

30151 - Missiles

Syllabus Information

Academic Year: 2022/23

Subject: 30151 - Missiles

Faculty / School: 179 - Centro Universitario de la Defensa - Zaragoza

Degree: 563 - Bachelor's Degree in Industrial Organisational Engineering

ECTS: 6.0

Year: 4

Semester: First semester

Subject Type: Optional

Module:

1. General information

1.1. Aims of the course

This course and its expected learning results obeys to the next objectives and plans.

This course's main aim is that future Officers of the Artillery fundamental specialty acquire the competences and learning outcomes listed in sections 2.1 and 2.2, which are fundamental for some aspects of their professional practice. More in detail, the specific competencies necessary to understand the design, conception, operation and performance of missile weapon systems; as well as the ability to evaluate the performance of a given missile system and critically analyze its suitability to perform a specific combat mission. It also helps to achieve a series of general competences of management, decision making, communication skills, teamwork and self-learning that must begin to be mastered as the end of the Degree studies is nearing.

Specialization in Defense: These approaches and objectives are in line with the following Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda (<https://www.un.org/sustainabledevelopment/es/>): 9 "Industry, innovation and infrastructure" and 16 "Peace, justice and strong institutions". In such a way that the acquisition of the learning outcomes of the subject provides training and competence to contribute to their achievement to some degree. The defense industry is a key sector in the Spanish economy, both for its economic and technological impact; on the other hand, without modern weapon systems it is impossible to guarantee peace and security for citizens.

1.2. Context and importance of this course in the degree

This Missiles subject is an elective one of 6 ECTS that is taught in the first semester of the fourth academic year. It is part of the Radar and Missile Systems Module, within the Elective Module of the specialization in defense.

Specialization in Defense: This subject contributes to the training of Army Officers, providing basic knowledge on the guidance and control of missiles and some technical skills that Army Officers of the Artillery fundamental specialty need to carry out their mission and thus contribute to the development of their professional career.

This subject is optional and its contents are oriented both to serve as a basis for their future preparation at the Artillery Academy of Segovia, as well as to be applied in the professional practice of future graduates. For this purpose, extensive use is made of scientific-technical knowledge previously acquired in other subjects of Basic and Compulsory Training of the Degree. A list includes:

- 1) The ability to solve mathematical problems that may arise in Engineering (differential calculus, ordinary differential equations and numerical methods) that have been achieved in the subjects of "Mathematics I", "Mathematics II" and "Mathematics III".
- 2) The understanding and mastery of the basic principles of mechanics, thermodynamics and electromagnetism in the optical range that have been achieved in the subjects of "Physics I" and "Physics II".
- 3) The basic knowledge of chemistry (thermodynamics and chemical kinetics) necessary to understand a combustion process that has been achieved in the subject of "Chemistry".
- 4) The capacity of abstraction to be able to view an object from different positions in space that is acquired in the subject of "Graphic expression and computer-aided design".
- 5) The ability to apply the knowledge of optimization acquired in the subjects of "Statistics" and "Operative Research".
- 6) The ability to identify the motion parameters of a mechanical system and its degrees of freedom, the understanding of the concepts of center of masses and inertia tensor and the application of vector theorems to mechanical systems acquired in the subject "Mechanics".
- 7) The fundamentals of rotating electrical machines acquired in "Electrical Engineering".
- 8) The identification of the applications and functions of electronics in engineering and the knowledge of basic electronic

components and devices, skills acquired in "Fundamentals of Electronics".

9) Knowledge of the fundamentals of automatisms and control methods acquired in "Automatic Systems".

10) The understanding of the concepts of stress and deformation acquired in "Strength of Materials".

11) The ability to handle technical literature written in English that is acquired in the different subjects of "English".

1.3. Recommendations to take this course

This subject is fourth year one and corresponds to the Fundamental Specialty of Artillery. As it is typical in most undergraduate curricula, it makes use of a wide range of competencies that the student has acquired in the previous subjects of the degree, so he should be able to successfully take it. It is convenient to review the previous point (1.2. Context and sense of the subject in the degree) for a list of the required previous competencies, but bear in mind that their use in this subject will be simplified and with a strongly applied character.

Given the organization of the syllabus, it will be necessary to introduce new concepts necessary to understand the operation of a missile, corresponding to subjects that the student has not studied, especially in relation to Aerodynamics. But this will not be a problem, since the concepts will be clarified and reinforced in class

2. Learning goals

2.1. Competences

After successfully completing this subject, the student will be more competent to ...

GENERIC COMPETENCES

C02 - Ability to plan, budget, organise, manage and monitor tasks, people and resources.

C04 - Ability to solve problems and take decisions with initiative, creativity and critical reasoning.

C06 ? Ability to communicate knowledge and skills in Spanish.

