General note: This draft version of the course syllabus is subject to change. Revisions will be posted to the FLBS website as they are received. The final syllabus will be marked final and will be distributed on day one of the course.

Prerequisites A (Ecologists): One year of college-level biology, chemistry, and mathematics; Prerequisites B (Engineers): Early proficiency in a computer programming language, computer aided design software, and/or manufacturing principles; or consent of instructor.

Course Description:
Autonomous environmental sensors are increasingly being used to collect real-time data about the natural world. Accordingly, there is a wide array of commercially available environmental and biological sensors but unfortunately they are sold for commercial monitoring applications and are often outside the price range of ecological study. Understanding how to design and produce appropriate sensors to answer specific scientific questions is therefore highly desired but requires knowledge from a broad range of disciplines.

The Flathead Lake Biological Station’s SensorSpace (https://sensorspace.tech) is a cutting edge facility that enables scientists and engineers to design and manufacture their own environmental sensor networks. This course is designed for both engineering and ecology students to work on small team projects to learn about, design, manufacture, and deploy robotic environmental sensor networks. This course will include instrumentation design/manufacturing, and wireless network communications in the field.

This is a practical field course in which ecology and engineering students will come together in teams to design and deploy sensors related to aquatic and terrestrial ecology. Data from the sensors will be collected and used to answer specific ecological/environmental questions. Example analytes for which cost-effective fieldable sensors can be produced by researchers include pH, O2, CO2, nutrients, temperature, light levels, accelerations, GPS, and more.

Through their specific team projects students will be introduced to methods of manufacturing including: 3D model design, CNC machining, additive manufacturing with 3D printing, laser cutting, and microlithography. Students will learn about various concepts associated with sensor design such as: sensitivity, dynamic range, specificity, stability, repeatability, and compatibility. Specific focus will be placed on those sensor technologies being used in their overarching project including chemical and physical sensors that operate by optical and voltammetric principals. Students will be introduced to key embedded systems concepts for field deployed electronics: power systems, microcontrollers, I/O, and various communication technologies to enable the inclusion of data logging and networking modules in their deployed sensor systems.
Student Learning Objectives:
After taking this course students will be able to:
1. design sensors and components, source materials, identify best approaches to sensor production given environmental and engineering constraints
2. produce sensor components using a variety of tools available in the SensorSpace
3. build microfluidic chips for optical sensing of oxygen, CO2, pH, temperature, soil moisture, and nutrients
4. program microcontrollers.
5. design electronic controls of field sensors
6. deploy and collect data from class-built sensors

Required Text: None.

Reference Texts: Reference materials and hand-outs provided.

Course and Field Supplies/Equipment: (*available for purchase at the FLBS Bookstore)
Students should bring the following supplies:
- Waterproof field notebook (Rite in the Rain 8.5" by 11")*
- Lab notebook*
- Pencils*
- Laptop computer
- Hot/cold mug*
- Lunch pack-up resealable container(s)*
- Warm jacket (layered clothing)
- Personal mess kit – plate, cup, silverware
- Sleeping bag
- Tent
- Rain gear
- Water bottle*
- Flashlight or headlamp with batteries
- Broken in light weight hiking shoes/boots

- REQUIRED Other Items to Bring Checklists and Overnight Field Gear: [http://flbs.umt.edu/urls/lists](http://flbs.umt.edu/urls/lists)

Evaluation and Grading:
Grades will be earned based on:
1. Regular attendance and participation in course activities,
2. Short quizzes,
3. A short oral presentation summarizing the group project sensor creation, deployment and results,
4. Completion and quality of laboratory write-ups summarizing the development and deployment of the field sensor.

Grades will be weighted as follows:
1. Attendance and participation in class lectures, discussions, and labs (20%),
2. Quizzes (20%),
3. Performance on oral presentation summarizing group projects (20%), and
4. Performance on write-ups of laboratory training exercises (40%).

Course Policies:
Students will adhere to University of Montana Student Conduct Code and Discrimination, Harassment, Sexual Misconduct, Stalking, and Retaliation Policy, which may be accessed at this link:
[http://www.umt.edu/safety/policies/](http://www.umt.edu/safety/policies/) and to the Biological Station Code of Conduct re: form signed to complete student registration.
Students who have not already completed the University of Montana PETSA training may access the Moodle module at this link: [http://www.umt.edu/petsa/](http://www.umt.edu/petsa/).

Students must also follow FLBS Rules and Regulations and abide by the Safety Orientation Checklist.

**Schedule**: Preliminary schedule (below) is subject to change.

*Note: Make sure you pack your brown bag lunch each day at breakfast!*

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<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Field Site</th>
<th>Lab Topic</th>
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<tbody>
<tr>
<td>(M)</td>
<td>Project Selection</td>
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<tr>
<td>26-Jun-18</td>
<td>Manufacturing Design</td>
<td>SensorSpace</td>
<td>CAD/CAM</td>
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<td>(W)</td>
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<tr>
<td>28-Jun-18</td>
<td>Electronic Sensing, Network Communications and Microcontroller</td>
<td>Flathead Lake</td>
<td>Voltammetry, PCB production, LoRaWAN deployments</td>
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<td>(Th)</td>
<td>Programming</td>
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<tr>
<td>2-Jul-18</td>
<td>Project Construction</td>
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<td>3-Jul-18</td>
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<tr>
<td>4-Jul-18</td>
<td>Project Deploy</td>
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<td>5-Jul-18</td>
<td>Data Management and Analysis Methods</td>
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<tr>
<td>6-Jul-18</td>
<td>Student presentations</td>
<td>SensorSpace</td>
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Students with disabilities may request reasonable modifications by emailing flbs@flbs.umt.edu or contacting Marie Kohler at 406-982-3301 ext. 221. The University of Montana assures equal access to instruction for students with disabilities in collaboration with instructors and Disability Services for Students. The University does not permit fundamental alterations of academic standards or retroactive modifications.