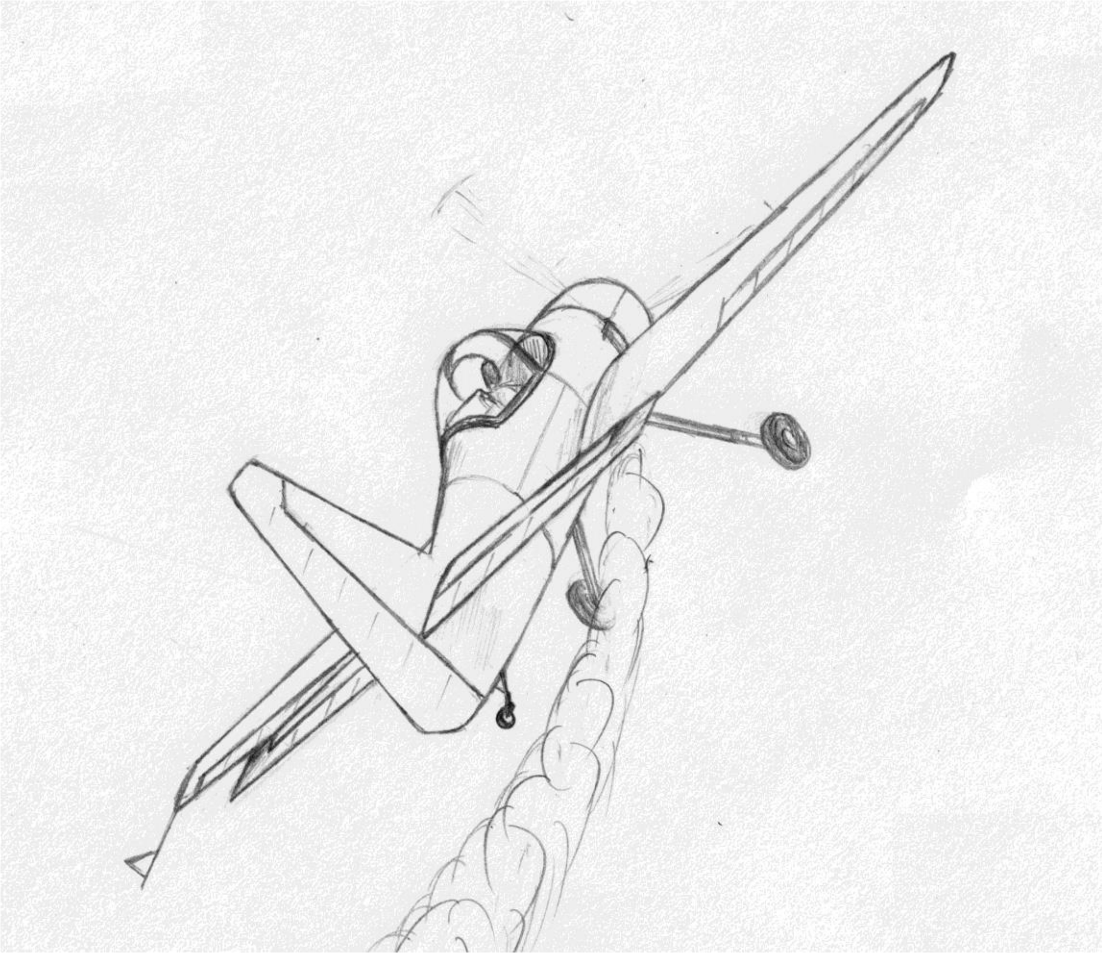
PROJETO DE AERONAVES
AIRCRAFT DESIGN – 15096

2024/2025



Curricular Unit Description

and

Design Project Description

PART I
THE CURRICULAR UNIT

1. OBJECTIVES

Students should acquire skills in the development of an aircraft subject to specific requirements and constraints, know how to apply aircraft design standards, develop integration, decision and compromise capabilities in a multidisciplinary team project and know how to communicate their results effectively.

