Aerospace propulsion: complement I

Academic Year: (2017 / 2018) **Review date: 28-04-2017**

Department assigned to the subject: Department of Bioengineering and Aerospace Engineering

Coordinating teacher: NAVARRO CAVALLE, JAUME

Type: Electives ECTS Credits : 6.0

Year : 4 Semester : 2

STUDENTS ARE EXPECTED TO HAVE COMPLETED

Aerospace Propulsion
Fluid Mechanics
Thermal Engineering
Introduction to Mechanics of Flight
Chemistry

COMPETENCES AND SKILLS THAT WILL BE ACQUIRED AND LEARNING RESULTS.

The aim of this course is that the student acquires a basic knowledge of the combustion processes and their physical laws and of rocket engines and their application to aerospace propulsion. This course is intended to provide the core of the 'aerospace propulsion minor' syllabus to students that followed the 'aerospace vehicles minor'. This complemented syllabus will give students a more solid background for continuing Master studies in Aerospace Engineering.

DESCRIPTION OF CONTENTS: PROGRAMME

Combustion
-Introduction to combustion phenomena and fuels.
-Thermochemistry.
-Chemical kinetics.
-Homogeneous reacting systems.
-Analysis of simple flame regimes.

Rockets
1. Rocket motors and fundamental parameters
- The rocket equation. Specific Impulse. Effective velocity increment; gravity and drag losses. Delta-V for various missions. Staging.
2. Rocket dynamics
- 2D Rocket motion. Parallel, perpendicular, and rotation equation. Trajectory during ascent. Aerodynamic stability. Lateral wind. Gravity turn.
3. Fundamentals of orbital mechanics
- Two-body problem. Kepler laws. Energy and angular momentum conservation. Types of orbits. Circular and escape velocities. Hohmann transfer.

4. Rocket nozzles.
- Quasi-1D model with ideal gas. Choked mass flow. Pressure ratio, area ratio, exit Mach number. Thrust and thrust coefficient. characteristic velocity. Variation with external pressure. Flow separation. Real effects. Method of characteristics for nozzle design. Expansion of reacting gas.
5. Heat transfer and cooling in rockets.
- Stanton number, film coefficient. The Reynolds analogy, Bartz's correlation. Regenerative cooling. Ablation cooling.

6. Solid propellant rockets.
- Grain composition, combustion and regression rate. Steady and transient mass balance. Massflow model. Chamber pressure selection. Construction. Grain geometry. Ignition.
7. Liquid propellant rockets.
- Mono- and bi-propellant rockets. Properties of common propellants. Pressurization cycles. Combustion instabilities. Injectors
8. Hybrid Rockets.
- Internal ballistics. Mass flow model.
9. Non-Chemical rockets.
- Nuclear. Electric propulsion and Low-Thrust. Types of electric thrusters.

LEARNING ACTIVITIES AND METHODOLOGY

Theory sessions.
Problem sessions working individually and in groups.
Homework exercises/class quizzes
Lab sessions.

ASSESSMENT SYSTEM

The course is composed of two parts: Combustion and Rocket Motors.

- Combustion (50%)
- Rocket Motors (50%)

The evaluation will be done with Homeworks and Quizzes and a final exam

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- G. Sutton and O. Biblarz Rocket Propulsion Elements, Wiley, 2010

- STEPHEN R. TURNS AN INTRODUCTION TO COMBUSTION, 3RD EDITION, MAC GRAW-HILL INTERNATIONAL, 2012