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OCR
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GCSE (9–1)

Delivery Guide

DESIGN AND TECHNOLOGY

J310
For first teaching in 2017

Topic Area 6: Technical understanding – Design engineering

Version 1

www.ocr.org.uk/gcsedesignandtechnology

Contents

TOPIC AREA 6: TECHNICAL UNDERSTANDING – DESIGN ENGINEERING

GCSE (9-1)

DESIGN AND TECHNOLOGY

A guide to approaching the teaching of the content related to Topic Area 6: Technical understanding – 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: Core consideration of mechanisms

Exam content

6.3 How do we introduce controlled movement to products and systems?

a. An overview of different sorts of movement and types of motion, including:

i. rotary

ii. linear

iii. oscillating

iv. reciprocating.

b. The effect of forces on the ease of movement, including:

i. load

ii. effort

iii. fulcrum.

c. How different mechanical devices are used to change the magnitude and direction sof motion or forces, including consideration of:

i. cams

ii. gears

iii. pulleys and belts

iv. levers and linkages.

NEA content

a. Apply technical principles appropriately to ensure functional requirements are achieved when developing a design solution.

Thinking conceptually

General approaches:

It is important that all learners are able to understand and identify the four different types of motion before further exploration of mechanical systems occurs. Without a clear understanding of these it is difficult to grasp the key concepts of a number of mechanisms, especially those which convert and transmit different types of motion.

There are a large number of different types of mechanisms that can all convert one type of motion to another or simply transfer motion, it is important for learners to understand the application of a number of different types of mechanisms and mechanical devices and identify why they have been used. Understanding the concept of load, effort and fulcrum (pivot point) can be approached by exploring the 3 classes of levers. Class 1, 2 and 3 levers all utilise a different fulcrum and positioning of the load and effort.

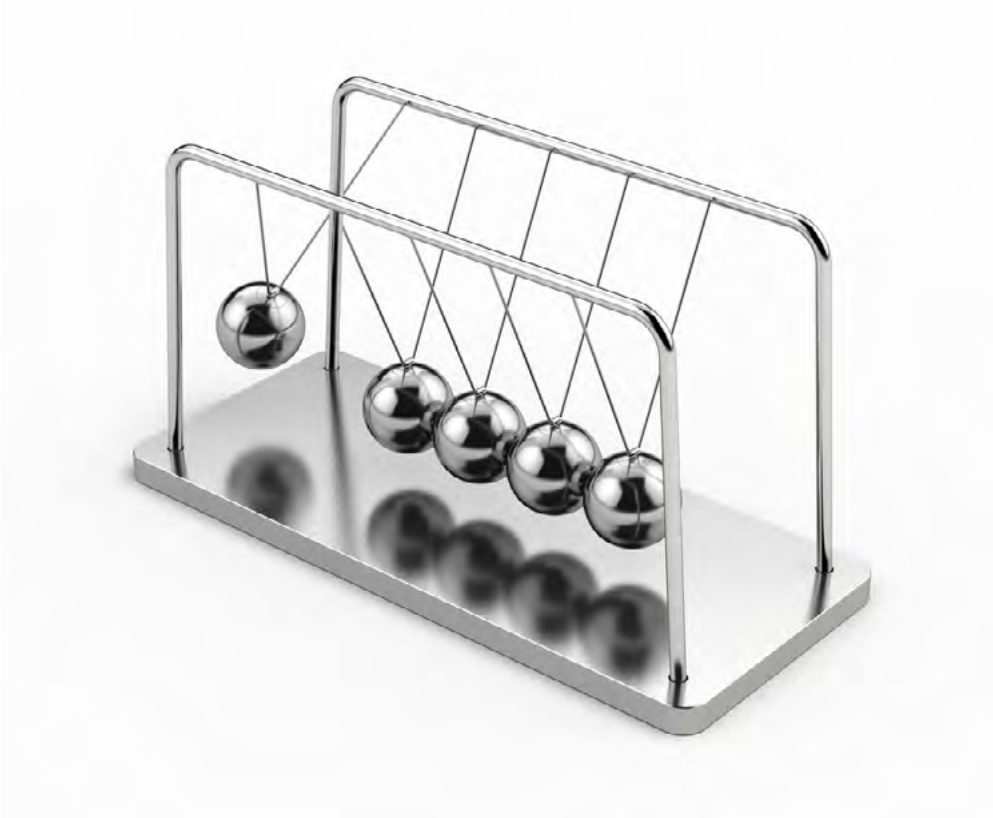
For learners pursuing Design Engineering in depth will be able to explore and take any of this understanding further and apply it in their NEA.

