GRADUATE STUDY: AERONAUTICS

SEMESTER (I)

Syllabus

Academic year 2021/2022

Course: **Aircraft Emissions**					
Head of course: Prof. **Tino Bucak**, Ph.D. Prof. **Ernest Bazijanac,** Ph.D.					
Co-lecturers: Ass. Prof. **Anita Domitrović**, Ph.D. **Jurica Ivošević**, Ph.D. **David Gerhardinger**					
Semester: **I**	Course code: **74702**	Lectures: **30**	Auditory exercises: **10**	Laboratory exercises: **5**	ECTS credits: **5**
Group for lectures: **15 students**			Group for auditory and laboratory exercises: **15 students**		

Objective of the course:

- To acquire knowledge required for understanding the environmental and ergonomic aspects of aircraft noise and exhaust emissions and to familiarize with respective measurement, analysis and monitoring methods.

Learning outcomes:

After completing the course, the student will be able to:

1. Define basic acoustical terms and physical descriptors of sound and noise
2. Evaluate the noise source attributes on aircraft
3. Interpret in practice the measured values of the basic parameters that characterize aircraft interior and exterior noise
4. Describe the application of aviation regulations concerning the impact of aviation emissions (noise and exhaust gases) - ICAO Annex 16
5. Define basic terms and physical values that characterize exhaust emissions
6. Describe the requirements for aviation exhaust gases trading and the principles of applying an effective fuel consumption program
7. Identify the importance of aviation noise and exhaust gas impact on the environment and human health

LECTURES and EXERCISES

Week	Syllabus	Form of classes	Performed by	Lessons	Remark
1.	▪ Introduction: General ▪ Introduction. Fundamentals of Acoustics.	L	Tino Bucak	3	
2.	▪ Definition of noise. Methods of noise measurements. Aircraft noise sources. Airborne and structure borne noise.	L	Tino Bucak	3	
3.	▪ Aircraft community noise. Ecological aspects. Noise monitoring. Noise mapping. Noise monitoring system at Zagreb International Airport.	L	Tino Bucak	3	
4.	▪ Exercises: sound parameters calculation	AE	Jurica Ivošević	3	

5.	▪ Interior (cabin) noise. Ergonomical, medical and safety aspects of cabin noise. Physiological and psychological effects of noise, acoustical discomfort. Noise as a stressor. Noise to speech interference.	L	Tino Bucak	3	
6.	▪ Noise abatement methods and procedures. Legislation.	L	Tino Bucak	3	
7.	▪ Laboratory exercises: aircraft exterior and interior noise measurements in situ	LE	Jurica Ivošević	3	
8.	▪ Exercises. Noise parameters calculation. ▪ Colloquium I: Aircraft Noise	AE	Jurica Ivošević	3	
9.	▪ Theoretical basics: Molar mass, Avogadro's law, gaseous mixtures, combustion basics, fuel types	L	Ernest Bazijanac	3	

10.	▪ Exercises: engine emissions parameters calculation	AE	David Gerhardinger	3	
11.	▪ ICAO Annex 16 - Volume II , Aircraft Engine Emissions: Definitions, symbols, exhaust gasses of turbo -fan and turbo -jet engines built for subsonic and supersonic aircraft, afterburning engine emissions. Limits for exhaust gas ratios, aircraft engine measurement and testing methods, gas emission evaluation.	L	Anita Domitrović	3	
12.	▪ Impact of exhaust gasses on the atmosphere, The Greenhouse Effect, development of technological and operational aircraft characteristics with the aim to reduce aircraft emissions: various engine manufacturers' (CFM Int., GE, RR, P&W) combustion chamber technological solutions . Breguet's equation depending on fuel mass and specific fuel consumption	L	Anita Domitrović	3	
13.	▪ EU ETS - Trading greenhouse gas emissions in commercial aviation: The Kyoto protocol and regulations, ETS and the environment, ETS and the local community, ETS, comparative elements with other traffic branches, introduction of CO2 emissions into EU ETS, Monitoring i verification, implementation deadlines, Fuel efficiency	L	Anita Domitrović	3	
14.	▪ Methods to reduce exhaust gas pollution, for piston and jet engines	L	Ernest Bazijanac	3	

15.	▪ Field exercises at Lučko, Measurement and analysis of a piston -engined aircraft's exhaust gasses at various power settings and fuel -to -air ratios	LE	David Gerhardinger	2	
	▪ Colloquium II: Aircraft gas emissions	AE	Anita Domitrović	1	

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

STUDENT OBLIGATIONS AND EXAMS

Conditions for obtaining signatures:

The subject consists of two major sections:
1. Aircraft noise
2. Exhaust gases emission.

Attendance to lectures and exercises is mandatory. The student can maximally miss two terms of lectures and exercises from both sections. Consequently, the student can collect 10 points, according to the Scoring system table.

LITERATURE

a) Obligatory literature:

1. Annex 16 ICAO Vol I i II, Montreal, 1988. (rev 2005)
2. FAR 36 Noise Standards, FAA, Washington, DC
3. Bucak, T.: Authorized lectures, FPZ, 2010.
4. Bazijanac, E., Domitrović, A.: Authorized lectures, FPZ, Zagreb, 2010/11.

b) Recommended literature:

1. Crocker, M. J.: Encyclopaedia of Acoustics, John Wiley & Sons, NY, 1997.
2. Hubbard, H. H. (ed.): Aeroacoustics of Flight Vehicles, ASA, 1995.
3. Smith, M. J. T.: Aircraft Noise, Cambridge University Press, 1989.
4. Advisory Circular AC 20-133: s, FAA, U.S. Dept. of Transportation, 1989.
5. ICAO Engine Exhaust Emissions Data Bank, 1st ed. 1995.
6. Penner, J. E. et al.: Aviation and the Global Atmosphere, pp. 384., ISBN 0521663008, Cambridge, UK: Cambridge University Press, June 1999
7. Norman, Lister: Development of the technical basis for a New Emissions Parameter covering the whole aircraft operation, Final Tech. Rep. 2003.

METHODOLOGY OF THE IMPLEMENTATION OF THE COURSE PLAN

1. LECTURES

Lectures follow the topics listed in the syllabus, and are performed by combined methods (schoolboard, Power Point, Flip Chart). Students are also referred to relevant data sources and programs on the Internet. In addition to the particular subject, multimedia material is presented to students along with a commentary for a better understanding.

2. AUDITORIAL EXERCISES

On auditorial exercises students solve numerical tasks that enable them to better understand the physical basis of acoustics and gas laws

3. LABORATORY EXERCISES

In laboratory exercises students learn about equipment and methods related to noise and exhaust gases measurements.

4. DOCUMENTATION

Attendance to lectures and exercises are registered and the records are kept.
Exam documentation is kept and archived in accordance with the Regulations of the Department of Aeronautics.

5. 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.	Attendance to lectures	5	10		**0,5**
2.	Attendance to exercises	5	10		**0,5**
3.	Written exam (or two colloquia)	70	100		**2**
4.	Oral exam (for both sections)				**2**
Σ		**80**	**120**		**5**

Table 2 - Explanation of the credit values in evaluations

CREDITS:	Estimate based on attendance and two colloquies (or written exam) - [3 ECTS]:	The final score [5 ECTS]:
80 - 90	Sufficient (2)	Determined after oral exam, except for maximum credits achieved
91 - 100	Good (3)	
101 - 110	Very good (4)	
111 - 120	Excellent (5)	

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/2021-2022/**
- **http://www.fpz.unizg.hr**