Unit 3: Engineering Product Design and Manufacture

Your set task

Unit 3 will be assessed through a task, which will be set by Pearson. You will need to use your understanding of engineering product design and manufacturing processes, considering function, sustainability, materials, form and other factors. You will complete a task that requires you to follow a standard development process of interpreting a brief, carrying out research, scoping initial design ideas, preparing a design proposal and evaluating your proposal.

Your Revision Workbook

This Workbook is designed to **revise skills** that might be needed in your assessed task. The selected content, outcomes, questions and answers are provided to help you revise content and ways of applying your skills. Ask your tutor or check the Pearson website for the most up-to-date Sample Assessment Material and Mark Scheme to get an indication of the structure of your actual assessed task and what this requires of you. The detail of the actual assessed task may change so always make sure you are up to date. Make sure you check the instructions in relation to having a pen, pencil, ruler, eraser, drawing instruments and calculator.

To support your revision, this Workbook contains a revision task to help you revise the skills that might be needed in your assessed task. The revision task is divided into sections.

Researching and making notes

You will use your skills to read a task brief and research into engineering design and manufacture in relation to a product, and make notes.

Reviewing further information

You will then interpret further information in relation to the product and the design and manufacturing processes to be considered.

Responding to activities

Your response to the brief will involve you in the following activities:

- project planning and product design changes made during an iterative development process
- interpreting a brief into operational requirements
- producing a range of initial design ideas based on the client brief
- developing a modified product proposal with relevant design documentation
- validating the design proposal.

To help you revise for your Unit 3 set task, this Workbook contains a **full revision task**. See the introduction on page iii for more information on features included to help you revise.

Revision Task

To support your revision, this Workbook contains a full revision task to help you revise the skills that might be needed in your assessed task. The details of the actual assessed task may change so always make sure you are up to date. Ask your tutor or check the Pearson website for the most up-to-date Sample Assessment Material to get an idea of the structure of your assessed task and what this requires of you. Start by reading the revision task brief below carefully.

Task brief

A manufacturer has been approached by one of its clients for whom it manufactures a jointing system for wooden roof beams. The system consists of two steel plates and a fixing kit.

The client has asked the manufacturer to optimise the design of the jointing system. The optimised solution should minimise the number of separate components required and be quick and easy to install.

You will research and prepare notes on the possible design, materials and manufacturing processes to achieve this.

Now read the task information below carefully. Then read the brief and information again, underlining key information.

Task information

The jointing system is used to fix wooden beams end to end by sandwiching the joint between the two metal plates.

The two low carbon steel plates are attached to either side of the joint using 6 off M12 medium carbon steel bolts and associated nuts, plain washers and spring washers. Fitting involves drilling six holes in the end of the beams, three on each side of the joint.

The metal plates are manufactured in batches of two thousand at a time.

Individual metal plates are laser cut from a large mild steel plate.

The plates are galvanised at the end of the manufacturing process.

The jointing system must be suitable for use in a wide range of environmental conditions and temperatures ranging from –40 °C to +50 °C.

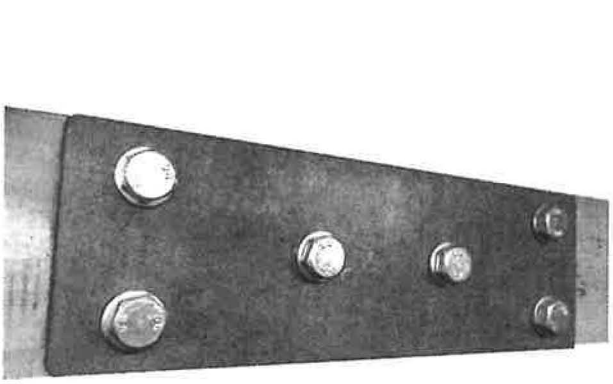


Plate dimensions: 300 × 95 × 5. All dimensions in mm.

Researching and making notes

Planning your time

When carrying out research you need to break it into stages. Estimate how long you will need for each stage, then plan and monitor your time to ensure you can complete everything within the time allocated. The stages involved in research in this Workbook are noted below. For your actual assessment, check the Sample Assessment Material on the Engineering page of the Pearson website for details in relation to research, notes, and timing.

Breakdown of task	Time
Description and analysis of existing design and identify important areas for research	
Research possible product designs, including each important area	
Research suitable materials, processes, fixtures, fittings, relevant numerical data	

