Course Number: ------

Course Name: **Cyber Physical Systems**

Course Type: Theory	Type & Max Unit: Constant 3
Prerequisite: Nothing.	Corequisite: Nothing.
Level: Graduate	First Presentation: W2019
Group: Digital Electronics Systems	Last Edition: W2021

Objectives: Cyber physical systems are large scale Industrial Internet of Things (IIoT) systems that are resulted from the integration of the IIOT computation layer with the field layer. The objective of this course is to teach students cyber physical systems, the necessity for upgrading large scale IIOT systems to cyber physical systems, main challenges in the development of cyber physical systems, the design principles of cyber physical systems and the implementation aspects of cyber physical systems by focusing on several case studies.

- **Topics:**

- **Cyber physical systems:**
  - Structure of IIOT systems
  - The necessity for upgrading IIoT systems to cyber physical systems
  - The advantageous of cyber physical systems over IIoT systems

- **Main issues to be considered in the development of cyber physical systems:**
  - Uncertainties in the exchange of data between field processors
  - Field devices limited memory and computational power
  - Field devices computational errors
  - Very high computational complexity of the available optimization, estimation, AI and ML algorithms for large scale IIoT systems

- **Cyber physical systems design principles:**
  - Algorithms for distributing the computational load of the convex constrained optimization problems to field distributed processors
  - Algorithms for distributing the computational load of the non-convex constrained optimization problems to field distributed processors
  - Algorithms for distributing the computational load of the linear/nonlinear estimation problems to field distributed processors
  - Methods for communication and computation resilience of cyber physical systems
  - Security of cyber physical systems

- **Applications of the available design techniques in the development of the available cyber physical systems:**
  - Australia's automated irrigation network
  - Iran Khodro fault diagnosis system

- Smart oil field
- Smart power grid

- References:

1- H. Song, D. B. Rawat, S. Jeschke and C. Brecher, Cyber Physical Systems: Foundations, Principles and Applications, Elsevier, 2016.
2- D. P. Bersekas and John Tsitsiklis, Parallel and Distributed Computation: Numerical Methods, Athena Scientific, Belmont, Massachusetts, 1997.
3- A. Farhadi and A. Khodabandehlou, Distributed Model Predictive Control with Hierarchical Architecture for Communication: Application in Automated Irrigation Channels, *International Journal of Control*, 89(8), pp. 1725-1741, August 2016.
4- S. Bolognani and S. Zampieri, A Distributed Control Strategy for Reactive Power Compensation in Smart Microgrids, *IEEE Transactions on Automatic Control*, 2013.