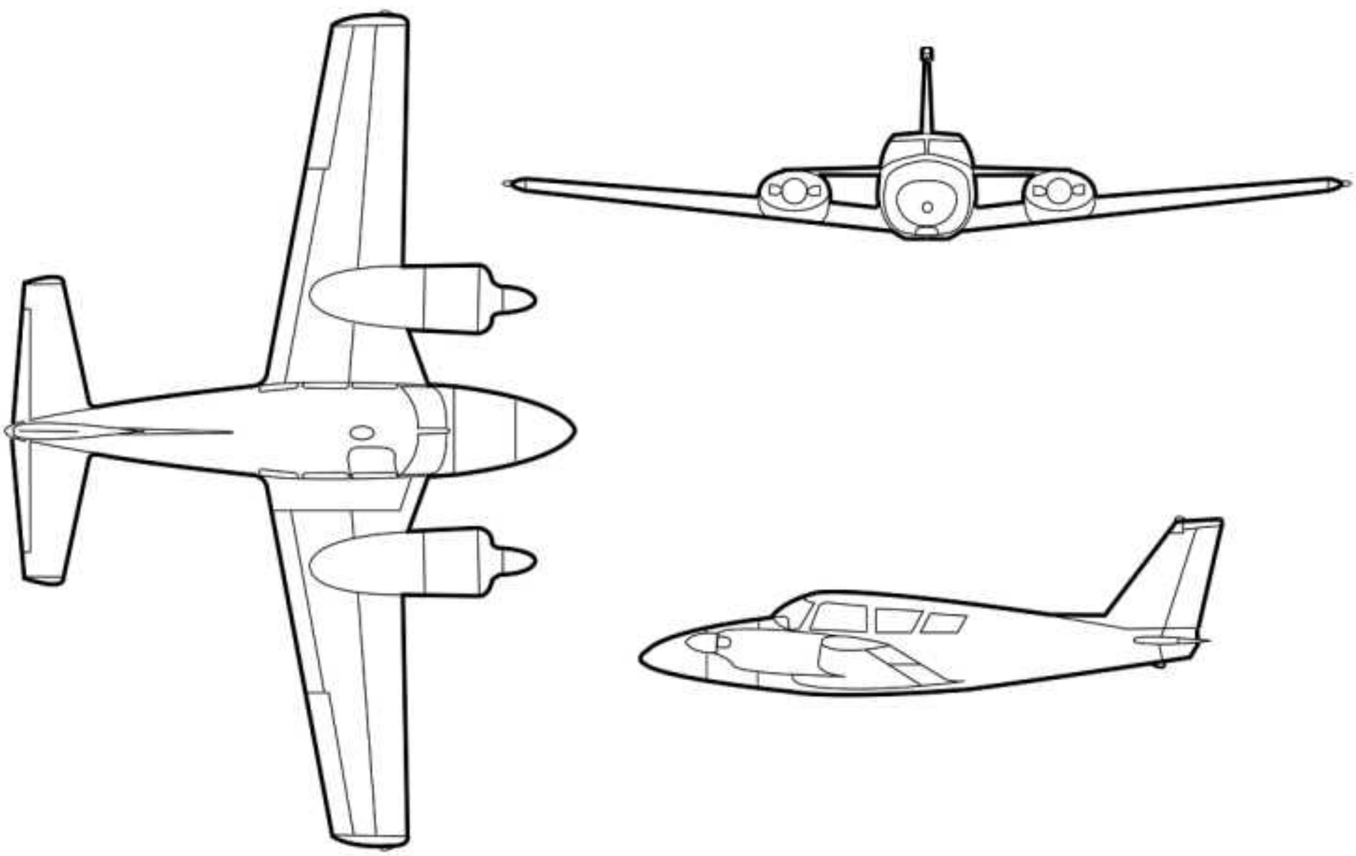
Multi Engine Ground School



Ground School Materials

Piper PA-30 Twin Comanche

N7261Y & N84JS

Systems

AIRSPEEDS (MPH)

Maneuvering (VA)__________
Max Cruising (VNO)_________
Never Exceed (VNE)_________
Flap Extended (VFE)________
Gear Extended (VLE)________
Best Rate (VY)_____________
Best Angle (VX)____________
Cruise Climb ________
Stall Speed (VS1)___________
Stall Speed (VS0)___________
Service Ceiling_____________

SINGLE ENGINE PERFORMANCE

V_{MC} ___________
V_{XSE} __________
V_{YSE} __________

Single Engine Service Ceiling (SESC) ____________
Single Engine Absolute Ceiling (SEAC) ____________

ENGINES

Engine Type________________________
Oil Capacity_____QTS
Fuel Octane_________
Cabin Heater Type_________

PROPELLERS

Type:____

________ Oil pressure drives the props to flat pitch (HIGH RPM). Complete loss of oil pressure allows the props to go to ____________.

During ground operations, ___________ fall into place at approximately __________ RPM to prevent the props from going to full feather.

Any over speed greater than 2700 RPM - Nitrogen charge
2700 RPM - prop linkage or similar Schrader Valve - 50 PSI

ELECTRICAL SYSTEM

	84JS	7261Y
System Volts	_____ Volts	_____ Volts
Battery Amps	_____ Amp Hour	_____ Amp Hour
Power Source	_____ Alternators	_____ Alternators
Power Source Amps	_____ Amps	_____ Amps

FUEL SYSTEM

Normal fuel consumption for the PA-30 is ________GPH per engine @ 75% power.

______Tanks _____Main_____Gallons Each ____Usable

_____ Aux_____ Gallons Each____ Usable

_____Fuel Pumps _____Engine Driven ______Electrical Boost

***84JS ONLY - ___ Transfer Tanks in nacelles. ___ Gallons Cap., ___ Gallons Usable
***84JS ONLY - ___ Transfer Pumps. Used to transfer fuel from Transfer Tanks to Mains

Cross Feed

To extend single engine range:

1) Decide which tank you want fuel to come from (on INOP engine)
2) Put selector valve on that tank (INOP engine)
3) Operating engine selector valve on cross feed

Fuel Travel

Tanks->selector valves->aux fuel pumps->engine driven pump->fuel servo-spider->

1) Cylinders
2) Fuel flow gauge

Heater uses _____ gallon per hour from the ________ fuel injector.

LANDING GEAR SYSTEM

The PA-30 has an electric gear system. A _______ switch located on the left main gear prevents inadvertently raising the gear on the ground.

A gear warning LIGHT flashes when ________ throttle is reduced below _____ and the gear is not down and locked.
A gear warning HORN sounds when ________ throttles are reduced below _____ and the gear is not down and locked.

VACUUM SYSTEM ***N84JS ONLY

There are ____ vacuum pumps. Vacuum gauge has ____ pop out red buttons that suck in along with “Check Valves” that suck open. When a pump fails check valve closes via a spring on door and red button is out in cockpit. Suction is taken over by operating pump.

