

**COURSE DATA****DATA SUBJECT****Code:** 34774**Name:** Theory and design of machines and process equipment**Cycle:** Undergraduate Studies**ECTS Credits:** 6**Academic year:** 2026-27**STUDY (S)**

Degree	Center	Acad. year	Period
1401 - Degree in Chemical Engineering	Escola Tècnica Superior d'Enginyeria	3	First quarter
1934 - Double Degree Program in Chemistry-Chemical Engineering	Facultat de Química	4	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1401 - Degree in Chemical Engineering	Equipment materials and design	COMPULSORY
1934 - Double Degree Program in Chemistry-Chemical Engineering	Cuarto curso	COMPULSORY

COORDINATION

SOLSONA ESPRIU BENJAMIN EDUARDO

SUMMARY

This course is divided into two different parts. The first one is the basis of the Theory of Machines and Mechanisms, whereas the second one deals with the mechanical design of process equipment.

The most simple and widely used mechanisms are considered and in particular the basis for the analysis of planar mechanisms is introduced at both kinematic and dynamic points of view. In that sense there is a special emphasis on vectorial methods to calculate velocities and forces acting on a mechanism.

Subsequently rotating mass balancing is treated which is a basic aspects for machine design.

As far as the mechanical design of process equipment is concerned, the second part of the course is

dedicated to the design of equipment undergo pressure by establishing a clear difference between that working under pressure and that working under vacuum. There is also a unit dedicated to the mechanical



design of towers used in the process industry. They have to be able to withstand the effects of wind and seismic activity. Finally the mechanical design of pipes is considered.

The mechanical design is performed using the standards from API-ASME (American Petroleum Institute and American Society of Mechanical Engineers) which are widely accepted.

The contents of the course are: Principles of Theory of Machines and Mechanisms and Mechanical design equipment, which are structured in the units listed in section Description of Contents.

The general objectives of the course are:

- To make use from a practical point of view of the concepts of Mechanics which have been seen in the subject of Physics I.
- To develop in students the ability to propose and solve numerical problems in which mechanisms appear as well as to interpret the results.
- To develop strategies to design mechanically the industrial equipment containing liquids and solids.
- Enhance students' skills in reasoning and systematic work.
- Promote and encourage those values and attitudes that must be inherent to engineers.

Theoretical lessons will be in Spanish and the practical classes in Spanish or Valencian, in agreement with the webpage of the Degree.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

To successfully pass the subject is advisable that students possess a series of prior knowledge at the level demanded in subjects studied previously. This knowledge comprises:

- Mechanics
- Materials science

COMPETENCES / LEARNING OUTCOMES

1401 - Degree in Chemical Engineering

Acquire knowledge of basic and technological subjects to facilitate the learning of new methods and theories, and develop the versatility to adapt to new situations.



Act autonomously in learning, make informed decisions in different contexts, issue judgements based on experimentation and analysis and transfer knowledge to new situations.

Be able to understand and apply the legislation required for the practice of the profession of technical industrial engineer.

Saber comunicarse de manera efectiva, tanto de forma oral como escrita, adaptándose a las características de la situación y de la audiencia

Solve problems with initiative, make decisions, think creatively and critically, and communicate and convey knowledge, skills and competences in the field of industrial engineering.

Understand the principles of machine theory and mechanisms.

Work in a multilingual and multidisciplinary environment.

DESCRIPTION OF CONTENTS

1. INTRODUCTION TO THE THEORY OF MACHINES AND MECHANISMS. BASIC CONCEPTS.

Basic concepts and general definitions. Degrees of freedom of a mechanism. Kinematic Inversions. The Grashof condition. Mechanical advantage. Dead point. Kinematic diagrams. Practical application of different mechanisms: Four-bar mechanisms; Crank-rocker mechanism; Slider-crank mechanism.

2. GEOMETRIC ANALYSIS OF PLANAR MECHANISMS

Introduction. Analytical methods: Raven's method.

3. KINEMATIC ANALYSIS OF PLANAR MECHANISMS BY VECTORIAL METHODS

Introduction. Speeds on the machines: Position, displacement and velocity of a point; Position, displacement and angular velocity of a solid; Method of relative velocity. Accelerations in machines: Acceleration of a point; Relative acceleration of two points either; Acceleration of two points on a rigid body; The Coriolis component of acceleration.



4. DYNAMIC ANALYSIS OF PLANAR MECHANISMS

Introduction. Static in machines: Transmission of forces in mechanisms; Conditions for static equilibrium; Principle of superposition. Dynamic Analysis: External actions; Internal actions or reaction; Dynamic equilibrium of a particle with mass; Components of inertia of a bar in planar motion; Components of inertia of a planar bar. Dynamic analysis. Matrix method.

5. MASS BALANCING

Introduction. Balancing of rotors: Static equilibrium; dynamic equilibrium; Analytical method to calculate the mass balancing. Balancing of engines: Single-cylinder engines; Multi-cylinder engine.

6. MECHANICAL DESIGN OF VESSELS UNDER INTERNAL PRESSURE

Introduction. Vessels under internal pressure. Mechanical design of vessels under internal pressure: Design of tanks containing gases; Design of tanks containing liquids; Vessels with intermediate walls; Thick-walled vessels; Methodology to design the thickness of a vessel under internal pressure. Solid storage systems.

