INTEGRATIVE PROJECT IME

LEARNING OUTCOMES

A. GENERAL LEARNING OBJECTIVE

At the end of the course, the student will be able to make a fully operational and real-application prototype applying the knowledge and skills acquired throughout the electromechanical engineering program using a new product development methodology based on a calculation memory to contribute to the student outcomes.

B. EDUCATIONAL CONTENTS

STUDENT OUTCOMES TO WHICH THE TRAINING SPACE CONTRIBUTES.

Specific student outcomes	1.- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. 2.- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. 6.- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
Student outcomes of emphasis	Does not apply

PERFORMANCE INDICATORS, SKILLS AND SCIENTIFIC-PROFESSIONAL KNOWLEDGE

The professional performance indicators, knowledge and skills promoted by this formation space are:

Learning results that the student will achieve in this training space	
Performance indicators	The student… 1.1 Relates the physical phenomena to the theories and mathematical models that describe them. 1.2 Applies theoretical knowledge to solve complex engineering problems. 1.3 Applies knowledge of different areas of engineering to solve complex engineering problems. 1.4 Calculates the geometric dimensions and stresses of mechanical elements subjected to loads. 1.5 Applies the mathematical models of electromechanical components, such as motors, generators, transformers, pumps, hydraulic actuators, pneumatic actuators and compressors. 1.6 Identifies and calculates the different forms of energy involved in mechanical, electrical, thermal, pneumatic, hydraulic, etc. systems. 1.7 Interprets and produces mechanical, electrical, pneumatic, hydraulic and control diagrams using symbology according to standards. 1.8 Calculates components of systems of conversion, transmission and distribution of electrical energy. 1.9 Identifies and performs calculations for the integration of renewable energy systems. 1.10 Identifies opportunities and applies strategies for energy savings in electromechanical systems. 1.11 Implements preventive and corrective maintenance work in electromechanical systems. 1.12 Uses specialized software to analyze mathematical models that describe the behavior of electromechanical components or systems.

	2.1 Applies a methodology for the design of a component, system or process. 2.2 Applies a methodology to weigh the technical, economic, environmental and social requirements that must be met by the design of a component, system or process. 2.3 Identifies and evaluates design constraints. 2.4 Applies a methodology for analysis and decision-making to design alternatives. 2.5 Establishes the technical, economic and environmental specifications that a component, system or process must meet. 2.6 Identifies various electromechanical components that can meet the functional requirements of a system or process. 2.7 Identifies and selects the manufacturing processes necessary to build an electromechanical component or system. 2.8 Establishes the quality criteria of a product or process. 2.9 Calculates the direct and indirect costs of a project. 2.10 Evaluates the net present value and the internal rate of return of a project. 2.11 Makes a quote to sell engineering services. 2.12 Uses modern engineering devices to control and automate equipment or processes. 6.1 Identifies the need for experiments. 6.2 Selects the materials, devices and methods necessary to design experiments. 6.3 Uses a logical organization of procedures and applies mathematical and graphic analysis to interpret the results of an experiment. 6.4 Identifies in advance the problems that may arise in an experiment. 6.5 Describes the experimental results and their relationship with fundamental concepts and principles. 6.6 Develops a mathematical model from experimental data. 6.7 Uses modern and appropriate computing resources for engineering practice. 6.8 Uses and interprets results of materials and electrical equipment testing. 6.9 Applies techniques for acceptance testing and preventive maintenance of electromechanical equipment.
Knowledge	Team integration. Contract writing. Technological advances related to the project. Goal writing. Report writing. Engineering design definitions. Design methodologies. English language readings Identification of the type of market in which the product can be marketed. Customer voice and the transformation into customer requirements. Quality Function Deployment development (phase 1) Holistic Requirements Model development for customer requirements. Project requirements hierarchy Product concepts generation Analytical Hierarchy Process to select the concept. Quality Function Deployment development (phase 2) Determination of the electromechanical components with which the Functional and Non-Functional Implementation Requirements are solved. Establishment of the project technical specifications. Investment return time and the internal rate of return estimation. Realization of the technical and economic proposal of the project. Realization of the activities program for the execution of the project. Subsystems identification (electrical, mechanical, thermal, etc.) into which the project is divided. Energy conversion diagrams realization.

