INSTITUTO POLITÉCNICO NACIONAL

SECRETARÍA ACADÉMICA

DIRECCIÓN DE EDUCACIÓN SUPERIOR

SYNTHESIZED SCHOOL PROGRAM

ACADEMIC UNIT: Escuela Superior de Cómputo

ACADEMIC PROGRAM: Ingeniería en Sistemas Computacionales.

LEARNING UNIT: Computational Intelligence in Control Engineering **LEVEL:** III

PURPOSE OF THE LEARNING UNIT:
The student design systems applied to industrial manufacturing problems, reducing energy consumption and improvements in the quality of production, based on intelligent control techniques.

CONTENTS:

I. Introduction to Expert Systems in Industry.
II. Intelligent Control and Techniques of Intelligent Control.
III. Elements of Fuzzy Logic and Fuzzy Reasoning.
IV. The Fuzzy Control Algorithm and Fuzzy Industrial Controllers.
V. Neural Control and Neuro-Fuzzy Control.

TEACHING PRINCIPLES:
The teacher will apply a Projects-Based learning process, through inductive, deductive and heuristic methods, with which it carried out the learning activities that will guide the development of abstraction and analysis skills, using theoretical and practical tools. The activities done in class encourage students work in collaborative, participatory, based on some techniques such as brainstorming, graphic organizers, investigation documents, worksheets, supplementary statement of issues, discussion and directed the execution of a project terminal. It is the responsibility of the teacher to monitor the characteristics of both the terminal project as deciding the complexity of the programs carried out by fixing the time of preparation and delivery the production of the learning evidences.

EVALUATION AND PASSING REQUIREMENTS:
This Learning Unit is will evaluate on the basis of portfolio of evidence, which is made up of: formative and summative assessment and rubric of Self-Evaluation, rubric of co-evaluation and hetero-evaluation.
The program will evaluate the students in a continuous formative and summative way, which will lead into the completion of learning portfolio. Some other assessing methods will be used, such as revisions, practical´s, class participation, exercises, learning evidences and a final project.
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 with a current cooperation agreement.

BIBLIOGRAFÍA:

- Jain, L. C., Johnson R. P., Takefuji Y., Zadeh L. A., (1999) *Knowledge-Based Intelligent Techniques in Industry*, Florida USA: CRC PRESS LLC. ISBN: 0-8493-9803-7/99.
- King, R. E., (1999). *Computational Intelligence in Control Engineering*, New York-Basel USA: Marcel Dekker, Inc, ISBN: 0-8247-1993-X (Book in ESCOM library).
- Lin, C.T., Lee, C. S. G. (1996). *Neural Fuzzy Systems: A neuro-fuzzy synergism to intelligent systems*. EU: Prentice Hall. ISBN 0-132351692.
- Nguyen H.T., Prasad N. R., Walker C. L., Walter E. A., (2003). *A First Course in FUZZY and NEURAL CONTROL*, Florida USA: CHAPMAN & HALL/CRC, A CRC Press Company, ISBN: 1-58488-244-1 (Book in ESCOM library).
- Wang, L. (1997). A *Course in Fuzzy Systems and Control*, NJ-USA: Prentice Hall PTR, Upper Sanddle River, ISBN: 0-13-540882-2 (Book in ESCOM library).

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: Computational Intelligence in Control Engineering.
TYPE OF LEARNING UNIT: Theorical - Practical, Optative.
VALIDITY: August, 2011
LEVEL: lll.
CREDITS: 7.5 Tepic, 4.39 SATCA

ACADEMIC AIM

This program contributes to the profile of graduated on Ingeniería en Sistemas Computacionales, to develop the abilities of design and implementation of Intelligent computer systems, for the development of computer systems implemented and related to: engineering process control applied to industrial manufacturing problems, reducing energy consumption and improvements in production quality. It also develops strategic thinking, creative thinking, collaborative and participatory work, leadership and assertive communication.

This program relates horizontally with the learning units: Unsupervised Artificial Neural Networks, Genetic Algorithms, and vertically with: Fuzzy Systems Applied to Engineering, Supervised Artificial Neural Networks, Terminal Work I and II.

AIM DE LA UNIDAD DE APRENDIZAJE

The student design systems applied to industrial manufacturing problems, reducing energy consumption and improvements in the quality of production, based on intelligent control techniques.

CREDITS 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 Ingeniería de software.

REVISED BY:
Dr. Flavio Arturo Sánchez Garfias.
Subdirección Académica

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

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

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

THEMATIC UNIT: I **TITLE:** Introduction to Expert Systems in Industry.

