Systems and Equipment Malfunctions

Objective	
To ensure the applicant learns the types of system and equipment malfunctions that are commonly encountered and how to deal with these problems correctly.	
Purpose	
Most pilots will at some point deal with an in-flight malfunction or emergency. This lesson introduces pilots to the types of failures that may occur in flight and how they should be handled.	

Schedule	**Equipment**
● **Ground Lesson**: 25 minutes ● Pre-Solo ■ **Flight**: 5-10 minutes - *Simulated Malfunction (per flight)* ● Pre-Checkride ■ **Flight**: 20 minutes - *Simulated Malfunctions Practice* ● **Debrief**: 10 minutes (*per flight*)	● Airplane Checklist ● Whiteboard / Markers (optional) ● Model Airplane (optional)
Student Actions	**Instructor Actions**
● Ask any questions, receive study material for the next lesson. ● Watch linked video. ● Review listed references.	● Deliver the ground lesson (below). ● Demonstrate the maneuver in flight. ● Debrief after each flight.

Completion Standards

- **Ground**: Student can explain the proper procedure for handling the following types of failures:
    - Suspected Carb Ice, Rough Running Engine/Partial Power Loss
    - Fuel Exhaustion, Low Oil Pressure, Total Power Loss
    - Smoke/Fire
    - Electrical System Failure
    - Door opening in flight, trim or flap malfunctions
- **Flight**: Student can perform the appropriate steps for each type of system failure in flight by:
    - Correctly identifying the problem
    - Following the appropriate emergency checklist or troubleshooting steps
    - Communicating (simulated) with ATC, as needed
    - Demonstrating Pilot-in-Command decision making

References

- Niko's Wings - "Cirrus SR22 - Inside a Real Emergency Over Illinois - Electrical Failure"
  - YouTube - https://www.youtube.com/watch?v=qRvJ-5JgT_4
- FAA-H-8083-3C (Airplane Flying Handbook) - Chapter 18 [Emergency Procedures]
- FAA-H-8083-25C (Pilot's Handbook of Aeronautical Knowledge) - Chapter 7 [Aircraft Systems]
- FAA-S-ACS-6C (Private Pilot ACS) - Area IX Task C
- FAA-S-ACS-7B (Commercial Pilot ACS) - Area IX Task C
- FAA-S-ACS-25 (CFI ACS) - Area XII Task C

Ground Lesson Outline

- Be the Pilot in Command - Be decisive. Make decisions in the interest of safety. DECIDE model.
  - Startle Response
  - Aviate, Navigate, Communicate, Follow Checklists, Use All Available Resources
- Smoke and Fire - Assume smoke means fire!
  - On the Ground
  - In Flight - Electrical vs Engine Fire
- Engine Issues
  - Rough running or partial power loss - Attempt to diagnose and resolve, otherwise land
    - Carb Ice, Fuel Starvation, Magneto Failure, Internal Engine Failure (Stuck valve, etc.)
  - Overheating - Attempt to lower temps, otherwise land
    - CHT and Airspeed, Low Oil Pressure, etc.
  - Low Oil Pressure - Land As soon as possible!
    - Low Oil Level, Imminent Engine Failure
  - Total Engine Failure - Forced Landing
    - Fuel Starvation (tank switching problems, etc), Carb Ice, Catastrophic Internal Engine Failure
- Electrical Issues
  - Alternator Failure - Two-sided Master Switch
    - Shed electrical load
    - Battery expected runtime
  - Popping Fuses/Circuit Breakers
    - Shed electrical load
  - Electrical short/fire - Turn off Master Switch entirely!
    - Remember some airplanes need electricity for flaps!
  - Night Considerations - Lights, radios (Pilot-Controlled Lighting)
- Instrument Failure - Pitot/Static System, Vacuum System, etc.
- Hydraulic Issues
  - Brakes - Aerodynamic Braking
- Landing Gear - Emergency extension procedures, landing with unsafe gear
- Door or Window Opening in Flight
  - Normally non-emergency!
    - Some airplanes must land, some can be closed in flight *carefully.*
- Inoperative or "Runaway" Trim
  - Circuit breaker for electric trim, If trim issues are suspected, stop using!
- Flap Malfunction
  - Flapless landings
- Pressurization / Oxygen System Malfunction - Descend now!