With this UC students should be able to:

- describe the traditional aircraft design process and adapt it to specific cases;
- develop simple programs for the analysis and conceptual/preliminary design of an aircraft;
- integrate knowledge from various areas of science and engineering in the development of a multidisciplinary design project;
- carry out the conceptual and preliminary design of an aircraft to meet specific requirements;
- analyse design results and identify the most relevant parameters for the optimization of a given aircraft;
- effectively communicate project results;
- work in a team.

2. PREREQUISITES

It is advisable for students to have passed Aircraft Drawing, Introduction to Aircraft Development, Flight Performance, Propulsion I, Aerospace Structures I, Flight Dynamics and Simulation, and Applied Aerodynamics.

3. SYLLABUS

I. Introduction
1. Introduction to the curricular unit. 2. The aircraft design process. 3. Airworthiness standards for aircraft design.

II. Conceptual Design
4. Sizing from a conceptual drawing. 5. Selection of the airfoil and geometry of the wings and tail. 6. Initial sizing. 7. Configuration and drawing. 8. Configuration considerations. 9. Cabin, passengers and payload. 10. Integration of the propulsive system and the power system. 11. Landing gear and other systems. 12. Case studies.

III. Sizing, Analysis and Optimization
13. Aerodynamics. 14. Propulsion. 15. Structures and loads. 16. Weight and balance. 17. Stability and control. 18. Performance. 19. Cost analysis. 20. Optimization.

IV. Design of a New Aircraft
21. Concept of operations. 22. Aircraft design. 23. Development of analysis and optimization tool. 24. Sizing and analysis. 25. Oral presentations. 26. Written report.

4. SYLLABUS/OBJECTIVES

The contents of this curricular unit are structured in four blocks, the first three consisting of oral exposition and discussion of topics and the fourth consisting in practical and application of the knowledge. Those were designed with the main objective to develop teamwork skills in a complex multidisciplinary project in which theoretical and practical, technical and scientific knowledge of various areas is necessary, in which the critical thought and compromise is essential and, at the same time, to foster the spirit of innovation through research of new scientific and technological information (outside the syllabus of the course) so that the requirements of a given project can be met.

In essence, the syllabus is designed so that students can deepen, develop and integrate knowledge from different areas (aerodynamics, propulsion, structures, materials, flight performance, flight stability and dynamics, systems, etc.) to produce a viable and optimized aircraft design.

5. TEACHING METHODOLOGIES

This curricular unit is structured in two parts: one essentially theoretical and the other essentially practical. In the first part, the material is transmitted orally with multimedia slideshow support and additional information written on the blackboard. In the second part, methods for building a spreadsheet tool for analysis and optimization are taught and a new aircraft design is partially developed based on specific design requirements.

6. TEACHING METHODOLOGIES/OBJECTIVES

The methodologies adopted for this curricular unit follow the trends of similar curricular units in other universities and the experience acquired by the University of Beira Interior in the development of several unmanned aircraft and in various research and development work. This curricular unit has four weekly hours of theoretical-practical lectures and is structured in two parts: one part (2 hours) essentially theoretical and the other (2 hours) essentially practical.

In the first part, the materials (blocks I, II and III) are orally transmitted using multimedia slides and supplementary information written on the board. The slides are made available online to students in pdf format for their individual study and for reference, as they are built in the form of notes. In this part, examples of application are also presented. The discussion of the topics presented is fostered during the contact hours for better understanding by the students and for the development of their critical thought.

In the second part (block IV), methodologies are taught for the construction of an analysis and optimization spreadsheet tool. With this basis and with the knowledge of the theoretical part, students develop in teams (typically 5 students) the conceptual design and preliminary design of a new aircraft to meet the requirements provided by the teacher. During these classes, the exchange of ideas among teams is also encouraged and short oral presentations concerning the design progress are made throughout the semester. A large volume of this work must be performed outside the class period due to the considerable amount of required work. This project allows the student to develop analytical and synthesis skills, also using knowledge acquired in other curricular units, and to acquire critical decision and teamwork skills in the development of a complex system. At the end of the curricular unit the design is orally presented, and a written design report is submitted.

