General description of	
Master's programme	کارشناسی ارشد مکاترونیک–مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***
Specialization	Control, Mechanical, Electrical/Electronic engineering, Computer science and Agricultural science
Institution(s)	Danesh'gahe San'ati Noshirvani Babol - *Babol Noshirvani University of Technology,* IRAN
Accreditation organization(s)	Iranian Ministry of Science, Research and Technology- Iran
Period of reference	Program validates for 3 years starting at 2018 September
Responsible person	Dr. Mostafa Rahimnezhad, Dr. Kamyar Nikzadfar
Qualification awarded	Master of Science (M. Sc.)
Length of programme	2 years
Number of credits	120 ECTS-credits
Cycle/Level of qualification	QF for EHEA: Second Cycle; EQF level: 7; NQF for Iran: Master of Science (کارشناسی ارشد)
Fields of study	Robotics systems, Robots control an unknown environment, Mechanics of agro-industrial mechatronic systems, Development of mechatronic systems
Specific admission requirements	Holding B.Sc. in Mechanical engineering/Electrical engineering/Computer engineering/Computer science/Agricultural engineering
Specific arrangements for recognition of prior learning	Formal
Qualification requirements and regulations	The students should participate in Iranian National Master Entrance Exam held by Sanjesh organization of I. R. Iran and obtain the required point on the exam.
Mode of study	Full-time
Examination regulations, assessment and grading	Preassessment is done through a centralized state exam (Conquer) for graduated students which are administered by the organization for assessment of the state education (Sanjesh) in the ministry of science, research and technology of Iran. The exam is held once each year in whole the country (usually in May). The students from different bachelor of engineering background as well as agricultural engineers might participate in the exam. Based on the result of test, they can select the Mechatronics-Agromechatronics as their priority for entering the program. The final result on situation of the applicant admission to program will be announced by Sanjesh organization before September each year. Also the non-Iranian students should pass the SAMFA test to measure the language proficiency of non-Iranian applicants who want to study in this program. Formative assessment is done by students their selves; also the progress of students is supervised by professors assigned to each student in the first year of program. The students are encouraged to participate in different Mechatronic related labs in the institute to increase their practical and research skills. Summative assessment is performed in different ways based on the characteristics of each Module. Quizzes, written exams, laboratory and project reports, presentations, in-class cooperation evaluation and final comprehensive exam are different methods employed for assessment of each module. The aim is to develop a research-orientated approach to a problem and to acquire essential skills that are highly valued by employers. Students are informed of the assessment procedure before the courses start and are also provided with previous examples. The degree exam consists of writing a thesis, which must possess the characters of originality, exhaustive documentation and scientific investigation and which will be discussed with a committee of two university professors besides thesis supervisor.

	Re-assessment is not done in this program.
Obligatory or optional mobility window	
Work placement(s) if applicable	
Occupational profiles of graduates	After successfully completing the master's degree, the graduates will be able to work as an agromechatronic engineer in public and private agriculture machine design sectors as well as smart farm and animal plants in Iran and abroad. The graduates can find job in private sector as a designer or consultant to promote the conventional agricultural process into smart ones. Also due to general aspects of application of mechatronics in today industry, the graduates are also able to find job in other industries where the automation systems are employed such as automotive, aviation, energy and power plants industries.
Access to further studies	The graduates may continue to attend Ph.D. in different disciplines of engineering such as mechanical engineering, electrical engineering, system or control engineering, computer science or agricultural mechanization engineering based on their master thesis and research background.

Programme Profile Statement
The second cycle in Mechatronics-Agromechatronics provides students with required knowledge, techniques and skills for design, develop and implement of mechatronic systems into agriculture process, machines and systems in order to increase the efficiency and decrease the cost and time of agricultural processes. They are professionally trained to know both the needs of agriculture processes to intelligence and the engineering methods to apply and implement the required intelligence into processes as well. As an agromechatronic engineer, empowered by proper research, communication and management skills, the graduates of this program are able to manage the professional teams of mechanical, electrical and computer engineers altogether with agriculture specialists from different nationalities in order to do complex international projects in agriculture related systems based on synergic integration of team member specialties. The graduates also will be trained to be able to do applied research in the field to develop this branch of science.

Programme Learning Outcomes	
On competition of this programme, students should be able to:	
LO1.	Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization
LO2.	Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design
LO3.	Select and apply the most appropriate and relevant system design methodology under consideration of economic aspects
LO4.	Analyze and complement engineering requirements on agricultural processes and systems
LO5.	Investigate the application of innovative evolutionary and mathematical based methods to mechatronic system performance optimization
LO6.	Employ the robots into agricultural process, select the prper robots fro specific agricultural process and develop the corresponding controller
LO7.	Function as a member or leader of a team with distinctive specialists from different scientific and knowledge backgrounds at national and international level
LO8.	Engage in independent investigation, critical reflection and lifelong learning to continue practicing at the forefront of mechatronics

The Programme Module Structure		
Year 1 (Two semesters of 16 weeks)		
Code	**Title**	**Credits**
CU1	Mechatronics 1	3
CU2	Advanced Control 1	3
CU3	Advanced engineering mathematics	3
CU4	Mechatronic 2	3
CU5	Agrotronics	3
CU6	Advanced robotics	3
Year 2 (Two semesters of 16 weeks)		
CU7	Robotics in agriculture	3
CU8	Selective Course	3
CU9	Seminar (2 credits)	2
CU10	Final Project (6 credits)	6
	Total credits	**32**