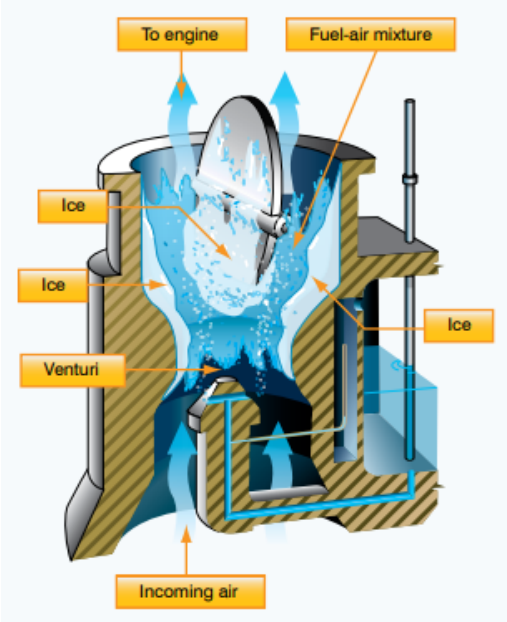
Common Errors

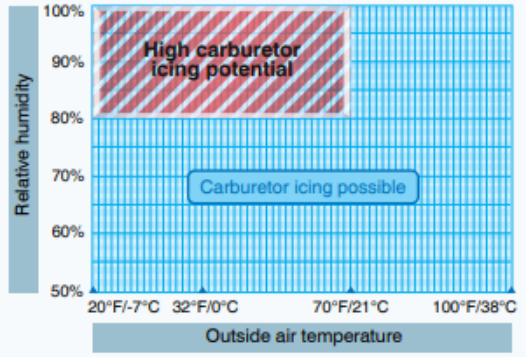
- **Failure to perform the appropriate emergency checklist.**
- **Failure to attempt to determine the cause of the malfunction.**

Ground Lesson Content

- **Be the Pilot in Command** - Be decisive. Make decisions in the interest of safety. Don't delay decision making.
    - **Startle Response** - It is normal for pilots to be startled when a system failures in flight, especially something like a door popping open. Keep calm and **Fly the Airplane** while evaluating what you will do.
    - **DECIDE Model** -
        - **D**- Detect the problem/Determine that an action is necessary
        - **E**- Estimate the significance of the action
        - **C**- Choose a desirable outcome
        - **I**- Identify actions needed in order to achieve the chosen option
        - **D**- Do the necessary action to achieve change
        - **E**- Evaluate the effects of the action
    - **Aviate, Navigate, Communicate** - The first responsibility of all pilots is to **maintain positive aircraft control at all times**. This is more important than troubleshooting problems, communicating with ATC, or navigation.
    - **Use all available resources** - Talk to ATC, ask for assistance, etc.
    - **Follow Emergency Checklists** - Always follow the appropriate emergency checklist!
- **Smoke and Fire** - Assume smoke means fire!
    - **On the Ground** - If during engine start, follow fire during start checklist. May need to evacuate and use a fire extinguisher if available.
    - **In Flight** - Fire in flight is a **dire emergency**, land immediately!
        - **Electrical Fire** - Turn off master switch, smoke/fumes in cockpit are a significant danger.
        - **Engine Fire** - Remove fuel source by cutting off mixture and fuel tanks, perform an emergency descent to increase airspeed and create an incombustible mixture. (Lean)

- **Engine Issues** - Prepare as if an engine failure is imminent.
    - **Rough running or partial power loss**
        - **Carb Ice** - The venturi effect of a carburetor creates low temperatures that can create carb ice even when outside temperatures are nowhere near freezing. When carb ice is suspected, apply carb heat immediately! If the engine runs rougher and then improves, carb ice was the likely cause.



