COURSE OUTLINE

(1) GENERAL

SCHOOL	ENGINEERING		
ACADEMIC UNIT	ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	**ECE_K550**	**SEMESTER**	**5**
COURSE TITLE	MEASUREMENT SYSTEMS AND SENSORS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	2	
Seminars /Practice exercises	1	
Laboratory	1	
Total	**4**	**5**
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (4).		

COURSE TYPE *general background, special background, specialised, general knowledge, skills development*	Special background
PREREQUISITE COURSES:	No. It is suggested for the students to have adequate knowledge on physics, electrical circuit analysis, analog and digital circuit design
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	https://www.ece.uop.gr/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning*

and Appendix B

- *Guidelines for writing Learning Outcomes*

The measurement process that ensures the objectivity and the accuracy of engineer's actions has moved from the laboratory regime and has acquired an effective role in industrial applications, as well as in every-day life. Among others, it performs control of processes operation, quality control, accuracy of production processes, parameters analysis and manages the processes in order to adjust and improve the operation of several systems. Modern measurement systems have to encounter the ever-increasing number of parameters to be measured, as well as the requirement for continuously quality and accuracy improvement. The growth of electronics and informatics has contributed in a large extent towards this direction, since several complex processes are currently implemented in integrated circuits and systems.

The objective of the course is the thorough examination of the theory and the practice of physical parameters measurement and sensors. In order to achieve that, the basic theory of measurements is combined with sensors technology and electric, electronic circuit theory and applications, as well as with display and recording devices technology, data acquisition and processing systems.

The course starts with an introduction to sensors and systems for measuring and controlling physical parameters. Several signal conditioning and matching techniques are studied, based on both passive and active circuits. After that, we put effort to understand in detail the operation and the technology of several sensors for measuring physical parameters, such as temperature, displacement, proximity, velocity, acceleration, strain, force, weight, volume, liquid-level, pressure and we present case studies of measurement and control applications. Basic methods and systems for display and recording devices for measurement data, as well as transmission systems, sample and hold circuits and multiplexing methods and systems, are studied. Emphasis is given on methods and standards regarding the interface of measurement systems with computing systems and on software tools for measurement data acquisition and processing.

Keywords: Measurement systems, control systems, sensors, data acquisition and processing systems.

Learning Outcomes

After the successful completion of the course, the students will be able to:

1. understand the basic principles of measurement systems and sensors,
2. understand the operations and the needfulness of passive and active circuits for conditioning and matching of sensors' signals,
3. understand the operation and the indispensability of analog-to-digital and digital-to-analog signal converters,
4. understand the operating principles and the fabrication technology of several sensors for measuring physical parameters such as temperature, displacement, proximity, velocity, acceleration, strain, force, weight, volume, liquid-level, pressure,
5. experiment with applications of several modern sensors,
6. know basic methods and systems for displaying and recording measurement data, measurement transmission systems, sample and hold circuits, as well as multiplexing systems for measurement data,
7. handle interface methods and standards between measurement and computing systems, analog and digital I/O boards, as well as software tools for measurement data acquisition and processing,

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Decision-making
- Working independently
- Team Work
- Production of free, creative and inductive thinking

(3) SYLLABUS

The course lectures cover the following thematic areas:

1. Introduction to sensors, introduction to measurement and control systems, sensors and their applications, use of sensors in measurement and control systems, measurement systems, open- and close-loop control systems, mean value and standard deviation of measurements, measurements distribution.

2. Sensor and measurement systems principles and characteristics: operating range, accuracy, types of error, linearity, sensitivity, resolution, hysteresis, repeatability, dead zone, response, drift, time of operation, reliability, stability.

3. Signal conditioning and matching with passive circuit techniques: signal conditioning and matching basics, signal conditioning with potentiometer and Wheatstone bridge, matching for maximum output voltage, matching for maximum load power, maximum load power through transformer.

4. Signal conditioning and matching with active circuit techniques I: active circuits, operational amplifier, ideal operational amplifier, inverting and non-inverting amplifier, isolator, adder, difference amplifier, instrumental amplifier.

5. Signal conditioning and matching with active circuit techniques II: integrator, differentiator, current to voltage and voltage to current converters, voltage comparator, analog-to-digital (A/D) and digital-to-analog (D/A) signal converters.

6. Temperature measurement: liquid-in-glass and liquid-in-metal thermometers, bimetallic strip, bimetallic thermometer and thermostat, electrical resistance thermometer, thermistor, Seebeck effect, thermocouple, radiation thermometers, pyrometers.