Programme Key Learning Outcomes Module Map									
	Module	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8
Year 1	CU1	✓	✓	✓	✓			✓	
	CU2	✓	✓			✓		✓	
	CU3	✓				✓			
	CU4	✓	✓	✓	✓			✓	
	CU5	✓	✓	✓	✓	✓	✓	✓	
	CU6		✓			✓	✓		
Year 2	CU7	✓	✓	✓	✓			✓	
	CU8	Differs based on the selective course							
	CU9								✓
	CU10								✓

Description of individual educational component (module)	
Advanced Control 1 **کنترل پیشرفته 1**	
کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Solid Design*
Responsible person	*Dr. A. Fathi, Dr. K. Nikzadfar*
Type of course unit	Compulsory
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	*Engineering Mathematics*
Course contents	Module 1. State space representation of continues dynamic systems Topic 1. States and state space Topic 2. Canonical forms of dynamic systems representation Topic 3. Solving the state space equations using state transfer matrix Topic 4. Presentation of system behavior using Eigenvalues and Eigenvectors Module 2. Discrete dynamic systems Topic 5. State space representation of dynamic discrete systems Topic 6. Conversion of continuous system representation to discrete representation Topic 7. Z transformation and pulse transfer function Module 3. Stability Topic 8. Definitions of stability Topic 9. Positive definite functions and Lypanouv theorem Module 4. Controllability of observability Topic 10. Definition of controllability and observability in continuous and discrete systems Topic 11. Controllability and observabilty matrices and relative tests Module 5. State vector feedback control Topic 12. Eigenvalue manipulation using state feedback Module 6. State observers Topic 13. Open loop observers and Luenberger observers Topic 14. Reduced order observer design Topic 15. Separation rule and design of feedback controller Module 7. Linear Quadratic Regulators Topic 16. Definition and Design of LQR controllers Topic 17. Riccati equations solving
Recommended or required reading and other learning resources/tools	Ogata, Katsuhiko, and Yanjuan Yang. *Modern control engineering*. Vol. 4. India: Prentice hall, 2002. Brogan, William L. *Modern control theory*. Pearson education india, 1974.
Language of instruction	Persian, English

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Outline different representation concepts of linear systems and transformation methods between mentioned representations 2. Indicate special aspects of state space dynamic systems representation 3. Describe linear systems and designed controllers in discrete time domain based on the definitions of sampling and sample time 4. Explain the concept of state feedback for dynamic systems 5. Calculate eigenvectors and eigenvalues of a linear system in a state space representation and associate it with system dynamics 6. Verify observability and controllability of linear systems 7. Synthesise time continues and time discrete controllers using forefront methods of the modern control theory 8. Design a state observer for linear systems with un-measurable states

Planned learning activities and teaching methods
Lecture

Assessment methods and criteria
Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO5. Investigate the application of innovative evolutionary and mathematical based methods to mechatronic system performance optimization LO7. Function as a member or leader of a team with distinctive specialists from different scientific and knowledge backgrounds at national and international level	On successful competition of this module students should be able to: 1. Outline different representation concepts of linear systems and transformation methods between mentioned representations 2. Indicate special aspects of state space dynamic systems representation 3. Describe linear systems and designed controllers in discrete time domain based on the definitions of sampling and sample time 4. Explain the concept of state feedback for dynamic systems 5. Calculate eigenvectors and eigenvalues of a linear system in a state space representation and associate it with system dynamics 6. Verify observability and controllability of linear systems 7. Synthesise time continues and time discrete controllers using forefront methods of the modern control theory 8. Design a state observer for linear systems with un-measurable states

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Advanced Dynamics **دینامیک پیشرفته** کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING*** **Course unit code**	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Solid Design*
Responsible person	*Dr. M. H. Ghasssemi*
Type of course unit	Selective
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	*Advanced Control*
Course contents	Module 1. Coordination systems Topic 1. Cartesian, tangent-normal, Cylindrical and spherical coordination systems Topic 2. Relative motion and calculation of nonhomogeneous rotation matrix Module 2. Kinematics Topic 3. Kinematics of rigid bodies Topic 4. Modeling of rigid body kinematics Topic 5. Modeling of elastic bodies Module 3. Kinetics Topic 6. Rigid body dynamics Topic 7. Formulation of motion equations Topic 8. Modeling of arm based on Newton-Euler equations Topic 9. Energy of rigid bodies in 3D motion Topic 10. LaGrange method Topic 11. Generalized momentum Topic 12. Hamilton method
Recommended or required reading and other learning resources/tools	- Meirovitch, Leonard. Methods of analytical dynamics. Courier Corporation, 2010. - Crandall, Stephen H. Dynamics of mechanical and electromechanical systems. McGraw-Hill, 1968. - D'Souza, A. Frank, and Vijay Kumar Garg. Advanced dynamics: modeling and analysis. Prentice Hall, 1984. - Ginsberg, Jerry H. Advanced engineering dynamics. Cambridge University Press, 1998. Harrison, H. R. N. T., and Trevor Nettleton. Advanced engineering dynamics. Butterworth-Heinemann, 1997.
Language of instruction	Persian, English

Learning outcomes of the course unit

As a result of studying the discipline, the trainee must demonstrate the following results:

1. Apply methods of kinematic analysis to rigid body systems
2. Apply methods of Newton-Euler, Lagrange and Hamilton mechanics to formulation of rigid body system equations
3. Calculate rigid body motion in appropriate reference system

Planned learning activities and teaching methods
Lecture, project

Assessment methods and criteria
Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO5. Investigate the application of innovative evolutionary and mathematical based methods to mechatronic system performance optimization LO6. Employ the robots into agricultural process, select the prper robots fro specific agricultural process and develop the corresponding controller	On successful competition of this module students should be able to: 1. Apply methods of kinematic analysis to rigid body systems 2. Apply methods of Newton-Euler, Lagrange and Hamilton mechanics to formulation of rigid body system equations 3. Calculate rigid body motion in appropriate reference system