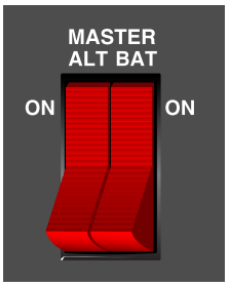


- **Fuel Starvation** - As a fuel tank runs dry, the engine may run rough momentarily before failure. Fast action to switch tanks or apply the fuel boost pump may avoid power loss.
- **Magneto Failure** - A failing magneto is a common cause of a rough running engine. The magnetos can be cycled in flight to determine if one has failed.
  - *Note: On aircraft with a controllable pitch prop, a magneto failure will be very hard to distinguish! (No loss of RPM, etc) Keep an eye out for an unexplained rise in EGTs!*
- **Internal Engine Failure (Stuck valve, etc.)** - Internal damage to the engine may cause a partial power loss. A total engine failure may be imminent.

- **Overheating** - Some overheating can be resolved in flight (e.g. by increasing airspeed), but overheating is a dangerous condition that should be monitored closely.
  - **CHT and Airspeed** - Flying at high power settings and low airspeeds can lead to excessively high cylinder head temperatures. Avoid prolonged climbs at Vx or Vy, particularly on hot days. **If your aircraft has cowl flaps, open them!**
  - **Low Oil Pressure** - Low oil pressure causes decreased lubrication, increased friction, and can lead to overheating. **Rising oil temperature is a sign of imminent engine failure!**
- **Low Oil Pressure** - Low oil pressure can lead to catastrophic failure of an engine and should always be considered an emergency.
  - **Low Oil Level** - Low oil level can cause low oil pressure by starving the oil pump.
  - **Imminent Engine Failure** - Low oil pressure will decrease lubrication and is usually an indication that total engine failure is imminent.
- **Total Engine Failure**
  - **Fuel Starvation** - Fuel starvation is one of the most common causes of engine failure. Be especially cautious when switching fuel tanks and verify that the fuel selector is fully in position! **Do not forget to switch tanks!**

    - **Carb Ice** - Carburetor ice that is not addressed promptly will lead to a total engine failure, which may not be easily corrected as the engine cools.
    - **Catastrophic Internal Engine Failure** - Total engine failure can also be caused (less commonly) by total failure of internal components.

- **Electrical Issues**
    - **Alternator Failure** - Alternators can fail in flight for a variety of reasons, including excessive load. All airplanes are equipped with a two-sided Master Switch, where cycling the alternator side of the switch resets the circuit breaker for the alternator. Cycling this switch may temporarily 'fix' the alternator, but pilots should assume it will fail again soon.



        - **Shed electrical load** - If electrical overload is the suspected cause, begin by turning off unnecessary electrical accessories or secondary radios.

Electrical Loads for Light Single	Number of units	Total Amperes
A. Continuous Load		
Pitot Heating (Operating)	1	3.30
Wingtip Lights	4	3.00
Heater Igniter	1	1-20
**Navigation Receivers	1-4	1-2 each
**Communications Receivers	1-2	1-2 each
Fuel Indicator	1	0.40
Instrument Lights (overhead)	2	0.60
Engine Indicator	1	0.30
Compass Light	1	0.20
Landing Gear Indicator	1	0.17
Flap Indicator	1	0.17
B. Intermittent Load		
Starter	1	100.00
Landing Lights	2	17.80
Heater Blower Motor	1	14.00
Flap Motor	1	13.00
Landing Gear Motor	1	10.00
Cigarette Lighter	1	7.50
Transceiver (keyed)	1	5-7
Fuel Boost Pump	1	2.00
Cowl Flap Motor	1	1.00
Stall Warning Horn	1	1.50

** Amperage for radios varies with equipment.
In general, the more recent the model, the less amperage required.
NOTE: Panel and indicator lights usually draw less than one amp.

