Module code: ELEN4006A	**Pre-requisites:**ELEN3002, ELEN3012,ELEN3016
Module name: Measurement Systems	**Co-requisites:** none
SAQA Course credits: 15	**CESM:** 080901
ECSA Course credits: 13	**Date of Last Revision:** Jan 2018

Module objectives
The purpose of this course is to form a bridge between the subjects of the previous three years and the design and laboratory projects. Sensors and condition elements are covered and the main emphasis is on analysis, visualization and modelling of measurement systems. Such systems are widely used in the engineering field almost before anything can be built or design measurements need to be taken. Thus measurements systems are integral engineering works.

Module outcomes

After successful completion of this course, students should be able to design, analyse, model complex measurement systems and communicate the work using the following:

Knowledge:

Apply knowledge of mathematics, basic science and engineering sciences from first principles to solve engineering problems

Skills:

Analysis of a measurement system and identification of important and critical components, calibration of a measurement system and the concept of traceability, identify, analyse and rectify: the effects of deterministic or systematic errors in a measurement system, random error in a measurement system, dynamic errors in a measurement system, the introduction and propagation of noise in a measurement system. Application of bridges, instrumentation amplifiers, analogue to digital (A/D) converters and various transducer technologies in measurement systems. Identify, assess, formulate and solve convergent and divergent engineering problems creatively and innovatively.

Competence with tools:

Demonstrate competence to:

1. Use appropriate engineering methods, skills and tools and assess the results they yield.
2. Use computer packages for computation, modelling, simulation, and information handling.

Assessment outcomes

The student will have reached the outcomes if he/she can:

- Work on a project which is a completely new topic.
- Solve exam problems previously unseen with the application of theory and original thinking.
- Successfully uses mathematics, physics and variety of basic engineering sciences, with the required integration of knowledge, to solve problems in the examination, laboratory, assignments and project.
- Use engineering tools such as but not limited to MATLAB, OCTAVE, SPICE, etc, for modelling, and simulation.
- Conduct data processing, calibration of instruments and perform error analysis.
- Identifies requirements, success criteria and constraints, Gathers, structures and assesses information.
- Performs required analyses, applies knowledge, uses appropriate methods, skills and tools, evaluates options critically and with judgement.
- Assesses the impact of the proposal.
- Communicate the logic and outcome of the work which will be assessed as follows: planning and structure of technical report. Selection of material and accessibility of logic behind the report. Style and use of English
  Accessibility of detailed study information, use of drawings, diagrams, tables, graphs and illustrative material Impact

Communication: The student should be able to communicate effectively, both orally and in writing, with the community at large, using appropriate structure, style and graphical support.	

Assessment

Please note: As the requirements are outcomes based, a student must successfully complete and pass all components, namely Exam, Laboratory and Project and also fulfil all the outcomes. Exam questions that meet the requirements of ECSA ELO 1 and 2 will be grouped together as a component. Failure of one or more of these components will result in failure of the entire course.

Assessment Criteria: On the laboratory work and course project, students must perform set experiments, answer questions posed and hand in short reports by the stipulated deadlines. One of the labs will be of greater extent. Projects are also performed in groups of two but reports are written on an individual basis. Laboratory exercises can be worked on and orally marked in pairs but written submissions are to be done individually. Course project oral presentations shall be done as part of the “workshop” type lectures and marks shall be allocated to these oral presentations. See details in the Lab and Project Briefs.

Examination: Tests fundamental principles, where emphasis is placed on design, application and analysis as opposed to regurgitation of bookwork.

Important: Plagiarism from any source is prohibited and will result in disciplinary steps in accordance with the relevant university policy.

Satisfactory Performance (SP): Examination, project and laboratory work, pass mark (See Rule 13 on the school notice board). The successful completion of the laboratory and project assignments are SP requirements. This rule will be strictly applied. No students (including repeats) will be exempted from the laboratories.

The student must demonstrate proficiency in the use of specialist software in the project. Failure to demonstrate this proficiency will result in failure of the project and failure of the entire course. The project must also be successfully completed which includes the use of fundamental principles to develop a smart measurement system in the course project. (see RuleG13).

Assessment methods and weights

Refer to **Rule G13** on the school’s notice board.