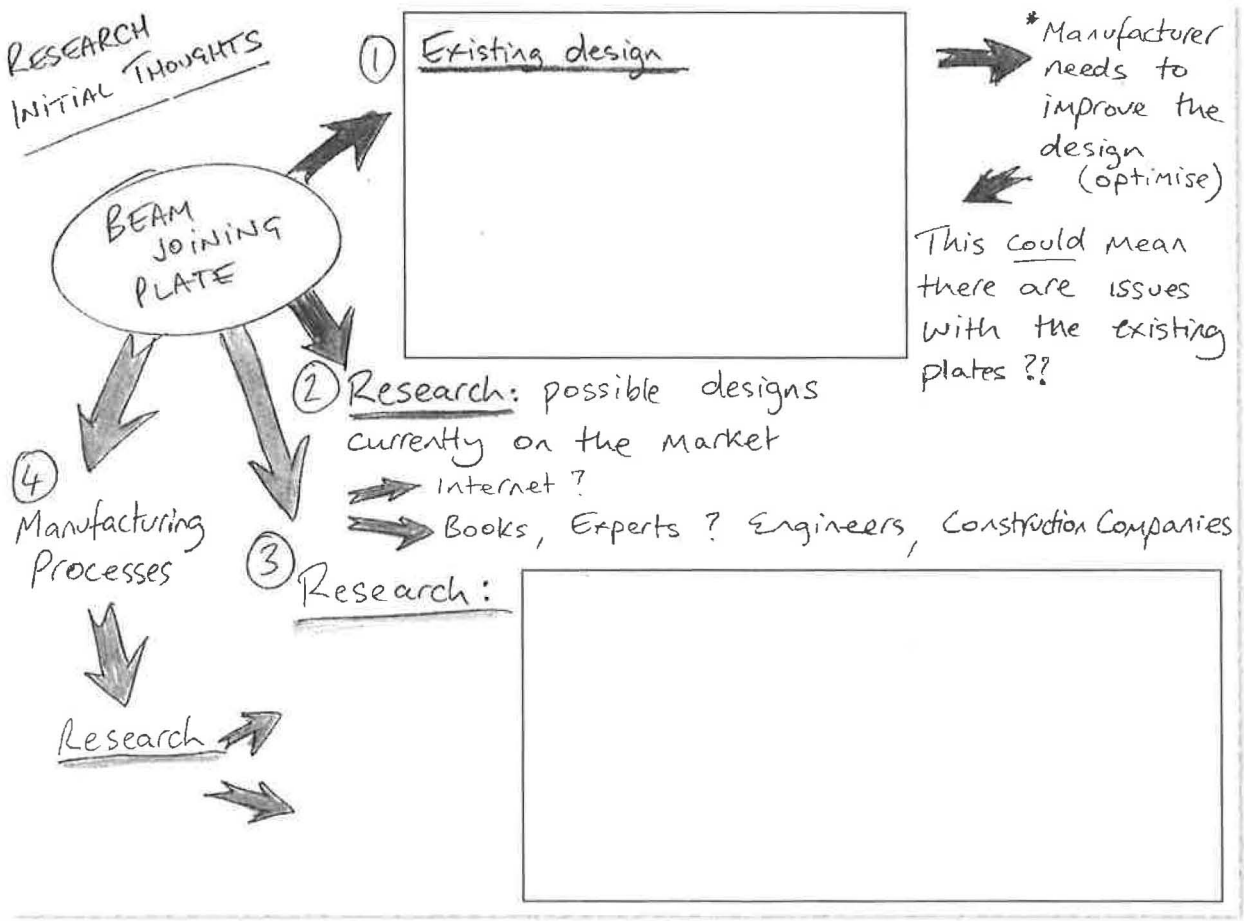
Identifying areas for research

Guided

Complete the following idea map by:

- writing a short description of the **existing product design**
- identifying possible **areas for research.** Your research focus will reflect the brief and task information and might include: how the existing product could be improved; optimising the existing design; similar existing products, manufacturing methods and processes, costs, materials and material properties; health and safety issues; sustainability and environmental issues; relevant numerical data; aesthetics; ergonomics; anthropometrics; joints/fixings; applied finish; and advantages/disadvantages of the design.

You may wish to summarise information in the diagram and use additional paper for more detailed notes.



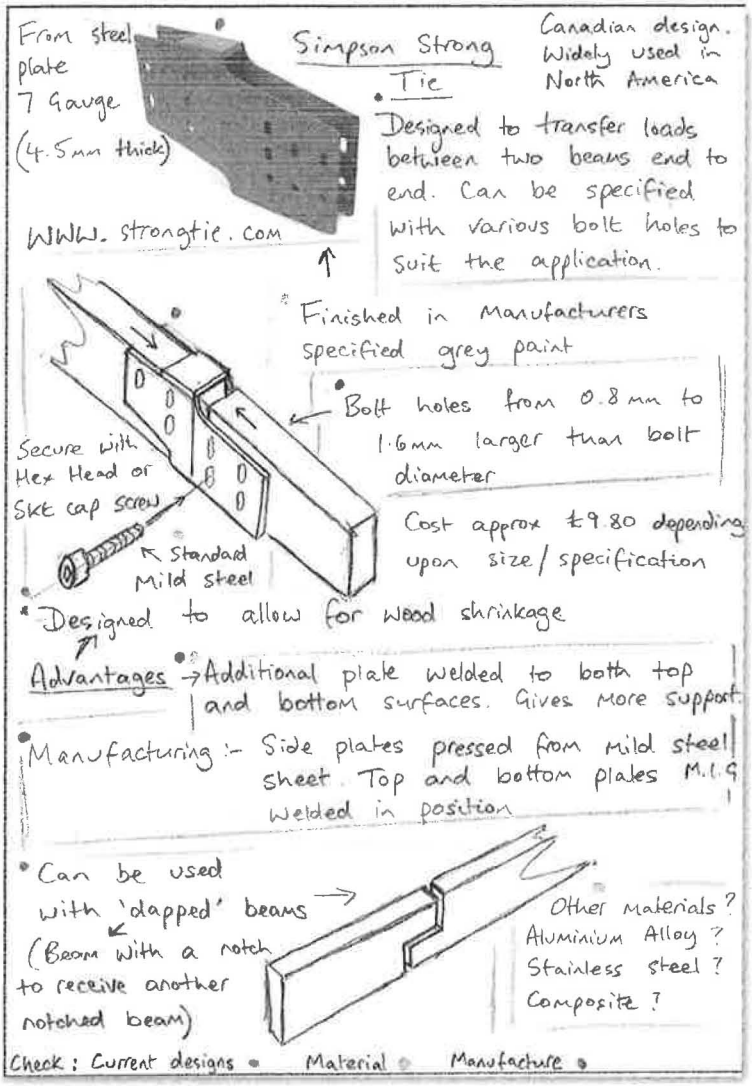
Links To revise interpreting a brief and planning research, see pages 154–155 of the Revision Guide.

