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GCSE (9–1)

Delivery Guide

DESIGN AND TECHNOLOGY

J310
For first teaching in 2017

Topic Area 7: Manufacturing processes and techniques – Design engineering

Version 1

www.ocr.org.uk/gcsedesignandtechnology

Contents

TOPIC AREA 7: MANUFACTURING PROCESSES AND TECHNIQUES – DESIGN ENGINEERING

Introduction

GCSE (9-1)

DESIGN AND TECHNOLOGY

A guide to approaching the teaching of the content related to Topic Area 7: Manufacturing processes and techniques – Design engineering

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- **Content:** A clear outline of the content covered by the delivery guide;
- **Thinking Conceptually:** Expert guidance on the key concepts involved, common difficulties learners may have, approaches to teaching that can help learners understand these concepts and how this topic links conceptually to other areas of the subject;
- **Thinking Contextually:** A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resources.feedback@ocr.org.uk

Link to qualification:

http://www.ocr.org.uk/qualifications/gcse-design-and-technology-j310-from-2017/

Specification content (Sub Topic 1)

Sub Topic 1: Making iterative models

Exam content

7.1 How can materials and processes be used to make iterative models?

The processes and techniques used to produce early models and/or toiles to support iterative designing.

NEA content

a. Be able to use specialist techniques and processes to shape, fabricate, construct and assemble at least one high quality prototype, including techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or system components being used.

b. Be able to use specialist tools and equipment, appropriate to the materials or system components used (including hand tools, machinery, digital design and manufacture), to create models and prototypes.

c. Be able to use appropriate and accurate marking out methods including: measuring and use of reference points, lines and surfaces; use templates, jigs and/or patterns where appropriate; work within tolerances; understand efficient cutting and how to minimise waste.

Thinking conceptually

General approaches:

There is no right or wrong way to produce iterative models, the whole emphasis of the iterative design process is to explore an idea and develop it based on the findings of each iteration. Choosing the correct materials and processes is very much dependent on the skillset of the learner. If they are more confident modelling with materials such as card and other boards, this would be a good start for the early iterations before introducing materials such as modelling foam. Once a solution to the problem has been found, the quality of the models will increase as the learner works towards their final prototype. However, it may not be possible to produce a single fully working prototype that contains an entire mechanism or electronic components, therefore a series of prototypes may be presented.

During the initial stages of the iterative design process, it may not be suitable or efficient to use machinery such as laser cutters or 3D printers to produce initial prototype(s). It may be easier and quicker to produce these initial prototype(s) using scissors, craft knives, glue and simple hand tools. The use of CAD and CAM will play a major role in the iterative design process but will need to be accompanied with and supported by manual skill. There is a large amount of skill required to CAD model a prototype to be 3D printed or laser cut which is recognised, but physical modelling skills must also be presented.

Common misconceptions or difficulties learners may have:

There may be a prototype to illustrate the final form of the concept with a further prototype model demonstrating the mechanism or electronics. It may not be possible, due to the facilities or timeframes available, to produce the system small enough to be housed within the prototype, so presenting a number of final prototype models is acceptable.

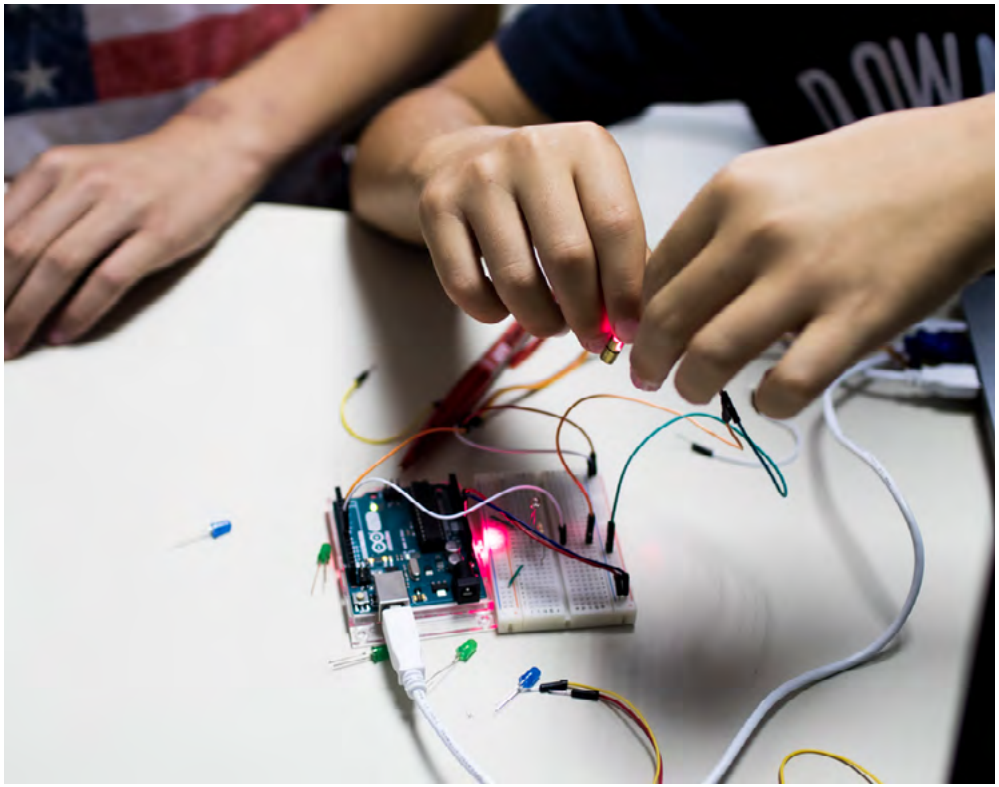
It is not necessary for every initial or developed prototype model to be of the highest quality. The idea of a prototype model is to demonstrate a concept, if this is in a relatively crude manner then it is not necessarily negative.