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Advanced Hydraulics and Pneumatics **هیدرولیک و نیوماتیک پیشرفته** کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Manufacturing*
Responsible person	*Dr. H. Basseri*
Type of course unit	Selective
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	
Course contents	Module 1. Operation of Hydraulics and pneumatics systems Topic 1. Operation and components of hydraulics and pneumatics systems Module 2. Hydraulics/pneumatics system components Topic 2. Compressed air supply Topic 3. Hydraulics fluids Topic 4. Compressors Topic 5. Pumps Topic 6. Hydraulic/pneumatic control valves Topic 7. Actuators Topic 8. Accumulators Module 3. Hydraulics/pneumatics circuits Topic 9. Hydraulic/pneumatic components symbols Topic10. Hydraulic/pneumatic circuit analysis Topic10. Hydraulic/pneumatic circuit modeling Module 4. Hydraulics/pneumatics control Topic 11. Measurement devices Topic 12. Static and dynamics of valves and their modeling Topic 13. Control methods in hydraulic/pneumatic circuits Topic 14. Servomechanisms
Recommended or required reading and other learning resources/tools	- Merritt, Herbert E. Hydraulic control systems. John Wiley & Sons, 1967. - McCloy, Donaldson, and Hugh Robert Martin. "Control of fluid power: analysis and design." Chichester, Sussex, England, Ellis Horwood, Ltd.; New York, Halsted Press, 1980. 505 p. (1980).
Language of instruction	Persian

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Recognize the hydraulic/pneumatic components and operation

2. Apply different control methods to hydraulic/pneumatic circuits including use of electronic control valves/pumps for special tasks
3. Design and develop an appropriate hydraulic/pneumatic circuit for special purposes
4. Model and simulate the hydraulic/pneumatic circuits

Planned learning activities and teaching methods
Lecture, project

Assessment methods and criteria
Project+Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO7. Function as a member or leader of a team with distinctive specialists from different scientific and knowledge backgrounds at national and international level	On successful competition of this module students should be able to: 1. Recognize the hydraulic/pneumatic components and operation 2. Apply different control methods to hydraulic/pneumatic circuits including use of electronic control valves/pumps for special tasks 3. Design and develop an appropriate hydraulic/pneumatic circuit for special purposes 4. Model and simulate the hydraulic/pneumatic circuits

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Advanced engineering mathematics **ریاضیات مهندسی پیشرفته** کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Solid Design*
Responsible person	*Dr. M. H. Ghassemi*
Type of course unit	Compulsory
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	*Engineering Mathematics*
Course contents	Module 1. Matrices Topic 1. Matrices and vectors Topic 2. Matrices and vectors derivation and functions Topic 3. Coordination and coordination transformations Module 2. Partial Differential Equations Topic 3. Algebraic and numeric methods for solving PDEs Module 3. Transformations Topic 6. Integral transformations and their application Module 4. Perturbation Topic 9. Algebraic, singular and nonsingular perturbations and their applications Module 5. Variational methods Topic 11. Variational and Hamiltonian methods
Recommended or required reading and other learning resources/tools	Arfken, George B., Hans J. Weber, and Frank E. Harris. Mathematical methods for physicists: a comprehensive guide. Academic press, 2011. Kreyszig, Erwin. Advanced engineering mathematics. John Wiley & Sons, 2010. Hildebrand, Francis B. "Advanced calculus for applications." (1962). Wylie, Clarence Raymond. "Advanced engineering mathematics." (1960).
Language of instruction	Persian

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Operate matrices and vectors using linear algebraic methods 2. Apply matrices transformation techniques for coordination transformation and composite rotations 3. Solve partial differential equations (PDE) using analytical and numerical methods 4. Employ integral transformations for simplifying the ODE and PDE solving 5. Solve the complex and nonlinear problems using perturbation method 6. Apply variation method and Hamiltonian method for optimization of systems

Planned learning activities and teaching methods
Lecture

Assessment methods and criteria
Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO5. Investigate the application of innovative evolutionary and mathematical based methods to mechatronic system performance optimization	On successful competition of this module students should be able to: 1. Operate matrices and vectors using linear algebraic methods 2. Apply matrices transformation techniques for coordination transformation and composite rotations 3. Solve partial differential equations (PDE) using analytical and numerical methods 4. Employ integral transformations for simplifying the ODE and PDE solving 5. Solve the complex and nonlinear problems using perturbation method 6. Apply variation method and Hamiltonian method for optimization of systems

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Advanced Robotics **رباتیک پیشرفته** کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Solid Design*
Responsible person	*Prof. H. M. Daniali*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	*Advanced Dynamics*
Course contents	Module 1. Introduction to robots Topic 1. The terminologies of robot arms Topic 2. A brief discussion on robot design and components Module 2. Robot kinematics Topic 3. Rotational and translational coordination transformations Topic 4. D-H parameters Topic 5. Forward kinematics Topic 6. Inverse kinematics Module 3. Robot kinetics Topic 7. Lagranian dynamics analysis of robots Topic 8. Forward kinetics Topic 9. inverse kinetics Topic 10. Simulation of robot arms
Recommended or required reading and other learning resources/tools	Craig, John J. Introduction to robotics: mechanics and control. Vol. 3. Upper Saddle River, NJ, USA:: Pearson/Prentice Hall, 2005. Mckerrow, Philip. Introduction to robotics. Addison-Wesley Longman Publishing Co., Inc., 1991. Spong, Mark W., and Mathukumalli Vidyasagar. Robot dynamics and control. John Wiley & Sons, 2008.
Language of instruction	Persian

