# Scheme of work

Introduction

This scheme of work offers a route through the GCSE Engineering (8852) specification.

It covers the specification in a logical order and suggests possible teaching and learning activities for each section of the specification.

The specification references are shown at the start of each section, whilst the learning outcomes indicate what most students should be able to achieve after the work is completed.

Timings have been suggested but are approximate. Teachers should select activities appropriate to their students and the curriculum time available.

The order is by no means prescriptive and there are many alternative ways in which the content could be organised.

The resources indicate those resources commonly available to schools, and other references that may be helpful. Resources are only given in brief and risk assessments should be carried out.

Assumed coverage

This scheme of work follows the Ofqual guidance of 120 hours Guided Learning Hours (GLH) and is based on a model of two hours per week over 60 weeks (35 weeks in year one and 25 weeks in year two).

The scheme is provided as a starting point but will need to be adapted to individual institutions ways of working. Some practical projects are suggested accompanied by more in-depth content supported by tests and quizzes.

Schools and colleges may wish to adapt this scheme or work to entirely different schemes. Those might be predominantly mechanical or electrical/electronic, but it is important to provide full coverage of the specification content.

When planning this work, it is necessary to keep in mind the weighting of assessment objectives across the two components. It is important to ensure sufficient time is devoted to the delivery of the content that will be examined on the written paper. This will form 60% of the overall weighting of the qualification.

During each project activity, the required background theory will need to be taught, this is shown in the listed topic areas. Accompanied by the reinforcement of learning through practical activities and skill acquisition.

This scheme of work uses topics to show where subject content might be covered.  You may wish to use the suggested projects where flagged within topics to bring this subject content to life.

The practical activities (or projects) are presented first but schools will need to adapt this dependant on facilities and any prior knowledge or experience their students have.

There are also two topics without practical projects, these are listed as Topics 1 and 2.

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**Timetable**

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| Week 31 | [Project 10: Understanding materials part 2](#project10_underastanding_materials_part2) | Factors influencing design of solutions 3.1.3  Composites 3.1.1.3  Other materials 3.1.1.4  Shaping 3.2.3 | 62 |
| Week 32 |
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| Week 35 | [Planning for the NEA](#Planning_for_the_NEA) | NEA | 64 |
| Week 36 | [NEA start](#week_36) | Opportunity should be taken to link and supplement the processes used, with previous learning. | 55 |
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| Week 50 | [NEA Finish](#week_36) | 56 |
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| Week 52 | [Topic 1: What influences design?](#Topic1_what_influences_design) | Factors influencing design of solutions 3.1.3  Material costs and supply 3.1.2 | 57 |
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| Week 55 | [Topic 2: Impact of modern technologies](#Topic_2_Impact_of_modern_technologies) | Impact of modern technologies 3.5 | 57 |
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**Subject content coverage**

**Topic 1: What influences design?**

**Aims**

The aim of this topic is for students to have knowledge and understanding of a wide range of factors that influence the design decisions when producing a solution.

**Duration**

3 weeks

**Sub-topic**

Energy production methods.

**Overview**

The objective of this work is to ensure students develop their understanding of a range of both renewable and non-renewable energy sources, benefits and drawbacks and any possible environmental impacts.

**Specification reference**

3.1.3

**Content**

* Students should learn about the following energy generation methods, including how they are produced:
  + Renewable energy and their sources.
  + Wind power- wind turbines.
  + Solar- the sun.
  + Tidal- the sea.
  + Biomass- organic matter.
  + Non-renewable energy and sources.
  + Fossil fuels- coal, oil and natural gas.
* Students should be aware that Nuclear energy uses radioactive materials and produce a reliable source of energy; however, the incorrect operation can result in significant damage to the environment for several years. Students can be introduced to case studies such as Chernobyl, Ukraine 1986 as a result of an earthquake or the Kashiwazaki-Kariwa Nuclear Power Plant in Japan 2007. They should also be aware that the radioactive waste must be disposed of extremely carefully.

**Activity**

* Divide the class into groups, with each group assigned to one energy generation method.
* In their groups, students are to research their assigned method, focusing on:
  + How the energy is generated.
  + Where this type of energy is produced in the world.
  + Benefits: advantages, energy efficiency, and contribution to global energy production.
  + Drawbacks: limitations, challenges, and potential risks.
  + Environmental impacts: carbon emissions, pollution, land use, water use, wildlife effects, etc.
* Students to prepare a presentation that covers their findings.
* Each group presents their research to the class, explaining their energy generation method, its benefits, drawbacks, and environmental impacts.
* Engage in a class discussion to compare and contrast the different energy generation methods, considering factors like energy output, cost, reliability, and potential scalability.
* Individually or in groups, propose recommendations for the most suitable and sustainable energy generation method, considering both benefits and drawbacks, and the environmental impacts.
* Assessment:
  + Presentation skills, research depth, understanding of benefits, drawbacks, and environmental impacts will be evaluated during the presentations.
  + The recommendations will be evaluated based on the clarity of reasoning and consideration of environmental sustainability.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Evaluative * Presentation * Reasoning * Research * Communication | * Renewable energy * Non-renewable energy * Fossil fuels * Nuclear power * Wind power * Tidal power * Biomass * Solar power * Energy generation * Environmental impacts * Reliable energy sources |

**Sub-topic**

Engineered lifespans

**Overview**

The objective of this task is for students to develop their understanding of what planned obsolescence is, its relevance to sealed parts and what maintenance requirements are.

**Specification reference**

3.1.3

**Content and activity**

* Students need to be aware that most engineered products have a limited lifespan, this could be planned due to the design or be a result of deterioration over time.
* Students must understand what planned obsolescence is, why engineered products and systems are planned to become obsolete over time, including implications, and the different types. They need to understand that engineered products and systems can also contained sealed parts to prevent the user from accessing or replacing parts.
* Students should be aware of the difference between proactive maintenance and reactive maintenance; maintenance allows the engineered product or system to be safe and continue to work as intended.
* They should also be aware of the different ways in which engineered products and systems can be maintained as well as scheduled maintenance.
* Examples such as engineering workshop machinery, cars, electronic products could be used.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Evaluative * Presentation * Reasoning * Research * Communication | * Planned obsolescence * Sealed parts * Maintenance requirements |

**Sub-topic**

Methods of maintenance of engineered products and the need for them

**Overview**

The objective of this task is for students to gain an understanding of why engineered products need to be maintained, including efficiency and safety as well as the reasoning behind the use of different types of maintenance work.

**Specification reference**

* 3.1.3
* 3.4.1
* 3.4.2

**Content**

* Students will need to be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification):
  + M1.1 Recognise and use expressions in decimal form.
  + M1.2 Recognise and use expressions in standard index form.
  + M1.3 Perform calculations using time and cost.
  + M2.2 find arithmetic means.
  + M2.4 collection, organisation and presentation of data.
* Students should be made aware that the maintenance of engineered products can ensure the safety of these products and prevent any potential hazards. They should also be aware of how maintenance also increases the efficiency and smooth running of engineered products.
* The following types of maintenance should also be covered:
  + Lubrication- reduces friction between parts, as a result reduces the likelihood of parts heating up which can sometime cause parts to seize up. It can also reduce wear on materials or mechanisms such as gears or stators.
  + Avoiding corrosion- corrosion can result in the loss of material; thus, reducing the part of an engineered product or system to perform in the way it was intended to. Lubrication, coatings and finishes can offer some form of protection against corrosion.
  + Compensating for wear-some parts of engineered products are intended for wear, for example car brake pads; the pads can be replaced before they are fully worn away. This can be done at certain intervals, for example miles covered or by checking the pads, so that the brakes never fail. Some engineered products and systems can also be adjusted in order to enable wear to take place.
  + End of Life (EOL), disposal and recovery of materials- effective maintenance extends the life of an engineered product, reducing disposal requirements. Maintenance also supports material recovery during repairs. Proper disposal at EOL lessens environmental impact. Designing products that are easy to disassemble enhances maintenance and material recovery. These concepts result in less impact on the environment.
* Students should also understand that statistics can be used to predict service intervals and the expected lifetime of components.

**Activity**

Students could be given a task to determine service intervals, time in service and cost implications demonstrating and applying the mathematical skills above.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Evaluative * Presentation * Reasoning * Research * Communication | * Planned obsolescence * Sealed parts * Maintenance requirements |

**Sub-topic**

Limitations of solutions due to material availability and forms; and how the requirements of users can influence decisions of materials and manufacturing processes.

**Overview**

The objective of this work is for students to gain an understanding of how the cost of engineered solutions can be affected by the availability of materials, and how the use of using non-standard forms would increase cost. Students should also be aware that when certain specifications are required of solutions such as high strength or lower weight certain materials may be required, thus requiring more specialist manufacturing processes.

**Specification reference**

* 3.1.3
* 3.4.1
* 3.4.2

**Content**

* Students will need to be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification).
* M1.4 Use ratios, fractions and percentages.

**Activity**

* Students could be given a list of a wide range of materials and standard forms they are available in and list of non-standard forms including costings of each. They could then be asked to calculate how much it would cost to manufacture an engineered product using the given materials from each list and discuss the implications of using non-standard components.
* Students should also understand that in order to acquire and achieve particular specifications and properties specific materials must be selected and this could have implications on cost; for example, titanium for higher strength or carbon fibre composites for lower weight.
* Assessment opportunity- an assessment or quiz based on material cost and supply.