FLAP SYSTEM

Electric motor down- air springs up,”a” symmetrical flap when one comes up and one doesn’t-lower to equal -land

ACCESSORY CASE

1) 2 Mags
2) Prop gov
3) Engine driven fuel pump
4) Oil filter
5) Vacuum Pump (***84JS ONLY)

Multi-Engine Aerodynamics

VMC

Defined as the slowest speed at which directional control can be maintained if the critical engine is suddenly made inoperative.

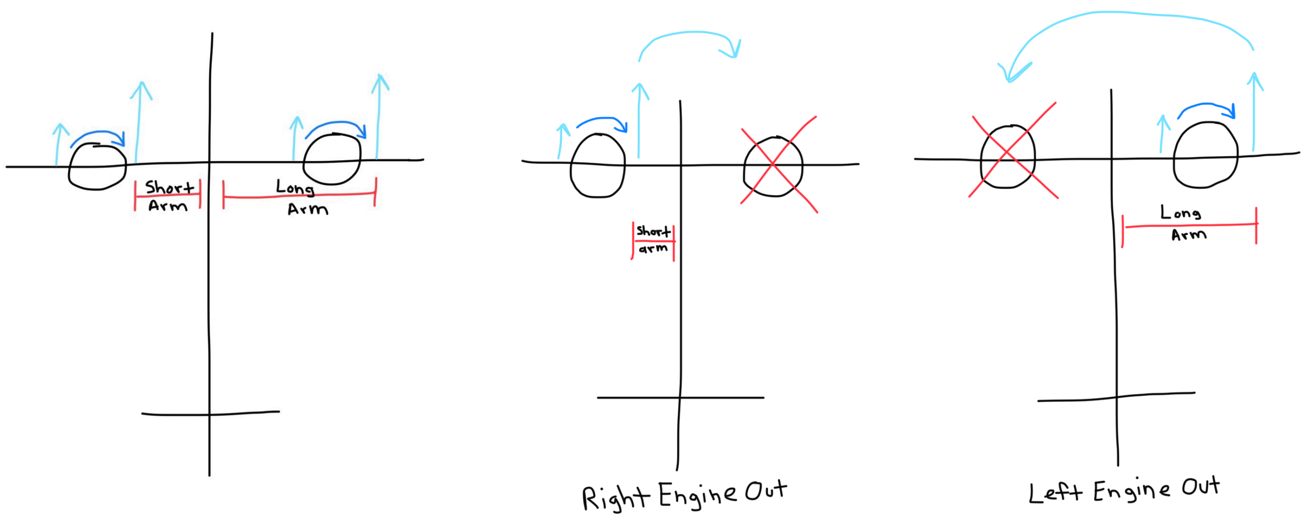
CRITICAL ENGINE

The engine that, if failed, would most adversely affect the aerodynamic control of the aircraft.

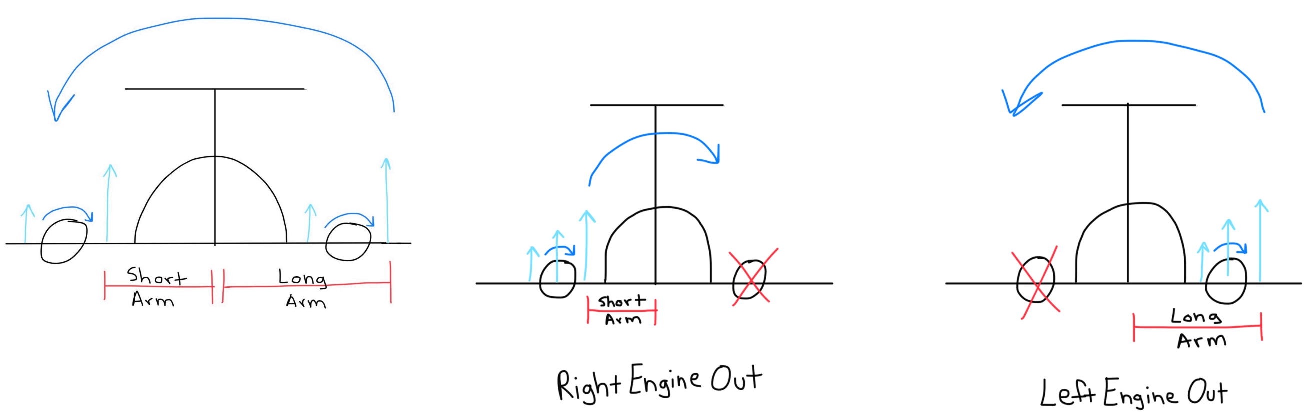
On U.S. manufactured aircraft with clockwise rotating props, the _______ engine is critical.

What makes the left engine critical? “PAST” Acronym:

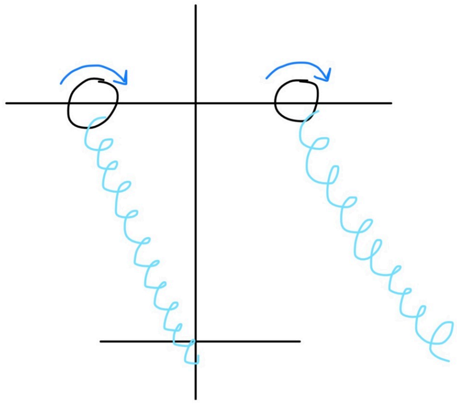
P _______________

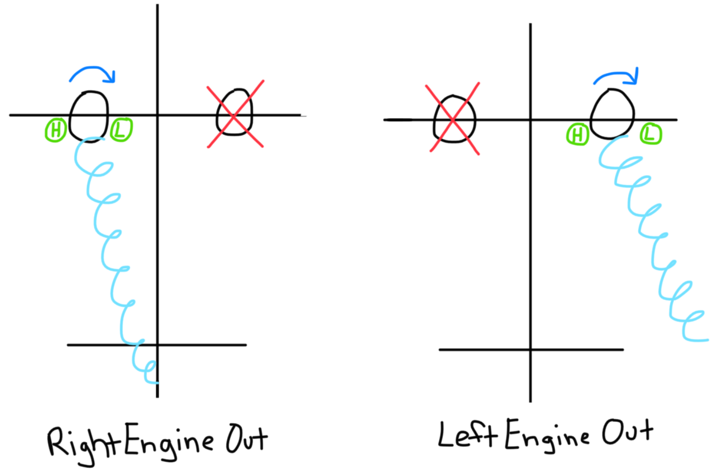


A ___________________________

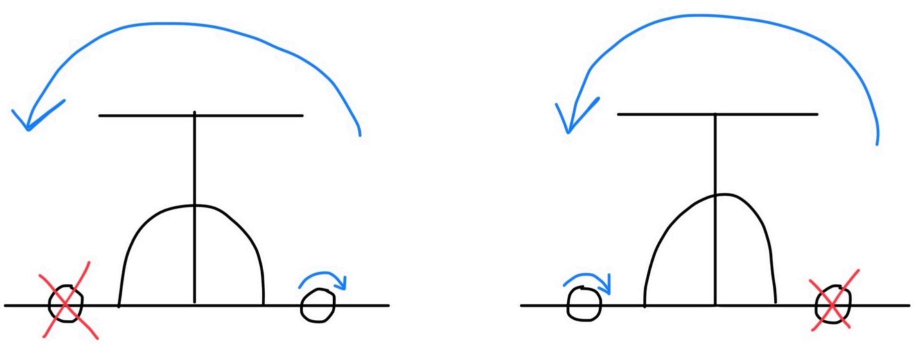


S_________________________





T ________________



Factors stipulated in FAR 23 which regulate the manufacturer's determination of the published VMC:

