Course guide
320052 - EF - Fluid Engineering

Last modified: 19/04/2023

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 729 - MF - Department of Fluid Mechanics.

Degree: BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: Castilla Lopez, Roberto

Others: Torrent Gelma, Miguel
Moreno Llagostera, Hipolit

PRIOR SKILLS

It is recommended that students have passed the second-year Fluid Mechanics subject in order to take Fluid Engineering.

REQUIREMENTS

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
3. MEC: Applied knowledge of the main systems and machines

Transversal:
1. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
2. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.

TEACHING METHODOLOGY

- Face-to-face lecture sessions.
- Face-to-face practical work sessions.
- Independent learning and exercises.
- Preparation and completion of group activities subject to assessment.

In the face-to-face lecture sessions, the lecturer will introduce the basic theory, concepts, methods and results for the subject and use examples to facilitate students' understanding. Practical class work will be covered in three types of sessions:
a) Sessions in which the lecturer will solve problems on the blackboard using techniques, concepts and theoretical results by way of example (40%).
b) Sessions in which the lecturer helps students analyse data and resolve problems (25%).
c) Sessions in which students sit tests (20%).
d) Sessions in which students give presentations of group work (5%).

Students will be expected to study in their own time so that they are familiar with concepts and are able to solve the exercises set, whether manually or with the help of a computer.

LEARNING OBJECTIVES OF THE SUBJECT

Theoretical knowledge
In the Hydraulic Machines and Systems section:
· A basic understanding of the fundamental concepts of fluid machines and systems, their properties and the fundamental laws that govern them, as well as mathematical knowledge to support this understanding.
In the Oleohydraulic and Pneumatic Systems section:
· Technical capabilities in the area of specialisation.
· An understanding of the subject's scientific foundation.
· The ability to apply technology and engineering skills, in particular to do the following:
· Assess advantages and disadvantages of the use of fluid power (either oleohydraulic or pneumatic).
· Identify the various elements that comprise oleohydraulic and pneumatic energy-transfer systems.
· Draw symbol-based diagrams and use software to represent and simulate systems.
· Design an oleohydraulic or pneumatic installation capable of driving machines or mechanisms.
Professional skills
· The ability to analyse specific situations, define problems, make decisions and implement action plans in order to find solutions.
· The ability to apply knowledge acquired in real situations and properly manage the available resources, while taking steps to minimise the environmental impact (energy recovery, noise mitigation, reduction of fluid-based contamination, etc.).
· The ability to interpret studies, reports, data, regulations and European directives (lifecycle, safety, etc.).
· The ability to select and use information sources.
· The ability to use the available computer tools as support.
· The ability to work in a multidisciplinary team.
· The ability to value comprehensive training, personal motivation and mobility.
Communication skills
· The ability to understand and use the appropriate terminology.
· The ability to debate and put forth arguments in a variety of forums.
·Technology transfer skills
· The ability to analyse and assess the environmental implications of their professional activity
· The ability to analyse and assess the social and ethical implications of their professional activity.
· A critical and innovative spirit.
· The ability to stay up-to-date on new technological advances by means of lifelong learning.
Applied knowledge
· Students will put their knowledge into practice by solving standard problems that help to understand and build on the knowledge acquired.
Aptitudes and attitudes
· Students will discover the benefits of learning about fluid mechanics and its applications, which form part of our everyday lives at all levels.
· Students will likewise learn to work, discuss and summarise their findings in groups.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	15,0	10.00
Hours large group	30,0	20.00
Self study	90,0	60.00
Hours small group	15,0	10.00

Total learning time: 150 h

CONTENTS

TOPIC 1: General principles

Description:
1.1. Propedeutic concepts of fluid mechanics.
1.2. Basic principles.

Specific objectives:
- To Remember the basic concepts of fluid mechanics.
- To interpret the basic principles of fluid mechanics.
- To use the basic principles of fluid mechanics.

Related activities:
E - Applied exercises

Full-or-part-time: 4h
Theory classes: 1h
Self study : 3h

TOPIC 2: TURBOMACHINERY

Description:
2.1. Pumps.
2.2. Fans.
2.3. Characteristic curves.
2.4. Selection.
2.5. Areas of application.

