Airplane Flight Dynamics (AERO0110)

Instructor: Willem AJ Anemaat

Course Highlights

• General airplane equations of motion
• Review of basic aerodynamic concepts
• Longitudinal aerodynamic forces and moments
• Lateral-directional aerodynamic forces and moments
• Thrust forces and moments
• The concept of static stability
• Applications of the steady state airplane equations of motion
• Effects of the flight control system; control forces
• Applications of the perturbed state equations of motion
• Dynamic stability: short period, phugoid, Dutch Roll, spiral and roll mode
• Review of flying qualities criteria
• Introduction to human pilot transfer functions
• Synthesis of stability augmentation systems

Course Description
Participants learn an overview of airplane static and dynamic stability and control theory and applications as well as classical control theory and applications to airplane control systems. An overview of flying qualities and regulations is included.

Who Should Attend?
Aeronautical engineers, mechanical engineers, electrical engineers needing to learn more about flight dynamics, along with pilots with some engineering background, government research laboratory personnel, engineering managers and educators.

Learning Objectives

• Airplane dynamic behavior
• How to perform trim
• How to check stability
• How aerodynamics and propulsion affect flying qualities and trim
• Introduction to stability augmentation systems
Course Outline

Day One

• The general airplane equations of motion: reduction to steady state and to perturbed state motions; emphasis: derivation, assumptions and applications
• Review of basic aerodynamic concepts: airfoils—lift, drag and pitching moment, lift-curve slope, aerodynamic center; Mach effects; fuselage and nacelles—destabilizing effect in pitch and in yaw; wings, canards and tails—lift, drag and pitching moments; lift-curve slope; aerodynamic center; downwash; control power
• Longitudinal aerodynamic forces and moments: stability and control derivatives for the steady state and for the perturbed state, example applications and interpretations

Day Two

• Lateral-directional aerodynamic forces and moments: stability and control derivatives for the steady state and for the perturbed state, example applications and interpretations
• Thrust forces and moments: steady state and perturbed state
• The concept of static stability: definition, implications and applications
• Applications of the steady state airplane equations of motion: longitudinal moment equilibrium, the airplane trim diagram (conventional, canard and flying wing), airplane neutral point, elevator-speed gradients, the nose-wheel lift-off problem; neutral and maneuver point (stick fixed)
• Applications of the steady state airplane equations of motion: lateral-directional moment equilibrium, minimum control speed with engine-out

Day Three

• Effects of the flight control system: reversible and irreversible flight controls; control surface hinge moments, stick and pedal forces, force trim; stick-force gradients with speed and with load factor; neutral and maneuver point stick free; effect of tabs—trim-tab, geared-tab, servo-tab, spring-tab; effect of down-spring and bob-weight; flight control system design considerations—reversible and irreversible, actuator sizing and hydraulic system design considerations
• Applications of the perturbed state equations of motion—complete and approximate longitudinal transfer functions; short period, phugoid, third mode, connections with static longitudinal stability, sensitivity analyses, equivalent stability derivatives; complete and approximate lateral-directional transfer functions—roll mode, spiral mode, Dutch roll mode and lateral phugoid, connections with static lateral-directional stability, sensitivity analyses, equivalent stability derivatives

Day Four

• Review of flying qualities criteria; MIL-F-8785C and FARs, Cooper-Harper ratings, relation to the airworthiness code
• Introduction to human pilot transfer functions; analysis of airplane-plus-pilot-in-the-loop controllability; synthesis of stability augmentation systems—yaw dampers, pitch dampers; effect of flight condition, sensor orientation and servo dynamics
Day Five

- Stability augmentation systems—yaw dampers, pitch dampers, α-feedback, β-feedback; longitudinal modes—attitude hold, control-wheel steering, altitude hold, speed control and Mach trim; lateral-directional modes—bank-angle hold, heading hold; coupling problems—roll-pitch and roll-yaw coupling, pitch rate coupling into the lateral-directional modes; effects of aeroelasticity—aileron reversal, wing divergence, control power reduction; effect of aeroelasticity on airplane stability derivatives
- Exercise using the Advanced Aircraft Analysis software showing stability and control derivatives, trim diagram, longitudinal and lateral-directional trim, take-off rotation, dynamics and flying qualities.

Classroom hours / CEUs
35.00 classroom hours
3.5 CEUs

Certificate Track
Aircraft Design, Flight Tests and Aircraft Performance

Course Fees
Early registration course fee: $2,495 if you register and pay by the early registration deadline (45 days out).

Regular registration course fee: $2,695 if you register and pay after the early registration deadline.

U.S. Federal Employee Discount
This course is available to U.S. federal employees at 10% off the registration fee. To receive the federal employee discount, you must enter the code FGV116 during the checkout process. Please note that you must validate your eligibility to receive this discount by entering your U.S. government email address (ending in .gov or .mil) when creating your online registration profile. This discount is available for both the early registration and regular registration fees.

Canada Department of National Defence Discount
This course is available to Canada DND employees at 10% off the registration fee. Please contact the DND Procurement Authority (DAP 2-3) for details. Please note that you cannot register using our online system when requesting this discount. This discount is available for both the early registration and regular registration fees.

Netherlands Defence Academy Discount
This course is available to Netherlands Defence Academy employees at a discounted registration fee. Please contact the NDA Procurement and Contracting department for details. Please note that you cannot register using our online system when requesting this discount.
This class is available for delivery at your company.
Your company can realize substantial savings by bringing an aerospace short course to your workplace. On-site delivery is ideal for organizations that need to train 10 or more employees on a specific topic. For more information on on-site course delivery, or to request a cost proposal, please contact us at 913-897-8782, or email us at ProfessionalPrograms@ku.edu.

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