NEW YORK CITY TECHNICAL COLLEGE
OF THE CITY UNIVERSITY OF NEW YORK

Course Title:	EET 3122 Sensors and instruments
Courses Description:	An introduction to the world of electrical and optical sensors with applications in bioengineering, environmental remote sensing fields and many more. The topics cover description of sensor performance, temperature sensors, light sensors, force sensors, displacement sensors, motion sensors, environmental sensors, sound sensors, chemical sensors, sensor interfacing, instrumentation techniques and switching mechanisms. The lab component of this course introduces sensors control using NI LabView software and NI ELVIS hardware
Credit hours:	3 course credits, consisting of 2 classroom hours, and 2 Lab hours
Prerequisites:	AAS degree in EET or department approval; Pre- or co-requisite: EET 3102
Required text:	Handbook of Modern Sensors. Physics, Designs and Applications by Jacob Fraden, Springer, 2016 Fundamentals of Sensors for Engineering and Science, by Patrick F. Dunn, CRC Press, 2011
Supplemental texts:	1. The measurement, Instrumentation and Sensors Handbook by John G. Webster, CRC Press, 1999 2. Sensors and Transducers by Ian Sinclair, Newnes, an imprint of Elsevier Science, Third Edition, 2003 3. Electronic Sensors and Transducers, Pearson, 1992, 4. SPIE Optical Remote Sensors, IEEE Journal Papers 5. Handouts
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Instructional Objectives and Assessment

Instructional Objectives: (ETAC/ABET Criterion 3)	**Assessment:**
1. Understand the physical principles and applications of different types of sensors and transducers. (ABET Criteria 3.1).	Students will be able to describe the working principles of the different types of sensors and transducers.
2. Implement different sensors and transducers in detection systems. (ABET Criteria 3.2, 3.4, 3.5)	Students will be capable to identify the applications of different sensors and describe the instruments incorporating the sensors in question. Students will use NI LabVIEW to control and analyze the data collected the different sensors studied in the class
3. Understand the impact that sensors have on the detecting systems they are part of (i.e. optical trains, integrated systems and system design). (ABET Criteria 3.1, 3.2, 3.3, 3.5)	Students will be demonstrate knowledge of the different building blocks of system using sensors. They will be able to determine the response of the sensors based on variations of the building blocks of the systems.
4. Analyze the signal-to-noise ratio (SNR), sensitivity and detector performance. (ABET Criteria 3.1, 3.2, 3.4,3.5)	Students will be able to calculate SNR, sensitivity and performance of sensors
5. Describe switch principles and mechanism. (ABET Criteria 3.1, 3.3, 3.5)	Students will demonstrate knowledge of the requirements, ratings, specifications and mechanisms of different switches.

Grading Procedure:	
2 midterm exams:	30%
Final Exam:	30%
Labs:	20%
Homework:	5%
Projects:	15%

Course contribution in meeting ETAC/ABET Criterion 5 requirements:

EET 3122 meets criterion 5 by providing students with a strong foundation of principles and project organization needed to work in a team environment and research information to present a project report, which focuses on solving broadly-defined engineering technology problems. Students present an understanding of the need for and an ability to engage in self-directed continuing professional development, an understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity, and a knowledge of the impact of engineering technology solutions in a societal and global context. Academic benchmarks, course outcomes, and assessment requirements have been established to ascertain student comprehension of commitment to quality, timeliness, and continuous improvement concepts. Additionally, by fostering critical thinking, communications, and team work, students develop the skills needed to solve problems in a classroom and laboratory environment which will later serve them in the work place.

Course Outline:

Week	***Lecture Topic***	***Laboratory***
1	**1. Data acquisition.** Sensors, signals, and Systems. Sensor classification, Units of measurement. **Sensor Characteristics** Transfer Function, Calibration, Span, Full scale output, Accuracy, Calibration error, Hysteresis, Nonlinearity, Saturation, Dead band, Resolution, Dynamic Characteristics, Environmental factors, Application Characteristics	Open and run a LabVIEW and NI ELVIS II unit. Digital Control Unit Build a Sensor Control Program
2	**Physical Principles of Sensing** Electric Charges, Fields and Potentials, Capacitance, Magnetism, Induction, Resistance, Piezoelectric effect, Pyroelectric effect, Hall effect, Thermoelectric effect, sound waves, Temperature and Thermal Properties of Materials, Heat Transfer, Light, Dynamic models of Sensor Elements	Breadboard Cable Control Analog and Digital Pulse Out, Wheatstone Bridge and its application to biomedical engineering