Specific objectives:
- Describe pumps and fans.
- Interpret characteristic curves.
- Apply selection criteria.
- Identify areas of application.
- Interpret selections in terms of areas of application.

Related activities:
E - Applied exercises
Practical P1. Centrifugal pump
Practical P2. Fan
2. Applied exercises

Full-or-part-time: 17h
Theory classes: 3h
Practical classes: 1h
Laboratory classes: 4h
Self study : 9h

TOPIC 3: FUNDAMENTAL EQUATION OF TURBOMACHINES

Description:
3.1. Euler triangles.
3.2. Degree of reaction.

Specific objectives:
- Describe and interpret Euler triangles.
- To Manipulate and calculate Euler triangles.
- To Define the degree of reaction.
- To Formulate and calculate the degree of reaction

Related activities:
E - Applied exercises
C - Test

Full-or-part-time: 6h
Theory classes: 1h
Practical classes: 1h
Laboratory classes: 1h
Self study : 3h

TOPIC 4: MODELS THEORY

Description:
4.1. Dimensional homogeneity and dimensionless groups.
4.2. Similarity.

Specific objectives:
- Identify the dimensional homogeneity of variables in a physical process expressed through an equation.
- Identify dimensionless groups related to hydraulic machines.
- Learn the basic dimensionless groups.
- Apply similarity and the theory of models to standard problems

Related activities:
E - Applied exercises

Full-or-part-time: 9h
Theory classes: 2h
Practical classes: 1h
Self study : 6h

TOPIC 5: TURBOMACHINERY INSTALLATIONS

Description:
5.1. Point of operation.
5.2. Regulation systems.
5.3. Control valves.
5.4. Selection.
5.5. Types.

Specific objectives:
- Determine the operating point.
- Interpret regulation systems.
- Identify and describe control valves.
- Apply selection criteria.
- Describe installation types.

Related activities:
E - Applied exercises
Practical P3 - Control valve

Full-or-part-time: 25h
Theory classes: 5h
Practical classes: 3h
Laboratory classes: 2h
Self study : 15h

TOPIC 6: UNSTABLE OPERATION

Description:
6.1. Water hammer.
6.2. Estimation of downtime.
6.3. Cavitation.

Specific objectives:
- Interpret and describe water hammer.
- Interpret and calculate estimated downtime.
- Describe the phenomenon of cavitation.
- Calculate limits of application to avoid cavitation.

Related activities:
E - Applied exercises
C - Test
Practical P4 - Water hammer

Full-or-part-time: 14h
Theory classes: 3h
Practical classes: 1h
Laboratory classes: 1h
Self study : 9h

TOPIC 7: FLUID ENERGY TRANSFER SYSTEMS

Description:
7.1. Oil/oleohydraulics.
7.2. Air/pneumatics.
7.3. Strengths and weaknesses of these technologies.

Specific objectives:
- Understand the differences between oil/oleohydraulics and air/pneumatics.
- Be able to describe the strengths and weaknesses of each.

Related activities:
E - Applied exercises

Full-or-part-time: 4h
Theory classes: 1h
Self study : 3h

TOPIC 8: BASIC COMPONENTS

Description:
8.1. Positive displacement devices.
8.2. Compressors.
8.3. Pressure equipment and power sources.
8.4. Basic installations (compressed-air treatment).

Specific objectives:
- Describe the operating principle of positive displacement devices.
- Describe the characteristics of pressure equipment and basic installations.

Related activities:
E - Applied exercises
Practical P5 - Morphology of positive displacement pumps

Full-or-part-time: 5h
Theory classes: 1h
Laboratory classes: 1h
Self study : 3h

TOPIC 9: OLEOHYDRAULIC AND PNEUMATIC REGULATION AND CONTROL ELEMENTS

Description:
9.1. Pressure-control valves.
9.2. Flow-control valves.
9.3. Directional-control valves.
9.4. Characteristic curves.

Specific objectives:
- Recognise the various types of valves.
- Describe the various types of valves.
- Interpret and explain the various types of valves and their basic structure
- Identify and use the characteristic curves of valves.

