

**Unit Code:** **D/651/0880****Level:** **5****Credits:** **15**

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## **Introduction**

The ability of successful companies to meet the growing demand of customers is heavily influenced by the development of advanced manufacturing technologies. Customers expect high complexity products, on demand, and with a growing element of customisation. In adopting advanced manufacturing technologies, successful companies will ensure faster time to market of new products, improve products and processes, use new, sustainable, materials, and customise to customer requirements. Manufacturing systems engineering underpins this development.

In order to meet changing customer expectations and gain competitive advantage, focus needs to be applied to developing smart factories and advanced manufacturing technologies. Manufacturing organisations will seek integration between manufacturing technology, high performance computing, the internet, and the product at all stages of its life cycle.

The unit will introduce Industry 4.0, 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 with the Internet of Things and services. For the manufacturing sector, this integration has been enabled by successfully combining high performance computing, the internet and the development of advanced manufacturing technologies. Industry 4.0 is changing the way the world’s most successful companies produce the products that their global customers demand.

On successful completion of this unit students will be able to analyse the use of a range of advanced manufacturing technologies to improve the competitive advantage of the organisations adopting them; digitalisation trends in advanced manufacturing technologies; and develop their own research activities into the latest developments.

## **Learning Outcomes**

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

- LO1 Examine a range of advanced manufacturing processes and their effective application
- LO2 Contrast advanced manufacturing technologies to determine their appropriateness for an application or process.
- LO3 Analyse an existing manufactured product and associated process to introduce proposals for possible improvements based on the introduction of advanced manufacturing technologies.
- LO4 Evaluate the concept of the next industrial revolution to determine the impact on both manufacturers and the consumer.

## **Essential Content**

### **LO1 Examine a range of advanced manufacturing processes and their effective application**

*Manufacturing processes:*

Subtractive machining, Pressing and forming, casting, and moulding, joining and soldering, mixing, final assembly, packaging, material handling, quality control/inspection.

*Advanced manufacturing processes:*

Additive manufacture process, fused deposition modelling, selective laser sintering, selective laser melting, Stereolithography, Powder bed and inkjet head 3D printing.

Thermal processes: Laser Beam Machining, Plasma Arc Machining, Electron Beam Machining

Mechanical processes: Abrasive Jet Machining, Abrasive Water Jet Machining, Abrasive Flow Machining, hybrid CNC machining (e.g. Millturn)

Hybrid manufacturing processes: additive manufacture and mechanical machining, welding and mechanical milling, laser cutting and electro-discharge machining.

Micro and Nano machining processes.

*Types of application or industry:*

Industry examples: aerospace, automotive, healthcare, electronics, food and beverage, chemical and pharmaceutical, minerals, oil and gas, retail, fashion

Application examples: assembly, joining, moulding, soldering.

## **LO2 Contrast advanced manufacturing technologies to determine their appropriateness for an application or process**

*Manufacturing technologies:*

High precision robotics and automation: healthcare (components and processes), aerospace, automotive, process control and visualisation through automation technology

Improvement in productivity through greater automation

Quality of manufacturing processes improved through integration of robotics

The application of hybrid processes in the manufacturing and repair of complex components (e.g. the use Hybrid Machine Combining Milling and Additive Manufacturing to manufacture rapid tooling such as moulds and dies).

Examples of using 3D printing and other forms of additive manufacturing to produce medical equipment, spares parts for items that may have become obsolete, mass customisation; what the customer wants, when they want it. Hybrid Additive manufacturing technology (e.g., replacing forming, moulding, pressing), impact on rapid prototyping, availability of spares/obsolete parts, medical components available and customised.

## **LO3 Analyse an existing manufactured product and associated process to introduce proposals for possible improvements based on the introduction of advanced manufacturing technologies**

*Manufactured product:*

Research the traditional methods used to manufacture an existing product, determine the associated processes required to bring it to market and identify the limitations of these methods and processes

Explore how advanced manufacturing technology could be applied to produce this product and suggest how applying such processes would influence its production, environmental impact, costs, time to market and customer satisfaction (e.g., healthcare/medical such as hip joint, traditional method vs mass customisation and the possible use of additive layer manufacture)

Additive layer manufacture and its availability is opening up new markets, but also new business models for organisations; explore the future possibilities for self-serve/or self-production of items.

## **LO4 Evaluate the concept of the next industrial revolution to determine the impact on both manufacturers and the consumer**

*Key technological drivers and Industry 4.0:*

Industry 4.0 – latest developments and future trends in advanced manufacturing sector

Internet of Things: over time industry has transformed from being local-based to communication-based technology; the possibilities for connected technology and connected factories are ever increasing

Cyber-physical systems: collaborative robotics and highly integrated manufacturing systems

Mass customisation: growing demand and desire for individual products; advanced manufacturing technology and the ability to manage complexity

Digitalisation and increased automation; the ability to simulate and create a digital twin has the potential to dramatically reduce time to market

The drive to increase efficiency requires innovation and innovative technology; Net zero, renewable energies, and waste reduction

Uses and trends in data collection systems, data formats, data analytics and dashboards

Big data; the development of an ever-connected production environment alongside cloud computing; challenges with a stream of production data and the need to analyse this in order to make timely informed decisions Discussion in groups involving industry case studies and impact of trending innovations.

## Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
<b>LO1</b> Examine a range of advanced manufacturing processes and their effective application		
<b>P1</b> Examine any two advanced manufacturing processes or technologies with examples of where they are most effective.	<b>M1</b> Compare a traditional manufacturer to one employing advanced manufacturing to discuss the fundamental differences.	<b>D1</b> Research and evaluate a manufactured product and identify the technology used.
<b>LO2</b> Contrast advanced manufacturing technologies to determine their appropriateness for an application or process		
<b>P2</b> Contrast advanced manufacturing technologies to determine their appropriateness for an application or process.	<b>M2</b> Explore how advanced manufacturing could be applied, and give examples of where technology would be suited.	<b>D2</b> Examine the potential justification for an organisation to invest in advanced manufacturing technology.
<b>LO3</b> Analyse an existing manufactured product and associated process to introduce proposals for possible improvements based on the introduction of advanced manufacturing technologies		
<b>P3</b> Analyse an existing manufactured product and the key technology used to produce the item.	<b>M3</b> Evaluate the effectiveness of the current method to suggest an alternative advanced manufacturing technology.	<b>D3</b> Critically evaluate the impact on both the customer and the manufacturer of using advanced manufacturing technology rather than the existing method.
<b>LO4</b> Evaluate the key technological drivers of Industry 4.0 – the next industrial revolution to determine the impact on both manufacturers and the consumer		
<b>P4</b> Evaluate the concept of a 4th industrial revolution. <b>P5</b> Examine the key technological drivers for Industry 4.0.	<b>M4</b> Evaluate the impact of advanced manufacturing on both manufacturers and the customer.	<b>D4</b> Justify the types of industry or product that would benefit most from an innovative advanced manufacturing approach.

## **Recommended Resources**

*Note: See HN Global for guidance on additional resources.*

### **Print Resources**

- Ajay, Singh H., Parveen and Almangour B. (Editors) (2023) *Handbook of Smart Manufacturing – Forecasting the Future of Industry 4.0*. 1st Ed. CRC Press.
- Baudin M. and Netland T. (2023) *Introduction to Manufacturing – An Industrial Engineering and Management Perspective*. 1st Ed. Routledge.
- Brauer D. and Cesaroni J. (2022) *Total Manufacturing Assurance – Controlling Product Quality, Reliability, and Safety*. 2nd Ed. CRC Press.
- Cheng F.T. (Editor) (2021) *Industry 4.1: Intelligent Manufacturing with Zero Defects*. Wiley-IEEE Press.
- Groover M.P. (2016) *Automation, Production Systems, and Computer-Integrated Manufacturing*. 4th Ed. Pearson Higher Education.
- Gupta K. and Salonitis K. (Editors) (2021) *Sustainable Manufacturing*. 1st Ed. Elsevier.
- Kalpakjian S. and Schmid S. (2022) *Manufacturing Engineering and Technology in SI Units*. 8th Ed. Pearson.
- Liker J.K. (2020) *The Toyota Way, Second Edition: 14 Management Principles from the World's Greatest Manufacturer*. 2nd Ed. McGraw-Hill.
- Patel C.D. and chen C.H. (Editors) (2024) *Digital Manufacturing – Key Elements of a Digital Factory*. 1st Ed. Elsevier.
- Popkova E.G., Ragulina Y.V. and Bogoviz A.V. (Editors) (2019). *Industry 4.0: Industrial revolution of the 21st century* (Vol. 169, p. 249). Cham: Springer.
- Pruncu C.I. and zbitou J. (2023) *Advanced Manufacturing Methods – Smart Processes and Modeling for Optimization*. 1st Ed. CRC Press.
- Singh C.D. and kaur H. (Editors) (2023) *Factories of the Future: Technological Advancements in the Manufacturing Industry*. Wiley.
- Steenhuis H.J. (2024) *The Business of Additive Manufacturing – 3D Printing and the 4th Industrial Revolution*. 1st Ed. Routledge.
- Youssef H.A., El-Hofy H.A. and Ahmed M.H. (2024) *Manufacturing Technology – Materials, Processes, and Equipment*. 2nd Ed. CRC Press.

## **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.*

[Additive Manufacturing](#)

[Additive Manufacturing Letters](#)

[Advances in Industrial and Manufacturing Engineering](#)

[Journal of Advanced Manufacturing Systems](#)

[Journal of Advanced Manufacturing Technology](#)

[Journal of Manufacturing Processes](#)

[Journal of Manufacturing Science and Technology](#)

[Journal of Manufacturing Systems](#)

[Manufacturing Letters](#)

[The International Journal of Advanced Manufacturing Technology](#)

## **Links**

This unit links to the following related units:

*Unit 5015: Manufacturing Systems Engineering*

*Unit 5016: Lean Manufacturing*

*Unit 5018: Sustainability.*