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Choose a coordinate system in order to establish the equations of motion of the robot 2. Apply methods of obtaining and processing spatially-bound data 3. Formulate a governing equation on robot arms kinematics and kinetics 4. Solve forward and inverse dynamics equation for robot arms 5. Analyze robot arms motion based on the simulation

Planned learning activities and teaching methods
Lecture

Assessment methods and criteria
Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO5. Investigate the application of innovative evolutionary and mathematical based methods to mechatronic system performance optimization LO6. Employ the robots into agricultural process, select the prper robots fro specific agricultural process and develop the corresponding controller	On successful competition of this module students should be able to: 1. Choose a coordinate system in order to establish the equations of motion of the robot 2. Apply methods of obtaining and processing spatially-bound data 3. Formulate a governing equation on robot arms kinematics and kinetics 4. Solve forward and inverse dynamics equation for robot arms Analyze robot arms motion based on the simulation

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Agrotronics **اگروترونیك** کارشناسی ارشد مکاترونیک–مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Solid Design*
Responsible person	*Invited Professor*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	
Course contents	Module 1. Introduction to agricultural sensors Topic 1. Introduction of soil and plant sensors Topic 2. Remote sensing Module 2. Control Topic 3. In-farm vehicle control Module 3. Information technologies in agriculture Topic 4. GIS and database based systems Topic 5. MIS and DSS systems
Recommended or required reading and other learning resources/tools	- Blackmore, Simon. "Precision farming: an introduction." *Outlook on agriculture* 23.4 (1994): 275-280. Lo, C. P., and AKW Yeung Concepts. *Techniques of Geographic Information Systems*. Prentice Hall, 2002.
Language of instruction	Persian, English

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Select sensors for data collecting in agricultural processes 2. Design control for mobile devices used at farms 3. Apply modern technologies to controlling of the plant characteristics 4. Use information and decision support systems in agricultural processes

Planned learning activities and teaching methods
lectures

Assessment methods and criteria
Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO3. Select and apply the most appropriate and relevant system design methodology under consideration of economic aspects LO4. Analyze and complement engineering requirements on agricultural processes and systems LO5. Investigate the application of innovative evolutionary and mathematical based methods to mechatronic system performance optimization LO6. Employ the robots into agricultural process, select the prper robots fro specific agricultural process and develop the corresponding controller LO7. Function as a member or leader of a team with distinctive specialists from different scientific and knowledge backgrounds at national and international level	On successful competition of this module students should be able to: 1. Select sensors for data collecting in agricultural processes 2. Design control for mobile devices used at farms 3. Apply modern technologies to controlling of the plant characteristics 4. Use information and decision support systems in agricultural processes

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Artificial intelligence and expert systems **هوش مصنوعی و سیستم های خبره**	
کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Electrical Engineering Faculty*
Department	*Control*
Responsible person	*Dr. S.J. S. Rostami*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	
Course contents	<u>Module 1. Artificial intelligence fundamentals</u> Topic 1. The fundamental of artificial intelligence, knowledge based systems and artificial neural networks <u>Module 2. Neural networks</u> Topic 2. Perceptron and learning rules Topic 3. Supervised training Topic 4. Multilayer perceptron Topic 5. Radial basis functions Topic 6. Recurrent networks Topic 7. Self-organizing networks Topic 8. Application of neural networks in function approximation, clustering and classification <u>Module 3. Fuzzy systems</u> Topic 9. Fuzzy sets, membership function and fuzzification Topic 10. Fuzzy logic and fuzzy inference systems Topic 11. Application of Fuzzy systems in pattern recognition, classification, modeling and control Topic 12. ANFIS
Recommended or required reading and other learning resources/tools	- Hagan, Martin T., Howard B. Demuth, and Mark H. Beale. *Neural network design*. Vol. 20. Boston: Pws Pub., 1996. - Haykin, Simon S., et al. Neural networks and learning machines. Vol. 3. Upper Saddle River, NJ, USA:: Pearson, 2009. - Kosko, Bart. "Neural networks and fuzzy systems: a dynamical systems approach to machine intelligence/book and disk." Vol. 1Prentice hall (1992).
Language of instruction	Persian, English

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results:

1. Define fundamental principles of artificial intelligence
2. Implement, analyse and use neural network structures and their training methods
3. Name neural networks applications
4. Outline main principles of fuzzy logic systems and their applications
5. Develop and train an Artificial Neural Network (ANN) for the specific aim
6. Develop fuzzy logic systems for specific aims

Planned learning activities and teaching methods
Lecture, project

Assessment methods and criteria
Project + Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO5. Investigate the application of innovative evolutionary and mathematical based methods to mechatronic system performance optimization	On successful competition of this module students should be able to: 1. Define fundamental principles of artificial intelligence 2. Implement, analyse and use neural network structures and their training methods 3. Name neural networks applications 4. Outline main principles of fuzzy logic systems and their applications 5. Develop and train an Artificial Neural Network (ANN) for the specific aim 6. Develop fuzzy logic systems for specific aims

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Control in Robotics **کنترل در رباتیک**	
کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Solid Design*
Responsible person	*Prof. H. M. Daniali*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	*Advanced robotics*
Course contents	Module 1. Introduction to robot control Topic 1. Problem definition and methodologies in robot control Module 2. Trajectory planning Topic 2. Linear, parabolic, 3rd and 5th order trajectories Topic 3. Design of trajectories in Cartesian coordination Topic 4. Optimal trajectory design Module 3. Control of robots Topic 5. Modeling of robot dynamics Topic 6. Linear and nonlinear position control design Module 4. Force control of robots Topic 7. Explicit and implicit, hybrid and impedance control techniques Module 5. Position control of robots Topic 8. Implicit and impedance control of bodies Topic 9. Multibody impedance control Module 6. Robot optimization Topic 10. Optimization of robot parameters
Recommended or required reading and other learning resources/tools	Spong, Mark W., and Mathukumalli Vidyasagar. Robot dynamics and control. John Wiley & Sons, 2008. Hogan, Neville. "Impedance control: An approach to manipulation: Part II—Implementation." *Journal of dynamic systems, measurement, and control* 107.1 (1985): 8-16.
Language of instruction	Persian