Related activities:
E - Applied exercises
Practical P6 - Morphology of valves

Full-or-part-time: 10h
Theory classes: 2h
Laboratory classes: 2h
Self study : 6h

TOPIC 10: LINEAR AND ROTARY ACTUATORS

Description:
10.1. Cylinders.
10.2. Engines
10.3. Description of basic components: materials, guides, joints.
10.4. Basic characteristics (pre-design).

Specific objectives:
- Recognise linear and rotary actuators.
- Describe cylinders and engines.
- Interpret and describe the basic components of actuators.
- Apply and calculate basic characteristics for pre-design

Related activities:
E - Applied exercises
C - Test

Full-or-part-time: 8h
Theory classes: 2h
Self study : 6h

TOPIC 11: BASIC PNEUMATIC AND OLEOHYDRAULIC CIRCUITS

Description:
Pneumatics:
11.1. Basic ideas.
11.2. Circuits with sequence controllers.
11.3. Electro-pneumatic circuits: control with relays, Grafcet and PLCs.
Oleohydraulics:
11.4. Open-centre and closed-centre circuits.
11.5. Sequence control.
11.6. Variable-speed profile control.
11.7. Accumulator circuits.
11.8. Regenerative circuits.
11.9. Force control.
11.10. Load-sensing circuits.

Specific objectives:
- Identify basic pneumatic and oleohydraulic circuits and their various elements.
- Interpret basic pneumatic and oleohydraulic circuits.
- Manipulate basic oleohydraulic circuits.

Related activities:
E - Applied exercises

Full-or-part-time: 21h
Theory classes: 4h
Practical classes: 5h
Self study : 12h

TOPIC 12: PRE-DESIGN OF BASIC CIRCUITS

Description:
12.1. Basic circuits

Specific objectives:
- Calculate basic oleohydraulic circuits.
- Analyse basic oleohydraulic circuits.

Related activities:
E - Applied exercises
Practical P7 - Circuit assembly

Full-or-part-time: 16h
Theory classes: 3h
Practical classes: 2h
Laboratory classes: 2h
Self study : 9h

TOPIC 13: DESIGN AND SIMULATION OF ELECTRONIC CIRCUITS

Description:
13.1. Simulation of the dynamic behaviour of basic circuits.

Specific objectives:
- Use software to simulate the dynamic behaviour of basic circuits.
- Analyse the results obtained from the software simulation.

Related activities:
E - Applied exercises
Practical P8 - Computer simulation

Full-or-part-time: 3h
Practical classes: 1h
Laboratory classes: 2h

TOPIC 14: FLUID CONDITIONING AND TRANSPORT ELEMENTS

Description:
14.1. Fittings, pipes and flexible parts.
14.2. Water tanks
14.3. Filtration.
14.4. Temperature control.
14.5. Environmental aspects.

Specific objectives:
- Recognise the main fluid conditioning and transport elements.
- Describe and explain the basic characteristics and operation of the main fluid conditioning and transport elements.

Related activities:
E - Applied exercises
C - Test

Full-or-part-time: 8h
Theory classes: 2h
Self study : 6h

ACTIVITIES

ACTIVITY 1: P1 - PUMP

Description:
A pump is a machine that converts mechanical energy into hydraulic energy by working with a liquid. The objective of this lab is to experimentally obtain its characteristics curves: HB-Q, Nabs-Q and ¿B-Q.

Specific objectives:
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

Material:
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

Delivery:
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

Full-or-part-time: 4h
Laboratory classes: 2h
Self study: 2h

ACTIVITY 2: P2 - FAN

Description:
The objective of this lab is to characterize a fan by calculating the characteristic curves: Ptot-Q, Nabs-Q and ¿v-Q.

Specific objectives:
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

Material:
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

Delivery:
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

Full-or-part-time: 4h
Laboratory classes: 2h
Self study: 2h

ACTIVITY 3: P3 - CONTROL VALVE

Description:
This practice aims to study a control valve. It is intended to obtain (i) the ratio Kv (flow coefficient/factor), (ii) the inherent curve and (iii) installed curve.

