Wireless networks provide the backbone for ubiquitous information access and resource sharing, which dramatically changes the way people and devices compute and communicate. The unprecedented recent advancements in wireless networks and embedded computing have spawned the emergence of Internet of Things (IoT) as an important field that is poised to change our lives, personally and professionally. Sensor technology is a key part, as well as a tangible realization, of IoT. It is a technology domain that is experiencing a rapid growth and is believed to be a multi-billion dollar industry. Wireless sensor networks are distributed systems, in which autonomous devices or Motes, observe what could be complex environments to collect data such as temperature, humidity, motion, and sound) or, even medical data (such as heart rate, blood oxygen level and pulse rate). The data is collected through a network, fused/aggregated, routed and transported to
control/analytics/ and decision making applications. Sensor networks are an enabler for a broad range of applications in different sectors such as agriculture, healthcare, manufacturing, mining, smart cities, etc.

In this course, the students will learn WSN theory and technology such as routing and security as well as will gain hands-on skills and practical knowledge in WSN. The course introduces diverse fundamental concepts encountered in designing and analyzing intelligent sensors and sensor networks (mobile and stationary), with emphases on mission critical applications. The course will cover theoretical models, and design principles; and explores the latest development and open research issues in wireless sensor network algorithms, protocols, architectures, and applications. Topics covered in this course include: Introduction to sensing and sensor networks, attributes of sensor networks, communication model and network stack, information routing, localization and synchronization, compressive sensing, sensor fusion and aggregation, graph signal processing, security, middleware and bigdata environments.

**LEARNING OBJECTIVES**

The objective of this course is to make the students

- Understand the basic WSN technology and supporting protocols,
- Understand the different sensor network stack in terms of layers and their role, operations and challenges,
- Understand and appreciate sensor fusion and data aggregation techniques as means for achieving accurate sensing and efficient data capture and transport,
- Learn the different layers of the sensor network stack in terms of their role, operations and challenges,
- Learn how Graph Signal Processing is emerging as a new domain of signal processing for analyzing the dynamics and topology of large scale sensor networks.
- Learn key routing protocols for sensor networks
- Understand the importance of sensor localization and synchronization and learn techniques for achieving location-aware synchronous sensor networks
- Appreciate how sensors are typically capable of wireless communication, but at the same time are significantly constrained in terms of the amount of available resources such as energy, storage and computation.
- The students will learn how such constraints make the design and operation of sensor networks considerably different from contemporary wireless networks. They will learn the importance of resource conscious protocols and management techniques.
- Lean advanced emerging sensor network security paradigms such as lightweight cryptography, and Blockchain.
### DETAILED COURSE TOPICS:

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<tr>
<td>2. Communication Model</td>
<td>Wireless sensor architecture and protocol stack. Stack layers: roles and challenges. Network capacity,</td>
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<td>Synchronization</td>
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<td>5. Sensor Fusion and</td>
<td>Sensor fusion paradigms, Probabilistic, Dempster-Shafer based, centralized and distributed Kalman filter, Q-digest</td>
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<td>Aggregation</td>
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<td>6. Compressive Sensing</td>
<td>Sampling theory, Sparse representations. Compressible signals, Sensing matrix design, Signal recovery, Lx-Norm Optimization</td>
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<td>7. Graph Signal Processing</td>
<td>Introduction to graph concepts, Spectral graph theory -- Orthogonal transforms review Frequency interpretation -- Nodal Theorem, Graph filtering -- Vertex and Spectral interpretations</td>
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<td>8. Advanced Topics</td>
<td>Bigdata, Security, Blockchain in WSN.</td>
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### LEARNING RESOURCES

- This course will be offered as an asynchronous teaching offering. I will post the course notes and lectured recording on the course LEARN website.
- Once a Teaching Assistant is assigned, his/her information will be published.
- Supplementary material such as scientific articles and technical reports will be posted on the course website on LEARN in synchrony with the topics covered.
- The OMNET++ simulation environment or similar environment, and the MATLAB S/W will be used to help the students practice the course topics.
- **Recommended Reading Material:**


ASSESSMENTS

- Assignments: There will be 4 assignment that will be used to reinforce course material. They will carry a total weigh of 35% of the course’s 100% final grade.
- Each student will be required to complete a fairly scoped project that demonstrates the student’s comprehensive understanding of a course topic(s). The project is expected to yield a technical report that matches, in terms of scope, depth, and format, a conference or a journal publication. This part will carry 25% of the course’s 100% final grade.
- A take-home final exam will be administered to test the student’s comprehensive understanding of the course material. This part will carry 40% of the course’s 100% final grade.

The final course grade will be calculated using the following categories:

<table>
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<tr>
<th>Assessment</th>
<th>Percentage of Final Grade</th>
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<tbody>
<tr>
<td>Assignments 4</td>
<td>35%</td>
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<tr>
<td>Project</td>
<td>25%</td>
</tr>
<tr>
<td>Final Examination</td>
<td>40%</td>
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COURSE POLICIES

- **Late-work policy:** If you submit work after the deadline your mark will be reduced by 10% for each working day that the work is late. For example, an assignment worth 20 points would lose 2 point per day (max 2 days of lateness).
- **Integrity:** (Please refer to the University of Waterloo Policy 71) “Academic integrity is a
commitment to five basic values: honesty, trust, fairness, respect and responsibility. It applies to all academic endeavours – teaching, learning and scholarship, and applies to a range of academic activities, from conduct in research to the writing of co-op work term reports.

Students are expected to know what constitutes academic integrity, to avoid committing offences, and to take responsibility for their actions.

Students are responsible for demonstrating behaviour that is honest and ethical in their academic work. Such behaviour includes:

- Abiding by University policies and provincial and federal legislation.
- Following the expectations articulated by instructors for referencing sources of information and for group work.
- Submitting original work, citing sources fully, and respecting the authorship of others.
- Preventing their work from being used by others, e.g. not lending assignments to others, protecting access to computer files.
- Asking for clarification of expectations as necessary. Students who are in any doubt as to whether an action on their part may be viewed as a violation of the standards of academic integrity should ask their instructors, lab assistants and/or advisors.
- Adhering to the principles of academic integrity when conducting and reporting research.”

Accommodations for students with disabilities: “If you have a disability and require accommodations, please refer to https://uwaterloo.ca/english-teaching-portal/managing-your-section-or-tutorial/accommodating-students-disabilities

If you have an accommodations letter from the Disability Services Office, I encourage you to discuss your accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate.