Course Code	ECE5SN
Course Name	Satellite Navigation and Sensor Fusion
Credits	4
Course Offered to	UG, PG
Course Description	Accurate position and velocity estimation i.e. navigation is an integral part of the operation of any autonomous vehicle. Advent of Global Positioning System (GPS)\Global Navigation Satellite System (GNSS) technologies have radically changed the navigation process. Satellite Navigation and Sensor Fusion course aims to make students familiar with satellite navigation, GPS\GNSS, GPS signal structure, acquisition and position computation techniques from GPS data. This course also focuses on fusion of GNSS and other available sensor observations to estimate accurate position and velocity, which is widely used for navigation of autonomous vehicles. The course will start with an introduction to radio navigation and GPS. After discussing GPS signal structure and positioning algorithms, various position error sources will be introduced and various error correction techniques will be explained. GPS signal acquisition and receiver structure are also within the scope of this course. Effects of interference, weak signal on GPS positioning will also be discussed. New GPS signals and other global and regional satellite navigation systems will be also introduced to the students. Inertial Measurement Unit (IMU) will be introduced in the second part of the course. The Kalman Filter (which is almost ubiquitous in navigation applications) and its non-linear variants will be discussed. Finally usage of GNSS and IMU observations in Kalman Filter framework to estimate accurate position and velocity will be explained.

Pre-requisites		
Pre-requisite (Mandatory)	**Pre-requisite (Desirable)**	**Pre-requisite(other)**
Digital Signal Processing	Probability and Random Process	

Post Conditions				
CO1	**CO2**	**CO3**	**CO4**	**CO5**
Describe basics of satellite navigation	Summerize GPS signal structure, acquistion and receiver mechanism, Explain position computation methods and various position correction techniques	Explain mechanism and dynamics of IMU (accelerometer and gyroscope), determine position and velocity using IMU observation, discuss limitations of IMU	Implement sensor fusion algorithms to estimate position and velocity using GNSS and IMU observations	Discuss recent developments in satellite navigation

Weekly Lecture Plan			
Week Number	**Lecture Topic**	**COs Met**	**Assignment/Labs/Tutorial**
1	Introduction to radio navigation and Global Positioning System	CO1	
2	GPS signal specification, principle of positioning	CO1, CO2	Assignment 1: Simulating GPS signals
3	Positioning errors, differential positioning, reference systems	CO1, CO2	
4	Augmentation System	CO2	
5	GPS signal acquisition, receiver structure	CO2	
6	AGPS, weak signals, interference	CO2	
7	New signals, Galileo and other Navigation Satellite Systems	CO5	Assignment 2: Acquiring GPS signal
8	Dynamics of Inertial Measurement Unit	CO3	
9	Introduction to sensor fusion, Kalman Filter	CO4	
10	Extended Kalman Filter	CO4	
11	Unscented Kalman Filter	CO4, CO5	
12	Position, velocity estimation using GNSS and IMU	CO3, CO4	Assignment 3: Sensor fusion

13	Seminar	CO5	

Assessment Plan	
Type of Evaluation	**% Contribution in Grade**
Assignments	30
Seminar	10
Midsemester	20
Endsemester	40

Resource Material	
Type	**Title**
Book	Kaplan, Elliott, and Christopher Hegarty. *Understanding GPS: principles and applications* . Artech house, 2005.