INSTITUTO POLITÉCNICO NACIONAL

SECRETARÍA ACADÉMICA

DIRECCIÓN DE EDUCACIÓN SUPERIOR

SYNTHESIZED SCHOOL PROGRAM

ACADEMIN UNIT: Escuela Superior de Cómputo

ACADEMIC PROGRAM: Ingeniería en Sistemas Computacionales

LEARNING UNIT: Digital Control **LEVEL:** III

AIM OF THE LEARNING UNIT:
The student evaluates the characteristics of control systems through the techniques of analysis in continuous time and discrete time.

CONTENT:

I. Continuous-time control systems.
II. Analysis of continuous-time control systems
III. Discrete-time control systems
IV. Analysis of discrete-time control systems
V. Discrete-time controllers design

TEACHING PRINCIPLES:

This unit is based on a project oriented learning strategy, alternating between a heuristic and analog method, this is to promote the metacognitive processes after the development of abilities for abstraction, observation, comparison, description, simulation, analysis and design of digital controllers, by using the appropriate analysis techniques and practical applications that shows evidence on the concepts from this unit. The learning techniques to employ will be: Problem solving, collaborative and participatory work, documental investigation, led discussions, worksheets, graphic organizer and a final project.

EVALUATION AND PASSING REQUIREMENTS:

This unit is going to be evaluated from a projects portfolio consisting of: formative and summative assessments beside self and co- evaluation rubrics.

Other means to pass this Unit of Learning:

- Evaluation of acknowledges previously acquired, with base in the issues defined by the academy.
- Official recognition by either another IPN Academic Unit of the IPN or by a national or international external academic institution besides IPN.

REFERENCES:

- Bolton, W. (2001). Ingeniería *de Control. (*2nd Edition). España: Alfaomega. ISBN 970-1506367.
- Dorf, R., Bishop, R. (2008). *Modern Control Systems*. (11th Edition). EU: Pearson. ISBN 978-0132270281.
- Ogata, K. (2003). Ingeniería *de Control Moderna*. (4ª Edición). España: Pearson. ISBN 84-20536784.
- Ogata, K. (1996). *Sistemas de Control en Tiempo Discreto*. (2ª Edición). México: Pearson. ISBN 968-880-539-4.
- Kuo, B. (2000).Sistemas de Control Digital. 1st Edition. Compañía Editorial CECSA. México 2000. ISBN-13: 978-9682612923.

INSTITUTO POLITÉCNICO NACIONAL

SECRETARÍA ACADÉMICA

DIRECCIÓN DE EDUCACIÓN SUPERIOR

ACADEMIC UNIT: Escuela Superior de Cómputo

ACADEMIC PROGRAM: Ingeniería en Sistemas Computacionales

LATERAL OUTPUT: Analista Programador de Sistemas de Información

FORMATION AREA: Professional

MODALITY: Presence

LEARNING UNIT: Digital control
TYPE OF LEARNING UNIT: Theorical - Practical, Optative.
VALIDITY: August 2011

LEVEL: III

CREDITS: 7.5 TEPIC – 4.39 SATCA

ACADEMIC AIM

This Unit contributes to the graduate profile of the computer systems engineer, by developing their abilities to design efficient digital controllers to solve computational problems as well as the implementation and evaluation of these systems. A critical, strategically and creative thinking is allowed besides a collaborative work and assertive communication.

This unit requires mainly of the learning units: Calculus, Differential equations, Advanced mathematics for engineering, Digital systems design, Introduction to microcontrollers, Instrumentation, database to manipulate the data received from the supervised physical variables to implement the digital controller.

AIM OF THE LEARNING UNIT:

The student evaluates the characteristics of control systems through the techniques of analysis in continuous time and discrete time.

CREDIT HOURS
THEORETICAL CREDITS / WEEK: 3.0

PRACTICAL CREDITS / WEEK: 1.5

THEORETICAL HOURS/SEMESTER: 54

PRACTICAL HOURS / SEMESTER: 27

AUTONOMOUS LEARNING HOURS: 54

CREDITS HOURS / SEMESTER: 81

LEARNING UNIT DESIGNED BY:
Academia de Sistemas Distribuidos

REVISED BY:
Dr. Flavio Arturo Sánchez Garfias
Subdirector Académico

APPROVED BY:
Ing. Apolinar Francisco Cruz Lázaro
Presidente del CTCE
.

