

Unit 4001: Engineering Design

Unit Code: T/650/9628

Level: 4

Credits: 15

Introduction

The tremendous possibilities of the techniques and processes developed by engineers can only be realised by great design. Design turns an idea into a useful artefact, the problem into a solution, or something ugly and inefficient into an elegant, desirable, and cost-effective everyday object. Without a sound understanding of the design process, the engineer works in isolation without the links between theory and the needs of the end user.

The aim of this unit is to introduce students to the methodical steps that engineers use in creating functional products and processes as an individual or part of a design team; from a design brief to the work, and the stages involved in identifying and justifying a solution to a given engineering need.

Among the topics included in this unit are: Gantt charts and critical path analysis, stakeholder requirements, market analysis, design process management, technical drawing, modelling and prototyping, manufacturability, sustainability and environmental impact, reliability, safety and risk analyses, and ergonomics.

On successful completion of this unit, students will be able to prepare an engineering design specification that satisfies stakeholders' requirements, implement best practices when analysing and evaluating possible design solutions, prepare a written technical design report, and present their finalised design to a customer or audience.

Learning Outcomes

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

- LO1 Create a design specification for a given design brief that meets stakeholder's requirements, along with a proposed design solution
- LO2 Analyse possible technical solutions to implement the proposed design specification
- LO3 Produce a design report considering all key aspects including manufacturability (or design for manufacturing and assembly) and environmental impact
- LO4 Present the design solution to an audience, including evaluation of feedback and future improvements.

Essential Content

LO1 Create a design specification for a given design brief that meets stakeholder's requirements, along with a proposed design solution

Planning techniques used to prepare a design specification:

Definition of client's/users' objectives, needs, and constraints

Definition of design constraints, function, specification (e.g., including sub-systems and integrated systems), and milestones

Planning the design task: Flow charts, Gantt charts, Design decision matrix, network, and critical path analysis necessary in the design process

Use of relevant technical/engineering/industry standards within the design process (e.g., BS8888).

Design process:

Process development, steps to consider from start to finish

The cycle from design to manufacture

Three- and five-stage design processes

Common tools and techniques used (e.g., Six Sigma, 8 wastes, etc.)

Use of data, relevant tools (e.g., design tools/software, data reporting tools)

Vocabulary used in engineering design.

Stage of the design process which includes:

Analysing the situation, providing problem statement, researching the problem, defining tasks and outputs, creating the design concept, and writing a specification

Suggest possible solutions, select a preferred solution, prepare working drawings, describe relevant manufacturing aspects/processes (e.g., serialised manufacturing, field level operations, and support), construct a prototype, test and evaluate the design against objectives, design communication (write a report).

Environmental considerations:

Design for recycling, net zero/Low carbon, design for service and repair, social equity and innovation.

Customer/stakeholder requirements:

Converting customer requests to a list of objectives and constraints

Interpretation of design requirements

Market analysis of existing products and competitors

Aspects of innovation and performance management in decision-making

Stakeholder engagement and communications in the context: Listening, non-verbal communication, clarity and brevity, friendliness, confidence, empathy, open-mindedness, respect, feedback, and picking the right medium; communication with groups including group expectations, dealing with reactions and disagreements, allowing and encouraging participation, acting on agreed outcomes, negative communication, motivating disillusioned colleagues, persuasion and negotiation.

LO2 Analyse possible technical solutions to implement the proposed design specification

Conceptual design and evaluating possible solutions:

Modelling, prototyping and simulation using industry standard software, (e.g., AutoCAD, Fusion 360, Catia, SolidWorks, Creo) on high specification computers

Sun systems and their integration into the final design

Use of evaluation and analytical tools, e.g., cause and effect diagrams, CAD, knowledge-based engineering; use relevant data management systems, databases, data formats, data analytics and workflows

Throughput, reliability, availability and maintainability (T-RAM)

Possible solutions using latest methods e.g. additive manufacturing, hot isostatic pressing (HIP)

Use of related documentation: job cards/build records, 2D & 3D drawing/models, Bill of Materials (BOM), Cost Analysis Reports, Compliance Report, Standard Operating Instructions (SOI's), Standard Process Instructions (POI's), Engineering Query Notifications (EQN's) and Drawing Query Notifications (DQN's).

LO3 Produce a design report considering all key aspects including manufacturability (or design for manufacturing and assembly) and environmental impact

Managing the design process:

Recognising limitations including cost, physical processes, availability of material/components and skills, timing, scheduling and design factors such as environmental impact and due considerations.

Working to specifications and standards, including:

The role of compliance checking, feasibility assessment, and commercial viability of product design through testing and validation

Analysing and interpreting data/information for documentation such as Parts Per Million (PPM) quality adherence, cost analysis and test data

Documentation control processes and procedures such as format, location, access, authorisation.