**Topic 2: The impact of modern technologies**

**Aims**

* The aim of this project is for students to develop and understanding of what new and emerging technologies are and to analyse their impact on production, society and the environment.
* Students should also demonstrate an in-depth understanding of both positive and negative impacts of engineering industries upon social and economic infrastructure.
* Timings are approximations and will be dependent on progress with projects and how additional time such as extension work is arranged.

**Duration**

Over Year 10 and Week 55 for consolidation.

**Sub-topic**

Technological Impact- Unravelling the impacts of modern technologies on production, society and the environment.

## Specification reference

3.5

**Overview**

This topic aims to explore the impact of modern technologies on production, society, and the environment, whilst investigating the positive and negative effects of engineering industries on social and economic infrastructure. Students will conduct research, gather data and present their findings using a range of methods to develop their understanding of the complex relationship between society and new and emerging technologies.

**Content and activity**

**Research**

Students begin by conducting research into various modern technologies and their applications in different industries; including the exploration of fields such as renewable energy sources, artificial intelligence (AI), biotechnology and manufacturing technologies.

Case studies: divide students into groups and assign each group a specific modern technology or engineering industry to focus on. Students will need to analyse and evaluate the implications related to their assigned modern technology or engineering industry. Case studies provided to the groups should reflect real life examples of positive and negative impacts on production processes, impacts on society and the environment.

**Interviews/Surveys/Industry talks**

Students can interview or listen to and pose questions to experts these fields remotely or in person related to the area they are focussing on. [STEM Ambassadors](https://www.stem.org.uk/user/register) is a platform that enables centres to get in touch with employers and employees within these fields). Students could also conduct surveys, gathering opinions on the impact of modern technologies on daily life, productivity, work and the environment.

**Debates and discussions**

Classroom debates and discussions where students can express their opinions the pros and cons of modern technologies. Students can debate and discuss ethical considerations, potential risks and the possible benefits of incorporating certain technologies into different industries.

**Educational visits (if possible)**

Visits to local engineering industries, research laboratories, factories, renewable energy facilities etc would give students an authentic experience into the technologies that are being implemented and their impacts.

Eco-tech proposal: students to work collaboratively to develop a proposal of a technology that can be implemented in their school or local community. This proposal should outline the potential positive impacts on production, society and the environment.

**Presentation**

Students can present their findings and ideas to an audience, for example their peers, teachers, events at the school to showcase their work and raise awareness about how important it is for responsible technological advancements.

**Assessment**

Students can be assessed based on their research, case studies, interviews, participation in debates and their Eco-tech proposal.

**Topic 3: Materials and their properties**

**Aims**

This project aims to support students develop a comprehensive understanding of various material properties based on their physical appearances, working properties and behavioural characteristics through being able to define key engineering properties.

**Duration**

1 Week

## Sub-topic

Materials property investigation; links to [Project 3: Understanding materials 1](#poj3).

**Overview**

The objective of this task is to help students develop a comprehensive understanding of various material properties, including toughness, brittleness, ductility, malleability, hardness, strength and stiffness through research and analysis. This project will also introduce students into several material areas.

## Specification reference

* 3.1.1
* 3.1.1.1
* 3.4.1
* 3.4.2

**Content**

**Introduction**

* Start the task by explaining the importance of material properties in a range of engineering, manufacturing and construction sectors. Briefly introduce each material property.
* As part of students mathematical understanding they should be able to calculate Stress, Strain and Young’s Modulus and how to use formulae correctly (as found in 7.1 Equations of the GCSE Engineering Specification):
  + E7 Stress = force/cross-sectional area σ =F/A
  + E8 Strain = change in length/original length ε=δl/l
  + E9 Young’s modulus = stress/strain E=σ/ε
* Note: these properties could also be demonstrated in a practical task.
* Ask students to discuss detailed definitions, explanations and properties of each characteristic.

**Property characteristics and applications**

Ask students to create a table or chart to organise their findings for each material property based on the materials researched/investigated. For each property they can include the following information:

* the definition and explanation of the property
* characteristics and behaviours of materials exhibiting the property
* real world examples where the property is advantageous
* examples of materials known for their specific property.

**Strengths and limitations**

Students should reflect on the strengths and limitations of each material property, whilst considering situations where a particular property might be desirable, as well as situations is could be a disadvantage.

**Comparisons**

Students to compare and contrast material properties that are similar; for example, malleability vs ductility or toughness vs hardness. They could also discuss the key differences between the properties, how they are measured and their significance in particular applications.

**Quiz or assessment**

Students could be given a short quiz, multiple choice questions to gauge what they have learnt.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Critical thinking * Analysis * Apply theory to practical situations | * Brittleness * Compressive strength * Cross sectional area * Ductility * Hardness * Malleability * Stiffness * Strain * Strength * Stress * Tensile strength * Torsional strength * Toughness * Ultimate tensile strength * Yield strength * Young’s Modulus |

**Sub-topic**

* Metals and alloys
* Links to [Project 1: Working with metals.](#project1_working_with_metals)

**Overview**

The objective of this work is for students to develop their understanding of ferrous metals and alloys as well as non-ferrous metals and alloys alongside how their mechanical properties can be changed.

## Specification reference

3.1.1.2

**Content**

* Properties and typical uses of the following:
  + Ferrous metals and alloys: cast iron, low and high carbon steels and steel alloys (stainless steel)
  + Non-ferrous metals and alloys: aluminium, copper, lead, zinc and alloys such as brass and bronze
* The addition of materials to form alloys.
* The heating of metals which can affect grain size.
* Cold working processes.
* Hardening and quenching.
* The corrosion of metals and alloys.
* The addition or subtraction of carbon in steels.

**Activity**

Metals and alloys search: divide the class into small groups giving each a group a list of both ferrous and non-ferrous metals and alloys that can be found in everyday objects. Groups to determine where each metal and alloy can be found in the class, around school, at home or anywhere else they can think of. Groups must also determine whether the metal or alloy is ferrous or non-ferrous, what its main properties are (link to 3.1.1) and speculate on the uses based on their knowledge.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Critical thinking * Analysis * Apply theory to practical situations * Inter-discipline knowledge | * Annealing * Carburising * Corrosion * Ferrous alloys * Ferrous metal * Hardened * Non-ferrous alloys * Non-ferrous metals * Normalising * Ores * Quenching * Tempered * Work hardening |

**Sub-topic**

* Polymers
* Links to [Project 10: Understanding materials part 2.](#project10_underastanding_materials_part2)

**Overview**

The objective of this work is for students to develop their understanding of thermoplastics and thermosetting polymers as well as the effects of heat on them, this [video](https://www.youtube.com/watch?v=rJv9bxbCa9g) may be useful.

## Specification reference

3.1.1.2

**Content**

* The following thermoplastics must be covered:
  + ABS.
  + Acrylic.
  + Nylon.
  + Polycarbonate.
  + polystyrene.
* The following thermosetting polymers must be covered:
  + Epoxy.
  + Polyester and Melamine Resins.
  + Polyurethane.
  + Vulcanised rubber.

**Activity**

Students to be presented with a range of products with Thermoplastics and Thermosetting Polymers, students to determine why this selection of polymer has been made and the properties required.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Critical thinking * Analysis * Apply theory to practical situations * Inter-discipline knowledge | * Polymer * Thermoplastic * Thermosetting polymers |

**Sub-topic**

* Composites
* Links to [Project 10: Understanding materials part 2](#project10_underastanding_materials_part2)

**Overview**

The objective of this work is for students to gain an understanding of what composites are, learn about a range of composites including how their mechanical properties can be changed (this video on [‘How does reinforced concreate work?](https://www.youtube.com/watch?v=A9dOzmRgYWA)’ may prove to be useful.)

## Specification reference

* 3.1.1.3

**Content**

* Students need to understand that composites are material made by combining two or more two or more materials different types of materials however, the materials are not chemically joined.
* The following composites must be covered:
  + fibre reinforced polymers (FRP) - carbon-fibre reinforced polymer and glass reinforced polymer (GRP)
  + plywood
  + Medium Density Fibre board (MDF)
  + Oriented Strand Board (OSB)
  + structural concrete.
* Students should also have knowledge of and understand how the mechanical properties of these materials can change through the:
  + direction/alignment of reinforcement
  + matrix in which the reinforcement is placed
  + amount of reinforcement used
  + size and shape of reinforcement.

**Activity**

Exploring composite materials:

* Presentation- show visuals of the range of composites students need to be aware of.
* Group activity: divide students into small groups to discuss real-life examples of the applications for each of the composites.
* Group presentations- each group to share their examples and reasons for selecting the chosen composites for chosen applications.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Critical thinking * Analysis * Apply theory to practical situations * Inter-discipline knowledge | * Composites * Laminated * Matrix * Particle * Reinforcement * Stranded |

**Sub-topic**

* Other materials
* Links to [Project 10: Understanding materials part 2.](#project10_underastanding_materials_part2)

**Overview**

The objective of this task is for students to develop an understanding of structural grade Timbers and Ceramics.

**Specification reference**

* 3.1.1.4

**Content**

* Structural grade timbers should be covered. Softwoods that come from coniferous trees are mostly used for structural purposes, some examples include Cedar, Spruce and Redwood.
* Ceramics - students should be aware of the properties that ceramics exhibit that make them suitable in engineering applications including hardness, resistance heat. They are generally able to withstand compression well, on the other hand they are brittle, not ductile and have very low tensile strength.
* Applications for Ceramics should also be covered, for example, insulation from heat, building materials (including breeze blocks, bricks, concrete, plaster and glass) and tools used for grinding and cutting.

