Unit 2: Airplane Instruments, Engines, and Systems

2.1 Compass Turning Error

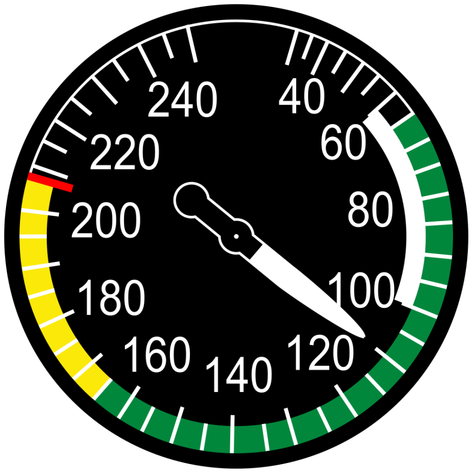
- Magnetic compasses can only be considered accurate during flight during straight-and-level flight at constant airspeed.
- Diff b/w a/c magnetic compass heading and magnetic compass heading not in an a/c is called deviation.
  - Magnetic fields caused by instruments and other metal parts in the aircraft disturb the compass needle.
- In the Northern Hemisphere: acceleration/deceleration error occurs when on an east or west heading.
  - Acronym - ANDS - accelerate north, decelerate south
  - When on an E/W heading, accelerating causes a magnetic compass to indicate a turn to the north
  - When on an E/W heading, decelerating causes a magnetic compass to indicate a turn to the south.
  - Acceleration/deceleration error does not occur when on a N/S heading.
- In the Northern Hemisphere, compass turning error occurs when turning from a north or south heading.
  - When turning from a north heading:
    - The compass lags and initially indicates a turn in the opposite direction.
    - If turning right (to the east), the compass initially indicates a turn to the west, then lags behind the actual heading until the a/c is facing east, where there is no error.
    - If turning left (to the west), the compass initally indicates a turn to the east, then lags behind the actual heading until the a/c is facing west, where there is no error.
  - When turning from a southern heading, the magnetic compass precedes (leads) the turn.
  - Turning errors do not occur when turning from an east or west heading.
- These errors diminish when the acceleration/deceleration or turn is completed.
- Magnets in a compass align with any magnetic field.
  - Fields can be caused by electric current, magnetic parts, current in the structure, etc.
  - Deviation changes with heading rather than with geographic location, unlike variation which depends on the location.

2.2 Pitot-Static System

- Pitot-static system is responsible for: altimeter, airspeed indicator, and vertical speed indicator.
- Pitot tube provides impact (or ram) pressure for the ASI only.

- If the static ports are clogged, all three of the above instruments provide inaccurate readings.
- If just the pitot tube is clogged, only the ASI provides an inaccurate reading.

2.3 Airspeed Indicator



- ASI markings are color coded.
  - White arc - full flap operating range
    - V_{S0} - lower limit of the white arc - power off stall speed with wing flaps and landing gear in landing position. (Think "V stall 0")
    - V_{FE} - upper limit of the white arc - maximum full flaps speed (Think V flaps extended)
  - Green arc - normal operating speed
    - V_{S1} - Lower limit of the green arc; power off stalling speed in a certain configuration, usually flaps up and gear up ("V Stall 1")
    - V_{NO} - upper limit of the green arc; maximum structural cruising speed for normal operations.
  - Yellow arc - "caution range"; only safe in smooth air.
  - Red radial line - V_{NE} - never exceed speed.
- Most important airspeed limitation NOT color coded is V_A - design maneuvering speed - max speed at which the a/c can be safely stalled; max speed for flight in turbulent air. It is the speed below which you can move a flight control one time in smooth air to its full deflection in only one axis without structural risk to the airplane.

2.4 Altimeter

- Altimeters have 3 hands like a clock. They are numbered 0-9
  - Short needle (or a short needle with a long, narrow tip and triangular end) is the 10,000 ft needle.
  - Medium needle is the 1,000 ft needle
  - Long needle is the 100 ft needle

- Reading an altimeter
  - First, determine whether the 10,000 ft needle is b/w 0 and 1, 1 and 2, or 2 and 3 - 1-10,000, 10,00-20,000, 20,000-30,000.
  - Then, determine the position of the 1,000 ft needle (between each whole number)
  - Then, determine the position of the 100 ft needle.

