# ELECTRICITY AND MAGNETISM B

## LEARNING OUTCOMES

### A. GENERAL LEARNING OBJECTIVE

At the end of the course, the student will be able to analyze the operation of devices used in the conversion, transmission, distribution, and use of energy using a project-based approach by building a direct current motor and three-phase alternating current generator using electromagnetic principles.

### 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.<br>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.<br>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…<br>1.1 Relates the physical phenomena to the theories and mathematical models that describe them.<br>1.2 Applies theoretical knowledge to solve complex engineering problems.<br>1.3 Applies knowledge of different areas of engineering to solve complex engineering problems.<br>1.5 Applies the mathematical models of electromechanical components, such as motors, generators, transformers, pumps, hydraulic actuators, pneumatic actuators and compressors.<br>1.6 Identifies and calculates the different forms of energy involved in mechanical, electrical, thermal, pneumatic, hydraulic, etc. systems.<br>1.7 Interprets and produces mechanical, electrical, pneumatic, hydraulic and control diagrams using symbology according to standards.<br>1.8 Calculates components of systems of conversion, transmission and distribution of electrical energy.<br>2.1 Applies a methodology for the design of a component, system or process.<br>2.3 Identifies and evaluates design constraints.<br>2.4 Applies a methodology for analysis and decision-making to design alternatives.<br>2.5 Establishes the technical, economic and environmental specifications that a component, system or process must meet.<br>2.7 Identifies and selects the manufacturing processes necessary to build an electromechanical component or system.<br>6.1 Identifies the need for experiments. |

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| | 6.2 Selects the materials, devices and methods necessary to design experiments.<br>6.3 Uses a logical organization of procedures and applies mathematical and graphic analysis to interpret the results of an experiment.<br>6.4 Identifies in advance the problems that may arise in an experiment.<br>6.5 Describes the experimental results and their relationship with fundamental concepts and principles.<br>6.6 Develops a mathematical model from experimental data.<br>6.7 Uses modern and appropriate computing resources for engineering practice. |
| **Knowledge** | Exercises in class on the topics of the course.<br>Study of the standard NOM-008-SCFI-2002 General System of Measurement Units (or the current version).<br>History of electricity and magnetism.<br>Analysis of the behavior of speed, induced voltage and current in a linear motor under load and voltage changes.<br>Analysis of a DC motor model using Matlab-Simulik and delivery of a report.<br>Analysis of the operation of a permanent magnet DC motor (visit to the electrical machines laboratory).<br>Design and construction of a DC motor armature that produces a torque and speed proposed by the teacher.<br>Symbology learning.<br>Establishment of design criteria for a armature.<br>Review and translation of videos related to the cd engine available at www.learnEngineering.org<br>Readings and videos related to the topics.<br>Reading and exhibition in English of an article related to new magnetic materials that the student must obtain from www.sciencedirect.com or www.scopus.com.<br>Reading the magnetic field density of a neodymium air core magnet.<br>Analysis of a magnetic circuit.<br>Design and construction of a permanent magnet DC motor that performs with the torque and speed proposed by the teacher.<br>Research on permeability of magnetic materials.<br>Establishment of design criteria for the DC motor.<br>Report on the design and construction of a permanent magnet DC motor that performs with the torque and speed proposed by the professor.<br>Design and construction of a shunt connection DC motor that performs with the torque and speed proposed by the teacher.<br>Report on the design and construction of a shunt connection DC motor that performs with the torque and speed proposed by the teacher.<br>Establishment of design criteria for DC motors.<br>Analysis and design of an electromagnet.<br>Design and construction of a three-phase AC generator.<br>Report on the design and construction of a three-phase AC generator.<br>Analysis of the ideal transformer.<br>Analysis of the principle of alternating current generation.<br>Analysis of the principle of electromagnetic induction.<br>Review and translation of videos related to the transformer, synchronous generator and eddy currents, available at www.learnEngineering.org.<br>Design and construction of a low power single-phase transformer.<br>Analysis and design of a Tesla coil.<br>Solution of RL circuit in CD using differential equations and Laplace transform.<br>Digital simulation of an RLC circuit.<br>Realization of laboratory practices. |
| **Skills** | Teamwork.<br>Client interview and identify their needs. |

