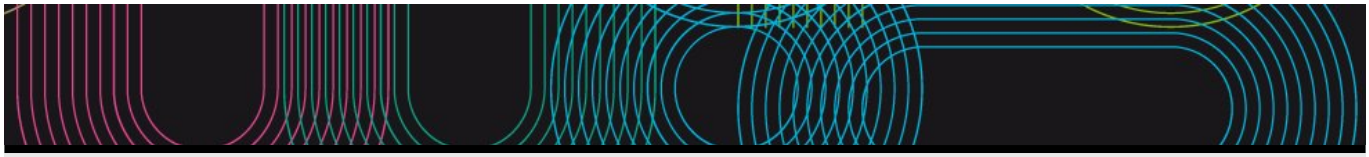

IDENTIFYING DATA				
Resources, installations and hydro-power plants				
Subject	Resources, installations and hydro-power plants			
Code	V09G310V01631			
Study programme	Degree in Mining and Energy Resources Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish English			
Department				
Coordinator	Paz Penín, María Concepción			
Lecturers	Molares Rodríguez, Alejandro Paz Penín, María Concepción			
E-mail	cpaz@uvigo.es			
Web	http://faitic.uvigo.es/			
General description	The main goal of this course is to acquire the scientific knowledge and the study of the technical application concerning energy conversion devices that employ water as the exchanger fluid. The application of fluid mechanics to hydropower systems is revisited here from an industrial point of view, dealing with the most common types of water pumps and turbines.			

Competencies	
Code	
B1	Scientific and technical training in order to work professionally as a Technical Mining Engineer, with knowledge of the functions of consultancy, analysis, design, calculation, planning, construction, maintenance, conservation and exploitation.
B2	Understanding of the many technical and legal considerations that arise during development within the field of mining engineering, according to section 5 of Order CIN7306/2009, which have to do with geological-mineral prospecting and research, mine exploitation of all types of geological resources, including groundwaters, underground works, underground stores, treatment and smelting plants, energy plants, mineral and iron and steel plants, construction materials plants, carbon-chemical, petro-chemical and gas plants, waste and effluent treatment plants, and explosives manufacturing plants. In addition, the capacity to employ proven methods and accredited technologies in order to attain improved efficiency while respecting the Environment and protecting the health and safety of workers and users.
B3	Capacity to design, write and plan partial or specific projects for the units described in the previous section, such as mechanical and electrical installations, together with their maintenance, energy transport networks, transport and storage facilities for solid, liquid and gaseous materials, dumping sites, pools or dams, supports and foundations, demolition, restoration, blasting and explosives logistics.
B4	Capacity to design, plan, operate, inspect, sign and manage projects, plants or installations within the field.
B5	Capacity to carry out land planning studies and environmental studies related to the projects, plants and installations within the field.
B6	Capacity to maintain, conserve and exploit the projects, plants and installations within the field.
B7	Knowledge required to undertake, within the scope of mining engineering knowledge as established in section 5 of Order CIN/306/2009, measurements, layouts, plans and maps, calculations, valuations, risk analyses, expert inspections, studies and reports, work plans, environmental and social impact studies, restorations plans, quality control systems, prevention systems, evaluation analyses of the properties of metal, ceramic, refractory, synthetic and other materials, soil and solid rock characterization and other similar tasks.
B8	Knowledge, understanding and capacity to apply the legislation needed when working professionally as a Technical Mining Engineer.
C45	Hydraulic works and installations. Hydraulic resources planning and management.
D1	Capacity to interrelate all the acquired knowledge and interpret it as components in a body of knowledge with a clear structure and strong internal coherence.

D2	Capacity to develop a complete project in any field included in this type of engineering, suitably combining acquired knowledge, accessing necessary information sources, undertaking the necessary enquiries and integrating into inter-disciplinary work teams.
D3	Propose and develop practical solutions, which develop suitable strategies based on theoretical knowledge, for problem phenomena and situations that arise as everyday realities in engineering.
D4	Encourage work based on cooperation, communication skills, organization, planning and recognition of responsibility in a multilingual and multidisciplinary working environment that fosters education in equality, peace and respect for fundamental rights.
D5	Know what sources are available for ongoing and continual updating of all the information required to undertake their work, with access to all the current and future tools for seeking information and adapting it in the light of technological and social changes.
D10	Become aware of the need for training and continual improvement in quality, developing the values associated with scientific thinking and showing a flexible, open and ethical attitude towards diverse opinions and situations, particularly in matters of non-discrimination on the grounds of gender, race or religion, respect for fundamental rights, accessibility, etc.

