

## TIME TABLE

TIME	Monday June 12	Tuesday June 13	Wednesday June 14	Thursday June 15	Friday June 16
9.00 - 9.45	Registration	Preumont	Gawronski	Chen	Genta
9.45 - 10.30	Gawronski	Preumont	Gawronski	Chen	Genta
11.00 - 11.45	Preumont	Clark	Gawronski	Chen	Genta
11.45 - 12.30	Preumont	Clark	Gawronski	Chen	Genta
14.30 - 15.15	Preumont	Clark	Pietrzko	Chen	
15.15 - 16.00	Preumont	Clark	Pietrzko	Chen	
16.30 - 17.15	Clark	Clark	Pietrzko	Genta	
17.15 - 18.00	Clark	Gawronski	Pietrzko	Genta	
18.00 - 18.45	Clark	Gawronski			



## ADMISSION AND ACCOMMODATION

The registration fee is 450,00 € for students and participants on the regular staff of universities and research centres, or 650,00 € for other participants.

Applicants must apply at least one month before the beginning of the course. Application forms can be sent by post or on-line through our web site: <http://www.cism.it>. A letter of confirmation will be sent to accepted participants.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered board and/or lodging in a reasonably priced hotel. Requests should be sent to CISM Secretariat by **April 12, 2006** together with the applicant's curriculum and a letter of recommendation by the head of the department or supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries which sponsor CISM.

The Deutsche Forschungsgemeinschaft offers scholarships to German students (please contact Mr Höfeld, DFG, Kennedyallee 40, 53175 Bonn, +49 (0) 228 885 2321, <http://www.dfg.de/>).

Information about travel and accommodation are available at [http://www.cism.it/cism/travel\\_reach.htm](http://www.cism.it/cism/travel_reach.htm), or can be mailed upon request.

*For further information please contact:*

CISM  
 Palazzo del Torso - Piazza Garibaldi 18  
 33100 Udine (Italy)  
 tel. +39 0432 248511 (6 lines)  
 fax +39 0432 248550  
 E-mail: [cism@cism.it](mailto:cism@cism.it)  
<http://www.cism.it>

Centre International des Sciences Mécaniques  
 International Centre for Mechanical Sciences



ACADEMIC YEAR 2006  
 The Stüwe Session

## ADVANCES IN MODELING AND CONTROL OF FLEXIBLE MECHANICAL SYSTEMS

*Advanced School  
 coordinated by  
 W. Gawronski  
 Pasadena, Ca, USA*

**Udine June 12 - 16 2006**

## ADVANCES IN MODELING AND CONTROL OF FLEXIBLE MECHANICAL SYSTEMS

Accurate and fast control of flexible systems is a requirement in many engineering applications, which includes robotic manipulators, spacecraft and space structures, large telescopes and antennas, high speed rotors, or hard disc drives. The purpose of this course is to present the recent approaches to modeling and control of high performance flexible mechanical systems. We shall discuss modeling techniques and control methods specifically developed for this class of problems along with more general modeling and control techniques, which have been adapted for flexible system purposes.

The modeling part of the lectures will include methods that help to achieve the precise and fast pointing goal. It will describe analytical tools, such as finite element analysis or state space modal analysis, and system identification methods – where test data are used. The structural modeling includes also actuator and sensor models, actuator and sensor placement using spatial compensation and system norms (to shape the closed-loop performance), and distributed filters. Also, modeling of sound radiation and transmission from flexible structures, and modeling of rotating systems, and the gyroscopic effect are included. Finally, the modeling part of the

lectures includes model reduction methods that allow for determination a low-order model with small modeling error.

The control part of the lectures describes high bandwidth control systems, with flexible modes within the bandwidth. Consequently, rigid body models are not adequate in the control system design. It will describe the design and analysis of the adaptive structures, structural acoustic radiation, control of rotating machinery, issues in the precision control of hard disc drives, precision tracking for large telescopes and antennas, active control of noise, sound transmission and radiation from

flexible structures, and active vibration isolation. The lectures will include control techniques using Integral Force Feedback, passivity-based techniques, LQG, and  $H_{\infty}$  algorithms.

The course lecturers are experienced representatives of the academia and industry thus the course will be a balanced mixture of analysis and its applications. The course is addressed to researchers, engineers, and professionals interested in system dynamics, control system design and analysis, robotics, electronic hardware design, structural control, and control of aerospace systems.