Common misconceptions or difficulties learners may have:

Friction is not necessarily a bad thing within mechanisms, although friction needs to be reduced to increase efficiency in many cases and also to reduce the often negative by-product heat, friction is required to allow mechanisms to operate. If you remove friction from a belt and pulley system, for instance, the entire system will no longer function. The important factor with friction is to balance it with efficiency.

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 and lays a solid foundation to aid the exploration of mechanical systems for the NEA tasks if the learner or centre wishes to take this topic in depth.

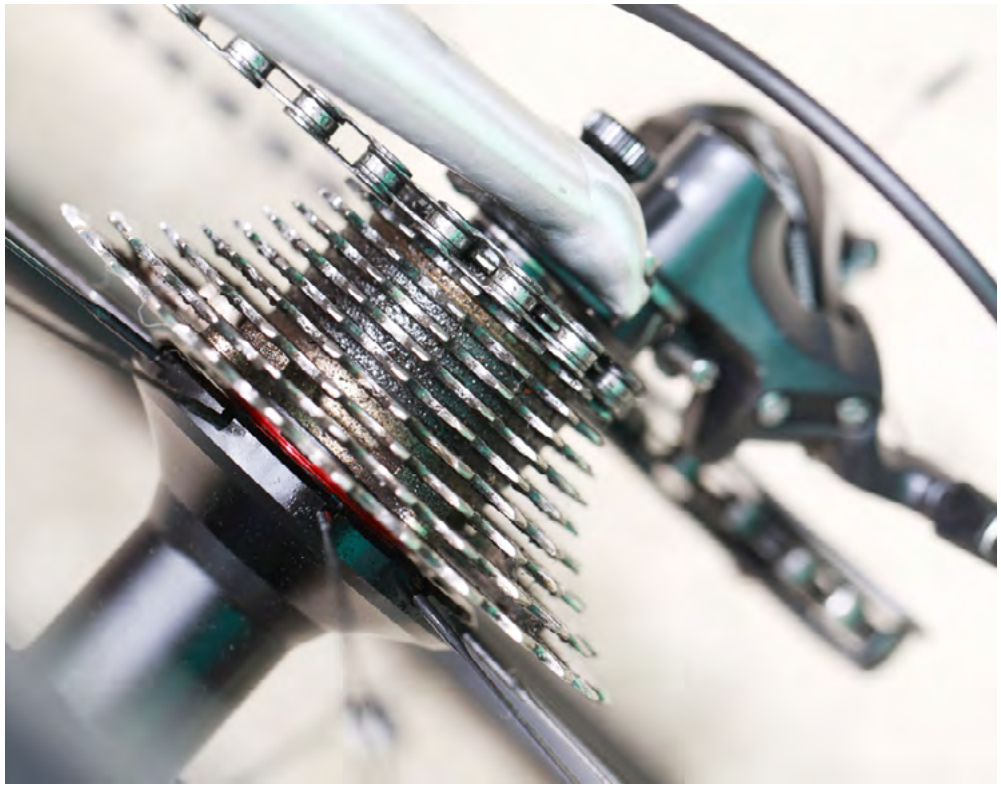


Thinking contextually

There are a number of workshop tools that utilise many different mechanisms. For instance, pillar drills often utilise the belt and pulley system to transfer motion, metalwork lathes transfer motion along two different axes and often utilise a worm gear, hand drills utilise a bevel gear and so on. Although not essential, it can be useful to obtain small mechanism kits containing different gears, pulleys and drive systems in order for learners to practically build the different mechanisms and explore the different types of motion in action.

A bicycle contains a transfer's number of different types of motion and can be useful and practical way of demonstrating rotary motion through the use of gear systems. Gear ratios can also be explored if a bicycle with a number of gears can be obtained. Learners could calculate the gear ratio by counting the teeth on the spur gears, applying the formula and then test their result in a practical form.

The more everyday examples you can find, the better, especially when delivering content that may appear daunting at first to new learners.



Learner Resources – Activities

Title	Organisation/ Company	Web link	Summary description	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
Types of motion	BBC Bitesize	http://www.bbc.co.uk/schools/gcsebitesize/design/systemscontrol/mechanismsrev8.shtml	This resource explains the different type of motion, mechanisms, levers and linkages. It is useful to reinforce learning.	Thinking conceptually	6.3
Levers	TutorVista	https://www.youtube.com/watch?v=DXtr9-S3lxw	This short video clip explains and explores the different types of levers.	Thinking conceptually	6.3 (b)

Learner Activity

Identifying types of motion

Introduction

There are a number of images on the attached sheet which can be linked to one or sometimes more of the types of motion you have just learnt.

The activity

Complete the attached sheet to identify the type of motion taking place in each image. Remember to state where the type of motion is taking place.

Extension activities/questions:

Try and think of your own examples that haven't already been identified for the 4 different types of motion.

