INDUSTRIAL ENGINEERING DEPARTMENT

IE 414
Smart Manufacturing Systems
Spring 2022

Type:	Elective
Credits/ECTS:	3 Credits / 6 ECTS
Class/Laboratory/PS schedule:	Some lectures on-line, rest in class. **ALL** Labs should be attended in-person. Detailed schedule to be announced.
Instructor:	Ümit Bilge
Co-requisite(s):	IE 306 (Systems Simulation), or equivalents.

COURSE DESCRIPTION:
This course is designed for introducing the third and fourth grade IE students to the state-of the-art concepts in smart manufacturing systems through hands-on experience in BUFAIM-Flexible Automation and Intelligent Manufacturing Laboratory. The course will cover the fundamentals of digital manufacturing technologies, automation and Smart Manufacturing (SM), through topics such as Industry 4.0, subtractive versus additive manufacturing, industrial robotics, manufacturing flexibility, real-time operational control, digital twin and data integration in SM applications. The students will work on Lab assignments and a term project using the available hardware and software in BUFAIM in teams of two-three people. Lab assignments will include CAD/CAM integration, 3D printing, robot programming and shop floor control applications. The term project will focus on the modelling and simulation of advanced manufacturing systems.

COURSE DELIVERY MODE:
The course will be delivered in a **hybrid mode**. Some of the lectures and some of the demos, where possible, will be held online via live Zoom sessions, the rest will be in-class. However, for the lab-work and the assignments that require using the hardware and software in the lab, the students **must** work in-person in the lab together with their teammates, one team at a time. This means the students will need to come to school for 2-4 hours per week by appointment. For this reason the course can be registered only by consent of the instructor and will be restricted to a small number of students who reside in Istanbul during the next semester. All hygienic precautions will be taken during lab work.

TOPICS COVERED:
1. Introduction: Overview of historical evolution of manufacturing and automation *(week 1)*
2. Basic Technologies and Concepts for Digital Manufacturing
    - 2.1. Computer Numerical Control vs Additive Manufacturing *(weeks 2-3)*
      LAB WORK: SpectraCAM-Turning and 3D Printing
    - 2.2. Industrial Robotics *(weeks 4-5-6)*
      LAB WORK: Robot programming for SCORBOT ER IX
    - 2.3. Flexible Manufacturing Systems and Automated Guided Vehicle Systems *(week 6)*
    - 2.4. Real-time Shop Floor Control *(week 7-8)*
      LAB WORK: Real-time control of BUFAIM Model Factory
3. Smart Manufacturing *(weeks 9-10)*
    - 3.1. Industrial Data Acquisition and Communication Networks
    - 3.2. Overall landscape: Digital Manufacturing, IIoT, Industry 4.0, Connected Smart Factories
    - 3.3. Data-driven Manufacturing
        - Purpose of Data: Operational Control, Tactical Planning, Strategic Planning
        - Horizontal and vertical integration
        - The roles of simulation, big data and machine learning
        - Cyber-Physical Systems and Digital Twin
    - 3.4. Roadmap to digital transformation
      LAB WORK: FMS.NET Simulation Software
4. Project *(weeks 10-13)*
      LAB WORK: Project design and experimentation meetings

TEXTBOOK(S) / OTHER REQUIRED MATERIAL:

Class notes, assignment information handouts, assignments, and other material will be available as softcopy as needed on Moodle. The following will be reserved at BUFAIM Lab for reference:

- Groover, M.P., "Automation, Production Systems, and Computer Integrated Manufacturing", Prentice Hall, 2008.
- Gibson, Rosen and Stucker, "Additive Manufacturing Technologies", Springer, 2015.

COURSE OBJECTIVES (AND PROGRAM OUTCOMES):

This course aims to provide students with the skills and methods for modeling, design, control and simulation of advanced manufacturing systems as well as using several automated hardware. By the completion of the course, the students will be able to:

- Discuss history and types of automation
- Understand the concepts of Industry 4.0 and future of manufacturing as smart manufacturing systems.
- Discuss the need for integration and flexibility in manufacturing
- Understand basic technological aspects and use correctly the main technical jargon related to several automation entities including numerical control, additive manufacturing, robotics, cobots, automated guided vehicles, RFID, IoT, augmented reality and communication networks.
- Use and program robots within cell control and shop floor control (SFC) contexts
- Use 3D printers and appreciate the new opportunities presented by additive manufacturing
- Comprehend how digitalized infrastructure is used to give smart decisions about the processes, and the use of digital twin by seeing examples
- Develop a simulation model to evaluate and compare various design alternatives and decide on a final design for an FMS and its operational control policies
- Conduct experimentation and report its results

Considering these objectives, this course mainly addresses the following student outcomes of the industrial engineering undergraduate program;

- *Student Outcome (b):* Ability to design and conduct experiments, as well as to analyze and interpret data
- *Student Outcome (c):* An ability to design diverse systems including manufacturing, service, logistics, financial and information, to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- *Student Outcome (e):* An ability to identify, model, formulate and solve industrial engineering problems
- *Student Outcome (k):* An ability to use the techniques, skills, and modern engineering tools necessary for industrial engineering practice.
- *Student Outcome (d):* An ability to function in (multi-disciplinary) teams

GRADING:

Assignment 1: SpectraCAM-Turning Exercise	5%
Assignment 2: Industry 4.0 survey	5%
Assignment 3: 3D Printing Application (Lab application)	12%
Assignment 4: Robotic Cell Control with RFID Application (Lab application)	22%
Assignment 5: Real-Time Shop Floor Control Application (Lab application)	10%
Term Project: FMS Design using Simulation (report and presentation)	30%
Final	16%

ELIGIBILITY FOR THE FINAL EXAM:

Attendance and participation is strictly required for passing

If more than two sessions are missed (including group-work and project meeting hours, excused or not) / or any task is not submitted on time/ or a student fails to participate in any one of the group projects/assignments, the student will lose the right to take the final exam.

Prepared by, and date of preparation: Ümit Bilge, Jan 2022