Product research and notes

Guided

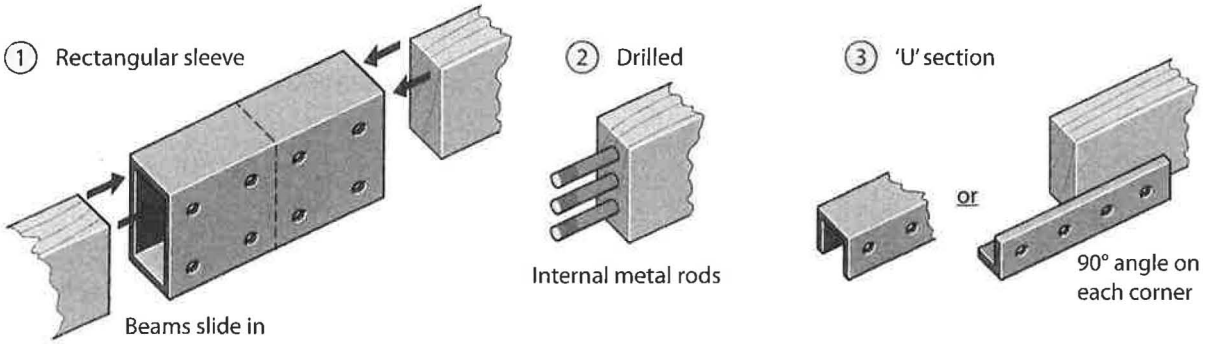
Use the internet to find at least **three different current products** that are available for **joining wooden roof beams**. The extract below is an example of notes on one product, to help guide your further product research. Make sure you include all the important areas in your research.

Product 1 – example



Focus for further product research

When finding products for research, look for designs that use methods similar to the ones used by the manufacturer. You could search for 'joist repair', 'roof beam join plates' or 'joining joists end to end'. The diagram below shows some alternative methods you may find from an internet search. Pay particular attention to those that are simple to fit, don't require to be held in place during fitting and use as few different component parts as possible.



Product 2

Guided

Use this page to make research notes on your chosen product 2. Consider how the existing product could be improved and aspects of the existing design that could be optimised.

Links To revise research notes, see page 156 of the Revision Guide.

Images of possible solution and function of product:

Manufacturing methods and processes:

Costs:

Materials and material properties:

Health and safety issues:

Sustainability and environmental factors:

Relevant numerical data:

Aesthetics, ergonomics, anthropometrics:

Applied finish:

Advantages/disadvantages of the design:

Product 3

Use this page to make research notes on product 3. You can use the example on page 55 and the headings on page 56 to help structure your research.

My research notes

Product 4

Use this page if you want to make research notes on product 4. You can use the example on page 55 and the headings on page 56 to help structure your research.

My research notes

Researching materials, processes, fixtures, fittings and relevant numerical data

You need to carry out any research that is specifically required by the brief you have been given.

Use the next two pages to make notes on:

1. roof beam materials and beam dimensions; 2. nail plates; 3. materials; 4. fasteners; 5. welding processes.

Guided

Carry out research on common **roof beam materials** and **beam dimensions**. Try looking for roof beams, joists or rafters. Make notes on the mechanical properties of the materials used and the range of standard sizes commonly used in construction.

The most popular wood species for roof joists and rafters is .....

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In the UK construction industry, beam dimensions are strictly specified according to the load they are expected to support. It also depends upon the grade of timber used. For example, ...

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Carry out research on **nail plates.** Make notes on how they work, the materials used, how they are manufactured, how easy they are to install and their overall strengths and weaknesses.

Nail plates are the most popular joist joining method in the UK. Most are manufactured in galvanised 1 mm steel plate. .....

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Research **low carbon steel** and potential alternative materials like **aluminium alloy duralumin** and **austenitic stainless steel alloy**. Make notes on their mechanical properties and other factors that might be important, such as corrosion resistance, cost and the effects of low temperatures.

The materials used for the joining plates might have to operate in temperatures as low as –40 °C, depending where in the world the building is situated.

My research has shown that low carbon steel can lose some of its impact strength at extremely low temperatures, making it brittle. Steel operating below the ductile to brittle transition temperature is far more likely to fail under shock loading.

However, duralumin and austenitic stainless steel alloys retain their impact strength and resistance to shock loading even at very low temperatures.

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Research a range of **fasteners**, such as **socket cap screws, structural bolts, washers** and **coach bolts.** Comment upon speed of assembly, load spreading ability and strength of the different options.

Research the **MIG** and **TIG welding processes** as possible manufacturing methods for a new joist joining bracket.

Using preparatory notes

In this **Revision Workbook** you can refer to any of the notes you have made as you give answers to the activities that follow. In your **actual assessment**, you may not be allowed to refer to notes, or there may be restrictions on the length and type of notes that are allowed. Check with your tutor or look at the most up-to-date Sample Assessment Material on the Pearson website for information.