C09 ? Ability to work in a multidisciplinary group and in a multilingual setting.

C11 ? Ability to continue learning and develop self-learning strategies.

SPECIFIC COMPETENCES

C58 - Familiarity with the fundamentals of Mathematics, Ballistic and Guided Missile Systems applicable to firing procedures for Artillery Weapons Systems.

2.2. Learning goals

The student, to pass this subject, must prove the following achievements ...

- Capacity to describe the different scientific subjects that are involved in the conception, design and operation of a missile and their relations with each other that may provide with an overview of the full system. Special emphasis will be made on the Guidance System.

- Technical competence to use and understand the information provided with existing missile systems, so that their possible use can be extracted. The student ...

1. knows how to classify and analyze the different Guidance Systems of a missile (missile block diagram) and is able to identify its components.

2. can analyze the functions performed by each component and how they affect the performance of the full missile system.

3. knows how to classify and identify the different missile trajectories and its use by different missile systems.

4. distinguishes the origin, factors and circumstances which intervene in the appearance of aerodynamical forces and knows to analyze how they are used.

5. can analyze and identify Control Systems as a fundamental component of any missile in use by weapons systems.

6. knows how to distinguish and analyze the different sensors and navigation systems of a missile: infrared sensor (IR), laser, inertial sensors (gyroscopes, accelerometers, IMU) and image processing.

7. can analyze the components of an Unmanned Aircraft/Aerial Vehicle (UAV).

2.3. Importance of learning goals

Relevance of the learning goals achieved through this subject

Learning goals are a part of the competences that a student must acquire as a part of his formation in the Fundamental Specialty of his choice. In particular, they will provide him with the ability to extract, from the technical information about missile systems, those data more relevant to determine the possible uses of the system.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

3.1. Type of tests and their value on the final grade and evaluation criteria for each test

The students must demonstrate that they have achieved the expected learning outcomes by means of the following assessment activities

FIRST CALL

Continuous assessment:

The students will be able to pass the total of the subject by the continuous assessment procedure. To do this, they must demonstrate that they have achieved the expected learning outcomes by passing the assessment instruments indicated below, which will be carried out throughout the semester:

1. A short examination of objective and short answer tests about the contents of the first two topics that will weight 10% on the final grade, if the grade obtained is higher than the one obtained in test 2; otherwise, it will not weight.
2. A long examination of theory and problem-solving about the contents of the first seven topics, which will be weighted 40% of the final grade, if the grade obtained is lower than that obtained in test 1; otherwise, it will be weighted 50% and test 1 will not be taken into account.
3. A short examination of objective and short answer tests on the contents of topics VIII, IX and X, which will be weighted 15% of the final grade.
4. A theoretical-practical study carried out in a team, with final report and minutes of the work meetings included, on the contents of topic XI, which will be weighted 15% of the final grade.
5. A practical class session in a computer classroom in which a problem-based learning activity will be carried out. In this activity, all the competences acquired in the subject will have to be applied. It will weight 20% of the final grade.

The final grade of continuous assessment (100%) will be calculated according to the specific weight of each continuous assessment activity. To pass the subject, the student must obtain a final grade higher or equal to five and not have obtained a grade lower than three in any of the continuous evaluation activities; with the exception mentioned for the first two activities, in which the combination most favorable to the student will be used.

Global test:

Students who do not pass the subject by continuous evaluation or who would like to improve their grade will have the right to sit for the Global Test set in the academic calendar; prevailing, in any case, the best of the grades obtained. This global test will be equivalent to the continuous evaluation tests described above and will have a weight of 100% in the final grade. It will consist of an oral exam on all the contents of the subject to which the student will be able to go with the written materials he/she wants to prepare his/her answer during half an hour, once the questions to be answered are known. In order to pass the course, the student must obtain a final grade higher or equal to five.

In the event that the average for continuous evaluation of the subject exceeds five, but there is an activity whose grade does not reach three, the student may request that the global test be limited to a repetition of the continuous evaluation tests in which he/she had not reached a grade of three. To these effects, the activities of continuous evaluation 1) and 2) will be considered as a single one.

SECOND CALL

Global test:

Students who do not pass the subject in the first call may sit for a Global Test set in the academic calendar for the second call. This global test will consist of an exam of questions of development and problem solving on all the contents of the course whose weighting will be 70% of the final grade and an oral presentation of a project to be developed between both calls whose weighting will be 20% of the final grade for the report and 10% for its oral defense. The evaluation criteria will be the same for both activities as those used in the FIRST CALL. The only novelty is that the project will require an oral defense of the results with a weighting of 10% of the final grade.

EVALUATION CRITERIA.

In the objective tests, no marks will be deducted for wrong answers.

In the short answer exams, not only the correctness of the answer will be valued, but also the capacity of synthesis to approach it.