UNIT OF COMPETENCE

The student describes the different industrial control systems based on the basic characteristics of expert systems and intelligent computing.

No.	CONTENTS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
1.1	Conventional control.	0.5		1.0		2B, 3C, 4B, 7B
1.2	Intelligent control.	0.5		1.0		
1.3	Computational intelligence in control.	0.5		1.0		
1.4	Expert systems in industry.	1.5	1.0	2.0	5.0	
1.4.1	Elements of an expert system.					
1.4.2	Introduction and stages in the development of an expert system.					
1.4.3	The representation of Knowledge.					
1.5	Nine paradigms of expert system.	1.5		2.0		
	Subtotals:	4.5	1.0	7.0	5.0	

TEACHING PRINCIPLES

This thematic Unit must begin with a framing of the course and the formation of teams.
The thematic Unit will be Projects-Based learning strategy, trough deductive method, with the techniques of documentary research and cooperative presentation elaboration. Development of practice No. 1 and project proposal and production of learning evidence.

LEARNING EVALUATION

Diagnostic Test	
Project Portfolio:	
Proposal of project.	15%
Worksheet.	10%
Report of Practicals.	20%
Cooperative Presentation.	5%
Self-Evaluation Rubrics .	5%
Cooperative Evaluation Rubrics.	5%
Written Learning Evidence.	40%

THEMATIC UNIT: II **TITLE:** Intelligent Control and Techniques of Intelligent Control.

UNIT OF COMPETENCE

The student analyzes intelligent control systems based on the characteristics of knowledge-based techniques.

No.	CONTENTS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
2.1	Conditions for the use of intelligent control.	0.5		1.0		2B, 3C, 4B, 5B, 6C, 7B
2.2	Objectives and techniques of intelligent control.	1.0		3.0		
2.2.1	Unconventional control.					
2.2.2	Autonomy and intelligent control.					
2.3	Knowledge base systems.	1.5	0.5	4.0	2.5	
2.3.1	Expert systems.					
3.3.2	Fuzzy control.					
2.3.3	Neural control.					
2.3.4	Neuro-fuzzy control.					
	Subtotals:	3.0	0.5	8.0	2.5	

TEACHING PRINCIPLES

The thematic Unit will be Projects-Based learning strategy, trough deductive method, with the techniques of conceptual maps, graphic organizer and cooperative presentation. Development of practice No. 2 and advance of the project.

LEARNING EVALUATION

Project Portfolio:	
Advance of the Project.	15%
Reports of conceptual maps and graphic organizer	10%
Report of Practicals.	20%
Cooperative Presentation.	5%
Self-Evaluation Rubrics.	5%
Rubric of Co-Evaluation.	5%
Written Learning Evidence	40%

THEMATIC UNIT: III **TITLE:** Elements of Fuzzy Logic and Fuzzy Reasoning.

UNIT OF COMPETENCE

The student integrates implication methods in the compositional rule of inference based on the basic concepts, algorithms and fuzzy reasoning.

No.	CONTENTS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
3.1 3.1.1 3.1.2 3.1.3	Elements of Fuzzy Logic. Basic concepts and Fuzzy algorithms. Fuzzy operators and Operations on fuzzy sets. Algebraic properties of fuzzy sets, linguistic variables y connectives.	1.5		2.5		2B, 3C, 4B, 5B
3.2 3.2.1 3.2.2 3.2.2.1 3.2.2.2 3.2.2.3 3.2.2.4 3.2.2.5 3.2.2.6 3.2.2.7 3.2.2.8	Fuzzy reasoning. The fuzzy algorithm. Only fuzzy reasoning. Generalized Modus Ponens (GMP). Generalized Modus Tollens (GMT). Boolean implication. Lukasiewicz implication. Zadeh implication. Mamdani implication. Larsen implication. GMP implication.	2.0	0.5	3.0	2.5	
3.3	The compositional rules of inference.	1.5		0.5		
	Subtotals:	5.0	0.5	6.0	2.5	

TEACHING PRINCIPLES

The thematic Unit will be Projects-Based learning strategy, trough inductive method, with the techniques of conceptual maps, exercise-solving and cooperative presentation. Development of practice No. 3 and advance of the project.

LEARNING EVALUATION

Project Portfolio:	
Advance of the Project.	20%
Reports of conceptual maps and exercise-solving	10%
Report of Practicals.	20%
Cooperative Presentation.	5%
Self-Evaluation Rubrics.	5%
Rubric of Co-Evaluation.	5%
Written Learning Evidence.	35%

THEMATIC UNIT: IV **TITLE:** The Fuzzy Control Algorithm and Fuzzy Industrial Controllers.

