# CE 5333
# Civil Engineering Sensor Systems Integration

## Time and Location

Time is listed on attached schedule below. This course is an instructor led special-topic course. There is substantial hands-on component and students need to obtain about $300 in supplies (listed below) to build the sensor projects. The projects are mostly water related but the methods are adaptable to other applications. The tabular schedule is a guideline; we will try to follow it closely, but be prepared to adjust to changes in pace dictated by our collective experience.

## Instructor

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## Office Hours

Open door – we can meet after each day for questions; also in mornings before/during breakfast

## Catalog Description and Prerequisites

CE 5333: Special Problems in Water Resources (3:3:0). Individual studies in water resources. May be repeated for credit. *co-requesite CE 3305*

# Textbook

Cleveland T. G., DIY Sensors for Civil Engineers *in progress*.

The textbook is located at:
`http://theodore-odroid.ttu.edu/pending-link`

# Purpose

A hands-on "maker" course to develop homebrew sensor and data aquisition tools. Useful for beginning researchers to collect data at low cost for screening level data. The sensors and programs are adaptable to professional use. Entire systems will be built and demonstrated – the projects are mostly water related, but concepts are transferable to other Civil sub-disciplines. Intended for graduate students with minimal electronics skills, and minimal computer administration skills. Students should know how to solder and have had a circuits class somewhere.

Topics include:

- System on chip computing (a little history).
- Pratical applications of sensing technology.
- Building a sensing and recording system (prototype) using RPi
- Making deployment copies on a RPi-Zero
- Wireless communications using the RPi 3/4 as the controller and the RPi-zero as the slave
- Remote procedures - running the remote from a distance.
- Data processing for interpretation
- Introduction to python

# Objectives

Upon completion of this course, students should be able to:

1. Provision a single-board computer(Raspberry PI; Hardkernel XU4; Arduino, etc) to run a Linux instance and host a wireless network.

2. Construct Analog-to-Digital Converter using MP3008 microprocessor.
3. Attach sensors to system using GPIO pins.
4. Write custom Python scripts to control senors, collect, and process data
5. Use custom built system to control a device based on sensor input.
6. Perform all control activities by remote procedure calls.

# Candidate Projects

Student teams will build and program a selection of the following example projects

1. Clean build RPi-3/4 with Ubuntu 19.X operating system (clean image ,not using noobs). Duplicate RPi-Zero
2. A/D converter 8-channel, 10-bit to convert analog signal to digital. Uses MCP3008.
3. Water-level detector, to detect 8 discrete water levels in a vessel (tank, channel, etc.) Uses the A/D converter.
4. Ultrasonic time-of-flight detector. Use as short range downlooking distance measure tool.
5. Optical laser time-of-flight detector. Similar application as ultrasonic
6. Hall-detector mass flow meter (counting type).
7. Tipping bucket raingage (counting type). Compare a DIY raingage to adapted flowmeter gage.
8. Gas pressure sensor. Install in a tensiometer.
9. Normal Stress sensor (similar to strain gage)(possibly improved water level trick)
10. Soil moisture sensor array. Similar programming as water level sensor.
11. Pump controller circuit to start a small pump based on sensor data.
12. IR remote temperature detection.
13. Thermal plume tracing using FLIR and image processing. (Advanced project only 2 sensors in inventory)

# Course Schedule

Table 1: CE 3305 Course Schedule – Summer 2016

[ID: Lecture code; each ≈ 1.5 hours in duration;
DATE & TIME: Date and time of scheduled lecture;
TOPIC: Lecture content synopsis;
READING: Relevant book pages.