Although the professor monitors the developed students' work during the contact hours, both in the theoretical and practical lectures, a considerable amount of individual work outside the class is necessary by the students, regarding the study of the syllabus of the curricular unit, the study of other related subjects contained in the bibliographic references and the realization of the design work. This individual work promotes the autonomy and critical capacity of the student.

To support the teaching of this curricular unit, different but essential teaching/learning resources are used, namely:

- Video projector
- Books, articles, and other bibliography
- Notes
- Computer
- Internet
- Spreadsheets
- Analysis software for: airfoils, wings, propellers, flight stability, etc.
- CAD/CAE software
- Aircraft models developed previously at UBI and others

7. CALENDAR

Lectures are divided into two main parts: one to present and discuss the fundamental topics; and another to discuss and develop the proposed design project. In the table below the syllabus chapters are assigned to the corresponding weekly lectures.

Week	Dates	Chapters
1	17/02/2025	1
	20/02/2025	2
2	24/02/2025	3, 4
	27/02/2025	21
3	03/03/2025	5
	06/03/2025	5
4	10/03/2025	25
	13/03/2025	6
5	17/03/2025	7
	20/03/2025	8, 9
6	24/03/2025	22
	27/03/2025	10
7	31/03/2025	11
	03/04/2025	12
8	07/04/2025	22
	10/04/2025	13
9	14/04/2025	13, 14
	17/04/2025	14
10	21/04/2025	break: Easter
	24/04/2025	break: Easter
11	28/04/2025	25
	01/05/2025	holliday: May 1st

12	05/05/2025	23
	08/05/2025	15, 16
13	12/05/2025	16, 17
	15/05/2025	17, 18
14	19/05/2025	23
	21/05/2025	Test
15	26/05/2025	19, 20
	29/05/2025	24
16	02/06/2025	25
	05/06/2025	25

The available time for questions is Monday at 16h00-17h30.

PART II
THE DESIGN PROJECT

Solar UAV for Crop and Cattle Monitoring

UAV-25

8. INTRODUCTION

In the past few years electric propulsion for aircraft has seen tremendous developments and a widespread use. Its application ranges from the model aircraft, UAVs, sailplanes, ultralight, general aviation aircraft and even passenger aircraft. Because batteries have a limited energy density, resulting in flights of short duration, the use of fuel cells for battery charging is an interesting option that has already been exploited. Conventional propulsion with a piston engine allows flights with longer duration and with the help of an alternator coupled to the engine batteries, that provide on-board power for systems, can recharge these in flight. To avoid consumption of petrol-based fuels to produce electricity, the incorporation of photovoltaic cells on the aircraft can provide part, or all, of the electrical energy required on board. In some situations, a hybrid propulsion system may be preferred.

Also, the developments in electrical propulsion, with increasing safety levels has enabled the study and implementation of several designs for urban air mobility to transport people and cargo and small passenger aircraft.

The main objective of this subject is to show students what the conceptual design of an aircraft is and what steps are necessary to follow given mission and performance requirements, design constraints, design methods and the need for optimization. To achieve this, the knowledge gained during the course will be applied to the design of a new aircraft subjected to specific requirements. The optimization of the project is of extreme importance in the development of a new aircraft.

This project description presents the requirements that the aircraft must respond to in terms of mission, layout, performance, systems, materials, and design standards. It also describes the necessary tasks to be carried out during the semester and the work plan to follow. This project requires dedication and continuous work to ensure that deadlines are met, and results lead to a good design.