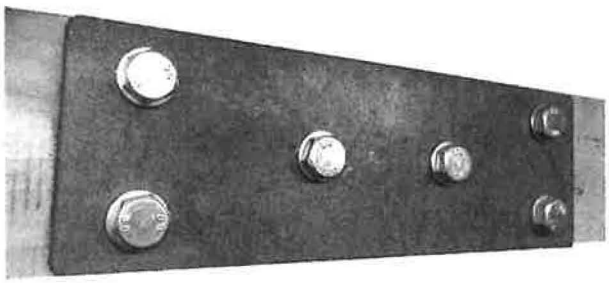
Use the checklist below for the research and notes you have completed in this Workbook.

- ☐ I have conducted research that is directly relevant to the task.
- ☐ I have considered how the existing product could be improved.
- ☐ I have anticipated aspects of the existing design that could be optimised.
- ☐ I have thoroughly researched other similar products on the market.
- ☐ I have made research notes that include:
  - the function of the product
  - manufacturing methods and processes
  - costs
  - materials and material properties
  - health and safety issues
  - sustainability and environmental issues
  - relevant numerical data
  - aesthetics
  - ergonomics
  - anthropometrics
  - joints / fixings
  - applied finish
  - advantages/disadvantages of the design.

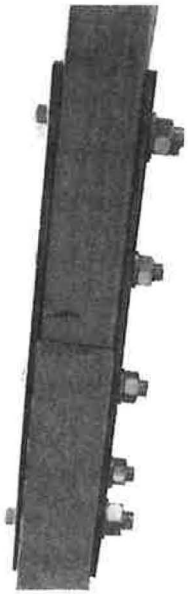
Reviewing further information

Review the further information below that repeats the product images from page 53 and provides **additional images and information**. Then read the **further task** information on pages 63–64 that relates to these images.

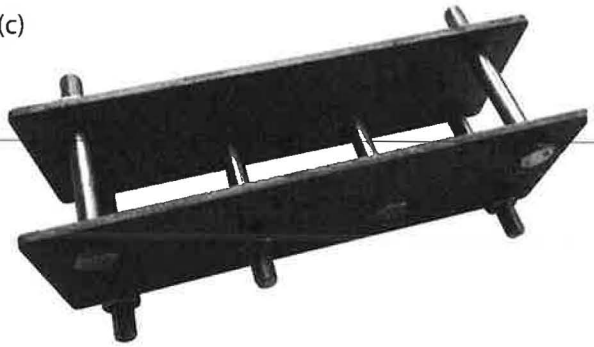
(a)



(b)



(c)



(d)

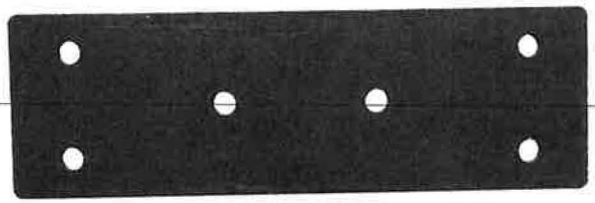
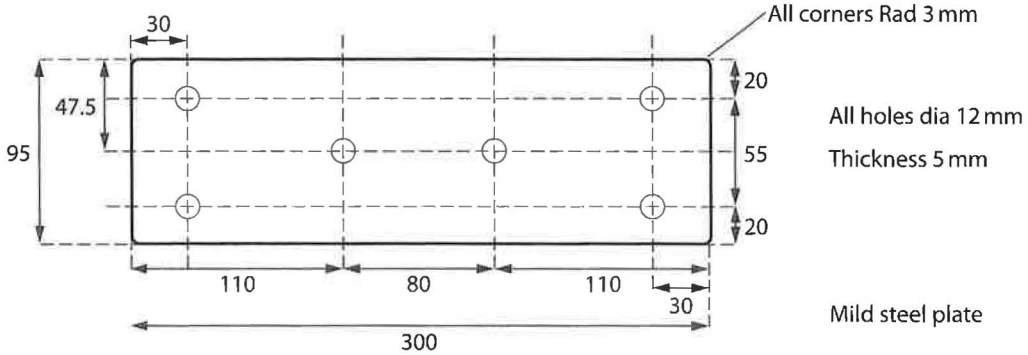


Plate dimensions: 300 × 95 × 5. All dimensions in mm.

(e)



Parts list

Name	Description	Quantity
Plates	Low carbon steel joining plates	2
Bolts	M12 × 1.75 × 60 mm	6
Nut	M12	6
Plain washer	M12	6
Spring washer	M12	6

Read the task information below carefully. It repeats the task brief and information from page 53 and provides **further information** with the **client brief**, which relates to the images on page 62. Underline the key information.

Task brief

A manufacturer has been approached by one of its clients for whom it manufactures a jointing system for wooden roof beams. The system consists of two steel plates and a fixing kit.

The client has asked the manufacturer to optimise the design of the jointing system. The optimised solution should minimise the number of separate components required and be quick and easy to install.

You will research and prepare notes on the possible design, materials and manufacturing processes to achieve this.

Task information

The jointing system is used to fix wooden beams end to end by sandwiching the joint between the two metal plates.

The two low carbon steel plates are attached to either side of the joint using 6 off M12 medium carbon steel bolts and associated nuts, plain washers and spring washers. Fitting involves drilling six holes in the end of the beams, three on each side of the joint.

The metal plates are manufactured in batches of two thousand at a time.

Individual metal plates are laser cut from a large mild steel plate.

The plates are galvanised at the end of the manufacturing process.

The jointing system must be suitable for use in a wide range of environmental conditions and temperatures ranging from –40 °C to +50 °C.

Further task information

Client brief

Images (a) and (b) show the jointing system in situ joining two beams together.

Image (c) shows an assembled jointing system that is not fitted to a beam, showing how the fasteners hold the two plates in place.

