

**GRADUATE STUDY: AERONAUTICS****SEMESTER (III)****Syllabus**

Academic year 2023/2024

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|--|-------------------------------|---------------------|--|--------------------------------|---------------------------|
| Course: Dynamics and Aircraft Ageing | | | | | |
| Head of course: Prof. Željko Marušić , Ph.D. | | | | | |
| Co-lecturers: David Gerhardinger , mag. ing. aero. ing. | | | | | |
| Semester: III | Course code: 172906 | Lectures: 30 | Auditory exercises: 12 | Laboratory exercises: 3 | ECTS credits: 5 |
| Group for lectures: 5 – 20 students | | | Group for auditory and laboratory exercises: 5 – 20 students | | |

Objective of the course:

- Provide the knowledge and information needed to identify the aspect of flight constraints on flight efficiency and safety.

Learning outcomes:

After the completion of the course the students will be able to:

1. Define the foundations of aviation constructions, the types of loads and their impact on the functionality, endurance and reliability of the aircraft.
2. Define and describe the fatigue of the material and the main influencing parameters on its formation and the method of improving the aerial constructions in order to prevent the occurrence of material fatigue.
3. Know to describe the essential features of aircraft materials and their properties, especially from the aspect of dynamic endurance, corrosion resistance and material fatigue.
4. Define vibration theory and their impact on aviation constructions.
5. Explain the relationship between fracture mechanics, non-destructive control, critical structural fault criterion, and define the sensitivity of the test.
6. Know how to calculate numerical tasks from ultrasound physics, non-destructive control method, and the basis of the fracture mechanics.
7. Apply knowledge on methods of testing the state of materials, shortcomings and faults, and remediation procedures.



**LECTURES and EXERCISES**

| Week | Syllabus | Form of classes | Performed by | Lessons | Remark |
|------|---|-----------------|----------------|---------|--------|
| 1. | <ul style="list-style-type: none"> Introductory expositions. Analysis of the causes of the most important aviation accidents caused by the damping of aerial constructions, with the effect on improvement of construction and maintenance procedures. | L | Željko Marušić | | |
| 2. | <ul style="list-style-type: none"> Mechanical loads of aerial constructions: static, dynamic, thermal and combined. The glare of the material. Aircraft construction mechanisms. | L | Željko Marušić | | |
| 3. | <ul style="list-style-type: none"> Examples and analysis of causes of dementia. Methods of non-destructive control of aerial constructions. The criterion of critical error. Holding seminar papers. | AE | Željko Marušić | | |
| 4. | <ul style="list-style-type: none"> Procedures for condition analysis and structural repairs after overload. The basis for the technology to repair the consequences of defective aircraft and damage during use and maintenance. | L | Željko Marušić | | |
| 5. | <ul style="list-style-type: none"> The basics of vibration theory. Analytical description of free and forced vibrations. Mudguard and resonance analysis and their impact on the fatigue of aircraft construction materials. | L | Željko Marušić | | |
| 6. | <ul style="list-style-type: none"> Examples and tasks in the field of dynamic, cyclic loads, fracture mechanics and corrosion. | AE | Željko Marušić | | |
| 7. | <ul style="list-style-type: none"> Dynamic vibration factor and phase shift. Own frequency of individual aircraft construction assemblies. Sensor systems for measuring vibration characteristics of circuits. | L | Željko Marušić | | |





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|-----|---|----|----------------|--|--|
| 8. | <ul style="list-style-type: none"> Dynamic cyclic load of aircraft hulls caused by overpressure, dynamic loading of wings, control surfaces, propulsion system and undercarriage, with the impact of material fatigue. | L | Željko Marušić | | |
| 9. | <ul style="list-style-type: none"> Exemplary examples of exhausted aviation structures. Solving numerical tasks from ultrasound testing technology, non-destructive control. | AE | Željko Marušić | | |
| 10. | <ul style="list-style-type: none"> Fundamentals of fracture mechanics, high-cracking cracks. Influence of stress concentration on material fatigue and dirt. Examples of stress concentration caused by structural and maintenance errors. | L | Željko Marušić | | |
| 11. | <ul style="list-style-type: none"> Influence of corrosion and tribochemical wear on the fatigue and endurance of aerial construction material. Optimizing Maintenance to Reduce Drifting Processes. | L | Željko Marušić | | |
| 12. | <ul style="list-style-type: none"> Visualization of cracking detection by boroscopic aircraft maintenance methods with qualitative examples. Shows examples of revitalization of older aircraft. | AE | Željko Marušić | | |
| 13. | <ul style="list-style-type: none"> Determination of load limits for the most loaded parts and assemblies of the aviation structure. | L | Željko Marušić | | |
| 14. | <ul style="list-style-type: none"> Analysis procedures of shape and reparation of aircraft structure after overloading. Basic technologies reparation of running out of aircraft and damages through exploitation and maintaining process. | L | Željko Marušić | | |
| 15. | <ul style="list-style-type: none"> Examples of case studies of old aircraft structures. Solving numerical problems in technology with ultrasonic testing and non-destructive testing. | AE | Željko Marušić | | |

