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# II.E. Airplane Flight Controls

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| **Objectives** | The student should develop knowledge of the elements related to primary flight controls, trim control, and wing flaps. |
| **Key Elements** | ✈ Primary flight controls—airflow and pressure distribution<br>✈ Trim relieves control pressures<br>✈ Flaps increase lift and induced drag |
| **Elements** | ✈ Primary flight controls<br>✈ Trim controls<br>✈ Wing flaps |
| **Schedule** | 1. Discuss objectives<br>2. Review material<br>3. Development<br>4. Conclusion |
| **Equipment** | ✈ White board<br>✈ Markers<br>✈ References |
| **Instructor's Actions** | 1. Discuss lesson objectives<br>2. Present lecture<br>3. Questions<br>4. Homework |
| **Student's Actions** | Participate in discussion<br>Take notes |
| **Completion Standards** | The student can explain the primary flight controls, their function, and how they do what they do. The student understands how trim works and can more effectively use it, and understands the different types of flaps and their differing characteristics. |

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| **References** | FAA-H-8083-25B, *Pilot's Handbook of Aeronautical Knowledge* (Chapter 6) |

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# Instructor Notes

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| **Introduction** | Overview—review objectives and key ideas.<br>Why—airplane's attitude controlled by deflection of primary flight controls. When deflected, the primary flight controls change the camber and angle of attack of the wing/stabilizer and change its lift and drag characteristics. Trim controls are used to relieve the control pressures. Flaps create a compromise between a high cruise speed and low landing speed. |
| **Primary flight controls** | Required to safely control the airplane during flight.<br>Secondary control systems improve performance characteristics or relieve excessive control forces (wing flaps, trim systems). |
| Ailerons | Control roll about the longitudinal axis. Operated through steel push rods.<br>Interconnected—operate simultaneously in opposite directions.<br><br>Moving controls to the right—causes right aileron to deflect upward and the left downward—upward deflection decreases camber and therefore lift, downward deflection increases camber and therefore lift—increased lift on the left/decreased lift on the right cause the aircraft to roll to the right. |
| Turning | Airplane turns because of the horizontal lift component.<br>Banked wings—horizontal and vertical component to lift. Horizontal component counteracts the centrifugal force pulling the airplane straight ahead. |
| Adverse yaw | Downward deflected aileron produces more lift, but also more induced drag.<br>Added drag attempts to yaw the nose in the direction of the raised wing.<br>Use rudder to counteract adverse yaw—more at low airspeed/high angle of attack and with large aileron deflections. |
| Types of ailerons | Differential ailerons—one aileron is raised a greater distance than the other is lowered, to produce an increased drag on the descending wing and reduce adverse yaw.<br><br>Frise-type ailerons—aileron being raised pivots on an offset hinge, which projects the leading edge of the aileron into the airflow, creating drag. Helps equalize drag created by the lowered aileron, reducing adverse drag. |

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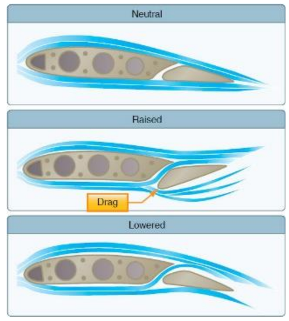
| | Slot forms, air flows smoothly over low aileron, more effective at high AOA.<br><br><br><br>Adverse yaw is not eliminated—coordinated rudder is still required.<br><br>172RG: Differential and Frise-type; down 20°—up 15° |
| Elevator | Control pitch about the lateral axis. Operated through steel push rods.<br><br>Pulling controls backwards deflects the trailing edge up—decreases the camber of the elevator, creates downward aerodynamic force—tail moves down, nose moves up about CG. Moving controls forward deflects trailing edge down, increasing the camber, creating more lift, moving the tail upward and pitching the nose down.<br>Strength determined by distance between CG and horizontal tail surface. |
| Types of elevators | T-tail: elevator above most effects of downwash from the propeller and airflow around the fuselage and wings in normal flight—consistent control movements in most flight regimes.<br>Slow speeds—elevator must be moved through a larger number of degrees to raise the nose a given amount, since it doesn't have the downwash to assist in raising the nose.<br><br>Stabilator: movable horizontal surface, combines horizontal stabilizer and the elevator.<br>Controls pulled back—stabilator's trailing edge raises, rotates nose up. Pushing forward—lowers trailing edge and pitches the nose down.<br>Anti-servo tabs incorporated on trailing edge to decrease sensitivity. Move in the same direction of the trailing edge. Movement of antiservo tab causes it to be deflected into the slipstream, providing a resistance so that the pilot does not overcontrol the airplane. |
| Rudder | Controls yaw around the vertical axis.<br>Operated through cables. |