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| | Management to obtain the material resources for the project.<br>Conflict resolution.<br>Calculation and design procedures.<br>Effective presentations.<br>Personal image.<br>Management of software for electromechanical design.<br>Management of software for mechanical design.<br>Management of equipment to carry out manufacturing processes.<br>Handling of tools to assemble electromechanical components.<br>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…<br>7.3 Has the ability to learn through the selection of reliable information sources.<br>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…<br>5.1 Contributes positively and widely to the work team.<br>5.2 Assumes responsibilities as a team member.<br>5.4 Assumes leadership responsibilities.<br>5.6 Uses strategies to respond to disagreement, focusing on constructive conflict resolution and consensus building |
| **Communication skills in spanish and other languages (**an ability to communicate effectively with a range of audiences**)** | The student…<br>3.1 Has organized oral communication, being consistent with the central message and using appropriate body language to express one's ideas.<br>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.<br>3.3 Uses modern presentation tools, such as audio, video, etc. effectively.<br>3.4 Uses extensive and appropriate vocabulary, as well as correct grammar.<br>3.5 Communicates orally and in writing in a language other than the first language.<br>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…<br>4.1 Identifies the facts and work methods considering ethical principles.<br>4.10 Selects the techniques and tools to give modern engineering solutions and makes |

# GENERAL STRUCTURE AND SUMMATIVE EVALUATION

## D. GENERAL DIDACTIC PLANNING

During the course the student will learn the electromagnetic principles that will allow him to analyze and design DC motors, transformers or an electromagnet; acquiring the ability to determine the minimum caliber of the conductors, number of turns, material properties, and identification of problems related to the malfunction of these devices. During the course, the student will build a prototype of a DC motor and an AC generator where he must obtain a sinusoidal system of three-phase voltages.

The teaching methodology is:
- By the teacher: Facilitate learning by exposing topics, perform calculation exercises during class, encourage group discussion of the topics covered and facilitate learning through practical examples.

- By the student: Carry out research, technical readings and articles in English, review standards, solve tasks, present in English, prepare projects as a team (of two people) and write reports on the construction of projects.

The course is divided into 5 topics with a total of 64 hours of theory, it consists of four partial exams which make up 80% of the total grade, the remaining twenty percent corresponds to learning activities related mainly to the construction of the project and report writing.

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. Magnetic field (14 h) | At the end of the unit, the student will be able to analyze the properties and characteristics of a magnetic field and the relationship with the electric field to know the importance that both have in the operation of a direct current motor through the detailed analysis of a linear motor and the mathematical model of the permanent magnet motor through the presentation of concepts by the teacher. | Specific educational content:<br>1.1.- Definition and properties of a magnetic field.<br>1.1.1.-Gauss's law of magnetism.<br>1.1.2.-Magnetic flux.<br>1.2.- Movement of a charged particle in a magnetic field.<br>1.3.- Magnetic force on a conductor that carries an electric current.<br>1.4.- Voltage induced in a conductor that moves in the presence of a magnetic field.<br>1.5.- Analysis of the operation of a linear machine in a permanent transitory stage.<br>1.6.- Calculation of the efficiency of a linear motor.<br>1.7.- Moment on a loop inside a uniform magnetic field.<br>1.8.- Operating principle of the DC motor.<br>1.9.- Model and dynamic analysis of the DC motor.<br>1.8.- Hall effect and applications.<br><br>**Learning activities:**<br>Exercises in class.<br>Study of the standard NOM-008-SCFI-2002 General System of Measurement Units (or the current version).<br>Analysis of the history of electricity and |