(1) Prop of the critical engine
  (A) Windmilling or
  (B) ___________, if the airplane has an ___________ device.
(2) Full power on the _____________ engine at sea level, standard temperature: (59º F , 29.92)
(3) Most unfavorable ___________
(4) Aircraft __________ for take-off
(5) Aircraft weight most __________
(6) Flaps__________
(7) Cowl Flaps __________
(8) Landing Gear __________
(9) Airborne and out of _______________
(10) Aircraft bank angle: Max _____ Degrees into the __________ engine

VMC AND ALTITUDE

As altitude is increased, VMC _______________
As altitude is increased, indicated stall speed __________

Normal Procedures

TAKE-OFF PROFILE

Takeoff Roll

1) Rotate at Vmc, 90mph
2) Positive Rate, Gear Up
3) Climb at Vy, 112 mph
4) 1000 FT checks
   a. Pumps off
   b. 25” MP / 2500 RPM — “25 Squared”
   c. Accelerate to cruise climb, 130 MPH

CRUISING FOR INSTRUCTION PURPOSES

Throttles:	20 inches
Props:	2300 RPM

TRAFFIC PATTERN

Throttles:	16 inches
Props:	2300 RPM
Downwind	120 mph
Base	110 mph
Final	90-100 mph
Power:	As needed 10-12
inches	

Use a gradual power reduction technique from 16” mp to idle

GUMPS

Gas, mains (Pumps on before switching tanks)
Undercarriage (gear down), green light, check mirrors
Mixtures (rich below 4,000)
Props (forward) (save until final)
Switches (pumps on)

LANDING GEAR

The PA-30 tricycle landing-gear system is a fully retractable air-oil, oleo-strut type, and is electrically operated by a selector switch located on the instrument panel. The gear selector is in the shape of a wheel to distinguish it from the flap control which is in the shape of an airfoil. The three landing gear are mechanically connected, and move as a unit.

The nose gear is steerable with the rudder pedals through a forty-degree arc. The steering mechanism is disconnected automatically during gear retraction to reduce rudder pedal loads in flight. The nose wheel is equipped with a hydraulic shimmy damper.

Retraction of the landing gear is accomplished by an electric motor and transmission assembly located under the floorboard, activating push-pull cables to each of the main gear, and a push-pull tube to the nose gear. Limit switches are installed in the system to cut off the gear motor when the gear is fully extended or retracted.

To guard against inadvertent movement of the landing-gear selector switch while on the ground, a mechanical guard is positioned just below the switch. The switch handle must also be pulled aft before being placed in the "GEAR UP" position. A warning horn will sound if the selector switch is placed in the "GEAR UP" position while the weight of the airplane is resting on the landing gear.

To prevent inadvertent retraction of the landing gear while the airplane is on the ground, a safety "squat" switch is installed on the left main gear to open the electric circuit to the landing-gear motor until the strut is fully extended.

If manifold pressure on both engines is reduced below approximately 12-inches, and the landing gear is not down and locked, a warning horn will sound to alert the pilot to the possibility of a gear-up landing. The landing-gear warning horn emits a continuous sound.

A green light on the instrument panel is the primary indication that the landing gear is down and locked. When the gear is fully extended, the series circuit that lights this lamp is completed through a switch located on each of the three gear. All three gear must be down and locked for the indicator to light. An amber light above the landing-gear selector switch indicates the gear is up. This lamp will flash if the landing gear is up and manifold pressure of one engine is reduced below approximately 12 inches. A third white light (installed on later models) will indicate that the landing gear is in transit. It is important to note that the landing-gear indication lights are automatically dimmed when the navigation lights are turned on.

A removable emergency handle is used to manually extend the landing gear in the event of a malfunction of the electrical system.

BRAKE SYSTEM

The brakes are activated by toe pedals mounted above the pilot (optional copilot) rudder pedals, or by a hand lever located below the left center of the instrument panel. The hydraulic brake system is a self-adjusting, single-disk, double-piston assembly. Each rudder pedal has its own master cylinder, but both share a common reservoir.

VACUUM SYSTEM SCHEMATIC

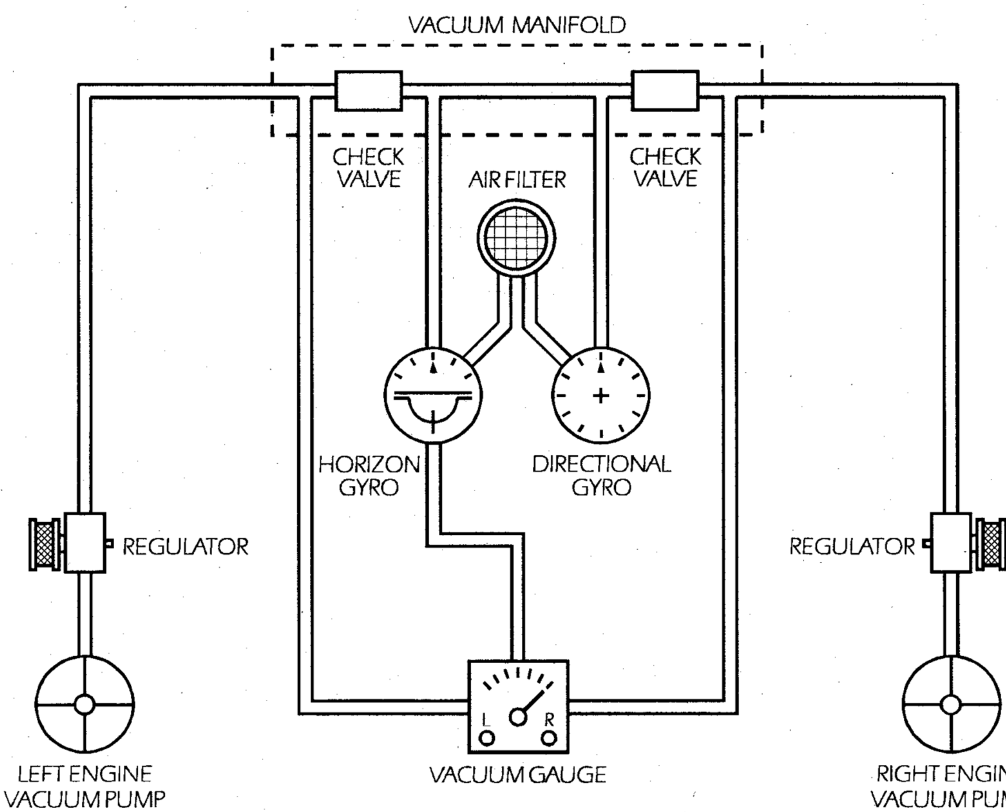


FIGURE 7-07

§ 23.149 Minimum control speed.