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

This topic links closely with 5.1 and 5.2.

Thinking contextually

Learners should be encouraged to begin to physically model alongside their sketched and CAD modelled iterations as soon as possible. Initial modelling should be quick and aim to model a particular element or feature of a concept rather than trying to encompass every feature straight away. Initial modelling techniques could include simple card modelling using old boxes, for instance, or by using modelling foam. Modelling foam is more suited to prototyping form rather than function. Mechanisms can easily be modelled using card, some parts that require a bit more precision such as gears, are often best used pre-made and combined with card rather than trying to laser cut versions which may not be quite so efficient or effective to model. When modelling electronic circuits, alongside CAD modelling breadboards with physical components should be used to demonstrate an understanding of the circuit and the ability to physically model.



Learner Resources – Activities

Title	Organisation/ Company	Web link	Summary description	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
Modelling a robotic arm with card	The Q	https://www.youtube.com/watch?v=P2r9U4wkjcc	This is a great video that demonstrates how to model a relatively complex prototype using card and other basic materials.	Thinking contextually	7.1
Prototyping and model-making	Product Tank	https://www.youtube.com/watch?v=gWk6br5Ngkc	You can never assume that just because something has been done before, you can progress straight to manufacture without prototyping your design. A quick prototype highlights problems and saves time, money and embarrassment. So you have to do this phase in the design process to identify problems.	Thinking conceptually	7.1
Prototyping techniques	Jude Pullen	http://www.judepullen.com/designmodelling/techniques/	This is a really useful website that contains lots of tips and tricks for modelling with a number of different materials.	Thinking contextually	7.1

Specification content (Sub Topic 2)

Sub Topic 2: Making final prototypes in a workshop

Exam content

7.2 How can materials be manipulated and joined in different ways in a workshop environment when making final prototypes?

a. The use of specialist techniques, hand tools and equipment used to shape, fabricate, construct and assemble high quality prototypes, with exemplification of the following processes:

i. wastage, such as:

- design engineering, e.g. etching*.

ii. addition, such as:

- design engineering, e.g. soldering*.

iii. Deforming and reforming, such as:

- design engineering, e.g. moulding*.

** and other processes appropriate to the materials or components being used in design engineering.*

7.3 How do designers and manufacturers ensure accuracy when making prototypes and products?

a. The use of appropriate and accurate marking out methods, including:

i. measuring and use of reference points, lines and surfaces

ii. templates, jigs and/or patterns

iii. working within tolerances

iv. understanding efficient cutting and how to minimise waste.

NEA CONTENT

a. Be able to use specialist techniques and processes to shape, fabricate, construct and assemble at least one high quality prototype, including techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or system components being used.

b. Be able to use specialist tools and equipment, appropriate to the materials or system components used (including hand tools, machinery, digital design and manufacture), to create models and prototypes.

c. Be able to use appropriate and accurate marking out methods including: measuring and use of reference points, lines and surfaces; use templates, jigs and/or patterns where appropriate; work within tolerances; understand efficient cutting and how to minimise waste.

Thinking conceptually

General approaches:

Final prototypes need to demonstrate both the learner's skill, use of specialist techniques and also understanding of the context and the design solution they have created. Specialist techniques within the electronics realm of design engineering include PCB manufacture using either an etching or engraving methods, for instance, and also soldering components to the aforementioned PCBs. Moulding techniques may be used to create casings and housings for systems. Specialist machinery may also be used to form specific components for mechanisms such as milling machines, 3D printers and laser cutters.

