Unit 1: Airplanes and Aerodynamics

1.1 Flight Controls

- Primary flight controls
  - Ailerons - control roll; longitudinal axis
    - Move yoke to the right -> right aileron moves up; left aileron moves down -> decreased lift on right wing, increased lift on left wing -> rolls right
  - Elevator - control pitch; lateral axis
    - Stabilator - one-piece elevator
    - Pull back on yoke -> TE of elevator deflects up -> downward aerodynamic force -> tail moves down and nose pitches up
  - Rudder - control yaw; vertical axis
  - Flight controls are more effective with higher speed due to increased airflow
- Secondary flight controls
  - Flaps
    - Increase lift during approach and landing without increasing airspeed
    - Slotted flap - high pressure air from under the wing moves above the flap; delays airflow separation
  - Spoilers
    - Increase drag and reduce lift on wings to reduce airspeed
  - Trim systems
    - Used to relieve pilot of flight control pressure

1.2 Aerodynamic forces

- Lift, weight, thrust, drag
- Unaccelerated flight = equilibrium
- Bernoulli's Principle - high speed, low pressure; low speed, higher pressure
  - Air travels farther above the wing in the same amount of time; higher speed; lower pressure; lift

1.3 AOA

- Chord - line from LE to TE
- **AOA is the angle b/w wing chord line and direction of relative wind**
- Relative wind - director of airflow relative to the wing when the wing is moving through the air
- **Critical AOA - when stalls occur; remains constant regardless of weight, loading, airspeed, etc.**

1.4 Stalls

- a/c can stall at any airspeed, and in any attitude. Stalls occur when critical AOA is exceeded
- An a/c in a given configuration will stall at the same IAS regardless of altitude, since the ASI is directly related to air density

1.5 Spins

- Spins occur when one wing is stalled less than the other wing
- Descending corkscrew path
- A/c must always be stalled first before entering into a spin

1.6 Ground effect

- Result of aerodynamic interference b/w ground/water and airflow around the wing
- Vertical component of lift is restricted; alters the wing's upwash, downwash, and wingtip vortices
    - Upwash - upward movement of air at the LE; downwash - downward movement of air at the TE
- Requires lower aoa to produce same lift, or increases lift if aoa is kept constant
- A/c is affected by ground effect when it is within one wingspan of the ground; felt most within ½ wingspan abv ground
- Ground effect can cause floating on landings or cause a/c to become airborne on takeoff with insufficient airspeed
- Must consider ground effect when taking off and landing
    - Taking off with insufficient airspeed causes reduced initial performance b/c of greater induced drag
    - a/c could possibly become airborne and settle back down to the runway

1.7 Turning

- Horizontal component of lift causes the turn.
    - The pilot must coordinate the rudder, aileron, and elevator during a turn.
- Rudder controls yaw but doesn't cause turning

1.8 Stability

- Inherently stable - returns to original condition after disturbance
- CG location w/ respect to center of lift (center of pressure) determines longitudinal stability
    - Changes in center of pressure affects a/c's aerodynamic balance and control
- Airplanes normally pitch down when power is reduced b/c downwash on the elevators from the propeller slipstream is reduced, reducing elevator effectiveness, causing nose to drop
    - Advancing throttle in flight causes ground speed and AOA to increase
- **When CG is at or rear of the aft CG limit, the a/c develops an inability co recover from stall conditions, is less stable at all airspeeds, and has an increased likelihood of inadvertent overstress.**

1.9 Torque and P-Factor

- **Torque effect (left-turning tendency) is greatest at low airspeed, high angle of attack, and high power (such as during takeoff)**
- **P-factor - asymmetric propeller loading - causes a/c to yaw to the left at high AoA b/c descending right side of the prop (viewed from the rear) has a higher AoA than the ascending blade and provides more thrust.**

1.10 Load Factor

- Refers to additional weight carried by the wings due to the a/c's weight plus centrifugal force
    - Amount of excess wing loading varies directly w/ speed and available excess lift.
        - Low speeds - very little excess lit; very little excess load can be imposed
        - High speeds - wings' lifting capacity is so great that the load factor can quickly exceed safety limits
    - **Increased load factor = airplane stalls at a higher airspeed**
    - As bank angle increases, load factor increases.
- Load factor chart - match load factor with bank angle. Multiply load factor by a/c weight to determine total load. Gleim fig 2, pg 28
    - Ex: The wings of a 2,000 lb a/c in a 60 deg bank must support 4,000 lb
- Load factor is in G-units; a multiple of the regular weight or force of gravity.

1.11 Velocity vs G-loads

- When an airplane is forced into an accelerated stall at 2x the normal stall speed, the load factor is about 4 Gs
- Velocity vs. G-Load chart - plot load factor and possible impact on the airplane. G-load is on y-axis and IAS is on x-axis. Gleim fig 72, pg 29
- Diagonal white lines - show gusts of various strengths against airspeed and show resultant load factor
- V_S - stalling speed
- V_A - maneuvering speed
- V_{NO} - maximum structural cruising speed
- V_{NE} - never-exceed speed
- Load limit factor - ratio of max sustainable load imposed on the a/c to the gross weight of the a/c
- Exceeding positive or negative load limit factor or Vne causes structural damage or failure to the a/c.

Unit 1 Quiz: 47/48
Questions missed:
45. Limit load factor is the ratio of maximum sustainable load to the gross weight of the airplane.