Multi-Engine Course Study Guide

This guide is a compilation of all the flashcard questions in the Multi-Engine Course. We highly recommend thinking about the content on your own and discussing any questions with your instructor before consulting this guide for the “answers”. Although it is not necessarily the most enjoyable process, thinking critically about the subject is the best way to encourage *long term retention* of this information, which is the real goal.

We are dedicated to providing the very best material that we can. If you find any errors, confusing phrasing, or have any recommendations for changes to this guide, please don’t hesitate to reach out to us at support@flightapprentice.com, on social media, or at FlightApprentice.com

Enjoy!
The Flight Apprentice Team

FLIGHT APPRENTICE

MULTI-ENGINE AERODYNAMICS

OEI AERODYNAMICS

How do pitch, roll and yaw forces change during an engine failure?

Pitch decreases, roll is induced towards the failed engine and yaw is generated towards the dead engine.

Which axis — pitch, roll, or yaw — usually gives the most obvious indication of an engine failure?

Yaw

Why does lift change on one wing during an engine failure?

From a reduction in accelerated slipstream caused by a loss of thrust in that engine.

How would the aerodynamic forces be different if an engine failure occurred on the ground?

The roll moment would not be felt as strongly because the wheels are on the ground and less lift is being generated; slipstream may not be as strong because it may be dampened from ground interference.

Why is it so important that pilots practice the body movements required to compensate for changing aerodynamic forces during an engine failure?

Because when a real engine failure occurs, the response needs to be prompt and correct.

OEI CLIMB PERFORMANCE

Why does a 50% reduction in power result in a far greater reduction in performance?

Because performance is a by-product of excess thrust. Because an engine failure not only reduces thrust but adds drag, the excess thrust is reduced.

Following an engine failure, how can performance be improved?

By reducing drag by establishing a zero sideslip condition and changing configuration as appropriate.

What pilot actions distinguish the sideslip angle from the zero sideslip angle?

In a sideslip condition, the pilot has used rudder and aileron to maintain a heading and keep the wings level. In a zero sideslip condition the pilot banks slightly towards the operating engine and reduces rudder pressure slightly until the airplane is slightly uncoordinated (split the ball).

APPLIED OEI CLIMB PERFORMANCE

How might a pilot plan differently for an engine failure after takeoff at sea level vs. at a high density altitude airport?

In an engine failure on departure, the airplane may have insufficient excess thrust to climb or even maintain level flight on a single engine. Hence, the pilot needs to consider a suitable off-airport location to land should an engine failure occur. Furthermore, the pilot may consider waiting until density altitude lowers, improving the situation.

What actions can a pilot take to increase single engine performance before departure?

Reduce weight, increase power (if possible), and change configuration for a maximum performance takeoff (short field takeoff)

V_{MC}

What aerodynamic force makes V_{MC} the minimum controllable airspeed?

Rudder force; Once the yawing force from an engine failure exceeds the pressure that can be exerted through maximum deflection of the rudder, V_{MC} has been reached.

Why is Vmc so important during takeoff?

Flying below V_{MC} after an engine failure on takeoff is likely unrecoverable, because recovery requires sufficient altitude.

What are all the certifying criteria used to establish V_{MC}?

Critical engine inoperative and windmilling
Operation engine at maximum power
Most unfavorable gross weight and CG
Bank up to 5° towards the operating engine
Able to maintain heading +/- 20°

Takeoff configuration (flaps, cowl flaps, trim)
Standard atmosphere at sea level (15° and 29.92'')
Out of ground effect
Gear up
150lbs rudder force maximum

What effect does landing gear have on V_{MC}? On performance?

Landing gear lowers V_{MC} and reduces performance.

Why is V_{MC} determined with landing gear up?

Landing gear provide a stabilizing effect (keel effect) which lowers V_{MC}. In an engine failure scenario, however, the gear will usually be retracted for performance, so V_{MC} is calculated with the gear up.

How does density altitude affect V_{MC}? Performance?

A higher density altitude lowers V_{MC} because it reduces engine power on the operating engine. It also reduces performance.

CRITICAL ENGINE

What are the four factors that make an engine critical?

P-factor
Accelerated slipstream
Spiraling slipstream
Torque

How does P-factor affect the critical engine?