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| | | | magnetism.<br>The student will know how the speed, induced voltage and current behave in a linear motor when faced with changes in load and voltage.<br>Analysis of the model of a DC motor using Matlab-Simulik and will submit a report (1 point)<br>The student must go to the electrical machines laboratory and review the operation of a permanent magnet DC motor.<br>Design and construction of a DC motor armature that produces a torque and speed proposed by the teacher (1 point).<br>Symbology learning.<br>Establishment of design criteria for an armature.<br>Review and translation of videos related to the cd engine available at www.learnEngineering.org<br>Completion of laboratory practices |
| 2 | 2. Magnetic circuits (13 h) | At the end of the unit, the student will be able to calculate magnetic circuits with magnets as a source of magnetomotive force so that the student can perform calculations for the construction of a permanent magnet DC motor by analyzing the magnetic field density with which the armature conductors will interact at through the presentation of theoretical concepts by the teacher. | **Specific educational content:**<br>2.1.- Magnetic properties of matter.<br>2.2.- Ferromagnetism, paramagnetism and diamagnetism.<br>2.3.- Hysteresis and magnetic saturation.<br>2.3.1.- Soft and hard materials.<br>2.4.- Magnetic permeability of materials.<br>2.5.- Research trends in new magnetic materials.<br>2.6.- Permanent magnet.<br>2.6.1.- Magnetomotive force, flux and reluctance.<br>2.6.2.- Analogy between magnetic and electric circuits.<br>2.6.3.- Magnetic circuits with permanent magnet and effect of the air gap distance.<br>2.7.- Magnetic model of a DC motor.<br>**Learning activities:**<br>Reading and presentation in English of an article related to new magnetic materials that the student must obtain from www.sciencedirect.com or www.scopus.com (1 point).<br>Reading the magnetic field density of a neodymium air core magnet.<br>Analysis of a magnetic circuit.<br>Design and construction of a permanent magnet DC motor that performs with the torque and speed proposed by the teacher (1 point).<br>Research on permeability of magnetic materials.<br>Establishment of design criteria for the DC motor.<br>Completion of laboratory practices |
| 3 | 3. Electromagnetic circuits (18 h). | At the end of the unit, the student will be able to calculate electromagnetic circuits with windings that conduct a current as a source of magnetomotive force so that the student can perform calculations for the construction | **Specific educational content:**<br>3.1.- Biot-Savart Law.<br>3.1.1.- Magnetic field density at the center of a square loop.<br>3.1.2.- Magnetic field density outside a square |

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| | | of a shunt-connection DC motor through the explanation of concepts by the teacher. | loop.<br>3.1.3.- Magnetic field density at the center of a circular loop.<br>3.1.4.- Magnetic field density in an axis that passes through the center of a circular loop.<br>3.1.5.- Magnetic field density along the axis that passes through the center of a solenoid.<br>3.1.6.- Magnetic force between two parallel conductors.<br>3.2.- Ampere's Law.<br>3.3.- Magnetic field of a solenoid.<br>3.4.- Magnetic field of a toroid.<br>3.5.- Multilayer solenoids.<br>3.6.- Displacement current.<br>3.7.- Generalization of Ampere's law.<br>3.8.- Electromagnetic circuits.<br>3.8.1.- With a single winding.<br>3.8.2.- With more than one winding.<br>3.9.- Energy stored in a magnetic field.<br>3.10.- Magnetic force.<br>3.11.- Operating principle of devices that switch by magnetic action (relays, solenoid valves, etc.).<br>**Learning activities:**<br>Exercises in class.<br>Design and construction of an electromagnetic circuit to supply a magnetic field to a DC armature.<br>Design and construction of a shunt connection DC motor that performs with the torque and speed proposed by the teacher (1 point).<br>Laboratory practices realization.<br>Written report on the design and construction of a shunt connection DC motor that performs with the torque and speed proposed by the teacher (1 point).<br>Establishment of design criteria for the DC motor.<br>Analysis and design of an electromagnet. |
| 4 | 4. electromagnetic induction (7 h) | At the end of the unit, the student will be able to know induction Faraday's law and Lenz's law to analyze the principle of operation of electromagnetic and electromechanical components through presentation of concepts by the teacher. | **Specific educational content:**<br>4.1.- Basic concepts of alternating current.<br>4.2.- Faraday's Law.<br>4.3.- Lenz's Law.<br>4.4.- Operating principle of the electric generator.<br>4.5.- Operating principle of the transformer.<br>4.5.1.- Transformer equation.<br>4.6.- Operating principle of an induction motor<br>4.7.- Eddy current losses and core losses.<br>4.8.- Operating principle of the induction furnace.<br>4.9.- Magnetic levitation.<br>4.10.- Maxwell's equations.<br>**Learning activities:**<br>Design and construction of a three-phase AC generator (1 point).<br>Report on the design and construction of a three-phase AC generator (1 point).<br>Laboratory practices realization. |