Image (d) shows a single joining plate (before it has been galvanised).

Image (e) shows an orthographic engineering drawing of a single joining plate.

The client is aware that the current design has a number of issues, but the redesign has been triggered by the plates fracturing in service when used in extreme environmental conditions.

The client had intended the life cycle of the plates to be at least 50 years. The client needs the manufacturer to identify the stage in the life cycle when the plates begin to exhibit signs of fracture and design a solution that will reduce the likelihood of the plates failing in service.

Based on extensive simulations and testing, the client has provided the following information in Table 1, which can be used to perform a statistical analysis of the service conditions in which the plates are used.

The client has asked the manufacturer to come up with an alternative solution that takes into account the most efficient and sustainable use of materials and manufacturing processes. The manufacturer also has an opportunity to optimise the design of the jointing system to make it quicker and easier to fit. This will involve combining the function of the two separate plates into a single component.

The method of joining the wooden beams must:

1. Join two beams (of section 95 × 30 mm) end to end.
2. Not protrude further than 40 mm from the top/bottom/side faces of the beams.

Table 1: Outcome of simulations and testing on existing plates

Plate	Location	Min temp inside building °C	Max temp inside building °C	Average humidity %	Life cycle (years)							
					Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
A	Brazil	8	44	80	40	48	55	51	49	49	50	56
B	Spain	6	40	78	40	47	52	52	51	44	46	47
C	U.K.	–4	28	50	39	39	41	37	40	34	31	37
D	Norway	–15	24	40	26	29	29	29	27	23	20	28
E	Alaska	–35	24	40	11	20	14	18	16	19	20	20

When you have read the additional information, you could make brief key notes that interpret it.

For example, with this client brief and information:

1. State the average expected life cycle of the product.
2. What is the diameter of the holes in the existing product?
3. Identify the main client motivation for redesigning the product.

1 .....

2 .....

3 .....

Links To revise data analysis, see pages 145–149, 159 and 163 of the Revision Guide.

When you have understood the task information, work through the five revision activities:

Page 65: Revision activity 1: A record of project planning and design changes made during the iterative development process.

Page 68: Revision activity 2: Interpretation of the brief into operational requirements.

Page 70: Revision activity 3: A range of initial ideas based on the client brief.

Page 74: Revision activity 4: A modified product proposal with relevant design documentation.

Page 79: Revision activity 5: An evaluation of the design proposal.

Responding to activities

To answer these revision activities, you will have carried out research in relation to the revision task brief and information on page 53 and the further information on pages 62–64, which includes a client brief, engineering drawings and data. In this **Revision Workbook** you can refer to any of the notes you have made as you give answers to the activities. In your **actual assessment** you may not be allowed to refer to notes, or there may be restrictions on the length and type of notes that are allowed. Check with your tutor or look at the most up-to-date Sample Assessment Material on the Pearson website for information.

Revision activity 1: Planning and design changes made during the iterative development process

At the start of the task create a short outline project time plan in your Workbook.

During the iterative development process you should also record in your Workbook:

1. Why changes were made to the design during each session.
2. Action points for the next session.

Make sure that:

- your plans and records are **logical** and show an **iterative** approach to the design process
- the design development activities lead to **refinements** that link to **research** and the **requirements** of the brief
- changes made to all design developments are **justified**
- identified action points for the next session are **logical**, **prioritised** and **SMART**: Specific, Measurable, Achievable, Realistic, and Time-based.

Guided

To **create a short outline project time plan** to show how you intend to use the time available for the activities, find out how much time you are allowed for activities in the actual assessment by asking your tutor or looking at the Sample Assessment Material on the Pearson website. Then, make your own plan below, breaking down the activities and time into detail. Use a format that best works for you, e.g. Gantt chart, timeline, flowchart of written list of tasks.

My project time plan

Links To revise time planning, see page 160 of the Revision Guide, and for iterative development see pages 144 and 166 of the Revision Guide.

Guided

To **record changes and action points** for the development process, use the pages that follow. For each session, record why changes were made and action for the next session. Action points should show forward planning that is clearly linked to the specifics of the product being redesigned, with consideration of what has happened in the previous session. Explain and justify the specific changes made in order to fulfil the requirements of the client brief. The first entry has been completed as an example.

Session 1: Date: Why design changes were made: As part of turning the brief into a list of operational requirements I analysed the numerical data given in the brief. It looks like use at low temperatures increases the chance of existing plates failing. I used my research on materials to look at ductile/brittle transition temperature for steel and now think the design should be changed to use a different material that won't become brittle in the cold.

Action for next session: I need to look at how I can make the jointing system easier to fit. I will use my research on existing beam joining products to help come up with more ideas.

Session 2: Date: Why design changes were made: .....

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Action for next session: .....

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Session 3: Date: Why design changes were made: .....

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Action for next session: .....

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Session 4: Date: Why design changes were made: .....

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Action for next session: .....

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Session 5: Date: Why design changes were made: .....

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Action for next session: .....

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Session 6: Date: Why design changes were made: .....

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Action for next session: .....

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Session 7: Date: Why design changes were made: .....

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Revision activity 2: Interpret the brief into operational requirements

Interpret the brief into operational requirements, to include:

- product requirements
- opportunities and constraints
- interpretation of numerical data
- key health and safety, regulatory and sustainability factors.

Make sure that:

- your product requirements are **cohesive** and **comprehensive**
- the opportunities and constraints are **feasible** and **meet the brief**, **enhancing** product performance
- your calculation and interpretation of numerical data is **accurate** and conclusions are commented upon/taken forward
- the health and safety, regulatory and sustainability factors are **relevant** to the given context with the redesign of the product in mind.