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Apply impedance control strategy to control design of robotic systems 2. Choose optimal geometric parameters of robot based on robot mission and environment restrictions 3. Apply methods of optimal trajectory planning and modern position and force control concepts to development of robot manipulation strategies

Planned learning activities and teaching methods
Lecture

Assessment methods and criteria
Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO6. Employ the robots into agricultural process, select the proper robots for specific agricultural process and develop the corresponding controller	On successful competition of this module students should be able to: 1. Apply impedance control strategy to control design of robotic systems 2. Choose optimal geometric parameters of robot based on robot mission and environment restrictions 3. Apply methods of optimal trajectory planning and modern position and force control concepts to development of robot manipulation strategies

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Digital Control **کنترل دیجیتال** کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty, Electrical Engineering Faculty*
Department	*M: Solid Design/ E:Control*
Responsible person	*Dr. K. Nikzadfar/Dr. S.J. S. Rostami*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	
Course contents	Module 1. Digital controller's specification Topic 1. Components of digital control systems and comparison with analog controllers Module 2. Presentation of digital control systems Topic 2. Time based models for presentation of discrete signals and systems Topic 3. Characteristics of time based discrete models (availability, observablility, controllability and …) Topic 4. Presentation of discrete systems in frequency domain and Z transformation Module 3. Sampling and discretization Topic 5. Sample and hold circuits Topic 6. Discretization of linear controllers (Bilinear and PIM methods) Module 3. Sampling and discretization Topic 7. Sample and hold circuits Topic 8. Discretization of linear controllers (Bilinear and PIM methods) Module 4. Digital controller design Topic 9. Design of controllers using root-locus and frequency domain methods Topic 10. Design of digital controllers in state space
Recommended or required reading and other learning resources/tools	Landau, Ioan Doré, and Gianluca Zito. *Digital control systems: design, identification and implementation*. Springer Science & Business Media, 2007. Paraskevopoulos, P. N. *Digital control systems*. London, 1996. Iserman, R. "Digital Control Systems. Volume 1I." (1991).
Language of instruction	Persian, English

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Show in-depth understanding of digital control system characteristics and components and analysis methods of digital system behaviour 2. Describe a discrete system in both time and frequency domain

3. Outline modern design methods for digital control
4. Convert a continuous-time system into discrete representation
5. Convert a time domain digital model to frequency domain using Z-transformation
6. Find the system performance characteristics based on pulse transfer function
7. Design a digital controller for discrete systems

Planned learning activities and teaching methods
Lecture, project

Assessment methods and criteria
Project+Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design	On successful competition of this module students should be able to: 1. Show in-depth understanding of digital control system characteristics and components and analysis methods of digital system behaviour 2. Describe a discrete system in both time and frequency domain 3. Outline modern design methods for digital control 4. Convert a continuous-time system into discrete representation 5. Convert a time domain digital model to frequency domain using Z-transformation 6. Find the system performance characteristics based on pulse transfer function 7. Design a digital controller for discrete systems

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Evolutionary optimization **روش های بهینه سازی تکاملی** کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Solid Design*
Responsible person	*Dr. A. Fathi*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	
Course contents	Module 1. Introduction to evolutionary optimization Topic 1. Optimization theory Module 2. Optimization problems Topic 2. Encoding problem Topic 3. Hybrid genetic algorithms Topic 4. Constrained optimization problems Topic 5. Stochastic optimization Topic 6. Nonlinear goal programming Module 3. Evolutionary optimization Topic 7. Evolutionary programming and evolutionary strategy Topic 8. Differential evolution Topic 9. Particle swarm optimization Topic 10. EV optimization algorithms Topic 11. Genetic programming Module 4. Multi-objective optimization Topic 12. Multi objective optimization
Recommended or required reading and other learning resources/tools	- Gen, Mitsuo, and Runwei Cheng. "Foundations of genetic algorithms." *Genetic Algorithms and Engineering Design*(1997): 1-41. - Engelbrecht, Andries P. *Fundamentals of computational swarm intelligence*. John Wiley & Sons, 2006. - Engelbrecht, Andries P. Fundamentals of computational swarm intelligence. John Wiley & Sons, 2006. - Deb, Kalyanmoy. Multi-objective optimization using evolutionary algorithms. Vol. 16. John Wiley & Sons, 2001.
Language of instruction	Persian

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results:

1. Outline evolutionary algorithms and optimization methods including constrained and multi-objective optimization
2. Apply evolutionary optimization methods to solving of constrained and multi-objective optimization problems

Planned learning activities and teaching methods
lectures

Assessment methods and criteria
Project + Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO5. Investigate the application of innovative evolutionary and mathematical based methods to mechatronic system performance optimization	On successful competition of this module students should be able to: 1. Outline evolutionary algorithms and optimization methods including constrained and multi-objective optimization 2. Apply evolutionary optimization methods to solving of constrained and multi-objective optimization problems