(a) V_{MC} is the calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplanewith that engine still inoperative, and thereafter maintain straight flight at the same speed with an angle of bank of not more than 5 degrees. The method used to simulate critical engine failure must represent the most critical mode of powerplant failure expected in service with respect to controllability.

(b) V_{MC} for takeoff must not exceed 1.2 V_{S1}, where V_{S1} is determined at the maximum takeoff weight. V_{MC} must be determined with the most unfavorable weight and center of gravity position and with the airplane airborne and the ground effect negligible, for the takeoff configuration(s) with -

(1) Maximum available takeoff power initially on each engine;

(2) The airplane trimmed for takeoff;

(3) Flaps in the takeoff position(s);

(4) Landing gear retracted; and

(5) All propeller controls in the recommended takeoff position throughout.

(c) For all airplanes except reciprocating engine-powered airplanes of 6,000 pounds or less maximum weight, the conditions of paragraph (a) of this section must also be met for the landing configuration with -

(1) Maximum available takeoff power initially on each engine;

(2) The airplane trimmed for an approach, with all engines operating, at V_{REF}, at an approach gradient equal to the steepest used in the landing distance demonstration of § 23.75;

(3) Flaps in the landing position;

(4) Landing gear extended; and

(5) All propeller controls in the position recommended for approach with all engines operating.

(d) A minimum speed to intentionally render the critical engine inoperative must be established and designated as the safe, intentional, one-engine-inoperative speed, V_{SSE}.

(e) At V_{MC}, the rudder pedal force required to maintain control must not exceed 150 pounds and it must not be necessary to reduce power of the operative engine(s). During the maneuver, the airplane must not assume any dangerous attitude and it must be possible to prevent a heading change of more than 20 degrees.

(f) At the option of the applicant, to comply with the requirements of § 23.51(c)(1), V_{MCG} may be determined. V_{MCG} is the minimum control speed on the ground, and is the calibrated airspeed during the takeoff run at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane using the rudder control alone (without the use of nosewheel steering), as limited by 150 pounds of force, and using the lateral control to the extent of keeping the wings level to enable the takeoff to be safely continued. In the determination of V_{MCG}, assuming that the path of the airplane accelerating with all engines operating is along the centerline of the runway, its path from the point at which the critical engine is made inoperative to the point at which recovery to a direction parallel to the centerline is completed may not deviate more than 30 feet laterally from the centerline at any point. V_{MCG} must be established with -

(1) The airplane in each takeoff configuration or, at the option of the applicant, in the most critical takeoff configuration;

(2) Maximum available takeoff power on the operating engines;

(3) The most unfavorable center of gravity;

(4) The airplane trimmed for takeoff; and

(5) The most unfavorable weight in the range of takeoff weights.

[Doc. No. 27807, 61 FR 5189, Feb. 9, 1996]

Factors of Vmc

V_{mc} Factor	V_{mc}	Performance
Maximum take-off Power at Sea Level (Density Altitude is at Sea Level)	Increase	Increase

For an airplane with non-supercharged engines, V_{mc} will Decrease as Density Altitude Increases. So directional control can be maintained at a lower airspeed than it can at sea level. As power decreases with altitude, the thrust moment of the operating engine lessens, thereby reducing the need for the rudder and it's countering yaw. So at Sea Level the V_{mc} is the highest. The higher the density altitude, the lower the V_{mc}.

At Gross Weight	Decrease	Decrease

V_{mc} is not affected by weight in straight and level flight, only by the weight of the airplane in a bank. When it is banked, a component of the aircraft weight acts along with the horizontal component of lift to create a more effective sideslip towards the operating engine. So for a given bank, the heavier the airplane, the lower the aircraft's V_{mc}. The lighter the airplane, the higher the aircraft's V_{mc}.

Most Adverse CG (usually Aft)	Increase	Decrease

V_{mc} is greatest when the CG is at the most aft position. An aft CG shortens the arm to the center of the rudder's horizontal lift, which means a higher airspeed would be required to counteract the engine-out yaw. So the aft CG has the highest V_{mc} and a forward CG would decrease V_{mc}.

Gear Up	Increase	Increase

The change in CG when the landing gear is put down may make the rudder more effective due to a longer moment arm, which would result in a slighter lower V_{mc}. The extended gear may also have a tendency to align with the oncoming relative wind, which can be directionally stabilizing. So the V_{mc} for this factor is at its highest when the gear is up, and decreases when the gear is extended.

Take-off Flaps	Increase	Increase

Extended flaps will increase both drag and lift. The increased drag from the extended flap behind the operating engine may tend to oppose the yawing motion of that engine, requiring less rudder to counteract that yaw. So V_{mc} will be lower with flaps extended, and higher with flaps retracted (the take-off position for this aircraft).

Take-off Trim	Decrease	Increase

Take-off Cowl Flaps	Decrease	Decrease

Cowl flaps in the open position will increase drag on the aircraft, and may also provide a very slight weathervaning/stabilizing effect on the yawing motion. Cowl flaps closed will increase V_{mc}, cowl flaps open will decrease V_{mc}.

Windmilling Propeller on Critical Engine	Increase	Decrease

A windmilling propeller will generate a significant amount of un-balanced drag. This will result in less directional control and a higher V_{mc}, and is one of the most significant of the factors.

Out of Ground Effect	Increase	Decrease

An aircraft in ground effect is “cushioned”, with less drag and greater lift. So in ground effect, V_{mc}decreases. As the aircraft lifts out of ground effect, it loses that lift and increases its drag, thereby increasing the V_{mc}.

Up to 5 degrees bank into the good engine	Decrease	Increase

During engine-out flight, keeping the ball centered and the wings level will actually cause a side-slip situation because of the one failed engine and the resulting drag and loss of lift. A sideslip would make stall characteristics worse, would decrease climb and acceleration capability, and would increase V_{mc}. Turning up to 5 degrees towards the good (operating) engine will prevent the airplane from being in a sideslip condition, will improve climb capabilities, improve stall capabilities, improve performance and will decrease V_{mc}.

Note on Stalls

WARNING

When practicing stalls maintain minimum terrain clearance of 5000 feet. Single engine or asymmetric power stalls prohibited. Power on stalls above 2100 RPM prohibited. Do not practice stalls when carrying passengers, when the airplane is heavily loaded or with the center of gravity near the aft limit.

The left wing on the Twin Comanche with clockwise rotating propellers will, generally speaking, under conditions of moderate symmetrical power, stall more rapidly than the right wing, and if recovery is not promptly initiated, the airplane will have a tendency to roll to the left.

As in any multi-engine aircraft, stall recovery in the Twin Comanche should be initiated at the first indication of a pre stall buffet or warning light. The aircraft should not be permitted to develop into a full stall.

Script for Engine Failures

"Pitch, step, and roll"
"Mixtures, props, throttles forward"
"Flaps up, gear up"

While doing the above, roll wings level if necessary and pitch for Blue Line (approx. 5 degrees nose up). Maintain control of aircraft, hold altitude/heading if necessary, and continue to follow through on any ATC instructions if needed. In other words, maintain localizer, VOR, heading, etc.