	Description of the product's operation through diagrams. Preliminary diagrams realization (manufacturing, mechanical, electrical, electronic, control, pneumatic assembly, etc.) Design flow diagrams realization. Quality Function Deployment development (phase 2 and 3) Electromechanical components specification by calculation Determination of the parameters of the manufacturing process for the components. Components purchase Final diagrams realization (manufacturing, mechanical, electrical, electronic, control, pneumatic assembly, etc.) Manufacture process. Official Mexican Standards application. Prototype construction. Final report writing. Checking calculations on energy consumption and efficiency. Direct and indirect costs of the project calculation. Internal rate of return for the company and for the client calculation. Installation, Operation and Maintenance Manual writing.
Skills	Teamwork. Client interview and identify their needs. Management to obtain the material resources for the project. Conflict resolution. Calculation and design procedures. Effective presentations. Personal image. Management of software for electromechanical design. Management of software for mechanical design. Management of equipment to carry out manufacturing processes. Handling of tools to assemble electromechanical components. Management of measuring instruments for testing electromechanical equipment

C. UASLP GRADUATE: PERFORMANCE INDICATORS AND TRANSVERSAL SKILLS

Graduate profile UASLP	Performance indicators and transversal skills promoted by this training space
Professional autonomy for learning (an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.**)**	The student… 7.1 Recognizes the importance of learning and using sources different of information to prepare projects and reports. 7.2 Seeks to constantly improve their knowledge related to their profession. 7.3 Has the ability to learn through the selection of reliable information sources. 7.4 Has information of engineering state-of-the-art.
Collaborative work skills (an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives**)**	The student… 5.1 Contributes positively and widely to the work team. 5.2 Assumes responsibilities as a team member. 5.3 Expresses his/her ideas and concerns without fear. 5.4 Assumes leadership responsibilities. 5.5 Identifies the roles, responsibilities and expectations of leading a team. 5.6 Uses strategies to respond to disagreement, focusing on constructive conflict resolution and consensus building
Communication skills in spanish and other languages	The student… 3.1 Has organized oral communication, being consistent with the central message and using appropriate body language to express one's ideas.

(an ability to communicate effectively with a range of audiences)	3.2 Has organized written communication, which is consistent with the central message, identified in the introduction, where the main points are linked to transitions and a conclusion. 3.3 Uses modern presentation tools, such as audio, video, etc. effectively. 3.4 Uses extensive and appropriate vocabulary, as well as correct grammar. 3.5 Communicates orally and in writing in a language other than the first language. 3.6 Prepares technical reports where made judgments as products of the results of engineering solutions.
Scientific, professional, and/or social creative project development	This student outcomes in engineering is considered as specific professional, the performance indicators are already integrated within this training space.
Social responsibility and ethical reflection (an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts)	The student… 4.1 Identifies the facts and work methods considering ethical principles. 4.2 Rejects work that has the purpose of violating the general interest of society. 4.3 Avoids putting personal interests before the matters entrusted, or colluding to exercise unfair competition. 4.4 Safeguards the interests of the institution or persons and makes good use of the resources allocated for the performance of their activities. 4.5 Complies with society, attending to the welfare and progress of the majority. 4.6 Complies with the regulations to calculate, install and operate electromechanical systems. 4.7 Demonstrates responsibility and awareness of the consequences of his/her activities for society in general. 4.8 Understands how economic factors affect professional practice. 4.9 Is aware of a variety of current events in a national and global context. 4.10 Selects the techniques and tools to give modern engineering solutions and makes judgments comparing the results with the alternative tools or techniques. 4.11 Manages the human and material resources necessary to maintain the operation of electromechanical systems.

