340600 - DIAP-R1012 - Applied Dynamics

Coordinating unit:	340 - EPSEVG - Vilanova i la Geltrú School of Engineering
Teaching unit:	712 - EM - Department of Mechanical Engineering
Academic year:	2017
Degree:	MASTER'S DEGREE IN AUTOMATIC SYSTEMS AND INDUSTRIAL ELECTRONICS (Syllabus 2012). (Teaching unit Compulsory)
ECTS credits:	5 Teaching languages: Catalan, Spanish

Teaching staff

Coordinator:	Ingrid Magnusson
Others:	Ingrid Magnusson

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

Theoretical explanations and practical examples solved with Matlab.

Learning objectives of the subject

The general objective of the subject is to acquire the necessary skills to be able to model and perform the dynamic analysis of a mechanical system. This study should allow the decision making both on the mechanical design process of the system as well as on the design of the control system.

Study load

Total learning time: 125h			
	Hours large group:	30h	24.00%
	Hours medium group:	0h	0.00%
	Hours small group:	15h	12.00%
	Guided activities:	0h	0.00%
	Self study:	80h	64.00%

340600 - DIAP-R1O12 - Applied Dynamics

Content

Mechanism mobility	Learning time: 20h
	Theory classes: 4h Laboratory classes: 2h Self study : 14h

Description:
 Generalized coordinates and speeds
 Independent coordinates and degrees of freedom. Holonomy
 Geometric Link Equations
 Redundancy
 Space of configuration and subspace of accessible configurations
 Unique configurations: deadlocks and bifurcation
 Resolution linkage equations: geometry and numerical methods (Newton - Raphson)

Specific objectives:
 - Identify the different types of generalized coordinates
 - Identify a non-holonomic system (one that has more independent coordinates than degrees of freedom)
 - Determine the degrees of freedom of the mechanism (number of independent generalized speeds). This number coincides with the minimum number of generalized coordinates that must be known to describe the configuration of the mechanism (independent coordinates) when the system is holonomic (general situation).
 - Determine how many degrees of freedom a mechanism needs to be in terms of the application of this mechanism
 - Propose the geometric linking equations necessary to be able to determine the configuration of the mechanism
 - Propose the kinematic linkage equations from the derivation of the geometric link equations (will be practiced in future dedication guides as well)
 - Recognize redundant links or elements and type of redundancy
 - Determine the configuration space and the subspace of accessible configurations of a mechanism.
 - Understand what happens to the mechanism in the singular configurations (dead center and bifurcation)
 - Solve the system of geometric link equations (nonlinear system) by applying geometry of triangles (sine rule and cosine).

Matlab:
 - Create a list of instructions to determine the configuration of the mechanism from an estimated initial solution, using the N-R method.
 - Create a routine to apply the N-R method sequentially to determine all configurations accessible from an initial configuration.
 - Present the results graphically.
 - Calculate the value of a trigonometric function at different points and represent the values ??of the function graphically, as a function of the independent variable
 - Graphically represent the subspace of accessible configurations
 - Make an animation with the movement of the mechanism (in order to show the different configurations of the mechanism, without paying attention to the time)
 - Raise the geometric linking equations necessary to be able to determine the configuration of the mechanism and solve them using the numerical method N-R.

340600 - DIAP-R1O12 - Applied Dynamics

Kinematics of mechanisms	Learning time: 38h
	Theory classes: 10h Laboratory classes: 2h Self study : 26h

Description:
Kinematic linkage equations from time derivation of the geometric linkage equations. Resolution by matrix method from the development in partial derivatives.
Kinematic linkage equations from the kinematic study of the links and the fundamental equations of kinematics.

Specific objectives:
- Derive "manually" the geometric linkage equations with respect to time to find the kinematic linkage equations (first and second derivative)
- Derive, with the help of Matlab, the geometric linkage equations with respect to time by its formulation in partial derivatives (use of the Jacobian matrix), to find generalized velocities and their derivatives.
- Formulate, where appropriate, the equations of government associated with each degree of freedom
- Solve with matrix methods implemented in Matlab the system of linear equations obtained with either of the two previously described methods, to find generalized velocities and their derivatives.
- Identify the geometric constraints imposed by the different kinematic links
- Apply the fundamental equations of kinematics for the calculation of velocities and accelerations in a member of the mechanism
- Express the set of previous equations in matrix form and solve the system for the generalized dependent velocities and their derivatives, "by hand" and with the help of Matlab.

Matlab:
- Create a routine for sequentially calculating the configuration (based on ICs), generalized speeds (based on generalized coordinates and independent generalized speeds) and those derived from generalized speeds (as a function of generalized coordinates, Generalized velocities and those derived from independent generalized velocities) in a mechanism.
- Obtain the kinematic study described in the previous point as a function of time if a governing equation is available for each independent coordinate.
- Graph the previous results.

NX:
- Starting from a 2D modeling assembly, define a simulation scenario (kinematic members and pairs, driving the motion and defining results) to perform the kinematic study of a mechanism with three-dimensional movement.

340600 - DIAP-R1O12 - Applied Dynamics

Dynamical analysis of mechanisms	Learning time: 59h
	Theory classes: 15h Laboratory classes: 8h Self study : 36h

Description:
Joint forces. Free Body Diagrams.
Dynamic inverse analysis of mechanisms. Method of d'Alembert.
Determination of all the unknowns of the system proposing matrix resolution. Particular case: mechanism in equilibrium.
Direct dynamic analysis.
Equation characteristic of the movement by the method of virtual powers
Equation characteristic of the movement by the method of reduction to an axis.