Do not be in a rush. The majority of the emergency is over. Pause and say, "We've had an engine failure." Then continue with procedure **(Identify, Verify, Feather)**

To **Identify** the dead engine, determine which rudder you ***are not*** stepping on. This is the dead engine.

"_____ foot is dead, ______ engine is dead."

To verify the dead engine, pull the associated throttle lever to idle. There should be no change in the amount of rudder input required.

"*Confirm* ______throttle, ***Verify*** _____ engine is inop."
"Confirm* _____ prop, ***Feather*** _____ prop."

* When pulling back the propeller lever to feather, stop in mid position to confirm that the engine you are feathering is actually the inoperative engine (you will hear a change in the engine sound if you are pulling back the wrong prop lever), and then continue to feather detent.

If above 2,000' AGL, call for engine troubleshooting checklist prior to feathering the prop and fix.

Departure Information

ATIS CODE __________ P-ALT __________
TEMP/DEW __________ DEN/ALT __________
ALTIMETER __________ WIND __________

WEIGHT AND BALANCE
PA30 N7261Y

Max Gross 3600
Empty Weight 2262.53
Empty Weight C.G. 83.49
Useful Load 1337.47

ITEM	WEIGHT X	ARM =	MOMENT
Empty Weight	2262.53	83.49	188906.61
Oil (7.5 LBS per Gal)	30.00	51.0	1530.00
Fuel (Inboard)	324.00	90.0	29160.00
Fuel (Outboard)	180.00	95.0	17100.00
Pilot/Pass. (Front)		84.8	
Passenger (Rear)		118.5	
Baggage (Max 200)	20.00	142.0	2840.00
TOTALS	__________		__________

C.G. = Total Moment Divided by Total Weight C.G. = __________ *Most Forward C.G. = 81*
Most Rearward C.G. = 92

S.E.S.C. ____________
(Single Engine Service Ceiling)

S.E.A.C. ______________
(Single Engine Absolute Ceiling)

Departure Performance

Takeoff Distance ____________ Rate Of Climb (Single Engine)____________

Landing Distance ____________ Rate Of Climb (Two Engines)____________

Accelerate Stop ______________ Accelerate Go ______________

((50 / (se roc x 60 / ground speed)) x 5280) + Takeoff Distance

a. se roc x 60 = a
b. a / ground speed = b
c. 50 / b = c
d. c x 5280 = d
e. d + TakeoffDistance = Accelerate-Go Distance
(where d is the distance from rotation to clear 50' obstacle)

Departure Information

ATIS CODE ___________	P-ALT ___________
TEMP/DEW ___________	DEN/ALT ___________
ALTIMETER ___________	WIND ___________

WEIGHT AND BALANCE
PA30 N84JS

Max Gross	3600
Empty Weight	2543
Empty Weight C.G.	84.86
Useful Load	1057

ITEM	WEIGHT	X ARM =	MOMENT
Empty Weight	2543.00	84.86	215798.98
Fuel Nacelle Tanks		93.0	
Fuel (Inboard)	324.00	90.0	29160.00
Fuel (Outboard)	180.00	95.0	17100.00
Pilot/Pass. (Front)		84.8	
Passenger (Rear)		120.5	
Baggage (Max 200)	20.00	142.0	2840.00
Wing Lockers	10.00	130.0	1300.00
TOTALS	________________		________________

C.G. = Total Moment Divided by Total Weight C.G. = __________ *Most Forward C.G. = 85.8*
Most Rearward C.G. = 92

S.E.S.C. ____________
(Single Engine Service Ceiling)

S.E.A.C. ______________
(Single Engine Absolute Ceiling)

Departure Performance

Takeoff Distance ____________

Rate Of Climb (Single Engine)____________

Landing Distance ____________

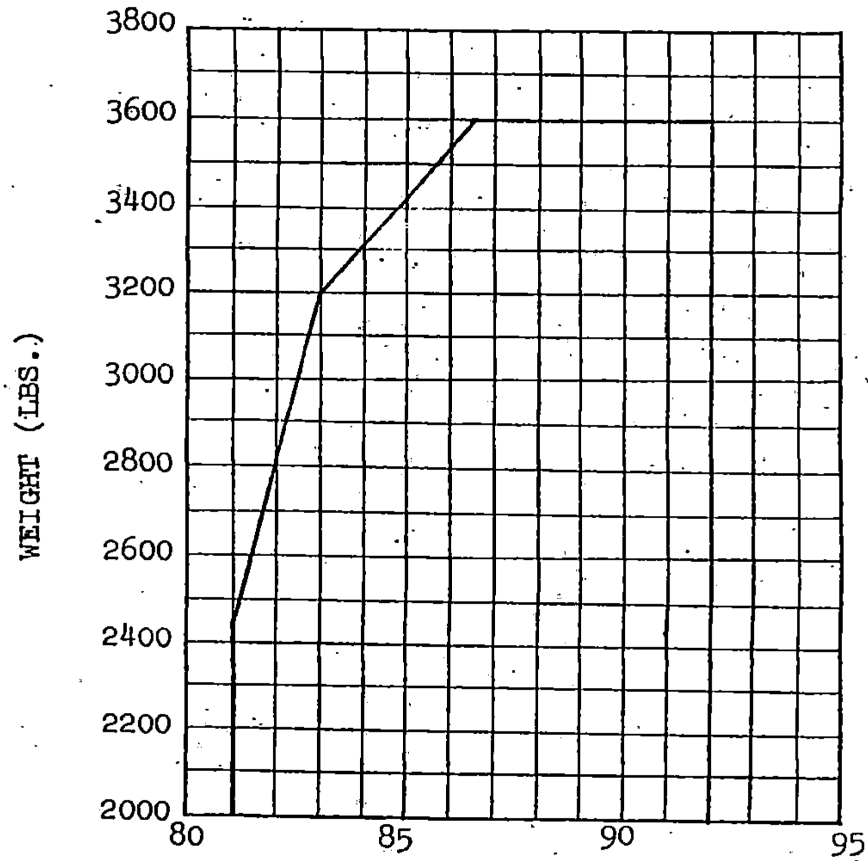
Rate Of Climb (Two Engines)____________

Accelerate Stop ______________

Accelerate Go ______________
((50 / (se roc x 60 / ground speed)) x 5280) + Takeoff Dist

i. se roc x 60 = a
ii. a / ground speed = b
iii. 50 / b = c
iv. c x 5280 = d
v. d + TakeoffDistance = Accelerate-Go Distance (where d is the distance from rotation to clear 50' obstacle)

APPROVED C.G. RANGE AND WEIGHT



Moment due to retracting Landing Gear = +770 in.-lbs.