2.5 Types of Altitude

- AGL - absolute altitude, above ground level, altitude above surface
- MSL - true altitude - actual distance above mean sea level; not susceptible to variation with atmospheric conditions
- Density Altitude - pressure altitude corrected for nonstandard temperatures
- Pressure altitude - height above the standard datum plane of 29.92 inHg. It is the indicated altitude when the altimeter is set to 29.92.
  - Pressure altitude = density altitude at standard temperature.
- Indicated altitude = true altitude (MSL) when standard conditions exist and the altimeter is calibrated properly
- Pressure altitude = true altitude when standard atmospheric conditions exist.
  - Standard atmospheric conditions: 29.92 inHg and 15C at sea level
- When the altimeter is adjusted on the ground so that the indicated altitude equals true altitude at airport elevation, the altimeter setting is that for your location (approx the setting the control tower would give you)

2.6 Setting the Altimeter

- Indicated altitude increases when you increase the altimeter pressure setting.
  - This is opposite to the altimeter's reaction to changes in air pressure.
  - If outside pressure increases and the altimeter setting is not changed, the indicated altitude will decrease.
- Indicated altitude changes at approx 1,000 ft per 1 inHg pressure change.
  - Ex. changing the altimeter setting from 29.15-29.85 = +0.70 inHg = +700 ft indicated altitude change (1000 * .70)

2.7 Altimeter Errors

- Altimeter readings are adj for changes in pressure but nottemperature. When flying in colder than standard temp air, the aircraft will be **lower** than the indicated altitude. On warm days, the aircraft flies **higher** than the indicated altitude.
- When pressure drops en route at a constant indicated altitude, the aircraft indicates higher than actual altitude until it is adjusted.
- Remember: high to low, look out below; low to high, clear the sky. High to low pressure or temperature.

2.8 Gyroscopic Instruments

- Three main gyros: heading indicator, turn coordinator, and attitude indicator
- Attitude Indicator - "artificial horizon"

    - The relationship of the mini airplane to the horizon bar is the same as the relationship to the actual horizon. Ex. right bank - horizon tilts to the left
    - Banking scale indicates degrees of bank from level flight.
    - Adjustment knob can be used to move the mini airplane up and down to suit the pilot's line of sight.
    - Gyro rotates horizontally; depends on rigidity in space for its operation.
- Turn coordinator shows roll and yaw movement of the a/c. Displays a miniature airplane, which moves proportionally to the roll rate of the a/c. When the bank is constant, the turn coordinator indicates the rate of turn.
    - The ball indicates whether the bank angle and rate of turn are coordinated.
- Heading indicator - gyro depends on the principle of rigidity in space for its operation. Must be periodically aligned with the magnetic compass due to gyroscopic precession.
- When a certain bank or altitude is exceeded, the heading indicator may "spill". It can be reset with the caging knob.

2.9 Glass Cockpits

- Glass cockpits (systems of advanced avionics)
    - Generally provide flight information such as flight progress, engine monitoring, navigation, terrain, traffic, and weather
    - Designed to decrease workload, enhance situational awareness and increase safety margin.
    - Systems are displayed in an electronic flight display (EFD)
- PFD - primary flight display; type of EFD. Integrates all flight instruments critical to safe flight on one screen.
    - Some PFDs incorporate or overlay navigation instruments on top of primary flight instruments.
- MFD - multifunction display; type of EFD. Not only shows primary instruments but can combine information from multiple systems on one page or screen.
    - Ex. moving maps (which should only be used as a supplement, not a primary navigation instrument)
    - Onboard weather systems incl radar
    - Other info, such as terrain, traffic avoidance, checklists, fuel
- EFDs use an air data computer (ADC) which receives pitot and static inputs; calculates the pressure difference; then displays the information on the PFD.
- AHRS- Attitude and heading reference system - no free-spinning gyros; solid state laser systems are used instead - no tumbling.
    - AHRS sends attitude information to the PFD to display the information of the attitude indicator.
    - Heading information comes from a magnetometer that senses the earth's lines of magnetic flux.

- Reliance on glass cockpits should not negate safety. A regular scan, both visually outside and inside on backup gauges, should be combined with other means of navigation and checklists to ensure safe flight.

2.10 Engine Temperature

- Excessively high engine temperature either in the air or on the ground will cause loss of power, excessive oil consumption, and excessive wear on the internal engine.
- The engine is cooled in part by circulating oil to reduce friction and absorb heat from engine parts.
- Reasons that temps can become too high:
    - Using too much power
    - Climbing too steeply (i.e at too low airspeed) in hot weather
    - Using fuel that has a lower-than-specified octane rating
    - Mixture too lean (too much air to fuel)
    - Oil level too low
- Excessive engine temp can be reduced by reversing any of the above.

2.11 Constant-Speed Propeller

- The pilot can adjust the pitch (angle) of the blades for most efficient performance
- Has both throttle and propeller controls
    - Throttle controls power output, which is registered on the manifold pressure gauge
    - Propeller control regulate engine RPMs, which are registered on the tachometer
- To avoid overstressing cylinders, excessively high manifold pressure should not be used with low RPM settings.

