Course guide
240141 - 240141 - Machine and Mechanism Theory

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Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering.

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Jordi Nebot, Lluïsa

Others: Cabré Gimeno, Marc
de la Fuente Morató, Albert
Díez Quílez, Cristian
Puig Ortiz, Joan
Rodríguez Fernández, Antonio
Romanos Roca, David
Salvadó Escuer, Pau
Sistiaga Vidal-Ribas, Javier
Zayas Figueras, Enrique Ernesto

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Knowledge on machines and mechanisms theory principles.
2. Knowledge and capacities to calculate, design and test machines.

TEACHING METHODOLOGY

The teaching load of the course is 6 ECTS; 5 of which are taught in slate lectures, theory and problems, in nominally groups of around 60 students; the remaining credit is taught in lab classes in groups of around 20 students.
In slate lectures, twice a week in 1h.40min, the basic theory concepts are exposed with the support of teaching material and a good number of examples. Exercises are presented, analysed and solved often inspired in real situations and are proposed to be done as personal work.
In lab classes, five during the semester and each two hours long, practices are carried out with material available in the Machines Lab, the program of analysis of machinery is introduced which is used in an exercise of simulation of mechanism.
The additional personal dedication to the slate and lab lectures is expected of 90 hours uniformly divided throughout the course but with slightly more emphasis on the last issues.

Simulation exercise
Is an exercise based in the cinematic and dynamic analysis of a mechanism of a mechanical system which is provided by the professors and it is developed during the course. To perform it some concepts must be taken into account:
- Must be performed in groups of 3 students of the same practice group. Groups must be formed no later than the day of the third practice.
- The report must have a maximum length of 4 pages with a format that conforms the guidelines which can be found on the subject's website.

Practices
. P1 Mechanism of a sewing machine. Schematization
. P2 Machinery elements. Analysis of various mechanisms.
. P3 Gear box and differential in an automobile
. P4 Simulation by computer of mechanisms. Mechanism analysis.
. P5 Simulation exercise

Practices are carried out in the Machinery Lab (Laboratori de Màquines). G Pavilion Floor -1.

LEARNING OBJECTIVES OF THE SUBJECT

General objectives
· To integrate the Theory of Machines and Mechanisms in Engineering studies using prior knowledge taught in previous subjects, working the capabilities of engineering and making it attractive and useful for students, willing or not to opt for a mechanical profile.
· To sensitize the students about the relationship between technology and society by analyzing the role of machines in this binomial and the sustainability of the current model of human activity.

Specific objectives
· Doing the kinematic, static and dynamic analysis of the mechanisms and machines, from the concepts of rigid body mechanics and using the basic and operational tools.
· Using computer applications for the calculation and the simulation of mechanisms.
· RecognizIng the mechanical components and basic mechanical groups of the machines and mechanisms from examples taken of real situations.
· Doing the energy balances and calculations of performance applied to the machines.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours small group	10,0	6.67
Hours large group	50,0	33.33

Total learning time: 150 h

CONTENTS

1 MACHINE AND MECHANISM

Description:
Definition of machine, mechanism and kinematic chain. Definitions and classification of members and kinematic pairs. Normalized representation, modeling and symbols. Linkages. Grashof's criteria. Cam mechanisms. Gears and Gear trains. Benefits of a mechanism.

Related activities:
Practice 1: Mechanisms of a sewing machine. Normalized representation of a mechanisms.

Full-or-part-time: 10h 30m
Theory classes: 4h 30m
Self study : 6h

2 MOBILITY

Description:
Coordinates and generalized velocities. Independent coordinates. Degree of freedom of a mechanism. Constraint equations. Holonomic system and non-holonomic system. Solving constraint equations: Newton-Raphson method. Space of configurations. Accessible configuration space. Redundancy. Grübler-Kutzbach's criteria. Singular configurations.

Related activities:
Practice 2: Elements of machines. Analysis of various mechanisms.

Full-or-part-time: 13h 30m
Theory classes: 5h 30m
Laboratory classes: 2h
Self study : 6h

3 KINEMATICS OF MECHANISMS

Description:
Kinematic study of mechanisms from geometric constraint equations. Redundancy and singular configurations. Kinematic study of mechanisms from kinematic constraint equations. Plane motion. Three centers theorem.

Full-or-part-time: 29h
Theory classes: 10h
Laboratory classes: 4h
Self study : 15h

4 GEARS AND GEAR TRAINS

Description:
Gears. Gearing condition. Conjugated profiles. Involute and cycloidal profiles. Pressure line and pressure angle. Gear Types. Fixed gear and planetary gear trains. Velocities ratio. Differential mechanism.

Related activities:
Practice 3: Gearbox and differential of a car.

