MSE4127: SMART SENSORS: FROM ENGINEERING TO APPLICATIONS

Effective Term
Semester A 2023/24

Part I Course Overview

Course Title
Smart Sensors: From Engineering to Applications

Subject Code
MSE - Materials Science and Engineering
Course Number
4127

Academic Unit
Materials Science and Engineering (MSE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
AP3244/MSE3244 Design Laboratory OR
AP3245 Design and Manufacturing Project

Equivalent Courses
AP4127 Smart Sensors: From Engineering to Applications

Exclusive Courses
Nil

Part II Course Details

Abstract

The course provides both fundamental and practical knowledge on sensors and instrumentation techniques suitable for a wide array of scientific and engineering disciplines. Emphasis will be placed on fundamentals but at a level appropriate for the senior undergraduate. Design for both the Applied Physics and Materials Engineering programs, this course addresses the essential area of measurement, including noise mechanisms, sampling theory, and the design of modern instrumentation. Upon completion of the course, students will be able to take better measurements through understanding the inner workings of the instrument and be able to pick the best machine for a given performance target. This is relevant to many areas including electronics, photonics, microscopy, and material characterization. Since the course is tailored for physics and materials science students, it does not require extensive knowledge in electrical engineering and computer programming. In a world where measurement and signal processing systems are wide-spread, this course provides students with the crucial framework to examine the integrity of data and to design various equipment used in industrial, medical, and consumer applications.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Comprehend the science of measurement, in particular sensor architecture and signal-to-noise performance			x	
2	Characterize measurement systems based on static, dynamic, and error properties			x	
3	Comprehend various noise mechanisms and the way in which they are derived from physical means			x	
4	Familiarize with the design, implementation, and application of modern instruments and sensors			x	

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Explain key concepts, such as theories related to smart sensors.	1, 2, 3, 4	3hrs/week

2	Assignment(s)	Requires students to individually, occasionally in group, to solve a series of problems to build analytical and synthesis skills.	1, 2, 3, 4	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignment(s)*	1, 2, 4	15	
2	Midterm(s)	1, 3, 4	35	
3	Examination^	1, 2, 3, 4		Duration 2 hours

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

* Three assignments are normally planned. In the case that it is pedagogically advantageous, a more substantial, multi-part assignment may be given instead, for example, to solidify a major concept.

Assessment Rubrics (AR)

Assessment Task

1. Assignment(s)

Criterion

1.1 CAPACITY to solve an engineering problem related to sensing, e.g., students should be able to answer questions related to sensor design.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Assessment Task
2. Midterm

Criterion
2.1 ABILITY to ANALYSE problems and EXPLAIN engineering concepts related to sensing,
e.g. students should be able to apply their understanding towards a design problem.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
3. Examination

Criterion
3.1 ABILITY to ANALYSE problems and EXPLAIN engineering concepts related to sensing,
e.g. students should be able to tackle complex design issues while explaining with proper design rationale.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

- **The Science of Measurement**
  sampling theory, data acquisition, signal-to-noise ratio, measurement applications
- **Performance Characteristics**
  static, dynamic, and error characteristics
- **Measurement Uncertainty**

noise mechanisms, systematic errors, random errors

- **Design and Implementation of Instruments and Sensors**
  analog-to-digital conversion, interfacing with digital computers, and signal processing
- **Calibration of Sensors and Instruments**
  gain and offset calibration techniques

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	“Measurement and Instrumentation - Theory and Application”, by A. Morris & R. Langari, Elsevier 2012
2	“Instrumentation”, by F. W. Kirk, T. A. Weedon, and P. Kirk, Amer Technical Pub, 5th edition, 2010
3	“The Measurement, Instrumentation and Sensors Handbook”, by J. G. Webster
4	“Handbook of Modern Sensors: Physics, Designs, and Applications” by J. Fraden, Springer, 4th ed., 2010
5	“Chemical Sensors and Biosensors”, by Florinel-Gabriel Banica, Wiley, 1 ed., 2012
6	“Semiconductor Sensors”, by S. M. Sze, Wiley, 1994
7	“Smart CMOS Image Sensors and Applications”, by J. Ohta, CRC Press, 2007
8	“Image Sensors and Signal Processing for Digital Still Cameras”, by J. Nakamura, CRC Press, 1 ed. 2005