Unit 4030: Industry 4.0

Unit Code: **F/651/0755**

Level: **4**

Credits: **15**

Introduction

Industry 4.0 is the term that has been adopted to describe the 'fourth' industrial revolution currently underway, at present, in the manufacturing and commercial sectors of our society. It is a revolution based on the integration of cyber-physical systems, Internet of Things, Big data, 3D printing, advanced robotics, simulation, augmented reality, cloud computing and cyber security. Industry 4.0 is changing the way the world's most successful companies produce the products that their global customers demand. For the engineering and manufacturing sector, this integration has been enabled by successfully combining high performance computing, the internet and the development of advanced manufacturing technologies and highly flexible and adaptive manufacturing processes.

The aim of this unit is to provide holistic understanding of industry 4.0 and current trends of the production, assembly and other key aspects modern manufacturing. Students are first introduced to the background and fundamental and historical concepts of the fourth industrial revolution and principles, technologies, and strategies driving it. Students will then explore cutting-edge technologies, such as the Industrial Internet of Things (IIoT), cyber-physical production systems (CPPS) and artificial intelligence, and learn how these innovations are transforming traditional manufacturing processes and business models. Students are expected to reflect on successful case studies of transitioning to Industry 4.0 and communicate the industry 4.0 concepts, technologies, and implications.

On successful completion of this unit students will be able to investigate and evaluate industrial revolutions along with the characteristics and real-world challenges. As potential managers, students will also be able to

assess the transformation of supply chains, business models, and workforce dynamics in the context of Industry 4.0 and associated benefits.

Learning Outcomes

By the end of this unit students will be able to:

LO1 Discuss the key concepts and principles of Industry 4.0

LO2 Review the range of cyber-physical production systems (CPPS) shaping Industry 4.0 and their integration with the Industrial Internet of Things (IIoT)

LO3 Explore the implications and impacts of Industry 4.0 in engineering and manufacturing processes and technologies

LO4 Examine the factors manufacturers need to consider when transitioning to Industry 4.0 and workforce Implications.

Essential Content

LO1 **Discuss the key concepts and principles of Industry 4.0**

Industrial revolution:

Industry 4.0 historical context: changes from Industry 1.0 to Industry 4.0 and future trends (e.g. Industry 5.0); analogous terms (e.g., Space 4.0, Agriculture 4.0, Maritime 4.0, Mining 4.0, Medical 4.0 etc.)

Fundamental concepts and characterisations

Design for service (DFS), Design for Assembly (DfA) and Design for Manufacturing (DfM) in the age of industry 4.Design Failure Mode and Effect Analysis (DFMEA)

Technology drivers: IoT, IIoT, Artificial Intelligence (AI), cloud computing and automation; integration of digital technologies, data and automation

Areas of impact and applications: For example, − workforce, skills, efficiency, change management; applications in energy, automotive, health and pharma, Agrifood, transportation, social mobility, business, science and technology, communications, geography etc.

Case studies: Example smart factory − connectivity, scalability, autonomy, agility, efficiency, voice-controlled user interfaces.

LO2 **Review the range of cyber-physical production systems (CPPS) shaping Industry 4.0 and their integration with the Industrial Internet of Things (IIoT)**

Definitions, characteristics, and architecture

Interconnected systems enabled by the IoT and cloud computing

Components of CPPS: sensors/smart sensors, actuators and communication protocols including wireless protocols e.g. WiFi, Bluetooth, Zigbee, MQTT, cellular, data, Z-Wave, near-field communication (NFC)

Data in Industry 4.0: data collection systems, data formats and storage, database solutions, data visualisation, forecasting, quality control, data-driven decision-making; data analytics – big data, types including streaming, spatial, time series, prescriptive, predictive, and decisive analytics.

Cloud computing and Industry 4.0: Types (SaaS, IaaS, PaaS); uses with IoT/IIoT; developments such as industrial edge computing, communication protocols and data protection.

Flow diagram of data/information transfer in the cloud

Blockchain technology applications for Industry 4.0

Threats, vulnerabilities, and risk mitigation

Data protection, privacy and compliance.

LO3 **Explore the implications and impacts of Industry 4.0 in engineering and manufacturing processes and technologies**

Robotics and automation in modern manufacturing:

Collaborative, programmable robots and autonomous systems

AI driven decision making and optimisation

Importance of 3D Printing in Industry 4.0

Concept and applications of Digital Twins for manufacturing

Applications of Augmented and Virtual Reality in manufacturing, relevant development/usage platforms (e.g., HoloLens, Metaverse)

Data-Driven Manufacturing

Process mining – types, tools, sector wide examples.

LO4 **Examine the factors manufacturers need to consider when transitioning to Industry 4.0 and workforce Implications**

Standardisation of technologies:

Application interfaces, Integration points and Automation technologies.

Transforming Operational Processes:

Digital Transformation, Merge OT with IT, Worker Mobility, Intelligent Machine Applications.