P-factor is the asymmetric thrust on the descending blade (the right side on most light twins). The distance from the CG to the descending blade is longer on the right engine than the left; meaning that when the left engine fails, the right engine will produce more p-factor than the left engine would if the right engine failed.

How does accelerated slipstream affect the critical engine?

Accelerated slipstream increases lift over the area of the wings directly behind the propellers and greater slipstream is located behind the descending blades. The distance from the CG to the section of wing with greater lift from accelerated slipstream is greater on the right side than the left. Failure of the critical engine results in a greater roll force asymmetry than failure of the non-critical engine.

How does spiraling slipstream affect the critical engine?

Spiraling slipstream passes underneath both engines and corkscrews off to the right. The critical engine slipstream hits the tail section, counteracting the yawing motion produced by a non-critical engine failure. The non-critical engine slipstream does not hit the tail and does not counteract the yawing motion created by the failure of the critical engine.

How does torque affect the critical engine?

In engines that turn to the right, torque effect creates a left turning tendency. When the non-critical engine fails, the remaining engine torque effect counteracts the right turning tendency. When the critical engine fails, the non-critical operating engine still produces a left turning tendency, exacerbating the left turning tendency.

Does an airplane with counter-rotating engines have a critical engine? Why or why not?

No. Counter-rotating engines prevent the four elements that create a critical engine. Both engines are equally critical.

MULTI-ENGINE SYSTEMS

GENERAL SYSTEMS

What is the major difference between the propeller governors in single-engine and multi-engine constant speed systems? Why are they designed differently?

In a multi-engine airplane, spring tension forces the propeller to high pitch, low RPM angle to reduce drag and facilitate in feather following a loss of oil pressure. In a single-single-engine airplane, the propeller fails to a low pitch, high RPM position to encourage windmilling for a restart.

What is the purpose of an unfeathering accumulator?

The unfeathering accumulator uses pressurized oil to force the propeller out of feather during a restart.

What is the purpose of a propeller synchronizer/synchrophaser? How do pilots without either keep the propellers in sync?

A propeller synchronizer/synchrophaser adjust propeller RPM to reduce vibration and noise. Without either, a pilot will keep the propellers in sync by roughly setting the RPM using the tachometer and finely tuning by hearing and reducing the oscillations/vibrations.

What is the difference between fuel cross-feed and fuel transfer systems?

A fuel cross-feed allows an engine to use fuel from an opposite-side tank. A fuel transfer system, physically transfers fuel from one tank to another.

What is the difference between de-ice and anti-ice systems?

De-ice systems get rid of existing ice, while anti-ice systems prevent ice accumulation.

How do de-ice boots function? What improper use can cause them to stop working?

De-ice boots use pneumatic pressure to expand a rubber boot which expands the leading edge of the wing enough to crack the ice, which then flies off. If boots are used without proper accumulation of ice, ice may adhere to the expanded boot, leaving them stuck in the inflated position and preventing system use.

How does a glycol bleed system work? What improper use can prevent it from working?

Glycol bleed systems force fluid through a series of “pores” on the wing which prevent ice accumulation. The common misuse of glycol anti-ice is allowing ice to accumulate before using the system. Glycol systems only *prevent* accumulation. They cannot rid an airfoil of existing ice.

What are the advantages and risks associated with a heated wing de-ice/anti-ice system?

A heated wing is both a de-ice and anti-ice system, which can be used at any time to get rid of existing ice or prevent ice build up, in contrast to boots and glycol systems which require very specific operation to work properly. The main hazard associated with heated wings is the extreme temperature of the air which heats the wings — a leak in the bleed duct can cause structural damage or a fire risk.

CESSNA 310 FUEL SYSTEM

** If you are not using a Cessna 310 for your training, feel free to ignore this section **

What happens to excess fuel that is delivered to the engine driven pump?

It is delivered back to the same side main fuel (wing tip) tank

What is the purpose of the internal main tank pumps?

To route fuel from the forward portion of the tank back to the electric driven pump, particularly in a steep descent.

Is the Cessna 310 able to cross-feed? Can it transfer fuel directly between main tanks?

The 310 is able to cross feed, but is unable to transfer fuel directly from main tank to main tank. It can, however, transfer fuel directly from the wing locker tank(s) to the corresponding main tank(s).

What is the total number of fuel pumps?