Specification content (Sub Topic 2)

Sub Topic 2: Core consideration of electronics

Exam content

6.4 How do electronic systems provide functionality to products and processes?

a. How sensors and control devices respond to a variety of inputs, including:

i. sensors including light dependent resistors (LDR), infra-red sensors

ii. switches including tilt switches, push-to-make switches and time-delay switches.

b. How devices are used to produce a range of outputs, including:

i. light-emitting diodes (LED) to produce light

ii. speakers and buzzers to produce sound

iii. motors to produce motion.

c. The use of programmable components such as microcontrollers, to embed functionality into products in order to enhance and customise their operation.

NEA CONTENT

a. Apply technical principles appropriately to ensure functional requirements are achieved when developing a design solution.

a

Thinking conceptually

General approaches:

All learners will be required to have a generic understanding of basics of electronic systems and the incorporation of a programmable component in different types of products. The basic knowledge required does not need to go far beyond the simply understanding of inputs and outputs with the level of exemplification outlined in the content, but this knowledge will be better understood through some practical activity.

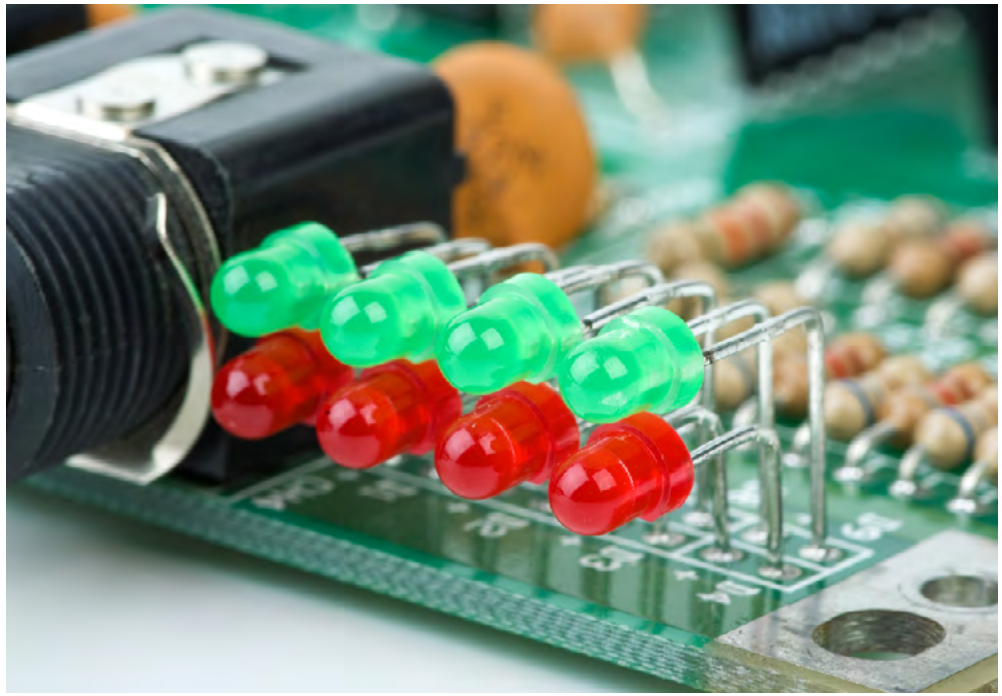
Approaching this topic through the system block diagram method is a very useful way for learners to understand and begin to categorise inputs, processes and outputs. Once learners have grasped the concept of the system block diagram, they should be able to identify each block in accordance with everyday electronic products. It is also important for learners to understand why an electronic system has been utilised within a product and what potential advantages and disadvantages this can bring.

Common misconceptions or difficulties learners may have:

When considering system block diagrams it is important to remember that not every circuit will contain a process. For instance, a simple on/off LED circuit may only include an input, a switch, and the output, an LED. Learners often confuse a power source as an input; this is only the case if the voltage/current is being measured by a microcontroller, for example, to control an output. If a power source is solely powering a circuit and not providing any measured input then it is not considered an input device.

