Course guide
220031 - DHAD - Helicopter and Aircraft Design

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Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 220 - ETSEIAT - Terrassa School of Industrial and Aeronautical Engineering.

Degree: BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 4.5 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Jordi Estrada
Daniel Yago

Others:

PRIOR SKILLS

The Helicopter and Aircraft Design subject is multidisciplinary and requires the knowledge of the concepts taught in previous subjects in order to complete it successfully.

Apart from the fundamental subjects of the first years, in particular Mathematics (Algebra and Calculus) and Physics, it is strongly recommended to have taken and passed the more technical subjects, such as Mechanics, Fluid Mechanics, Aerospace Vehicles, Theory of Structures, Aerodynamics, Aerospace Structures and Flight Mechanics.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE25. Adequate knowledge and application to Aeronautical Engineering of: design and project calculation methods for aircraft; the use of aerodynamic experimentation and the most significant parameters in theoretical application; handling of experimental techniques, equipment and measurement instruments specific to the discipline; simulation, design, analysis and interpretation of experimentation and flight operations; aircraft maintenance and certification systems. (Specific Technology Module: Aircraft)
CE26. Adequate applied knowledge in: aerodynamics, mechanics, and thermodynamics, flight mechanics, aircraft engineering (fixed-wing and rotary-wing), and theory of structures. (Specific technology module: Aircraft)

TEACHING METHODOLOGY

Teaching methods basically fall into:
1. Theoretical contents in attended sessions, made with the help of presentations and / or other documents previously uploaded in Athena.
2. Practical exercises in attended sessions, for the direct application of the theory. Teacher proposes exercises and gives instructions for the students, so that autonomously they obtain the resolution. Shortly before the end of the class, the teacher gives the solution with the final results, so that students can compare their numerical values.
3. Teamwork assignments, in which a project is proposed, that students should develop out of class time.

LEARNING OBJECTIVES OF THE SUBJECT

The main objective of this course is to introduce the student to the different aspects related to the design of rotary-wing aircraft:
1. Understand and identify the different elements and systems comprising a rotary wing aircraft (mainly the helicopter).
2. Understand the physical principles that support the theory of rotary wing aircraft, in particular the momentum theory and the blade element theory.
3. Using the aforementioned theories, apply them properly in order to compute performance of rotary wing aircraft, as well as its stability and controllability.
4. Acquire knowledge that enables to carry out the preliminary design of a helicopter and justify techniques used on a particular design....

STUDY LOAD

Type	Hours	Percentage
Hours medium group	14,0	12.44
Self study	67,5	60.00
Hours large group	31,0	27.56

Total learning time: 112.5 h

CONTENTS

- Module 1: General Concepts and Description of Helicopters

Description:
Topic 1. Introduction to helicopters and other aircrafts.
Topic 2. Definition and description of helicopter components: Rotor, Blades, Transmission, Control system, Engine, Hydraulics, Fuel system, Electrical system, Instruments and Auxiliary systems.

Full-or-part-time: 4h 30m
Theory classes: 2h 30m
Self study : 2h

- Module 2: Theoretical Fundamentals of Helicopters

Description:
Topic 3. Momentum Theory. Axial flight.
Topic 4. Blade Element theory. Axial flight.
Topic 5. Combination of the two theories.
Topic 6. Constant induced velocity rotors.
Topic 7. Momentum Theory. Forward flight.
Topic 8. Blade Element theory. Forward flight.
Topic 9. Equilibrium of moments. Anti-torque rotor.

Full-or-part-time: 26h
Theory classes: 6h 30m
Practical classes: 4h
Self study : 15h 30m

- Module 3: Dynamics and Vibrations of Blades

Description:
Topic 10. Blade Dynamics
10.1. Fully articulated rotor: static balance and dynamic response
10.2. Other types of rotors: semi-rigid, flexible (hingeless) and teetering rotors

Full-or-part-time: 5h 30m
Theory classes: 2h 30m
Self study : 3h

- Module 4: Stability and Control of Helicopters

Description:
Topic 11. Stability and control. General approach.
Topic 12. Helicopter equilbrium.
12.1. Equilibrium of moments. Anti-torque rotor.
12.2. 2D Force equilibrium.
12.3. 3D forces and moments equilibrium.
Topic 13. Static and dynamic stability.

Full-or-part-time: 9h 30m
Theory classes: 2h 30m
Practical classes: 1h
Self study : 6h

- Module 5: Helicopter Performance

Description:
Topic 14. Energy method
Topic 15. Axial Flight
15.1. Hover Flight. Ceiling
15.2. Axial Flight. Rate of climb
Topic 16. Forward Flight
16.1. Maximum and Minimum speeds
16.2. Maximum Range speed
16.3. Maximum Endurance speed
Topic 17. Ground Effect
Topic 18. Autorotation Flight
18.1. Axial autorotation. Rate of Descent
18.2. Forward autorotation. Characteristic speeds
18.3. Safety altitude

Full-or-part-time: 11h 30m
Theory classes: 2h 30m
Practical classes: 2h
Self study : 7h

- Module 6: Preliminary Helicopter Design

Description:
This module will study what types of rotating aircraft exist and a description of the different systems and parts of a helicopter. It will also describe what its main missions are and what its maintenance scheme is.