L = Lectures; AE = Auditory Exercises; LE = Laboratory Exercises; S = Seminars





STUDENT OBLIGATIONS AND EXAMS

Conditions for obtaining signatures:

The student acquires the right to get a signature for $\geq 70\%$ of attendance during the lectures (10 credits from Table 1) and attendance at $\geq 70\%$ of exercises (10 credits from Table 1). There are no pre-conditions from other courses except basic knowledge of mechanics, aerodynamics and materials. If part-time students attend consultations, this is regarded as attendance in class, if absence from class has been excused and announced to teachers. The attendance in the percentage lower than 70% at lectures and exercises may be compensated by making an additional seminar paper for documented absence due to a justified cause and in this case a positively graded seminar paper is worth 20 credits (Item 3 in Table 1). The scope and content of the seminar paper depends on the number of absences.

Written exam: written evaluation of the cognitive skills of applying empirical facts and theoretical knowledge, as well as logical thinking in analytical tasks, with the aim of achieving learning outcomes from 1 to 6.

There are two ways of passing the exam:

- a) **Written quizzes** – consist of written tests twice during the semester. The first quiz can be attended by all students enrolled in the course in the current academic year. The second quiz at the end of the semester can be attended by the students who have been attending at least 50% of the classes and have acquired a positive grade from the obligatory seminar paper defended orally during consultations or at any time agreed with the lecturer (minimum or more than 10 credits, Item 4 – Table 1), and have acquired more than zero credits at the 1st quiz. From the positively graded both quizzes it is possible to acquire 10 to 20 credits (each quiz – maximum 10 credits).
- b) **Written test** – consists of a written exam at regular examination periods. The written exam can be attended by students who are eligible for signature in the course Dynamics and Aircraft Ageing (if not exempted from the written part of exam, according to Table 2, or if they want to achieve a better grade than the one obtained in the written quizzes), provided they have received a positive grade from the obligatory seminar paper defended orally at the time of consultation or at time agreed with the lecturer (minimum 10 credits or more, Item 4, Table 1). For successful completion of the written part of the exam it is possible to obtain 10-20 credits.

Seminar works (mandatory): The students independently prepare a seminar work, independently studying the recent professional and scientific literature, and finally present the seminar work in lecturer's consultations with the aim of achieving learning outcomes 1, 3, 4 and 6.

Oral exam after positively graded written part of the exam:

After exemption from the written part of the exam (minimum 40 or more credits from all items from 1 to 6 in Table 1), or a positive grade of the written part of the exam (minimum 10 credits, Item 7, Table 1); with a positive grade of the obligatory seminar paper orally defended during the





consultation or at time agreed with the lecturer (minimum 10 and more credits, Item 4, Table 1) the student attends the oral (theoretical) part of the examination.

The students who acquire a minimum of 56 or more credits from all items from 1 to 6 in Table 1 are exempted from oral part of examination (see Table 2).

Extra credits:

The obligatory seminar paper defended orally at the time of consultation (minimum 10 credits, Item 4 of Table 1). The student proposes the topic of the seminar paper to one of the lecturers of their own choice, and the chosen lecturer accepts and approves of the topic, and evaluates the completed seminar paper.

The students who will participate in field research with the lecturers (measuring, recording, interviewing, surveying), or who will be co-authors on a expert or scientific paper, or who will be awarded with Rector's award or Dean's award, may be exempted from writing the obligatory seminar paper or written exam, depending on the extent of their involvement.

LITERATURE

a) Obligatory literature:

1. Željko Marušić, Aircraft Dynamics and Ageing, Authorized Lectures, 2015
2. Bruce K. Donaldson: Introduction to structural dynamics, 2006
3. O'Connor, P. D. T.: Practical Reliability Engineering, John Wiley&Sons, Ltd, West Sussex, England, 2002

b) Recommended literature:

1. Marušić, Ž., Bartulović, D., Maković, B., Methods to detect and prevent Fatigue in Ageing Aircraft Structures, Tehnički vjesnik, VOL. 22, 2015, pp 793-803, ISSN 1330-3651
2. Marušić, Ž., Bartulović, D., Mikulić, D., Cold expansion techniques to mitigate fatigue cracks in aircraft structuree, 23rd International Symposium on Electronics in Transport - ISEP 2015, Ljubljana, Slovenija, 23.3.2015.





