AEROSPACE ENGINEERING (LM52)

(Brindisi - Università degli Studi)

Teaching FLIGHT MECHANICS (MOD.2) C.I.

GenCod A005144

Owner professor Giulio AVANZINI

Teaching in italian FLIGHT MECHANICS (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 Ore-Attivita-frontale: 54.0

For enrolled in 2020/2021

Taught in 2020/2021

Course year 1

Language INGLESE

Curriculum CURRICULUM AEROSPACE DESIGN

Location Brindisi

Semester Primo-Semestre

Exam type Orale

Assessment

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

BRIEF COURSE DESCRIPTION

The course is aimed at introducing the student to the methods for estimating aircraft performance as a function of aerodynamic configuration and propulsion system. Based on models derived from first principles, the students will learn how to evaluate fixed-wing aircraft range and endurance, flight envelope, take-off and landing distance, climb and turn performance. The course is mainly focused on rigid fixed-wing aircraft, but a few notion on rotorcraft performance and space flight mechanics (orbits, orbit perturbations and orbital maneuvers) are also provided.

Tutorials will allow the students to apply the notions learned to representative examples and case studies, developing the capabilitiy of solving simple problems and write computer programs that allow for a systematic analysis of the relation between aircraft characteristics and its expected behavior.

REQUIREMENTS

Good knowledge of physics (mechanics, in particular), analytical mechanics and basic tools of calculus are necessary.

COURSE AIMS

At the end of the course the student is expected to

1) understand the relations between aircraft configuration, mission requirements and expected performance;

2) evaluate performance from the knowledge of aerodynamic and propulsion characteristics;

3) understand basic features of rotary wing aircraft configurations and evaluate their performance;

4) understand basic features of space flight mechanics;

5) handle mathematical tools and write simple software programs in order to develop the ability for quantitative analysis of aircraft behavior as a function of design parameters.

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 expressions for minimum and maximum airspeed of a turbojet aircraft;
- **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 minimum and maximum airspeed of a turbojet aircraft at a given altitude, knowing maximum thrust-to-weight ratio and aerodynamic coefficients;
- **computer lab. classes**, where students are required to write simple computer programs for performing parametric analysis, in order to assess aircraft performance for a wider range of design variables; example: plot the flight envelope of a turbojet aircraft in the altitude vs airspeed plane.
Results from homework and conputer lab classes will be collected in a report to be delivered and

ASSESSMENT TYPE

The written test is divided into 2 parts.
Part 1, to be completed in 90 minutes, **without using books or lecture notes**:
- 2 theoretical questions, that require analytic evaluation of some physical facts regarding aircraft performance and/or dynamics;
- 2 descriptive questions, where the student is required to demonstrate his understanding of some specific facts of aircraft configuration, systems or features of its dynamic behaviour;
Part 2, to be completed in 60 minutes, **using books and/or lecture notes**:
- 2 problems, where the students prove their ability in quantitavely evaluating aircraft performance from its geometrical, inertial and aerodynamic characteristics.
The use of programmable devices and/or devices connected to the internet is strictly forbidden.
Calculations can be performed by means of a non-programmable scientific calculator.

The oral exam starts with the discussion of the results of homeworks and activities performed in the computer lab., collected in a report, in order to assess the capability of the student in solving more complex problems, where numerical tools or a large number of calculations are required, using some mathematical programming software and/or spreadsheet.
The oral exam also includes the discussion of more general aspects regarding aircraft configuration or performance, in the large.

ASSESSMENT SESSIONS

Exam diets are performed according to current University regulations (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

- Fixed wing aircraft: configurations, applied aerodynamics and basic facts (8 hours)
- International Standard atmosphere and on-board instruments (4 hours)
- Performance Analysis: steady state flight; gliding flight; flight envelope; propulsion systems and propellers; cruise; climbing flight; maneuvers and turning flight; take-off and landing (12 hours)
- Tutorials on performance evaluation (10 hours)
- Project 1: Determination of the balanced field length (2 hours)
- Project 2: Optimal climb strategy for supersonic aircraft (2 hours)
- Rotary-wing aircraft: configuration and commands; actuator disk theory; required power estimate (4 hours).
- Keplerian orbits (3 hours). Space environment and orbit perturbations (2 hours). Orbit maneuvers (3 hours).
- Project 3: Laboratory on basic facts on orbit dynamics and orbit transfers (4 hours)

REFERENCE TEXT BOOKS

Introduction to Aeronautics

Darrol Stinton. *The Anatomy of the Aeroplane*, 2nd ed., Blackwell science, 1998
E. Torenbeek. *Flight Physiscs*, Springer, 2009
Holt Ashley. *Engineering Analysis of Flight Vehicles*, Dover, 1992
Barnes W. McCormick. *Aerodynamics, Aeronautics, and Flight Mechanics*, J. Wiley & Sons, 1994
Richard Von Mises, *Theory of Flight*, Dover, 1959
Daniel P. Raymer. *Aircraft design: a conceptual approach*, 4th ed., AIAA Education Series, 2006

Performance

Francis J. Hale. *Introduction to Aircraft Performance, Selection and Design*. J. Wiley & Sons, 1984
J. D. Anderson jr. *Aircraft Performance and design*, McGraw Hill, 1999
J.B. Russell. *Performance and Stability of Aircraft*, Arnold, 1996
Nguyen X. Vinh. *Flight Mechanics of High Performance Aircraft*, Cambridge University Press, 1995
D.R., Kermode (R.H., Philpott and A.C. Barnard editors). *Mechanics of Flight*, 11th ed. Prentice Hall, 2006

In Italiano

A. Lausetti e F. Filippi. *Elementi di Meccanica del Volo*. Levrotto e Bella, 1956
M. Calcara, *Elementi di Dinamica del Velivolo*, Edizioni CUEN, Napoli, 1988
M. Venuti, *Aerodinamica Oggi*, TOTEM, 2002
G. Guglieri. *Introduzione alla Meccanica del Volo*. CELID, 2005

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 space flight mechanics (orbital dynamics and orbit maneuvers

R. Battin. *An Introduction to the Mathematics and Methods of Astrodynamics*, AIAA Education Series, 1987
Roger B. Bate, Donald D. Mueller, and Jerry E. White, *Fundamentals of Astrodynamics*, Dover, 1971
D.A. Vallado. *Fundamentals of Astrodynamics and Applications*, Microcosm Press, 2013
F.P.J. Rimrott, *Introductory Orbit Dynamics*, Vieweg, 1989

In Italiano

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