UNIT OF COMPETENCE

The student experiment with different types of fuzzy controllers based on the principal methods of fuzzy inference and fuzzy control elements.

No.	CONTENTS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
4.1 4.1.2 4.1.3 4.1.4	Controller decomposition. Fuzzification. Output membership function y types of defuzzification. Design considerations.	0.5		1.0		1B, 2B, 3C, 5B, 7B
4.2 4.2.1 4.2.2	Fuzzy industrial controllers. Controller tuning. Fuzzy three- term controllers.	0.5		1.0		
4.3 4.3.1 4.3.2 4.3.3	Real-time fuzzy control. Supervisory fuzzy controllers. Design embedded fuzzy controllers. The real-time execution scheduler.	1.0	1.0	1.0	5.0	
4.4 4.4.1 4.4.2 4.4.3 4.4.4 4.4.5	Model-based fuzzy control. The Takagi-Sugeno model-based approach to fuzzy control. Fuzzy variables and fuzzy spaces. The fuzzy process model. Fuzzy control law. The locally linearized process model.	1.0		1.0		
	Subtotals:	3.0	1.0	4.0	5.0	

TEACHING PRINCIPLES

This unit will be projects-Based learning strategy, trough heuristic methods, with the techniques of elaboration of cognitive mapping, comparative maps and cooperative presentation. Development of practice No. 4 and advance of the project.

LEARNING EVALUATION

Project Portfolio:	
Advance of the Project.	20%
Reports of cognitive mapping and comparative maps	5%
Report of Practicals.	20%
Cooperative Presentation.	10%
Self-Evaluation Rubrics	5%
Rubric of Co-Evaluation.	5%
Written Learning Evidence.	35%

THEMATIC UNIT: V **TITLE:** Neural Control and Neuro-Fuzzy Control.

UNIT OF COMPETENCE

The student design automation systems based on neural control and neuro-fuzzy controllers, based on learning methods of artificial neural networks.

No.	CONTENTS	Teacher led-instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
5.1 5.1.2 5.1.3 5.1.4	The elemental artificial neuron. Topologies of multi-layer neural networks and neural control. Properties of neural controllers. Neural controller architectures.	0.5		1.0		2B, 3C, 4B, 6C
5.2 5.2.1 5.2.2 5.2.3	Neural network training. The Widrow-Hoff training algorithm. The Delta training algorithm. Multi-layer Artificial neural networks (ANN)training algorithm and the back-propagation (BP) algorithm.	0.5	1.0	1.0	5.0	
5.3 5.3.1 5.3.2	Rule-based neural control. Encoding linguistic rules. Training rule-based neural controllers.	2.0		2.0		
5.4 5.4.1 5.4.2	Neuro-Fuzzy control. Neuro-fuzzy controller architectures. Neuro-fuzzy Isomorphism.	3.5	1.0	3.0	2.0	
	Subtotals:	6.5	2.0	7.0	7.0	

TEACHING PRINCIPLES

This unit will be projects-Based learning strategy, trough heuristic methods, with the techniques of elaboration of bibliographic Inquiry, conceptual maps and cooperative presentation. Development of practices No. 5 and No. 6. Defense and project delivery

LEARNING EVALUATION

Project Portfolio:	
Defense and project delivery.	30%
Reports of conceptual maps.	5%
Report of Practicals.	20%
Cooperative Presentation.	5%
Self-Evaluation Rubrics.	5%
Rubric of Co-Evaluation.	5%
Written Learning Evidence	30%

RECORD OF PRACTICALS

No.	NAME OF THE PRACTICAL	THEMATIC UNITS	DURATION	ACCOMPLISHMENT LOCATION
1	Introduction to expert systems.	I	6.0	Computer Labs.
2	Introduction to intelligent systems.	II	3.0	
3	Types of fuzzy reasoning.	III	3.0	
4	Fuzzy control	IV	6.0	
5	Learning algorithms of artificial neural networks.	V	6.0	
6	Neuro-fuzzy control	V	3.0	
		TOTAL OF HOURS	27.0	

EVALUATION AND PASSING REQUIREMENTS:
The practicals are considered mandatory to pass this unit of learning.
The practices contribute 20% of the grade of each thematic unit.
These practices are considered a prerequisite for establishing the learning unit.
The practices contribute 20% of the final grade.

Laboratory work is evaluated based on the written report.
The criteria for evaluation of the practices are: objective, introduction and description of the topic, test simulations and / or programs carried out, theoretical solution or desktop test, source code, screens execution, results analysis, conclusions and references.