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| | | | Analysis of the ideal transformer.<br>Analysis of the principle of alternating current generation.<br>Analysis of the principle of electromagnetic induction.<br>Review and translation of videos related to the transformer, synchronous generator and eddy currents, available at www.learnEngineering.org.<br>Design and construction of a low power single-phase transformer.<br>Analysis and design of a Tesla coil. |
| 5 | 5. Inductors and RLC circuits in direct and alternating current. (12 h) | At the end of the unit, the student will be able to know self-induction as a consequence of a change in current over time to analyze the effect on RL and RLC circuits through explanation of concepts by the teacher | **Specific educational content:**<br>5.1.- Definition of self-inductance.<br>5.2.- Mutual inductance.<br>5.3.- Relationship between voltage and current for a resistance, inductance and capacitance<br>5.4.- Resistive circuit in DC and AC.<br>5.5.- RL circuit in DC and RL circuit in AC.<br>5.6.- Resistances and reactance. The concept of impedance in series and parallel.<br>5.7.- The concept of phasor.<br>5.8.- RLC circuit before DC and AC.<br>5.9.-Transfer function.<br><br>**Learning activities:**<br>Solution of RL circuit in CD using differential equations and Laplace transform.<br>Digital simulation of an RLC circuit.<br>Laboratory practices realization. |

## E. EVALUACIÓN

The summative evaluation proposal for the training space is shown below. According to it, students will receive an ordinary grade. This subject reports four partial grades before the ordinary final grade, the percentages and weighting are as shown in Table 1. The learning activities that are indicated with a value of one point are mandatory for all groups of the subject. Additionally, the teacher will leave learning activities that he considers necessary and will be mandatory for the right to exam, the learning activities with right to exam can be chosen from those shown in the general didactic planning. The exam includes the topics developed by the teacher in class and the result of the learning activities developed by the student.

Table 1.

| # | Time of evaluation | Proposal for the summative assessment of learning | Evaluation percentage |
|---|---|---|---|
| 1. | Evaluation of the first part according to the College calendar. The first subject of the course is evaluated. | Simulation in MATLAB 1 point<br>Construction of an armature 1 point<br>Written exam 8 points | 25 % |
| 2. | Evaluation of the second partial exam according to the College calendar. The second subject of the course is evaluated. | Presentation of an article 1 point<br>Construction of a permanent magnet DC motor 1 point<br>Written exam 8 points | 25 % |