Full-or-part-time: 13h
Theory classes: 3h 30m
Practical classes: 2h
Self study : 7h 30m

- Module 7: Inicial Airworthiness

Description:
Part 21
DOA i POA
Certifications Specifications (CS)

Full-or-part-time: 18h 30m
Theory classes: 4h 30m
Practical classes: 2h
Self study : 12h

Module 8: Continious Airworthiness

Description:
Part M and Part 145

Full-or-part-time: 24h
Theory classes: 6h 30m
Practical classes: 3h
Self study : 14h 30m

ACTIVITIES

- ACTIVITY 1: LARGE GROUP SESSIONS / THEORY

Description:
Large group sessions in which the contents of the different modules of the course will be introduced.

Specific objectives:
Achievement of the most important theoretical knowledge of rotary-wing aircraft design.

Material:
Recommended bibliography of the subject, notes and collections of solved exercices, available at Atenea.

Full-or-part-time: 55h
Theory classes: 28h
Self study: 27h

- ACTIVITY 2: MEDIUM GROUPS SESSIONS / PROBLEMS

Description:
Resolution of exercises in medium-sized group sessions to consolidate the contents of theory lectures.

Specific objectives:
Assess students' familiarity with the concepts presented in theory lectures and prepare them for the exams.

Material:
Lecture notes and recommended bibliography of the subject.

Full-or-part-time: 30h 30m
Practical classes: 14h
Self study: 16h 30m

- ACTIVITY 3: PROJECT 1

Description:
Group project in which a commercial helicopter will be evaluated in a practical way using the theories studied in modules 1-5 of this subject.

Specific objectives:
Assess the student's level of knowledge concerning the contents of modules 1-5.

Delivery:
The project mark will represent a 15% of the final mark of this subject.

Full-or-part-time: 12h
Self study: 12h

- ACTIVITY 4: PROJECT 2

Description:
Preparation of a draft of the Compliance Checklist according to the applicable certification specifications for a specific aircraft.

Delivery:
The project mark will represent a 20% of the final mark of this subject.

Full-or-part-time: 12h
Self study: 12h

- ACTIVITY 5: MID-TERM EXAM

Description:
Written test in which problems related to topics from modules 1-5 will be solved.

Specific objectives:
Assess the knowledge of Modules 1-5 of the subject.

Delivery:
The exam mark will represent a 35% of the final mark of this subject.

Full-or-part-time: 1h 30m
Theory classes: 1h 30m

- ACTIVITY 6: FINAL EXAM

Description:
Written test in which problems related to topics from modules 6-8 will be solved.

Specific objectives:
Assess the knowledge of Modules 6-8 of the subject.

Delivery:
The exam mark will represent a 30% of the final mark of this subject.

Full-or-part-time: 1h 30m
Theory classes: 1h 30m

GRADING SYSTEM

The final mark for the course is obtained from 4 evaluation activities:
- Mid-term exam of the first part (35%)
- Practical project of the first part (15%)
- Final exam of the second part (30%)
- Practical project of the second part (20%)

In case a student has failed the partial exam or has been unable to attend the exam, he/she will have a second attempt on the same date of the final exam. The new mark of the examen will replace the old one, only if it is higher. The student must notify the teacher in advance of his/her intention to retake the exam.

EXAMINATION RULES.

For both the partial and final exam, students can make use of a form under the conditions indicated in class and/or Athena.

BIBLIOGRAPHY

Basic:
- Leishman, J. Gordon. Principles of helicopter aerodynamics. 2nd ed. Cambridge: Cambridge University Press, 2006. ISBN 9780521858601.
- Bramwell, A.R.S.; Done, G.; Balmford, D. Bramwell's helicopter dynamics [on line]. 2nd ed. Reston: Butterworth-Heinemann, 2001 [Consultation: 16/07/2024]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9780750650755/bramwells-helicopter-dynamics. ISBN 0750650753.
- Padfield, Gareth D. Helicopter flight dynamics: the theory and application of flying qualities and simulation modeling. 2nd ed. Oxford: Blackwell, 2007. ISBN 9781563479205.

Complementary:
- Stepniewski, W.Z.; Keys, C.N. Rotary-wing aerodynamics [on line]. New York: Dover, 1984 [Consultation: 06/09/2024]. Available on: https://search-ebscohost-com.recursos.biblioteca.upc.edu/login.aspx?direct=true&AuthType=ip,uid&db=nlebk&AN=1152401&site=ehost-live&ebv=EK&ppid=Page-___-1. ISBN 0486646475.
- Prouty, Raymond W. Helicpoter performance, stability and control. Malabar: Krieger, 2003. ISBN 1575242095.
- Watkinson, John. The art of the helicopter [on line]. Oxford: Elsevier Butterworth-Heinemann, 2004 [Consultation: 07/10/2022]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9780750657150/art-of-the-helicopter. ISBN 0750657154.
- Hollmann, Eric M. Modern helicopter design. Monterey: Martin Hollmann, 1996.

RESOURCES

Other resources:
Notes and presentations available in Athena
Collections of exercises with numerical solutions