| ID | DATE | TOPIC | READING |
|---|---|---|---|
| 1 | date | Introduction; | pp. 1 - 25 |
| 2 | date | Linux images: using Etcher to make an image | pp. 26 - 43 |
| 3 | date | Install OS onto RPi; configure network | pp. 44 - 78 |
| 4 | date | Acquire GPIO software (from class website) | pp. 79 - 86 |
| 5 | date | Simultaneous Linear Equations | pp. 87 - 112 |
| 6 | date | Project 1: AD converter using MCP3008 | pp. 113 - 119 |
| 7 | date | Project 1: Test AD converter as a voltmeter | pp. 120 - 125 |
| 8 | date | Project 2: Water level sensor using resistive sensing | pp. 126 - 133 |
| 9 | date | Project 2: Polling the MCP3008 to detect 8-levels of water | pp. 134 - 144 |
| 10 | date | Project 3: Hall detector flowmeter (digital counting) | pp. 145 - 153 |
| 11 | date | Project 3: Testing the detector | pp. XX-XX |
| 12 | date | Project 4: Gas pressure sensor | pp. XX-XX |
| 13 | date | Project 4: Testing the sensor | pp. XX-XX |
| 14 | date | Project 5: IR remote temperature sensing | pp. XX-XX |
| 15 | date | Project 6: Pump controller circuit | pp. XX-XX |
| 16 | date | Final Sensor challenge (Choose remaining projects) | pp. XX-XX |
| 17 | date | Project 7: | pp. XX-XX |
| 18 | date | Project 7 | pp. XX-XX |
| 19 | 1 date | Project 8 | pp. XX-XX |
| 20 | date | Project 8: | pp. XX-XX |
| 21 | date | Project 9: | pp. XX-XX |
| 22 | date | Project 9: | pp. XX-XX |
| 23 | date | Final Demonstrations | pp. XX-XX |
| 24 | date | Alibi Demonstrations | pp. XX-XX |

# Assessment Instruments

## Sensor Projects

Project completion – all students need functioning projects. OK to work in teams. Project reports are comprised of:

1. Problem statement and sketch of the system
2. Identify and list the environment and values to be sensed
3. Identify relevant governing equations and state assumptions
4. Identify sensor components needed.
5. Identify and write control programs to access sensors and acquire data.
6. Demonstrate working project (photograph evidence adequate)
7. Discuss the results

## System Documentation

All projects need documentation of sufficient detail so others can implement. The documentation will be in a portfolio (collection of reports for each project) using the above reports.

## Deployment

End of semester a deployment scenario that uses one or more projects will be assigned to student teams. Students must sucessfully demonstrate their sensor systems to the class.[1]

## Grading Policy

Final grades are determined based on performance during the course. Letter grades will be assigned using University standards. The **approximate** weighting of graded material in determining the final grade is as follows[2]:

[1] If they fail in demonstration, teams will have one week to debug and retry.

[2] Graded materials with fewer than 100 points will have raw scores normalized to 100 points for calculating the final grade.

| Item | Percent of Grade |
|---|---|
| Projects Completion | 70% |
| Portfolio Completion | 10% |
| Deployment Demonstration | 20% |

## ABET Program Outcomes

A subset of the ABET Program Outcomes are addressed in CE 3305, these outcomes are listed below:[3]

- `3[a].` Ability to apply knowledge of mathematics, science, and engineering.
- `3[b].` Ability to design and conduct experiments, as well as to analyze and interpret data.
- `3[e].` Ability to identify, formulate, and solve engineering problems.
- `3[i].` Recognition of need for life-long learning.
- `3[k].` Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- `8[d].` Proficiency in water resources engineering.

## Academic Misconduct

Refer to the Texas Tech University Catalog and operating policies (OP 34.12) regarding academic integrity, cheating, and plagiarism. Academic dishonesty will not be tolerated.

## Disability Policy

*"Any student who, because of a disability, may require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make any necessary arrangements. Students should present appropriate verification from Student Disability Services during the instructors office hours. Please note instructors are not allowed to provide classroom accommodations to a student until appropriate verification from Student Disability Services has been provided. For additional information, you may contact the Student Disability Services office at 335 West Hall or 806- 742-2405."*

[3]Item 3[b] below is only partially fulfilled – in this course students will analyze and interpret data, design of experiments is beyond the scope of the class.