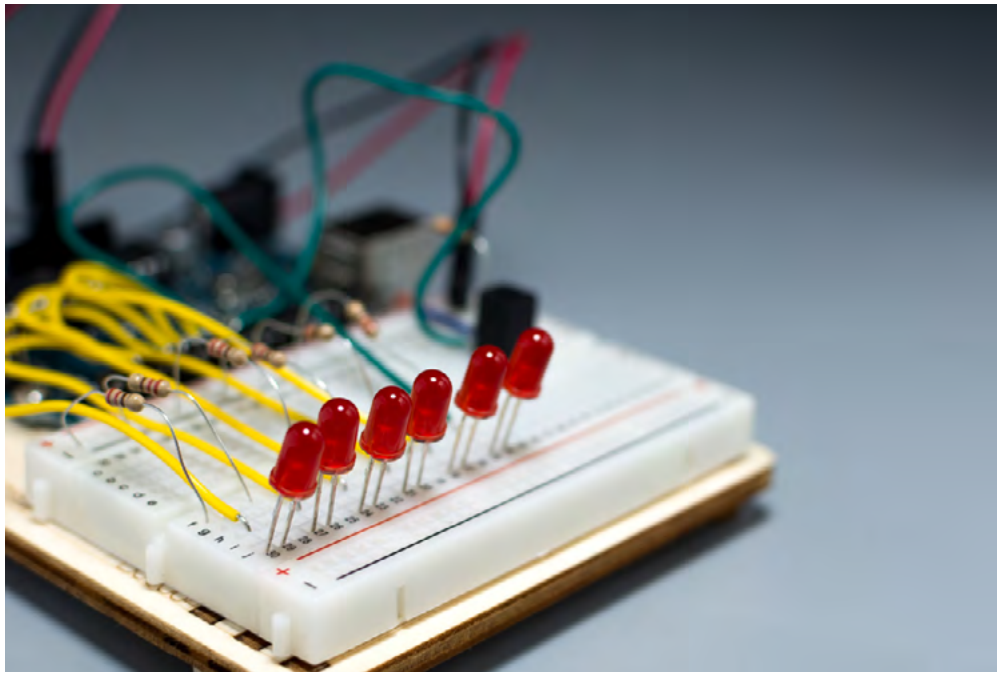
Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

This topic links well with subtopics 5.2 and 5.4. This topic links well to and lays a solid foundation to aid the exploration of electronic systems for the NEA tasks if the learner or centre wishes to take this topic in depth.



Thinking contextually

This topic is best delivered via practical means once the theoretical understanding of inputs/processes/outputs is understood. Exploring the world of electronics through breadboards and the handling of components is very valuable and can help learners' understanding when they can see an electronic system that they have built working before their eyes. If the handling of physical components, breadboards and using power sources is not an option, then there are also a number of free, online packages available such as Autodesk Circuits. The electronics lab hub allows you to build and simulate a virtual breadboard without the need for physical components. Programmable controllers such as Arduino boards can also be simulated and programmed using the software.



Building simple push switch circuits that control LEDs and motors are a good place to start before exploring more in depth topics and programmable components.

Learner Resources – Activities

Title	Organisation/ Company	Web link	Summary description	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
Electronics Lab Hub	Autodesk Circuits	https://circuits.io/	This online resource allows you to build and simulate virtual breadboard circuits. Programmable devices such as Arduino boards can also be virtually programmed and simulated. All files are stored in the cloud but also able to be downloaded for conversion into a PCB etc.	Thinking contextually	6.4
Electronic components	BBC Bitesize	http://www.bbc.co.uk/schools/gcsebitesize/design/systemscontrol/electronicsrev6.shtml	This is a really useful resource for identifying the different types of electronic components. Although unless studying this topic in-depth it is not necessary to cover Logic Gates.	Thinking conceptually	6.4
An introduction to switches	Make:	https://www.youtube.com/watch?v=S2AHimvbovI	There is a huge variety of switch types and sizes available nowadays. This video is great intro to many of the different types of switches and when/ where they are used.	Thinking contextually	6.4

Learner Activity

System Block Diagrams

Introduction

System block diagrams are all around us but can you identify some?