In the development exams, in addition to the cognitive competences, the communicative skills will be valued, writing with a fluent style, without spelling mistakes and with a good use of punctuation and logical reasoning.

In problem-solving exams, explanations given as to why each step is followed will be especially valued. A simple collection of formulas and numbers, completely correct but without any explanation, corresponds to a maximum grade of 6 out of 10 in the corresponding problem.

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he theoretical-practical study will be evaluated by means of the minutes of the meetings of the work team that has carried out the study (20% of the grade of this activity) and the quality of the final report evaluated with criteria similar to those of the Final Degree Project; although without oral exposition: content 60% of the grade of the activity and presentation 20% of the grade of the activity (spelling, good structure of the work, sensible logical reasoning, use of connectors, ...; but not decorative aspects).

The practical class session has a formative evaluation purpose even more important than the summative one. It is an application of the acquired competences to the study of a realistic and complex problem under the guidance of the teacher. Attitudinal skills (behavior during the session, raising doubts, ability to discuss with colleagues) will be evaluated with a weight of 20% of the activity grade, as well as cognitive skills (use of notes and bibliography to justify the process of obtaining the resolution) with a weight of 30% of the activity grade, and procedural skills (being able to rigorously apply a working method that leads to a set of correct results within the applied simplifications) with a weight of 50% of the activity

grade. These last two sections will be evaluated by means of a small report that the students will send to the teacher within the deadlines established by the teacher.

In the oral tests, if they are carried out, a dialogue between the teacher and the student will be established and the student's ability to communicate and respond to unforeseen events will be assessed, in addition to the specific knowledge of the subject. The SOLO (Structure of Observed Learning Outcome) method will be applied with questions aimed at evaluating the level of acquisition of competencies according to this scale: very deficient, numerical score 1, (the tasks are not correctly posed and the answers are usually irrelevant comments), insufficient, numerical score 3, (the student only focuses on one aspect and gives relevant answers but without depth), sufficient, numerical score 6, (the student identifies the fundamental aspects but is not able to relate them and has difficulties of expression), remarkable, numerical score 8, (knowledge has been integrated as a whole and there is the ability to analyze the same issue from different points of view) and outstanding, numerical score 10, (a level of abstraction has been reached that allows applying the concepts learned to situations different from those raised in the classroom, including real life).

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The approach, methodology and assessment of this course are prepared to be equivalent in any teaching scenario. They will be adjusted to the socio-sanitary conditions of each moment, as well as to the indications given by the competent authorities.

The teaching methodologies detailed below have been taken from among those proposed in the "Degree Verification Report", section 5.3.

The learning process that has been designed for this course is based on the following

There will be lectures in which the professor will explain the syllabus of the subject. Students will be provided with notes in advance and it would be advisable that they have read, without the need to study in depth, those corresponding to the session given beforehand. It is essential that these sessions are used to raise doubts and that students have developed their ability to take notes. Competences C6, C11 and C58 will be worked on.

There will be practical classes of resolution of exercises and problems in which the student's participation will be promoted. The teacher will announce in advance the problems to be solved so that the students can work on them. It is fundamental to try and solve the problems in an autonomous way before the sessions. Even when a correct result has not been achieved, it is of great benefit to identify the points where a mistake was made. After the sessions, it is a good idea to try and solve more problems independently. Remember that all problems can be solved using the skills acquired or in the process of being acquired. If any student feels, after a couple of days of seriously trying to solve a problem, that he is stuck, he should ask for tutoring. Skills C2, C4, C11 and C58 are worked on.

There will be a group work activity dedicated to the theoretical-practical study of Unmanned Aerial Vehicles. The teams will consist of a number of students between three and five, who, in their work meetings, will have to rotate the functions of moderator and secretary who takes minutes of the progress and discussions that have taken place. These minutes will be subject to evaluation. The group constitution meeting will be a half-hour tutorial session with the professor and, from then on, the work will be autonomous, with the possibility of requesting additional tutoring if deemed necessary. It should be remembered that this is a group activity in which "everyone is responsible for everything". An organization of the activity in which each member is in charge of only one topic and neglects the remaining ones will result in the final report being uneven in style and quality, which will be reflected in a low grade for all members of the group. In case of internal problems in the functioning of the group, a tutorial session can be requested so that the teacher may help in the search for a solution. Competences C2, C4, C6, C9 and C58 are worked on.

There will be a practical class session in a computer classroom, spread over several days, in which a problem-based learning on a realistic missile weapon system will be addressed and analyzed according to the knowledge acquired. Throughout the session, it will be necessary to make use of numerical simulation tools whose use will be supervised by the teacher, to obtain answers to a series of questions about the operation of the system. The practice will be carried out in pairs or groups of three students at most if the total number is odd. Once the data collection is completed in the practical class session, a small report will be written explaining the objectives, the working method and the results obtained, which will be sent to the teacher for the evaluation of the cognitive and procedural competences. At the end of each day of this activity, a series of numerical values and observations will be recorded in a questionnaire, which will be collected by the teacher, to check the adequacy between what has been studied in the classroom and the results presented in the report. The competences C2, C4, C6 and C58 will be worked on.

