Rocket Motors

Academic Year: (2017 / 2018) **Review date: 28/04/2017 11:02:10**

Department assigned to the subject: Bioengineering and Aeroespace Engineering Department

Coordinating teacher: NAVARRO CAVALLE, JAUME

Type: Compulsory ECTS Credits : 3.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

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

OBJECTIVES

The goal of this course is that the student acquires knowledge about rocket engines and their application to aerospace propulsion.

Competences and learning results:
- Applied knowledge of: theory of propulsion; jet propulsion performances; propulsion systems engineering.
- Adequate and applied engineering knowledge of: methods of calculation and development for propulsion systems; regulation and control of propulsion systems; experimental techniques, equipment and measurement instruments for the specific discipline; fuels and lubricants used in aircraft engines and automotive engines; numerical simulation of the most significant physical-mathematical processes; systems maintenance and certification of aerospace engines.
- Basic knowledge of combustion processes, the laws that govern them and propulsion applications.
- Basic knowledge of the characteristics and performance of rocket engines and its application in aerospace propulsion.
- Adequate and applied techniques and procedures for turbomachinery design knowledge.

DESCRIPTION OF CONTENTS: PROGRAMME

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

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	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 is composed of laboratory reports (15%) and quizzes/exercises (25%)

BASIC BIBLIOGRAPHY

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

- Howard D. Curtis Orbital Mechanics for Engineering Students, ELSEVIER, 2014

ADDITIONAL BIBLIOGRAPHY

- M. Martinez-Sanchez Rocket Propulsion, MIT OCW (Open Course Ware).