IDENTIFYING DATA				
Fluid machines				
Subject	Fluid machines			
Code	P52G381V01305			
Study programme	(*)Grao en Enxeñaría Mecánica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	3rd	2nd
Teaching language	Spanish			
Department				
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General description	The subject "Fluid Machines" is a subject of the specific mechanical block that is taught in the second semester of the third course of the degree in mechanical engineering taught at the CUD. The subject uses the fundamental tools used in the study of fluid movement (differential, integral and dimensional analysis) acquired in the subject "Fluid Mechanics" and applies them to energy transformer devices in which energy is transferred between the fluid that runs through the machine and its moving parts. The subject is focused on the study of machines with incompressible fluid. The need to reconcile the specific military training of the future Navy Officer with that of the degree in mechanical engineering leads to the subject being taught and evaluated aboard the "Juan Sebastián de Elcano" Training Ship.			

Competencies	
Code	
B3	Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations.
C24	Applied knowledge of the basics of fluidmechanics systems and machines.
D2	Problems resolution.
D9	Apply knowledge.
D10	Self learning and work.
D17	Working as a team.

Learning outcomes			
Expected results from this subject	Training and Learning Results		
Understand basic concepts of fluid machinery.	B3	C24	D2 D9 D10
Acquire skills in the sizing process of pumping facilities and fluid machines	B3	C24	D2 D9 D10 D17
ENAEE Learning outcome: KNOWLEDGE AND UNDERSTANDING: RA1.2.- Knowledge and understanding of engineering disciplines underlying their specialisation, at a level necessary to achieve the other programme outcomes, including some awareness at their forefront [Level of development of each sub result (Basic (1), Appropriate (2) and Advanced (3)] In this sub-result appropriate (2).	B3	C24	
ENAEE Learning outcome: ENGINEERING ANALYSIS: RA2.2.- Ability to analyse complex engineering products, processes and systems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; to correctly interpret the outcomes of such analyses [Appropriate (2)].			D2 D9

ENAEE Learning outcome: ENGINEERING DESIGN: RA3.2.- Ability to design using some awareness of the forefront of their engineering specialisation [Basic (1)].	C24	D9
ENAEE Learning outcome: INVESTIGATIONS: RA4.3.- laboratory/workshop skills and ability to design and conduct experimental investigations, interpret data and draw conclusions in their field of study [Basic (1)].	C24	D9
ENAEE Learning outcome: ENGINEERING PRACTICE: RA5.1.- Understanding of applicable techniques and methods of analysis, design and investigation and of their limitations in their field of study [Basic (1)].	C24	D9
ENAEE Learning outcome: ENGINEERING PRACTICE: RA5.2.- Practical skills for solving complex problems, realising complex engineering designs and conducting investigations in their field of study [Basic (1)].		D9
ENAEE Learning outcome: ENGINEERING PRACTICE: RA5.3.- Understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations in their field of study [Basic (1)].		D9
ENAEE Learning outcome: LIFELONG LEARNING: RA8.2.- . Ability to follow developments in science and technology [Basic (1)].		D10

Contents

Topic	
Unit 1: Fluid machinery classification.	1.1.-Fluid machinery classification. 1.2.-Constitutive parts. 1.3.-Fluid machinery applications.
Unit 2: Energy balance in fluid machinery.	2.1.-Characterisation of fluid machinery. Inlet and outlet sections definition. 2.2.-Total energy conservation law. 2.3.-Internal energy conservation law. 2.4.-Mechanical energy conservation law. Hydraulic head. 2.5.-Mechanical energy balance and performance in driven machinery. 2.6.-Mechanical energy balance and performance in driving machinery.
Unit 3: Positive displacement machinery.	3.1.-Positive displacement machinery. Principles and classification. Characteristics. Applications. 3.2.-Alternative volumetric pumps. 3.3.-Rotary and peristaltic volumetric pumps. 3.4.-Hydraulic motors and linear actuators. Performance curves.
Unit 4: Principles of hydraulic circuits.	4.1.-General diagram of hydraulic circuits. Functional decomposition and simbology. 4.2.-Control elements and accessories in hydraulic circuits. 4.3.-Design and control of elementary hydraulic circuits.
Unit 5: Principles of pneumatic circuits.	5.1.-General diagram of pneumatic circuits. Functional decomposition and simbology. 5.2.-Control elements and accessories in pneumatic circuits. 5.3.-Design and control of elementary pneumatic circuits.
Unit 6: Hydraulic turbomachinery fundamentals.	6.1.-Introduction. Reference systems. Normalized views. 6.2.-Angula momentum conservation law. Euler theorem. 6.3.-One-dimensional theory. 6.4.-Bernouilli equation in rotor reference frame. 6.5.-Simplified theory of radial turbomachines. Centrifugal pumps. Francis turbines. 6.6.-Simplified theory of axial turbomachines. Kaplan turbines. 6.7.-Dimensional analysis and physical similarity in hydraulic turbomachinery.
Unit 7: Fluid machinery and instalations practice.	7.1.-Pumps and pump stations calculations. Pump performance and installation curves. 7.2.-Pelton turbine operation. Regulation. 7.3.-Francis turbine operations. Regulation. 7.4.-Marine propellers. 7.5.-Wind turbines. 7.6.-Revesible hydraulic plants.
Practice 1: Identification of the elements of fluid machinery in CAD assemblies.	Aims and development: In this first practical session the student opens CAD files prepared by the lecturer to visualise the constitutive elements of fluid machinery and hydraulic installations. The main aim of this practical activity is to strengthen the nomenclature and facilitate the three-dimensional visualisation of the flow in the interior of fluid machines.