ECSA Exit Level Outcomes

	ELO 1	**ELO 2**	**ELO 3**	**ELO 4**	**ELO 5**	**ELO 6**	**ELO 7**	**ELO 8**	**ELO 9**	**ELO 10**	**ELO 11**
Is this ELO applicable?	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	No	No
On what level is it applicable?	Exit	Exit			Exit	Exit		Exit	Exit		

Description of assessment of applicable ELOs
• **ELO 1:** Problem solving is assessed through writing tests and exams. Exam contains problems that require application of theory, evidence and judgement. • **ELO 2:** Engineering and scientific knowledge are applied during all tests, exams and project. Student can apply basic mathematics and computing knowledge in the laboratory component to develop a model and to use the model to analyse a typical measurement system. Using fundamental principles to develop a smart measurement system in the course project. • **ELO 5:** Demonstrate competence to use appropriate engineering methods, skills and tools, such as but not limited to Octave/Matlab, Pspice, etc in the course project and laboratories for modelling, simulation, processing data, calibration procedures, error analysis. • **ELO 6:** Students should prepare a presentation based on the project, and present it orally. Project reports are written on an individually bases. The report is assessed on background and problem understanding, technical communication, quality of engineering output, critical analysis and evaluation and overall impact. • **ELO 8:** Examination and project report must be conducted individually. Though students will work on the project as a team, they will produce an individual report. Each student should complete their individual contributions to the team for the completion of the course project. There should be evidence of good team work. At the same time students should work independently to produce their individual project reports. • **ELO 9:** Students will independently work on a project from non-lectured material. The project topic is completely new to the students. Individual project reports will be submitted.

Detailed course content

Instrumentation systems concepts and terminology. Static and dynamic properties of measurement systems, calibration. Introduction to statistical techniques for handling measurement uncertainty. Noise. Transducers based on varying R, L, C. Signal conditioning. Thermocouples, piezoelectric transducers.

Prior Knowledge Assumed
All 1st, 2nd and 3rd year electrical engineering courses with emphasis on Physics, Signals and Systems, Electronics, Software and Control.

Lectures: The lectures are run as "workshops" and not the traditional "supply students with information" approach. This is because all the information for the design and analysis of measurement systems is available in data books, web sites and the prescribed text book. What will be discussed is the philosophy and design approach used in developing, analysing and modelling measurement systems with specific emphasis on student originated discussions. To enable students to cope with the "workshop" approach the first few lectures will discuss the modelling of measurement systems. Students are required to bring the prescribed text book to the lectures.

Students are required to provide input to the lecturing process and stay concurrent with the topics. The main content of the lectures will be to discuss project related concepts and problems and marks shall be assigned to the oral presentations presented by the students.

Two lectures per week (double period) plus one (single period) for self-study which may be used (at the discretion of the lecturer) for a lecture or a tutorial. The use of the self-study period for a lecture/tutorial will be announced verbally during the normal lectures. Printed course notes are not handed out. Students are expected to attend all lectures, understand the lecture material and make their own notes.
Tutorials: There are no formal tutorials for this course, but students are advised to do the problems at the end of the relevant chapters in Bentley.

Laboratories: See Lab Brief that will be handed out.

Project: See the Project Brief that will be handed out. The project will be assessed, as required by ECSA, against a problem solving framework (see assessment outcomes).

Satisfactory assessment requires that the student must produce a complete solution with, at most, minor flaws. The School's policy on timely submission of projects and assignments will be enforced.

Recommended textbook(s)

Prescribed textbook:
Bentley, J. P., Principles of Measurement Systems, 4th ed., Harlow, England: Pearson, 2005

Further reading:

- Considine, D.M., Process Instruments and Controls Handbook, McGraw-Hill, 1974.
- Doebeline, E.O., Measurement Systems: Application and Design, 4th Ed., McGraw-Hill, 1990.
- Dally, J.W., Riley, W.F. and McConnell, K.G., Instrumentation for Engineering Measurements, John Wiley, 1984.

Information to support the course

Course home page:
Further information and announcements regarding the course is posted on SAKAI, the course home page at, https://cle.wits.ac.za/portal/site/ELEN4006A_2018.

All students are expected to consult the course home page at regular intervals. Further information and announcements regarding the course will be communicated either via the 4th year notice board, verbal announcements or printed material distributed during lectures or posted on the course home page/SAKAI.

All students are expected to consult the notice board and the course homepage at regular intervals

Course schedule	
Semester	1
Weeks per semester	13
Duration of lecture/tutorial period	45min = 0.75 hr
Number of lectures per week	2
Number of tutorials per week	1
Hours of practicals/labs per semester	13
Other non-contact time per semester (hr)	30

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