Guided

Read the **further information** and **client brief** carefully (pages 62–64) and make a list of all the **product requirements**. The first one has been done for you.

The product must join wooden beams of section 95 × 30, end to end.

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Make a list of all the **opportunities** and **constraints**. The first one for each has been done for you. Remember, you can always come back and add to these once you have fully analysed the task.

Opportunities

1 Joining the beams without drilling through them could be a better solution than the existing design.

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Constraints

1 The chosen solution must not protrude from any face of the beams by more than 40 mm.

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Interpret the data in Table 1 (page 64) to show understanding of the client brief by completing the sentences below.

The mean life cycle in years for plates used in the United Kingdom is .....

The mean life cycle in years for plates used in Norway is .....

The country where beam plates have the shortest average life cycle is .....

The country where beam plates have the longest average life cycle is .....

The temperature range the plates are subjected to is least in .....

The temperature range the plates are subjected to is the biggest in .....

The plates are subjected to the lowest average humidity in .....

The data would seem to suggest that the likely cause of premature failure of the beam plates is .....

I believe this may be because .....

Additional information from the numerical data .....

.....

Complete the list of key **health and safety**, **regulatory** and **sustainability** factors.

Health and safety

1 The chosen solution must pose no risk to the person fitting it to the joining beams. This applies to fitment when the beams are in position in the roof, or prior to fitment, on the ground.

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Regulations

1 The chosen solution must be compatible with the relevant British standards relating to beam sizes and load bearing. My research on materials and sizes of roof beams .....

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.....

Sustainability

1 The chosen solution must be manufactured from materials that can be recycled or reused at the end of the product life cycle. Aluminium is suitable for recycling .....

.....

.....

Links To revise interpreting the brief, see pages 162–163 of the Revision Guide.

Revision activity 3: Produce a range of initial design ideas based on the client brief

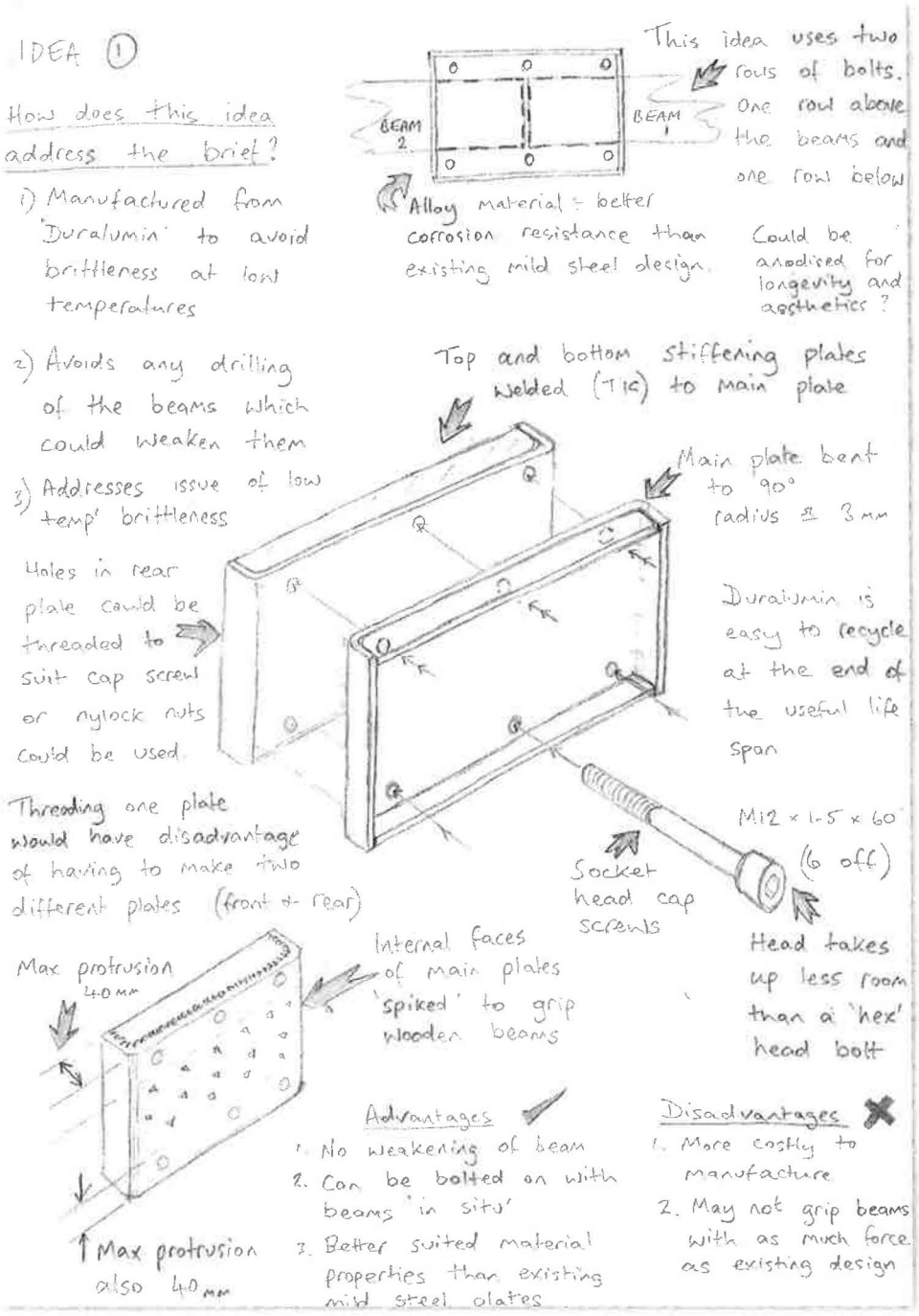
Produce a range of (three or four) initial ideas based on the client brief, to include sketches and annotations.