GENERAL STRUCTURE AND SUMMATIVE EVALUATION

D. GENERAL DIDACTIC PLANNING

During the course, the student will gain experience in developing an electromechanical prototype following the methodology oriented to new product development proposed by Ulrich and Eppinger [2]. The methodology consists of the following steps: planning, concept development, system-level design, detail design, testing and refinement, and prototype presentation. The strategies include: (1) the follow-up of the methodology, (2) the presentation in plenary session of the preliminary draft and the advances in the implementation of the methodology, (3) the presentation of weekly advances, (4) the presentation of individual reports, and (5) the presentation of the project final result.

The total hours of the course are divided into three parts: Part 1, in the first 48 hours, the teaching method is used, consisting of presentations by the teacher where the topics of the subject are covered. Part 2, the following 64 hours, the student guided by the professor develops laboratory practices within of the College of Engineering, in other Colleges of the UASLP or outside the UASLP, whose content is variable, where he uses the topics presented by the professor and the knowledge acquired throughout his electromechanical engineering program to develop the project. Part 3, in the remaining 48 hours, the student carries out work outside the facilities of the College of Engineering to investigate and prepare individual and team reports.

The training and learning structure proposed for the training space is shown below:

#	Name of the unit or training phase	Unit learning objective	Specific educative contents (performance indicators, skills, knowledge)
1.	1. Operating principles for project development (1h)	At the end of the unit, the student will be able to establish and apply the operating principles for the project development, such as reviewing the state of the art, establishing work teams, setting the project objective, among other core elements	**Specific educational content:** 1.1 Course guidelines and evaluation method. 1.2 Team integration, project selection and contract signing. 1.3 Review of the state of the art. 1.4. Objective of the project. **Learning activities:** Team integration. Contract writing. Knowledge of the latest technological advances related to the project. Goal writing. Report writing
2	2. Design Methodology (1h)	At the end of the unit, the student will be able to define and list the phases of the electromechanical design process as a starting point for the integrative project IME development by reviewing the engineering design literature.	**Specific educational content:** 2.1 Engineering design definitions. 2.2 Design process phases. **Learning activities:** Definition of engineering design. Learning about design methodologies from various authors. English language readings.
3	3. Concept development (30 h)	At the end of the unit, the student will be able to develop the methodology of Holistic Quality Function Deployment phase 1 and 2, in order to generate product concepts and justify the choice of a concept and find design solutions (electromechanical components).	**Specific educational content:** 3.1 Phase 1 of Quality Function Deployment. 3.2 Requirements, broad markets and narrow markets. 3.3 Customer voice and transform it into customer requirements. 3.4 The Holistic Requirements Model. 3.4.1 Operational Requirements. 3.4.2 Functional Requirements. 3.4.3 Non-Functional Performance Requirements. 3.4.4 Non-Functional Implementation Requirements. 3.4.5 Non-Functional System Requirements. 3.5 To hierarchize and prioritize the Operational and Non-Functional Requirements of the System. 3.6 Relationship matrix. 3.7 To determine the units of measurement for the Functional and Non-Functional Implementation Requirements. 3.8 To Establish Non-Functional Performance requirements. 3.8.1 Analysis of the current state of technology. 3.9 To determine the opportunity for improvement with respect to the current state of technology. 3.10 Creative generation of ideas and concepts.