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|---|---|---|---|
| 3. | Evaluation of the third part according to the College calendar. The third subject of the course is evaluated. | Construction of a shunt DC motor 1 point<br>DC Motor Design Written Report 1 point<br>Written exam 8 points | 25 % |
| 4 | Evaluation of the partial quarter according to the College calendar. The fourth and fifth subject of the course is evaluated. | Construction of the three-phase generator 1 point<br>Written report of the construction of the generator 1 point<br>Written exam 8 points | 25 % |

| | |
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| **Ordinary final evaluation** | The ordinary grade will be the sum of all the evaluation points referred to in Table 1 multiplied by the evaluation percentage. The grade will be reported based on 10 and will proceed according to the Examination Regulations to declare the subject accredited or, if appropriate, EE or ET. The evaluation value is 100% |
| **Extraordinary evaluation** | Written exam. 100% of the topics and the result of the learning activities of this training space will be evaluated. The value of this evaluation is 100% |
| **Sufficiency Title evaluation** | Written exam. 100% of the topics and the result of the learning activities of this training space will be evaluated. The value of this evaluation is 100% |
| **Regularization evaluation** | Written exam. 100% of the topics and the result of the learning activities of this training space will be evaluated. The value of this evaluation is 100% |

## F. BIBLIOGRAPHIC AND DIGITAL RESOURCES

**BASIC TEXTS:**

1. Raymond Serway, Jewett, Jonh W Física: electricidad y magnetismo 9a ed, Cengage, 2016.
2. Tipler Paul Allen, Mosca Gene; Física para la ciencia y la tecnología 6a ed, Reverté, 2010.
3. Giancoli Douglas C, Física para universitarios 3a edición, Pearson Educación, 2002.
4. Boylestad Robert L. Introducción al análisis de circuitos, Pearson Educación, 2011
5. Young Hugh D., Freedman Roger A, Sears y Zemansky. Física universitaria 12a ed, Pearson Educación, 2009.
6. Resnick Robert, Halliday David, Krane Kenneth S., Física 4a ed. CECSA, 2002.
7. Chapman, Stephen J., Máquinas eléctricas 5a ed, McGraw Hill, 2012
8. Philip R Coursey (1918), Simplified Inductance Calculations, with Special Reference to Thick Coils, Proc. Phys. Soc. London, 31 155-167
9. Martínez, J. R. (2007). Francisco Javier Estrada, el físico mexicano más notable y olvidado del siglo XIX. Lat. Am. J. Phys. Educ. Vol, 1(1), 101.
10. Coltman, J. W. (2002). The transformer [historical overview]. IEEE Industry Applications Magazine, 8(1), 8-15.

ELECTRONIC ADDRESSES OF INTEREST:

www.scopus.com
www.sciencedirect.com
https://ocw.mit.edu/courses/physics/8-02-physics-ii-electricity-and-magnetism-spring-2007/class-slides/
www. learnEngineering.org
https://ieeexplore.ieee.org/Xplore/home.jsp

# CURRICULAR AND SCHOOL DATA

| Area | Line | Type of credit | Type of formation space | Language of instruction | Method of delivery |
|---|---|---|---|---|---|
| Basic (Math & Basic Sciences) | 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 | Presential hours of practice per week | Hours of autonomous student work per week | Credits per agreement 17/11/17(before 279) |
|---|---|---|---|---|---|
| 3 | 16 | 4 | 1 | 9 | 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 Electricity and Magnetism A (key 5567) |

## 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 and Electrical and Automation 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 academic and professional training and experience that the profile of the teacher who teaches this training space must meet, and that must be considered in the hiring and training of the teacher, is:

**Formation and academic experience**

- Electrical Mechanical Engineer or Electricity and Automation Engineer or related career with Master's or doctorate studies.

**Formation and professional and work experience**

- The teacher must have experience in the subjects of the courses.

**The teacher's role**

The teacher will have the task of facilitating the student's learning in the course topics, as well as providing the necessary theoretical tools for the student to develop the projects. He will monitor the activities carried out by the student through reviews of the projects. He will issue a grade in each part according to the percentages established in Table 1.

## 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 | M. Eng. Aurelio Hernández Rodríguez |
| | PhD. Beatriz Morales Cruzado |
| | |