**Activity**

Assessment opportunity- an assessment or quiz about Engineering Materials could take place.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Critical thinking * Analysis * Apply theory to practical situations * Inter-discipline knowledge | * Timber * Ceramics |

**Topic 4: Material cost and supply**

**Aims**

The aim of this work is for students to have knowledge and understanding of the cost, availability, forms and supply of the engineering materials they had learnt about in the previous project.

**Duration**

2 weeks

**Sub-topic**

Cost, availability, form and supply of engineering materials; links to [Topic 1: What influences design?](#Topic1_what_influences_design)

**Overview**

The objective of this task is to ensure students are aware of the comparative costs of different materials within and across the engineering material groups studied; for example, copper vs gold for the use in electrical components or timber vs steel for structural components.

**Specification reference**

* 3.1.2
* M1.1
* M1.2

**Content**

* Students should be aware of the range of forms materials covered in 3.1 of the specification are widely available in and how these are known as standard forms. Students must also be aware how the use of standard forms can reduce production costs as more components can be purchased rather than produced, therefore engineers and companies may decide to change their original designs to use standard form sizes and shapes.
* Students should be able to calculate costs to manufacture/produce items to inform the development of an engineered solution in industry.
* Alongside this they will be expected to understand the following:
  + Available stock sizes and supply.
  + Use economies of scale to reduce costs (price breaks based on quantity).
  + Waste produced.
* They will be expected to be able to apply their understanding of how to use the following formulae correctly (as found in 7.1 Equations of the GCSE Engineering Specification) and be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification):
  + E1 Area of a rectangle A=L×W
  + E2 Volume of a cuboid V=L×W×H
  + E3 Area of a circle Ac=πr2
  + E4 Volume of a cylinder Vc=Ac×L
  + E5 Area of a triangle At=½(B×H)
  + M1.1 Recognise and use expressions in decimal form.
  + M1.2 Recognise and use expressions in standard index form.
* Students will need to be aware of properties in relation to material selection, both for aesthetic purposes as well as functional purposes for example:
  + Blades and cutting tools would require hardness, toughness and be cost effective.
  + Wiring for electrical products would require cost effectiveness, electrical conductivity and ductility (this would also give opportunity to discuss standard forms and lengths available).
  + Structure for a building would require structural integrity, resistance to corrosion, strength and weight.
* Students will need to be aware of the relative cost, ability/cost to be machined, treating ability/cost, ability to be shaped/formed and recyclability of the materials set out in 3.1 of the specification.

**Activity**

Assessment opportunity: An assessment or quiz about Engineering Materials, Cost and Supply could take place.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Mathematical * Evaluation * Analysis * Comparative * Selection | * Aesthetics * Availability * Cost * Form * Forming * Machining * Recycling * Shaping * Supply * Treatment |

**Topic 5: Engineered lifespans**

**Overview**

The objective of this task is for students to develop their understanding of what planned obsolescence is, its relevance to sealed parts and what maintenance requirements are.

**Specification reference**

* 3.1.3

**Contents and activity**

* Students need to be aware that most engineered products have a limited lifespan, this could be planned due to the design or be a result of deterioration over time.
* Students must understand what planned obsolescence is, why engineered products and systems are planned to become obsolete over time, including implications, and the different types. They need to understand that engineered products and systems can also contained sealed parts to prevent the user from accessing or replacing parts.
* Students should be aware of the difference between proactive maintenance and reactive maintenance; maintenance allows the engineered product or system to be safe and continue to work as intended.
* They should also be aware of the different ways in which engineered products and systems can be maintained as well as scheduled maintenance.
* Examples such as engineering workshop machinery, cars, electronic products could be used.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Evaluative * Presentation * Reasoning * Research * Communication | * Planned obsolescence * Sealed parts * Maintenance requirements |

**Topic 6: Methods of maintenance of engineered products and the need for them**

**Overview**

The objective of this task is for students to gain an understanding of why engineered products need to be maintained, including efficiency and safety as well as the reasoning behind the use of different types of maintenance work.

**Specification reference**

* 3.1.3

**Content**

* Students will need to be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification):
  + M1.1 Recognise and use expressions in decimal form.
  + M1.2 Recognise and use expressions in standard index form.
  + M1.3 Perform calculations using time and cost.
  + M2.2 find arithmetic means.
  + M2.4 collection, organisation and presentation of data.
* Students should be made aware that the maintenance of engineered products can ensure the safety of these products and prevent any potential hazards. They should also be aware of how maintenance also increases the efficiency and smooth running of engineered products.
* The following types of maintenance should also be covered:
  + Lubrication- reduces friction between parts, as a result reduces the likelihood of parts heating up which can sometime cause parts to seize up. It can also reduce wear on materials or mechanisms such as gears or stators.
  + Avoiding corrosion- corrosion can result in the loss of material; thus, reducing the part of an engineered product or system to perform in the way it was intended to. Lubrication, coatings and finishes can offer some form of protection against corrosion.
  + Compensating for wear-some parts of engineered products are intended for wear, for example car brake pads; the pads can be replaced before they are fully worn away. This can be done at certain intervals, for example miles covered or by checking the pads, so that the brakes never fail. Some engineered products and systems can also be adjusted in order to enable wear to take place.
  + End of Life (EOL), disposal and recovery of materials- effective maintenance extends the life of an engineered product, reducing disposal requirements. Maintenance also supports material recovery during repairs. Proper disposal at EOL lessens environmental impact. Designing products that are easy to disassemble enhances maintenance and material recovery. These concepts result in less impact on the environment.
* Students should also understand that statistics can be used to predict service intervals and the expected lifetime of components.

**Activity**

Students could be given a task to determine service intervals, time in service and cost implications demonstrating and applying the mathematical skills above.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Evaluative * Presentation * Reasoning * Research * Communication | * Wear compensation * Avoiding corrosion * Safety in operation * Efficiency of operation |

**Topic 7: Limitations of solutions due to material availability and forms; and how the requirements of users can influence decisions of materials and manufacturing processes**

**Overview**

The objective of this work is for students to gain an understanding of how the cost of engineered solutions can be affected by the availability of materials, and how the use of using non-standard forms would increase cost. Students should also be aware that when certain specifications are required of solutions such as high strength or lower weight certain materials may be required, thus requiring more specialist manufacturing processes.

**Specification reference**

* 3.1.3

**Content**

* Students will need to be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification).
* M1.4 Use ratios, fractions and percentages.

**Activity**

* Students could be given a list of a wide range of materials and standard forms they are available in and list of non-standard forms including costings of each. They could then be asked to discuss the implications of using non-standard components.
* Students should also understand that in order to acquire and achieve particular specifications and properties specific materials must be selected and this could have implications on cost; for example, titanium for higher strength or carbon fibre composites for lower weight.
* Assessment opportunity- an assessment or quiz based on material cost and supply.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Evaluative * Presentation * Reasoning * Research * Communication | * Material choice * Specialised manufacturing * Strength of materials |

**Topic 8: Engineering manufacturing process**

**Aims**

The aim of this topic is for students to gain knowledge and understanding of a wide range of manufacturing processes and techniques; based on prior learning in this scheme of work they should develop an understanding of which manufacturing processes are appropriate for specific materials and how the covered manufacturing processes are carried out. Most of this can be achieved whilst carrying out practical project work.

**Duration**

4 weeks

|  |  |  |
| --- | --- | --- |
| Skills | Understanding | |
| * Analysis * CAD * Mathematical * Evaluative * Collaboration | * Additive manufacturing * Annealing * Bending * Composite lay up * Cutting * Dip coating * Drilling * Electroplating * Etching * Folding * Fused deposition modelling * Hardening * Injection moulding * Laser cutting * Milling * Normalising * Painting * PCBs * Polishing | * Press forming * Press moulding * Pressure die casting * Punching * Quenching * Rapid prototyping * Rivets * Sand casting * Sawing * Shearing * Sintering * Soldering * Stamping * Stereolithography * Tempering * Threaded fastening * Turning * Wasting |

**Sub-topic**

* Additive manufacturing
* Links to [Project 10: Understanding materials part 2](#project10_underastanding_materials_part2) and[Project 6: CAD-CAM.](#Project6_CAD_CAM)

**Overview**

This topic aims to develop students’ understanding of the different types of additive manufacturing including fused deposition, sintering (for metals) and rapid prototyping (for polymers).

**Specification reference**

* 3.2.1

**Content and activity**

* Students need to understand what fused deposition modelling is; they should be aware that this process is demonstrated in 3D printing. 3D printers can use a wide range of polymers in industry including thermoplastics and thermosetting polymers. More common polymers that are used in 3D printing include PLA, PETG, ABS, PP and Nylon.
* The video on [Fused Deposition Modelling (FDM) Technology](https://www.youtube.com/watch?v=WHO6G67GJbM) may prove useful when introducing students to this process.
* Students should understand the process of sintering metal parts; they should be aware that metal powders are filled into a mould with both pressure and heat applied in order to fuse the metal powder together requiring less energy than other manufacturing processes for metals. Students should also be aware how a range of metal powders can be used for this process in cases where metals would not usually mix together.
* Students should be aware of what rapid prototyping is in the context of polymers, they should be aware that it comprises of the manufacture of a complete part in a single operation. They should consider the advantageous nature of producing a 3D CAD (computer aided design) model, which could have internal parts/mechanisms, and use it to perform processes that produce complex polymer parts using stereolithography or fused deposition modelling (covered previously). Students should be aware that rapid prototyping is currently limited by the amount of materials that are available for use with these processes.
* The video on [Stereolithography (SLA) Process at Loughborough University](https://www.youtube.com/watch?v=oNpAnBhgIIs) may prove useful in demonstrating the process of stereolithography.

**Sub-topic**

* Material removal
* Links to [Project 1: Working with metals**,**](#project1_working_with_metals)[Project 4: Make an electronic lock/alarm](#Project4_make_an_electronic_lock_alarm)and [Project 8: Make a casting/moulding.](#Project8_make_a_casting_moulding)

**Overview**

This project aims to develop students’ understanding of the different ways in which materials can be removed to produce parts. Material removal can also be known as wasting, as waste material is removed in order to achieve a particular shape or form.

**Specification reference**

* 3.2.2

**Content**

* The following manufacturing processes can be used for a range of materials, students are expected to be aware of what these processes entail however they are not required to have practical experience of them.
* Awareness of Health and Safety, risk assessments, the use of PPE (personal protective equipment) and workshop safety procedures should be covered before practical work.
* For this task students will need to be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification):
  + M1.1 Recognise and use expressions in decimal form.
  + M1.6 Calculate angles of a triangle using trigonometry.
  + M1.7 Use Pythagoras’ theorem.
  + M2.3 make order of magnitude calculations
* Students should be aware of the different types of turning including cylindrical, tapered and boring. They should also be able to calculate angles for example when tapering, using trigonometry and Pythagoras’ theorem. Students should have knowledge of the different types of metals that are generally turned on an engineering lathe.
* Students should also be aware that drilling can take place on an engineering lathe known as ‘centre drilling’.
* Students also need to be aware of the process of milling; they need to know that milling can be used in order to produce faces as well as slots. Milling machines can either be horizontal or vertical cutting. In milling the cutting tool remains in a fixed position and the material being processed moves. They should be aware that the term ‘facing’ is used to describe the process of making the surface of a material flat with a smooth finish and a ‘slot’ can either go through a material from one end to the other producing a square groove across or in between the material resulting in circular edges. They should also be aware of the types of metals that are used in milling.
* Students should be aware of the process of drilling and how it is used to make holes in a material; unlike centre drilling, in other types of drilling the work piece remains stationary. They should understand the importance of securing the work piece before drilling and should be aware of different types of drills. The speed and torque of a drill can be adjusted based the type of bit and material being used.

**Activity**

* Students could be given a range of standard form materials to determine the most appropriate process of cutting, including sawing, shearing and laser cutting each of the materials, for example a copper pipe, 4mm clear acrylic sheet and a 0.2mm low carbon steel sheet justifying their choices.
* A discussion could then take place around the justification of each and a task set on the calculation of cutting speeds and materials that could be used with each process.
* If it is possible for students to gain practical experience of cutting different materials and standard forms using the processes listed above, they would be able to understand the importance of using the most appropriate process, for example shearing a copper pipe can result in deformation.
* Demonstrations or practical work could include the use of a hacksaw (for metals and polymers), rip saws (for structural timbers), jigsaws (dependent on blade used), Tinsnips (for thin metal sheets), guillotines (for thick metal sheets) and laser cutters (for sheets of metals and polymers).
* Students could be given a task to calculate spindle speeds, on a range of materials that would be used in drilling, using formula given in 7.2 of the engineering specification: M2.3 make order of magnitude calculations.
* Students should develop and understanding of PCB manufacture, in the specification chemical etching is covered however, students being aware of any other PCB manufacture eg milling will also be accepted.
* Assessment opportunity- an assessment or quiz based on additive manufacture and material removal.

**Sub-topic**

* Shaping
* Links to [Project 1: Working with metals**,**](#project1_working_with_metals)

**Overview**

This project aims to develop students’ understanding of the different ways in which materials can be shaped and formed.

**Specification reference**

* 3.2.3
* 3.4.1

**Content**

* Students should be aware of the Mathematical skills in order to calculate angles, tolerances and pressure or force (as found in 7.2 Mathematical skills of the GCSE Engineering Specification):
  + E10 Pressure = force/area P=F/A
  + M1.1 Recognise and use expressions in decimal form.
  + M1.2 Recognise and use expressions in standard index form.
  + M1.5 Calculate squares and square roots.
  + M1.6 Calculate angles of a triangle using trigonometry.
* Students should understand the difference between forming and shaping. They should understand how the following processes are carried out and what materials can be used for each of the processes:
  + Bending: jigs and formers are used to bend materials.
  + Folding: mallets can be used to bend material once gripped securely, for more heavy duty purposes a hydraulic ram can be used.
  + Press forming: can be used to transform a ductile metal sheet into a 3D shape, a car bonnet is a good example of this, a sheet material is placed between a ram and die or two moulds. When pressure is applied the part is formed.
* Students should understand:
  + Composite lay-up uses a mould in order to produce a part.
  + Punching is when the part pushed out is the scrap part.
  + Stamping is when the part pushed out is the part required and the rest is scrap.

**Activity**

* Students could be given the steps for composite lay up in a random order and be asked to place them in the correct order justifying why they have placed the steps in that particular order.
* Students could use the formula to work out pressure to determine the pressure required to stamp out a part from a metal sheet.

**Sub-topic**

* Casting and moulding
* Links to [Project 8: Make a casting/moulding.](#Project8_make_a_casting_moulding)

**Overview**

This project aims to develop students’ understanding of pressure die casting, sand casting and injection moulding.

**Specification reference**

* 3.2.4

**Content and activity**

* Students should understand how pressure die casting is used to manufacture parts from metals that are non-ferrous (links to engineering materials topic). The video on [Die casting](https://www.youtube.com/watch?v=_V9oyvWovHQ) outlines the steps for this process.
* Students should understand the process of sand casting and how it is generally used to make small quantities of parts. The video on [Sand casting animation](https://www.youtube.com/watch?v=EIBDp6U8bHo) outlines the steps for this process.
* Students should understand how injection moulding can be used to produce a wide range of engineered products from polymers (links to engineering materials topic). It is a very versatile process and can be linked to a wide range of engineered products that students will be aware of.
* The video on [Injection moulding animation](https://www.youtube.com/watch?v=b1U9W4iNDiQ) outlines the steps for this process.

**Sub-topic**

Joining and assembly

**Overview**

* This project aims to develop students’ understanding of a range of temporary and permanent joining methods including riveting, threaded fastenings, soldering (soft and hard), brazing and welding.
* Students should understand why some engineered systems and products use temporary fixings and why some use permanent fixings.

**Specification reference**

* 3.2.5
* 3.6

**Content and Activity**

**Rivets**

* Students should understand that rivets are a permanent joining method used to join sheets of material together. They should be aware of the difference between rivets and pop rivets.
* Activity: Students could be introduced to a case study on why rivets are used in aircraft, they could be introduced to the following points after their initial discussions:
  + Most aircraft are made from aluminium which is not very tolerant of heat- welding the parts together which can affect the aluminium’s properties (linked to material properties).
  + Rivets can join two sheets from the inside rather than welding, which is from the edges, this enables the aircraft to be placed under the severe stress during flight.
  + Rivets fill the entire hole used to join the two components together as opposed to screws or bolts that grip materials together with thread, but can come loose with vibrations at high speeds.

**Thread fastening**

* A wide range of threaded fastenings are available on the market, including a wide range of screws and nuts and bolts. They are available in steel, thermoplastics and brass; they can also be coated. The decision of what material fastenings selected could be based on material properties. Whilst some threaded fastenings can become loose over time they provide easy access to internal components of engineered products or systems for upgrades or maintenance and can even be helpful at the EOL for reusing or recycling purposes.
* Students should be aware of a range of threaded fastening methods and their advantages as well as their disadvantages including properties, for example, steel threaded fasteners could rust over time if used outside

**Soldering**

* Students should be aware that solder is an alloy containing other materials, the solder would have a lower melting point than the materials being soldered together.
* They should be aware that when the solder is heated:

|  |  |
| --- | --- |
| Temperature the solder is heated at |  |
| < 450°C | Soft soldering |
| > 450 °C | Hard soldering |

* Demonstration/activity opportunity: Links to [Project 4: Make an electronic lock/alarm.](#Project4_make_an_electronic_lock_alarm)
* A demonstration could take place using a visualiser on how to safely create good soldering joints. If possible, students could be given an opportunity, wearing appropriate PPE and being aware of relevant Health and Safety information can solder components of a circuit onto a PCB.
* Students should also be aware of the process of wave soldering, the video [Agrowtek Wave Soldering Process for Electronic Manufacturing](https://www.youtube.com/watch?v=VWH58QrprVc) is useful in demonstrating a visual of the process.

**Brazing**

* Students should be aware that in brazing a dissimilar material to the materials being joined together is used as the filler, the base materials are not melted, and the filler material is used to create the joint.
* Activity: Students could be given an activity with step-by-step images of the process of brazing and could then fill in what is taking place in each part of the process.

**Welding**

* Students should be aware of the different types of welding and the process involved in each. They should be aware that in welding the base metal is melted so the two parts fuse together. They should be aware that very high temperatures are used to achieve this.
* Types of welding could include (all are not required):
  + electric arc welding
  + MIG welding
  + TIG welding
  + spot welding
  + gas welding.
* Activity: Students could be given a selection of engineered products that have been welded and to match the product to the type of welding that would have been most appropriate for use.

**Sub-Topic**

* Heat and chemical treatment.
* Links to [Project 1: Working with metals](#project1_working_with_metals)

**Overview**

This work aims to develop students’ understanding of a range of heat and chemical treatments.

**Specification reference**

3.2.6

**Content and activity**

Students should be aware of different types of heat and chemical treatments including normalising, annealing, hardening and quenching.

**Normalising**

* Students should be aware that normalising is a treatment that uses heat and results in the metal being treated to become more ductile and significantly more tough.
* They should also be aware of how the normalising process takes place and the changes in the materials molecular structure and what materials can be used with this process.

**Annealing**

* Students should be aware that annealing is a process that is used for both non-ferrous and ferrous metals; it results in the material being treated softer which makes it easier to work with.
* They should also be aware of how the annealing process takes place and the changes in the materials molecular structure and what materials can be used with this process.

**Hardening**

* Students should be aware that hardening is a process that results in an increased hardness of a material. Students should be aware that once the metal is heated in the process it is quenched to prevent the atoms from rearranging again; quenching is when the metal is immersed swiftly into salt water (brine) or oil.
* They should also be aware of how the hardening process takes place and the changes in the materials molecular structure and what materials can be used with this process.

**Sub-topic**

* Surface finishing.
* Links to [Project 1: Working with metals](#project1_working_with_metals)

**Overview**

This work aims to develop students’ understanding of a range of surface finishes including their aesthetic and functional properties.

**Specification reference**

3.2.7

**Content and activity**

Students should be aware of the following surface finishes: painting, dip coating, electroplating, galvanising and polishing.

**Painting**

Students should be aware that painting is very commonly used to provide a surface finish on a wide range of materials. It improves the aesthetics and isavailable in a wide range of colours. It is relatively cheap in comparison to other finishing methods and can be applied by both physical labour, using a paintbrush/roller/spray or automation including robotic arms.

**Dip coating**

* Students should be aware that dip coating is used to apply a polymer coating onto a part to prevent corrosion. They should be aware that polymers such as nylon and PVC can be used in the process and should be aware of steps carried out during this process.
* Activity: students could organise the steps of dip coating into the correct order and have a discussion justifying the order they have given.
* Students could think about what engineered products are dip coated and why.

**Electroplating**

* Students should be aware that electroplating uses electricity and a chemical solution to create a coating on a metal part.
* Both anodising and electrolysis are electroplating processes.
* Anodising: is a process used for titanium or aluminium when electrolysis takes place, which results in a thick oxide layer which gives a durable finish that is resistant to corrosion.
* Students should be aware of how anodisation takes place and the steps involved in this process.

**Electrolysis (may also be covered in science lessons)**

* Electrolysis is used to coat a part with thin layer of metal, this can be with a wide range of ferrous and non-ferrous metals including aluminium, brass, bronze, copper, iron, nickel, tin and zinc.
* Activity:
  + Students could complete annotation of an image showing the electroplating process and a step-by-step guide.
  + If possible, a demonstration could be shown to students.

**Galvanising**

* Galvanising is process that is used to provide very good corrosion resistance; the process is performed by dipping steel into molten zinc.
* The below video [Hot-Dip Galvanising Process](https://www.youtube.com/watch?v=UE7zY9JoVIc) is useful in demonstrating how the galvanising process takes place.

**Polishing**

* Polishing can be performed manually using a non-abrasive cloth or using machinery such as a buffing wheel to remove very little surface material resulting in a smooth surface.
* Activity: Students could be given a metal which they can polish with a non-abrasive cloth and describe the different in properties including less friction.

**Assessment opportunity**

An assessment or quiz based on shaping, casting and moulding, joining and assembly, heat and chemical treatment and surface finishing.

**Topic 9: Systems**

**Aims**

The aim of this project is to develop students’ knowledge and understanding of the use and roles of systems within engineering settings.

**Duration**

7 weeks

|  |  |
| --- | --- |
| Skills | Understanding |
| * Logical thinking * Mathematical skills * Calculation * Organisation * Presentation * Computing | * Analogue signals * Bearings * Cams/followers * Chain and sprocket * Digital signals * Discrete components * Electric current * Flowcharts * Gear trains * Linkages * Mechanical advantage * Motion conversion * Output components * Output devices * Process devices * Programmable devices * Pulleys * Schematics * Sensor inputs * System building blocks |

**Sub-topic**

* Systems
* Links to [Project 2: Systems: Build a small robot](#Project2_systems_build_a_small_robot)and [Project 4: Make an electronic lock/alarm.](#Project4_make_an_electronic_lock_alarm)

**Overview**

* Students should be familiar with the function of the system building blocks specified in the systems below and be able to describe the way in which parts of a system can be divided into sub-systems.
* Students should be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification):
  + M1.3 Perform calculations using time and cost.
  + M2.4 collection, organisation and presentation of data.

**Specification reference**

* 3.3
* 3.3.3
* 3.4.1

**Sub-topic**

* Systems descriptions.
* Links to [Project 2: Systems: Build a small robot](#Project2_systems_build_a_small_robot), [Project 7: Producing engineering drawings](#Project7_producing_engineering_drawings) and [Project 4: Make an electronic lock/alarm.](#Project4_make_an_electronic_lock_alarm)

**Overview**

This work aims to develop the understanding of students in system block diagrams (input, process, output), schematic drawings and flow charts.

**Specification reference**

* 3.3
* 3.4.1
* 3.3.1
* 4.4.6.3
* 4.4.6.6

**Content and activity**

**System block diagrams**

* Students should be aware of what system block diagrams are and how they represent systems or sub-systems.
* They should be aware of simple system block diagrams with one input, process and output as well as more complicated systems with multiple inputs and outputs.
* Activity: Students to create system block diagram for the following systems:
  + outdoor PIR light
  + toaster
  + house alarm system.

**Schematic drawings**

* Students should develop their understanding of schematic drawings, showing individual components using circuit symbols and labelling values.
* Activity:
  + Students could draw a schematic diagram of given circuits.
  + Students must develop their understanding of flowcharts (this may also have been covered in KS3 Design and Technology and KS3 Computing).
  + Students should be encouraged to draw a range of flowcharts which show the steps of a range of systems and processes including any projects they have worked on including health and safety and quality control checks.

**Sub-topic**

* Mechanical systems
* Links to [Project 2: Systems: Build a small robot](#Project2_systems_build_a_small_robot)

**Overview**

The aim of this project is to is to develop students understanding of linkages, conversion of motion, gear trains, cams and followers, pulleys and bearings.

**Specification reference**

3.3.1

**Content and activity**

Students should be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification):

* Ratio of simple gears and mechanical advantage.
* E14 Ratio of simple gears: Gear ratio = Number of teeth on driven gear/ number of teeth on driver gear.
* E15 Mechanical Advantage = load/effort MA=Fb/Fa
* M1.4 Use ratios, fractions and percentages.
* M3.2 change the subject of an equation.
* M3.3 substitute numerical values into algebraic equations using appropriate units for physical quantities.

**Linkages**

* Students should be aware of different types of linkages and how they can be used to convert motion including rotary to reciprocating and linear to oscillating.
* The should be aware of linear, rotary, reciprocating and oscillating motion including different types of mechanisms, how they work and where they could be used.
* Activity: Students could use card cut outs and paper fasteners/split pins to create linkages and attach them onto a sheet of card to test how motion can be converted, this should also be linked to the mathematical skills mentioned above including mechanical advantage.

**Gears and pulleys**

* Students should be aware of gear trains including chains and sprockets and cams and followers; they should be aware of how to calculate gear ratios, what chain and sprocket system is, how it works and examples of where it can be implemented including the pedal system of a bicycle and the different types of cams and followers; including how they are used in engines.
* The video [How Car Engine Works](https://www.youtube.com/watch?v=DKF5dKo_r_Y) can be linked to many of the systems that have been covered.
* Students should understand how pulleys can be used to transfer power within a system and reduce the amount of effort when lifting loads.
* Activity: Students could be given tasks to work out velocity ratio by being given diameters of a driven and driver pulley and work out mechanical advantage using by being given the force of the load and effort.

**Bearings**

* Students should be aware of bearings and the different types.
* Activity: Students could list the advantages of using bearings, they could then be provided with images and a description of the different types of bearings to determine where they may be used.

**Sub-topic**

* Electrical systems and power supplies.
* Links to [Project 2: Systems: Build a small robot](#Project2_systems_build_a_small_robot)and [Project 4: Make an electronic lock/alarm.](#Project4_make_an_electronic_lock_alarm)

**Overview**

This project aims for students to develop their understanding of electrical systems comprising of: power supplies (mains and batteries), input control devices and output devices; it also aims to cover the difference between Alternating Current (AC) and Direct Current (DC).

