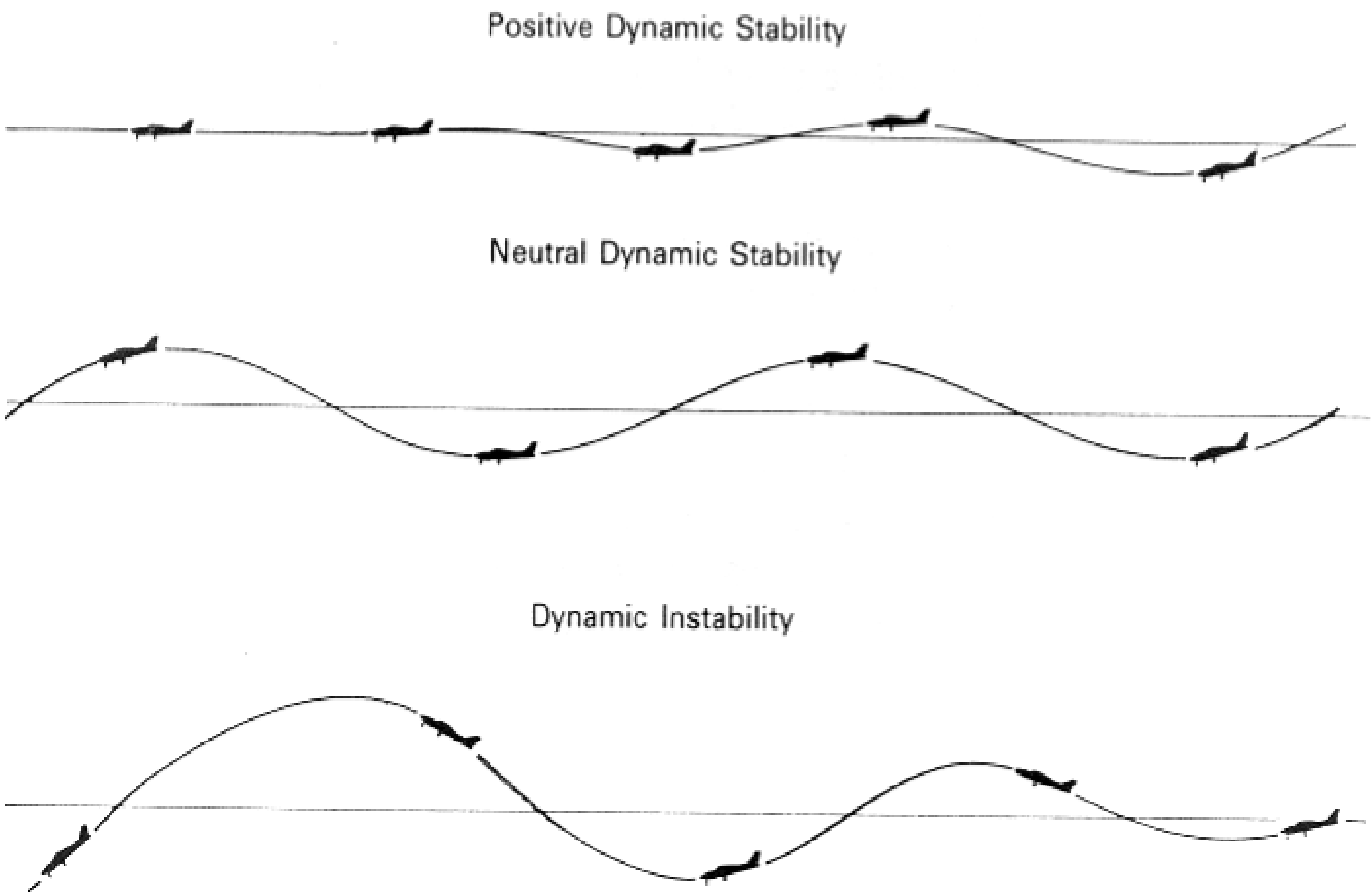
Static and Dynamic Stability

Aside from longitudinal, lateral, and directional stability, there is also static and dynamic stability.

Static stability is the initial tendency that airplane displays after its equilibrium is disturbed, or how it initially moves relative to the trimmed position. The aircraft will either experience positive, neutral, or negative static stability. Positive stability means the aircraft initially reverts to the trimmed position. Neutral stability means the aircraft stays in the position the disturbance caused. Negative stability means the aircraft continues further in the direction of the disturbance.



<u>Dynamic stability</u> is the aircraft's response over time to the disturbance that has been created to the aircraft's pitch, yaw, or roll. Like static stability, the aircraft will either experience positive, neutral, or negative dynamic stability. Positive stability means that over time, the aircraft will deviate back toward the original state. Neutral stability means the aircraft will stay displaced, not returning to the original state nor trending further away. Negative stability means oscillations getting bigger or going further and further from the original state as time goes on.

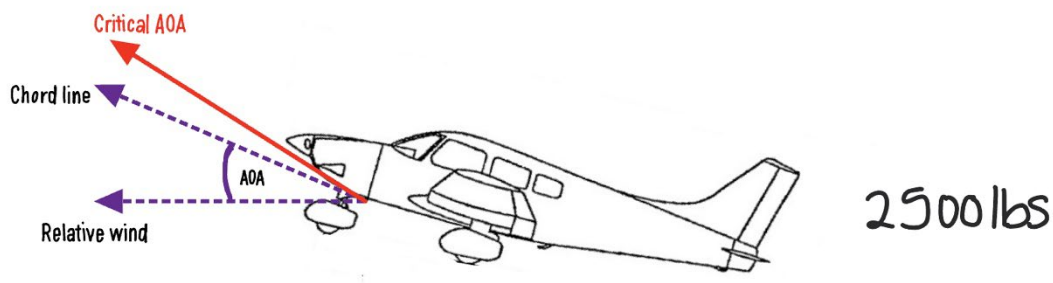


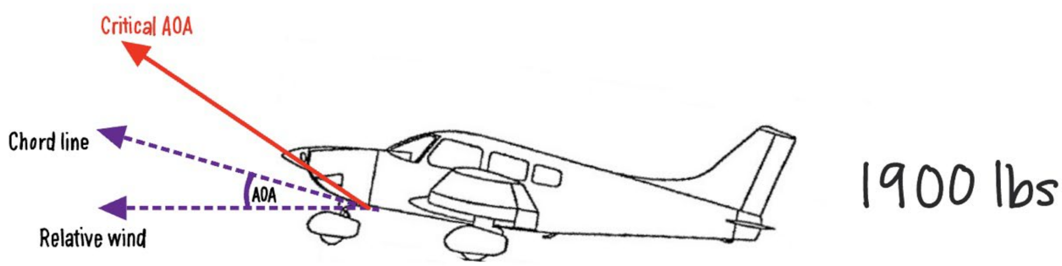
Stall speed and Maneuvering Speed

A stall is a reduction in lift as the airfoil exceeds the critical angle of attack. The speed at which a stall occurs can vary based on the weight of the aircraft.

When the aircraft is at a higher weight, it must maintain a higher angle of attack, to create enough lift to support the weight of the plane. Maintaining this higher AOA means that the aircraft is closer to the critical angle of attack, therefore, causing the airplane to stall at a higher speed.

When the aircraft is at a lower weight, enough lift can be generated to support the plane at a lower angle of attack. Therefore, you will be further from the critical angle of attack, and your stall speed will be decreased.