Design for testing, including:

Material selection to suit selected processes, tools, and technologies

Consideration of manufacturability, reliability, life cycle and environmental impact (e.g. UN sustainability goals)

The importance of safety, risk management, and ergonomics

Organisation approved Standard Operating Procedures (SOP's) and documentation recording systems, risk assessment, and the potential implications on safety, quality, and delivery if they are not adhered to.

Conceptual design and effective tools:

Technologies and manufacturing processes used in order to transfer engineering designs into finished products.

Design report:

Sample professional design reports and widely used professional formats, key sections of the report, referencing formats including citation.

LO4 Present the design solution to an audience, including evaluation of feedback and future improvements

Communication and post-presentation review:

Selection of communication/presentation tools/methods (e.g. formal and informal presentations, written reports, verbal, electronic, social media, data metrics), team presentation and management (e.g., team integration and dynamics, effective communications, conflict management).

Analysis of presentation feedback:

Strategies for improvement based on feedback, including systematic, proactive and transparent approach to improve design solutions.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Create a design specification for a given design brief that meets stakeholder's requirements, along with a proposed design solution		D1 Compare and contrast the completed design specification against a formal professional engineering specification.
<p>P1 Create a design specification from a given design brief.</p> <p>P2 Explain the influence of the stakeholder's design brief and requirements in the preparation of the design specification.</p> <p>P3 Produce a design project schedule with a graphical illustration of the planned activities.</p>	<p>M1 Evaluate potential planning techniques, presenting a case for the method chosen.</p> <p>M2 Demonstrate critical path analysis techniques in design project scheduling/planning and explain their use.</p>	
LO2 Analyse possible technical solutions to implement the proposed design specification		
<p>P4 Analyse industry standard evaluation and analytical tools used in formulating possible technical solutions.</p> <p>P5 Use appropriate design techniques to produce a possible design solution.</p>	M3 Apply the principles of modelling, simulation and/or prototyping, using appropriate software, to develop an appropriate design solution.	D2 Evaluate potential technical solutions, presenting a case for the final choice of solution.

Pass	Merit	Distinction
<p>LO3 Produce a design report considering all key aspects including manufacturability (or design for manufacturing and assembly) and environmental impact</p>		<p>D3 Evaluate the effectiveness of the formal professional engineering technical design report for producing a fully compliant finished product.</p>
<p>P6 Prepare a formal engineering technical design report.</p> <p>P7 Explain the role of design specifications and standards in the technical design report including environmental impact.</p>	<p>M4 Assess any compliance, safety, and risk management issues contained within the technical design report.</p>	
<p>LO4 Present the design solution to an audience, including evaluation of feedback and future improvements</p>		<p>D4 Justify potential improvements to the design solution and/or presentation based on reflection and/or feedback.</p>
<p>P8 Present the recommended design solution to the identified audience.</p> <p>P9 Explain possible communication strategies and presentation methods that could be used to inform the stakeholders of the recommended solution.</p>	<p>M5 Reflect on the effectiveness of the chosen communication strategy in presenting the design solution.</p>	

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Barberio M., Colella M., Figliola A. and Battisti A. (Editors) (2023) *Architecture and Design for Industry 4.0: Theory and Practice – Lecture Notes in Mechanical Engineering* (Hardback). Springer.

Dul J. and Weerdmeester B. (2008) *Ergonomics for beginners*. 3rd Ed. Boca Raton: CRC Press.

Dym C.L., Little P. and Orwin E. (2014) *Engineering Design: a Project Based Introduction*. 4th Ed. Wiley.

Griffiths B. (2003) *Engineering Drawing for Manufacture*. Kogan Page Science.

Jack H. (2021) *Engineering Design, Planning, and Management*. 2nd Ed. Academic Press.

Leake J.M, Goldstein M.H., and Borgerson J.L. (2022) *Engineering Design Graphics: Sketching, Modeling, and Visualization*. 3rd Ed. Wiley.

Nassersharif B. (2022) *Engineering Capstone Design*. 1st Ed. CRC Press.

Planhard D.C. (2023) *Engineering Design with SOLIDWORKS 2023: A Step-by-Step Project Based Approach Utilizing 3D Solid Modelling*. 1st Ed. SDC Publications.

Pugh S. (1990) *Total Design: Integrated Methods for Successful Product Engineering*. 1st Ed. Prentice Hall.

Reddy K.V. (2008) *Textbook of Engineering Drawing*. 2nd Ed. Hyderabad: BS Publications.

Simmons C. H. (2012) *Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards*. 4th Ed. Butterworth-Heinemann.

Voland G (2014) *Engineering by Design*. 2nd Ed. Pearson.

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.

[ASME Journal of Mechanical Design](#)

[Design Science](#)

[Journal of Engineering Design](#)

[Journal of Engineering Design and Technology](#)

[Research in Engineering Design](#)

Links

This unit links to the following related units:

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

Unit 5001: Research Project.