UNIVERSIDAD AUTÓNOMA DE BAJA CALIFORNIA

COORDINACIÓN GENERAL DE FORMACIÓN BÁSICA
COORDINACIÓN GENERAL DE FORMACIÓN PROFESIONAL Y VINCULACIÓN UNIVERSITARIA
PROGRAMA DE UNIDAD DE APRENDIZAJE

I. IDENTIFICATION DATA

1. **Academic Department**: Faculty of Engineering, Mexicali; Faculty of Engineering, Architecture and Design, Ensenada; and School of Sciences of Engineering and Technology, Valle de las Palmas.

2. **Study Program(s):** Bioengineering

3. **Syllabus Validity:** 2020-1

4. **Name of Learning Unit:** Principles of Bioelectric Measurements

5. **Code**: 36234

6. **HC:** 01 **HL:** 02 **HT:** 01 **HPC:** 00 **HCL:** 00 **HE:** 01 **CR:** 05

7. **Stage of formation to which belongs**: Disciplinary

8. **Type of Learning Unit**: Obligatory

9. **Requirements for enrollment in learning unit:** Electricity and Magnetism

UNIVERSIDAD AUTÓNOMA DE BAJA CALIFORNIA
REGISTRADO
22 MAR 2019
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COORDINACIÓN GENERAL DE FORMACIÓN BÁSICA

PUA Formulated by: **Signature**

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II. GENERAL PURPOSE OF THE COURSE

The purpose of this course is to know the principles of electrical measurement techniques and apply them in typical circuit scenarios that are found in the practice of bioengineering; These electricity and bioelectricity scenarios consist of power sources, standard components and distribution elements.

This course will form quantitative skills and tools in the student, as well as give him a certainty to obtain correct measurements that will help him to advance in the aspects of biomedical instrumentation. The course is taught in the disciplinary stage, is mandatory and requires prior course of the subject of Electricity and Magnetism, it is also recommended to master the English language and contributes to the area of knowledge of Engineering Sciences.

III. COURSE COMPETENCIES

Apply electrical measurement techniques through scientific knowledge, technological principles and the proper use of measuring instruments, to make measurements with the least possible error, with a responsible attitude and confidence.

IV. EVIDENCE OF PERFORMANCE

1. Development of practices in the laboratory.
The report related to each practice must be delivered in the specified format and include: cover, introduction, objective, theoretical framework, experimental development, discussion of results, conclusions and bibliographical references.
2. Portfolio of evidences that includes the solution of exercises and problems induced in workshops, tasks and research work.

V. COURSE CONTENT DISTRIBUTION

UNIT I. Fundamentals of applied electricity

Student Competence:

Interpret the concepts and principles of applied electricity, based on the use of scientific foundations, instrumentation, technology and theoretical-practical methods, for the solution of everyday problems and of engineering, with responsibility and willingness for collaborative work.

Content: **Duration:** 3 hours

1.1 Units of electrical measurements
1.2 Concepts of applied electricity
    1.2.1 Voltage, current and power
    1.2.2 Direct current (DC) and alternating current (AC).
1.3 Identification of electrical and electronic components, symbols, physical appearance (encapsulation) and function (model).
    1.3.1 Passive components
    1.3.2 Active components (semiconductors)
    1.3.3 Instruments for measuring passive components
1.4 Block and schematic diagram: how to read interconnectivity.

UNIT II. Electrical measurement instruments

Student Competence:

Use measurement instruments for relevant electrical magnitudes in the industrial and professional field, following the recommendations of the equipment manuals, to obtain data in a correct and precise way, with a practical attitude, responsible, with order and confidence.

Content: **Duration:** 3 hours

2.1 Instruments that compose a basic measurement bench.
- 2.1.1 Ammeters, voltmeters, ohmmeters
- 2.1.1 Power supply
- 2.1.2 Bench multimeter
- 2.1.3 Oscilloscope
- 2.1.4 Function generator
- 2.1.5 Handheld multimeter.

2.2 PC interface for data communication.
2.3 Error estimate
2.4 Limits of operation and protection circuits

UNIT III. Measurement of voltage and current in circuits

Competence:

Use the measurement method and the appropriate instrument for a particular application, through the assembly of a measurement experiment, for the data recording of a physical magnitude, with order and responsibility in compliance with safety and hygiene standards.