PREPARED
CHECKED
APPROVED

TAKEOFF GROUND RUN DISTANCE

WING FLAPS: 15 DEGREES
RUNWAY SURFACE: PAVED, LEVEL, DRY

FULL THROTTLE AND MAX RPM
TAKEOFF SPEED = 80 MPH IAS

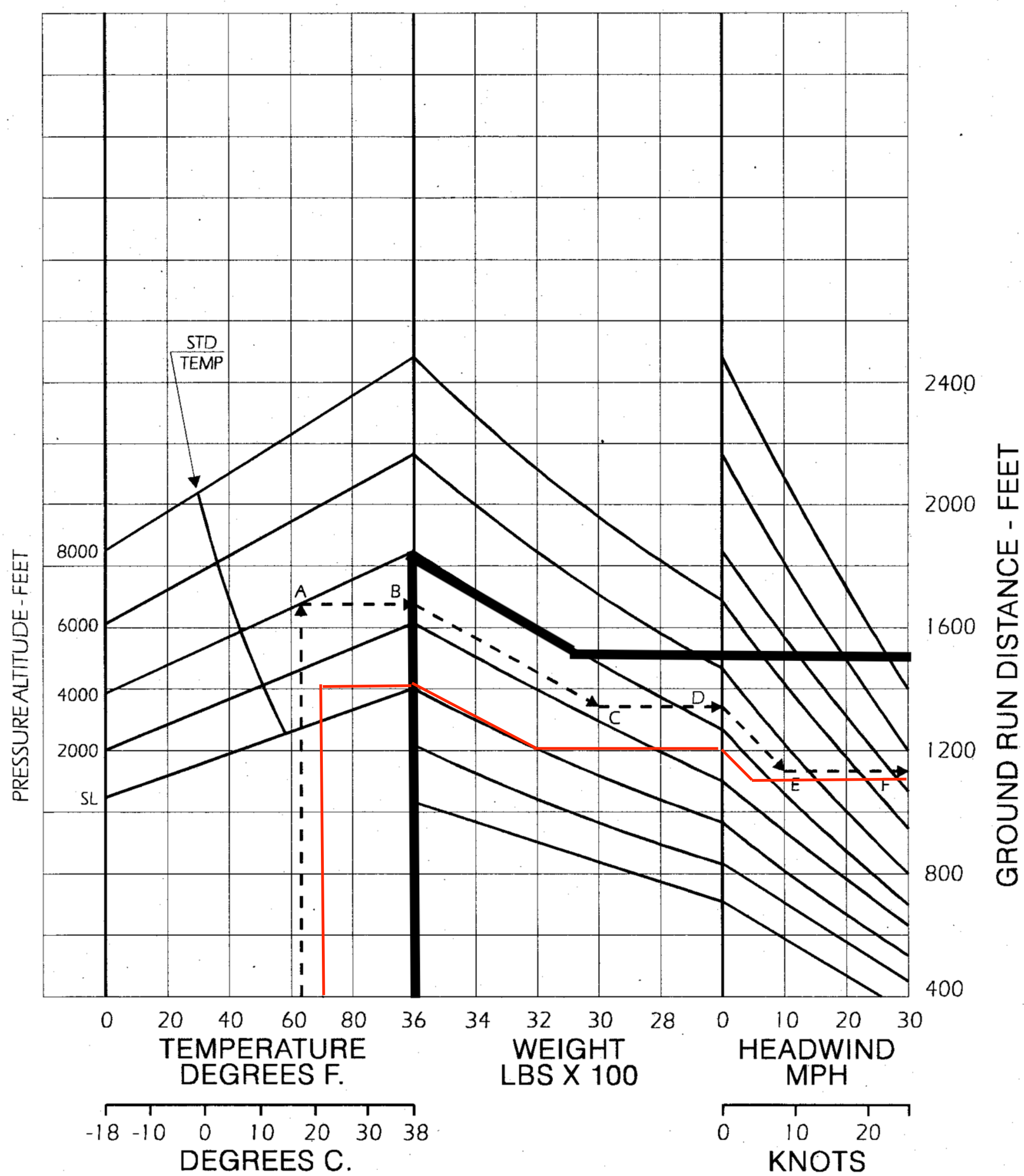


FIGURE 5-06

ACCELERATE - STOP DISTANCE

WING FLAPS RETRACTED
FULL THROTTLE AND MAX RPM
BOTH THROTTLES CLOSED AT DECISION SPEED

RUNWAY SURFACE: PAVED, LEVEL, DRY
ACCELERATE TO 90 MPH IAS
MAXIMUM BRAKING EFFORT

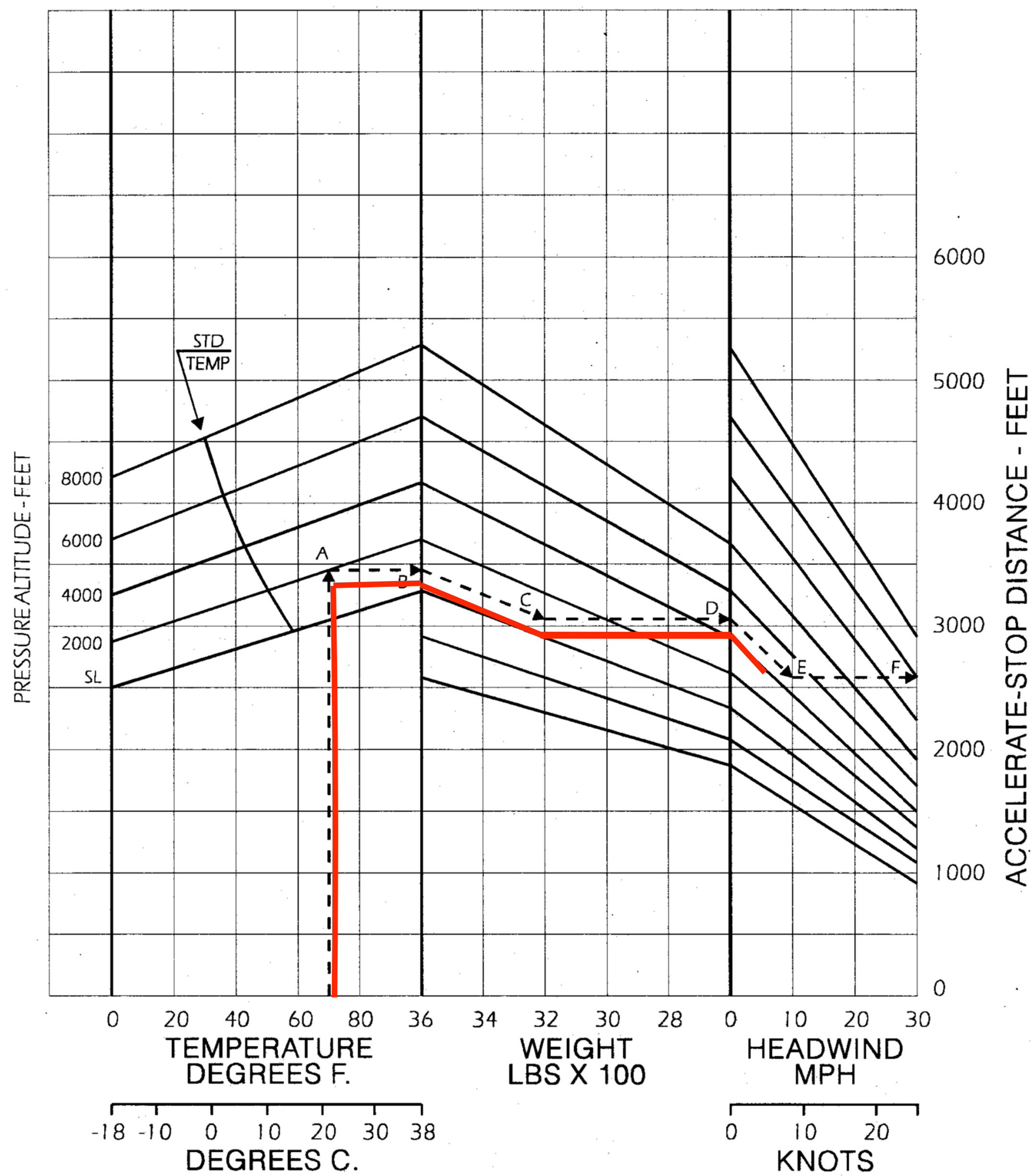


FIGURE 5-08

MULTI-ENGINE RATE OF CLIMB
VS