        - **Battery expected runtime**- The airplane will run for several minutes to half an hour on battery, but **battery power must be conserved to operate flaps, radios, etc!**
    - **Popping Fuses/Circuit Breakers** - If circuit breakers are popping, there may be an electrical short, or an overload condition.
        - Shed electrical load by turning off non-critical items and then attempt to reset the breakers. **Do not continuously reset breakers if they keep failing, this could be evidence of a short circuit that could lead to an electrical fire!**
    - **Electrical short/fire** - Turn off Master Switch entirely!
        - Remember some airplanes need electricity for flaps! Prepare for a flapless immediate landing.
    - **Night Considerations** - Airplane Lights (such as landing lights) may be unavailable, and radios

are necessary to control Pilot-Controlled Lighting at non-towered airports. Carrying a portable VHF transceiver may be useful as a backup when making night flights.

- **Instrument Failure**
  - **Pitot/Static System** - Instruments such as the airspeed indicator, altimeter, and VSI depend on the pitot/static system. The failure of the pitot or static system is most commonly caused by blockages, usually in the form of ice or liquid, that collect in the pitot tube and static ports. If a pitot tube blockage is suspected, apply pitot heat. If a static port blockage is suspected, switch to the alternate static source.

Effect of Blocked Pitot/Static Sources on Airspeed, Altimeter, and Vertical Speed Indications	Indicated Airspeed	Indicated Altitude	Indicated Vertical Speed
Pitot source blocked	Increases with altitude gain, decreases with altitude loss.	Unaffected	Unaffected
One static source blocked	Inaccurate while sideslipping; very sensitive in turbulence.		
Both static sources blocked	Decreases with altitude gain, increases with altitude loss.	Does not change with actual gain or loss of altitude.	Does not change with actual variations in vertical speed.
Both static and pitot sources blocked	All indications remain constant, regardless of actual changes in airspeed, altitude, and vertical speed.		

  - **Vacuum System** - In airplanes with vacuum systems, a failure of this system will cause the attitude indicator and directional gyro to indicate unreliably. Monitor the suction or vacuum gauge, and **if vacuum failure is likely, cover the attitude indicator and directional gyro to prevent distraction!**
- **Hydraulic Issues**
  - **Brakes** - If hydraulic brakes fail, pilots can use aerodynamic braking to partially compensate.
- **Landing Gear** - Follow emergency extension procedures in the appropriate checklist. If unsuccessful, prepare to touch down at the lowest possible speed, ideally at a towered airport where emergency services will be available.

- **Door or Window Opening in Flight**
  - Normally this is a non-emergency! **Remember to fly the plane first!**
    - Some airplanes must land, some can be closed in flight *carefully.* It may be necessary to reduce airspeed or gently sideslip the airplane to allow closure of the door.
    - If closure is not possible, land and close the door or window.
- **Inoperative or "Runaway" Trim** - Runaway trim can be extremely dangerous and requires prompt action.
  - Runaway trim only occurs with electric trim, so be familiar with the location of the electric trim circuit breaker and be prepared to use it!
    - **In most aircraft, holding down the Autopilot Disconnect button will interrupt power to the trim system while you search for the breaker.**
  - If trim issues are suspected, stop using trim! Most airplanes can be landed safely even when trimmed incorrectly. Be prepared for increased control pressures.
- **Flap Malfunction** - The most dangerous flap malfunction is asymmetric flap extension. This would cause an uncontrollable roll to one side. If this happens, **reverse the flap setting immediately!**
  - Flapless landings are simple and should be practiced often. They simply require pilots to fly a slightly faster final approach.
- **Pressurization / Oxygen System Malfunction - Descend now!** The time of useful consciousness is very low, and pilots must descend below 12,500 feet as soon as possible. Consider an emergency descent!

Altitude	Time of useful consciousness
45,000 feet MSL	9 to 15 seconds
40,000 feet MSL	15 to 20 seconds
35,000 feet MSL	30 to 60 seconds
30,000 feet MSL	1 to 2 minutes
28,000 feet MSL	2½ to 3 minutes
25,000 feet MSL	3 to 5 minutes
22,000 feet MSL	5 to 10 minutes
20,000 feet MSL	30 minutes or more