Learning outcomes

Expected results from this subject	Training and Learning Results		
Have a basic grounding in fluid machines.	B1 B2 B3 B4 B5 B6 B7 B8	C45	D1 D2 D3 D4 D5 D10
Acquire the abilities used in the sizing process for hydraulic installations.	B1 B2 B3 B4 B5 B6 B7 B8	C45	D1 D2 D3 D4 D5 D10
(*)*CT2 Resolution of problems.			

Contents

Topic	
I. Introduction about hydraulic machines	I.1 Introduction. I.2 Fluid machines classification. I.3 Singular parts of turbomachinery. I.4 Classification of turbomachines.
II. Energy balance of hydraulic machines.	II.1 Introduction. II.2 Total energy conservation. II.3 Internal energy conservation. II.4 Mechanical energy conservation. II.5 Mechanical power balance and efficiency of pumps. II.6 Mechanical power balance and efficiency of turbines. II.7 Pump and turbines heating evaluation. II.8 Pumping and turbines facilities. Head losses calculation.
III. Dimensionless analysis and similarity in turbomachines.	III.1 Introduction. III.2 Working parameters of a turbomachine. III.3 Dimensionless analysis applied to turbomachinery. III.4 Pumps performance curve. III.5 Turbines operating curve. III.6 Dimensionless parameters.
IV. General theory of hydraulic turbomachinery.	IV.1 Introduction. IV.2 Control volume approach. Conservation of mass. IV.3 Angular momentum conservation. Euler s theorem. IV.4 Euler s equation. IV.5 Bernoulli s equation in a non-inertial reference frame. IV.6 Reaction ratio.
V. One dimensional theory for hydraulic turbomachines	V.1 Hypotheses and targets of the one-dimensional approach. V.2 Continuity and meridional velocity. V.3 Eulers s equation and azimuthal velocity. V.4 One-dimensional approach for axial turbomachines.

VI. Two dimensional theory for radial turbomachines.	VI.1 Introduction. Finite number of blades. VI.2 Incompressible flow inside a centrifugal impeller. VI.3 Angular deviation of flow at the outlet of the impeller. Corrections.
VII. Two dimensional theory for axial turbomachines.	VII.1 Introduction. VII.2 Two-dimensional flow through a fixed blade cascade. VII.3 Two-dimensional relative flow through the blades. VII.4 Reaction ratio. VII.5 Radial equilibrium of an axial turbomachine.
VIII. Viscid flow and cavitation phenomena in hydraulic turbomachines.	VIII.1 Introduction. VIII.2 Viscous effects, boundary layer and secondary flows in turbomachines. VIII.3 Friction losses and fluid leaks. VIII.4 Principles and effects of cavitation. VIII.5 Cavitation conditions. VIII.6 Similarity and cavitation. Thoma□s number.
IX. Actual facilities.	IX.1 Introduction. IX.2 Basics of pump design. IX.3 Pumping facilities. Working point. Pumps arrangement and working point adjustment. IX.4 Selection of hydraulic turbines. Performance curves as a function of volumetric flux and rotating velocity. Fink□s distributor effect. IX.5 Classification and general description of power plants, dams and reservoirs. IX.6 Pumped-storage hydroelectric plants IX.7 River flow control. Electric energy production and consumption. Automatic control of hydroelectric power plants.

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practises	5	0	5
Troubleshooting and / or exercises	18	39.5	57.5
Master Session	26.5	40	66.5
Troubleshooting and / or exercises	0	6	6
Reports / memories of practice	0	12	12
Long answer tests and development	3	0	3

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

Methodologies

	Description
Laboratory practises	Mainly, laboratory practices will consist of experimental activities in order to clarify the theoretical concepts seen on the previous master classes. Additionally, they can also include: Simulation Solution of problems Team working
Troubleshooting and / or exercises	Problem and exercise solving. They will apply the concepts tackled in the lectures. It includes activities such as: Readings Seminars Solution of problems Team working Study of actual cases
Master Session	The basics of the theory are explained in these sessions. They are mainly comprised of lectures but can also include: Readings Bibliographic review Exercise solving Conferences Technical films Oral presentations

Personalized attention

Methodologies	Description
Master Session	Personalized attention will be given to the students during the office hours of the teacher for tutorships. Updated information concerning the schedule for the office hours will be published in □Faitic□ (virtual teaching platform). Office room No. 112 of the industrial engineering school (EEI)

Laboratory practises	Personalized attention will be given to the students during the office hours of the teacher for tutorships. Updated information concerning the schedule for the office hours will be published in Faitic (virtual teaching platform). Office room No. 112 of the industrial engineering school (EEI)