**Specification reference**

3.3.2

**Content and activity**

Students should be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification):

* M3.2 change the subject of an equation.
* M3.3 substitute numerical values into algebraic equations using appropriate units for physical quantities.
* M3.4 solve simple algebraic equations.
* M4.1 translate information between graphical and numeric form.
* M4.5 interpret data presented in graphical form.
* E12 Ohm’s law: current = voltage/resistance I=V/R

**Inputs and outputs**

* Students should know about the difference between mains electricity and batteries; they should be aware that mains electricity provides high voltage power and batteries provides low voltage.
* Students should be aware of a range of input control devices such as relays and switches, they should be aware of their functions as well as their symbols. They should be aware that the primary function of switches is to make or break a circuit. They should be aware that relays are switches which are operated electrically to change a small control current to a large load current.
* Activity:
  + Students could be introduced to the above-mentioned output devices symbols.
  + Following on from this students could produce a schematic and flowchart.

**AC and DC current**

Students should be aware that UK mains electricity alternating current (AC) changes direction fifty times in a second, it is shown graphically as a sine wave. They should be aware that direct current (DC) flows in one direction only, graphically shown as a straight line or a current wave.

**Sub-topic**

* Programmable devices and interfacing.
* Links to [Project 2: Systems: Build a small robot](#Project2_systems_build_a_small_robot)and [Project 4: Make an electronic lock/alarm.](#Project4_make_an_electronic_lock_alarm)

**Overview**

The aim of this project is to develop students understanding of electronic systems, programmable devices, interfacing components, analogue to digital conversion, output components, discrete components and programming for monitoring and controlling processes.

**Specification reference**

* 3.3.3

**Content and activity**

Students should be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification):

* M3.1 understand and use the symbols =, <, ≤, ≥, >, ±, α, ~
* M3.2 change the subject of an equation.
* E12 Ohm’s law: current = voltage/resistance I=V/R
* E13 Series resistance Rt = R1 + R2
* M2.1 use an appropriate number of significant figures.
* M2.3 make order of magnitude calculations.

**Electronic systems**

* Students should be aware of electronic systems comprising of electronic inputs (below are examples of inputs students could learn about):

|  |  |  |
| --- | --- | --- |
| Input sensor | Function | Example of use |
| Light-dependent resistor (LDR). | Changes the resistance as the level of light changes, the change in resistance is the input. | Street lights, patio lighting etc. |
| Thermistor. | Changes the resistance as the temperature changes, the change in resistance is the input. | Greenhouse, heating systems and fridges. |
| Piezoelectric sensor. | Changes mechanical motion into electrical energy- it can produce an electrical pulse with pressure. | Microphones. |

* Students should understand how systems can use both analogue and digital signals- they should be aware of how analogue and digital waveforms are graphically presented and the differences between both analogue and digital signals. They should also develop an understanding of process devices including timers, counters, comparators and logic (AND, OR and NOT).
* Students will need to develop their understanding of timer circuits, a good example of this would be a 555 monostable timing circuit.
* Activity: Students could generate their own schematic of a timer circuit based on given requirements (this could be done using CAD software.

**Counter circuits**

* Content: Students will need to know about counter circuits and how they can be used in order to count the amount of times a certain thing happens, for example how many people enter a shop (link to a decade counter circuit).
* Activity: Students could discuss the potential inputs that could be used for this type of system and a range of potential uses.

**Comparator circuits**

* Students should be aware of comparator circuits and how they work.
* Activity: Students could discuss where a comparator circuit would be used and why, they could reflect on input voltages and the type of inputs components or sensors that could be used.

**Programmable devices**

* Students should gain an understanding of programmable devices including microcontrollers, for example peripheral interface controller (PIC) used to perform more complex operations or replace discrete process integrated circuits.
* They should be aware of what PICs are, forms they available in, how they can be programmed and uses they have. Students should also be made aware of key advantages of using PICs, however also realise comparatively to other options they are quite costly, some advantages include:
  + using a microcontroller can remove the need to use several discreet components, thus decreasing the number of components on a circuit
  + PICs can be connected to several input and output systems allowing them to control systems that are very complicated
  + they can be reprogrammed making them versatile.
* Students should be aware that they can be programmed using flowchart software as well as other programming languages.

**Interfacing components**

* Students should gain an understanding of interfacing components including drivers required for loads that process or programmable devices cannot supply (transistor, field-effect transistor (FET)).
* Students should be aware that FETs amplify voltage; they are commonly used in integrated circuits and offer advantages such as low power consumption. Students should also be aware of types of circuits they are used in and why. They should be aware that an FET has three legs, the source, gate and drain.

**Analogue to digital conversion (ADC)**

* Students will also need to gain an understanding of the use of ADC in a programmable device.
* Students should be aware that most input devices produce analogue signals and microcontrollers only recognise digital signals, therefore modern microcontrollers tend have an ADC (analogue to digital converter) built in.
* Activity: Students could produce a flowchart program that converts analogue signals into digital signals.

**Truth tables**

Students should be introduced to truth tables for each of the gates covered in the specification and be aware of how AND, OR and NOT gates are graphically represented.

**Components**

* Students will need to be aware of the following output components, their function and how they work: (these can be linked to many of the systems already covered supporting recall, mathematical skills E12 can also be revisited):
  + LEDs.
  + 7 segment display.
  + Buzzer.
  + Piezo sounder.
* Students will need to be aware of the following output components, their function and how they work: (these can be linked to many of the systems already covered supporting recall, mathematical skills E12 can also be revisited):
  + Resistors (fixed and variable).
  + Diodes (signal, rectifying).
  + Capacitors (polarised and non-polarised).

**Programming**

* Students should also possess an understanding of simple programming for monitoring and controlling processes: using flow charts for explanation, limited to three inputs and three outputs within an engineered system eg a pick and place machine used in the production of electronic circuits.
* Activity: Using either a graphical programming language, eg Blockly, LabVIEW, Flowol, or text based, eg Robot C, PBasic, program microcontroller based devices to control a system.

**Operations**

* Reading from a sensor or switch.
* Time delays.
* Absolute and relative measurements.
* Decisions (switches).
* Loops, conditional, unconditional.
* Variables and constants.
* Output to devices – lamps, motors, solenoids.
* Analogue to digital conversion, using a PIC with this facility.
* Activity:
  + Several short tasks using a combination of the following, finishing with an open task requiring synoptic application on knowledge and understanding.
  + Using either a graphical programming language, eg Blockly, LabVIEW, Flowol, or text based, eg Robot C, PBasic, program microcontroller based devices to control a system.
  + Sensing, using sensors (as available) to detect and measure:
  + touch switches, used for detecting objects (bump switch) or as manual input stop/start
  + light/colour sensing
  + temperature sensing
  + sound
  + position – by compass or rotational (gyro)
  + distance, ultrasonic.

**Sub-topic**

* Pneumatic and hydraulic systems.
* Links to [Project 2: Systems: Build a small robot](#Project2_systems_build_a_small_robot)

**Overview**

The aim of this topic is for students to develop an understanding of the uses of and differences between pneumatic and hydraulic circuits. Students will need to be aware of specific circuits to be able to provide an example of when the different types of circuits could be used and why.

**Specification reference**

3.3.5

**Content**

* Students should be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification): E10 Pressure = force/area P=F/A
* Students should be aware that pneumatic and hydraulic systems are known as fluid power systems as they use fluids to control and transfer power. They should be aware of the differences between pneumatic and hydraulic systems including applications of each and be able to justify when each type should be used and why.
* Students could be made aware of specific examples within:
  + Robotics.
  + Process/factory automation.
  + Machinery.

**Activity**

* Students could be given questions to calculate force based on a range of questions relating to pneumatic and hydraulic systems.
* Assessment opportunity- an assessment or quiz about Systems could take place.

**Understanding**

* Pneumatics
* Hydraulics

**Topic 10**

* Structural systems
* Links to [Project 5: Build a bridge.](#Project5_build_a_bridge)

**Overview**

This topic aims for students to become aware of how simple imposed, dynamic and static loads are applied and transmitted, including space frame and monocoque structures, leading to bending and torsion/buckling (recall links to tensile stress and compressive stress 3.1.1).

**Specification reference**

3.3.4

**Content and activity**

Students should be aware of the Mathematical skills (as found in 7.2 Mathematical skills of the GCSE Engineering Specification): E11 Factor of safety = material strength/yield stress FoS=σy/L

**Load**

* Students should be aware of the implications of loads on structures; they will need to be aware of the difference between static and dynamic loads. In line with the specification space frame and monocoque structures will be covered.
* Dynamic loads are not constant and therefore varies, for example a child swinging on a swing or people being transported in a lift.
* Static loads are constant and therefore remain the same, for example a structure such as the Eifel Tower or a building as it remains a constant in the same place.

**Space frame structures**

* A space frame structure is a type of engineering framework made up of a network of linear elements, such as bars or tubes, these are strategically arranged to form a geometric pattern resembling triangles or pyramids. These interconnected elements create a three-dimensional lattice-like framework that offers high strength and stability whilst minimising the use of material. Space frames are known for their lightweight nature and high load-bearing capacity, making them suitable for spanning large areas without the need for numerous columns or heavy support structures.
* Students can be introduced to authentic examples such as the Eden Project in Cornwall, Kings Cross Station in London and the Olympic Stadium in Munich, Germany.

**Monocoque structures**

* A monocoque structure is an engineering design characterised by its integral load-bearing capabilities; the outer shell of the engineered product functions as a significant structural element. Unlike traditional frame structures that rely on internal frameworks for support, a monocoque design distributes loads and stresses across its entire surface. Monocoque structures often involve using lightweight and strong materials, such as composites or metals, to create a self-supporting shell.
* Students can be introduced to authentic examples, aircraft including the Airbus A350 or Formula 1 Race Cars.