			3.11 Concept selection using the Analytical Hierarchy Process. 3.11.1 Sensitivity analysis. 3.12 Technical specifications. 3.13 Phase 2 of Quality Function Deployment 3.14 Direct and indirect costs estimation. 3.15 Internal rate of return and investment return time estimation. 3.16 Make the technical and economic proposal. 3.17 Project development planning. **Learning activities:** Identification of the type of market in which the product can be marketed. Customer voice and the transformation into customer requirements. Quality Function Deployment development (phase 1). Holistic Requirements Model development for customer requirements. Project requirements hierarchy. Product concepts generation. Analytical Hierarchy Process to select the concept. Quality Function Deployment development (phase 2). Determination of the electromechanical components with which the Functional and Non-Functional Implementation Requirements are solved. Establishment of the project technical specifications. Investment return time and the internal rate of return estimation. Realization of the technical and economic proposal of the project. Realization of the activities program for the execution of the project.
4	4. System-level design (10 h)	At the end of the unit, the student will be able to identify subsystems that make up the project to make functional diagrams in order to start the detailed design phase.	**Specific educational content:** 4.1 Describe the project in subsystems. 4.2 Functional diagram of the system. 4.3 Energy conversion diagrams. 4.4 Preliminary diagrams (manufacturing, mechanical, electrical, electronic, control, pneumatic assembly, etc.) **Learning activities:** Subsystems identification (electrical, mechanical, thermal, etc.) into which the project is divided. Energy conversion diagrams realization. Description of the product's operation through diagrams. Preliminary diagrams realization (manufacturing, mechanical, electrical, electronic, control, pneumatic assembly, etc.) Design flow diagrams realization. English language readings Report writing.

5	5. Detail design (80 h)	At the end of the unit, the student will be able to calculate through the detail design the specification of the prototype components to define whether they are acquired or manufactured and from these define the manufacturing parameters and quality control through the Quality Function Deployment phase 3 and phase 4 in order to obtain a prototype according to the customer needs.	**Specific educational content:** 5.1 Design flow diagram. 5.2 Robust experimental design 5.2.1 The robust design process. 5.2.2 Implementation of the experiment to mitigate "noises". 5.2.3 Report of the scientific experiment. 5.2 Technical specifications of the electromechanical components 5.3 Materials and characteristic values of design solutions. 5.4 Quality Function Deployment (phase 3). 5.5 Parameters of the manufacturing process. 5.6 Purchase and manufacture of parts. 5.6.1 Inspection format design. 5.7 Quality Function Deployment (phase 4). 5.8 Construction of the prototype. 5.9 Final diagrams (manufacturing, mechanical, electrical, electronic, control, pneumatic assembly, etc.). 5.10 Final economic proposal. **Learning activities:** Quality Function Deployment development (phase 3 and 4). Electromechanical components specification by calculation. Determination of the parameters of the manufacturing process for the components. Components purchase Final diagrams realization (manufacturing, mechanical, electrical, electronic, control, pneumatic assembly, etc.) Manufacture process. Official Mexican Standards application. Prototype construction. Final report writing.
6	Testing and refinement (38 h).	At the end of the unit, the student will be able to demonstrate the operation of the prototype, operating at full load in order to verify that it meets the Non-Functional Performance Requirements through production tests and electrical tests.	Specific educational content: 6.1 Prototype tests. 6.2 Product release format. 6.3 Energy considerations (power demand, measurement of energy consumed and efficiency). 6.4 Calculation of direct and indirect costs. 6.5 Calculation of the investment return time and internal rate of return. 6.6 Sale price of technological development. **Learning activities:** Checking calculations on energy consumption and efficiency. Direct and indirect costs of the project calculation. Internal rate of return for the company and for the client calculation. Installation, Operation and Maintenance Manual writing.

			Report writing

E. ASSESSMENT

The summative assessment proposal for the training space is shown below. According to it, students will receive an ordinary grade. This course reports two partial grades before the ordinary final grade, the first grade corresponds to the one obtained by the students in the preliminary presentation, the second corresponds to the presentation of their progress. These qualifications only correspond to 2.5 % of the ordinary qualification. Both presentations are made in the Auditorium or in the Aula Magna of College of Engineering before an evaluation committee assigned by the Academy of Integration of Engineering Projects.

Table 1.