9. REQUIREMENTS

The current requirements present a need for an electric autonomous solar UAV (also capable of being remotely piloted) with the capability to fly over agricultural or pasture fields during relatively long periods to monitor soil, crop or cattle characteristics. The requirements for this aircraft are listed below and during the development of the project they must be respected. Possible changes in the requirements will be discussed and agreed upon by the teacher and all the elements involved in the project.

It is required to perform the conceptual and preliminary design of this UAV taking into account some specific design requirements. The aircraft must have good flying qualities to allow easy and precise flying. The vehicle’s structure and aerodynamics must be carefully designed to achieve low power consumption levels. Simplicity, robustness, and ease of repair are essential to maintain high levels of operational readiness of the UAV.

9.1. Mission

The UAV must be designed for the following mission: it must be hand-launched or catapult-launched, then climb to a cruise height of between 100 m and 500 m, cruise/loiter for 36 km, 72 km or 108 km acquiring images of the fields, return to the launch site and land on the ground. The objective of the operation is to fly over agricultural or pasture fields to obtain high quality photos or videos of the ground for posterior off-line analysis to assess soil humidity, crop diseases, vegetable or fruit maturation and/or to count cattle heads or study its movements over time. This concept of operations is to be studied for the Cova da Beira region. The payload necessary for this mission is a camera suitable for the above-mentioned requirements. The turnaround time should be as low as possible yet less than 10 minutes to allow for urgent flights in critical weather conditions or during difficult managing situations.

It is desirable, though not mandatory, to have a vehicle that can complete the mission as many times as possible during the day. There may be a centrally placed base from which the vehicle operates and to which it returns at the end of the mission.

The vehicle should be able to be disassembled into parts of no more than 0.8 m in length, so that it can easily fit in a typical car boot.

9.2. Performance

The vehicle must show the following performance figures (ISA – *International Standard Atmosphere* conditions):

Take-off	hand-launched or external launcher from the field
Cruise speed	around 36 km/h
Range	three versions are to be considered: 36 km, 72 km and 108 km
Flight operational radius	at least 18 km
Data link range	at least 36 km (line-of-sight)
Operational ceiling	at least 1000 m
Landing	on the ground in the field

9.3. Propulsion

The aircraft shall utilise an electric powertrain using batteries for energy storage and solar cells for energy harvesting. Up to two motors and up to two propellers may be used. In selecting the motor(s), careful attention must be given to its durability and reliability. Proper cooling of the motor(s) must be provided. Propellers must be fixed pitch. The propellers must be selected according to the motor performance and UAV performance required. The aircraft can either have tractor or pusher propellers. No thrust vectoring is permitted. The design shall be fault tolerant: able to continue to fly safely and land having suffered a failure of a single motor, battery, or propeller.

The batteries must be sized to provide both the required maximum power and range/endurance for 30 minutes. Batteries may only be used between 100% and 20% energy levels, to allow a reserve. It may be assumed that a 100% discharge rate is available throughout this range. Proper cooling of the batteries must be provided. Teams must clearly state and justify their choice of battery parameters (e.g. specific power, discharge rate) based on battery cells currently available – not cells that are simply at the research stage.

Electric motors (including controllers) shall have a power density of no greater than 7 kW/kg continuous (for cruise and descent) and 10 kW/kg peak (for a maximum of 5 minutes). Batteries shall have a specific energy of not more than 250 Wh/kg at the cell level and a value of not more than 200 Wh/kg for the cells integrated into packs, including monitoring, control, and cooling.

9.4. Wings

The aircraft shall have a fixed wing configuration, with a maximum wingspan of 3 m. The wings must be well designed, both aerodynamically and structurally, so that the overall efficiency of the vehicle is high and to allow the required mission to be accomplished with low energy requirements. According to the mission, the wings can be designed for high lift-to-drag ratio. The structure should be as simple as possible and use high impact-resistant light materials to ease repair in the case of accidents and to allow for an empty weight as low as possible.