Practice 2: CFD simulation of positive displacement pumps.	Aims and development: In this first CFD practice activity, dynamic mesh models are explained in order to define the movement of pistons, valves and rotary parts in volumetric pumps.
Practice 3: Hydraulic circuit simulation with demo software.	Aims and development: To strengthen the theoretical knowledge related with lesson 4, in this practice a hydraulic circuit will be designed, with the aim to understand the activities of each one of the elements involved: elements of generation, actuation and of control.
Practice 4: Pneumatic circuit simulation with demo software.	Aims and development: To strengthen the theoretical knowledge of the subject 5 it is expected that the student designs a pneumatic circuit of intermediate complexity to satisfy some requirements imposed by the lecturer, analyse the operation of the different elements and look for the greater simplicity of the circuit.
Practice 5: Analysis of a real hydraulic or pneumatic circuit using Fluidsim software	Aims and development: In order to strengthen the theoretical knowledge acquired in topics 4 and 5, and to reinforce the concepts and skills of software management developed in practices 3 and 4, this practice is proposed, in which Fluidsim software is used, the updates of which incorporate knowledge of Vanguard. In it, the student has to analyze a simple case of a real hydraulic or pneumatic circuit (hydraulic jack, hydraulic component of an excavator, opening of a door ...). The student will choose the component that he wants to analyze so that different components are studied and each student has to face different problems.
Practice 6: Problem solving involving turbopumps and installations.	Aims and development: The student will solve a problem of turbopumps in which parameters of design of the impeller and the installation come into play. Taking as a starting point a table with the record of experimental measurements, the operating curves of a centrifugal turbopump are derived and the operating point is evaluated for different configurations.
Practice 7: Calculation of a real hydraulic installation using the Epanet software	Aims and development: In this practice, problems with real pumping facilities are modeled and solved with the Epanet software. This practice is intended to inculcate that the available software tools facilitate the calculation work, but do not free the user from having the necessary engineering knowledge for the correct introduction of the data and interpretation of the results.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	26	39	65
Laboratory practical	14	21	35
Problem solving	22	1	23
Objective questions exam	4	4	8
Problem and/or exercise solving	10	9	19

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	In these sessions the basic theoretical contents of the program will be explained in detail, exposing clarifying examples that deepens in the understanding of the subject. A digital board will be used in exposition and edition mode. At the beginning of the course, copy of the slides will be provided to the students that request it in the office of the sailing ship. Anyway, paper copies of the slides never should be considered like substitutes of textbooks or notes, but like complementary material.
Laboratory practical	Practices of laboratory with computer. Computer sessions are of paramount importance. Circuit simulations facilitate enormously the understanding of hydraulic and pneumatic systems. In a similar way, CFD simulations allow to visualise the three-dimensional flow in turbomachines and volume chamber evolution in volumetric machines. Resolution of problems and/or exercises in autonomous form. Some practical sessions conclude by posing a problem like closing activity of the practice.
Problem solving	Resolution of problems and/or exercises. The teacher solves a representative problem linked to the theory.

Personalized assistance

Methodologies	Description
Problem solving	In personalized tutorials, each student, individually, will be able to discuss with the teacher any problem that is preventing them from adequately monitoring the subject, in order to find some kind of solution between them. This is intended to compensate for different learning rhythms through attention to diversity. The teacher of the subject will personally attend to the doubts and queries of the students, both in person (being available in the midshipmen library every school day from 18:15 - 19:00), and through telematic means (email, videoconference, FAITIC forums, etc.) by appointment.