AUTHORIZED BY: Comisión de Programas Académicos del Consejo General Consultivo del IPN. 2011

_____
Ing. Rodrigo de Jesús Serrano Domínguez
Secretario Técnico de la Comisión de Programas Académicos

THEMATIC UNIT: I **TITLE:** Continuous time control systems

UNIT OF COMPETENCE

The student interprets continuous-time control systems fundamental concepts based on the necessary mathematics tools.

No.	CONTENTS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
1.1	Introduction	0.5		0.5		1B, 2B,4B,5C
1.1.1	Examples of control systems					
1.1.2	Closed loop control versus open loop control					
1.2	Laplace transform	0.5		2.0		
1.2.1	Laplace transform theorems					
1.2.2	Inverse Laplace transform					
1.2.3	Solution of linear differential equations and time invariant systems					
1.3	Modeling of Mechanical systems	1.0	1.5	3.0	1.5	
1.3.1	Block diagram					
1.3.2	Transfer function and impulse response					
1.3.3	Automatic control systems					
1.3.4	Mechanical, electrical and electronic systems					
1.4	State variable model					
1.4.1	State variable model for a dynamic system	1.0		3.0	1.5	
1.4.2	State-space differential equation					
1.4.3	State transfer function					
1.4.4	State-transition matrix					
	Subtotals:	3.0	1.5	8.5	3.0	

TEACHING PRINCIPLES

This thematic unit must begin with a framing of the course and the formation of teams, a lecture of the main topics is given by the facilitator, by using the heuristic method.
The approach to this unit is using the project oriented learning strategy and the heuristic and analog method. This approach is going to permit encourage of the next learning strategies: brainstorming, investigation reports, documental researching, directed discussions, conceptual maps, problem solving, lectures given by the team of complementary themes and reports of practices.

LEARNING EVALUATION

Diagnostic Test

Projects Portfolio:

Conceptual map	5%
Cooperative Presentation	15%
Exercise-solving	15%
Reports of practicals	20%
Project proposal	5%
Self-evaluation Rubrics	5%
Cooperative Evaluations Rubrics	5%
Written Learning Evidence	30%

THEMATIC UNIT: II **TITLE:** Analysis of continuous time control system.

UNIT OF COMPETENCE

The student determines stability of continuous time control systems trough on their response a test signals and adequate mathematical techniques.

No.	CONTENTS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
2.1 2.1.2 2.1.3 2.2 2.2.1 2.2.2 2.2.3 2.3 2.3.1 2.3.2	Analysis of transitory and permanent response. First- and second order systems. Superior order systems. Stability of linear feedback systems. Stability concept. Routh-Hurtwitz stability criterion. Relative stability. Root-locus analysis. Root-locus graphs. Conditionally stable systems.	1.0 1.5 1.5	0.5 0.5 0.5	1.5 1.5 1.5	2.0 2.0 2.0	1B,2B, 5C,7B,8C
	Subtotals:	4.0	1.5	4.5	6.0	

TEACHING PRINCIPLES

The approach to this unit is using the project oriented learning strategy beside the heuristic and analog method. This approach is going to permit encourage of the next learning strategies: brainstorming, investigation reports, documental researching, led discussions, conceptual maps, problem solving, lectures given by the team of complementary topics and reports of practicals.

LEARNING EVALUATION

Projects Portfolio:

Conceptual Map	5%
Cooperative Presentation	15%
Exercise-solving	15%
Report of Practicals	20%
Advance of Project	5%
Self-evaluation Rubric	5%
Co-evaluation Rubric	5%
Written Learning Evidences	30%

UNIDAD TEMÁTICA: III **TITLE:** Discrete-time control systems

UNIDAD DE COMPETENCIA

The student classifies discrete-time control systems trough in adequate mathematical techniques.

No.	CONTENTS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
3.1	Structure of a Discrete-time system	0.5				3C,6B,5C,8C
3.2	Discrete-time digital signals	1.0	1.5	2.5	1.5	
3.2.1	Step signal					
3.2.2	Ramp signal					
3.2.3	Impulse signal					
3.2.4	Exponential signal					
3.3	Examples of sampled discrete-time systems	0.5		2.5		
3.4	Difference equations.	1.5				
3.5	Z transforms.	1.5		3.0		
3.5.1	Mapping of the s plane to the z plane.					
3.5.2	Inverse Z-Transform					
3.5.3	Convergence regions					
3.5.4	Z-transform technique and application to solve difference equations.					
	Subtotals:	5.0	1.5	8.0	1.5	

TEACHING PRINCIPLES

The approach to this unit is using the project oriented learning strategy beside the heuristic and analog method. This approach is going to permit encourage of the next learning strategies: brainstorming, investigation reports, documental researching, led discussions, conceptual maps, problem solving, lectures given by the team of complementary topics and reports of practicals.