#	Time of evaluation	Proposal for the summative assessment of learning	Evaluation percentage
1.	Knowledge test. Third week of the semester	The knowledge exam consists of a written evaluation on the topics taught during the first three weeks of the semester.	10 %
2.	Preliminary project. Third week of the semester	The preliminary project is a document that must be delivered at the end of the third week. It is expected that the methodology development will be included until to the design stage at the system level. The student can consult the evaluation rubric through the platform http://didac-tic.uaslp.mx/.	10 %
3.	Personal electronic portfolio. From week 4 to 15 of the semester.	The personal electronic portfolio consists of weekly individual reports that must be carried out in accordance with the Course Guidelines. The report must be written in 750 and 1250 words. The student can consult the evaluation rubric through the platform http://didac-tic.uaslp.mx/	15 %
4	Group electronic portfolio. From week 4 to 15 of the semester.	The group electronic portfolio consists of weekly reports that must be made in accordance with the Course Guidelines. The group report is a progress presentation, in the implementation of the methodology. The progress presentations of weeks 4 and 11 are reviewed by committee assigned by the Engineering Projects Integration Academy. The rest of the presentations are reviewed by the professor of the subject. The student can consult the evaluation rubric through the platform http://didac-tic.uaslp.mx/	15 %
5	Final Evaluation of the Project. Week 16 of the semester.	The project Final Evaluation will consist of: 1. The evaluation of the Installation, Operation and Maintenance Manual. The student can consult the evaluation rubric through the platform http://didac-tic.uaslp.mx/. 2. The evaluation of the Final Report of the Project that will be qualified based on the development of the methodology. The student can consult the evaluation rubric through the platform http://didac-tic.uaslp.mx/. Note: these first two reports must be delivered in week 15 for reviewing by committee. 3. The Project presentation takes place in this week and consist in a presentation that includes the most important	50 %

		aspects around the development of the project The student can consult the evaluation rubric through the platform http://didac-tic.uaslp.mx/. 4. A demonstration of the final product. This presentation involves a start-up of the equipment where the teamwork shows the main characteristics. A thorough assessment is performed by the committee where the correct installation and operation is assessed. 5. The team that does not participate in the Integrating Project Expo will obtain a failed laboratory grade LR	

Ordinary final assessment	The ordinary grade will be the sum of all the evaluation points referred in Table 1 with a total evaluation value of 100%. The evaluation committee of the Ordinary Exam determines if the project was accredited and the grade in the Ordinary Exam will be the sum of the grades obtained throughout the semester and the grade obtained in the project evaluation. In the event that the project is not accredited, the new presentation instance will be indicated (Extraordinary Examination or Sufficiency Title Examination) and observations will be made to correct the project, the documents and/or the presentation itself. To have the right to accredit the course, the team must deliver (in addition to the Final Report, Prototype and Installation, Operation and Maintenance Manual) the following: 1) Poster to be presented at the exhibition of posters in the Expo Integrative Project. 2) Video that shows the correct functioning of the prototype. 3) Survey on competencies. 4) Evidence of attendance meetings with the project advisor. The evaluation committee of the projects must be formed by the professor, the project advisor and a third synodal proposed by the Academy of Engineering Projects and endorsed by the Coordination of Electromechanical Engineering.
Extraordinary assessment	The extraordinary evaluation consists of a review of the requirements of the evaluation committee. In this evaluation, the percentages of each of the items are those indicated in Table 1 with a value of 100%.
Sufficiency Title assessment	The sufficiency evaluation consists of a review of the requirements of the evaluation committee. In this evaluation, the percentages of each of the items are those indicated in Table 1 with a value of 100%.
Regularization assessment	This subject does not contemplate Regularization Exam

F. BIBLIOGRAPHIC AND DIGITAL RESOURCES

BASIC TEXTS:

[1] R. G. Budynas, J.K. Nisbeth, Diseño en ingeniería mecánica de Shigley, McGraw-Hill, 2015
[2] K. T. Ulrich, S D. Eppinger, Diseño y desarrollo de productos, McGraw-Hill, 2013.
[3] E. Mu. M. Pereyra-Rojas, Practical decision making an introduction to the analytic hierarchy process (AHP), Using Super Decisions V2. Springer, 2017.
[4] Gutiérrez Pulido Humberto, De la Vara Salazar Román, Análisis y diseño de experimentos 3ª Edición, McGraw-Hill, 2012.
[5] J. J. Cristiano, JK Liker, CC White, Custormer-driven product development through quality function deployment in the U.S. and Japan, J. Prod. Innov. Manag. 2000; 17:286-308.