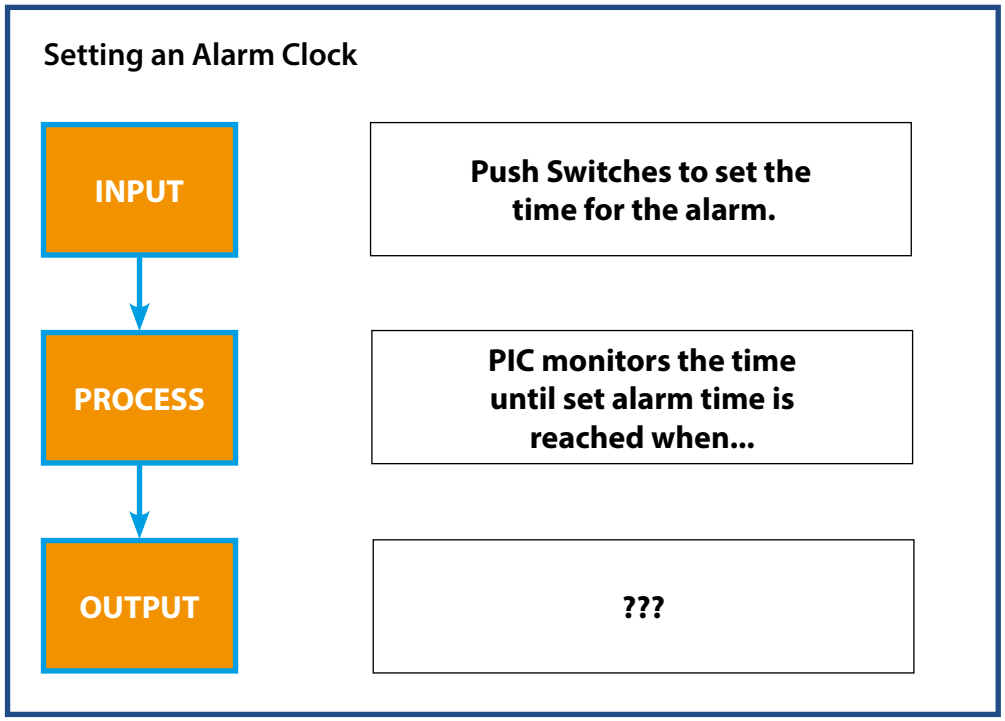
The activity

Choose five different electronic products and identify the System Block Diagram for each product.

Remember Some electronic products only have an Input and an Output. Process components are not always required.

For example a standard desk lamp has 1 input (the switch) and 1 output (the bulb).

Try and identify at least 2 products that make use of input(s), process, output(s).



Extension activities/questions:

Try and identify three different system block diagrams that may be used within a smart phone…

Specification content (Sub Topic 3)

Sub Topic 3: In-depth consideration of mechanisms

Exam content

6.3 How do we introduce controlled movement to products and systems?

a. An overview of different sorts of movement and types of motion, including:

More depth to be covered through practical application for 'in-depth' learners

b. The effect of forces on the ease of movement, including:

More depth to be covered through practical application for 'in-depth' learners

c. How different mechanical devices are used to change the magnitude and direction of motion or forces, including consideration of:

More depth to be covered through practical application for 'in-depth' learners

NEA content

a. Apply technical principles appropriately to ensure functional requirements are achieved when developing a design solution.

Thinking conceptually

General approaches:

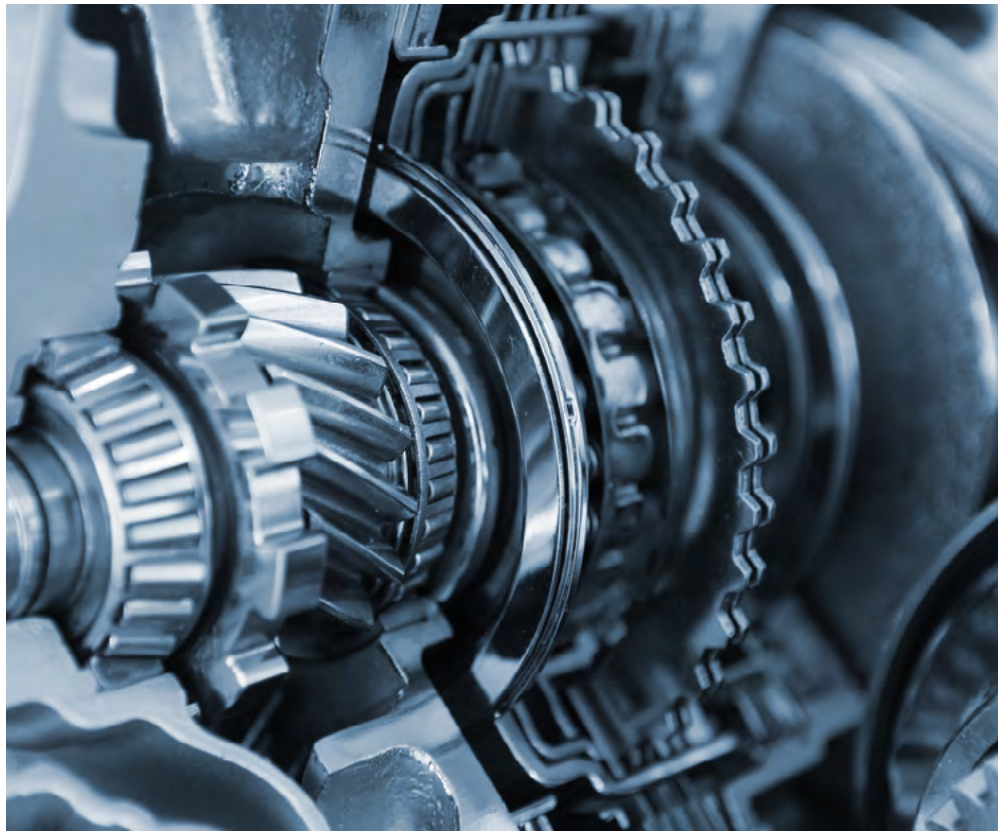
The best way to explore the use of mechanisms in more depth is to analyse existing mechanical systems and observing how they operate while evaluating their efficiency. When studying the topic in greater depth, more emphasis on the mathematical principles such as gear ratios and velocity ratios should be considered. Learners will gain further understanding through building mechanical devices in response to a brief or challenge. For instance, increasing or reducing the output speed of a motor by 'x' or transferring motion from point A to point B.