The exact number will vary on your fuel tank configuration: There are 2 engine driven pumps, 2 auxiliary pumps, 1 internal transfer pump per each main tank, and 1 pump per locker tank. With 1 locker tank, there are 7 pumps total. With two locker tanks, there are 8 pumps total.

How many fuel tanks are there?

5 or 6, depending on locker tank configuration: 2 mains (wing tip), 2 auxiliary (in wing) and either 1 or 2 locker tank(s).

How many fuel selectors?

There are two fuel selectors.

How many fuel strainers?

There are two fuel strainers, one per engine.

If the wing tip main tanks are full, how long should a pilot fly before switches to the aux tanks?

At least one hour

Which tanks should be used for takeoff and landing? Why?

The main tanks. The auxiliary fuel pumps are connected to the main tanks. Prior to takeoff and landing, the auxiliary pumps should be on LOW. If, while in LOW, the engine driven pump fails, the auxiliary pump will automatically switch to HIGH, ensuring adequate fuel delivery.

Note that in the event of an automatic switch from LOW to HIGH, the pilot may need to lean the mixture as the auxiliary pumps on HIGH have a tendency to deliver too much fuel.

What incorrect operation could cause a pilot to inadvertently dump fuel overboard?

Operating on the aux tanks with full, or near full, wingtip tanks

MULTI-ENGINE OPERATIONS

TAKEOFF SPEEDS

What is critical speed?

Critical speed is the minimum speed, as published by manufacturers, at which an airplane with a single engine will have sufficient performance to fly.

Is an aborted takeoff after critical speed ever acceptable?

Yes! It is preferable, so long as there is runway available.

What is blue line?

Vyse, or the single engine best rate of climb speed.

What is red line?

Vmc, or the minimum controllable airspeed with an engine inoperative. Actual Vmc speed, as opposed to the red line, is dynamic, based on configuration, power output and bank; The absolute value is based on the least preferable combination of these, as illustrated by the acronym COMBATSOG150

In many multi engine airplanes, V_{XSE} and V_{MC} are very close together. What is the significance of that as it pertains to safety?

During a short field takeoff, where a Vx climb is expected, the pilot must realize that following an engine failure on takeoff, a Vxse climb will be necessary, and puts the airplane very near Vmc. Precise flying is required to ensure control is maintained.

ACCELERATE STOP/GO

What is accelerate-stop distance?

The distance required to accelerate from a stop, abort the takeoff at critical speed, and come to a complete stop.

What is accelerate-go distance?

The distance required to accelerate from a stop to critical speed, experience an engine failure, and continue the takeoff to a height of 50 feet.

What is a balanced field condition?

A balanced field condition is one in which accelerate stop and accelerate go distances are the same.

Does a "balanced field condition" have anything to do with the actual runway length?

No. Balanced field is a performance concept.

TAKEOFF BRIEF

Why is a takeoff brief so important, particularly to a multi-engine pilot?

When an engine fails during the takeoff roll, there is no time to talk about it. A pilot's actions must be pre-briefed and include scenarios for an engine failure before and after critical speed. Execution must be timely.

A takeoff brief should include at least three main scenarios. What are they?

Engine failure before critical speed, engine failure after critical speed, and the two engine or normal departure procedure.

The visibility is near approach minimums at your departure airport. How could your takeoff brief change accordingly?

Several considerations

- You may be unable to return to the airport following an emergency
- Visibility will be degraded during takeoff, decreasing SA particularly following an engine failure
- Following an aborted takeoff, the airplane may not be visible to other pilots on either end of the runway. Either clearing the runway or making positive radio communication could be critical.

There is rising terrain to your left and water to your right. How might this incorporate into your takeoff brief?

You will want to modify your engine failure procedure to meet the requirements of the terrain — in this case most likely turning right to fly over the water as you prepare to landing again.

MULTI-ENGINE MANEUVERS

DRAG DEMO

What is the purpose of the drag demo?

The drag demo is used to demonstrate the increase in drag from various factors during single engine operations and the resulting effect on performance.

What are the approximate drag factors for your airplane?

** Consider drag factors for gear, flaps, and cowl flaps.**

V_{MC} DEMO

What is the purpose of the V_{MC} demo?

The Vmc demo illustrates the loss of control that occurs as the airplane slows below Vmc during single engine operations.

What is an appropriate deceleration rate for the V_{MC} demo?

1 knot per second.