Maneuvering speed is the speed at which a full-scale deflection of the flight controls about one axis is guaranteed to stall the plane before causing structural damage. However, it is important to remember that the maneuvering speed is everchanging based on weight. The same rule applies with maneuvering speed as it does with stall speed. When the aircraft's weight is greater, you must fly at a higher angle of attack to maintain enough lift to support the aircraft. Therefore, when you are at a higher AOA with a higher stall speed, the speed at which the full-scale deflection can be safely done also increases.

When you increase the angle of attack to create more lift, you are increasing the load factor. The load factor is measured in G's (acceleration of gravity) and is the ratio of lift to the weight of the aircraft. For example, when an aircraft is experiencing 2 G's, the load being placed on the aircraft is twice its weight. When you increase the load factor, maneuvering speed is increased

Section II: Speeds, Weights, and Performance

Piper Archer PA-28-181 Speeds

Speed	KIAS	Description	Airspeed Indicator Marking
V_{SO}	45	Stall speed in landing configuration	Bottom of white arc
V_{S}	50	Stall speed with no flaps	Bottom of green arc
V_{R}	60	Rotation speed	
V_{X}	64	Best angle of climb	
V_{Y}	76	Best rate of climb	
V_{G}	76	Best glide speed at max weight	
V_{FE}	102	Maximum flap extension speed	Top of white arc
V_{NO}	125	Max structural cruising speed	Top of green arc
V_{NE}	154	Never exceed speed	Red line
V_{A}	113	Maneuvering speed at 2,550 lbs.	
V_{A}	89	Maneuvering speed at 1,634 lbs.	

The maximum demonstrated crosswind is 17 knots

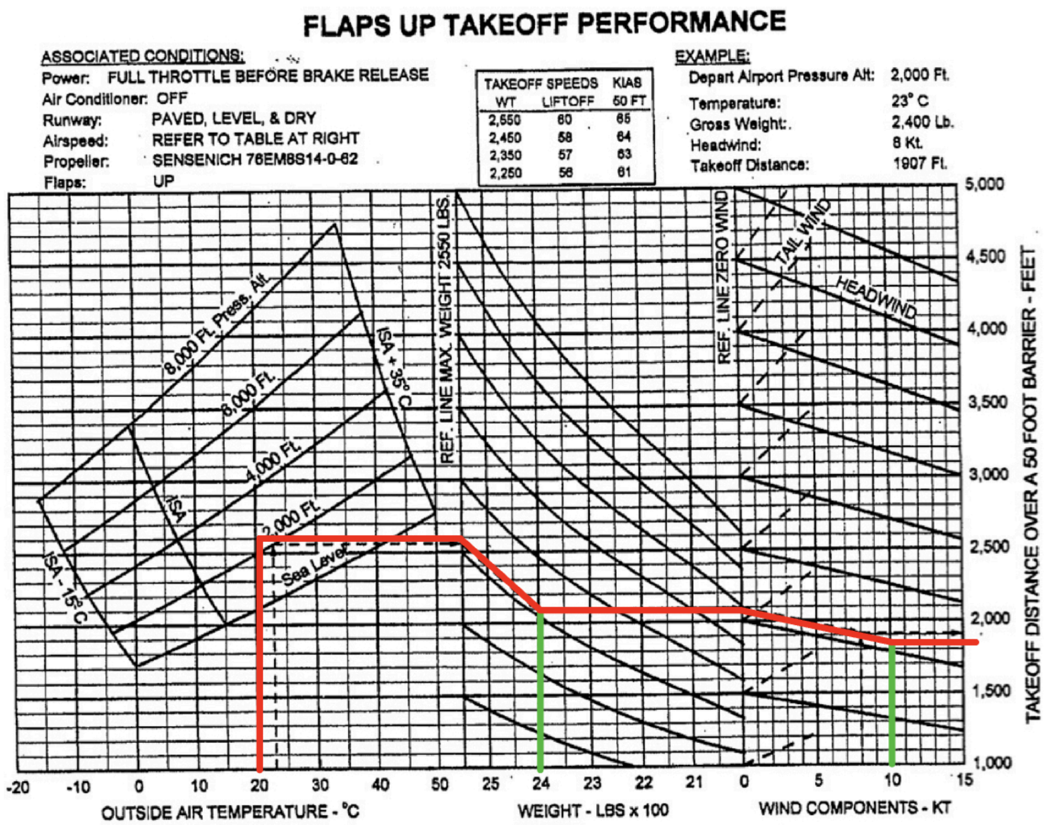
Piper Archer PA-28-181 Weights

Maximum Ramp Weight (lbs.)	2,558
Maximum Takeoff Weight (lbs.)	2,550
Maximum Landing Weight (lbs.)	2,550
Maximum Weight in Baggage compartments (lbs.)	200