Specific objectives:
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

Material:
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

Delivery:
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

Full-or-part-time: 4h
Laboratory classes: 2h
Self study: 2h

ACTIVITY 4: P4 - WATER HAMMER

Description:
This laboratory session aims to introduce students to techniques of control, measurement, study and prevention of water hammer.

Specific objectives:
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

Material:
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

Delivery:
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

Full-or-part-time: 4h
Laboratory classes: 2h
Self study: 2h

ACTIVITY 5: P5 - MORPHOLOGY OF POSITIVE DISPLACEMENT PUMPS

Description:
The aim of this laboratory session is to get familiar with the morphology of volumetric positive displacement pumps, identify and describe them, components and key features.

Specific objectives:
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

Material:
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

Delivery:
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

Full-or-part-time: 4h
Laboratory classes: 2h
Self study: 2h

ACTIVITY 6: P6 - MORPHOLOGY OF VALVES

Description:
The aim of this laboratory session is to get familiar with the morphology of hydraulic valves, identify and describe them, components and key features.

Specific objectives:
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

Material:
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

Delivery:
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

Full-or-part-time: 4h
Laboratory classes: 2h
Self study: 2h

ACTIVITY 7: P7 - CIRCUIT ASSEMBLY

Description:
The aim of this laboratory session is to assemble hydraulic circuits in a basic didactic panel, manipulate the elements and analyse their performance.

Specific objectives:
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

Material:
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

Delivery:
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

Full-or-part-time: 4h
Laboratory classes: 2h
Self study: 2h

ACTIVITY 8: CP - LABMULTIPLE-CHOICE TEST

Description:
The aim of this session is to assess the knowledge and progress in the lab sessions.

Specific objectives:
Acquiring the ability to know, understand and apply knowledge of the basic principles of the modules / topics, individual or team work and time management.

Material:
Formula sheet done by the students themselves on one side of A4 paper.

Delivery:
Activity assessable where the note is within of the rating system of the subject.

Full-or-part-time: 2h
Laboratory classes: 1h
Self study: 1h

ACTIVITY 9: C - MULTIPLE-CHOICE TEST

Description:
The aim of this session is to assess the knowledge and progress in the lecture sessions.

Specific objectives:
Acquiring the ability to know, understand and apply knowledge of the basic principles of the modules / topics, individual or team work and time management.

Material:
Formula sheet done by the students themselves on one side of A4 paper.

Delivery:
Activity assessable where the note is within of the rating system of the subject.

Full-or-part-time: 15h
Theory classes: 5h
Self study: 10h

ACTIVITY 10: E - APPLICATION EXERCISES

Description:
Exercises, reading articles, reading books chapter, attending seminars and / or conferences, etc. proposed by the teacher.

Specific objectives:
Promote the work with the contents and main topics of the subject.

Material:
Activity assessable where the note is within of the rating system of the subject.

Delivery:
Deliverable activity. Some of the exercises will have mark and other exercises will be self-assessed. The part to note is placed within the corresponding percentage of the rating system of the subject.

Full-or-part-time: 54h
Theory classes: 19h
Practical classes: 15h
Self study: 20h

EX1 - 1st Assessment. Mid-semester exam

Description:
Individual partial test.

Material:
Formula sheet done by the students themselves on one side of A4 paper.

Delivery:
The test is 35% of the final grade and will be done on the scheduled date and time.

Full-or-part-time: 23h
Theory classes: 3h
Self study: 20h

EX2 - 2nd Assesment. Final exam

Description:
Individual partial test.

Material:
Formula sheet done by the students themselves on one side of A4 paper.

Delivery:
The test is 35% of the final grade and will be done on the scheduled date and time.

Full-or-part-time: 23h
Theory classes: 3h
Self study: 20h

ACTIVITY 13: AC - AUTOMULTIPLE-CHOICE TEST

Description:
Evaluable autotests to make as individual self-learning.

Specific objectives:
Acquiring the ability to know, understand and apply knowledge of the basic principles of the modules / topics, individual work and time management.

Material:
Questionnaires in ATENEA by WIRIS

Delivery:
Activity assessable where the note is within of the rating system of the subject.