Accuracy is an important factor for learners to consider especially with their NEA project. Learners should be able to demonstrate an awareness of the techniques used to ensure accuracy, such as templates, jigs and specialist tools such as Vernier Callipers and micrometers. When testing and ensuring the quality of electronic circuits and PCBs, multimeters can be used to test voltage across two points for instance and can also be used to trace potential faults.

Common misconceptions or difficulties learners may have:

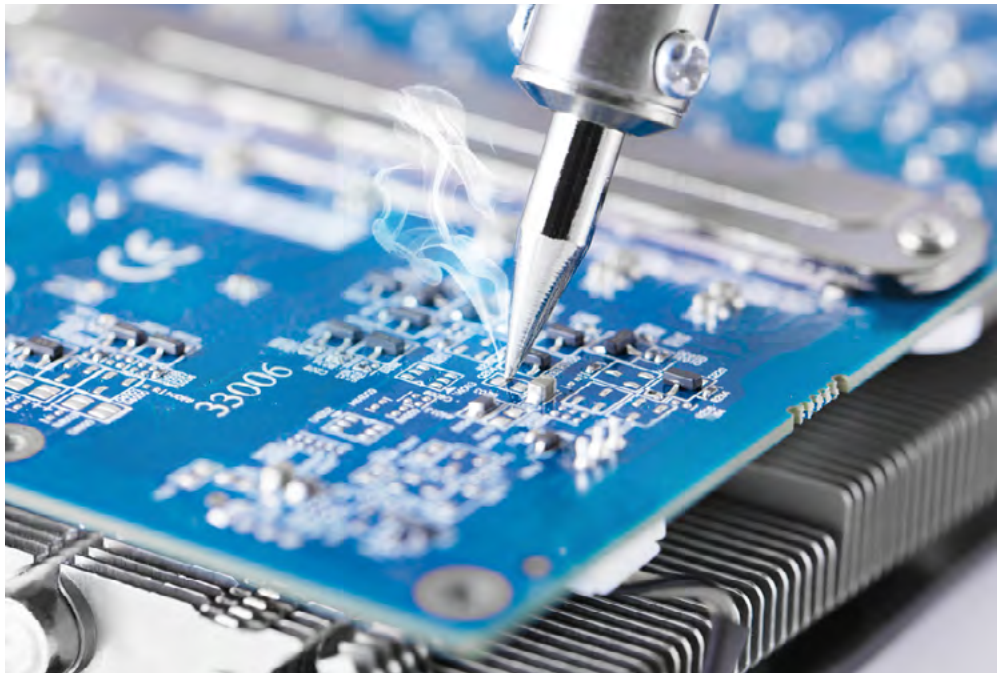
If a centre does not have the facility to manufacture PCB or specialist components that require milling machines, for instance, learners are still able to gain credit for the creation of the files required to produce the item. Learners are not able to access marks for the manufacture if this has been outsourced as they are not able to demonstrate how they have potentially set-up the machine and carried out the necessary Health and Safety, QC & QA checks before the manufacture takes place. However, so long as a learner demonstrates evidence of the required practical skills elsewhere in their NEA, these can still have consideration when marking the practical skills used in the production of the final prototype(s).

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

This topic links well with 5.2, 6.1, 6.3 and 6.4.

Thinking contextually

When exploring the electronics-side of design engineering, it is important that learners are aware of the different methods available to produce components such as PCBs. This may include the etching process and also the milling process which involves removing sections of a copper laminated GRP board to leave behind the tracks and pads. If a centre has the facility to produce a PCB, a short project which involves the design and creation of a PCB prior to starting the NEA will greatly benefit learners. The theoretical side of the process can also be emphasised alongside building on the learner's practical skill and understanding of the method. In a similar vein, soldering is best learnt through getting hands-on and short projects such as assembling and soldering simple LED torches, allow learners the opportunity to experience the technique.



Similarly, short projects can be used to gain knowledge and understanding of the use of jigs and tolerances. Learners may be required to replicate a design a number of times within a set tolerance through the use of jigs, templates and measuring devices such as Vernier Callipers and micrometers. A mini production line for a simple product could be created with each learner or small group of learners responsible for the creation and accuracy of a certain part or stage of assembly.