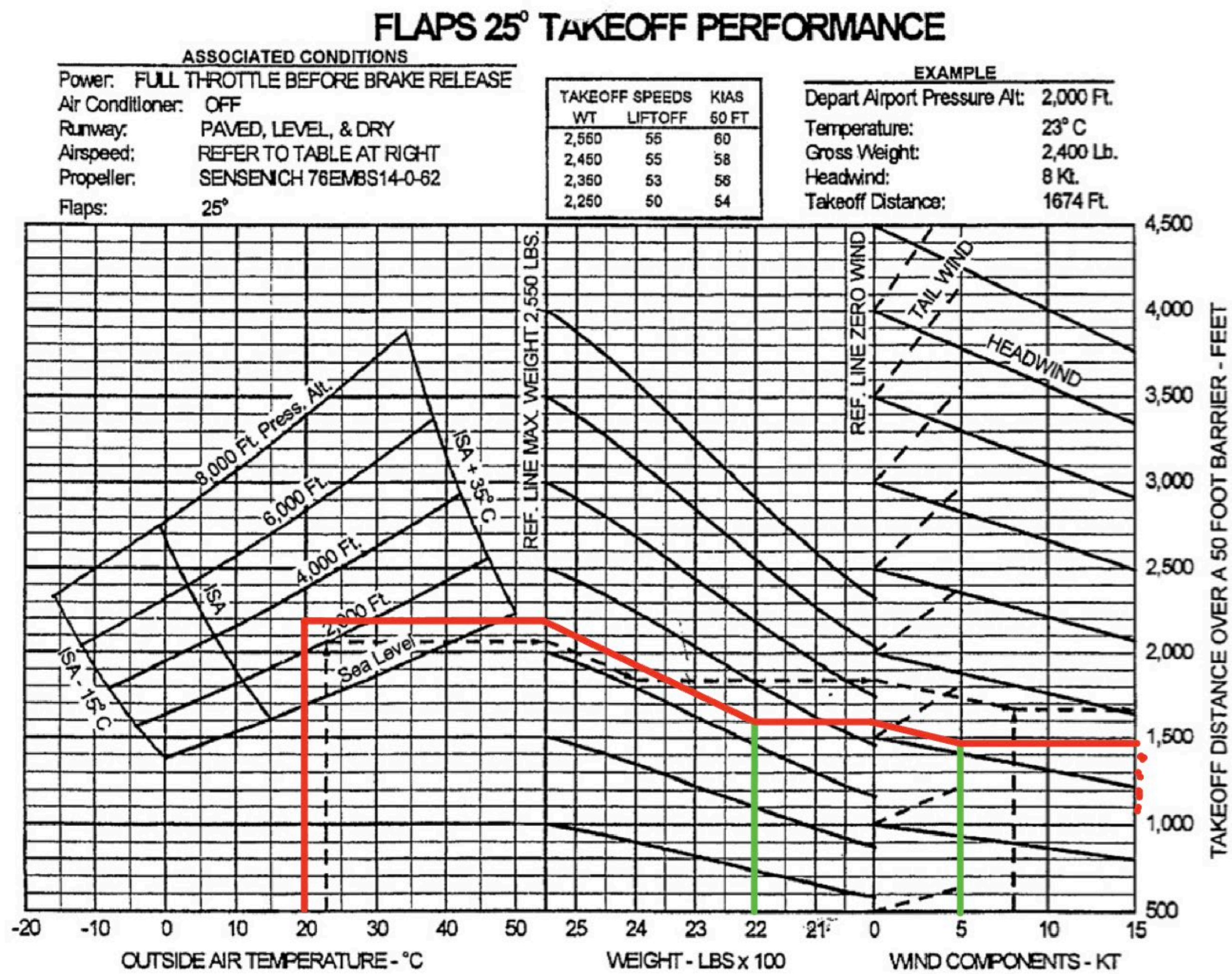
Takeoff and Landing Distances

Normal Takeoff Distance

Example:
Temperature – 20 degrees
Pressure altitude – 2,500 ft.
T/O weight – 2,400 lbs.
Wind component – 10 kts

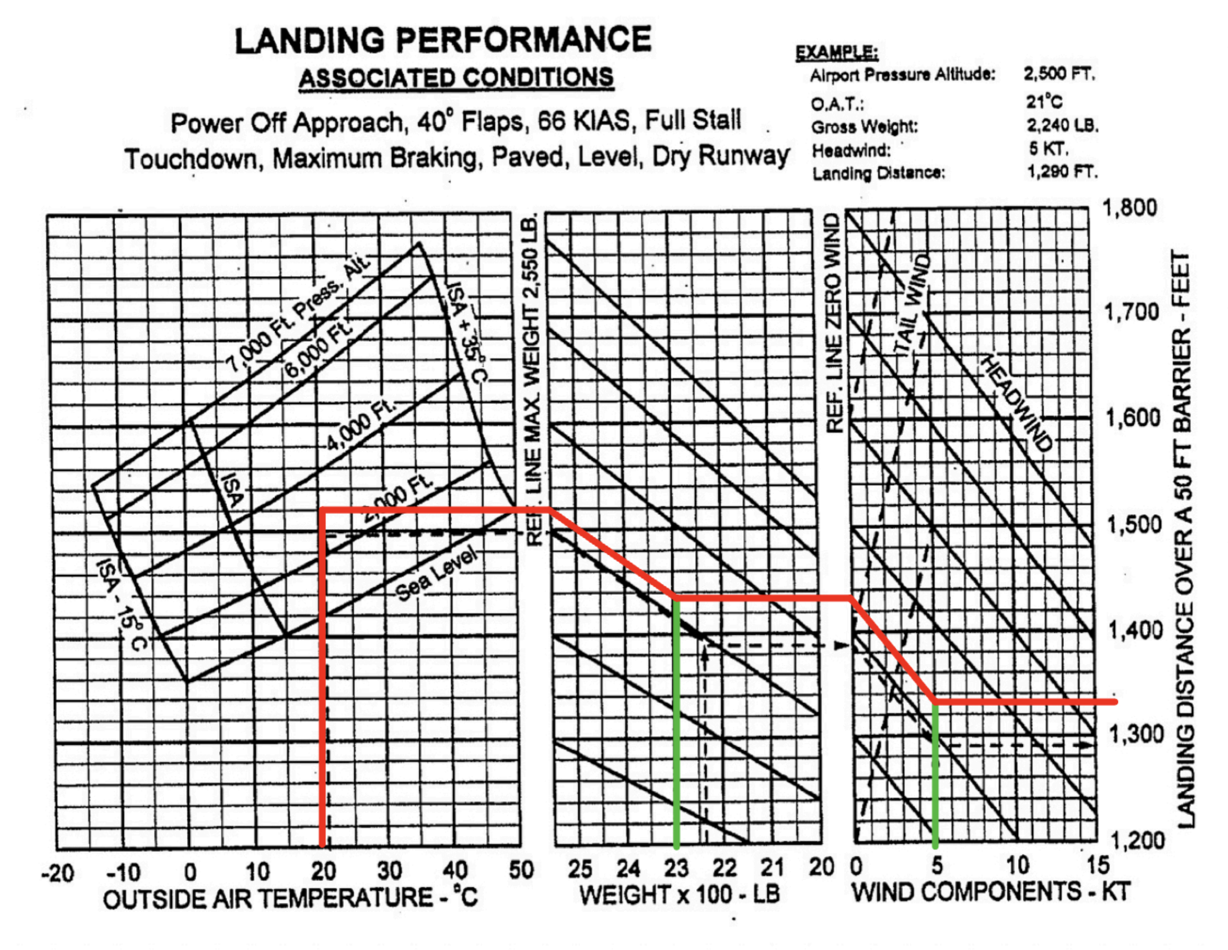


Example:
Temperature – 20 degrees
Pressure altitude – 2,500 ft.
T/O weight – 2,200 lbs.
Wind component – 5 kts



Landing Distance

Example:
Temperature – 20 degrees
Pressure Altitude – 3,000 ft.
LDG weight – 2,300 lbs.
Wind component – 5 kts

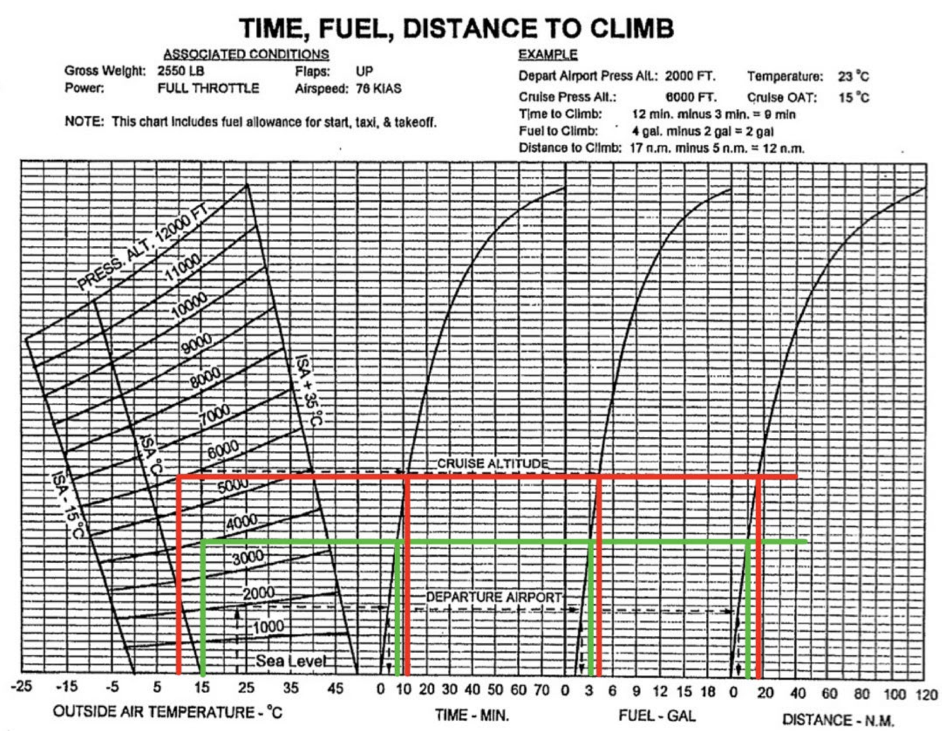


Time, Fuel, and distance calculations

Example:

Departure airport:
Temperature – 10 degrees
Pressure altitude – 6,000 ft
Time – 10 minutes
Fuel – 4 gallons
Distance – 18 nm

Cruise altitude:
Temperature – 15 degrees
Pressure altitude – 4,000 ft
Time – 8 minutes
Fuel – 3 gallons
Distance – 10 nm



Answer
Time: 10 min – 8 min = 2 min
Fuel: 4 gal – 3 gal = 1 gal
Distance: 18 nm -10 nm = 8 nm

Cruise Calculations

Based on desired fuel burn and percent power, we can use the following charts to find the recommended RPM for that specific condition.