3	**Optical Components of Sensors** Radiometry, Photometry, Windows, mirrors, lenses, Fresnel Lenses, Fiber Optics and Waveguides, Concentrators, Coatings and Thermal absorption Nano-optics **Interface electronic Circuits** Input Characteristics of Interface Circuits, light to voltage converters, Excitation Circuits, Analog to Digital Converters, Direct Digitization, Capacitance-to-Voltage Converters, Integrated Interfaces, Ratiometric Circuits, Differential Circuits, Bridge circuits, Data Transmission, Noise in Sensors and Circuits,	Using Op-Amps and Filters to Design a Hearing Aid
4	**Occupancy and Motion Detectors** Dynamometers, Ultrasonic Detectors, Microwave motion Detectors, Capacitive Occupancy Detectors, Triboelectric Detectors, Optoelectronic motion	Dynamometer and ECG data collection. Muscle Activity and fatigue.

Week	***Lecture Topic***	***Laboratory***
	Detectors, Optical Presence detectors, Pressure-Gradient Sensors	
	Exam 1	
5	**Position Displacement and Level** Potentiometric Sensor, Capacitive sensors, Inductive and Magnetic Sensors, Optical Sensors, Ultrasonic Sensors, Radar Sensors, Thickness and Level Sensors, Pointing Devices	ECG Sensors designer, Instrumentation Amplifier
6	**Velocity and Acceleration** Accelerometer Characteristics, Capacitive Accelerometers, Piezorezistive Accelerometers, Piezoelectric Accelerometers, Thermal Accelerom., Gyroscopes, Piezoelectric Cables, Gravitational Sensors	Vernier Rotary Motion Sensor
7	**Force Strain and Tactile Sensors** Strain Gauges, Tactile Sensors, Piezoelectric Force Sensors **Pressure Sensors** Mercury Pressure Sensors, bellows, Membranes and Thin plates, Piezoresistive sensors, Capacitive Sensors, VRP Sensors, Optoelectronic Pressure Sensors, Indirect Pressure Sensors, Vacuum Pressure Sensor, Barometer	Collect Barometer Data for environmental applications. Blood Pressure Sensor

8	**Flow Sensors** Basics of Flow Sensors, Pressure Gradient Technique, Thermal Transport Sensors, Ultrasonic Sensors, Electromagnetic Sensors, Breeze Sensors, Coriolis Mass Flow Sensors, Drag Flow Sensor, Drag Force Sensors, Dust and Smoke Detectors, Ionization Detectors, Optical detector,	Data collection with a cup anemometer, Air flow and lung volume
9	**Acoustic sensor** Resistive Microphones, Condenser Microph., Fiber-Optic Microph., Piezoelectric Microph., Electret Microph., Dynamic Microph., Solid States Acoustic Detectors, **Exam 2**	Read Microphone Data, Analyze Microphone Data
10	**Humidity and Moisture Sensors** Concept of Humidity, Capacitive Sensors, Electrical Conductivity Sensors, Thermal Conductivityt Sensors, Optical Hygrometer, oscillating Hygrometer	Data Collection with a Relative Humidity Sensor
11	**Light Detectors**	Sunphotometer, Light Sensors

Week	***Lecture Topic***	***Laboratory***
	Photodiodes, Phototransistor, Photoresistor, Cooled Detectors (IR), Image Sensors, Thermal Detectors, Optical Design, Gas Flame, Detectors	
12	**Radiation Detectors** Scintillating Detectors, Ionization Detectors, Cloud and Bubble Chambers	Field Trip
13	**Temperature Sensors** Coupling with Object, Temperature Reference Points, Thermoresistive Sensors, Thermoelectric Contact Sensors, Semiconductor pn Junction Sensors, Optical Temperature Sensors, Acoustic Temperature Sensors, Piezoelectric Temperature Sensors,	Read Temperature Data, Above Threshold Warning of Temperature Data Data collection with a Vernier Surface temperature Sensor
14	**Chemical Sensors** Chemical Sensors Characteristics, Classes of Chemical Sensors, Biochemical Sensors, Multisensors arrays, Electronic Noses and Tongues, Special Difficulties	**Project Presentations**
15	**Final EXAM**	**Project Presentations**