Content: **Duration:** 4 hours

3.1 Measurement of DC and AC voltage and current.
3.2 Electrical impedance, measurement of RC circuits, transient and frequency response.
3.3 Sources of noise and error
3.4 Functional characteristics to express the relationship between measurements of two values: Decibel, amplification and signal-to-noise ratio.

UNIT IV. Introduction to bioelectricity and electrical measurements in the human body

Competence:

Classify the various bioelectrical potentials related to the systems of the human body through the analogy with electrical systems, to understand their clinical applications, with an attitude of service and respect.

Content: **Duration:** 2 hours

4.1 Ion current flow, resting potential, and Nernst-Planck equation
4.2 Model of equivalent circuit of cells, tissues and organs
4.3 Action potential and surface body potentials
4.4 Types of electrodes and clinical applications
4.5 Bioimpedance and applications

UNIT V. Tools for electronic design automation.

Competence:

Virtually measure complex circuits, using software tools focused on the design of semiconductors and electronic products, to simulate the functionality of the components, with an honest, creative and proactive attitude.

Content: **Duration:** 2 hours

5.1 Schematic capture software
5.2 Software for circuit simulation
5.3 Software for manufacturing planning

UNIT VI. Instrumentation systems

Competence:

Classify the electrical transducers, choosing and coupling the suitable characteristics to be measured and recorded, to convert physical magnitudes such as temperature, pressure, flow, force and others into electrical signals, with an orderly and responsible attitude.

Content: **Duration:** 2 hours

6.1 Electrical transducers and transducer selection.
6.2 Signal conditioning and processing.
6.3 Digital analog conversion, sampling, quantization and coding.
6.4 Data acquisition system.

VI. STRUCTURE OF WORKSHOP PRACTICES				
Practice No.	**Proficiency**	**Description**	**Support materials**	**Duration**
UNIT I				
1	Identify the electrical components and use their mathematical model, through the revision of specifications and the solution of exercises, to demonstrate their existence and function, with order and attitude of analysis.	Identification of electrical and electronic components, symbols, physical appearance (encapsulation) and function (model). and how to know the connectivity in schematics.	Devices provided by the teacher. Exercises Calculator Notes	3 hours
UNIT II				
2	Ensure the proper conditions of the measuring instruments, through the procedures of the operation manual, to reduce the risk and the measurement error, with responsibility, order and confidence	Understand the Instruments that compose a basic measurement bench. Review manuals of the power supply, bench multimeter, oscilloscope, function generator and handheld multimeter.	Equipment operation manuals	3 hours
UNIT III				
3	Solve circuits conditions, through the methodology of linear circuits, to compare the results with those obtained in the experimental measurement, with an attitude of attention to the environment and order.	DC and AC voltage and current circuits exercises. Calculation of electrical impedance in RC circuits, expression of the relationship between measurements of two values: Decibel, amplification and signal-to-noise ratio.	Exercises Calculator Notes	4 hours
UNIT IV				
4	Recognize and discuss various clinical applications of biopotentials, through the relationship with the systems of	Calculations using the Nernst-Planck equation, demonstration of electrode types and various clinical applications.	Exercises Calculator Notes Presentation of biomedical	2 hours

	the human body, to understand the applications of bioelectricity, with an attitude of service and respect.		equipment	
UNIT V				
5	To learn the software tools for design of electronic products, through the revision of specifications and demonstrations of the suppliers, for the manufacture of a circuit sample, with honest, creative and proactive attitude.	Review of the schematic capture software for simulation of circuits and for the realization of a printed circuit board.	Specifications and demonstrations of commercial software, and example of a proposed circuit. Workshop manual Projector Computer Programming software Data storage unit	2 hours
UNIT VI				
6	Compare electrical transducers, to measure temperature and pressure, reviewing the convenient characteristics to be recorded and measured in a data acquisition system, with an orderly and responsible attitude.	Evaluation of pressure and temperature transducers, and low-cost data acquisition modules: National Instruments (USB-6009), Digilent (Analog Discovery)	Manufacturer data sheets	2 hours