### PRELIMINARY SUGGESTED READINGS

*B.M. Chen: Hard Disk Drive Servo Systems, Springer, New York, 2002*

*R. Clark: Adaptive Structures: Dynamics and Control, John Wiley, New York, 1998.*

*F. Fahy, Sound and Structural Vibration: Radiation, Transmission, and Response, Academic Press, 1987.*

*C.R. Fuller, Elliott Nelson, P. R. Nelson Active Control of Vibration, Academic Press, 1997.*

*W. Gawronski: Advanced Structural Dynamics, and Active Control of Structures, Springer, New York, 2004.*

*G. Genta: Dynamics of Rotating Systems, Springer, New York 2005.*

*A. Preumont: Vibration Control of Active Structures, An Introduction, Kluwer, Dordrecht, 2002.*

### INVITED LECTURERS

**Ben M. Chen** - National University of Singapore, Singapore  
*6 lectures on: Modeling and control of hard disk drives; modeling, robust control and composite nonlinear feedback control. Single-stage or dual-stage voice-coil-motor actuators. Modeling and compensation of friction and nonlinearities. Software package on the hard disk drive control will be demonstrated and distributed.*

**R. Clark** - Duke University, U.S.A.  
*8 lectures on: Modeling and control of adaptive structures. Overview of adaptive structures, structural dynamics primer, structural acoustics primer, sensors and actuators, controller design, application/examples.*

**W. Gawronski** - NASA/Jet Propulsion Laboratory, U.S.A.  
*7 lectures on: Modeling and control of antennas and telescopes. Antenna models: analytical and from the system identification; modal and balanced models; system norms; model reduction; sensor and actuator placement; LQG controller design.*

**G. Genta** - Politecnico di Torino, Italy  
*6 lectures on: Modeling and control of rotating systems. Simple models of rotating systems, effects of damping on flexible rotor dynamics, gyroscopic effect, dynamics of multi degree of freedom rotors, dynamics of controlled rotors, reduced models for the control of rotating systems. The lectures include numerical and physical experiments.*

**S. Pietrzko** - EMPA Swiss Federal Laboratories, Switzerland  
*4 lectures on: Modeling and control of sound radiation and transmission. Principles and modeling of sound radiation and transmission from flexible structures, feedforward and feedback control of sound radiation and transmission, and sensors and actuators for active noise control.*

**A. Preumont** - Université Libre de Bruxelles, Belgium  
*6 lectures on: Modeling and control of piezoelectric structures; Passive and active damping with piezoelectric transducers; Piezoelectric beams and shells, distributed filters; Collocated control systems; Active damping of cable structures; Active vibration isolation.*

### LECTURES

*All lectures will be given in English. Lecture notes can be downloaded from CISM web site, instructions will be sent to accepted participants.*

**ADVANCES IN MODELING AND CONTROL OF FLEXIBLE  
MECHANICAL SYSTEMS**

**Udine, June 12 - 16, 2006**

**Application Form**

(Please print or type)

Surname \_\_\_\_\_

Name \_\_\_\_\_

Affiliation \_\_\_\_\_

Address \_\_\_\_\_

\_\_\_\_\_

E-mail \_\_\_\_\_

Phone \_\_\_\_\_ Fax \_\_\_\_\_

**Method of payment upon receipt of confirmation  
(Please check appropriate box)**

- I shall send a check of Euro 650,00 / 450,00  
VAT (IVA) included and bank charges excluded
- Payment will be made to CISM - Bank Account N° 094570210900,  
VENETO BANCA - Udine (CAB 12300 - ABI 05418 - SWIFT AMBPIT2M - IBAN  
CODE IT83Z 05418 12300 09457 0210900).  
Copy of the receipt should be sent to the secretariat
- I shall pay at the registration counter with check, cash or VISA  
Credit Card (Mastercard/Eurocard, Visa, CartaSi)

**IMPORTANT: CISM is obliged to present an invoice for the above sum. Please  
indicate to whom the invoice should be addressed.**

Name _____
Address _____
_____
_____
C.F.* _____
VAT/IVA* No. _____
(*) Only for EU residents or foreigners with a permanent business activity in Italy.

**Only for Italian Public Companies**

- I ask for IVA exemption (ex law n. 537/1993 - art. 14 comma 10)

**Privacy policy:** I understand that, according to the Italian law 675/96 in defence of  
privacy, personal data will be used exclusively for CISM's activities; any other use will  
require my explicit authorisation.

**Cancellation policy:** I have read the "Admission and Accommodation" terms and  
conditions and agree to the policy.

Date \_\_\_\_\_ Signature \_\_\_\_\_