AEROSPACE ENGINEERING (LM52)

(Brindisi - Università degli Studi)

Teaching ATMOSPHERIC AND SPACE FLIGHT DYNAMICS (MOD.2) C.I.

GenCod A005138

Owner professor Giulio AVANZINI

Teaching in italian ATMOSPHERIC AND SPACE FLIGHT DYNAMICS (MOD.2) C.I.

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SSD code ING-IND/03

Reference course AEROSPACE ENGINEERING

Course type Laurea Magistrale

Credits 6.0

Teaching hours Front activity hours: 54.0

For enrolled in 2024/2025

Taught in 2024/2025

Course year 1

Language

Curriculum SPACE TECHNOLOGY

Location Brindisi

Semester Second Semester

Exam type Oral

Assessment

Course timetable https://easyroom.unisalento.it/Orario

BRIEF COURSE DESCRIPTION

The course is aimed at introducing the student to the methods for modeling the dynamic behavior of an aircraft as a function of its aerodynamic configuration, propulsion system and inertial characteristics. Based on models derived on first principles, the students will learn the tools necessary for the determination of aircraft characteristics in terms of static and dynamic stability and response to controls. The course is focused on the dyanmics of rigid aircraft. Effects of structural deformation on stability and control are introduced at an elementary level. A few notion on rotorcraft dynamics (helicopter trim and rotor blade flapping dynamics) and satellite attitude dynamics and control are also provided.

Tutorials will allow the students to apply the notions learned to representative examples and case studies, maturing the capabilitiy of interpreting aircraft and spacecraft motion as a function of controls.

REQUIREMENTS

Basic knowledge of fluid-dynamics and a good knowledge of flight mechanics and analytical dynamics are highly recommentded.

COURSE AIMS

A the end of the course the student is ecpected to be able to

1) determine trim conditions, aircraft stability and response to controls for conventional configurations;

2) understand basic features of rotary wing aircraft dynamics and its response to controls;

3) understand basic features of rigid spacecraft dynamics and how to control it;

4) handle mathematical and numerical tools for simulating aircraft and spacecaft dynamic behavior.

TEACHING METHODOLOGY	The course is delivered with class and laboratory activities, in three different forms: - **standard class lectures**, where the teacher presents methods and models; students are encouraged to participate by discussing validity of the assumptions at the basis of the models and physical meanings of the results derived from the analysis performed; ***example:*** *derive the expression of aircraft neutral point*; - **tutorial classes**, during which problems are stated, where the students refine their understanding, by numerically evaluating aircraft performance from geometric, propulsion and aerodynamics characteristics; the teacher supports the class by recalling relevant models and highlighting the procedure; some calculations (e.g. for a different set of parameters) can be proposed to the students as homework; ***example:*** *evaluate the position of aircraft neutra point from aircraft geometric and aerodynamic data*; - **computer lab. classes**, where students are required to write simple computer programs for performing parametric analysis, and/or use or implement Simulink models for simulation; ***example:*** *evaluate aircraft response in simulation for differnet control inputs*. Results from homework and conputer lab classes will be collected in a report to be delivered and discussed during the oral exam.
ASSESSMENT TYPE	The exam is oral. The exam starts with a discussion of the projects proposed during the tutorials and lab. classes in order to evaluate the capability of the student in analyzing complex problems, where numerical tools or a large number of calculations are required, using some mathematical programming software and/or simulation tools. The oral exam also includes the discussion of more general aspects regarding aircraft and helicopter dynamics, spacecraft attitude dynamics and control.
ASSESSMENT SESSIONS	Exam diets are performed according to current University reguations (3 exam diets at the end of each semester, 1 exam diet in September, 2 extraordinaty exam diets for students who finished the regular course). Exact dates are provided on the University website, as soon as they are available.
OTHER USEFUL INFORMATION	**Orario di ricevimento:** al termine delle lezioni, oppure previo appuntamento da concordare via e-mail (indirizzo istituzionale giulio.avanzini@unisalento.it). **Office hours:** at the end of the lectures or arranging a meeting, to be scheduled by sending a request via e-mail to giulio.avanzini@unisalento.it.

FULL SYLLABUS

- Equations of motion for rigid aircraft (4 hours).
- Equilibrium in the longitudinal plane: longitudinal static stability; longitudinal control and trim; directional stability and dihedral effect; lateral-directional control; non-symmetric flight (6 hours).
- Tutorials on trim curves and static stability (4 hours)
- Dynamic stability: linearization of aircraft equations of motion; stability derivatives; longitudinal dynamics; lateral-directional dyanmics (16 hours)
- Tutorials on dynamic stability and response to controls (4 hours)
- Nonlinear phenomena: inertial coupling; autorotation; spin (2 hours).
- Rotary-wing aircraft: helicoper commands; swashplate; flap dynamics (4 hours).
- Project 1: Laboratory on basic facts in aircraft flight simulation (4 hours)
- Rigid spacecraft dynamics: free-spinning motion and passive stabilization (4 hours).
- Rigid spacecraft active control: sensor and actuators; control tecniques (4 hours).
- Project 2: Laboratory on spacecaft attitude dynamics simulation (4 hours)

REFERENCE TEXT BOOKS

Flight Dynamics

B. Etkin. *Dynamics of Atmospheric Flight*. Dover, 2005 (original hardcover edition: , J. Wiley & Sons, 1972)
B.L. Stevens, and F.L. Lewis. *Aircraft Control and Simulation*, 2nd edition, , J. Wiley & Sons, 2003
R.F. Stengel. *Flight Dynamics*, Princeton University Press, 2004
G. Guglieri, and C.E.D. Riboldi. *Introduction to Flight Dynamics*. CELID, 2014
M. R. Napolitano. *Aircraft Dynamics (from modeling to simulation)*, J. Wiley & Sons, 2012.

In Italiano
M. Calcara, *Elementi di Dinamica del Velivolo*, Edizioni CUEN, Napoli, 1988

Suggested readings from...

M.J. Abzug and E.E. Larrabee. *Airplane Stability and Control: a History of the Technologies that Made Aviation Possible*. Cambridge University Press, 1997.

Handbooks on spacecraft attitude dynamics and control

Bong Wie. *Space Vehicle Dynamics and Control*, 2nd ed., AIAA Education Series, 2008
P.C. Hughes. *Spacecraft Attitude Dynamics*, Dover, 2004 (original hardcover edition: , J. Wiley & Sons, 1986)

In Italiano

G. Mengali e A. Quarta. *Fondamenti di Meccanica del Volo Spaziale*, Pisa University Press, 2013