

Unit 4023: Computer Aided Design and Manufacture (CAD/CAM)

Unit Code: A/651/0744

Level: 4

Credits: 15

Introduction

The capacity to quickly produce finished components from a software model is now essential in the competitive world of manufacturing. Businesses now invest heavily in Computer Aided Design (CAD) software, Computer Aided Manufacture (CAM) software and Computer Numerical Control (CNC) machines (Additive Manufacture (AM)) and subtractive machining) to facilitate this, thus reducing product lead times. CAD gives design engineers the platform to creatively model components that meet the specific needs of the consumer. When these models are combined with CAM software, manufacturing is made a reality.

This unit introduces students to all the stages of the CAD/CAM process and to the process of modelling components using CAD software specifically suitable for transferring to CAM software. Among the topics included in this unit are: programming methods, component set-up, tooling, solid modelling, geometry manipulation, component drawing, importing solid model, manufacturing simulation, data transfer, CNC machine types, and inspections.

On successful completion of this unit students will be able to learn about the key principles of manufacturing using a CAD/CAM system; 3D solid models of a component suitable for transfer into a CAM system; CAM software to generate manufacturing simulations of a component; and designing a dimensionally accurate component on a CNC machine or AKM system using a CAD/CAM system.

Learning Outcomes

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

- LO1 Describe the key principles of manufacturing using a CAD/CAM system
- LO2 Prepare 3D solid models of a component suitable for transfer into a CAM system
- LO3 Use CAM software to generate manufacturing simulations of a component
- LO4 Produce a dimensionally accurate component on a CNC/AM machine using a CAD/CAM system.

Essential Content

LO1 Describe the key principles of manufacturing using a CAD/CAM system

Hardware:

CAD workstation, printers, USB flash drives and network cables.

Software:

Operating systems, hard disk requirements, processor, CAD software e.g., SolidWorks, Autodesk Inventor, CATIA, Creo, Siemens NX; CAM software e.g., FeatureCam, Edgecam, GibbsCAM, SolidCAM, Cura.

Inputs:

CAD model, material specifications, tooling data, spindle speeds and feed rate data calculations, STL file, sliced 3D models (infill, wall thicknesses, material, speeds).

Outputs:

CAM files (eg .stp file), program code (gcode) and coordinates, manufacturing sequences, tooling requirements, auxiliary data.

Programming methods:

CAD/CAM, manual programming, conversational programming.

Component set-up:

Zero datum setting, tool set-up and offsets, axis of movements.

Work-holding:

Machine vice, chuck, fixtures, clamping, jigs.

Tooling:

Milling cutters, lathe tools, drills, specialist tooling, tool holders, tool turrets and carousels.

Overview of emerging technologies:

Industry case studies (e.g., Additive Manufacturing/3D printing).

LO2 Prepare 3D solid models of a component suitable for transfer into a CAM system

Solid modelling:

Sketch commands, extrude, cut, holes, sweep, revolve, shell, fillet, chamfer. Use lines, arcs, points, construction planes to generate surface forms. Assign material to review properties of solid models e.g., mass, centre of gravity, surface area.

Geometry manipulation:

Mirror, drag, rotate, copy, array, offset. Model tree manipulation and reordering.

Component/Assembly drawing:

Set-up template, orthographic and multi-view drawings, including sections, detail and exploded views, scale, dimensions, drawing from 3D model data.

Implementation of BS8888 (UK's national framework standard for engineering drawings and geometrical tolerancing)

Attributes e.g., Notes, Bill of Materials (BOM), material, reference points, tolerances, finish, nomenclature (naming convention, e.g. part numbering).

LO3 Use CAM software to generate manufacturing simulations of a component

Import solid model:

Set-up, model feature and geometry identification, stock size, material.

Manufacturing simulation:

Operations e.g., roughing and finishing, pockets, slots, profiling, holes, tool and work change positions, tool sizes and IDs, speeds and feeds, cutter path simulations, program editing

CADCAM used in production of Additive Manufacturing (3D Printing)

Use of Industry 4.0 and CAD/CAM: connectivity, advanced toolpaths, testing; integration of systems through simulation.

LO4 Produce a dimensionally accurate component on a CNC/AM machine using a CAD/CAM system

CNC machine types:

Machining centres, turning centres, hybrid machining (e.g. Mazak, HAAS, Meltio), Robotic arm/gantry routers, MCUs e.g., Fanuc, Siemens, and Heidenheim.

AM machine types:

FDM, SLS, SLM, SLA (VP), DED, L-PBF, EB-PBF.

Data transfer:

Structured data between CAD and CAM software e.g., datum position and model orientation; file types e.g., SLDPRT, parasolid, STL, IGES, STEP, DXF, gcode; transfer to CNC machine e.g., network, USB, Ethernet, Dashboard UI.