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| | When the rudder is deflected, it exerts a horizontal force in the opposite direction. Pushing the left pedal moves the rudder left, altering the airflow around the vertical stabilizer, creating a sideward lift—moves the tail right, yaws the nose to the left.<br>Effectiveness increases with speed. Any slipstream flowing over the rudder increases effectiveness.<br><br>Primary purpose is to counteract adverse yaw and provide directional control and coordination. |
| **Trim controls** | Used to relieve the need to maintain constant pressure on the flight controls.<br>Usually consist of cockpit controls and small hinged devices attached to the trailing edge of primary control surfaces.<br>Minimize workload by aerodynamically assisting movement/position of controls. |
| Trim tabs | Most common installation. Single trim tab attached to the trailing edge of the elevator. Operated manually through control wheel/crank.<br>Moves in opposite direction of elevator surface—placing the trim in full nose-down moves the tab to its full up position.<br>Tab up, into airstream, airflow over the tail forces the elevator down, causing the tail to move up, resulting in a nose-down pitch change.<br>Tab down, air flowing under the tail hits the tab forcing the elevator up, reduces elevator's AOA, causing the tail to move down, resulting in a nose-up pitch change. |
| Balance tabs | Look/function like trim tabs, but they are attached to the control surface rod.<br>When controls are deflected, the tab automatically moves in the opposite direction, easing the load.<br>If the linkage is adjustable from the cockpit, the tab acts as both a trim and balance tab. |
| Antiservo tabs | Serve to decrease sensitivity and also as trim devices to relieve and maintain control pressure.<br>When the trailing edge of the stabilator moves up, the trailing edge of the tab moves up. Works the same way as the balance tab, but moves in the same direction. |
| Ground adjustable tabs | Metal trim tab on the rudder bent in either direction while on the ground to apply a trim force. Displacement found through trial and error. |
| **Flaps** | Most common high lift devices. Attached to the trailing edge of each wing to increase lift and induced drag for any given AOA. |

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| | ✈ Allow compromise between high cruise and low landing speeds, since they can extend and retract.<br>✈ Allow for a slower landing speed, decreasing landing distance.<br>✈ Allow for a steeper descent angle without increasing speed and safe obstacle clearance.<br>✈ Can be used to shorten the takeoff distance and provide a steeper climb path.<br><br>White arc on airspeed indicator. |
| Plain | Simplest type of flaps—they increase the camber, resulting in a significant increase in the coefficient of lift at any given AOA. Drag also greatly increased. Center of pressure moves aft on airfoil, resulting in a nose down pitching moment. |
| Split | Deflected from lower surface of airfoil. Produces slightly greater increase in lift than plain flaps. Produce more drag because of the turbulent airflow behind the airfoil. |
| Slotted | Most popular on airplanes currently. Increase lift coefficient significantly more than plain/split flaps. When lowered, flap forms duct between flap well in wing and flap's leading edge. High energy air from lower surface is ducted to the upper surface, accelerating upper boundary layer, delaying airflow separation, resulting in a higher coefficient of lift. |
| Fowler | Type of slotted flap which changes the camber of the wing and increases the wing area. Slides backward on tracks and then retracts downward.<br>The first portion of the extension increases lift a lot and drag very little. As the extension continues, the flap drops downward, increasing drag a lot and lift a little.<br><br>Provides the greatest amount of lift with the least amount of drag; creates the greatest change in pitching moment. |
| Flap control | Pilot-controlled (manually, electrically, or hydraulically).<br>172RG: 3-position electrical operating switch.<br>Flap settings:<br>✈ Cruise: 0°<br>✈ Takeoff: 0° (Soft field: 10°)<br>✈ Landing: 30° |
| **Spoilers** | Disrupt the airflow over the wing, killing left and controlling rearward stall. Puts more weight/pressure on the wheels for more effective braking. Increases drag to slow plane down. |

Can also assist in turning the plane if needed to increase bank.

**Autopilot**

Pilot relieve modes.
Reduces pilot’s workload.
Can maintain direction and altitude, accounts for the wind.
Conflicting signals or unusual attitudes might disengage the autopilot.

**Canard**

Make attaining a higher AOA harder, but increases maneuverability when there and can maintain higher AOA better.
May provide lift after the main wing has stopped providing lift.

**Conclusion**

Brief review of main points.
Airplane's attitude controlled by deflection of primary flight controls.
Trim controls relieve necessary control pressures.
Flaps increase lift and induced drag, creating compromise between high cruise speed and low landing speed.

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**CFI PTS**

**Objective:** To determine that the applicant exhibits instructional knowledge of the elements related to the airplane flight controls by describing the purpose, location, direction of movement, effect, and proper procedure for use of the:

1. Primary flight controls.
2. Secondary flight controls.
3. Trim controls.

**Slat vs slot**

Slat extends out for tighter boundary layer

Slot is a hole in the wing, permanent and fixed, also keeps boundary layer under control

RG aileron has balance weights

Bicycle chain for autopilot