Specific objectives:

340600 - DIAP-R1O12 - Applied Dynamics

- Identify the reactions potentially existing in the different links (in plane mechanisms it will also contemplate the reactions in other plans that are not the one of movement).
- Represent the DCLL of all members of the mechanism.
- Arrange the necessary vector equations in each member of the mechanism, express them in matrix form and solve the system with the help of Matlab.
- Interpret the results obtained from the static analysis of the mechanism.
- Represent the DCLI of each member within the mechanism, including for each member its D'Alembert torque.
- Arrange the necessary vector equations in each member of the mechanism, express them in matrix form and solve the system with the help of Matlab.
- Interpret the results obtained from the dynamic analysis of the mechanism.
- Propose one or more appropriate virtual movements so that the application of the method for each virtual movement allows to obtain the equations necessary to determine the unknowns of interest.
- For each virtual movement apply the method, which implies:
Or identify which forces have a non-zero associated virtual power
Or determine the virtual velocity distribution necessary to determine all non-zero virtual powers (all speeds must be a function of a single generalized velocity)
Or replace the virtual speeds and eliminate the generalized velocity thus obtaining the dynamic equation
- Express these dynamic equations in matrix form
- Solve, with the help of Matlab, the dynamic equations together with the kinematic equations of the accelerations, in one or consecutive configurations of the mechanism.
- Determining the expression of the equivalent mass of a reduced system to a linear coordinate
- Determine the expression of the equivalent moment of inertia of a reduced system at an angular coordinate
- Determining the expression of the reduced force to a linear coordinate, for any force or torque applied on a system
- Determine the expression of the reduced torque at an angular coordinate, for any force or torque applied on a system
- From the reduced parameters of a system, express the equation of its motion. This may allow the student to:
O In case of cyclical machines, from the study of motion calculate the degree of irregularity of the speed.
O Calculate the time (and space) used by a machine in the acceleration transient until it reaches the speed regime.
O Calculate the time (and space) used by a machine to move from the speed of the speed to the point of stop.
- Determine the flywheel necessary to achieve a certain degree of irregularity.
- Determine the inertia required of a machine in case of having to limit the maximum acceleration of the machine (elevators, forklifts, amusement park …)
- Determine the linking forces in the mechanism with or without steering wheel in the different parts of a machine and, therefore, to assess the quality of the kinematic chain in case of having to comply with limited linking forces.

Actuators	Learning time: 13h
	Theory classes: 4h
	Self study : 9h

Description:
Mechanical characteristic of the motors
Sturdy characteristic curve
Equilibrium of a mechanical system. stability
Regulation of a machine

340600 - DIAP-R1O12 - Applied Dynamics

Planning of activities

(A1) CLASS THEORY AND PROBLEMES	Hours: 67h 30m
	    Theory classes: 30h
	    Self study: 37h 30m

Description:
  Work in the classroom

Support materials:
  Digital Campus Notes

(A2) Laboratory Practices	Hours: 45h
	    Laboratory classes: 18h
	    Self study: 27h

Description:
  Conduct by the student of a proposed mechanical design of practical application.
  Calculation and design of mechanical systems and transmission needed to solve a specific problem.
  Selection and sizing of drives required.

Support materials:
  Computer simulation software and mechanical design (CAD-CAE)

Descriptions of the assignments due and their relation to the assessment:
  Design 3D mechanical design
  Project specification and calculations
  Rules used

Specific objectives:
  Apply knowledge of the student in the calculation and mechanical design for the realization of a mechanical draft
  practical application.
  It includes the design of the motion transmitting mechanism and the choice of the drives.

(A3) Assessment of Learning	Hours: 12h 30m
	    Guided activities: 3h
	    Self study: 9h 30m

Description:
  Individual Exams.
  Performing a mechanical project.

Specific objectives:
  Certify the degree of achievement of aprenetatge

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340600 - DIAP-R1O12 - Applied Dynamics

Qualification system

The final grade (QF) takes into account all the work done over the course. It is obtained from the expression:
QF = 0.25 x Partial Exam + 0.25 Continuous Avaluation of practical exercises + 0.5 Final Exam
There is a reevaluation exam where the 75% of the subject corresponding to exams can be revaluated (not the 25 % corresponding to the Continuous Avaluation of practical exercises).

Regulations for carrying out activities

All exams are to be done individually but consulting all documents and sources considered necessary.

Bibliography

Basic:

Cardona i Foix, Salvador. Teoria de màquines [on line]. 2a ed. Barcelona: Edicions UPC, 2008Available on: <http://hdl.handle.net/2099.3/36644>. ISBN 9788483019634.

Khamashta Shahin, Munir; Álvarez Martínez, Lorenzo; Capdevila Pagés, Ramón. Problemas de cinemática y dinámica de máquinas. 2ª ed. corregida. Terrassa: Departament d'Enginyeria Mecànica, 1993-1994. ISBN 847653003X.

Complementary:

Calero Pérez, Roque ; Carta González, José Antonio. Fundamentos de mecanismos y máquinas para ingenieros. Madrid [etc.]: McGraw-Hill, 1999. ISBN 844842099X.

Beer, Ferdinand Pierre [et al.]. Mecánica Vectorial para Ingenieros. Estática. 9a ed. México [etc.]: McGraw-Hill, 2010. ISBN 9786071502773.

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Riba i Romeva, Carles. Selecció de motors i transmissions en el projecte mecànic. Barcelona: ETSEIB. CPDA, 1988.

Riba i Romeva, Carles. Disseny de màquines [Recurs electrònic] [on line]. 3a ed. Barcelona: Edicions UPC, Universitat Politècnica de Catalunya, 2001 [Consultation: 04/03/2016]. Available on: <http://hdl.handle.net/2099.3/36688>. ISBN 9788498800807.

Riba i Romeva, Carles. Mecanismes i màquines. Volum III. Dinàmica de màquines. Barcelona: Edicions UPC, 1999-2000. ISBN 8483013479.