School of Industrial Engineering, Purdue University

IE588 Design of e-Work, e-Service, and Cyber-Physical Systems

New course title: **Cyber-Physical Work Systems**

Instructor: Professor Shimon Y. Nof (nof@purdue.edu) *Office*: GRIS 243
Office hours: Open door policy, and by email
Email: Please send all class related email beginning the subject line with [IE588]

TA: TBD

Lectures: MWF 2:30-3:20 PM GRIS134 **Web:** brightspace.purdue.edu ("Bs")

Course Objective: Learn the fundamental theories, models and applications in the design of digital and cyber supported work, including e-Manufacturing, e-Production, e-Logistics, and other e-Services.

Course description: e-Work is the foundation for digital and robotic e-Manufacturing, e-Service, e-Commerce, e-Business, and other digital production/service activities. As a new way of working in the digital economy and society, e-Work is defined as the interactive, collaborative, computer-, communication-, and cyber- supported/augmented work in highly distributed, networked and connected organizations of humans/ machines/ robots/ sensors /agents/ autonomous systems. This course is devoted to learning and expanding your own expertise in the basic principles, theories, models, technologies and applications in the design of effective (optimized) digital and cyber-physical work systems. Relevant and emerging discoveries at Purdue and elsewhere are also presented and explored. Students will develop a semester project in 3 parts, based on this course.

Prerequisites: IE332 or equivalent; or graduate student in Engineering. Note: Computation is required, programming is optional. Using AI apps is encouraged.

Textbooks: All available as e-books on Purdue library.

Required: Nof, Ceroni, Jeong, Moghaddam, *Revolutionizing Collaboration through e-Work, e-Business, and e-Service*, Springer, ACES Series, 2015

Required: Nof (Ed.) *Springer Handbook of Automation 2nd Ed.*, 2023. Selected chapters will be used.

Optional: Huang and Yoon (Eds.) Systems Collaboration and Integration: See Past and Future Research through the PRISM Center. Springer ACES Series, 2023

	Topics
1.	• Fundamentals of e-Work, digital manufacturing, e-Service, and course objectives • Digital and cyber-physical work and service (CPW/S); The Computational + Analytics + Informatics/Machine Learning/Cyber IE (a.k.a. "Data Scientist IE"); Communications, Internetworking, and cyber fundamentals
2.	• Protocols: Communication-, Interaction-, Workflow-, and Task Administration- • Roles of agents, servers and cloud services; digital manufacturing network paradigms and service models; The collaborative factory of the future
3.	• Producer-Client Model (PCM); Client Side and basic protocols; e-Mfg./ e-Business/ e-Service design models; resource-, tasks-, and network- models; Brain models • Industrial Internet / Cyber Physical Systems (CPS) / Internet of Things/ Services (IoT/IoS); Cyber support or Cyber augmentation?
4.	• Factory sensors and sensor networks; Server Side and basic protocols • Tools for e-Work; Design with Collaborative Control Theory (CCT) for systems collaboration
5.	• e-Work, e-Service, and CPW/S case studies • Design criteria; Performance metrics; Product and service design and development

6.	• Design of IT networks for e-Commerce • Workflow models and techniques for precision, service quality, e-Maintenance, and quality assurance; Cybernetics, learning, and evolutionary techniques
7.	• Integration networks, supply and grid networks, and e-Service; • TIE, Teamwork IntegrationEvaluation; TIE/Agent; TIE/Protocol; TIE/Sensor. Integration and negotiation protocols
8.	• Digital and cyber work design and optimization • Machine learning, evolutionary, and bio-inspired design models of cyber-physical work and service.
9.	• Cyber collaborative design; CLM; Networked interoperability and standards • Error and conflict prognostic, prevention
10.	• Collaborative intelligence, brain models, and applications in CPW/S
11.	• Distribution and inventory models for integrated e-Commerce and supply chains / networks • Tele-work, tele-collaboration and tele-robotics
12.	• e-Service industry • Digital and tele-medicine; Wearables and precision medicine
13.	• Rationalizing digital work and cyber-augmented collaboration • Pricing models for online and traditional channel coordination; Financial transactions Internet security; Information assurance; blockchain models
14.	• Credibility and trust issues; e-Products • Alliances and affiliates; Legal and ethical issues
15.	• Project presentations • Emerging trends

Note for literature (articles) review: For each homework, students will include research summaries based on two to three relevant research articles. Good summaries include 5 parts (max. 2 pages each summary):

(1) The **problem** (challenge) addressed and its significance to the course and your project topics;

(2) **Background** and known practice;

(3) New **methods** and **results**;

(4) **Strengths** and **limitations** of this article;

(5) **Evaluation**: Impact on: a. your understanding, b. creativity, and c. research contribution; open questions.

Course grade: HW - 60% (6X10%); Midterm - 20%; Project in 3 phases - 20%. +/– applies.

The take-home midterm exam will be assigned.

Our course motto:

Collaborative automation augments our abilities to live, serve, compete, and impact.