

AEROSPACE

SHORT COURSES

Airplane Flight Dynamics (AERO0110)

Instructor: Willem A.J. Anemaat

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.

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

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: \$2,595 if you register and pay by the early registration deadline (45 days out).

Regular registration course fee: \$2,795 if you register and pay after the early registration deadline.

Course Materials

Course materials, including outlines, presentation copies, and supplementary materials, will be accessible through Canvas, KU's online learning system. Instructions to access Canvas will be provided upon completed registration. Students are required to bring a computer or other electronic device with PDF-viewing capabilities with them to class each day. If you require accommodation contact us at professionalprograms@ku.edu and we will work with you on an accessible solution.

Students enrolled in this class should acquire a copy of the textbook(s) listed below.

- Textbook Name:
 - Airplane Flight Dynamics & Automatic Flight Controls Part 1
 - Airplane Flight Dynamics & Automatic Flight Controls Part 2
- URL: [Airplane Flight Dynamics & Automatic Flight Controls 2 Part Set \(darcorp.com\)](http://darcorp.com)

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 **FGVT116** 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.

Instructor Bio

Willem A. J. Anemaat is president and co-founder of Design, Analysis and Research Corporation (DARcorporation), an aeronautical engineering and prototype development company. DARcorporation specializes in airplane design and engineering consulting services, wind and water tunnel testing and design and testing of wind energy devices. Anemaat is the software architect for the Advanced Aircraft Analysis (AAA) software, an airplane preliminary design and analysis tool. He has been actively involved with more than 400 airplane design projects and has run many subsonic wind tunnel tests for clients. Anemaat has more than 30 publications in the field of airplane design and analysis. He is the recipient of the SAE 2010 Forest R. McFarland Award, an AIAA Associate Fellow and an associate editor for the AIAA Journal of Aircraft. Anemaat is Vice-Chair of the AIAA Aircraft Design Technical Committee. Anemaat holds an M.S.A.E. degree from the Delft University of Technology in The Netherlands and a Ph.D. in aerospace engineering from The University of Kansas.

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