7. MECHANICAL DESIGN OF VESSELS UNDER EXTERNAL PRESSURE

Introduction. Design of cylindrical vessels. Design of conic shells and heads. Design of spheres and spherical, ellipsoidal and torispherical ASME code heads: Spherical shells and heads; ellipsoidal 2:1 and torispherical heads. Stiffening rings design: Number of stiffening ring; Design of stiffening rings.

8. HIGH TOWERS MECHANICAL DESIGN

Introduction. Design of towers to support the wind action or pressure: Design for a tower with constant wind load (P_w); Design for a tower with variable diameter; Design for a constant diameter tower and a wind load that varies with altitude. Design of towers to support their weight. Tower design to withstand vibration. Design of towers to withstand seismic loads. Design of towers to withstand eccentric loads. Elastic stability conditions: Tray supports: stiffeners, tubes for fluid rise or fall. Combination of stresses: Estimation of the distance where the longitudinal and tangential stresses are the same. Skirt support design.



9. MECHANICAL DESIGN OF PIPES

Introduction. Wall thickness in pipes. Pipe support. Water hammer in pipes.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	30,00
Classroom practices	30,00
Total hours	60,00

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	10,00
Independent study and work	0,00
Preparation of lessons	63,50
Preparation for assessment activities	16,50
Resolution of case studies	0,00
Total hours	90,00

TEACHING METHODOLOGY

The development of the course is structured around the theory classes and practical activities. Some of these activities will be evaluated and will contribute to the final mark.

In the theory classes lecture model will be used to explain the most complex or difficult notions and always during periods of less than 30 minutes. Many of the theoretical concepts will be prepared by students working with the material provided to them.

Problems will be developed in practical class sessions following two models. Some problems will be solved by the teacher so that students find out the way to address them, while others will be solved by students, individually or in groups under the supervision of the teacher. After the work, the problems will be collected, analyzed and corrected by the teacher or the students.

The proposed work for the students will be of several types: Questions or short exercises, problems similar in complexity to those of the exams and self-correcting tests performed in the e-learning platform. All of



these activities will be done in class or at home, and will have a timetable for completion and delivery, their contribution to the final mark being established as well. After correction, the students will be informed of their results and will be given with a summary of the most common mistakes.

EVALUATION

In a first round, the assessment of student learning will be carried out using two models:

- 1) Through continuous assessment where activities delivered by students and the marks obtained in individual exams will be taken into account (Model A).
- 2) From the mark of a final exam to be held on the scheduled date and the activities delivered in time along the course (Model B).

In model A the student evaluation will be carried out considering two separate blocks:

Block I: issues 1 to 4;

Block II: issues 5 to 9.

The exam of Block I will be carried out after finishing the subject of this block, whereas the exam of Block II will be on the date of the first call. The requirements to be qualified by the model A) are:

- deliver in time all the activities.
- to get in each of the individual exams a mark equal or greater than 4.

The final mark for this model A) will be calculated using the following criteria:

20% Activities delivered

48% Individual exam Block I

32% Individual exam Block II

To pass the course with this model A) the final mark will have to be equal to or greater than 5. Any student who does not meet any of the mentioned requirements will have to pass the course on the first round by the model B).

In model B) the student has to do a final exam of the two blocks, on the date scheduled, which will only count 80% of the final mark, whereas the remaining 20% of the mark will be obtained from the activities



delivered on time. In the final exam, a mark equal or greater than 4 must be obtained and, in order to pass the course, the final mark must be equal or greater than 5.

In the second call, only the model B is applicable. If during the course the students have not completed the Activities, they will be able to complete them before the exam of the second call.

Copying or plagiarism of any activity that is part of the evaluation will result in the impossibility of passing the course, and the student will then be subject to the appropriate disciplinary procedures indicated in the ACTION PROTOCOL FOR FRAUDULENT PRACTICES AT THE UNIVERSITY OF VALENCIA ([ACGUV 123/2020](#)).

In any case, the evaluation system will be governed by that established in the regulations of the Universitat de València about the evaluation "Reglament de Avaluació i Qualificació de la Universitat de València per a Graus i Màsters" ([ACGUV 108/2017](#)).

REFERENCES

- Fundamentos de Teoría de Máquinas A. Simón i altres (Bellisco, 2004)
- Pressure Vessel Handbook. 14th Ed. E. F. Megyesy (PV Publishing, 2008)
- Resistencia de materiales L. Ortiz Berrocal. (McGrawHill, 2007). Libro en formato electrónico para miembros de la UV
- Chemical Engineering. Vol 6 J. M. Coulson, J. F. Richardson (Pergamon Press, 1983)
- Diseño de maquinaria: síntesis y análisis de máquinas y mecanismos R. L. Norton (McGrawHill, 2009)
- Problemas resueltos de teoría de máquinas y mecanismos J. L. Suñer et al. (Editorial UPV, 2001)
- Pressure vessel design manual. 14th ed. D. R. Moss, M. Basic (Elsevier, 2013); Libro en formato electrónico para miembros de la UV
- Pressure Vessels Field Manual. Common Operating Problems and Practical Solutions M. Stewart, O. T. Lewis (Elsevier, 2013); Libro en formato electrónico para miembros de la UV