Common misconceptions or difficulties learners may have:

Often the mathematical application of formulae can cause problems for learners that find this topic challenging. It is important for learners to be able to identify the input and output / driver and driven to be able use the gear ratio and velocity ratio formulas in the correct manner. To begin with, learners often find it difficult to build and are disheartened by complex mechanisms, therefore, a firm understanding of each type and the transfer of different types of motion provides a stable base to begin to combine and increase the complexity.

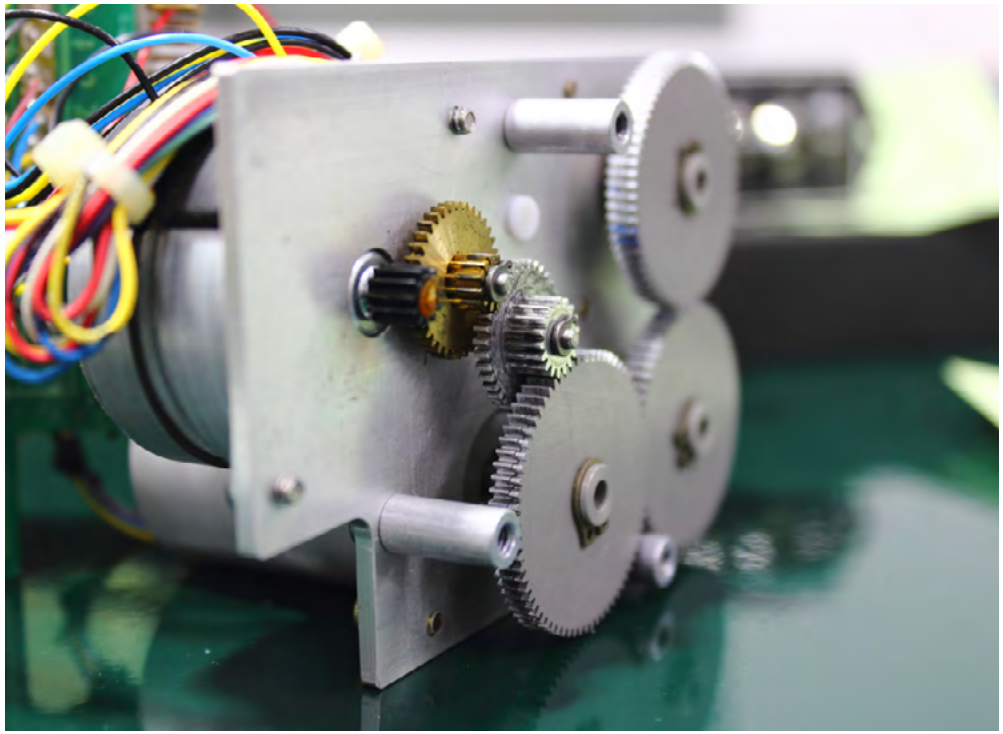
Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

This topic is especially useful when considering electronic prototypes as part of an NEA submission.



Thinking contextually

Providing learners with the equipment required to build mechanical devices is essential when studying this topic in-depth. In order to grasp the more complex principles of this topic, learners need to see and test the mechanisms in front of them. Setting challenges such as developing a mechanism that spans from point A to point B, or changing the output speed etc. are useful ways to challenge learners. To further challenge, combine multiple requirements such as available space or surface area and varying spindle speeds.



Learner Resources – Activities

Title	Organisation/ Company	Web link	Summary description	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
The Writer Automaton	BBC	https://www.youtube.com/watch?v=bY_wfKVjuJM	The Writer Automaton is a 240-year-old doll that can write; a clockwork creation by Pierre Jaquet-Droz. This video highlights how complex mechanisms can be utilised to perform complex tasks.	Thinking contextually	6.3
Mechanisms we use everyday	Creative Mechanisms	https://www.creativemechanisms.com/blog/6-different-mechanisms-we-use-everyday	Engineering mechanisms are simple devices that make a huge difference in our day-to-day lives (often without us even realizing it). Here are six really important mechanisms we use nearly every day to design functional prototypes. Further info on each is provided via a hyperlink.	Thinking conceptually	6.3
Manual transmission - How it works	Learn Engineering	https://www.youtube.com/watch?v=wCu9W9xNwtI	This short video explains how a manual gearbox in a car works. This is very useful for understanding how gears and gear ratios function.	Thinking contextually	6.3

Specification content (Sub Topic 4)

Sub Topic 4: In-depth consideration of electronics

Exam content

6.4 How do electronic systems provide functionality to products and processes?

a. How sensors and control devices respond to a variety of inputs, including:

More depth to be covered through practical application for 'in-depth' learners

b. How devices are used to produce a range of outputs, including:

More depth to be covered through practical application for 'in-depth' learners

c. The use of programmable components such as microcontrollers, to embed functionality into products in order to enhance and customise their operation.