METHODOLOGY OF THE IMPLEMENTATION OF THE COURSE PLAN

1. LECTURES

Lectures accompanying material exposed in authorized materials (presentations and written templates) in detailed in the required and supplemental literature and perform combined: the use of a Power Point presentation for the purpose of analysing all relevant factors affecting the aging of aircraft constructions and their mutual influence. In the lecture, the team encourages discussion of issues that commits.

2. AUDITORIAL EXERCISES

Auditory exercises are performed in a way to solve numerical tasks of teaching units explained in lectures, or to analyse methods and models to detect and prevent ageing and fatigue in aircraft structures. Students are provided by complete authorized instructional material in print form.

Note: Individual and/or group viewing negative written test

Individual at the time of consultation or a designated period after each colloquium and / or written exam. If necessary and at the request of a group of students in the form post exam exercises in order to explain the most common mistakes typical, after discussion with the team responses to individual student issues.





3. DOCUMENTATION

Kept electronic records of presence in lectures and exercises (students carry out records using student cards). In Excel, the leading communications Tabulation registers earned points for attendance at lectures and exercises, making compulsory seminar paper, as well as to partially pass the written exam over two colloquia. The points obtained under the conditions in Table 1 are several times during the semester published at specified places (bulletin boards, teachers and the cabinet door panels Faculty official web traffic such as e-science student).

There is a paper and electronic record only database in Excel for all students taking the date of signature of the index and the exam date. Students sign their names on a record sheet during the personal collection of signatures in the index and the personal collection assessment in the index.

4. SCORING SYSTEM

Table 1 The scoring system for the monitoring of students and explained credit values in ECTS credits

| no | Segment: | Required credits to be achieved: | | Remark: | ECTS credits |
|----------|---|----------------------------------|-------------------------------|--|----------------------------------|
| | | Min. | Max. | | |
| 1. | Presence in lectures: | 10 | 10 | Presence \geq 70% | 0,5 |
| 2. | Presence at the training: | 10 | 10 | Presence \geq 70% | 0,5 |
| 3. | Seminar paper (as needed) | 20 | 20 | <i>Replacement items 1. 1 and 2.</i> | 1 |
| 4. | Seminar paper (mandatory): | 10 | 20 | Preparation at home and oral presentation at the time of consultation | 1 |
| 5. | Participation in research and / or measurements (students associates on projects), co-authorship on an expert or scientific paper, Rector's award, Dean's award | 10 | 20 | <i>Replacement items 4. or for 4. and 6. (depending on the volume)</i> | Σ 1 - 3 |
| 6. | Colloquies (written 2x per semester): | Σ 10 | Σ 20 | Numeric part (tasks) | Σ 2 |
| 7. | Written exam (terms): | 10 | 20 | <i>Replacement items 6.</i> | 2 |
| 8. | The verbal part of the exam: | / | / | Theoretical part with lectures | 1 |
| Σ | Overall points: | Σ 40 | Σ 60 | Overall ETCS points: | Σ 5 |

Assessment and evaluation of student during teaching and on the final exam:

Final evaluation is based on attendance, written exam, compulsory seminar paper and verbal parts of exam



**Table 2** - Explanation of the credit values in evaluations

| CREDITS: | Estimate based on attendance, seminar paper and two colloquies (or written exam) - [4 ECTS]: | The final score [5 ECTS]: |
|----------|--|---|
| 40 - 45 | Sufficient (2) | Exemption from the written part of the exam, the final score after oral exam |
| 46 - 50 | Good (3) | |
| 51 - 55 | Very good (4) | |
| 56 - 60 | Excellent (5) | Exemption from verbal parts of exam |

All 5 ECTS can be gained in total only if the student has received a positive opinion on the oral part of the exam, or according to Table 2 free verbal parts of exam, the student is in index 5 credits recorded simultaneously with the entry of the final grade.

Information for students (scoring system, implementation plan, learning outcomes, syllabus, literature, consulting teachers, announcement of results of examinations or colloquium, and all other information):

- <https://moodle.srce.hr/2022-2023/>
- <http://www.fpz.unizg.hr>

Student assistants: Additional individual work with the students through individual consultations for assignments from auditory exercises, for optional homework, as well as for insight into the negatively written part of the exam.