Learner Resources – Activities

Title	Organisation/ Company	Web link	Summary description	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
PCB Milling	Adafruit Industries	https://www.youtube.com/watch?v=Yvp9IfGyrXQ	This video demonstrates how PCBs can be made using a PCB milling machine.	Thinking conceptually	7.2
BMW Quality Management	BMW	https://www.youtube.com/watch?v=TiuaFwzJ4FU	This is short video clip that details the QC & QA methodologies applied by BMW.	Thinking contextually	7.2
The importance of QC in industrial fabrication	Polaris	http://www.polarisengr.com/fabrication/why-quality-control-is-crucial-industrial-fabrication-shops/	This website details Polaris' commitment to QC in their products and services they offer. This is a useful resource to use from a manufacturers viewpoint.	Thinking contextually	7.2

Specification content (Sub Topic 3)

Sub Topic 3: Using digital tools to support design development and manufacture

Exam content

7.4 How do industry professionals use digital design tools when exploring and developing design ideas?

a. The use of 2D and 3D digital technology and tools are used to present, model, design and manufacture solutions, such as:

- rapid prototyping
- image creation and manipulation software
- digital manufacture
- interpretation of plans, elevations of 3D models
- CAD, CAM, CAE.

NEA content

b. Be able to use specialist tools and equipment, appropriate to the materials or system components used (including hand tools, machinery, digital design and manufacture), to create models and prototypes.

Thinking conceptually

General approaches:

The use of digital design tools in both in industry and within centres is ever increasing and it important for learners to understand how and why these digital tools are used. Computer-Aided Design (CAD) allows designers to develop design solutions in a virtual environment and apply a variety of testing strategies such as stress analysis and shape optimisation often referred to as CAE (Computer-Aided Engineering). Due to its nature, Computer-Aided Manufacture (CAM) links very closely with CAD in order to rapid prototype design solutions and produce CNC parts.

Digital design tools also offer the opportunity for designers to render and output realistic digital representations of their products for advertising and display purposes. Elevations of designs are also generated for use in instructions manuals to demonstrate how a product should be assembled or disassembled.

Common misconceptions or difficulties learners may have:

The stigma regarding automation and digital design taking jobs always appears when considering the impacts of CAD/CAM. Whilst correct in some respects; more manual skilled jobs are beginning to cease to exist, the need for CAD/CAM technicians and maintenance engineers has increased.

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

This topic links very well with 3.1 'What are the impacts of new and emerging technologies when developing design solutions?', 4.1 'How can design solutions be communicated to demonstrate their suitability to a third party?'

Thinking contextually

It is important that learners are able to access CAD modelling and understand the processes behind producing digital designs and iterations. This topic could be delivered as part of a learner's NEA as they begin to produce and develop their design iterations through the use of CAD software and, if possible, rapid prototype their iterations for further analysis. The CAD software themselves vary in approach, but many will boast testing and analysis features that can be applied to 3D models to critically evaluate their suitability.

If learners are able to access CAM equipment this will provide great benefit with their NEA as they will be able to demonstrate their use/supervised use of the machinery in order to manufacture parts or elements of their design solutions. As previously mentioned, learners will not be able to gain credit for their practical skills when components have been externally produced or outsourced.

Learner Resources – Activities

Title	Organisation/ Company	Web link	Summary description	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
CAD CAM explained	Inc.	https://www.inc.com/encyclopedia/computer-aided-design-cad-and-computer-aided-cam.html	This website provides a bit more detail on CAD/CAM and also highlights the advantages and disadvantages.	Thinking conceptually	7.4
What is CAD CAM & CAE?	Tech Know Travel	https://www.youtube.com/watch?v=baWZ4YnWG2w	The video explains the concept of CAD, CAM, CAE in the most simplest form possible. It explains how a design process starts and how CAD, CAM, CAE simplified the design process.	Thinking conceptually	7.4
A day in the life – CAD technician	The world of work	https://www.youtube.com/watch?v=yVkwHLMXx48	This is a really useful short clip about the sorts of things a CAD technician experiences on a daily basis.	Thinking contextually	7.4

Specification content (Sub Topic 4)

Sub Topic 4: Making products to different scales of production

Exam content

7.5 How do processes vary when manufacturing products to different scales of production?

a. The methods used for manufacturing at different scales of production, including:

i. one-off, bespoke production

ii. batch production

iii. mass production

iv. lean manufacturing and just-in-time (JIT) methods.

b. Awareness of manufacturing processes used for larger scales of production, such as:

- design engineering, e.g. laser cutting, rapid prototyping and 3D printing.

7.6 How do new and emerging technologies have an impact on production techniques and systems?

a. Critical evaluation of the benefits and implications of incorporating new and emerging technologies into production processes, such as:

- consideration of economies of scale
- how disruptive technologies such as 3D printing and robotics are changing manufacturing.