Full-or-part-time: 5h
Self study: 5h

GRADING SYSTEM

- First mid-semester examination: 35%
- Second mid-semester examination: 35%
- Multiple-choice tests (during theory or problem sessions): 15%
- Laboratory practicals: 10%(Laboratory 5%+LabMultiple-choice tests 5%)
- AutoMultiple-choice tests (virtual questionaries) 2.5%
- Applied exercises (problems, reading assignments such as articles or book chapters, attendance of seminars and/or lectures, etc.): 2.5%

*The unsatisfactory result of the examination of the first mid-term, may be re-conducted by a written exam to be carried out on the day (official date and time) of the final examen of the subject. Only students with a grade lower than 5 of the evaluation act could take this examination. The written exam will consist of a problem related to the first mid-term subjects of the course. The mark of the exam is between 0 and 10. The mark obtained in this examination will be averaged with the grade obtained in the first act of evaluation and will replace the mark of the first act of evaluation unless it is lower.

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.
If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

EXAMINATION RULES.

The test sessions will consist of a multiple choice paper, which will last approximately 30 minutes. Students will mark them in pairs. Students will work in groups of three on problems that must be handed in. They may be asked to explain their results in applied sessions.

BIBLIOGRAPHY

Basic:

- Ingram, Grant. Basic concepts in turbomachinery [on line]. Bookboon, 2009 [Consultation: 08/06/2020]. Available on: https://bookboon.com/en/key-concepts-in-turbo-machinery-ebook. ISBN 9788776814359.
- Lewis, R. I. Turbomachinery performance analysis. London : New York: Arnold ; Wiley, 1996. ISBN 9780340631911.
- Turton, Robert Keith. Principles of turbomachinery. 2nd ed. London, etc.: Chapman & Hall, 1995. ISBN 9780412602108.
- Mataix, Claudio. Mecánica de fluidos y máquinas hidráulicas. 2a ed. Madrid: Ediciones del Castillo, 1982. ISBN 8421901753.
- Turton, R. K. Rotodynamic pump design [on line]. Cambridge: Cambridge University Press, 1994 [Consultation: 12/07/2022]. Available on: https://www-cambridge-org.recursos.biblioteca.upc.edu/core/books/rotodynamic-pump-design/8CF27C600CE6B2D8DF26BF6D28A1A650. ISBN 0521305020.
- Stepanoff, A. J. Centrifugal and axial flow pumps : theory, design and application. 2nd ed. New York: John Wiley & Sons, 1957. ISBN 0894647237.
- Balje, O.E. Turbomachines : a guide to design, selection and theory. New York: John Wiley & Sons, 1981. ISBN 0471060364.
- Wallis, R. Allan. Axial flow fans and ducts. New York: Wiley, 1983. ISBN 0471870862.
- Hutchinson, J. W. ISA handbook of control valves. 2nd ed. Pittsburgh: Instrument Society of America, 1976. ISBN 0876642342.
- Fluid power systems: ISO Standards Handbook. Geneva: International Organization for Standardization, 1986. ISBN 9789267101095.
- McCloy, D. The control of fluid power. London: Longman, 1973. ISBN 058247003X.
- València, Eugeni [et al.]. Oleohidràulica: problemes resolts [on line]. Barcelona: Edicions UPC, 1998 [Consultation: 12/05/2020]. Available on: http://hdl.handle.net/2099.3/36393. ISBN 8483012723.
- Ducos, Claude. Oléo-hydraulique : recueil de schémas et de problèmes. PAris: Technique et documentation-Lavoisier, 1992. ISBN 2852068729.
- Karassik, Igor J. Bombas centrífugas : selección, operación y mantenimiento. México: Cia. Continental S.A, 1966.
- Codina, E.; Heras, S. de la. Monografíes sobre components i sistemes oleohidràulics. Departament de Mecànica de Fluids,
- Heras, Salvador de las. Fluidos, bombas e instalaciones hidráulicas [on line]. 2a ed. Barcelona: Iniciativa Digital Politècnica, 2018 [Consultation: 10/03/2023]. Available on: http://hdl.handle.net/2117/127556. ISBN 9788498807288.
- Korpela, Seppo A. Principles of turbomachinery. 1st ed. Wiley, 2011. ISBN 9780470536728.
- Japikse, David; Baines, Nicholas C. Introduction to Turbomachinery. Vermont, US : Oxford: Concepts ETI ; Oxford University Press, 1994. ISBN 0198565259.
- Dixon, S. L; Hall, C. A. Fluid mechanics and thermodynamics of turbomachinery [on line]. 7th ed. Oxford: Butterworth-Heinemann, 2014 [Consultation: 19/07/2022]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9780124159549/fluid-mechanics-and-thermodynamics-of-turbomachinery. ISBN 9780124159549.