Make sure that:

- your range of ideas are **appropriate** and **comprehensively** address the brief, including adaptations that are major improvements when compared to the existing product and the brief
- your ideas are communicated **clearly** and **concisely** with appropriate use of **annotation** and **technical terms**
- your ideas are **feasible**, **fit for purpose**, and reasonably different to the existing product shown and each other, when considering both form and approach.

Guided

An extract from example idea 1 is sketched and annotated below. Use the following pages to sketch and annotate two of your own initial ideas. Use your research on **existing products** and **other aspects** of the design to **support**, **inform** and **inspire** your work.



Sketch and annotate idea 2 below. Refer to the example on page 70, your research and the key headings on page 56.

Links To revise initial ideas, see pages 164–165 of the Revision Guide.

Sketch and annotate **idea 3** below. Refer to the example on page 70, your research and the key headings on page 56.

Sketch and annotate idea 4 below. Refer to the example on page 70, your research and the key headings on page 56.

Revision activity 4: Develop a modified product proposal with relevant design documentation

Develop a modified product proposal with relevant design documentation. The proposal must include a solution, existing products, materials, manufacturing processes, sustainability, safety and other relevant factors.

Guided

Your response to this activity will be significant in showing your skills and knowledge. Use the checklist below to make sure you **address the 10 important categories** as you **structure and document the development** of your final design. Use the following pages to **develop a modified product proposal with relevant design documentation for the brief** in this Workbook. Make **full use of the research** carried out on materials, processes and other aspects of the product and how it could be manufactured.

Optimisation

Prove that your solution is the best possible response to the original brief.

Justification

When compared with the existing product, prove that your solution is a significant improvement, with clear variation when considering form and approach. Provide a balanced argument, giving reasons to support your view. Show how you arrived at your conclusions.

Informed decisions

Show you have a thorough understanding of existing alternative products and make it evident how the features of existing products relate to the chosen solution.

Materials

Prove you have investigated all possible options for materials and fully justified your choice.

Manufacturing

Prove you have investigated all possible options for methods of manufacture and fully justified your choice.

Sustainability

Show you have considered sustainability at all points of the product life cycle in relation to, for example, raw materials extraction, material production, production of parts, assembly, use and disposal/recycling in the context of the chosen solution.

Safety

Prove you have designed out all possible risk and that the proposal is safe to use and interact with, in relation to the existing product.

Documentation

Provide all the necessary information so that a third party can understand every aspect of your design, including, for example, a reasonably accurate orthographic projection.

Annotation

Provide detailed annotation so an engineer could manufacture the product.

Technical terminology

Use technical language correctly and accurately throughout, including annotation of your designs.

Guided

Use the sample **development response sheet 1 below** relating to manufacturing methods, to help you **develop** your own ideas into a **final solution**. Your final development section must cover: a developed solution, existing products, materials, manufacturing processes, sustainability, safety and any other relevant factors. This should be supported by any investigations you carried out into these areas in your research.

DEVELOPMENT : MANUFACTURING PROPOSED DESIGN

The beam is secured between two fabricated clamping plates Ⓐ and Ⓑ. They are shown with individual parts colour coded for clarity. Material for all parts (except the bolts) is duralumin

- Top and bottom strengthening plates
- M12 x 1.5 x 60 Cap
- Main clamp body
- Anti-twist plates

Ⓐ

Why duralumin?
Alloy of aluminium with 4% copper, 0.5% magnesium and <1% manganese
Light, strong, good tensile strength, easily re-cyclable
Widely used in aircraft industry

Top & bottom plates are Ⓑ snug fit prior to GTAW weld

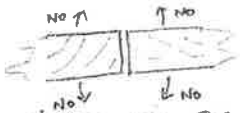
* After folding corners will have a 3 mm radius not shown on this diagram

+ All holes 12 mm dia

Why T.I.G?
Very clean weld.
Low profile bead
No slag left on weld
Ideal for thin sheet material

(BEAM HERE)

The top and bottom anti-twist plates prevent movement of the roof beams in the vertical plane



These plates are TIG welded onto face of main clamp body. Recent technology has meant duralumin can be laser cut. All parts are cut to shape this way for accuracy and consistency in mass production

Holes for bolts can be formed at the same time as the plates are laser cut

Main body ends bent on folding machine. Could this be done before heat treatment * Further research needed.

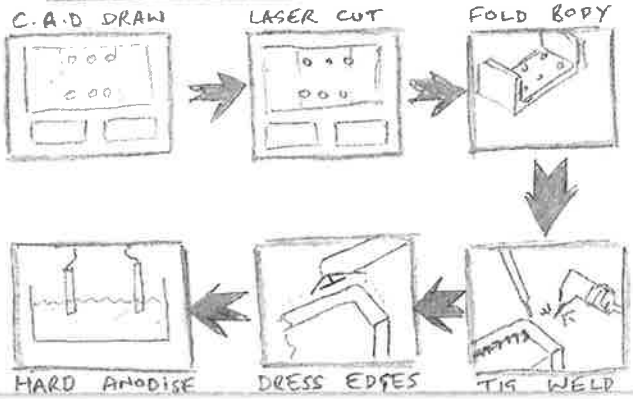
Hard anodised finish. Natural colour

Anti-twist plate

Alloy is quenched from just below its melting point then 'aged' for up to 3 days. Hardens appreciably.