Example:
Power – 55%
Fuel burn – 8.2 GPH
Pressure altitude – 2,000 ft
Temperature – ISA + 20
Desired RPM – 2305

Engine / Cruise Performance for Non-ISA OAT*
RPM for Constant 55% Power
Fuel Flow: Best Economy Mixture, 8.2 GPH

Pressure Altitude Feet	Indicated Outside Air Temperature °C	°C	°F	Engine Speed RPM	True Air Speed Knots **
Sea Level	ISA-15	0	32	2245	105
	ISA	15	59	2265	
	ISA +10	25	77	2275	
	ISA +20	35	95	2285	
	ISA +30	45	113	2295	106
2000	ISA -15	-4	25	2265	106
	ISA	11	52	2280	
	ISA +10	21	70	2295	
	ISA +20	31	88	2305	
	ISA +30	41	106	2315	107
4000	ISA -15	-8	18	2285	106
	ISA	7	45	2300	
	ISA +10	17	63	2315	
	ISA +20	27	81	2325	
	ISA +30	37	99	2335	108
6000	ISA -15	-12	10	2305	107
	ISA	3	37	2320	
	ISA +10	13	55	2330	
	ISA +20	23	73	2345	
	ISA +30	33	91	2355	108
8000	ISA -15	-16	3	2320	107
	ISA	-1	30	2340	
	ISA +10	9	48	2350	
	ISA +17.5	16.5	62	2360	108
9000	ISA -15	-18	0	2330	107
	ISA	-3	27	2350	
	ISA +8.5	5.5	42	2360	108
10000	ISA - 15	-20	-4	2340	107
	ISA	-5	23	2360	108

NOTE: * Aircraft weight 2550 Lbs., Wheel pants and strut fairings installed
** Subtract 3 KTAS if wheel pants are removed.

ENGINE/CRUISE PERFORMANCE (55%)

Example:
Power – 65%
Fuel burn – 9.5 GPH
Pressure altitude – 4,000 ft
Temperature – ISA
Desired RPM – 2450

Engine / Cruise Performance for Non-ISA OAT*
RPM for Constant 65% Power
Fuel Flow: Best Economy Mixture, 9.5 GPH

Pressure Altitude Feet	Indicated Outside Air Temperature °C	°C	°F	Engine Speed RPM	True Air Speed Knots **
Sea Level	ISA-15	0	32	2385	113
	ISA	15	59	2405	
	ISA +10	25	77	2415	
	ISA +20	35	95	2430	
	ISA +30	45	113	2440	116
2000	ISA -15	-4	25	2405	114
	ISA	11	52	2425	
	ISA +10	21	70	2440	
	ISA +20	31	88	2450	
	ISA +30	41	106	2465	117
4000	ISA -15	-8	18	2430	115
	ISA	7	45	2450	
	ISA +10	17	63	2460	
	ISA +20	27	81	2475	
	ISA +30	37	99	2485	118
6000	ISA -15	-12	10	2450	116
	ISA	3	37	2470	
	ISA +10	13	55	2485	
	ISA +20	23	73	2495	
	ISA +30	33	91	2510	119
8000	ISA -15	-16	3	2475	117
	ISA	-1	30	2495	
	ISA +10	9	48	2505	
	ISA +17.5	16.5	62	2515	119
9000	ISA -15	-18	0	2485	117
	ISA	-3	27	2505	
	ISA +8.5	5.5	42	2515	119
10000	ISA -15	-20	-4	2495	118
	ISA	-5	23	2515	119

NOTE: * Aircraft weight 2550 Lbs., Wheel pants and strut fairings installed
** Subtract 3 KTAS if wheel pants are removed.

ENGINE/CRUISE PERFORMANCE (65%)

Example:
Power – 75%
Fuel burn – 11 GPH
Pressure altitude – 3,000 ft
Temperature – ISA + 10
Desired RPM – 2580

Engine / Cruise Performance for Non-ISA OAT*
RPM for Constant 75% Power
Fuel Flow: Best Economy Mixture, 11.0 GPH

Pressure Altitude Feet	Indicated Outside Air Temperature °C	°C	°F	Engine Speed RPM	True Air Speed Knots **
Sea Level	ISA-15	0	32	2485	119
	ISA	15	59	2515	
	ISA +10	25	77	2535	
	ISA +20	35	95	2550	
	ISA +30	45	113	2565	124
2000	ISA -15	-4	25	2520	121
	ISA	11	52	2545	
	ISA +10	21	70	2565	
	ISA +20	31	88	2580	
	ISA +30	41	106	2600	126
3000	ISA -15	-6	21	2535	122
	ISA	9	48	2560	
	ISA +10	19	66	2580	
	ISA +20	29	84	2595	
	ISA +30	39	102	2615	127
4000	ISA -15	-8	18	2550	123
	ISA	7	45	2575	
	ISA +10	17	63	2595	
	ISA +20	27	81	2610	
	ISA +30	37	99	2630	128
5000	ISA -15	-10	14	2565	124
	ISA	5	41	2590	
	ISA +10	15	59	2610	
	ISA +20	25	77	2625	
	ISA +25	30	86	2635	128
6000	ISA -15	-12	10	2580	125
	ISA	3	37	2605	
	ISA +10	13	55	2625	
	ISA +15	18	64	2635	128
7000	ISA -15	-14	6.8	2595	126
	ISA	1	34	2625	
	ISA +7.5	8.5	47	2635	128

NOTE: * Aircraft weight 2550 Lbs., Wheel pants and strut fairings installed
** Subtract 3 KTAS if wheel pants are removed.

ENGINE/CRUISE PERFORMANCE (75%)

Airframe

- Low-wing monoplane of all metal construction
- Four seats, with a maximum baggage weight of 200 pounds
- The majority of the aircraft is constructed with aluminum alloy except the following components:
  - Engine mount. (tubular steel)
  - Steel landing gear struts
  - Other misc. parts
- Semi-tapered wings
  - Tapered wings decrease the length of the chord from the root to the wing tip. This causes a decrease in drag, and an increase in lift.

Flight Controls

Primary Flight Controls

- Ailerons
  - Controls roll about the longitudinal axis. They are located at the outboard trailing edge of the wing.
  - Connected by cables, bell cranks, pulleys, and/or push-pull tubes
  - Moving the yoke to the right causes the right aileron to deflect up and the left aileron to deflect downward. Moving the yoke to the left causes the left aileron to deflect upward and the right aileron to deflect downward.
  - Differential ailerons
    - One aileron is raised significantly more, and the other aileron is lowered, which produces an increase in drag on the descending wing. The aileron deflected up is going a further distance than the aileron deflected down, which creates more drag and counteracts adverse yaw.

