Course guide
340600 - DIAP-R1O12 - Applied Dynamics

Last modified: 17/05/2023

Unit in charge: Vilanova i la Geltrú School of Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering.

Degree: MASTER'S DEGREE IN AUTOMATIC SYSTEMS AND INDUSTRIAL ELECTRONICS (Syllabus 2012). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: Gonzalez Rojas, Hernan Alberto

Others: Magnusson Morer, Ingrid

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
2. CC09 - Identify the symbols of mechanical systems and obtain the knowledge to determine the number of drives that will allow the desired movement of the system.

Transversal:
1. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

TEACHING METHODOLOGY

LEARNING OBJECTIVES OF THE SUBJECT

The general objective of the subject is to acquire the necessary skills to be able to model and carry out the dynamic analysis of a mechanical system. This study will allow decisions to be made about the mechanical design process of the system, as well as the design of the control system.

Specific objectives
1. Kinematic analysis of mechanisms, using generalised coordinates to determine the position, velocity and acceleration of a mechanical system.
2. Dynamic analysis of a system, application of a standard methodology for obtaining the Lagrange equations in a generalised coordinate system.
Solution of the system of differential equations associated with the physical problem and simulation of the behaviour of the system.

STUDY LOAD

Type	Hours	Percentage
Self study	80,0	64.00
Hours large group	30,0	24.00
Hours small group	15,0	12.00

Total learning time: 125 h

CONTENTS

Introduction

Description:
Introduction to basic concepts required for the course such as kinematic diagrams and the determination of degrees of freedom. Then an overview of the different coordinates used to model mechanism, independent coordinates, relative coordinates, reference point coordinates, natural or generalised coordinates and mixed coordinates.

Specific objectives:
Obtaining basic knowledge for the development of the course.

Related activities:
1.1 Construction of kinematic diagrams.
1.2 Determination of degrees of freedom of a system and/or mechanism 1.3.
1.3 Classification of the different coordinate systems used to model mechanisms. Identification of advantages and disadvantages when simulating with different coordinates.

Full-or-part-time: 2h
Theory classes: 2h

Modelling the position of mechanical systems using natural coordinates

Description:
To model the position of different mechanical and/or dynamic systems. To this end, the equations governing the position problem of different mechanical systems are defined. These equations, also called constraint equations, are constructed from rigid solid equations and geometric equations obtained from vector algebra such as the inner product and the vector product.

Specific objectives:
To construct models to determine the position of mechanical and/or dynamic systems.

Related activities:
2.1 Obtaining rigid solid and geometric constraint equations, associated with a mechanism.
2.2 Construction of models of a crank-crank-piston mechanism and of a 4-bar mechanism.
2.3 Solution of the system of non-linear equations associated with the position problem of the crank-crank-piston mechanism and the 4-bar mechanism.

Full-or-part-time: 4h
Theory classes: 4h

Modelling velocity and acceleration of mechanical systems using natural coordinates

Description:
Model the velocity and acceleration of different mechanisms and/or dynamic systems. From the aforementioned constraint equations (point 2 of the content). The Jacobian matrix associated with the velocity and acceleration problems is obtained. The form taken by the velocity and acceleration equation as a function of the Jacobian matrix is shown. Velocity and acceleration problems for mechanism are solved.

Specific objectives:
Build models to determine the velocity and acceleration of mechanical and/or dynamic systems.

Related activities:
3.1 Understand that from finite displacements, velocities and accelerations can be obtained.
3.2 Obtaining the Jacobian matrix associated with kinematics problems.
3.3 Obtaining the velocity equation as a function of the Jacobian matrix and the solution of the system of equations associated with the velocity problem.
3.4 Obtaining the acceleration equation as a function of the Jacobian matrix and the solution of the system of equations associated with the acceleration problem.
3.5 Application to velocity problems in systems with simple and epicyclic gears.

Full-or-part-time: 4h
Theory classes: 4h

Static Modelling

Description:
To model the problem of forces in a static mechanical system. To pose the equations of conservation of linear and angular momentum. Determine the reaction forces at the joints of the different components that form part of the system.

Specific objectives:
Construct static models of mechanical systems.