Complementary:

- Heras Jiménez, Salvador Augusto de las. Mecánica de fluidos en ingeniería [on line]. Barcelona: Iniciativa Digital Politècnica, 2012 [Consultation: 12/05/2020]. Available on: http://hdl.handle.net/2099.3/36608. ISBN 9788476539354.
- Belforte, Guido. Manuale di pneumatica. Milano: Tecniche Nuove, 2005. ISBN 8848105416.
- Heras, Salvador de las. Modelización de sistemas fluidos mediante bondgraph. Terrassa: Departamento de Mecánica de Fluidos, 1999. ISBN 8460570355.
- De las Heras, S. Màquines hidràuliques. Reprografia ETSEIAT,
- Lamit, L. G. Piping systems: drafting and design. Englewood Cliffs: Prentice Hall, 1981. ISBN 0136764452.
- Osborne, William C. Fans. 2nd ed. Oxford: Pergamon Press, 1977.
- Sulzer Pumps Ltd. Sulzer centrifugal pump handbook. Oxford: Elsevier, 1998. ISBN 1851664424.
- Whitfield, A.; Baines, N. C. Design of radial turbomachines. Essex: Longman Scientific & Technical, 1990. ISBN 0582495016.
- Stepanoff, A. J. Turboblowers: theory, design, and application of centrifugal and axial flow compressors and fans. New York: John Wiley & Sons, 1955.
- Groote, J. P. de. Tecnologia de los circuitos hidráulicos. [3ª ed.]. Barcelona: CEAC, 1986. ISBN 8432911135.
- Wilson, D. G. The design of high-efficiency turbomachinery and gas turbines. Cambridge, MA ; London: MIT Press, 1984. ISBN 026223114X.
- Carulla, M.; Lladonosa, V. Circuitos básicos de neumática. Barcelona: Marcombo Boixareu, 1993. ISBN 8426709095.
- Bouteille, Daniel. Los mandos lógicos por fluidos y la automatización industrial. Madrid: Dossat, 1971.
- Ewald, R. [et al.]. Técnica de válvulas proporcionales y de servoválvulas. Lohr a. Main: Mannesmann Rexroth, 1988. ISBN 3802308980.
- Roquet Fernández de Aramburo, P. Apuntes de técnica oleohidráulica. Tona: Pedro Roquet, 198?.
- Ewald, R. [et al.]. Técnica de válvulas proporcionales y de servoválvulas: libro de información y estudio de válvulas proporcionales y servoválvulas y de los componentes electrónicos utilizados en mandos y circuitos de regulación. Lohr a. Main: Mannesmann-Rexroth,

1988. ISBN 3802308980.
- Virto Albert, Luis. Dinamica de gases [on line]. Barcelona: Iniciativa Digital Politècnica, 2017 [Consultation: 12/05/2020]. Available on: http://hdl.handle.net/2117/114130. ISBN 9788498806915.
- Gamez Montero, Pedro Javier; Codina Macià, Esteban. Fluidotecnia: problemas resueltos [on line]. Terrassa: Iniciativa Digital Politècnica, 2018 [Consultation: 12/05/2020]. Available on: http://hdl.handle.net/2117/126277. ISBN 9788498807332.
- Exner, H. [et al.]. Fundamentos y componentes de la oleohidráulica: manual de enseñanza e información sobre fundamentos y componentes de la técnica de fluidos - oleohidráulica. 2ª ed. Lohr a. Main: Mannesmann-Rexroth, 1991. ISBN 3802302664.

RESOURCES

Other resources:
http://www.gerolab.es/