- Stabilator
  - A one-piece horizontal stabilizer that moves around a central hinge point.
  - Stabilators are very sensitive to control inputs, so antiservo tabs are often placed on the trailing edge of the surface. These tabs deflect in the same direction as the stabilator, making it to where the pilot must increase force on the controls. This aids with overcontrolling the airplane.
  - Connected by cables, bell cranks, pulleys, and pushrods

- Rudder
  - Controlled by the left and right rudder pedals
  - Connected by cables, pulleys, and push/pull tubes.
  - Rudder effectiveness increases with speed. Deflecting the rudder to either direction, alters the airflow and creates a side component of lift. This lift will push the tail one direction, and yaw the nose in the opposite direction.

Secondary Flight Controls

- Flaps
    - Manually operated and spring loaded
    - Three extended positions: 10 degrees, 25 degrees, and 40 degrees
    - Slotted flaps
        - Increases lift coefficient without excessive drag
        - When the flap is lowered, a duct forms between the flap and the wing allowing airflow and delaying airflow separation.

Power Plant and Propeller

- Power plant
    - Lycoming O-360-A4M
        - 180 horsepower, 360 cubic inches of displacement, 2700 RPM
    - Horizontally opposed
        - Pistons oppose each other
        - 4 cylinders, 2 spark plugs a piece for increased reliability (8 total)
    - Air-cooled
        - Not liquid cooled
        - Cooling fins aid in heat dissipation allowing the engine to cool faster
    - Naturally aspirated
        - Takes in air under normal atmospheric pressure
        - Not supercharged or turbocharged
    - Direct drive
        - Propeller is directly connected to crankshaft, so it turns at the same speed as the crankshaft.
    - Fuel injected vs. carbureted
        - Fuel injected engines are more fuel efficient due to the air-to-fuel mixture being more precise. In these engines, the fuel and air mixture is mixed directly in the cylinder. Although fuel injected engines have many pros, they are harder to maintain and more expensive. They are also susceptible to vapor lock. This is when the fuel in the lines evaporates and turns to a gas.
        - Carbureted engines are cheaper to maintain. In these engines, the fuel/air mixture is mixed in the carburetor and then sent to the cylinders. This causes the fuel/air

mixture to be less precise. Another con to carbureted engines is the chance to encounter carburetor icing.

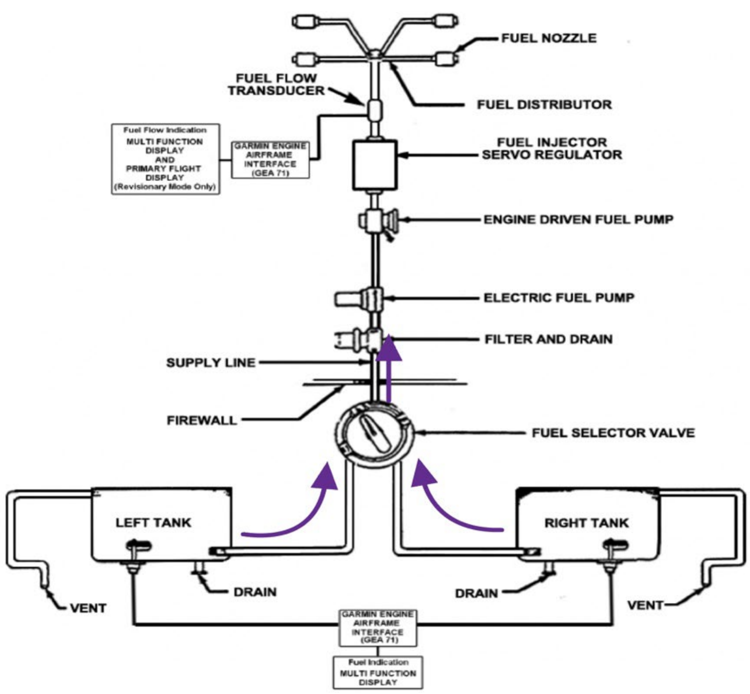
- Carburetor icing can occur in temperatures of 20 degrees Fahrenheit to 70 degrees Fahrenheit. This occurs due to the increased velocity of the air through the carburetor venturi. When the velocity increases, the temperature decreases causing the fuel/air mixture to freeze. To correct this, turn on carb heat.

- Propeller
  - Equipped with a 2 blade, 76-inch, metal Sensenich propeller.
  - The propeller is fixed pitch, meaning the AOA of the propeller is set and cannot be changed during flight.

Oil and Fuel

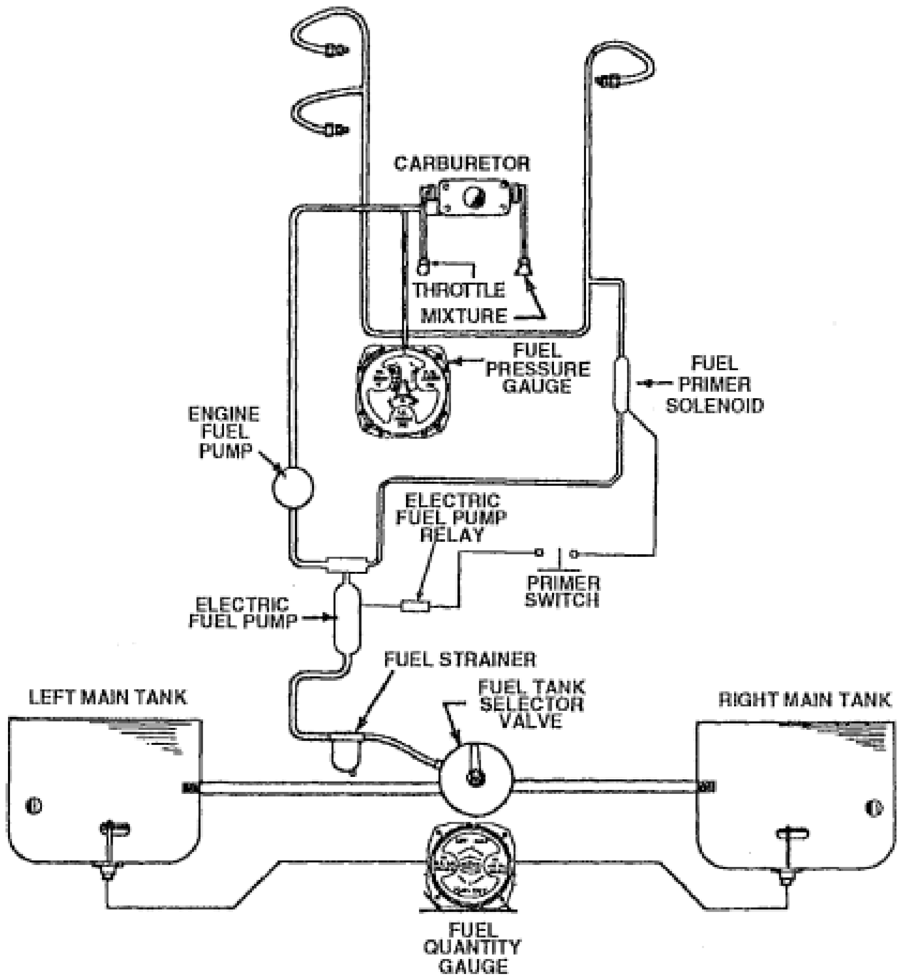
Fuel System

- 2 tanks, one in the left wing and one in the right wing
- 25 gallons a piece (50 total), however one gallon per side is unusable. Therefore, we have 48 usable gallons.
- A fuel injected engine has a slightly different flow than carbureted.