Transforming Business Models:

New Digital Business, Industrial Analytics, Identify and procure suitable resources including finance, supplies, tools and equipment; role of stakeholders; Supplier, manufacturer, and customer integration.

Transform the Workforce:

Support and training for the workforce, safe and professional working practices, ethical and social considerations, legislative requirements, functional safety standards and application (IEC 61508, IEC 61511, IEC 62061, ISO 10218, IEC 61784, EN 50159, IEC 62280, IEC 62443), environment and sustainability considerations.

Safety first culture within the context:

Health and safety policies, procedures and regulations, compliance, risk assessment and mitigation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the key concepts and principles of Industry 4.0		
P1 Discuss the key milestones of industrial revolutions leading to the Industry 4.0. **P2** Describe any two example areas of impacts for Industry 4.0 in a chosen sector of engineering and manufacturing.	**M1** Analyse two different use cases for the main technology drivers of Industry 4.0. **M2** Explore the implications of DFMEA in the context of Industry 4.0.	**D1** Evaluate the application areas, wider impact and threats of Industry 4.0.
LO2 Review the range of cyber-physical production systems (CPPS) shaping Industry 4.0 and their integration with the Industrial Internet of Things (IIoT)		
P3 Review the relationship between cyber-physical production systems (CPPS) and the Internet of Things (IoT). **P4** Explore a program plan for the IOT and a range of wireless communication protocols available for the smart factory.	**M3** Analyse the principles and benefits of cloud computing and its role with suppliers, manufacturers, and customers within Industry 4.0 for an example case study. **M4** Investigate the risk mitigation strategies for the treats and vulnerabilities of cyber physical systems within a case study.	**D2** Evaluate a case study design of cyber-physical systems architecture with complete process flow for Industry 4.0 based manufacturing systems.
LO3 Explore the implications and impacts of Industry 4.0 in engineering and manufacturing processes and technologies		
P5 Examine the process flow for the design of data-driven manufacturing. **P6** Explore Process mining within a given engineering/ manufacturing sector.	**M5** Explore the role of robotics and automation in modern production and manufacturing.	**D3** Demonstrate the application and benefits of digital twinning for Industry 4.0 manufacturing.
LO4 Examine the factors manufacturers need to consider when transitioning to Industry 4.0 and workforce Implications		
P7 Examine the key principles of operational process transformation to Industry 4.0. **P8** Explore the safety requirements and standards for transition to Industry 4.0.	**M6** Analyse the potential skills required by the Industry 4.0 workforce to enable effective transition.	**D4** Critique the digital business models within Industry 4.0 for agile transition.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

André J. (2019) *Industry 4.0: Paradoxes and Conflicts.* Wiley.

Bali V., Bhatnagar V., Aggarwal D., Bali S., and Diván M. J. (2021) *Cyber-Physical, IoT, and Autonomous Systems in Industry 4.0.* CRC Press.

Barkai, J. (2016) *The Outcome Economy: How the Industrial Internet of Things is Transforming Everyday Business*. CreateSpace Independent Publishing Platform.

Elanqovan U. (2023) *Industry 5.0 The Future of the Industrial Economy.* 1st Ed. CRC Press.

Frenz W. (2022) *Handbook Industry 4.0.* Springer.

Hassoun A. (2024) *Food Industry 4.0.* 1st Ed. Elsevier.

Kandasamy J., Muduli K., Kommula V. P., and Meena P. L. (2023) *Smart Manufacturing Technologies For Industry 4.0 Integration, Benefits, and Operational Activities.* CRC PRESS.

Massaro A. (2021) *Electronics in Advanced Research Industries: Industry 4.0 to Industry 5.0 Advances.* Wiley.

Mavropoulos A. and Nilsen A.W. (2020) *Industry 4.0 and Circular Economy: Towards a Wasteless Future or a Wasteful Planet?* Wiley.

Sharifzadeh M. (2022) *Industry 4.0 Vision for the Supply of Energy and Materials: Enabling Technologies and Emerging Applications.* Wiley.

Sullivan M. and Kern J. (2021) *The Digital Transformation of Logistics: Demystifying Impacts of the Fourth Industrial Revolution.* Wiley.

Tromp J.G., Le D. and Le C.V. (2020) *Emerging Extended Reality Technologies for Industry 4.0: Early Experiences with Conception, Design, Implementation, Evaluation and Deployment.* Wiley.

Vasant P., Munapo E., Thomas J.J., and Weber G. (2022) *Artificial Intelligence in Industry 4.0 and 5G Technology.* Wiley.

Windpassinger, N. (2017) *Digitize or Die: Transform your Organisation, Embrace the Digital Evolution, Rise above the Competition*. New York: IoT Hub.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Manufacturing Letters

Cogent Engineering

Complex and Intelligent systems

Industry 4.0 Clustering of Concepts and Characteristics

New Frontiers in Industry 4.0

Procedia Manufacturing

Links

This unit links to the following related units:

Unit 4068: Industrial Robots

Unit 4085: Mechatronic Systems in Manufacturing

Unit 5017: Advanced Manufacturing Technology