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Industrial Automation **اتوماسیون صنعتی** کارشناسی ارشد مکاترونیک–مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty/ Electrical Engineering*
Department	M: Solid Design/ E: Control
Responsible person	*Dr. K. Nikzadfar/Dr. S.J. S. Rostami*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	1
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face
Maximum attendance	
Name of lecturer(s)	1
Prerequisites and co-requisites	*Mechatronics 1*
Course contents	Module 1. Industrial automation Topic 1. Automation technology, components and devices Topic 2. Electrical machine drivers and electrohydraulic devices Module 2. Logical control in automation Topic 3. A review on switching theory and binary logic Topic 4. Industrial switching components Topic 5. Implementing logics by ladder type diagrams, combinational and sequential circuits, flow diagrams, truth tables and … Module 3. Programmable logic controllers Topic 6. PLC modules and operation Topic 7. PLC programming techniques Module 4. Industrial sensor and actuators Topic 8. Industrial sensors Topic 9. Industrial actuators and drivers Module 5. Industrial networks Topic 10. Supervised control and data gathering systems Topic 11. Fieldbus technology
Recommended or required reading and other learning resources/tools	- Bolton, William. *Programmable logic controllers*. Newnes, 2015. - Webb, John W., and Ronald A. Reis. *Programmable logic controllers: principles and applications*. Prentice Hall PTR, 2002. Johnson, Curtis D. *Process control instrumentation technology*. Prentice Hall PTR, 1999.
Language of instruction	Persian

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: – know: The automation system components: sensors, PLCs and actuators

Electrical machine and drivers
Industrial networks components and fieldbus technology

– be able to:
Develop proper industrial automation systems using PLC
Select proper sensors for specific tasks
Program the PLC using proper approach
Make interconnections using industrial networks

Planned learning activities and teaching methods
lectures, presentation, individual work, group work, experiment

Assessment methods and criteria
Project + Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1: Demonstrate ... LO7: Manage …	On successful competition of this module students should be able to: 1. Develop ….
LO3: Evaluate … LO8: Design and implement … LO9: Use … LO11: Engage in …	1. Demonstrate ability … 2. Work actively …. 3. Demonstrate ... (please, see also **Designing a Degree Programme v12**)

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Mechatronics 1 **مکاترونیک 1** کارشناسی ارشد مکاترونیک–مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	Solid Design
Responsible person	Dr. Kamyar Nikzadfar
Type of course unit	Compulsory
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	1
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face
Maximum attendance	
Name of lecturer(s)	1
Prerequisites and co-requisites	*Fundamental of electrical circuit design, Electronics, Linear control*
Course contents	*Contents:* Module 1. Introduction to mechatronics Topic 1. The mechatronic design philosophy and V-type system design Topic 2. Mechatronic systems components and modules Module 2. Model based design technique Topic 3. Multidisciplinary systems modeling Topic 4. System Identification Topic 5. Digital controller design Module 3. Mechatronics systems implementation Topic 6. Sensors and signal conditioning Topic 7. Actuators and driver circuits Topic 8. Digital processors and logic implementation
Recommended or required reading and other learning resources/tools	
Language of instruction	Persian

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Define a mechatronic system and explain the benefits of mechatronic systems versus electromechanical systems 2. Design multidisciplinary mechatronic systems according to specific requirements using model based design approaches 3. Select and dimension sensors and actuators for mechatronic systems according to specific requirements 4. Design and implement a sensor signal conditioning and actuator driver circuits at Personal Computers (PCs) and microcontroller platforms 5. Choose the proper processing unit for implementation of control systems into mechatronic systems

Planned learning activities and teaching methods
lectures, presentation, individual work, group work, experiment

Assessment methods and criteria
Project + Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO3. Select and apply the most appropriate and relevant system design methodology under consideration of economic aspects LO4. Analyze and complement engineering requirements on agricultural processes and systems LO7. Function as a member or leader of a team with distinctive specialists from different scientific and knowledge backgrounds at national and international level	On successful competition of this module students should be able to: 1. Define a mechatronic system and explain the benefits of mechatronic systems versus electromechanical systems 2. Design multidisciplinary mechatronic systems according to specific requirements using model based design approaches 3. Select and dimension sensors and actuators for mechatronic systems according to specific requirements 4. Design and implement a sensor signal conditioning and actuator driver circuits at Personal Computers (PCs) and microcontroller platforms 5. Choose the proper processing unit for implementation of control systems into mechatronic systems

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Mechatronics 2 **مکاترونیک 2** کارشناسی ارشد مکاترونیک–مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING*** **Course unit code**	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	Solid Design
Responsible person	Dr. Kamyar Nikzadfar
Type of course unit	Compulsory
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	1
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face
Maximum attendance	
Name of lecturer(s)	1
Prerequisites and co-requisites	*Fundamental of electrical circuit design, Electronics, Linear control*
Course contents	*Contents:* Module 1. Introduction to mechatronics Topic 1. The mechatronic design philosophy and V-type system design Topic 2. Mechatronic systems components and modules Module 2. Model based design technique Topic 3. Multidisciplinary systems modeling Topic 4. System Identification Topic 5. Digital controller design Module 3. Mechatronics systems implementation Topic 6. Sensors and signal conditioning Topic 7. Actuators and driver circuits Topic 8. Digital processors and logic implementation
Recommended or required reading and other learning resources/tools	
Language of instruction	Persian

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Apply operating principles of electrical machines and drives in design of mechatronic systems 2. Outline characteristics of industrial network components and fieldbus technology 3. Develop an industrial automation system according to specified requirements using Programmable Logic Controller (PLC) 4. Select appropriate sensors for specific tasks 5. Programme Programmable Logic Controller (PLC) according to specification 6. Build interconnections using industrial network technology

Planned learning activities and teaching methods
lectures, presentation, individual work, group work, experiment