9.5. Fuselage

The fuselage should be slender and light yet possess the necessary internal space for systems, batteries, and payload. Equipment substitution and payload access should be quick and simple to perform. A separate pod for the payload may be considered. The payload compartment should be capable of carrying the camera in such a way to have a clear downward view but to prevent any damage during landing.

9.6. Tail

The tail, when present, must be small and effective. It should use in their structure the same materials selected for the wings. Proper stability and control should be guaranteed by the tail design.

9.7. Landing Gear

No landing gear is to be used.

9.8. Payload

The payload (up to 0.5 kg) must be well secured in the fuselage to avoid any movement during flight. The payload is the image acquiring camera. High resolution camera should be considered.

9.9. Weight and Balance

A Maximum Take-off Mass (MTOM) of 3 kg is mandatory. The centre of gravity (CG) travel must be such that no negative impact on the stability or on the normal operation of the aircraft is imposed. It is important that the maximum take-off mass of the aircraft is kept as low as possible.

9.10. Controls and Systems

The control system will include autopilot boards that can perform automatic navigation and control of the UAV for a predefined mission profile. A receiver must also be installed for remote piloting from the ground. Control surfaces must be sized and must be actuated by servo mechanisms. The aircraft must be aerodynamically stable in all axes. Artificial stability systems may not be used to enhance an otherwise aerodynamically unstable aircraft.

All electronic and electric components and mission equipment must be placed within the fuselage or wings according to their function and in such a way as to allow its quick preparation or replacement. The electric system should be powered by batteries and solar cells.

9.11. Design Airworthiness Requirements

The design airworthiness requirements that should be used in the structural sizing are the EASA CS-LSA, CS-VLA or CS-23. The design manoeuvre limit load factors are, in principle, +2 and -2, but those should be checked with a V-n diagram. All work performed in the design should aim at achieving high levels of safety and performance.

10. TASKS

There are several tasks in the design project that must be carried out according to the time plan below. All tasks depend on each other so that there must be a close interaction and updating between them. The design process is also iterative in nature, but perfection is not possible nor is necessary, but an effort must be put forward to achieve a good optimization level in the outcome.

The necessary calculations may be performed with the help of spread sheets and other analysis computer programs. All drawings should be developed in CATIA V5 or similar.

10.1. Concept of Operations

The exact mission profile and the way it is going to be operationally implemented must be defined and explained. The design of the vehicle will follow from the concept of operations (CONOPS) proposed to respond to the mission requirements.

10.2. Layout

The layout and functionalities of the vehicle must be selected so that the requirements are fully met. This task is very important because it integrates all needs of the other parts of the project into a viable configuration: aerodynamic/stability, propulsion/performance, structure/materials and systems/costs aspects should be addressed. A preliminary three-dimensional (3D) study of all major components must be performed, and these must be incorporated in the aircraft structure. 3D drawings must be produced in a CAD system for the complete UAV.

10.3. Aerodynamics and Stability

The aerodynamic study must cover the selection of the aerofoils, geometry and size of the lifting surfaces, controls, nacelles, and the computation of the aerodynamic characteristics of the whole vehicle (C_L, C_D e C_M). It must be assured that all choices made in the overall design do not impair the aerodynamic performance. A study of the stability and control of the UAV must also be performed.

The aerodynamics work must concentrate on the wings design and tail sizing. These must be optimized having in mind the necessary compromises for different flight conditions.

10.4. Propulsion and Performance

The propulsive system (motor, propeller, power source) must be selected and sized according to the requirements. An estimate of the vehicle's main performance figures (range, endurance, rate of climb, ceiling, speeds) and mission performance (speeds, times, battery energy usage, etc.) must be carried out.

10.5. Structure and Materials

The type of structure and materials for the different components of the vehicle must be selected and thoroughly defined keeping in mind their configuration and function. Connections among components and assembling/disassembling requirements must be devised. The V-n diagram needs to be determined. Preliminary sizing of the wing should be addressed. A database containing such data as suppliers, physical characteristics, mechanical characteristics, and price of all materials selected must be produced.