Assessment

	Description	Qualification	Training and Learning Results	
Troubleshooting and / or exercises	Resolution of proposed problems and/or exercises, that might include: - a number of weekly deliveries (no face-to-face) - face-to-face resolutions during class time LEARNING RESULTS: Have a basic grounding in fluid machines. Acquire the abilities used in the sizing process for hydraulic installations.	10	C45	D1 D2 D3 D4 D5 D10
Reports / memories of practice	Written report about the activities developed in the laboratory sessions, including experimental results and data analysis. LEARNING RESULTS: Have a basic grounding in fluid machines. Acquire the abilities used in the sizing process for hydraulic installations.	10	C45	D1 D2 D3 D4 D5 D10
Long answer tests and development	Written test that may consist of: - theoretical questions - practical questions - exercises solving - specific point to be developed LEARNING RESULTS: Have a basic grounding in fluid machines. Acquire the abilities used in the sizing process for hydraulic installations.	80	C45	D1 D2 D3 D4 D5 D10

Other comments on the Evaluation

Continuous evaluation: it represents 20% of the note. Except official indication from the center direction of the renunciation of the student to the continuous evaluation, the student follows the course in this modality.

Marks of the continuous evaluation will not be kept for the next year.

Final examination: it represents the 80 % of the note of the course.

If the student attends all the continuous exams and lab classes during the course but does not attend the final examination of May, the student will be considered as non presented to the course.

July final exam: The final examination represents 80% of the note, being the remaining 20% evaluated with the marks obtained from the continuous evaluation

Calendar of exams:

- End of Career: 19/09/2017

- Ordinary call 2º period: 31/05/2018

- Extraordinary call Julio: 03/07/2018

This information can verify /consult of up to date form in the page web of the centre:

http://minasyenergia.uvigo.es/es/docencia/examenes

Sources of information

Basic Bibliography

Round, George F., **Incompressible Flow Turbomachines. Design, Selection, Applications, and Theory**, 1ª ed., Elsevier - Gulf Professional Publishing, 2004

Agüera Soriano, José, **Mecánica de fluidos imcompresibles y turbomáquinas hidráulicas**, 5ª ed., Editorial Ciencia 3, S.L., 2002
Mataix Plana, Claudio, **Mecánica de fluidos y máquinas hidraúlicas**, 2ª ed., Ediciones del castillo, S.A., 1986
Hussian, Z. and Abdullah, Z. and Alimuddin, Z., **Basic Fluid Mechanics and Hydraulic Machines**, 1ª ed., CRC Press, 2009
Modi, P. N. and Seth, S. M., **Hydraulics and Fluid Mechanics Including Hydraulic Machines (In SI Units)**, 15ª ed., Standard Book House, 2004

Complementary Bibliography

Mataix Plana, Claudio, **Turbomáquinas hidráulicas**, 2ª ed., ICAI, 2009
Girdhar, P. and Moniz, O., **Practical Centrifugal Pumps. Design, Operation and Maintenance**, 1ª ed., Elsevier - Newnes, 2005
Hernandez Krahe, Jose Maria, **Mecánica de Fluidos y Máquinas Hidráulicas/Unidades Didácticas V y VI**, 1ª ed., UNED, 1995
Kothandaraman, C. P. and Rudramoorthy, R., **Fluid Mechanics and Machinery**, 2ª ed., New Age International (P) Ltd., Publishers, 2007
Vasandani, V. P., **Theory and Design of Hydraulic Machines Including Basic Fluid Mechanics**, 11ª ed., Khanna Publishers, 2010
Gülich, Johann F., **Centrifugal Pumps**, 3ª ed., Springer, 2014
Kumar, P., **Hydraulic Machines: Fundamentals of Hydraulic Power Systems**, 1ª ed., CRC Press, 2012
Bansal, R. K., **A Textbook of Fluid Mechanics and Hydraulic Machines (in SI units)**, 1ª ed., Laxmi Publications, 2005
Gupta, S. C., **Fluid Mechanics and Hydraulic Machines**, 1ª ed., Pearson Education Canada, 2006
Patra, K. C., **Engineering Fluid Mechanics and Hydraulic Machines**, 1ª ed., Alpha Science Intl Ltd, 2012
de Lamadrid Martínez, Abelardo, **Máquinas hidráulicas. Turbinas Pelton. Bombas centrífugas**, 1ª ed., Servicio de Publicaciones, ETSII - UPM, 1986

Recommendations

Subjects that it is recommended to have taken before

Fluid mechanics/V09G310V01305