**Understanding**

* Static loads
* Dynamic loads
* Space frame structures
* Monocoque structures

**Topic 11**

* Testing and investigation.
* Links to [Project 2: Build a small robot](#Project2_systems_build_a_small_robot), [Project 3: Understanding materials part 1](#project3_underastanding_materials_part1), [Project 10 Understanding materials part 2](#project10_underastanding_materials_part2) and [Project: 6 CAD-CAM](#Project6_CAD_CAM).

**Overview**

The aim of this project is to develop students’ knowledge and understanding of a range of testing and investigation methods; their ability to apply relevant mathematical calculations when engineering a solution.

**Specification reference**

3.4

**Duration**

Part of linked projects plus homework.

|  |  |
| --- | --- |
| Skills | Understanding |
| * Modelling * Calculation * Mathematical * Collaboration * Critical thinking * Logical thinking * Observation * Analytical * Practical | * Predicting performance * CAD simulation * Pythagoras’ theorem * Trigonometry * Area * Volume * Density * Load conversion * Stress * Strain * Young’s modulus * Stiffness * Factor of safety * Mechanical advantage * Gear ratio * Velocity ratio * Tensile testing * Physical modelling * Destructive testing * Non-destructive testing * Modifying programs * Quality control * Aerodynamics * Lift * Drag * Thrust |

**Topic 12**

* Modelling, calculating and testing
* Links to [Project 3: Understanding materials part 1](#project3_underastanding_materials_part1), [Project 4: Make an electronic lock/alarm](#Project4_make_an_electronic_lock_alarm), [Project 5: Build a bridge](#Project5_build_a_bridge) and[Project 6: CAD-CAM.](#Project6_CAD_CAM)

**Overview**

This topic aims to develop students understanding of how they can predict performance in any of the systems referred to in 3.3 of the specification as well as the utilisation of testing methods.

**Specification reference**

* 3.4.1
* 3.4.2
* 3.1

**Content**

* Students should also cover the following areas as part of this project under testing:
  + Methods of testing and evaluating materials and structural behaviour under load, including determining tensile/compressive strength.
  + Destructive and non-destructive testing.
  + Testing control programs for programmable devices through modelling and enactment.
  + Modifying a program to improve performance.
  + Quality control methods.
* Whilst students will be expected to use calculations, simulations and modelling either manually or with Computer Aided Design (CAD) to:
  + design and test electronic circuits
  + calculate hydraulic/pneumatic forces.

**Activity**

* Students could be given a task to manually or using CAD to calculate some of the below as a recall task from previous projects:
  + area
  + volume
  + stiffness
  + density
  + Young's Modulus
  + factors of safety
  + forces within/applied to a component or a system
  + conversion of load/extension to stress/strain (when investigating tensile strength of a material)
  + resistance in series and parallel, current or voltage.

If Computer Aided Design (CAD) software is available students could complete the task below:

* Using CAD simulations. Physical testing eg tensile strength, extension under strain.
* Using a standard engineering CAD package eg SolidWorks, Fusion 360, Rhino 3D, Inventor or SpaceClaim model the performance of components under load.
* Physical testing:
  + Tensile testing a variety of materials under load, eg nylon fishing line, cotton, hair, copper fuse wire, using a commercial tester or by improvised methods.
  + Measuring extension under strain, total length v original length and comparing the thickness of end sections with middle to detect waisting.
* Calculations: Stress, strain and Young's modulus.

If software is available for use students could complete the tasks below:

* Design and test electronic circuits. Draw block diagrams and use sensors, output devices, buzzer piezo sounder, light emitting diodes (LEDs), process devices and logic and programmable devices.
* Systems approach:
  + looking at circuit design in terms of input, process, output
  + understanding the function of sensing devices eg light dependent resistors, thermistors.
* Understanding how to match required function with available process devices:
  + timers eg 555NE
  + counters eg 4017B decade counter
  + comparators eg CA 3140
  + logic and, or, not 4001B, 4011B.
* Component level:
  + resistance in series/parallel
  + knowing the following components and their function within a circuit:
  + bi-polar transistor, field effect transistor
  + LED, rectifier diode and signal
  + capacitors, polarised and non-polarised
  + resistors fixed and variable
  + microcontrollers (PIC)
  + buzzers, bells, piezo sounder, lamps and solenoid.
* Circuit design:
  + using a circuit design package eg Circuit Wizard, Design SparkPCB, Techsoft 2D PCB
  + using a simulation package eg Circuit Wizard, Picaxe VSM, Yenka
  + physical modelling, using prototyping board for circuit construction and testing.
* Printed board and circuit construction:
  + producing a PCB by either etching or milling
  + build a circuit using a PCB.
* Testing the circuit for continuity and short circuits.

**Topic 13**

* Aerodynamics
* Links to [Project 9: Make it go faster?](#Project9_make_it_go_faster)

**Overview**

This project aims to cover lift, drag and thrust.

**Content**

Students may be asked about the terms lift, drag and thrust within a context and they should be able to give an example. Therefore, they should be aware of what the terms mean (these terms may have been covered in Science lessons).

**Specification reference**

3.4.3

**Activity**

Students could be given a task to determine which of the following relates to lift, drag or thrust:

1. An aeroplanes engine produces a force that propels the aircraft forward.
2. A parachute slows down the descent of a skydiver by creating resistance against the motion through the air.
3. A bird adjusts the angle of its wings to create an upward force that counters gravity and keeps it airborne.
4. A rocket engine expels high-speed exhaust gases backward, causing the rocket to move forward.
5. A race car's spoiler is designed to minimize the negative force that opposes its forward motion.
6. A Frisbee spins while in flight, generating a lift force that keeps it airborne and gliding.
7. A sailboat uses the wind to generate a forward force, allowing it to move across the water.
8. A cyclist leans forward to reduce air resistance and increase their speed.
9. A paper aeroplanes design includes curved wings to generate an upward force as it flies.
10. A helicopters rotor blades create a downward flow of air, generating an upward force that enables the helicopter to hover.
11. A Formula 1 cars diffuser is engineered to improve downforce, enhancing traction and stability during high-speed turns.
12. A kite is lifted into the air when wind flows over and under its surfaces.
13. A supersonic jet produces a shockwave as it approaches the speed of sound, causing a sudden increase in drag.
14. A bullet fired from a rifle experiences both lift and drag forces as it travels through the air.
15. A wind turbine's blades are shaped to capture wind energy and convert it into rotational motion.

Assessment opportunity: An assessment or quiz about testing and investigation could take place.

**Non-examined assessment**

**Duration**

1 week

**Activity and content**

Planning for the non-examined assessment (NEA):

* analysing the opportunities of the set theme
* looking at the provided examples.

**Specification reference**

4.4

**Year Two NEA**

**Duration**

Weeks 36 to 51

**Content and activity**

**Weeks 36 to 50**

* NEA: Working on the task within the approximate time limit of the course (30 hours).
* Activity: Produce the following:
  + a written or digital design folder containing:
  + detailed explanation of what the problem involves
  + alternative solutions – in outline
  + a solution that integrates different types of system – both electrical/electronic and mechanical
  + detailed design with sufficient detail to produce a fully working solution including any systems used to control the device
  + explanations of how the system functions.
  + production plans
  + manufacturing diary
  + evidence of testing, planning and carrying out the test(s)
  + reports of any remedial actions needed after testing
  + an evaluation of the effectiveness of the solution
  + photographic evidence of the final manufactured prototype.
* Additional clarification should be obtained from the specification, 4.4.2.1.
* Exam preparation/revision, dependent on timing of exam written paper.
* Exam dates can vary annually, so this needs to be a flexible programme. The time available to students will differ dependent on their available time as exams may have already begun and school policies, such as study leave, will vary.

**Week 51**

* Revision and exam preparation starts.
* NEA marks to be submitted to AQA by due date.

**Specification reference**

* Link and supplement the processes used, with previous learning.
* 4.4.6.2
* 4.4.6.3
* 4.4.6.4
* 4.4.6.5
* 4.4.6.6
* 4.4.6.7

**Exam preparation and revision**

**Duration**

2 weeks

**Activity and content**

* Exam preparation/revision, dependent on timing of exam written paper.
* Exam dates can vary annually.

**Topic 1: What influences design?**

**Content and activity**

* Energy production:
  + Availability of supply.
  + Fossil fuels.
  + Renewable energy sources:
    - Wind.
    - Solar.
    - Tidal/wave.
    - Geo-thermal.
* Engineered lifespan.
* Maintenance:
  + Lubrication, to reduce friction and wear.
  + Accessibility, to ensure it is carried out.
* End of life disposal:
  + Recycling, by manufacturers, third parties.
  + Disposal of harmful materials, heavy metals e.g. batteries, radio-active material etc.
  + Reusing parts.
* Availability of materials.
* Cost factors.
* User requirements.

**Topic 2: Impact of modern technologies**

**Content and activity**

Production methods, automation and robotics:

* Reduced production costs.
* Greater reliability.
* Different skill set/working pattern required by work force.
* Impact on numbers employed.

Society, increased availability of products:

* Social impact, creating demand, advertising/marketing.
* Changes to living style, easier communication.

The environment/pollution in cities, visual impact in the countryside.

**Project overviews**

**Project 1: Working with metals**

**Aim**

* To introduce understanding and working to formal engineering drawings.
* It is assumed that student will have used some equipment before in KS3 Design and Technology lessons.