Full-or-part-time: 15h 30m
Theory classes: 4h 30m
Laboratory classes: 2h
Self study : 9h

5 DYNAMIC ANALYSIS

Description:
Vectorial theorems. Free body diagram. D'Alembert's inertia forces. Direct and inverse dynamic analysis of mechanisms. Solution using matrices. Static and dynamic balance of rotors. Balance of mechanisms.

Related activities:
Practice 4: Simulation of mechanisms

Full-or-part-time: 18h 30m
Theory classes: 4h 30m
Laboratory classes: 2h
Self study : 12h

6 CONTACT FORCE. CONSTRAINT FORCE. PASSIVE RESISTANCES

Description:
Constraint forces and passive resistances. Resistance to sliding, rolling and pivoting motions. Friction and rolling resistance models. Extreme conditions in the kinematic pairs. Wedging in guides and joints. Mechanisms based on friction.

Full-or-part-time: 16h
Theory classes: 7h
Self study : 9h

7 VIRTUAL POWER METHOD

Description:
Virtual power associated to a system of forces. Virtual Motions. Obtaining motion equations and constraint forces. Generalized forces.

Related activities:
Practice 5: Simulation exercise

Full-or-part-time: 22h
Theory classes: 7h
Self study : 15h

8 WORK AND POWER IN MACHINES

Description:
Energy theorem. Reduced inertia to a generalised velocity. Steady and transient state. Cyclic operation of a machine. Irregularity degree. Flywheels.

Full-or-part-time: 25h
Theory classes: 7h
Self study : 18h

ACTIVITIES

SIMULATION EXERCISE

Description:
It is an exercise based on kinematic and dynamic analysis of a mechanism of a mechanical system that, in principle, will facilitate the teaching staff. For its realization it is necessary to keep in mind that:
· It must be done in groups of 3 students of the same practice group. Groups must be formed no later than the day of the third practice.
· The report must have a maximum extension of 4 pages in a format that conforms to the guidelines that can be found on the web page of the subject.

Full-or-part-time: 5h
Guided activities: 5h

PARTIAL EXAM

Description:
Assessment of knowledge.

Delivery:
Solved exam.

FINAL EXAM

Description:
Assessment of knowledge.

Delivery:
Solved exam.

GRADING SYSTEM

The final mark, Nfinal, rounded to the decimal point, will be the following weighted average:
Nfinal = Màx(0,6 Nef + 0,3 Nparcial, 0,9 Nef)+ 0,1 * Nexer, where:
Nfinal: final mark
Nef: mark of the final exam. The final exam will consist on a set of exercises of similar valuation. For its performance, three hours will be given.
Nparcial: Mark of the partial exam. The partial exam will consist on a set of exercises of similar valuation. For its performance an hour and a quarter will be given.
Nexer: Mark of the mechanism simulation exercise.

Reevaluation
The reevaluation exam will be of a type test with theoretical and practical questions. The mark obtained -Nreaval- replaces Nparcial and Nef marks.
Paragraph 3.1.3 of NAGARMA will be applied.

EXAMINATION RULES.

During the evaluations:
- Regarding to written material, students can only dispose of an A4 original manuscript, with the contents deemed necessary.
- Calculator and basic tools for writing are essential (pencil, rubber ¿) so as to help neatness in presentation.
- It is forbidden to use any storage device or information transmission, mobile phone or other.
- Questions to professors may refer only to the comprehension of the statement.

Neatness, conciseness and accuracy while doing the exercises is valued.
To obtain the highest mark possible in an exercise, the numeric values must be found and indicate their units.

BIBLIOGRAPHY

Basic:
- Cardona i Foix, S. ; Clos Costa, D. Teoria de màquines [on line]. 2a ed. Barcelona: Edicions UPC, 2008 [Consultation: 12/09/2022]. Available on: https://upcommons.upc.edu/handle/2099.3/36644. ISBN 9788483019634.

Complementary:
- Hernández, Alfonso. Cinemática de mecanismos : análisis y diseño. Madrid: Síntesis, DL, 2004. ISBN 8497562240.
- Norton, Robert L. Diseño de maquinaria : síntesis y análisis de máquinas y mecanismos [on line]. 5a ed. México: McGraw Hill, 2013 [Consultation: 19/10/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=5701. ISBN 9786071509352.
- Calero Pérez, Roque. Fundamentos de mecanismos y máquinas para ingenieros. Madrid: McGraw Hill, 1999. ISBN 844812099X.
- Agulló i Batlle, Joaquim. Mecànica de la partícula i del sòlid rígid. 3a ed. Barcelona: OK Punt, 2002. ISBN 8492085061.
- Beer, Ferdinand Pierre. Mecánica vectorial para ingenieros [on line]. 11a ed. México: McGraw Hill, 2017 [Consultation: 07/05/2020]. Available on: http://www.ingebook.com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=8077. ISBN 9781456255268.

RESOURCES

Other resources:
Collection of problems and solved examples and other material: http://www.em.upc.edu/docencia/estudis_grau/etseib/teoria_maquines