[6] S. Burge. A functional approach to quality function deployment. BHW and the Systems Engineering Company. Technical Paper 0001/sb, 2007.
[7] T. L. Saaty, how to make a decision: the analytic hierarchy process, Journal of Operation Research, 1990, 48:9-26.
[8] T. L. Saaty, Decision making with the analytic hierarchy process, Int. J. Services Sciences, (2008) 1:83–98.

CURRICULAR AND SCHOOL DATA

Area	Line	Type of credit	Type of formation space	Language of instruction	Method of delivery
Deepening (Engineering Topics)	N/A	Required	Course	Spanish	In person

CREDITS

According to the official curricular proposal, the school data of the formation space are:

Semester	Number of weeks	Classroom hours per week	Contact hours of practice per week	Hours of autonomous student work per week	Credits per agreement 17/11/17(before 279)
10	16	3	4	3	10

REQUIREMENTS TO ATTEND THE FORMATION SPACE

The school requirements for the formation space are noted below, if necessary

#	REQUIREMENTS
1.	The student must have accredited the training spaces for semester VII and earlier.
2.	The student must have accredited 360 credits.

EQUIVALENCIES OF THE FORMATION SPACE

Next, the equivalences of the training space with spaces of previous educational programs are indicated, if necessary.

EQUIVALENCES
There are no equivalent training spaces.

INTEROPERABILITY

This formation space is shared with other educational programs and/or academic entities: No.

ACADEMIC INSTITUTION AND EDUCATIONAL PROGRAMS
College of Engineering: Electromechanical Engineering

OTHER FORMS OF ACCREDITATION

- This formation space can be accredited through the presentation of a document certifying that the student has already acquired the necessary learning: **No**.

- This formation space can be accredited through an exam that certifies that the student has already acquired the necessary learning: **No**.

FORMATION OPTIONS

This formation space is part of the following options:

Training option	Yes / No
Bachelor's Degree	Yes
Dual formation program	No
Higher University Technician	No
Executive career	No
Partial accreditation option	No
Residency or internship	No

TEACHER PROFILE

The teacher must know about the student outcomes that are promoted in the students of the electromechanical engineering program.

Formation and academic experience

- Electromechanical Engineer or related career with Master's or doctorate studies. Five years teaching subjects in the professional area in the Electromechanical Engineering Program.

Formation and professional and work experience

- The teacher must have experience in the development of electromechanical projects.

The teacher's role

- The teacher will have the task of exposing the methodology, in the first three weeks of the semester, as well as the necessary tools for the student to develop the project. Subsequently, he will follow up on the practical activities carried out by the student through meetings with the teams at least once a week. The professor will issue a grade for the weekly presentations of the teams and for the individual reports presented. He will also be in charge of suggesting specialized advice to the team by other teachers.

The project advisor.

- The advisor will be an expert chosen by the team or assigned by the professor, he will act as a guide for the students in specific areas that are part of the project; His main function will be to give suggestions and alternative solutions, propose sources of information for consultation and resolve specific doubts within his field of experience. He must not, under any circumstances, solve student problems, or prepare parts of the project.

MAXIMUM AND MINIMUM NUMBER OF STUDENTS PER GROUP

- Maximum number of students to guarantee academic, pedagogical, and financial viability: 20
- Minimum number of students to guarantee academic, pedagogical, and financial viability: 3

TYPE OF PROPOSAL

- It is a version of programs that are presented as a curricular adjustment of content within the framework of an existing educational program.

DEVELOPERS AND REVIEWERS

Developers of this programs	Reviewers of this programs
PhD. Baudel Lara Lara	Eng. Jorge Eduardo González Muñoz
MA. Vérulo Castro López	