Related activities:
4.1 Produce free body diagrams of a mechanism in two dimensions.
4.2 Apply the balance of forces and moments to systems at rest.
4.3 Obtain the equations of equilibrium of a mechanism.
4.4 Determine the angle of transmission in a torque and estimate the efficiency of the mechanism.

Full-or-part-time: 8h
Theory classes: 8h

Dynamic Modelling

Description:
Modelling the dynamic problem in different systems and mechanisms. To do this, the Lagrange equation must be obtained for the different mechanisms studied. It is shown how a particular form of the Lagrange equation can be used systematically to model different mechanical systems. This methodology is applied to different one-dimensional problems with and without energy dissipation and the Lagrange equation is solved to obtain the behaviour of the system.

Specific objectives:
Construct dynamic models of mechanisms and systems.

Related activities:
5.1 Know the Lagrange equation and its origin.
5.2 Know and use the particular form that the Lagrange equation takes for rigid solid problems where the kinetic energy is a function of the velocities and position of the parameters, and the potential energy is a function of the position of the parameters of the system.
5.3 Apply the Lagrange equation for a mechanism dynamics problem by finding all the terms of the equation.

Full-or-part-time: 6h
Theory classes: 6h

Solution of system of differential equations associated with the dynamic problem

Description:
The system of Lagrangian differential equations in generalised coordinates for mechanisms in two and three dimensions has no direct solution. Several formulations have been developed to solve this system of equations, the penalty formulation being one of the most widely used. The penalised Lagrangian is applied to simulate spatial dynamics problems.

Specific objectives:
To solve penalised Lagrange equations.

Related activities:
6.1 Know the form that the penalised Lagrangian equation takes.
6.2 Solve the penalised Lagrange equation system using finite differences or any other method..

Full-or-part-time: 6h
Theory classes: 6h

ACTIVITIES

(A1) CLASS THEORY AND PROBLEMES

Description:
Work in the classroom

Material:
Digital Campus Notes

Full-or-part-time: 67h 30m
Theory classes: 30h
Self study: 37h 30m

(A2) Laboratory Practices

Description:
Resolution by the student of different dynamic studies of mechanical systems, sometimes individually and other times in groups. The resolution is carried out applying different methodologies: proposing the equations of the theoretical model and solving them by programming in MATLAB; or, by simulating the systems through the CAD / CAE program of SIEMENS NX.

Specific objectives:
To apply the knowledge introduced in the theory sessions in the study of different practical cases.

Material:
Reports with the statement (specification of the mechanical system to be studied) and the results to be obtained from the study, available to the students on the platform of the DIGITAL CAMPUS. Both the MATLAB and the SIEMENS NX are installed in the informatic classrooms of the school. The school also has licenses to install the SIEMENS NX on each student's personal computer, so they can work more autonomously.

Delivery:
Most of the activities will be evaluated individually, vis a vis with the teaching staff, without the need to write any report. Some of the activities will require the presentation of a report with the description of the work carried out and the results and conclusions obtained. Both the reports (if required) and the files that justify the different studies carried out, will be delivered through the platform of the DIGITAL CAMPUS.

Full-or-part-time: 45h
Laboratory classes: 18h
Self study: 27h

(A3) Assessment of Learning

Description:
Two individual and written tests, carried out with the help of a computer that has MATLAB and SIEMENS NX. In addition, a continuous assessment is carried out in individual tutorials, distributed throughout the course, in which the correct acquisition of the concepts worked is verified and their adequate application in the study of practical cases (proposed and worked in the laboratory sessions).

Specific objectives:
Certify the degree of achievement of aprenetatge

Full-or-part-time: 12h 30m
Guided activities: 3h
Self study: 9h 30m

GRADING SYSTEM

BIBLIOGRAPHY

Basic:
- Beer, Ferdinand Pierre. Mecánica vectorial para ingenieros. Vol. 2, Dinámica [on line]. 11a ed. México: McGraw-Hill Education, 2017 [Consultation: 20/02/2024]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=11979. ISBN 9781456255268.
- Cardona i Foix, Salvador; Clos Costa, Daniel. Teoria de máquinas [Recurs electrònic] [on line]. 2a ed. Barcelona: Edicions UPC, 2008 [Consultation: 02/05/2022]. Available on: https://upcommons.upc.edu/handle/2099.3/36645. ISBN 9788498803808.
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