PERIOD	UNIT	EVALUATION TERMS	
1	I y II	Continuous evaluation 60% and written learning evidence	40%
2	III y IV	Continuous evaluation 65% and written learning evidence	35%
3	V	Continuous evaluation 30% and written learning evidence	30%
		The learning unit I and II is 30% worth of the final score. The learning unit III and IV is 35% worth of the final score. The learning unit V is 35% worth of the final score. Other means to pass this Learning Unit: • Evaluation of acknowledges previously acquired, by developing a computer program and a written evidence of learning. • Official recognition by either another IPN Academic Unit of the IPN or by a national or international external academic institution besides IPN agreement which has. If accredited by Special Evaluation or a certificate of proficiency, this will include a practical part which contribute 50% of the grade and a theoretical part that will provide the remaining 50%, based on guidelines established by the academy.	

CLAVE	B	C	BIBLIOGRAFÍA
1	X		Jain, L. C., Johnson R. P., Takefuji Y., Zadeh L. A., (1999) *Knowledge-Based Intelligent Techniques in Industry*, Florida USA: CRC PRESS LLC, ISBN: 0-8493-9803-7/99.
2	X		King, R. E.,(1999). *Computational Intelligence in Control Engineering*, New York-Basel USA: Marcel Dekker, Inc (Book in the library of the ESCOM). ISBN: 0-8247-1993-X
3		X	Lin, C.T., Lee, C. S. G. (1996). *Neural Fuzzy Systems: A neuro-fuzzy synergism to intelligent systems*. EU: Prentice Hall. ISBN 0-132351692.
4	X		Nguyen H.T., Prasad N. R., Walker C. L., Walter E. A., (2003). *A First Course in FUZZY and NEURAL CONTROL*, Florida USA: CHAPMAN & HALL/CRC, A CRC Press Company, (Book in the library of the ESCOM). ISBN: 1-58488-244-1
5	X		Passino, K. M., Yurkovich S., (1998). *Fuzzy Control*, California USA: Addison Wesley Longman, Inc, ISBN 0-201-18074-X.
6		X	Von Altrock, C., (1995). *Fuzzy Logic and Neurofuzzy Aplications Explained,* United States of America: Prentice Hall PTR, ISBN 0-13-368465-2
7	X		Wang. L. (1997). A *Course in Fuzzy Systems and Control*, NJ-USA: Prentice Hall PTR, Upper Sanddle River, (Book in the library of the ESCOM). ISBN: 0-13-540882-2

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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 **NIVEL** III

FORMATION AREA:

Institutional	Basic Scientific	Professional	Terminal and Integration

ACADEMY: Ingeniería de Software **LEARNING UNIT:** Computational Intelligence in Control Engineering

SPECIALTY AND ACADEMIC REQUIRED LEVEL: Masters Degree or Doctor in Electric Engineering or Computer Science.

2. AIM OF THE LEARNING UNIT:

The student design systems applied to industrial manufacturing problems, reducing energy consumption and improvements in the quality of production, based on intelligent control techniques.

3. PERFIL DOCENTE:

KNOWLEDGE	PROFESSIONAL EXPERIENCE	ABILITIES	APTITUDES
• Concepts of expert systems theory. • Concepts of fuzzy logic theory and neural networks (ANN). • Main components of a fuzzy system and RNA. • Troubleshooting process control, expert systems and evolutionary systems. • Conocimientos del Nuevo Modelo Educativo Institucional. • Knowledge of the Institutional Educational Model. • English.	• In teaching as a facilitator of knowledge higher level of two years. • In the management of computer equipment for the laboratory. • Experience in the design and implementation of intelligent computer systems. • Experience in group management and collaborative work. • Two year experience in the Institutional Educational Model.	• Ability to manage and disseminate knowledge groups. • Teaching skills. • Ability to design intelligent control systems and neuro-fuzzy systems. • Capacity for analysis and synthesis. • Ability to solve problems. • Ease of teamwork and leadership. • Decision Making. • Applications of institutional educational model (MEI).	• Responsibility for the performance of their duties. • Tolerance and respect for ideas and people around them. • Possess social commitment. • Responsible. • Tolerant. • Honest. • Respectful. • Cordial. • Sharing. • Collaborative. • Participatory. • Interest in learning. • Assertive.

DESIGNED BY	REVISED BY	AUTHORIZED BY
M. en C. Edmundo René Durán Camarillo. COORDINATING PROFESOR **M. en C. José Luis Calderón Osorno** **M. en C. Ignacio Ríos de la Torre** COLLABORATING PROFESSORS	**Dr. Flavio Arturo Sánchez Garfias** SUBDIRECTOR ACADÉMICO	**Ing. Apolinar Francisco Cruz Lázaro** DIRECTOR

Date: 2011