Assessment methods and criteria
Project + Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO3. Select and apply the most appropriate and relevant system design methodology under consideration of economic aspects LO4. Analyze and complement engineering requirements on agricultural processes and systems LO7. Function as a member or leader of a team with distinctive specialists from different scientific and knowledge backgrounds at national and international level	On successful competition of this module students should be able to: 1. Apply operating principles of electrical machines and drives in design of mechatronic systems 2. Outline characteristics of industrial network components and fieldbus technology 3. Develop an industrial automation system according to specified requirements using Programmable Logic Controller (PLC) 4. Select appropriate sensors for specific tasks 5. Programme Programmable Logic Controller (PLC) according to specification 6. Build interconnections using industrial network technology

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Application of microprocessors **کاربرد ریزپردازنده ها**	
کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Electrical Engineering Faculty*
Department	*Electronics*
Responsible person	*Dr. Gholitabar*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	*Advanced Control*
Course contents	Module 1. Introduction to digital logic Topic 1. Binary logic and algebra, logic gates Topic 2. Digital circuits Module 2. Processor construction Topic 3. Microcontrollers vs. microprocessors Topic 4. Microprocessor architecture Topic 5. Memories Topic 6. I/O ports Topic 7. Interrupts Topic 8. A/D and D/A Topic 9. Counters and timers Topic 10. UART Module 2. AVR microcontroller programming Topic 11. Introduction to AVR architecture Topic 12. Introduction to C programming Topic 13. Codevision Topic 14. Ports, timers, counters, ADC, serial interface and … Module 3. Autocode generation Topic 15. Automatic code generation for microcontrollers using MATLAB
Recommended or required reading and other learning resources/tools	- Brown, Stephen D. Fundamentals of digital logic with Verilog design. Tata McGraw-Hill Education, 2007. - Hall, Douglas V., and Andrew L. Rood. Microprocessors and interfacing: - programming and hardware. McGraw-Hill, 1986. - Mazidi, Muhammad Ali, Sarmad Naimi, and Sepehr Naimi. AVR microcontroller and embedded systems: using assembly and C. Prentice Hall Press, 2010.
Language of instruction	Persian, English

Learning outcomes of the course unit

As a result of studying the discipline, the trainee must demonstrate the following results:

1. Describe the microcontroller function, architecture and modules
2. Programme different types of microcontrollers using C-code and auto code generation
3. Implement digital controllers on AVR microcontrollers

Planned learning activities and teaching methods
lectures, presentation, individual work, group work

Assessment methods and criteria
Project + Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO3. Select and apply the most appropriate and relevant system design methodology under consideration of economic aspects	On successful competition of this module students should be able to: 1. Describe the microcontroller function, architecture and modules 2. Program different types of microcontrollers using C-code and auto code generation Implement digital controllers on AVR microcontrollers

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Nonlinear Control **کنترل غیرخطی** کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Solid Design*
Responsible person	*Dr. K. Nikzadfar*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	*Advanced Control*
Course contents	Module 1. Nonlinear systems characteristics Topic 1. Characteristics of nonlinear systems Topic 2. Application of nonlinear systems Module 2. Analysis of nonlinear systems Topic 3. Phase plane analysis Topic 4. Qualitative analysis of nonlinear systems Module 3. Limit cycles Topic 5. Limit cycles and stability analysis of limit cycles Module 4. Stability Topic 6. Lypanouv theory and applications Topic 7. Controllability and observabilty matrices and relative tests Module 5. Nonlinear controller design Topic 8. Feedback linearization Topic 9. Sliding mode control
Recommended or required reading and other learning resources/tools	Slotine, Jean-Jacques E., and Weiping Li. Applied nonlinear control. Vol. 199. No. 1. Englewood Cliffs, NJ: Prentice hall, 1991. Khalil, Hassan K. Nonlinear control. Prentice Hall, 2014. Khalil, Hassan K. "Noninear systems." Prentice-Hall, New Jersey 2.5 (1996): 5-1. Isidori, Alberto. Nonlinear control systems. Springer Science & Business Media, 2013.
Language of instruction	Persian, English

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Demonstrate in-depth knowledge of nonlinear system characteristics and stability criteria 2. Outline modern methods of analysis, modelling and control design for nonlinear systems 3. Analyse nonlinear system properties using complex methods of analytical modelling

4. Analyse nonlinear system stability properties based on the Lyapunov theorem Design control for nonlinear systems using advanced methods of control theory

Planned learning activities and teaching methods
Lecture, project

Assessment methods and criteria
Project + Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO1. Demonstrate in-depth knowledge and understanding of mechatronics processes and synergic combination of mechanical, electrical and computer science for automation process optimization LO5. Investigate the application of innovative evolutionary and mathematical based methods to mechatronic system performance optimization LO6. Employ the robots into agricultural process, select the proper robots for specific agricultural process and develop the corresponding controller	On successful competition of this module students should be able to: 5. Demonstrate in-depth knowledge of nonlinear system characteristics and stability criteria 6. Outline modern methods of analysis, modelling and control design for nonlinear systems 7. Analyse nonlinear system properties using complex methods of analytical modelling 8. Analyse nonlinear system stability properties based on the Lyapunov theorem 9. Design control for nonlinear systems using advanced methods of control theory

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Renewable energies **انرژی های تجدید پذیر** کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Chemical Engineering Faculty*
Department	
Responsible person	*Dr. M. Rahimnejad*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	
Course contents	The class will cover concepts involving conventional fossil fuel sources of energy, along with biofuels and renewable resources, with a focus on: • National and regional energy issues. • Understanding of existing versus alternative energy development • Knowledge of regulatory tools and issues that professionals need for jobs in policy and planning, management and consulting. • Developing the analytical skills needed for problem solving and interpretation of technical, regulatory and policy concepts involving renewable energy generation.
Recommended or required reading and other learning resources/tools	Hans P. Blaschek, Thaddeus C. Ezeji, Jürgen Scheffran, Biofuels from Agricultural Wastes and Byproducts, A John Wiley & Sons, Inc., Publication (2010) Caye M. Drapcho, Nghiem Phu Nhuan, Terry H. Walker, Biofuels Engineering Process Technology, Mac Grow Hill, New York Chicago San Francisco (2008) Bruce E. Rittmann, Perry L. McCarty-Environmental Biotechnology_ Principles and Applications-McGraw-Hill (2001) (Chapter 13)
Language of instruction	Persian, English