Note that holes in Part Ⓐ could be threaded but this will increase manufacturing costs. Threads could be created on Milling Machine or by hand using taper tap and plug tap. Threading the holes would make fitting onto the beams quicker and easier for the end user

MANUFACTURE FLOW CHART



Develop your own ideas into a final solution using this page for **development response sheet 2**. Refer to the example on page 75, your research and the key headings on page 56.

Links To revise developing a modified product proposal into a final design, see pages 166–169 of the Revision Guide.

Develop your own ideas into a final solution using this page for **development response sheet 3**. Refer to the example on page 75, your research and the key headings on page 56.

Develop your own ideas into a final solution using this page for **development response sheet 4**. Refer to the example on page 75, your research and the key headings on page 56.

Revision activity 5: Validate the design proposal

Your final Workbook entry must evaluate:

- success and limitations of the completed solutions
- indirect benefits and opportunities
- constraints
- opportunities for technology-led modifications.

To evaluate and validate your final design proposal you should:

- give a **balanced** and **thorough** appraisal of your design
- provide a **sound rationale** for why the design solution is more **effective** in relation to the **brief**
- **communicate**, with detailed **evidence**, how further **technology-led** modifications help optimise the solution.

Guided

Read the **example validation** below, which relates to the sketched idea 1 on page 75, then write your **own validation** of your design proposal.

Validating the design proposal

The idea I have proposed is fabricated from Duralumin, which offers a number of advantages. Firstly, it performs well at low temperatures, which will help avoid the issues with the brittleness of the original plates. Secondly, Duralumin is very well suited to recycling at the end of the product life cycle. One of the main features of this design is that there is no requirement to drill the beams, which can weaken them. The plates also feature a folded edge, which improves the stiffness of the joint. The success of this design is further enhanced through the use of threaded holes in one of the plates, which will reduce the time needed for assembly. This also cuts out the need for additional nuts and washers, which saves cost. Duralumin is a non-ferrous metal that does not require an applied finish, although anodising could be used to enhance the aesthetics and further extend the expected life cycle (cost would be increased).

The design does have some limitations. It is more difficult to manufacture than the original plates and may not grip the beams with as much force because the bolts are positioned above and below the faces of the beam. However, the inner faces do feature 'spikes' to grip the wooden beam, which will help eliminate any movement or 'creeping' of the beam over time.

This design directly addresses the following areas of the brief:

- The change in material has removed the chances of brittle failures in low temperature conditions.
- Using tapped holes in the plates instead of nuts and washers reduces the number of components in the kit.
- Not having to drill holes in the beam makes the joint easier to fit.
- By fitting the top bolts whilst on the floor the jointing system can be easily hooked over the beams, which will hold it in place during fixing. This makes it safer and easier to install than the original.

There is an indirect benefit from use of this design, too. These plates would be suitable to replace the existing plates without having to disturb the beams, or be used to repair beams that have developed weak spots.

The use of these beam plates may, however, be constrained in some places because they do protrude above and below the existing beam by 40 mm.

A future development of this design could be 'quick release' bolts that require only a half turn to lock into position. This would decrease fitment and removal time.

A technology-led adaptation for use in extreme environments would be to fit the jointing plates with low-cost sensors to monitor overloading or any movement in the beams. This would allow action to be taken before failure. This might be useful in extreme cold with high snow loading on the roof.

Validate your final design proposal. Use the headings to help you structure your validation.

Simple sketch of final proposal:

Brief explanation of main features:

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Success of the completed solution:

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Limitations of the completed solution:

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Indirect benefits and opportunities of the completed solution:

Constraints of the completed solution:

Opportunities for technology-led modifications in relation to the completed solution:

Links To revise validation, see pages 150 and 170–171 of the Revision Guide.

Now **check** that your work covers all the **important aspects**. Below is a checklist for each activity and the **qualities** that you should show in your **solution**.

Tick off each one if you have addressed it during your completion of this Workbook revision task.

Activity criteria checklist

Activity	Breakdown of required tasks	Completed?
1	My Workbook activities are logical with an iterative approach throughout.	
	My design development links to research and requirements of the brief.	
	I have fully justified my design developments.	
	I have identified action points for the next session that are well-defined, logical and prioritised.	
2	I have interpreted the brief with a full list of product requirements.	
	I have accurately interpreted and calculated numerical data.	
	I have considered health and safety, sustainability and any relevant regulations with relevance to the context.	
3	I have given a range of ideas that fully address the requirements of the brief.	
	I have communicated each idea with clarity and technical annotation, linked to the brief.	
	Each idea is feasible, realistic, and fit for purpose.	
4	I have optimised my design solution and justified all alterations and developments.	
	My design proposal is informed and demonstrates a thorough understanding of existing products.	
	I have investigated material options and justified selection.	
	I have investigated manufacturing options and justified selection.	
	I have considered sustainability throughout life cycle of product.	
	I have clearly referenced the safety of the design and designing out risks.	
	My formal documents allow a third party to make the product correctly, with concise annotation of the solution and use of accurate technical terminology.	
5	I have shown a balanced and thorough appraisal of success and limitations of completed solutions, indirect benefits and opportunities, and constraints.	
	I have provided a sound rationale that states why the design is more effective in relation to the brief than the original solution.	
	I have communicated with detailed evidence how technology-led modifications could further optimise my chosen solution.	

END OF TASK