2.12 Engine Ignition Systems

- One purpose of the dual-ignition systems is to provide for improved performance; other is for safety
- Loose or broken wires can cause problems. Ex: the ignition switch is off, but the magneto continues to fire because the ignition switch ground wire is disconnected. If this occurs, move the mixture lever to the idle cutoff position, then have the system checked by an A&P

2.13 Carburetor Icing

- Carburetor-equipped engines are more susceptible to icing than fuel-injected engines.
    - The operating principle of float-type carburetors is the difference in air pressure between the venturi throat and the air inlet.
    - Fuel-injected engines do not have a carburetor
- First indication of carb ice with fixed-pitch props and float-type carburetors is loss of RPM
- Carb ice is likely to form when outside air temp is b/w 20 and 70 F and humidity is high

- When carb heat is applied to eliminate carb ice in airplanes equipped with fixed-pitch props, the RPM decreases further (as the hot air entering the engine is less dense) and gradually increases as the ice melts.

2.14 Carburetor Heat

- Carb heat enriches the mixture b/c warm air is less dense than cold air.
    - When air density decreases (due to warm air) the mixture becomes richer b/c there is less air for the same amount of fuel.
- Applying carb heat decreases engine output and increases operating temp.

2.15 Fuel/Air Mixture

- At higher altitudes, the mixture must be leaned to decrease the fuel flow in order to compensate for the decreased air density (to keep the mixture constant)
    - If you descend from high to low altitude without enriching the mixture, it becomes leaner b/c the air is more dense.
- If running up the engine at a high-altitude airport, you can eliminate roughness by leaning the mixture, esp if the engine runs even worse with carb heat, since carb heat enriches the mixture (as above)
- The definition of "fuel/air ratio" is the ratio between the weight of fuel and weight of air entering the cylinder.

2.16 Abnormal Combustion

- Detonation - when the mixture explodes rather than burns evenly
    - Caused by using lower octane of fuel or excessive temp
    - Detonation causes excessive engine wear and higher-than-normal operating temps
- Lower the nose slightly if you suspect that an engine with a fixed-pitch prop is detonating during the climb after takeoff. Increased airflow helps cool the engine.
- Pre-ignition - uncontrolled firing of the fuel/air change in advance of the normal spark ignition.

2.17 Aviation Fuel Practices

- Using the next-higher octane grade is better than using the next-lower grade to prevent detonation and running hot.
- Filling the fuel tanks at the end of the day prevents moisture from building up in the tanks by eliminating the airspace for condensation to build.
- Drain all sumps and fuel strainer drains before each flight to ensure there is no water in the fuel.
- When the a/c has fuel pumps, the auxiliary electric fuel pump is used in the event the engine-driven fuel pump fails.

2.18 Starting the Engine

- After starting the engine, adjust the throttle for proper RPM and check the engine gauges, esp the oil pressure.

2.19 Cold Weather - Attention

- During cold weather conditions, pay special attention during the preflight.

- The crankcase breather lines may become clogged with ise. When crankcase vapor cools, it could condense and cool in the breather lines, clogging them.

2.20 Electrical System

- Most a/c have either 14 or 28 Volt DC electrical system.
- Engine driven alternators supply electrical current to the electrical system and maintain electrical charge on the battery.
    - The alternator voltage output should be higher than the battery voltage to ensure charging.
- The master switch turns on the electrical system, which provides current to all electrical systems except the ignition system. Ex: lights, radios, electric fuel pumps
- Ammeter shows if the alternator is producing an adequate supply of electrical power and indicates whether the battery is receiving an electrical charge.
    - Positive indication on ammeter - shows the rate of charging on the battery; negative indication - rate of change drain on the battery
- Alternators provide more electrical power at lower engine RPM than generators do.
    - Alternators vs generators: alternators only provide AC power, while generators can provide both AC and DC. Generators are less effective at low RPMs.
- Electrical system failure (battery and alternator) usually results in avionics systems failure.

Unit 2 Quiz: 94/98
Questions missed:
34. True altitude is vertical distance above MSL
43. When flying from an area of low pressure to an area of high pressure, the altimeter setting is now too low, and indicates a lower than actual altitude.
44. When flying from an area of high pressure to low pressure, the altimeter setting is now too high, indicating a higher than actual altitude.
51. The direction of bank is determined on an attitude indicator using the relationship between the mini airplane and horizon bar. It is confusing to use the direction of the banking scale because it may move in the opposite direction.