Fuel flows from the tanks to the fuel selector, through the strainer, then the electric fuel pump. It then goes through the engine driven pump, to the regulator, then the distributor that injects the fuel into all cylinders.

- Carbureted engines follow the same general flow, with the exception being the fuel must go through one more step. It must be taken to the carburetor to be mixed with air before being distributed to the cylinders.



Oil

- The range for the oil on the PA-28-181 is 6-8 quarts. Ensure the oil level is always above 6 quarts before departing.

Pitot Static and Stall Warning device

- The ram air pitot is located on the front side of the pitot mast. The drain hole is on the bottom, and the static port is located on the backside of the mast.
- Alternate static is located in the cockpit, under the panel that the PFD is on.

- The stall warning alert is activated five to ten knots above stall speed. Aside from the stall warning, you may encounter a buffet of the airplane. To test the stall warning alert, turn on the battery master and lift the detector on the wing.

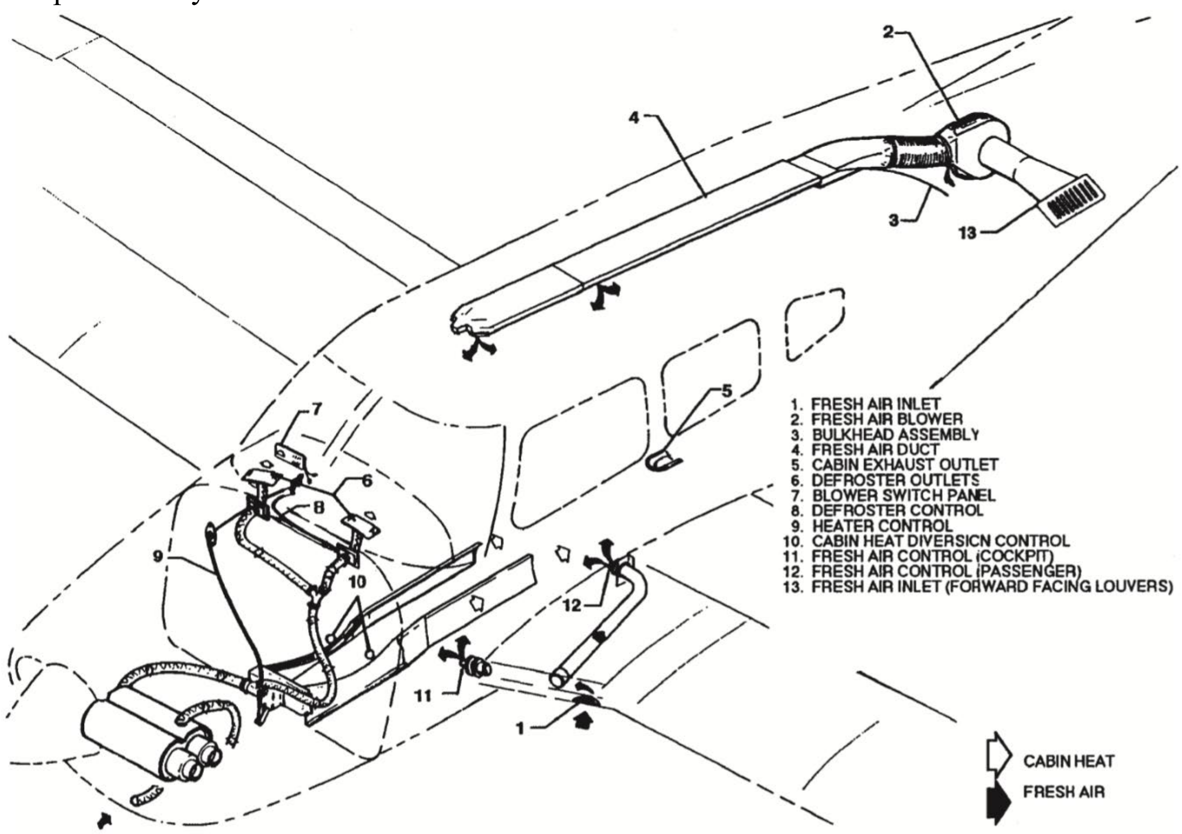
Anti-Ice and De-Ice

- Pitot heat
  - Heat is directed into the pitot tube and is able to melt any ice forming inside of the instrument.
- Defrost
  - Air goes over the exhaust shroud and is heated. Then it travels through a heater muff into the cockpit over the dash and under the center floor panel. The heat on the windshield prevents ice from forming.
- Carburetor Heat
  - Directs heat to the carburetor and melts any ice that may be present due to the high velocity of the fuel/air mixture through the venturi.

Environmental

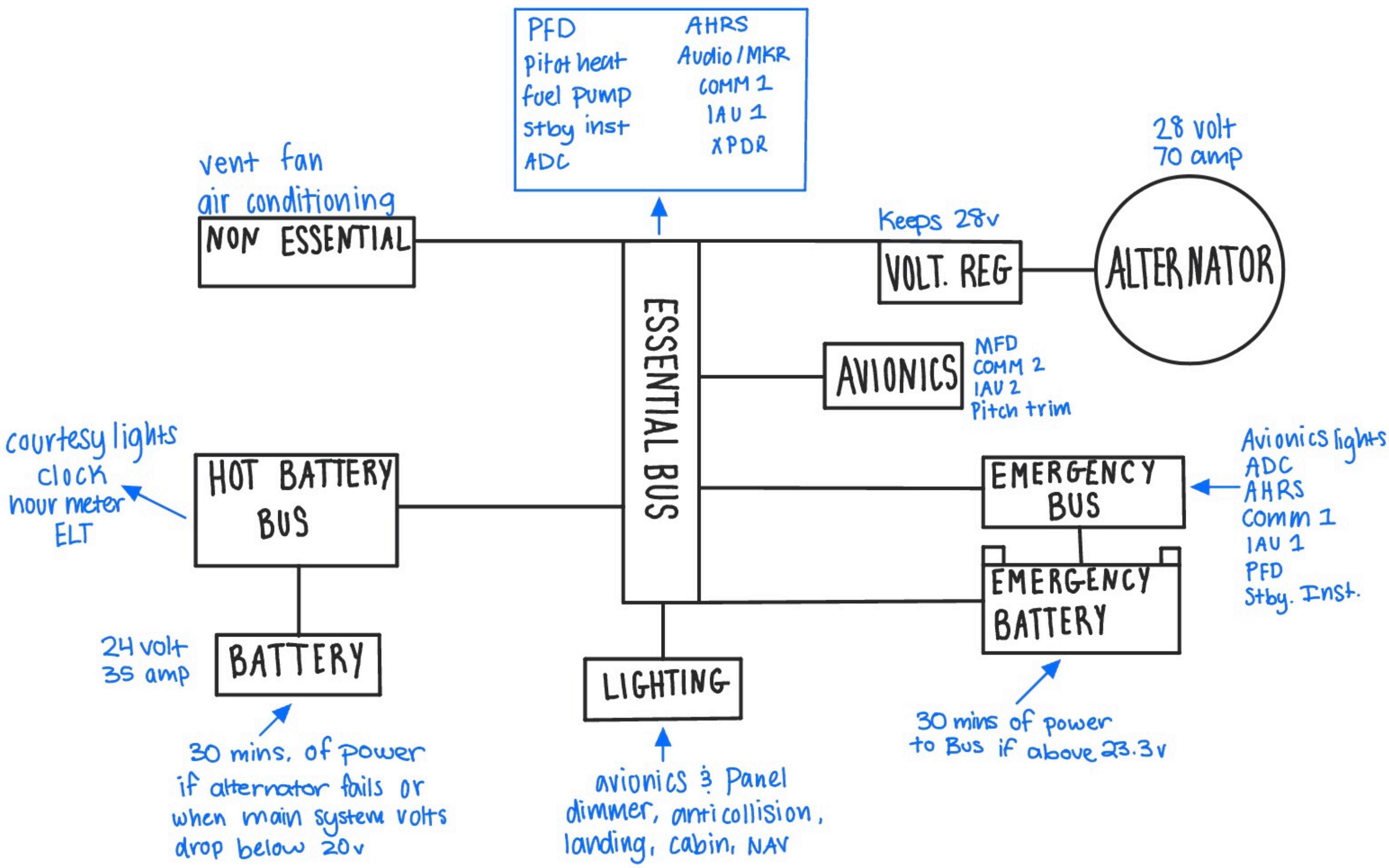
- Fresh air inlets can be found in the onboard portion of the leading edge near the wing and near the aft portion of the fuselage. The vents in the ceiling and the floor of the aircraft are adjustable to each seat location. There is also a cabin air blower that is in the cockpit and is operated by a fan.
- Cabin heat can be regulated by controls on the right side of the cockpit. This heat is provided by the same heater muff attached to the exhaust.