LEARNING EVALUATION

Project Portfolio:

Conceptual map	5%
Cooperative presentation	10%
Exercise-solving	10%
Report of Practicals	20%
Advance of the Project	25%
Self-Evaluation Rubric	5%
Co-Evaluation Rubric	5%
Written Learning Evidences	20%

THEMATIC UNIT: IV **TITLE:** Discrete-time system analysis

COMPETENCE UNIT

The student analyzes discrete time system stability based on the defined criteria by the z-plane and frequency domain.

No.	CONTENTS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
4.1	Impulse sampling	1.0			1.5	3C,6B,5C,7B,8C
4.1.1	Data retention.					
4.1.2	Reconstruction of sampled signals					
4.2	Definition of discrete transfer function	1.0		2.0	1.5	
4.2.1	Transfer functions for elements in cascade.					
4.2.2	Closed-loop transfer function.					
4.3	Stability of discrete time systems	1.0		2.0	1.5	
4.3.2	Stability criteria based on z-plane					
4.3.3	Jury's stability test					
4.3.4	The Routh Hurtwitz criteria					
4.4	Frequency domain criteria	1.0	1.5	2.0		
4.4.1	Bode plot					
4.4.2	Nyquist plot					
4.4.3	Gain and phase margin					
	Subtotals:	4.0	1.5	6.0	4.5	

TEACHING PRINCIPLES

The approach to this unit is using the project oriented learning strategy beside the heuristic and analog method. This approach is going to permit encourage of the next learning strategies: brainstorming, investigation reports, documental researching, led discussions, conceptual maps, problem solving, lectures given by the team of complementary topics and reports of practicals.

LEARNING EVALUATION

Projects Portfolio:

Conceptual map	5%
Cooperative presentation	10%
Exercise-solving	10%
Report of Practicals	20%
Advance of Project	25%
Self-Evaluation Rubric	5%
Co-Evaluation Rubric	5%
Written Learning Evidences	20%

THEMATIC UNIT: V **TITLE:** Discrete-time controllers design

UNIDAD DE COMPETENCIA

The student implements digital controllers in a feedback system using frequency techniques and pole location.

No.	CONTENIDOS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
5.1 5.1.1 5.1.2 5.1.3 5.1.4 5.2 5.2.1 5.3	Digital controller types. Proportional controller (P). Proportional-integral controller (PI). Derivative controller (PD). Proportional-Integral controller (PID). Frequency domain controller design. Frequency domain of PID controller design. Design of state-feedback controllers by pole placement method.	1.0 1.5 1.5	 1.5 	1.0 3.0 3.0	1.5 1.5 1.5	3C, 5C, 6B 7B, 8C
	Subtotals:	4.0	1.5	7.0	4.5	

TEACHING PRINCIPLES

The approach to this unit is using the project oriented learning strategy beside the heuristic and analog method. This approach is going to permit encourage of the next learning strategies: brainstorming, investigation reports, documental researching, led discussions, conceptual maps, problem solving, lectures given by the team of complementary topics and reports of practicals.

LEARNING EVALUATION

Portfolio of evidences:

Conceptual map	5%
Cooperative presentation	15%
Exercise-solving	15%
Report of Practice	20%
Implement Project	45%
Self-Evaluation Rubric	5%
Co-Evaluation Rubric	5%

RECORD OF PRACTICALS

No.	NAME OF THE PRACTICAL	THEMATIC UNITS	DURATION	ACCOMPLISHMENT LOCATION
1	Mathematic modeling of mechanical systems.	I	1.5	Computer Labs.
2	State variable models.	I	3.0	
3	Analysis of transient response of first order continuous system.	II	1.5	
4	Analysis of transient response for n-order continuous systems.	II	3.0	
5	Stability in linear feedback systems, using root locus method.	II	3.0	
6	Plot discrete signals in MATLAB	III	3.0	
7	Signal sampling.	IV	1.5	
8	Signal sampling and hold using microcontrollers	IV	3.0	
9	Transient response analysis with MATLAB-simulink	IV	1.5	
10	Controllers tuning with MATLAB-SIMULINK.	V	3.0	
11	Design of a digital controller	V	3.0	
		HOURS	27.0	

EVALUATION AND PASSING REQUIREMENTS:

The practical are considered mandatory to pass this unit of learning.
The practical mean 20% in each thematic unit.