The theoretical study of the contents of the subject and the practical study of its application to the resolution of exercises and problems, in an autonomous way by the student, is fundamental in the learning process of the course and to be able to pass the evaluation tests. It can be done individually or in small groups. Students can request support from the teacher through tutoring or consultations in the virtual course of the subject in the Moodle platform. It is advisable to keep some kind of record (notebook, diary, blog, ...) in which to note any doubts and achievements to facilitate a later review and to reflect on the learning strategies that are most profitable for each student. Competences C2, C4, C11 and C58 will be worked on.

4.2. Learning tasks

The program offered to the student to help him achieve the expected results comprises the following activities....

1) Classroom activities (60 hours), based on:

- The presentation of the main contents of the subject in lectures.
- Problem solving and case studies using the theoretical contents and bibliographic references in practical classes.

2) Activities outside of classroom (90 hours), which include:

- Autonomous work of the student of resolution of exercises and study of the theoretical documentation available to consolidate the acquired knowledge.
- The elaboration of a report as a result of the collaboration of a group of between three and five students.
- The elaboration of a report in pairs as a summary of the practice in the computer classroom based on the resolution of a problem.

4.3. Syllabus

The syllabus comprises the following didactic units:

Topic I. **Introduction to missile systems.**

Concept of missile. Components and classification of missile weapon systems.

Topic II. **Introduction to guidance and control systems.**

Purpose of guidance and control systems. Block diagrams. Causes of error. Guidance system elements. Implications for tactical use.

Topic III. **Aerodynamic and structural design.**

Geometry of a missile. Fundamentals of aerodynamics. Structural design.

Topic IV. **Flight mechanics.**

Equations of motion of an aircraft. Aerodynamic configuration of different types of missiles. Natural response of a missile. Stability and maneuverability. Natural performances of different types of missiles.

Topic V. **Control systems.**

Inadequacy of the natural response according to the type of target. Feedback mechanisms and their effect on the response.

Topic VI. **Missile-target kinematics.**

Descriptions of relative missile-target kinematics. Guidance conditions. Guidance laws. Guidance orders. Trajectories. Comparison between guidance laws Complete guidance loop.

Topic VII. Navigation systems.

Inertial navigation: gyroscopes and accelerometers. Other navigation methods.

Topic VIII. **Physical laws on thermal radiation. Radiometry.**

Electromagnetic spectrum in the optical range. Heat and temperature. Physical laws of radiation. Comparison between meters. Radiometry. Radiation sources: the environment and targets. Optical properties of the atmosphere.

Topic IX. **Infrared sensors: components and operation.**

Optics: focal, aperture, field and Airy circle. Optical modulation and digital image processing. Thermal and photonic sensors. Quantum wells.

Topic X. **Lasers: devices and control techniques.**

The laser as coherent optical radiation by stimulated emission. Laser media and pumping. Resonant cavities. Modulation of laser pulses. Applications and safety.

Topic XI. **Introduction to UAV's systems.**

Definitions. Components and classification. Legislation. Operational. Military use.

4.4. Course planning and calendar

Learning planning activities in hours. Calendar of classroom sessions and presentation of papers

	Classroom hours	Autonomous hours	Total hours
Lectures	38	-	38
Problems/exercises solving	10	-	10
Problem-based learning	6	-	6
Tutoring	2	-	2
Continuous assesment tests	4	-	4
Group work	-	8	8
Preparation of practical report	-	3	3
Auotonomous theoretical study	-	54	54
Autonomous practical study	-	25	25
TOTAL HOURS	60	90	150

(*) The data shown in the table of planning by hours are for guidance purposes, considering the homogeneity of the students.

(**) In the last three years the rate of exit has been 100%, with the global evaluation test reduced to being the last of the continuous evaluation tests. This year, with 100% of the grade available through continuous evaluation, it is not expected that any student who does not want to improve his grade will take the global test. Due to the extraordinary nature of this test, it has not been included in the planning.

Calendar of classroom sessions and delivery of assignments

It will be announced by the teacher, both in class and through the moodle support platform, <https://moodle2.unizar.es/add/>

To consult and expand on all topics related to the course, please visit: <http://moodle2.unizar.es> and <http://tud.unizar.es>.

In these addresses you can obtain information about:

- Academic calendar.
- Schedules and classrooms.
- Examination dates.

In addition, the professor will inform about any other issue that may arise related to the subject.

4.5. Bibliography and recommended resources

<http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=30151>