

# COURSE OUTLINE (W24)

(VERSION 1)

**ELEC 4906: SATELLITE BASED INTEGRATED NAVIGATION**  
**DEPARTMENT OF ELECTRONICS**  
**CARLETON UNIVERSITY**

## 1 INSTRUCTOR INFORMATION AND OFFICE HOURS

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Tashfeen Karamat:  
tashfeen.karamat@carleton.ca  
Office: 4526 EDC  
Office Hours: By appointment (using Zoom)  
TA Information: NA

## 2 COURSE MODE OF DELIVERY

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Course will be delivered In-Person, which includes all the lectures, labs/PA sessions, Midterms, quizzes, and exams. There will be one three-hour lecture every week and Lab/PA session alternate week.

## 3 COURSE OBJECTIVES

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This course will introduce students to various engineering subjects such as:

1. Overview of Navigation which includes navigation basics and reference frames.
2. Introduction to Global Navigation Satellite Systems (GNSS)
3. GPS Segments and Observables
4. GPS Signals and Computation of Satellite position and velocity.
5. Computation of user position and velocity.
6. Differential Positioning
7. Precise Point Positioning
8. Concepts of GPS Receiver.
9. Fundamental concepts of Inertial Navigation Systems (INS)
10. Overview of Kalman filtering (KF).
11. Basics of Integration of INS/GPS using Kalman filter
  - a. Loosely Coupled Integration
  - b. Tightly Coupled (Centralized) Integration.
  - c. Ultra-tightly Coupled Integration

## 4 LEARNING OUTCOMES

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By the end of this course, students should:

1. Be familiar with concepts of Navigation and basics and reference frames.

2. Learn the fundamentals of Global Navigation Satellite Systems (GNSS) and specifics of Global Positioning System (GPS)
3. Know the details of GPS Segments and Observables
4. Be able compute position & velocity of the satellite from the orbital data (ephemeris)
5. Be able to compute user position and velocity from the raw data (pseudorange and Doppler)
6. Learn the concepts of Differential Positioning and Precise Point Positioning.
7. Be able to know key concepts of GNSS Receiver.
8. Know the fundamental concepts of Inertial Navigation Systems (INS)
9. Learn the basics of Kalman filtering (KF) and its use in Navigation
10. Learn the basics of various modes of GPS and INS Integration using Kalman filter

## **5 COURSE MATERIAL**

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### **5.1 TEXTBOOK**

- Nouredin A., Karamat T. and Georgy J.: “Fundamentals of Inertial Navigation, Satellite-based Positioning and their Integration” Springer, ISBN 978-3-642-30465-1, October 2012.

### **5.2 REFERENCE BOOKS**

- Frank van Diggelen: “A-GPS: Assisted GPS, GNSS, and SBAS” Artech House; 1st edition, March 31, 2009
- Pratap Misra, Per Enge: Global Positioning System: Signals, Measurements, and Performance, Ganga-Jamuna Press 2010.

## **6 COURSE MANAGEMENT: BRIGHTSPACE**

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Course information, lectures, grades and other relevant material will be posted on the ELEC 4906 Brightspace site. Students are expected to regularly check the Brightspace site for course handouts, lecture notes and course announcements. Students are expected to check their progress regularly and in case of any discrepancy in grades, they are required to contact the course instructor within two days of grade posting.

## **7 EVALUATION AND GRADING SCHEME**

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There will be two Midterms and one final exam. Lab/PA session would be conducted every alternate week which will also include a short Quiz. The final exam is for assessment purposes only and will not be returned to the students. The overall grade will be calculated as follows:

<b>Component</b>	<b>Weight</b>
Lab/PA/Quiz	15%
Midterm 1	15%
Midterm 2	15%
Final Exam	55%

Students who fail the final exam (achieve a grade of less than 50% on the final exam) will receive a course grade of F, regardless of their marks in the other components.

## **8 GENERAL REGULATIONS**

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### **8.1 COPYRIGHT ON COURSE MATERIALS**

The materials created for this course (including the course outline and any slides, notes, program source code, labs, projects, assignments, quizzes, exams and solutions) are intended for personal use and may not be reproduced or redistributed or posted on any website without prior written permission from the author(s).

### **8.2 ATTENDANCE**

Students are expected to attend all lectures and Lab/PA sessions In-Person. **Lab/PA attendance is graded a mandatory requirement of the course.** The University requires students to have a conflict-free timetable. For more information, see the current *Undergraduate Calendar, Academic Regulations of the University, Section 1.2, Course Selection and Registration and Section 1.5, Deregistration.*

### **8.3 HEALTH AND SAFETY**

Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: <http://sce.carleton.ca/courses/health-and-safety.pdf>

### **8.4 DEFERRED TERM WORK:**

Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. For more information, see the current *Undergraduate Calendar, Academic Regulations of the University, Section 2.6, Deferred Term Work.* In an eventuality of course being going online, the

students are required to have a stable and reliable internet connection, a poor internet connection will not be considered a sufficient reason to defer an online exam.

## **8.5 APPEAL OF GRADES**

The processes for dealing with questions or concerns regarding grades assigned during the term and final grades is described in the *Undergraduate Calendar, Academic Regulations of the University, Section 2.7, Informal Appeal of Grade and Section 2.8, Formal Appeal of Grade*.

## **8.6 ACADEMIC INTEGRITY**

Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at: <https://carleton.ca/registrar/academic-integrity/>. This site also contains a link to the complete Academic Integrity Policy that was approved by the University's Senate.

### **8.6.1 Plagiarism**

Plagiarism (copying and handing in for credit someone else's work) is a serious instructional offense that will not be tolerated.

## **8.7 ACADEMIC ACCOMMODATION**

You may need special arrangements to meet your academic obligations during the term. Carleton University is committed to providing access to the educational experience in order to promote academic accessibility for all individuals. You can obtain detailed information on academic accommodation at <https://students.carleton.ca/course-outline/#accommodation-for-student-activities>.