More depth to be covered through practical application for 'in-depth' learners

NEA content

a. Apply technical principles appropriately to ensure functional requirements are achieved when developing a design solution.

Thinking conceptually

General approaches:

Exploring this topic in-depth will require the creation and development of more complex circuits through practical application. Learners will need to understand the impact of sensors, such as LDRs (Light Dependent Resistors) and how they can be combined within a potential divider circuit to control outputs such as LEDs. Further understanding of components, such as resistors, including how they are identified and combined to provide different functionality within circuits, will be required.

Learners will be required to develop their knowledge of programming through either graphical or text-based coding. This can be used to program control devices such as microcontrollers to respond to inputs and activate outputs. Again, this can be achieved through virtual environments, but hands-on practical knowledge of working with components and programmable devices will be required if electronic components are to be used as part of a learner's NEA prototype(s).

An understanding of schematics will be required and learners should be able to produce a schematic for a circuit and also convert an pre-existing breadboard or PCB to a schematic.

Common misconceptions or difficulties learners may have:

Electronic components and their associated principles can seem daunting at first therefore, as with many topics, it is recommended to build confidence on basic electronics before introducing concepts such as potential dividers and programmable components.

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 is especially useful when considering mechanical prototypes as part of an NEA submission.

Thinking contextually

Setting learners the challenge of developing and prototyping a circuit that can do or perform a specific task, gives learners direction and something to aim for. For instance, setting the task of creating a circuit that will automatically activate under 'x' conditions for 'x' amount of time while controlling and output.

Pelican crossings are a good way to introduce programming principles alongside a variety of inputs and outputs. First, learners must identify the required inputs and outputs by creating a system block diagram then analyse how the system currently operates before developing their own solution. This context will cover principles such as responding to an input, time delays and controlling a number of outputs at the same time.

Learner Resources – Activities

Title	Organisation/ Company	Web link	Summary description	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
Electronic components and what they do	Dummies.com	http://www.dummies.com/programming/electronics/basic-electronic-components-and-what-they-do/	This website provides further detail on a number of different electronic components and what they are used for.	Thinking conceptually	6.4
Resistor colour codes	All About Circuits	https://www.allaboutcircuits.com/textbook/reference/chpt-2/resistor-color-codes/	This resource explains how to identify and read the value of a resistor. It also contains links to resistor colour code calculator if required.	Thinking conceptually	6.4

Learner Activity

Schematics

Introduction

This activity is designed to help you practice converting schematics to breadboards and vice versa.