HEATING AND VENTILATING SYSTEM



Electrical System and Avionics

PA-28-181 Electrical System



G5

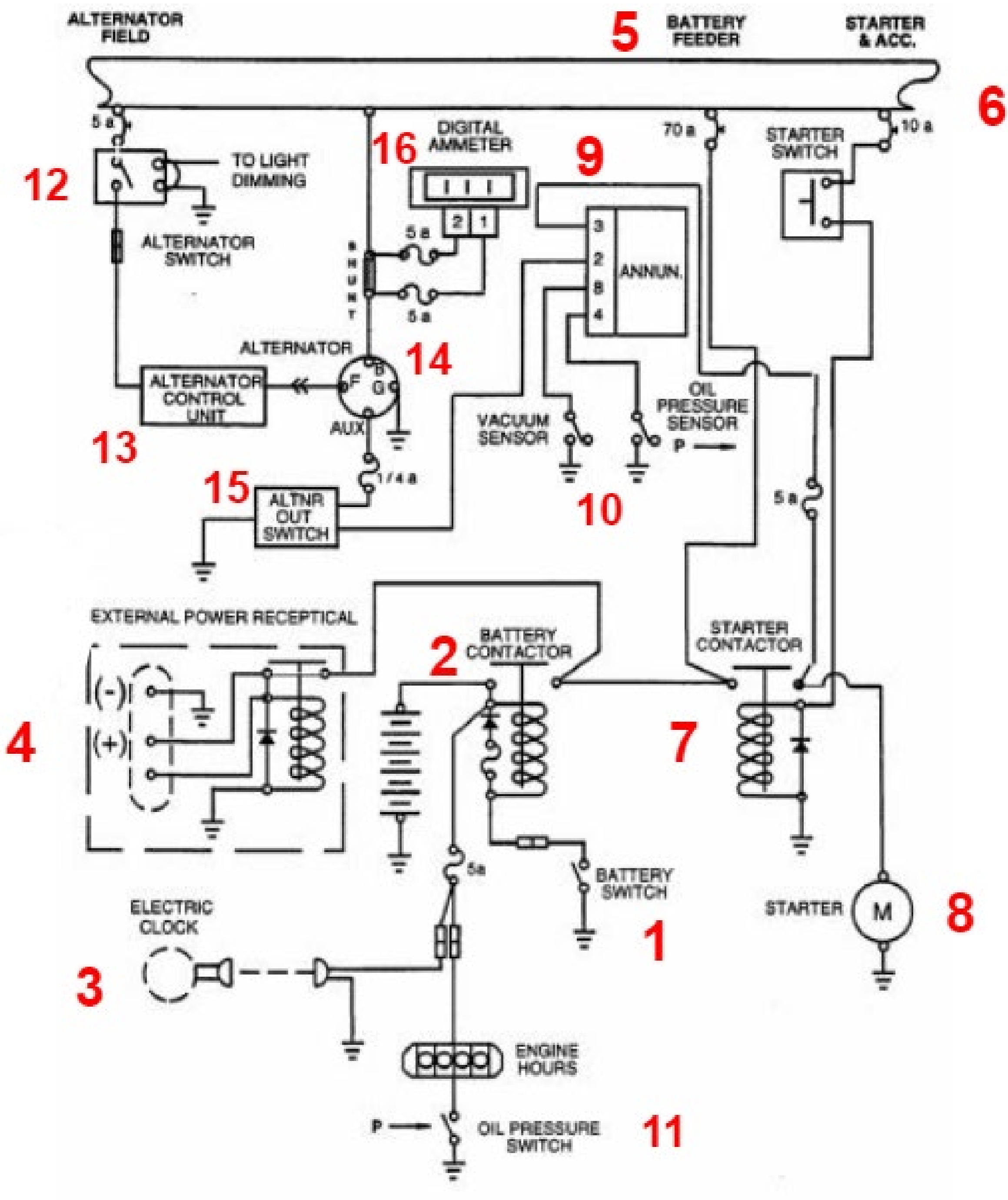
Contains internal backup batteries that can power the device up to 4 hours if aircraft electrical power is lost. It uses an external magnetometer under the right wing.

Aspen

Additional 30 minutes of power. It uses the internal magnetometer.