VI. STRUCTURE OF LABORATORY PRACTICES				
Practice No.	**Proficiency**	**Description**	**Support materials**	**Duration**
UNIT I				
1	Be informed of the harmful effects of electric current on the human body by reviewing the established limits to realize the importance of working with safety measures, with responsibility.	The student will be previously provided with a reading about the rules regarding electrical safety. In the laboratory, students will be shown what happens to different sensitive materials when they are subjected to high enough currents to burn, emit light or deform materials. The student must present a report with his conclusions of the reading and what he observed in the experiment.	Readings. Current source. Ampmeter Materials sensitive to electric current	2 hours
2	Use the DVM, the capacitance meter and the inductance meter to make measurements of electrical components through the proper use of instruments, with responsibility and willingness to work in teams.	Different passive components will be provided for the student to measure their value with the corresponding device.	Capacitor meter Inductance meter Handheld multimeter Equipment manuals Passive components	2 hours
3	Verify the proper functioning of electrical circuits by following schematic diagrams to configure future measurement experiments with responsibility and in an orderly manner.	The student will be provided with an electrical circuit diagram to perform the physical interconnection of the components in the breadboard. It will be verified that the student performs a suitable circuit wiring, and as part of the review will be asked to perform continuity tests to verify the connections.	Power supply, multimeter, cables for connection, breadboard, capacitors, resistors and LED.	2 hours
UNIT II				

4	Apply electrical measurement techniques by using the direct current power supply, the bench multimeter, oscilloscope and function generator, to identify the different electrical parameters, working orderly and with discipline.	Students will be provided with diagrams of simple circuits that they must assemble in the breadboard and perform the measurement of different parameters of the same.	DC power supply, bench multimeter, oscilloscope, function generator, breadboard and different circuit elements. Documents: use of the DC power supply, multimeter, function generator and oscilloscope	4 hours
UNIT III				
5	Measure typical electrical circuits using the methodology for the operation of measuring instruments, to compare the results of their measurements with the calculated values using mathematical models, with reflective and ordered attitude according to the safety and hygiene standards of the laboratory.	Students will be provided with a direct current circuit diagram that they will have to assemble and measure voltage and current in different points on it.	Measuring equipment (basic bench) Practices manual	2 hours
6		Students will be provided with an alternating current circuit diagram that they will have to assemble and measure voltage and current in different points on it.	Measuring equipment (basic bench) Practices manual	2 hours
7		Students will be provided with an alternating current circuit diagram that they will have to assemble and measure the impedance at different points on it.	Measuring equipment (basic bench) Practices manual	2 hours
8		Students will be provided with a circuit diagram that must assemble and feed with a square signal in such a way to observe its transient response in the oscilloscope.	Measuring equipment (basic bench) Practices manual	2 hours
UNIT IV				
9	Apply an appropriate level of alternating current to the human body, to obtain the measurement of the impedance Z (module and phase between current and associated electrical voltage), with the help of an array of surface	Students will carry out the measurement of their electrical impedance safely. For this, they will be previously provided with readings that indicate how the measurement is carried out safely.	Measuring equipment (basic bench) Practices manual Electrodes Gel Alternating current source Oscilloscope	4 hours

	electrodes in a range of frequencies, following the rules of safety and hygiene of the laboratory.			
UNIT V				
10	Use the basic functions of schematic editing, to create your own electrical diagrams by using software in an orderly and efficient way.	The teacher will explain how to edit a circuit using the software and the student will execute these steps simultaneously. Then the student will be asked to do the editing of a given circuit.	Practice manual Projector Computer Pspice Software	2 hours
11	Observe the behavior of the energized components, by means of the Pspice simulator, for the correct use in applications, in a disciplined and efficient way.	Various circuits will be provided for the student to edit and simulate in the software.	Practice manual Projector Computer Pspice Software	2 hours
12	Design the template of a PCB board of a given circuit through the use of software and then proceed to its manufacture with a creative and proactive attitude.	The fabrication and soldering of a given printed circuit will be made, from its edition in the software to the placement of its components. Then its operation will be verified by continuity tests, and by observing its response in the oscilloscope.	Practice manual Projector Pspice Software Computer and printer Copper plate Ferric acid Various components Multimeter Oscilloscope	4 hours
UNIT VI				
13	Analyze the transduction of physical magnitudes, by using electrical measuring equipment to obtain an estimate of the state of a system or process, in an orderly and systematic manner.	Temperature sensors, pressure and the necessary electronics will be used to observe in the measuring devices how the voltage varies when the input to the sensors varies.	Pressure sensor Temperature sensor Various components Protoboard Multimeter Oscilloscope	2 hours