PERiOD	UNIT	ASSESSMENT PROCEDURE
1	I y II	Continuous evaluation 70% and written learning evidences 30%.
2	III y IV	Continuous evaluation 80% and written learning evidences 20%.
3	V	Continuous evaluation 100% The learning unit I is 20% worth of the final score The learning unit II is 20% worth of the final score The learning unit III is 20% worth of the final score The learning unit IV is 20% worth of the final score The learning unit V is 20% worth of the final score Other means to pass this Learning Unit: • Evaluation of acknowledges previously acquired, with based in the issues defined by the academy. • Official recognition by either another IPN Academic Unit of the IPN or by a national or international external academic institution besides IPN. If accredited by Special Assessment or a certificate of proficiency, this will be based on guidelines established by the academy on a previous meeting for this purpose.

KEY	B	C	REFERENCE
1	X		Bolton, W. (2001). Ingeniería *de Control. (*2ª Edición). España: Alfaomega. ISBN 970-15-0636-7.
2	X		Dorf, R., Bishop, R. (2008). *Modern Control Systems*. (11th Edition). EU: Pearson. ISBN 978-0-13-227028-1.
3		X	Ellis, G. (2004). *Control System Design Guide. Using Your Computer to Understand and Diagnose Feedback Controllers* (3a. Edición): Academic Press. ISBN-13: 978-0122374616.
4	X		Ogata, K. (2003). *Ingeniería de Control Moderna*. (4ª Edición). España: Pearson. ISBN 84-205-3678-4.
5		X	Ogata, K. (1998). *Problemas de Ingeniería de Control Utilizando MATLAB*. (1ª Edición). España: Pearson. ISBN 84-832-2046-6.
6	X		Katsuhiko, O. (1996). *Sistemas de Control en Tiempo Discreto*. (2ª Edición). México: Pearson. ISBN 968-880-539-4
7	X		Kuo, B. (1996).*Sistemas de Control Automático*. (7ª Edición). México: Pearson. ISBN 968-880-723-0.
8		X	Kuo, B. (2000). *Sistemas de Control Digital*. (1ª Edición). México: Compañía Editorial CECSA. ISBN-13: 978-9682612923.

INSTITUTO POLITÉCNICO NACIONAL

SECRETARÍA ACADÉMICA

DIRECCIÓN DE EDUCACIÓN SUPERIOR

TEACHER EDUCATIONAL PROFILE PER LEARNING UNIT

1. GENERAL INFORMATION

ACADEMIC UNIT: Escuela Superior de Cómputo

ACADEMIC PROGRAM: Ingeniería en Sistemas Computacionales **LEVEL** III

FORMATION AREA:

Institutional	Basic Scientific:	Professional	Terminal and Integration

ACADEMY: Sistemas Distribuidos **LEARNING UNIT:** Digital Control

SPECIALTY AND REQUIRED ACADEMIC LEVEL: Masters Degree or Doctor in Control, Mechatronics or Electronics.

2. AIM OF THE LEARNING UNIT: The student evaluates the characteristics of control systems through the techniques of analysis in continuous time and discrete time.

3. PROFESSOR EDUCATIONAL PROFILE:

KNOWLEDGES	PROFESSIONAL EXPERIENCE	ABILITIES	APTITUDES
• Mathematics for engineering • Linear algebra • Control in continuous- and discrete-time • Data acquisition systems • Computer architecture • Microprocessors and microcontrollers • Communications • MEI knowledge	• One year on automatic controller design • One year in simulation software • One year in groups management and collaborative work • One year in the Institutional Educational Model.	• Analysis and synthesis • Group management • Verbal fluency • Teaching skills • Problem solving • Leadership • TIC knowledge	• Responsible. • Honest. • Respectful. • Tolerant. • Assertive. • Collaborative. • Participatory. • Social and institutional commitment

DESIGNED BY	REVISED BY	AUTHORIZED B Y
M. en C. María del Rosario Rocha Bernabé COORDINATING PROFESSOR M. en C. José Alfredo Jiménez Benítez COLLABORATING PROFESSOR	Dr. Flavio Arturo Sánchez Garfias Subdirector Académico	Ing. Apolinar Francisco Cruz Lázaro Director