10.6. Systems and CG

A study of the landing gear system (if it exists), of the control system and of the electric system must be performed. These studies should include not only the selection of the main components and definition of its functionalities but also the positioning of components and cables routing inside the aircraft. Commercially available components are preferred to speed up both design and building processes. A database containing such data as suppliers, working characteristics, mass, power consumption and price of all selected components must be produced. Estimates of weight and balance must also be performed.

10.7. Manufacturing and Costs

A study on the manufacturing processes to be used in the main structural components needs to be carried out. An estimate of the total cost of the UAV, based on the materials and systems used and the number of units to be produced should be obtained.

10.8. Operations and Costs

Based on the proposed CONOPS, one or more operational scenarios for an operator to use the designed UAV or a fleet of several UAVs should be devised together with estimates of the costs and gains associated with those operational scenarios.

10.9. Structural Sizing

Preliminary sizing of the main components (wings, tails, fuselage and landing gear) are to be performed based on the structural concepts proposed in the Structure and Materials task.

10.10. Time plan

The table below presents the time plan with the tasks required to complete de project.

Month	F	F	M	M	M	M	A	A	A	A	A	M	M	M	M	J	J	J	J	J
Task \ Week	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Lectures																				
Concept of operations																				
Layout																				
Aerodynamics/Stability																				
Propulsion/Performance																				
Structure/Materials																				
Systems																				
Manufacturing/Costs																				
Operations/Costs																				
Structural Sizing																				
Test														21						
Presentations				10							28									
Report																06				
Exams																				

Legend: Lectures; Design work; Weeks without lectures; Assessment

10.11. Design Teams

The design is carried out by groups of 5 students who need to perform mandatory tasks 1 to 6. If, for any well justified reason, groups have 6 students one additional task from tasks 7 to 9 must be selected. All students should work hard for the project objectives to be fulfilled in time. Each team should select a single flight range value from 36 km, 72 km and 108 km to design its UAV, considering that each range value can only be selected by three teams.

	Student's Name	Nº	Team	E-mail	Task
01	36-David Simões	49384	A		layout
02	Bernardo Piteira	49399	A	bernardo.piteira@ubi.pt	aerodynamics/stability
03	Miguel Robalo	49646	A		propulsion/performance
04	Luís Calmeiro	49636	A		structures/materials
05	Leonardo Ferreira	49538	A		systems/CG
06	José Costa	48214	A		manufacturing/costs
07	108-Raquel Loureiro	49406	B	raquel.loureiro@ubi.pt	layout
08	André Teixeira	49858	B	andre.magalhaes.teixeira@ubi.pt	aerodynamics/stability
09	Beatriz Massano	49796	B	beatriz.massano@ubi.pt	propulsion/performance
10	Margarida Guerreiro	49588	B	margarida.guerreiro@ubi.pt	structures/materials
11	Rúben Marçal	50508	B	ruben.miguel.marcal@ubi.pt	systems/CG
12			B		
13	72-Joana Sousa	49496	C	joana.t.sousa@ubi.pt	layout
14	Bruno Bernardino	50257	C		aerodynamics/stability
15	Nicole Silva	50022	C		propulsion/performance
16	Alex Burdujan	49989	C		structures/materials
17	Orlando Fortunato	49672	C		systems/CG
18	Dmytro Kovalchuk	50140	C		manufacturing/costs