Assessment

	Description	Qualification	Training and Learning Results		
Lecturing	The theory contents taught in the master sessions are evaluated by 2 intermediate exams along the semester. These intermediate exams are short written tests (1 hour) carried out in the daily class schedule and whose purpose is to evaluate the assimilation of the contents by the students, motivate the autonomous study and identify those students requiring attention individual tutorial attention. During the course two intermediate tests are carried out consisting of conceptual questions and short problems.	30	B3	C24	D2 D9 D10
Laboratory practical	The evaluation of the practices carries out realising the average of the punctuations obtained in each one of the sessions. In each script of practices collect the tasks to realise and the criteria of evaluation. The activity of evaluation is varied according to the practice. In some of the practices evaluates with report, in others with questionnaire of short answer and others with resolution of problems posed.	30		C24	D2 D9 D17
(*)	Final written exam is a long-term test (4 hours) that aims to evaluate the learning of all the contents of the subject.	40	B3	C24	D2 D9 D10

Other comments on the Evaluation

Student final mark is obtained by a weighted sum over the scores achieved in each of the above mentioned parts. A continuous evaluation mark (NEC) is defined according to : NEC = 0,15 * IntExam1+ 0,15* IntExam2 + 0,3 * PracticeMark+ 0,4 * FinalExam Passing the course by continuous evaluation requires a NEC mark equal to or greater than 5 points. However, minimum requirements will be required in some sections in order to ensure a satisfactory balance between all types of skills. These requirements are: 1. Carry out of both intermediate exams and conduct at least 6 of the 7 practical sessions. 2. Obtain a grade of 4 or more points out of 10 in the Final Exam Students with NEC less than 5 or who do not fulfill one of the two previous requirements must attend to the regular exam in order to pass the subject. For those students who do not meet the two requirements the final mark of continuous evaluation is obtained as: NEC FINAL = min (4, NEC). In addition, the option to attend the regular exam is offered to all those students who wish to improve their continuous evaluation mark. Students that do not achieve to pass the subject by continuos evaluation shoult attend to a eight-hours intensive course previous to the date of the regular exam. Both the regular and the extraordinary exam (July exam) will evaluate all the subject skills. Therefore, these exams will include a question regarding the tasks performed during the practices. ETHICAL COMMITMENT: Students are expected to have appropriate ethical behavior. If unethical behavior (cheating, plagiarism, use of unauthorized electronic devices or others) is detected, the student will be penalized with the impossibility of passing the subject by the continuous evaluation modality (in which he/she will obtain a grade of 0). If this type of behavior is detected in regular or extraordinary exams, a 0 mark qualification is transferred to his/her academic record.

Sources of information

Basic Bibliography

C. Paz Penín, E. Suárez Porto, A. Eirís Barca, **Máquinas hidráulicas de desplazamiento positivo**, 2012

J. Agüera Soriano, **Mecánica de fluidos incompresibles y turbomáquinas hidráulicas**, 5ª, 2002

J. Roldán Viloria, **Tecnología y circuitos de aplicación neumática, hidráulica y electricidad**, 2012

Complementary Bibliography

A. Esposito, **Fluid power with applications**, 7ª, 2009

J. Hernández Rodríguez, P. Gómez del Pino, C. Zanzi, **Máquinas hídráulicas. Problemas y soluciones**, 2016

A. Serrano Nicolás, **Oleohidráulica**, 2002

Recommendations

Other comments

Fluid Mechanics fundamentals are invoked very often during the course. In case of difficulties it is recommended that students refresh acquired knowledge and they can also go to tutorials.

Contingency plan

Description

MODIFICATIONS IN CASE OF EXTRAORDINARY SITUATIONS THAT INVOLVE THE SUSPENSION OF THE PRESENTIAL ACADEMIC ACTIVITY.
Next, those aspects that will be modified in the guide are detailed in the event that any action derived from security criteria is determined.

Sections of the teaching guide where changes will be reflected:

5. Teaching methodology
Two new teaching methodologies are added:
5.1 Classes and practices in the online modality:
It is taught through a web video conferencing platform. Each room contains various display panels and components, the design of which can be customized to best suit the needs of the classroom. In the virtual classroom, teachers (and those authorized participants) can share their computer screen or files, use a whiteboard, chat, stream audio and video, or participate in interactive online activities (surveys, questions, etc.).
5.2. Discussion forums: activities developed in a virtual environment to resolve doubts and / or debate on issues that arise in the study of the subject.

7. Assessment of learning
7.1. The evaluation tests will be carried out by combining the FAITIC-Moodle remote teaching platform and the Remote Campus of the University of Vigo