

TECHNICAL UNIVERSITY "GH. ASACHI" IAȘI

Faculty of Automatic Control and Computer Engineering

Major: Systems Engineering

Specialization: Systems and Control

Instruction type: Master

Year/level of study: 2

Year: 2010-2011

S Y L L A B U Sfor course: **Modeling and Design of Robot Systems****1. Instructor: Assoc. prof. dr. ing. Ștefan Dumbravă****2. Course type: Elective****code: AMS 204****3. Class structure:**

Term	Number of hours per week				Final evaluation method	Number of hours per term				
	C	S	L	P		C	S	L	P	Total
3	2	-	2	-	exam	28	-	28	-	56

4. Course objectives:

The course main objectives are to introduce the basic theoretical knowledge necessary for cinematic and dynamic modeling of robotic systems, and to elaborate proper control methods and controller design. Consequently, the course presents the basic mechanical modeling methods for obtaining the cinematic and dynamic model of the rigid robot systems, using numerical and symbolic computer assisted methods. For controller design, modern control methods based on reference model in joint and cartesian coordinate systems are studied. The control methods performances are emphasized by simulation and animation experiments using Matlab and Mathematica software packages.

5. Relation between course objectives and curriculum objectives:

Through both objectives and content, the course develops the students knowledge from the core disciplines Motion control (AMS100), Nonlinear dynamics (AMS105), System theory for control (AMS101), by applying the control methods for the case of modelling and design of robotic systems.

6. Learning results from knowledge, technical or professional point of view:

Knowledge learning results refer to acquiring competences both for elaborating cinematic and dynamic models for different robot systems configurations, and for controller design and overall stability analysis of the robot system. Technically, the students acquire abilities to use software packages for numeric and symbolic computation, and use these abilities for obtaining the robot model and simulating the designed system. Professionally, based on theoretical knowledge and using the computer assisted techniques, the students will have competences for complex robotic system design and performance evaluation.

7. Method of instruction:

During the lectures both multimedia and classical methods will be used. Theoretical methods will be emphasized by explanatory examples and proposed problems. The dialog with the students will be encouraged in order to assess the understanding level and the impact of the acquired knowledge. The laboratory activity will be focused on the ability of using the theoretical knowledge for elaborating

software programs for cinematic and dynamic robot models, as well as for designing controllers. Quality criteria refer to the degree of understanding, the ability of applying the acquired methods, originality of the proposed solutions, homework quality and the frequency and correctness of responses.

8. Grading basis:

Continuous evaluation:

Seminar / laboratory / project / experimental activity

Percentage in final grade: 15 %

Interim tests

Percentage in final grade: 15 %

Other assignments

Percentage in final grade: 10 %

Final evaluation:

Percentage in final grade: 60 %

Assignment(s): theoretical test with open questions (10%), theoretical test with closed questions (25%), exercises and proofs (65%), closed book exam.

9. Course content:

a) Lecture

I. Cinematic robot system model (Mathematical transforms, orientation matrix, Euler angles, homogeneous transformations, joint and Cartesian coordinate systems, Denavit-Hartenberg parameters, forward and inverse cinematic problems, Pfeifer Theorem, velocity and acceleration computation, Jacobian matrix, singularities and redundancies. 6 hours

II. Dynamic robot system model (Forces and torques, Newton Euler method, Lagrange method, Kane equations, model linearization, modeling the actuating system) 6 hours

III. The design of robot system control (Linear controller design, non-linear model reference control methods, PD controller, computed torque method, “sliding” control methods, control methods based on passivity principle, adaptive and robust variants of model reference control, observer system design, controller-observer system design). 10 hours

IV. Hybrid and impedance control (Position-force control, inclusion matrix method, hybrid force-movement control, general structure of impedance control, virtual spring-damper concept, defining the robot desired impedance, impedance control scheme) 6 hours

Total 28 hours

b) Seminar/laboratory

1. Cinematic and dynamic robot system modeling using symbolic software packages 6 hours

2. Cinematic and dynamic robot system modeling using numerical software packages; SimMechanics Matlab toolbox. 4 hours

3. 3D robot representation and movement animation using SimMechanics and Virtual Reality toolboxes. _4_ hours
4. Design and simulation of nonlinear model based controllers _10_ hours
5. Design of robot systems integrated in manufacturing systems; examples using Robot Studio software. _4_ hours

Total 28 hours

10. Reading list

1. Bekey, G., (2005), *Autonomous Robots*, MIT Press.
2. Spong M., Vidyasagar, M., (1989), *Robot Dynamics and Control*, J. Wiley & Sons.

Complementary reading

1. Asada, H., Slotine, J.-J., (1986), *Robot Analysis and Control*, J. Wiley & Sons.
2. Asfahl, C., (1992), *Robots and Manufacturing Automation*, J. Wiley & Sons.
3. Close C., Frederick, D., (1993), *Modeling and Analysis of Dynamic Systems*, Houghton Mifflin.
4. Dorf, R., (1983), *Robotics and Automated Manufacturing*, Reston (Prentice-Hall).
5. Nakamura, Y., (1991), *Advanced Robotics: Redundancy and Optimization*, Addison-Wesley.
6. Wolovich, W., (1987), *Robotics: Basic Analysis and Design*, Holt, Rinehart, and Winston.
7. Woods, R., Lawrence, K., (1997), *Modeling and Simulation of Dynamic Systems*, Prentice-Hall.

Signatures:

Date: 18.01.2008

Lecture instructor: *Ștefan Dumbravă*
Seminar instructor: *Ștefan Dumbravă*