DENSITY ALTITUDE AND WEIGHT

COWL FLAPS OPEN
FULL THROTTLE AND MAX RPM
LANDING GEAR AS NOTED

MIXTURE: ADJUST FOR SMOOTH OPERATION
OPTIMUM AIRSPEED
WING FLAPS AS NOTED

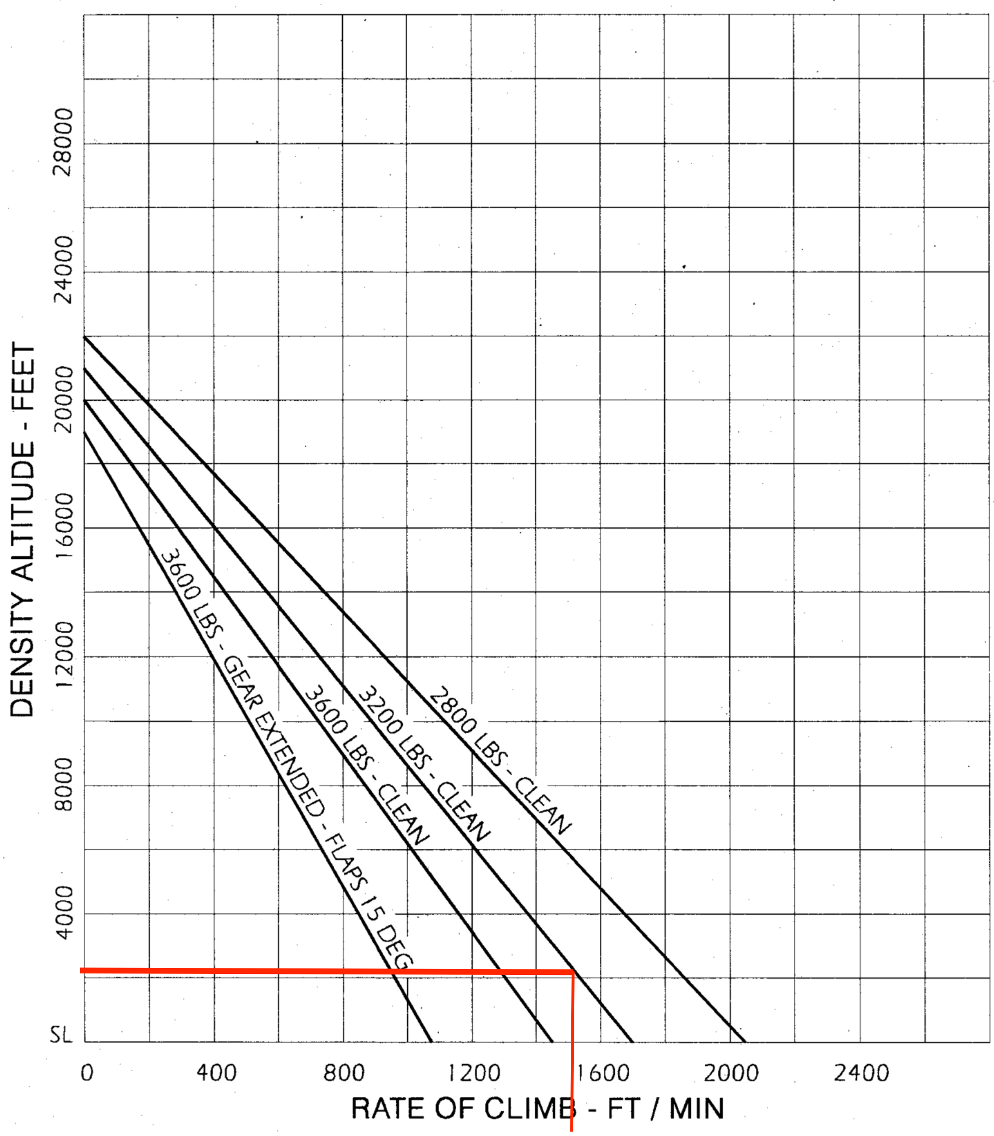


FIGURE 5-09

SINGLE-ENGINE RATE OF CLIMB

VS

DENSITY ALTITUDE AND WEIGHT

LEFT ENGINE: INOPERATIVE
LEFT PROPELLER: FEATHERED
RIGHT ENGINE: FULL THROTTLE
RIGHT PROPELLER: MAX RPM

MIXTURE: ADJUST FOR SMOOTH OPERATION
GEAR AND WING FLAPS RETRACTED
OPTIMUM AIRSPEED
COWL FLAPS OPEN

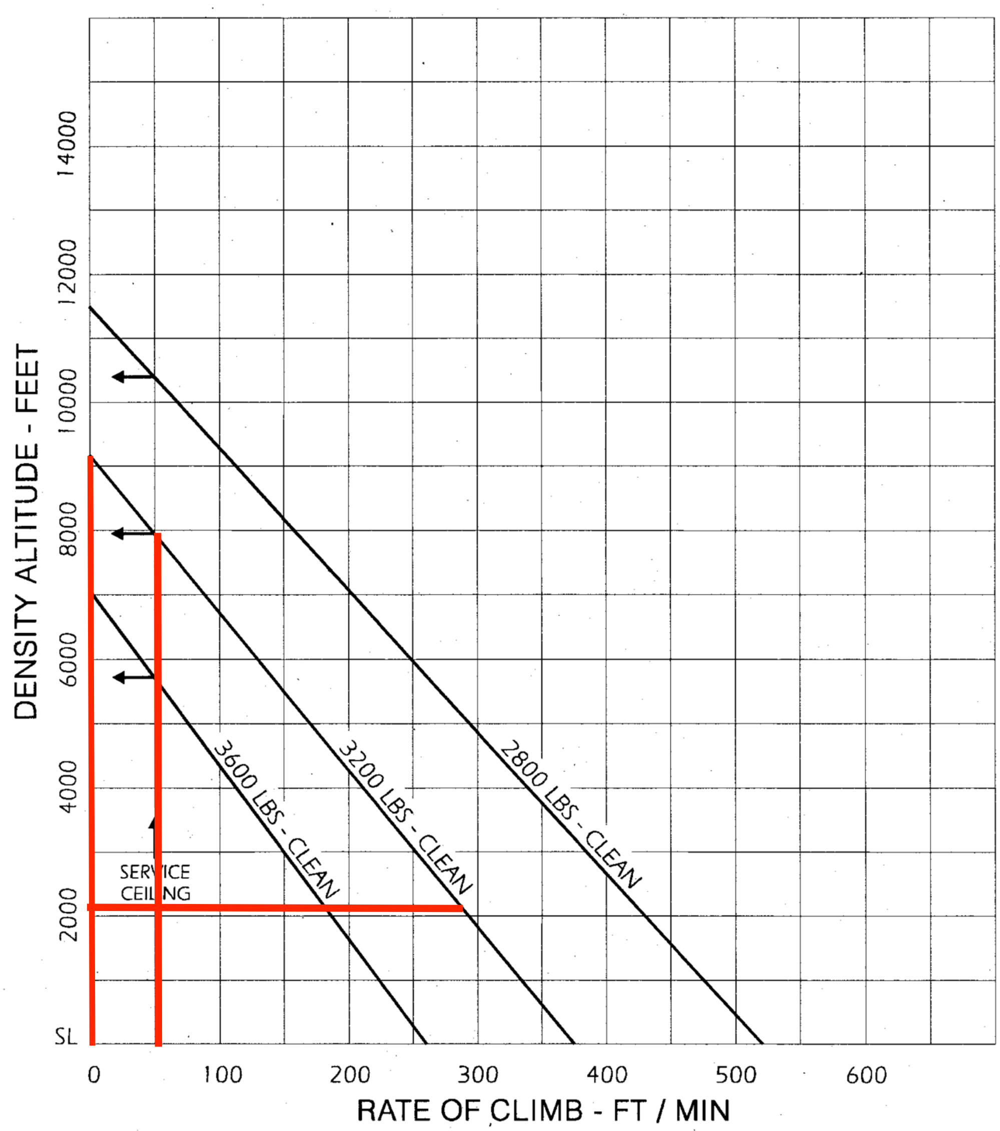