19	36-Afonso Salvador	49818	D		layout
20	Gonçalo Coimbra	49495	D	goncalo.coimbra@ubi.pt	aerodynamics/stability
21	André Azevedo	50930	D		propulsion/performance
22	Jéssica Oliveira	49721	D		structures/materials
23	Daniel Santo	50949	D		systems/CG
24	João Bezerra Silva	48733	D		manufacturing/costs
25	72-Daniela Pereira	49428	E		layout
26	Maria Inês Pina	49547	E	maria.ines.pina@ubi.pt	aerodynamics/stability
27	José Barros	49616	E		propulsion/performance
28	Patrícia Dores	49521	E		structures/materials
29	Manuel Pereira	49535	E		systems/CG
30	Simão Serra	49553	E		operations/costs
31	108-José Bizarro	49904	F		layout
32	Samuel Macedo	49552	F		aerodynamics/stability
33	Rafael Andrade	50298	F		propulsion/performance
34	Nuno Riscado	49681	F		structures/materials
35	Manuel Bernardo	50666	F		systems/CG
36	João Branco	49935	F	joao.p.branco@ubi.pt	manufacturing/costs
37	36-David Andrade	49560	G	david.andrade@ubi.pt	layout
38	João Rodrigues	50061	G		aerodynamics/stability
39	Vasco Castro	49551	G		propulsion/performance
40	Rodrigo Matos	50053	G		structures/materials
41	Rafael Ferreira	49855	G		systems/CG
42	Romeu Daniel	49895	G		manufacturing/costs
43	108-Gustavo Domingues	49620	H		layout
44	Rodrigo Condeço	50498	H	rodrigo.condeco@ubi.pt	aerodynamics/stability
45	Tiago Sequeira	50873	H		propulsion/performance
46	Joana Quelhas	50177	H		structures/materials
47	José Prata	49563	H		systems/CG
48	Beatriz Santos	49536	H		manufacturing/costs
49	72-Pedro Simões	49781	I		layout
50	Carolina Gomes	49561	I		aerodynamics/stability
51	Tomás Saraiva	50180	I		propulsion/performance
52	Maria Rebelo	50345	I		structures/materials
53	Max Filho	49598	I		systems/CG
54			I		
55	72-		I		layout
56			I		aerodynamics/stability
57			I		propulsion/performance
58			I		structures/materials
59			I		systems/CG
60			I		

11. ASSESSMENT

The grade of this subject is given based on one written test (T), three oral presentations (P) and one report (R).

11.1. Test

The test covers all the topics discussed during classes up to the date of the test (21 May 2025, week 14). The test is divided into two parts: the first is closed book and the second is open book.

11.2. Presentations

There will be 3 oral presentations: one for the concept of operations (10 March 2025 – week 4); one for the conceptual design (28 April 2024 – week 11); and one for the complete design (2 & 5 June 2025 – week 16). In the presentations, each design team (all elements of the team must participate in the presentations) must describe its concepts, design philosophy, analyses, and results. The first and second presentations should take only 10 to 12 minutes each while the last presentation should take 20 to 24 minutes, depending on the number of teams. The presentation files in *pdf* format should be forwarded to the professor (pgamboa@ubi.pt) at the end of each presentation session.

All presentations will be assessed based on:

- Oral expression and quality of the information on the slides.
- Relevance and scope of the presented information.
- Objectivity and coherence of the discussed topics.
- Adequate understanding of the discussed matters and knowledge of the design.
- Technical content.
- Replies to audience questions.
- Usage of the available time.

11.3. Report

Each team must write up a design report that should contain all relevant steps taken in the aircraft design process. A typical structure of the report would include the following:

- Introduction: presentation of the requirements, the objectives of the design, and the team members' tasks.
- Concept of operations: presentation of the concept of operations devised to perform the mission.
- Conceptual Design: short description of the state-of-the-art relevant to the design, initial sizing based on the state-of-the-art, description and justification of the main features and innovations in the design – layout, aerodynamics, propulsion, structure and systems concepts (drawings should be used to illustrate these concepts).
- Preliminary Design: presentation of analyses and sizing – aerodynamics and stability properties; propulsion and performance estimates; structural, weight and balance calculations (mass breakdown of the aircraft, including reasonable estimates for each major component); systems integration in the airframe; cost analysis; optimization studies; manufacturing considerations; and operations costs – and three-view general arrangement drawing of the design with all relevant dimensions and major aircraft characteristics.
- Conclusions: summary of design outcomes based on the objectives.
- References: list of literature sources used in the report.
- Appendices: presentation of complementary data, drawings, and analyses.