VII. ASSESSMENT METHODS

Course frame of reference:
On the first day of class, the teacher must establish the form of work, evaluation criteria, quality of academic work, and the rights and obligations of teacher and student.

Teaching strategy (educator):
Through the presentation by the teacher in an orderly and consistent manner, the student will receive the fundamentals concerning the methods of measuring components in simple electrical circuits. In workshop sessions, practical exercises will be developed on the blackboard with the participation of the students, in which they identify and explore the basic concepts; following with dynamics in working groups for the solution of exercises, being the teacher a monitor and guide of these. Finally, schoolwork exercises are recommended in individual and team modalities. In addition, laboratory practices of the topics seen in class will be carried out.

When new concepts are presented in class, it is advisable to have a work circle before the end of the session, where the students make a feedback of the class by describing the concepts and applying them.

Learning strategy (student):
Through teamwork, workshop and experimental sessions, the student applies the concepts, principles and laws that govern the phenomena of electricity and magnetism in the study of a system of this nature. The reports and the logbook, elaborated in strict adherence to reflection and criticism, will position the student in full recognition of the acquired skills that, together with a research process, make him able to execute and present the calculations and measurements made in an electric or magnetic circuit.

VIII. EVALUATION CRITERIA

The evaluation will be carried out permanently during the development of the learning unit as follows:

Accreditation criteria

- 80% attendance to have the right for ordinary exam and 70% attendance to be entitled for extraordinary examination according to the School Statute articles 71 and 72.
- Scores are scaled from 0 to 100, with a minimum approval of 60.

Evaluation criteria

Partial evaluations (4) 60%
- Evidence of performance 1 ..... 15%
  (Reports in electronic format of laboratory practices)
- Evidence of performance 2 ..... 15%
  (Preparation of a log in electronic format)
- Homeworks and teamwork 10%

Total 100%

IX. BIBLIOGRAPHY

Required

Gibilisco, S. (2018). *Beginner's Guide to Reading Schematics* (4th ed.). México: McGraw-Hill

Gibilisco, S., y Monk, S. (2016). *Teach Yourself Electricity and Electronics* (6th ed.). México: McGraw-Hill

Grimnes, S. (2014). *Martinsen, Ørian. Bioimpedance and bioelectricity basics* (3th ed.). Germany: Academic Press

Platt, C. (2014). Encyclopedia of Electronic Components *1: Resistors, Capacitors, Inductors, Switches, Encoders, Relays* (1st ed.). United States: Maker Media

Platt, C., y Jansson, F. Encyclopedia of Electronic Components *2*: *LEDs, LCDs, Audio, Thyristors, Digital Logic, and Amplification*. United States: Maker Media

Tsividis, Y. (2002). *A first lab in circuits and electronics*. United States: Wiley [clásica]

Suggested

Regtien, P. P. L. (2004). *Measurement Science for Engineers*. United States: Butterworth-Heinemann [clásica]

Webster, J. G. *Measurement, instrumentation, and sensors handbook: spatial, mechanical, thermal and radiation measurement* (2nd ed.). United States: CRC Press

X. PROFESSOR PROFILE

The teacher of this subject must have initial training in Engineering, in Physics or related area, Master or Doctorate in Science or Engineering. Professional experience in the area of Bioengineering or Electronics and as a teacher in the area of Bioengineering. In addition, it must manage information technologies, communicate effectively and facilitate collaboration. Be a proactive, innovative, analytical, responsible person, with a high sense of ethics and capable of proposing methodical solutions to a given problem, with a vocation of service to teaching.