7. Motion parameters measurement I: motion parameters measurement basics, displacement measurement instruments, linear potentiometer, linear variable differential transformer (LVDT), variable area capacitor, measurement and sensors for linear and rotary displacement (rotating potentiometer, absolute optical decoder, incremental optical decoder, absolute optical decoder).

8. Motion parameters measurement II: DC and AC tachometers, proximity sensors (microswitches, variable magnetic resistance sensor, Hall effect sensor, optical proximity sensors), accelerometers (seismic accelerometer, piezoelectric accelerometer), strain gauge, weight and force sensors.

9. Liquid-level measurement: liquid-level measurement typical methods, mechanical and electrical floater sensor, capacitive probe, conductive probe, ultrasonic level transceiver, air bubble level sensor, level measurement with pressure sensors.

10. Pressure sensors: pressure measurement methods, liquid manometers, Bourdon pipe, elastic pressure sensors, capacitive pressure sensors, piezoelectric pressure sensors, pressure sensors with strain gauges, barometers.

11. Display and recording devices for measurement systems: analog display devices, moving-coil and moving-iron meters, ohmmeter, oscilloscope, digital display devices with light-emitting diodes (LED) and liquid crystal displays (LCD).

12. Measurement data acquisition and processing systems I: basic principles of data acquisition and processing systems, measurement transmission systems, sampling, hold and sampling circuits, multiplexing and multiplexers.

13. Measurement data acquisition and processing systems II: serial and parallel computer interface for measurements systems, direct interface, IEEE and RS232 standards, analog and digital DAQ boards, measurements data acquisition, software tools for data acquisition in industrial environment and production control.

The practical part of the course includes:

Practical study of temperature sensors (thermocouple, thermistor, RTD), practical study of variable linear differential transformer and strain gauge, practical study of analog-to-digital (A/D) and digital-to-analog (D/A) signal converters, practical exercises on the software tool Labview (programming with graphical user interface environment and virtual instruments, DAQ boards).

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face in-class lecturing
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	• Slides (ppt) of the presentation of the theoretical part of the course, which will be available from the beginning of semester through e-Class. • Combined use of projector (for slides) as well as of whiteboard. • Guidelines for the practical exercises (one for each exercise), which will be available from the beginning of the semester through e-Class. • Homework assignments after the completion of each exercise. • Support of teaching procedure through the e-Class platform (notification of the teaching procedure, distribution of slides, supplementary material, announcements, relative links and literature, provision of test and the final examination) • Specialized software and hardware relevant to the course.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS.*	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other*	Evaluation of theoretical part through final written exam that includes solving exercises, multiple choice questions, comparative evaluation of theory elements. Evaluation of the practical part through the homework assignments, a semester mid-time short written exam that includes solving exercises and multiple choice questions and a final exam that includes a written exam (solving exercises and multiple choice questions) as well as a short practical part. The final grade is the weighted result of the grades of the theoretical part and the practical part of the course. The weights are defined and the beginning of each semester and they will be announced via e-Class.

Activity	***Semester workload***
Lectures	26
Seminars / Practice exercises	13
Laboratory	13
Practical exercises preparation and homework assignment	24
Study of lectures and bibliography	49
Course total	**125 hours (5 ECTS)**

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.	The final exams are in Greek language. The examination process and the evaluation criteria are publicly available to the students through e-Class.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

1. C. Kalaitzakis, E. Koutroulis, Electrical measurements and sensors, Klidarithmos, 2010.
2. C. Kalovrektis, N. Katevas, Sensors for measurement and control, Tziolas, 2018.
3. P. Elgar, Sensors for measurement and control, Tziolas, 2003.
4. S. Boultadakis, I. Kalomiros, Hardware and software for measurements: Examples and applications, Tziolas, 2009.
5. C. Kalovrektis, Labview for engineers: Programming DAQ systems, Tziolas, 2007.
6. W. Nawrocki, Measurement Systems and Sensors, Artech House, 2005.
7. J. Fraden, Handbook of modern sensors, Springer, 2004.

- Related academic journals:

1. IEEE Transactions on Instrumentation and Measurements.
2. IEEE Sensor Journal
3. Measurement: Sensors, Elsevier
4. Sensors Review: The International Journal of Sensing for Industry, Emerald
5. Measurement Science and Technology, IOP Science