The number of pages is limited to around 30, using letter size 10-12, depending on letter type, single line spacing and 20 mm left and right margins. The report in *pdf* format should be forwarded to the professor (pgamboa@ubi.pt) at the last day of lectures (06 June 2025 – week 16).

11.4. Exam

There will be no written exam. If students fail the "Frequência" assessment or wish to improve their final grade, they must hand in an improved report of their design project at the dates of the exam, in weeks 18 and/or 20.

11.5. Grade

The mark of this subject is given by F = 0.3T + 0.2P + 0.5R and approval is obtained if F ≥ 10. The same is true for the exam final mark.

1.		Frequência (F = 0.3T + 0.2P + 0.5R)		100
	T	Test	21-05-2025	30
	P	Presentations	10-03-2025 ; 28-04-2025 ; 02 & 05-06-2025	20
	R	Report	06-06-2025 (24h00)	50
2.		Exam (E = 0.3T + 0.2P +0.5 R1)		100
	R1	Report (*época normal*)	??-06-2025 (??h30)	50
	R1	Report (*época recurso*)	??-07-2025 (??h30)	50
3.		Exam (E = 0.3T + 0.2P +0.5 R2)		100
	R2	Report (*época especial*)	??-07-2025 (??h30)	50

12. BIBLIOGRAPHY

The books listed below can be used for the design. The design reports of previous years may also be useful as general guideline and source of ideas. However, one must bear in mind that the information contained in them may be incorrect. A lot of information can also be found in the internet using appropriate search criteria.

12.1. Notes

00. Gamboa. P.V., Apontamentos de Projeto de Aeronaves, ~600 acetatos, UBI, 2024

12.2. Textbook

01. Raymer, D. P., *Aircraft Design: A Conceptual Approach* – 5th edition, AIAA Education Series, 2012

12.3. Aircraft Design Books

02. Gudmundsson, S., *General Aviation Aircraft Design: Applied Methods and Procedures*, Elsevier, 2014.
03. Torenbeek, E., *Advanced Aircraft Design: Conceptual Design, Analysis and Optimization of Subsonic Civil Airplanes*, Hoboken, New Jersey: John Wiley & Sons, 2013.
04. Gundlach, J., *Designing Unmanned Aircraft Systems: A Comprehensive Approach*, AIAA Education Series, 2012
05. Jenkinson, Lloyd R., Marchman III, James F., *Aircraft Design Projects for Engineering Students*, Butterworth-Heinemann, 2003
06. Corke, T. C., *Design of Aircraft*, Pearson Education, Inc., 2003
07. Howe, D., *Aircraft Conceptual Design Synthesis*, Professional Engineering Publishing,

2000
08. Jenkinson, L. R., Simpkin, P., Rhodes, D., *Civil Jet Aircraft Design*, Arnold, 1999
09. Brandt, S. A., Stiles, R. J., Bertin, J. J., Whitford, R., *Introduction to Aeronautics: A Design Perspective*, AIAA Education Series, 1997
10. Roskam, J., *Airplane Design* – Volumes I to VIII, The University of Kansas, 1990
11. Stinton, D., *The Design of the Aeroplane*, Blackwell Science, 1983
12. Torenbeek E., *Synthesis of Subsonic Airplane Design*, Delft University Press, 1982
13. Barros, C., *Introdução ao Projecto de Aeronaves* – Volumes 1 & 2, CEA/UFMG, 1979
14. Pazmany, L., *Light Airplane Design*, Pazmany Aircraft Corporation, 1963

12.4. Other Books

15. Abbot & Doenhoff, *Theory of Wing Sections*, Dover Publications Inc, 1959
16. Barnaby Wainfan, *Airfoil Selection – Understanding and Choosing Airfoils for Light Aircraft*, 1988
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