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Analyse and review the economic and environmental impacts of different energy policy options involving renewable energy-based electricity generation 2. Analyse and review major national and regional legislation governing the renewable energy sector 3. Calculate the costs and evaluate the processes required to develop renewable energy generation projects 4. Research and compose in-depth policy briefs and analyses on energy legislation and regulation 5. Evaluate the feasibility of renewable energy projects within a framework of political, economic, social and technical consideration

Planned learning activities and teaching methods
lectures, presentation, individual work, group work, experiment

Assessment methods and criteria
Project + Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO4. Analyze and complement engineering requirements on agricultural processes and systems	On successful competition of this module students should be able to: 1. Analyse and review the economic and environmental impacts of different energy policy options involving renewable energy-based electricity generation 2. Analyse and review major national and regional legislation governing the renewable energy sector 3. Calculate the costs and evaluate the processes required to develop renewable energy generation projects 4. Research and compose in-depth policy briefs and analyses on energy legislation and regulation 5. Evaluate the feasibility of renewable energy projects within a framework of political, economic, social and technical consideration

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.

Description of individual educational component (module)	
Robotics in Agriculture **کاربرد رباتیک در کشاورزی**	
کارشناسی ارشد مکاترونیک-مکاترونیک سیستم‌های کشاورزی ***Second Cycle Degree in MECHATRONICS/AGRO-MECHATRONICS ENGINEERING***	
Course unit code	
Organisation	*Babol Noshirvani University of Technology*
Faculty	*Mechanical Engineering Faculty*
Department	*Solid Design*
Responsible person	*Invited Professor*
Type of course unit	Optional
Level of course unit	Second cycle (for master's programme)
Year of study (if applicable), semester/trimester when the individual educational component is delivered	
Number of ECTS credits allocated	
Total hours	*108*
Contact hours	*48*
Self-study hours	*60*
Mode of delivery	Face-to-face/Distance learning
Maximum attendance	15
Name of lecturer(s)	1
Prerequisites and co-requisites	
Course contents	<u>Module 1. Introduction to robotics in agricultural</u> Topic 1. Necessity of robotics and automation in agricultural processes Topic 2. Specification of agricultural robots and their differences with general robots <u>Module 2. Agricultural robots</u> Topic 3. Stationary and mobile robots in farms Topic 4. Different robot platforms in agriculture Topic 5. Sensors and actuators of robots in agriculture Topic 6. Design and systems and algorithms of agro-robots Topic 7. Ultrasonic, LIDAR and 3D position and GPS sensors Topic 8. Machine vision in agro-robots Topic 9. Semi-automatic and full automatic robots in farms
Recommended or required reading and other learning resources/tools	- Más, Francisco Rovira, Qin Zhang, and Alan C. Hansen. Mechatronics and intelligent systems for off-road vehicles. Springer Science & Business Media, 2010. Blackmore, B., and H. Griepentrog. "Mechatronics and Applications." CIGR Handbook of Agricultural Engineering 6 (2006): 204-215.
Language of instruction	Persian, English

Learning outcomes of the course unit
As a result of studying the discipline, the trainee must demonstrate the following results: 1. Demonstrate in-depth knowledge of innovative robot types used in agricultural processes, their capabilities and components 2. Select a robot type and associated robot components for specific agricultural tasks 3. Use complex navigation systems for motion control of mobile robots in agricultural processes

Planned learning activities and teaching methods

lectures

Assessment methods and criteria
Midterm Written Exam+ Final Written Exam

Mapping Programme Key Learning Outcomes to Module Learning Outcomes	
Programme Key Learning Outcomes	**Module Learning Outcomes**
LO2. Develop new agro-mechatronic products, processes and systems with defined specifications requiring integration of knowledge from different fields and non-technical constraints employing model based design LO4. Analyze and complement engineering requirements on agricultural processes and systems LO6. Employ the robots into agricultural process, select the proper robots for specific agricultural process and develop the corresponding controller	On successful competition of this module students should be able to: 1. Demonstrate in-depth knowledge of innovative robot types used in agricultural processes, their capabilities and components 2. Select a robot type and associated robot components for specific agricultural tasks 3. Use complex navigation systems for motion control of mobile robots in agricultural processes

Assessment criteria table					
Attribute	**Grade A (Excellent)**	**Grade B (Good)**	**Grade C (Satisfactory)**	**Grade D (Sufficient)**	**Failed / Insufficient**
Content (70%)	The content of the work was at high standard.	The content of the work was a high standard but with some weaknesses regarding evidence.	The content of the work was of a good standard but with several weaknesses regarding evidence and/or some lack of clarity.	The content of the work was a passing grade but with a weak evidence base/or a wide lack of clarity.	The content of the work fell short of that required to pass due to lack of evidence base/or very poor clarity.
Literature review (20%)	The literature library assembled by the student was outstanding with no serious missing articles.	The literature library assembled by the student was very good with only a few missing key articles.	The literature library assembled had a number of missing key articles and lacked breadth.	The literature library lacked breadth to a great degree and was missing many key articles.	The literature library was lacking in breadth and key articles to an extent that fell short of a passing grade.
Report quality (10%)	The style and clarity of the report was excellent.	The style and/or clarity of the report were very good.	The style and/or clarity of the report were good.	The style and/or clarity of the report were adequate.	The style and/or clarity of the report fell short of a passing grade.