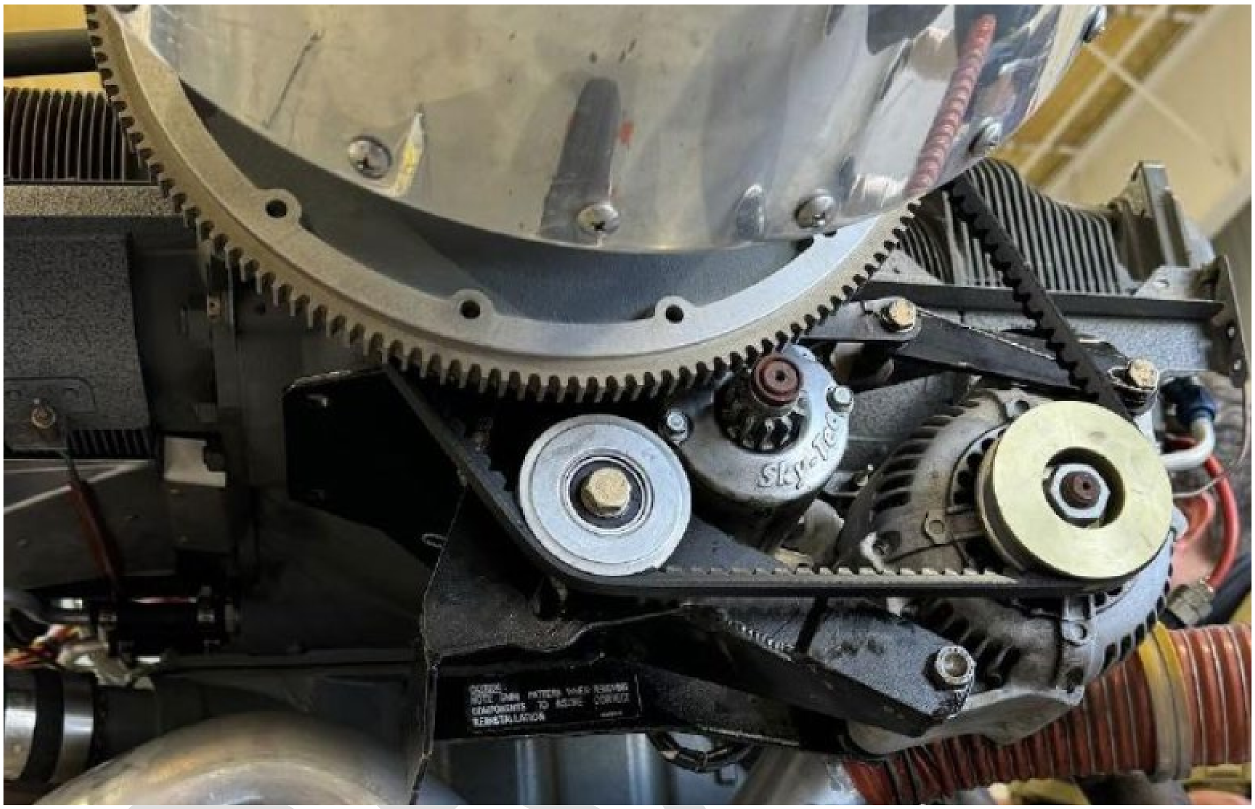
ELECTRICAL SYSTEM SCHEMATIC

-Numbers indicate the flow of the electrical current.



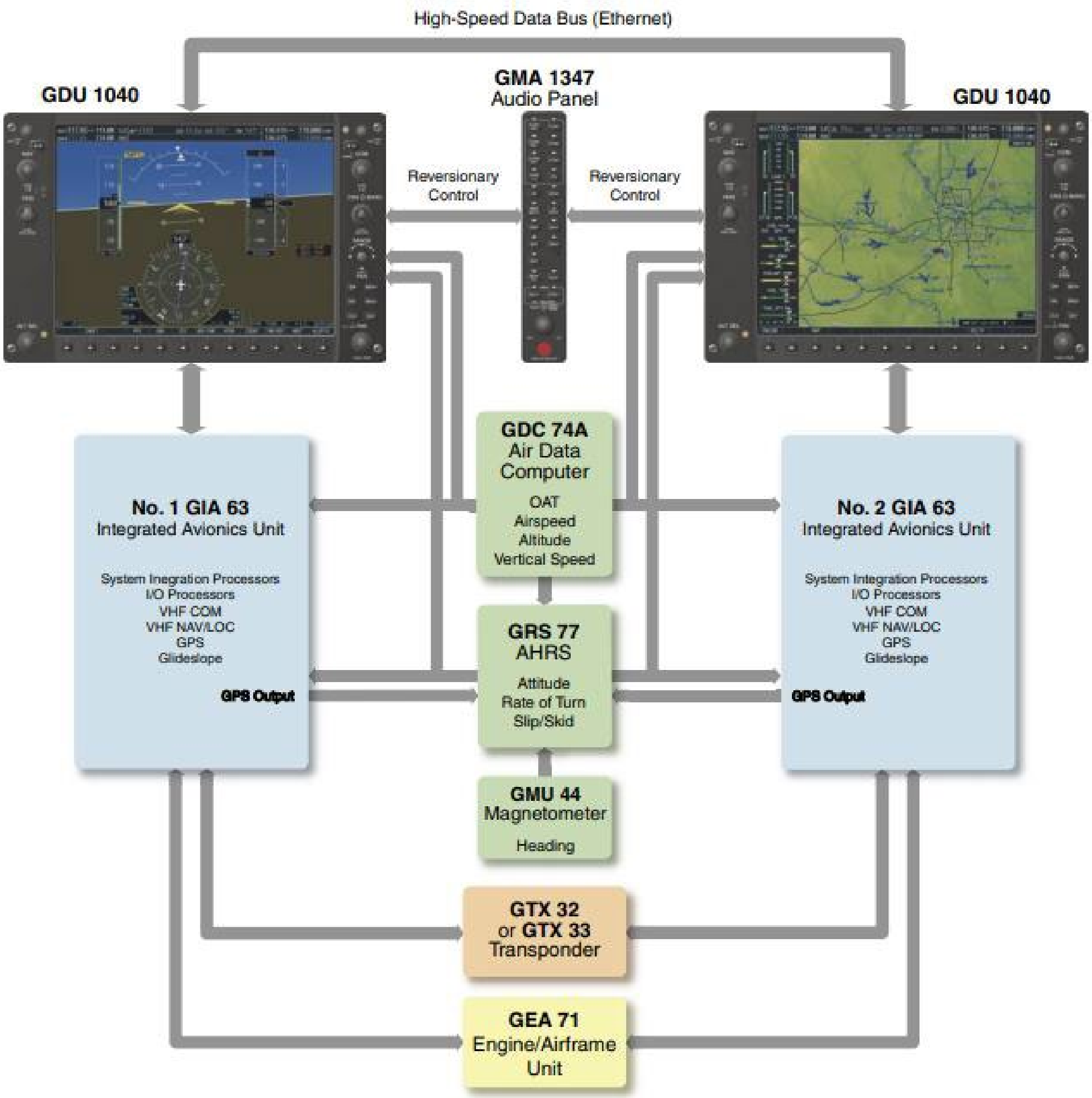
ALTERNATOR

-Primary source of aircraft electrical power.



PA-28-181 G1000

The Garmin G1000 includes a Primary Flight Display (PFD), Multifunction Flight Display (MFD), audio panel, Air Data Computer (ADC), Attitude and Heading Reference System (AHRS), and vital engine information.



Sources

A new look at Maneuvering Speed. AOPA. (2020, May 4). https://www.aopa.org/news-and-media/all-news/2020/may/flight-training-magazine/ol-maneuvering-speed

Why does maneuvering speed change with weight?. Online Flight Training Courses and CFI Tools. (n.d.). https://www.boldmethod.com/learn-to-fly/aerodynamics/why-does-maneuvering-speed-change-with-aircraft-weight-stall/

Left-turning tendencies explained: Why your plane pulls left during takeoff. Online Flight Training Courses and CFI Tools. (n.d.-a). https://www.boldmethod.com/learn-to-fly/aerodynamics/why-you-need-right-rudder-on-takeoff-to-stay-on-centerline-during-takeoff/

The Federal Aviation Administration. (n.d.). Chapter 5 - Aerodynamics of Flight. https://www.faa.gov/sites/faa.gov/files/07_phak_ch5_0.pdf

The Federal Aviation Administration . (n.d.-b). Chapter 6: Flight Controls. https://www.faa.gov/sites/faa.gov/files/08_phak_ch6.pdf

ATP. (n.d.-a). Piper Archer ill PA-28-181. https://s3.amazonaws.com/atp-program-docs/manuals/aircraft/pa-28-g1000.pdf