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**Academic Year: ( 2022 / 2023 )****Review date: 21-07-2022**

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**Department assigned to the subject: Aerospace Engineering Department****Coordinating teacher: IANIRO , ANDREA****Type: Electives ECTS Credits : 6.0****Year : 3 Semester : 1**

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## REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Fluid Mechanics I

Fluid Mechanics II

Thermal Engineering

Introduction to structural analysis

We strongly advise you not to take this course if you have not passed Fluid Mechanics II and Thermal Engineering

## OBJECTIVES

Adequate knowledge, with application to the engineering of: the methods of calculation and development of facilities of the propulsive systems; the regulation and control of propulsive systems installations; the handling of experimental techniques, equipment and measuring instruments of the discipline; the fuels and lubricants used in aviation and automotive engines; the numerical simulation of the most significant physical-mathematical processes; the maintenance and certification systems of aerospace engines.

Applied knowledge of: internal aerodynamics; propulsion theory; performances of airplanes and jet aircrafts; propulsion system engineering; Mechanics and thermodynamics.

Applied knowledge of: theory of propulsion; jet engine performance; propulsion system engineering.

## DESCRIPTION OF CONTENTS: PROGRAMME

1 Introduction to aerospace propulsion:

Thrust generation and jet propulsion  
Effect of external expansion on thrust  
Global performance parameters  
Range of aircraft  
Efficiencies

2 Aircraft Engine Modeling: the Turbojet:

Thrust equation  
Shaft balance for the turbojet  
Fuel consumption  
Design parameters  
Effect of mass flow on thrust  
Note on Ramjets  
Propulsive efficiency  
Thermal and overall efficiencies

3 Introduction to Component Matching and Off-Design Operation

Discussion on nozzle choking  
Component matching  
Effects of Mach number  
Examples

## Compressor-turbine matching. Gas generators

### 4 Turbofan Engines

Ideal turbofan model

Shaft balance

Velocity matching condition

Optimal compression ratio

### 5 Inlets and Nozzles

Inlets or Diffusers

Subsonic Inlets

Supersonic Inlets

Exhaust nozzles

### 6 Principles of Compressors and Fans

Euler equation

Velocity triangles

Isentropic efficiency and compressor map . .

### 7 Compressor Blading, design and multi-staging

Diffusion factor. Stall and surge

Compressor blading and radial variations

Multi-staging and flow area variation

Mach Number Effects

The Polytropic Efficiency

Starting and Low-Speed Operation

### 8 Turbines. Stage characteristics. Degree of reaction:

Euler's Equation

Degree of Reaction

Radial variations

Rotating blade temperature

### 9 Turbine solidity. Mass flow limits. Internal cooling:

Solidity and aerodynamic loading

Mass flow per unit of annulus area and blade stress

Turbine cooling. General trends and systems. Internal cooling.

### 10 Film cooling. Thermal stresses. Impingement:

Film cooling

Impingement cooling

Thermal stresses

How to design cooled blades

### 11 Combustion: Combustors and Pollutants

Combustion process

Combustor chambers

Combustor sizing

Afterburners

Pollutants: regulations

Mechanisms for pollutant formation

Upper-Atmospheric Emissions

### 12 Introduction to engine noise and aeroacoustics:

Noise propagation

Acoustic energy density and power flux

Noise sources and noise modeling

Jet Noise

Turbomachinery noise

### 13 Engine rotating structures

Blade loads

Centrifugal stresses and disc design

14 Fundamentals of rotordynamics:  
Bearings and engine arrangements  
Lumped mass model  
Critical speeds  
Forces on bearings  
Comments on blade vibrations

#### LEARNING ACTIVITIES AND METHODOLOGY

Theory sessions.  
Problem sessions working individually and in groups.  
Computer sessions.  
Lab-sessions.

#### ASSESSMENT SYSTEM

<b>% end-of-term-examination:</b>	60
<b>% of continuous assessment (assignments, laboratory, practicals...):</b>	40

In order to pass the subject, two requirements need to be met:

- 1) To have a MINIMUM mark of 4.0/10 in the end-of-term exam;
- 2) To have a MINIMUM overall mark of 5.0/10 (weighing 60% the end-of-term exam mark and 40% the mark of the continuous evaluation).

The continuous evaluation includes 2 partial exams (each one corresponding to 10% of the final mark) and 4 reports of laboratory practices (each one corresponding to 5% of the final mark).

#### BASIC BIBLIOGRAPHY

- J.D. Mattingly Elements of Propulsion: Gas Turbines and Rockets, AIAA, 2006
- J.L. Kerrebrock Aircraft Engines and Gas Turbines, MIT Press, 1992

#### ADDITIONAL BIBLIOGRAPHY

- N. Cumpsty Jet Propulsion, Cambridge Univ. Press, 2003
- Saeed Farokhi Aircraft Propulsion, Wiley, 2014