Inspection:

Manual inspection e.g., using Micrometer, Vernier gauges, bore micrometres, thread gauge, radius guage, go-no-go gauge.

Automated inspection e.g., co-ordinate measuring machine (CMM), stages of inspection throughout manufacturing process, Machine Vision inspection, metrology level 3D scanner.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the key principles of manufacturing using a CAD/CAM system		D1 Critically evaluate, using illustrative examples, the impact of different machining conditions and specifications on component manufacturing.
<p>P1 Describe the hardware and software elements of a typical CAD/CAM system.</p> <p>P2 Describe, with examples, the inputs and outputs of the CAD/CAM process.</p> <p>P3 Explain the different methods of component set-up, work-holding/build plate adhesion and tooling/nozzle type/configuration available on CNC/AM machines.</p>	M1 Analyse the suitability of different programming methods of CNC/AM machines.	
LO2 Prepare 3D solid models of a component suitable for transfer into a CAM system		D2 Critically evaluate the effectiveness of using a CAD/CAM system and solid modelling to manufacture components.
<p>P4 Prepare a CAD solid model of a component or multi-part assembly to be manufactured on a computer numerically controlled systems.</p> <p>P5 Design a working drawing of a component/assembly containing specific manufacturing detail.</p>	<p>M2 Assess the importance of using different geometry manipulation methods for efficient model production.</p> <p>M3 Analyse accuracy aspects of drawing to aid inspection.</p>	

Pass	Merit	Distinction
L03 Use CAM software to generate manufacturing simulations of a component		D3 Analyse the effect of applying different manufacturing techniques and modifications to achieve an optimised production time.
P6 Use CAM software to generate a geometrically accurate CAD solid model of a component.	M4 Using CAM software, generate cutter tool path simulations. M5 Review sliced file/toolpath, part orientation, infill, supports, wall thickness, build plate adhesion.	
L04 Produce a dimensionally accurate component on a CNC/AM machine using a CAD/CAM system		D4 Critically analyse, giving illustrative examples, the different methods of data transfer through a CAD/CAM system.
P7 Produce a part program for a component using CAM software and transfer the part program to a CNC/AM machine and manufacture a component. P8 Describe the structural elements of a CNC Machining Centre or 3D Printer. P9 Review a component manufactured on a CNC/AM machine to verify its accuracy.	M6 Compare different methods of component inspection used in manufacturing.	

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Bethune J.D. (2019) *Engineering Design Graphics with Autodesk Inventor 2020*. 1st Ed. Pearson.

Bi Z. and Wang X. (2020) *Computer Aided Design and Manufacturing*. Wiley.

BS 8888 (2017) *Technical product documentation and specification*.

Chang K.H. (2021) *Virtual Machining Using CAMWorks 2021 – CAMWorks as a SOLIDWORKS Module*. 1st Ed. SDC Publications.

Chitale A.K. and Gupta R.C. (2023) *Product design and manufacturing*. PHI Learning Pvt. Ltd.

Confalone G.C., Smits J. and Kinnare T. (2023) *3D Scanning for Advanced Manufacturing, Design, and Construction*. Wiley.

Groover M.P. (2020) *Fundamentals of modern manufacturing: materials, processes, and systems*. John Wiley & Sons.

Metwalli S.M. (2021) *Machine Design with CAD and Optimization*. Wiley.

Omura G. and Benton B.C. (2014) *Mastering AutoCAD 2015 and AutoCAD LT 2015 Essentials*. Autodesk Official Press

Pitroda H. P (2019) *Computer Aided Design: Textbook and Practice book*. Walnut publication

Sarkar J., (2014). *Computer aided design: a conceptual approach*. CRC Press.

Shih R.H. (2024) *Principles and Practice: An Integrated Approach to Engineering Graphics and AutoCAD 2024*. 1st Ed. SDC Publications.

Simmons C.H., Dennis E. and Maguire N.P. (2020) *Manual of Engineering Drawing-British and International Standards*. 5th Ed. Butterworth-Heinemann.

Stark J. (2021) *What Every Engineer Should Know about Practical CAD/CAM Applications*. CRC Press.

Zeus Precision Charts Ltd. (2007) *Zeus Precision Data Charts and Reference Tables for Drawing Office, Toolroom & Workshop*. Metric Revision.

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.

[CAD Journal – CAD and Applications](#)

[Computer-Aided Design](#)

[Computer-Aided Design and Applications](#)

[International journal of Computer Integrated manufacturing](#)

[International Journal of CAD/CAM](#)

Links

This unit links to the following related units:

Unit 4001: Engineering Design

Unit 4027: CAD for maintenance Engineers

Unit 4034: Computer Aided Design (CAD) for Engineering