FIGURE 5-10

LANDING GROUND ROLL DISTANCE

WING FLAPS: 27 DEGREES
RUNWAY SURFACE: PAVED, LEVEL, DRY
THROTTLES CLOSED

MAXIMUM BRAKING EFFORT
APPROACH SPEED = 90 MPH IAS
TOUCHDOWN SPEED = 70 MPH IAS

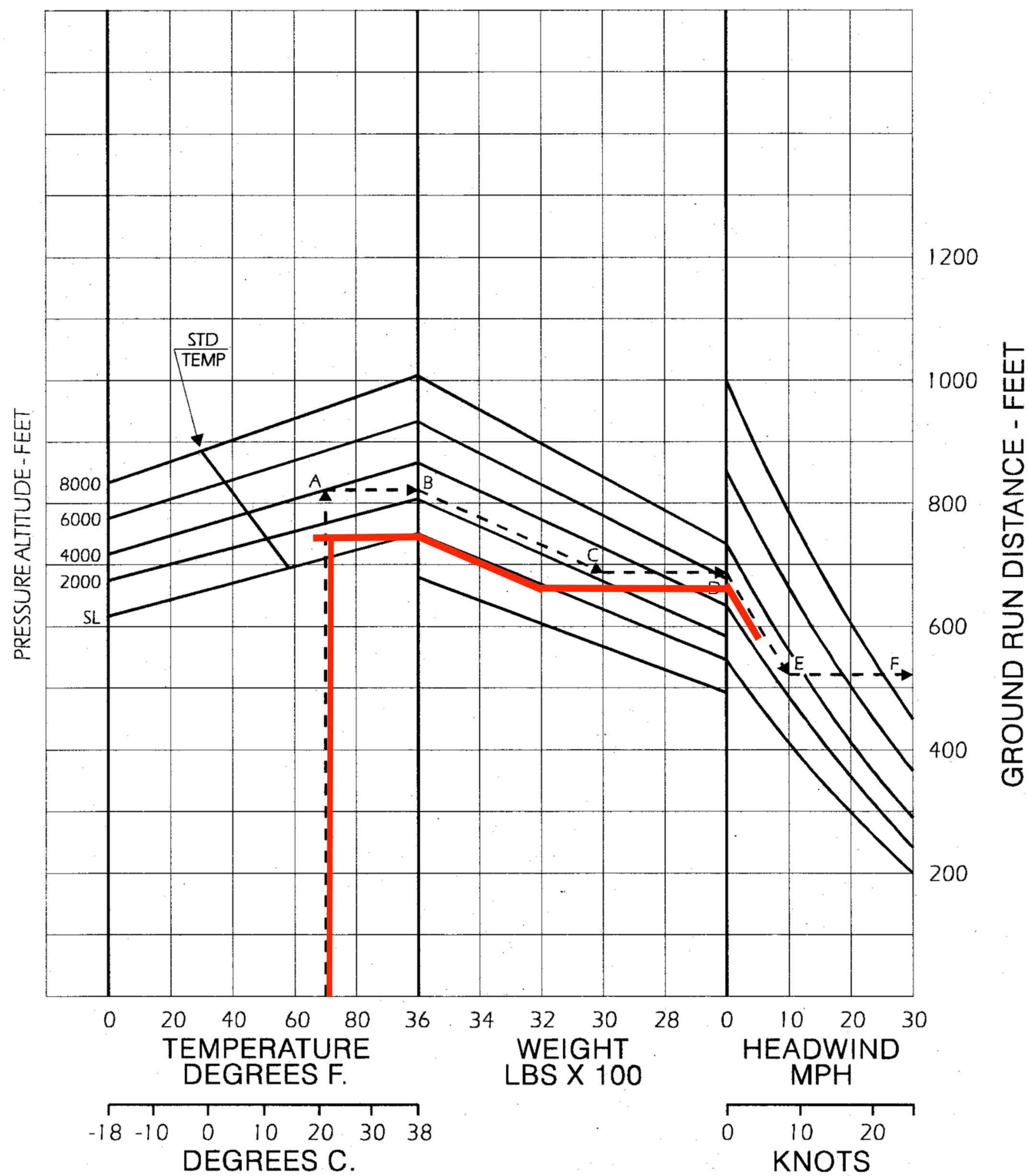


FIGURE 5-15

STUDY LINKS

YOUTUBE:

1) PRETTYFLYFORACFI

ALL MULTI ENGINE AERODYNAMICS

PAST:

- P-Factor
- Accelerated Slipstream
- Spiraling Slipstream
- Torque

2) PA30 GEAR EXTENSION

GOOGLE:

“Leave Yourself An Out”

http://www.avhf.com/html/Library/Leave_Yourself_An_Out.pdf