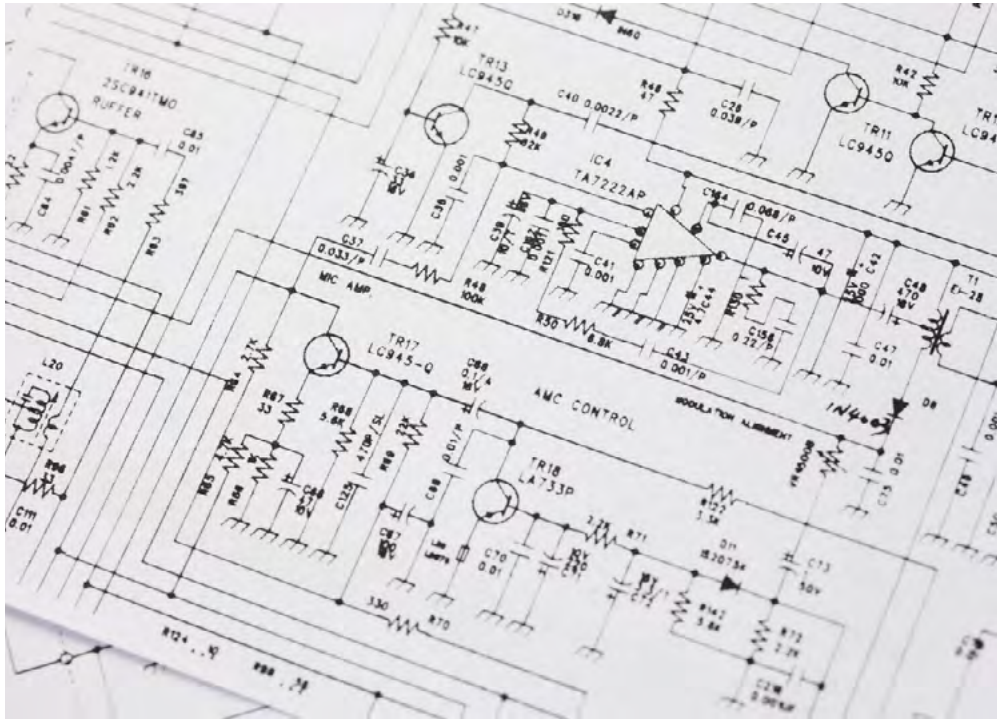
The activity

Attempt to convert the first two schematics to a breadboard. Simply draw the component symbols over the breadboard but remember to highlight the connections.

Once you have completed this, try converting the two breadboard circuits to schematics, you may need to look up the circuit symbols if you don't know them.

Extension activities/questions:

Try and create your own schematic for a circuit and convert it to a breadboard layout.



Specification content (Sub Topic 5)

Sub Topic 5: Ensuring structural integrity

Exam content

6.1 What gives a product structural integrity?

a. How and why **specific materials** and/or **system components** need to be reinforced or stiffened to withstand forces and stresses.

b. Awareness of the processes that can be used to ensure the structural integrity of a product, such as:

- triangulation
- plastic webbing
- reinforcing.

NEA content

a. Apply technical principles appropriately to ensure functional requirements are achieved when developing a design solution.

Thinking conceptually

General approaches:

Many products utilise reinforced parts to increase their structural integrity and strength-to-weight ratio. Often triangulation and webbing is used to increase the strength or stability of a material, while minimising material use and reducing the need for often heavy and impractical solid components. Often hollow parts, thinner walls, supporting beams etc. are used to reduce the overall weight of a product which will improve the products efficiency or performance.

With an increase in environmental awareness and material usage, reducing the amount of material a product uses is of paramount importance for designers which is where this topic comes to the fore.

Common misconceptions or difficulties learners may have:

While often providing an aesthetic appeal, the main principle that underpins triangulation and webbing techniques is to improve the structural integrity of a product. Often webbing is designed in a way to improve aesthetic appeal but the designer must strike a balance between aesthetics and structural integrity.

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 topic 5.2 and 5.4 when considering selecting the appropriate materials and the available forms for a product.

Thinking contextually

This topic can be explored through the development of simple structures, such as bridges and the impact of triangulation on their designs. Building simple bridges from paper straws that span a gap and applying a force to the centre of the bridge will highlight the weaknesses in the designs. The bridges can be strengthened using triangulation and supporting beams in weak areas and developed in order to withstand the forces applied. This is a really useful and practical way to explore the concept of triangulation.

Often load bearing products will feature webbing or triangulation such as chairs and learners should be able to spot the reinforcements applied or included within the original manufacture of the product. Ribs and other reinforcing techniques are often applied in injection moulded products that allow for increased strength but allow the product to remain lightweight and efficient.

Learner Resources – Activities

Title	Organisation/ Company	Web link	Summary description	Relevant chapter (i.e. Content, Thinking Conceptually, Thinking Contextually)	Mapping to specification level
Lightweighting	Autodesk	https://sustainabilityworkshop.autodesk.com/products/lightweighting	To create lightweight products, you need to take into account the types of materials you're using, the manufacturing processes required for your design, and the geometry of your design. This resource provides a number of links that explore this topic in further detail.	Thinking conceptually	6.1
Hollow parts, reinforcements and trusses	Autodesk	https://www.youtube.com/watch?v=CPMFn4d2TWI	Using hollow parts, reinforcements, and trusses in lightweighting can help you make your designs strong and light by optimising geometry and structure. Learn how to apply greener practices to engineering problems with the Autodesk® Sustainability Workshop for learners. Strategies include hollow parts, ribs, posts, corrugation, trusses, and gussets.	Thinking contextually	6.1
Bridges around the world	Geographic TV	https://www.youtube.com/watch?v=3klEIN9x4zg	There are many different bridge designs that all serve unique purposes and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it and the funds available to build it.	Thinking contextually	6.1

Learner Activity

Structural Integrity

Introduction

After watching the bridges around the world documentary, you will have seen and learnt all about different types of bridge structures which you will now put to the test.

The activity

Pick a bridge from the documentary and analyse its effectiveness by considering the following:

- Which material was used in its construction?
- What methods were applied to improve its structural integrity?
- Were/are these methods suitable?
- What are the weaknesses of your chosen bridge and how could they be improved?

Extension activities/questions:

Image your chosen bridge was to be re-built today using modern materials and techniques, how would the design of your bridge differ and why?

The small print

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