

Academic Year: ( 2020 / 2021 )

Review date: 10-07-2020

Department assigned to the subject: Bioengineering and Aerospace Engineering Department

Coordinating teacher: IANIRO , ANDREA

Type: Electives ECTS Credits : 6.0

Year : 3 Semester : 1

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

Introduction to Fluid Mechanics

Fluid Mechanics

Thermal Engineering

Introduction to structural analysis

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

**OBJECTIVES**

CE.TE.PA1. 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.

CE.TE.PA2. 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

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).

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

## 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