**Skills**

* Reading and understanding orthographic drawings, engineering conventions, dimensioning.
* Marking out methods using rule, square, dividers.
* Measurement with varying degrees of accuracy, using rule, calipers, micrometer and vernier callipers.
* Turning, using manual or CNC lathe (or both if available), turning, facing, drilling.
* Tool types and parts of the lathe; headstock, tail stock (if fitted), slides.
* Methods of producing tapers or radius.
* Cutting: using hacksaw, tinsnips.
* Drilling, using both Pillar drill, and lathe, twist drills, countersinking. Using a jig.
* Bending and forming, using the vice/folding bars, bending jigs or fixtures. Hot working/forging.
* Shaping and finishing, filing, possibly milling if available, use of abrasives.
* Follow a provided production plan.
* Be aware of Health and Safety. The use of PPE and risk assessments.

**Understanding**

* Workshop safety procedures.
* The need for different feeds. Cuts, choice of tools and equipment.
* Orthographic drawings and Engineering conventions / dimensioning.
* Tolerances.

**Project 2: Systems: Build a small robot**

**Aim**

To introduce working with a systems approach using mechanical and electronic components/devices.

**Content and activity**

* Several short tasks using a combination of the following content, finishing with an open task requiring synoptic application of knowledge and understanding.
* Using a commercially available educational robotic mechanical construction kit introduce the concept of systems thinking, inputs, processes and outputs.

**Sensing**

Using sensors (as available) to detect and measure:

* Touch switches, used for detecting objects (bump Switch) or as manual input stop/start.
* Light/colour sensing.
* Temperature sensing.
* Sound.
* Position – by compass or rotational (gyro).
* Distance, ultrasonic.
* Acceleration.
* Force.

**Mechanism**

* Gearing, using spur gears, crown wheels, bevel gears, belts and pulleys.
* Transmitting power using shafts, gearing systems, belts and pulleys, chains and sprockets.
* Linkages, push-pull, bell crank, cranks and four bar mechanisms including crank-slider, parallel motion.
* Cams.
* The need for bearings.

**Pneumatics**

Use or demonstrate how pneumatics can be used to activate or control mechanical systems:

* Single and double acting cylinders.
* Applications, bus/train doors, testing rigs eg IKEA, tailgate operation on hatchback cars.

**Programming**

Using either a graphical programming language, eg Blockly, LabVIEW, Flowol, or text based, eg Robot C, PBasic, program microcontroller based devices to control a system.

**Operations**

* Read from a sensor or switch.
* Time delays.
* Absolute and relative measurements.
* Decisions (switches).
* Loops, conditional, unconditional.
* Variables and constants.
* Output to devices – lamps, motors, solenoids.
* Analogue to digital conversion, using a PIC with this facility.

**Skills**

* Analysing situations.
* Problem solving.
* Collaboration.
* Preparing flowcharts.

**Understanding**

* Velocity ratios.
* Mechanical advantage.
* Problem solving.
* Analysing procedures to enable control programs to be constructed.
* Kinematic chains.
* Forces.
* Levers.
* Conversion of motion.

**Project 3: Understanding materials part 1**

**Aim**

Introduce materials testing as a design method of predicting performance under load.

**Content and activity**

Computer Aided Design:

Using a standard engineering CAD package eg On-shape, SolidWorks, Fusion 360 or SpaceClaim model the performance of components under load.

**Physical testing**

* Tensile testing a variety of materials under load, eg nylon fishing line, cotton, hair, copper fuse wire, using a commercial tester or by improvised methods.
* Measuring extension under strain, total length v original length and comparing the thickness of end sections with middle to detect waisting.

**Calculations**

Stress, strain and Young’s modulus.

**Project 4: Make an electronic lock/alarm**

**Aim**

* To introduce circuit design, use a CAD package for modelling circuit behaviour, test the outcomes of changing component values.
* Become aware of Ohms Law equations.
* Construct a working circuit.
* Compare the use of discrete integrated circuits with programmable devices.

**Content and activity**

**Systems approach**

* Look at circuit design in terms of; input, process, output.
* Understand the function of sensing devices eg Light Dependant resistors, thermistors.
* Understand how to match required function with available process devices:
  + Timers eg 555NE.
  + Counters eg 4017B Decade Counter.
  + Comparators eg CA 3140.
  + Logic AND, OR, NOT 4001B, 4011B.

**Component level**

* Resistance in series/parallel.
* Know the following components and their function within a circuit:
  + Bi-polar Transistor, Field Effect Transistor.
  + Light Emitting Diode, rectifier diode and signal.
  + Capacitors, polarised and non-polarised.
  + Resistors fixed and variable
  + Microcontrollers (PIC).
  + Buzzers, bells, piezo sounder, lamps and solenoid.

**Circuit design**

* Using a circuit design package eg Circuit Wizard, Design SparkPCB, Techsoft 2D PCB.
* Using a simulation package eg Circuit Wizard, Picaxe VSM, Yenka.
* Physical modelling, using prototyping board for circuit construction and testing.

**Printed circuit board and circuit construction**

* Producing a PCB by either etching or milling.
* Build a circuit using a PCB.
* Test the circuit for continuity and short circuits.

**Project 5: Build a bridge**

**Content and activity**

* Build trussed structure from lightweight materials eg balsa, paper, thin card and destructively test.
* Calculate factor of safety, weight/load ratio.
* Build monocoque structures from card or form using vacuum moulding and test with dynamic and static loading, analyse failed structure for evidence of compression failures, distortion and buckling under load. Packaging a fragile object.
* Test a variety of materials for behaviour and failure modes in torsion and bending.

**Project 6: CAD-CAM**

**Content and activity**

* Using a 2D drawing package eg Techsoft 2D or Corel Draw alternatively a 3D package, working on a single plane to produce drawings that conform to standard. If facilities permit, drawings could be produced for export to laser/vinyl cutters or CNC lathes.
* Using CAD to design 3D objects, working with a 3D package, using parametric constraints, and functions such as extrude, shell, chamfering with methods of joining or locating components eg mating.
* Testing using CAD simulation, for stress or to articulate and test movements.
* Outputting 3D designs for CAM processes including rapid prototyping, CNC milling, routing.

**Project 7: Producing engineering drawings**

**Content and activity**

**Orthographic drawings – third angle**

* Placement of views, plan and elevations.
* Dimensioning.
* Conventions:
  + Centre lines.
  + Screw threads
  + Holes.

**Sectional views**

* Cross hatching.
* Conventions and rules.

**Isometric projection including isometric circles**

**Assembly drawing using a disassembled product**

**Project 8: Make a casting/moulding**

**Content and activity**

* Using a prepared pattern, demonstrate sand casting including all relevant terminology, cope, drag, pourer, riser. Explain contraction and the need for venting.
* Make and use simple cut outs as moulds to cast pewter.
* If available demonstrate injection moulding , or using a hot-glue gun an improvised method.

**Project 9: Make it go faster?**

**Content and activity**

* Introduce the aerodynamic concepts of thrust, drag and lift.
* Look at applications including F1 in schools, paper dart launchers and commercial applications such as, for example, golf clubs.

**Project 10: Understanding materials 2**

**Content and activity**

**Polymers, types and properties**

* Thermoforming.
* Thermosetting.
* Working with thermoforming polymers.
* Applications of polymers.

**Composites and reinforcements**

* GRP, Carbon fibre, Kevlar.
* Reinforcements eg steel in concrete.

**Timber**

Structural grade timber, selection and testing, uses.

**Ceramics**

* Properties and uses.
* Advantages and disadvantages.

**Heat treatment of metals**

* Annealing.
* Hardening and tempering.
* Case hardening.

**Avoiding corrosion and finishes**

Plating, galvanising, anodising, painting.

**Problem solving techniques**

**Content and activity**

* Using a logical and systematic approach:
  + Producing flowcharts and systems block diagrams to describe operations and procedures.
  + Establishing/describing systems boundaries and components.
  + Describing sub-systems within systems.
  + Mapping problems.
* Analyse and evaluate existing solutions to problems:
  + Look at similar devices that perform the same function including disassembly.
  + Examine different ways of doing things.
  + Making judgements about the effectiveness of existing solutions.
* Using data and evaluating:
  + Data gathering methods.
  + Statistical analysis.
  + Drawing conclusions.

**Planning for the Non-examined assessment**

**Content and activity**

* Analyse the opportunities of the set theme.
* Look at the provided examples.

**Non-examined assessment**

**Content and activity**

Working to the task set by AQA, within the approximate time limit set by AQA for this aspect of the course (30 hours). Produce the following:

* A written or digital design folder containing:
  + Detailed explanation of what the problem involves.
  + Alternative solutions – in outline.
  + A solution that integrates different types of system – both electrical/electronic and mechanical.
  + Detailed design with sufficient detail to produce a fully working solution including any systems used to control the device.
  + Explanations of how the system functions.
* Production plans.
* Manufacturing diary.
* Evidence of testing, planning and carrying out the test(s).
* Reports of any remedial actions needed after testing.
* An evaluation of the effectiveness of the solution.
* Photographic evidence of the final manufactured prototype.

Additional clarification should be obtained from the [specification](https://www.aqa.org.uk/subjects/engineering/gcse/engineering-8852/introduction).

Exam preparation/revision, dependent on timing of exam written paper.

Note: Exam dates can vary annually, so this needs to be a flexible programme. Dependent on students’ available time, as exams may have already begun, and school policies such as study leave the time available will differ.