Course guide
220305 - 220305 - Rockets Combustion and Propulsion

Last modified: 05/07/2024

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 724 - MMT - Department of Heat Engines.

Degree: MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: Jordi Ventosa Molina

Others: Borja Borràs Quintanal
David Bermejo Plana

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE18. MUEA/MASE: The ability to design, execute and analyse propulsion systems tests and carry out the systems' entire certification process.
CE12. MUEA/MASE: Sufficient knowledge of advanced fluid mechanics, particularly experimental and numerical techniques used in fluid mechanics.
CE13. MUEA/MASE: Understanding and mastery of combustion and heat and mass transfer phenomena.

Basic:
CB06. Manage original concepts in research projects.
CB08. Generate decision from incomplete information assuming its social and ethical responsibilities.
CB10. Improve self-learning capacity

TEACHING METHODOLOGY

The teaching methodology is divided into three parts:
- Classroom activities: theory and excercices
- Computer classroom: computer practices with specific combustion and rockect software
- Self study work and exercises and activities.

In the classroom activities, the teaching staff will introduce the theoretical bases of the subject, concepts, methods and results illustrating them with convenient examples and requesting, where appropriate, the accomplishment of exercises to facilitate their understanding.
In the practical training session, the teaching staff will guide the student in the analysis and resolution of rocket combustion processes, using calculation programs. These sessions are planned to be held in the computer rooms that exist in the school. The methodology and the calculation tools treated (programs) will have to be used by the student in the resolution of combustion problems proposed by the teacher.
As a final activity of the subject, the student will have to work as a team on a topic related to the subject. This work will be presented in class and will be evaluated by the teaching staff.
In summary the teaching methodology is based on classroom activities (theory, problems) and on self-employed work carried out by the student outside the classroom (combustion problems, final work). The teaching staff will provide appropriate tutoring and monitoring of the activities and work done by the students.

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course the student should:

- Know the theoretical fundamentals and limitations of thermal rocket propulsion.
- Know the theoretical foundations and calculation methodology of the combustion process in thermal rockets.
- Know the characteristic elements and systems of rocket propulsion: combustion chamber, nozzle, injectors, pumps, tanks. Chemical, thermal and mechanical compatibility of materials.
- Know the procedures for the design of nozzles.
- Have the fundamentals to carry out a preliminary analysis of the mission requirements.
- Know the principles of operation and internal ballistics of the different types of rocket engines.
- Have criteria for the selection of the most suitable type of chemical propulsion for each mission.
- To be trained for the basic design and preliminary project of chemical rockets in solid, liquid and hybrid propergols.
- To know about experimental test techniques: Test bench and its instrumentation.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	24.00
Hours small group	15,0	12.00
Self study	80,0	64.00

Total learning time: 125 h

CONTENTS

Module 1: Specificity and applications of different types of rocket propellants

Description:
Performance parameters
Type of missions
Type of rockets
Rocket evaluation

Full-or-part-time: 12h 30m
Theory classes: 3h
Laboratory classes: 1h 30m
Self study : 8h

Module 2: Rocket fuels and oxidisers

Description:
Basic combustion concepts
Type of fuels used
Physical model of the ideal rocket engine
Liquid propellants

Full-or-part-time: 16h 40m
Theory classes: 4h
Laboratory classes: 2h
Self study : 10h 40m

Module 3: Combustion applied to rockets

Description:
Stoichiometry
Thermochemistry
Sample exercices

Full-or-part-time: 16h 40m
Theory classes: 4h
Laboratory classes: 2h
Self study : 10h 40m

Module 4: Historical overview of rocket propellants

Description:
Analyse the rocket propellants used in different missions throughout the history of rockets.

Full-or-part-time: 12h 30m
Theory classes: 3h
Practical classes: 1h 30m
Self study : 8h

Module 5: Solid propellant rockets

Description:
Load composition and formulation
Grain geometry design
Combustion and thrust law
Internal ballistics
Ignition systems

Full-or-part-time: 16h 40m
Theory classes: 4h
Laboratory classes: 2h
Self study : 10h 40m

Module 6: Technical performance qualities of rockets

Description:
Rocket gas exit velocity
Thrust and expansion ratio
Characteristic velocity
Thrust coefficient

Full-or-part-time: 16h 40m
Theory classes: 4h
Laboratory classes: 2h
Self study : 10h 40m

GRADING SYSTEM

There will be four evaluation tests:
- First evaluation (35%)
- Second evaluation (35%)
- Combustion problems (10%)
- Assignments (20%)

For students who do not pass the first evaluation, a make-up exam will be made that will take place on the day of the second evaluation.
Make-up Exam Rules:
- Only students who have failed the first evaluation can attend the make-up exam
- Maximum mark limited to 6.0 out of 10.0
- The final grade of the first evaluation will be the highest that the student obtains between the two exams (ordinary exam and make-up exam)

BIBLIOGRAPHY

Basic:
- Sutton, G. P.; Biblarz, O. Rocket propulsion elements [on line]. 8th ed. New York: John Wiley & Sons, 2010 [Consultation: 03/05/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=818989. ISBN 9781118174616.
- Kuo, K. K. Principles of combustion. 2nd ed. New York: John Wiley & Sons, 2005. ISBN 0471046892.
- Malcom W. Chase, Jr. NIST-JANAF thermochemical tables. 4th ed. Washington: American Chemical Society and American Institute of Physics, 1998. ISBN 1563968312.
- Huzel, D. K.; Huang, D. H. Modern engineering for design of liquid-propellant rocket engines. Washington: American Institute of Aeronautics and Astronautics, 1992. ISBN 1563470136.
- Brown, Charles D. Spacecraft propulsion. Washington, DC: American Institute of Aeronautics and Astronautics, 1995. ISBN 1563471280.
- Huzel, D. K.; Huang, D. H. Design of liquid-propellant rocket engines [on line]. 2nd ed. Washington: National Aeronautics and Space Administration, 1971 [Consultation: 12/04/2022]. Available on: https://ntrs.nasa.gov/api/citations/19710019929/downloads/19710019929.pdf.

Complementary:
- Mattingly, Jack D. Elements of propulsion: gas turbines and rockets [on line]. Reston: American Institute of Aeronautics and Astronautics, 2006 [Consultation: 05/05/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=3111475. ISBN 1563477793.
- Turchi, Peter J. Propulsion techniques: action and reaction. Reston: American Institute of Aeronautics and Astronautics, 1998. ISBN 1563471159.
- Oates, Gordon C. Aerothermodynamics of gas turbine and rocket propulsion. 3rd ed. Reston: American Institute of Aeronautics and Astronautics, 1997. ISBN 1563472414.

RESOURCES

Other resources:
Material prepared and/or compiled by the teacher available on the ATENEA virtual campus.