Thinking conceptually

General approaches:

Learners will need to have an awareness of the main manufacturing methods and their associated scale of production. Discussing the different types in direct relation to products is a useful way to explore the context. Alongside developing a learner's ability to identify the scale/type of production used to produce a product, learners should be able to apply this knowledge to their NEA. Within the NEA, learners should show consideration for commercial techniques that may be used if their prototype(s) were to be produced on an associated scale and support this with relevant technical detail.

In terms of how new and emerging technologies have an impact on production techniques and systems, one of the most prevalent factors at the moment is the introduction of automated production through the use of robotics and such like. It is important that learners are able to understand both sides of an argument when it comes to disruptive technologies and not purely focus on one over the other. 3D printing is becoming far more accessible and, in turn, can be classed as becoming more disruptive, the ability for learners to identify how and why this is the case is an important skill.

Learners should also be aware of the manufacturing techniques used to manufacture products at the varying scales of production. For instance, laser cutting may be used when smaller quantities of products are required and the material suits but the scale may increase to a point when laser cutting is no longer efficient. Also, where a prototype may be 3D printed within a centre, that may not be the case in industry where the product may be injection moulding, for instance. It is also important to distinguish between the different types of 3D printing such as Fused Deposition Modelling (FDM) and Selective Laser Sintering (SLS).

Common misconceptions or difficulties learners may have:

There are often overlaps between the different scales of production and quite often a product could have been produced using a number of different methods on different scales. Therefore, it is important for learners to be able to justify their reasoning and identify the product traits that may indicate the scale of production associated.

A disruptive technology is not necessarily negative, and often quite the opposite. It is important for learners to understand that although the word disruptive is classed as negative, this can often have positive effects on society and industry as changes and developments are forced.

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

This topic links well to 7.4, 2.1 & 2.2.

Thinking contextually

There are a number of video clips that provide an insight into the different scales of production and are highlighted in the associated learner resources. Showing these clips to a group of learners and frequently pausing and discussing the production method/scale used to produce is a good way for learners to add context to each of the scales of production alongside associating products with them.

Setting up a small production line to produce a simple product such as a novelty card or small product made of multiple parts is a good way to practically demonstrate the scales of production. Learners could be tasked to individually produce as many of the entire product as possible in a set time limit on their own, then as small groups with a specific task each, then as a whole group with each learner assigned a different task. Learners should be able to notice and identify the differences in scales of production between each.

These topics can be linked to a learner's chosen NEA context and the product they aim to produce as due care and consideration must be given towards the commercial viability of the product.

Learner Resources – Activities

Title	Organisation/ Company	Web link	Summary description	Additional description detail	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
Production methods	Various	https://www.youtube.com/watch?v=DTWnQDAhp9k	This is a really useful video that shows a number of different products in production. Learners should be able to make informed choices with regards to the scale of production from each.		Thinking contextually	7.5
Disruptive technologies	Pacific Council	https://www.youtube.com/watch?v=M27KECEL5Zo	Stanford Instructor, Tony Seba explains how major global industries such as energy and transportation will undergo a complete "disruption" by the year 2030.	This resource may be best used as further extension material on the topic or segments of the video used to emphasise particular points.	Thinking contextually	7.6
How 3D printing is enabling the '4th Industrial Revolution'	TEDx Talks	https://www.youtube.com/watch?v=IsJLZ1UYxGc	In this video, Dr Tim Minshall discusses 3D printing as a fundamentalbuilding block of the '4th industrial revolution' that has the potential to transform the way in which production and consumption are connected. This talk explores how this is happening using examples from medical prosthetics, aerospace, disaster relief, and education.	Tim Minshall is a Reader in Technology and Innovation Management at Cambridge University Engineering Department and a Fellow of Churchill College. His research, teaching and outreach is focused on open innovation, the adoption of new technologies, the development of engineering skills, and the growth of the Cambridge high tech cluster.	Thinking contextually	7.6

Learner Activity

Production Methods

Introduction

Identifying and understanding production methods can be much clearer if you link the method to a product. While watching the 'Production Methods' YouTube clip, try to identify as many different products and their associated production method.

The activity

Watch the 'Production Methods' YouTube clip a couple of times.

- The first time you watch it try and make a note of the products that are being produced.
- The second time you watch it try and link the products to their associated production method.

Now you have watched the clip a couple of times and associated the products with a production method, why did you choose that particular method? Justify your reasoning, you may consider the following points:

- scale
- possible machinery being used
- number of workers present
- type/category of product.

Extension activities/questions:

Think of the number of products you encounter in your everyday life. Try and list as many as possible along with their associated production method. Remember to justify your choice of method!

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