ME22007 Sub-assembly design exercise

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Welcome

Welcome to ME22007 *Design, materials and manufacturing 2*! This unit consists of several coursework assignments over the year. This document focuses on the first *sub-assembly design exercise* which takes place in weeks 1–8, and accounts for 30% of the unit credit.

This handbook introduces the aims of the unit (Chapter 1) and practical information about the operation of the unit, groupwork, lectures, studio sessions, feedback, and marking (Chapter 2).

Chapter 3 presents the specific design task you will be solving in this year's design exercise.

Chapter 4 describes what steps you should be taking each week to progress with the design exercise, and Chapter 5 gives details of the individual and group coursework submissions in week 6 and week 8.

> **Tip**
>
> You can download a PDF version of this handbook using the download icon in the title of the sidebar.

1 Introduction

In this design exercise, you will work together in teams of (typically) four to develop a complete design and manufacturing plan for a power-transmission shaft sub-assembly. Since there are many possible good solutions to the design problem to explore, within your teams you will first analyse individually your own candidate solution (with an individual "stage-gate" submission in week 6). These individual assessments will then form the basis for your group's choice of final design, and final group coursework submission in week 8.

Over the first 5 weeks of the semester, you will learn about the design, materials and manufacturing topics you will need to then apply to complete the design exercise. This includes:

- **W1-2: Design elements and solid mechanics**
  - Relevant design elements (stepped shafts, bearings, transmissions) and how to evaluate their suitability.
  - Application of solid mechanics theory to test whether your power-transmission shaft design is suitable for the loading.
- **W3-4: Material selection**
  - Relevant materials and material selection approaches and theory.
  - Practical use of materials databases and selection tools.
- **W4-5: Manufacturing processes**
  - Relevant transformative and subtractive manufacturing processes
  - Analysis of the kinematics and dynamics of processes to evaluate their performance/costs.

Each of these parts involves lectures to introduce concepts and examples, tutorial sheets and tutorial sessions to help you practice application of these methods, and studio sessions to support you as you apply these topics to your design work.

For the last two weeks of the design exercise, you will work as a group to develop your final design report and technical drawings. During these two weeks, lectures will support you in this process, including compiling the report and technical drawings (CAD), but there will be no new technical content or analysis.

What's in this briefing document?

The rest of this page explains the aims and relevance of this design activity, and Chapter 2 describes practical arrangements.
The specific design brief is presented in Chapter 3.
Details about steps you will need to take to complete the coursework are given in Chapter 4, and details of the submissions in weeks 6 and 8 are given in Chapter 5.

1.1 Aim: an iterative approach to detailed design

The idea of this design exercise is for you to develop your design skills and understanding in five main ways.

1. We will be focusing on the **details** of design, using **technical analysis** to make informed decisions. In this exercise, you will use your knowledge of solid mechanics from first year, and other component selection methods you will learn in this unit, to make sure your design is suitable for the loading and environment it needs to operate in.
2. We will take an **integrated approach** to materials, manufacturing and design. These three topics are tightly related (e.g. changing material to a stronger one may allow the design to be made smaller and lighter, but this might increase manufacturing time or cost) so it's important to consider them together as part of the design process.
3. We will be using an **iterative approach** to improve an initial design. For any reasonably complex design problem, it is impossible to find the best solution in one step. Achieving a successful solution involves proposing an initial design and then intelligently improving it to meet (and ideally exceed) the minimum requirements that have been defined.
4. As a professional engineer you will take responsibility for your (and others') work being **correct**, so keeping clear working, and **checking** your (and others') work is important. In this exercise we will help you to do this by guiding you to check your group's work at each stage. By doing this as you go along, you will get feedback on your work and increase your chances of reaching a successful design.
5. In the end, a great design is no good unless you can communicate it, so you will fully document your final design using **technical drawings** and a short **technical report.**

1.2 How is this design exercise relevant to real-world engineering?

Why are we designing a power transmission shaft? Their fundamental function is to carry loads, making them a good problem to practice applying your technical analysis to make sure they won't fail in operation. They require you to consider both the design of your own custom part (the shaft) and how it integrates with the selection of off-the-shelf components (e.g. bearings). These elements are at the core of many important machines (Figure 1.1) so what you learn by designing the relatively simple shaft we consider in this exercise will equip you to work on a variety of engineering applications.

(a) A wind turbine has a large shaft to support the rotor and transmit power to the gearbox and generator.

(b) Gas turbines contain complex shafts.

(c) Many types of transport depend on shafts, such as this electric cargo trike.

Figure 1.1: Examples of machines containing power transmission shafts.

2 Unit practicalities

2.1 Groups

For this design exercise, you will work in teams of (typically) four. The groups will be allocated and announced in Week 1. New groups will be formed for the later design exercises in the unit.

Teamwork is an essential part of the design projects in this unit. By combining your individual ideas and analysis with those of your teammates, you can consider more options and develop a better design as a result. Successful teamwork takes effort: you will need to make sure your team meets regularly, and that you communicate well to agree your approach and expectations.

2.2 Lectures and studio sessions

Timetabled sessions for this unit take place on Tuesdays and Thursdays. The design studio sessions are designed to set you off in the right direction for working on each step of your coursework. You will need to arrange in your teams to work together outside these sessions to complete the design exercise. The tutorial sessions will review the tutorial sheet questions, or other questions on the material that come up as you apply the methods to your coursework project.

Session	Activity	Location
See timetable	Lectures	*See timetable*
Tuesday 11:30 – 13:05	Design studios	4 East 3.40/3.44/2.32
Thursday 12:15 – 13:05	Tutorial session	4 East 3.40/3.44/2.32

See Chapter 1 for an overview of the topics covered in each week.

In week 6 (reading week), the normal pattern of sessions will pause. Instead the following sessions will be happening:

Session	Activity	Location
Monday 11:30 – 13:05	Manufacturing tutorial 2	4 East 3.40/3.44/2.32
Tuesday – Friday, 11:30 – 13:05	Design studios	4 East 3.40/3.44/2.32

The design studios will be available for you to use. Members of staff will be available to support you at times to be confirmed during the week.

2.3 Lecture notes, slides and reference material

The course notes (on Moodle) give reference material on technical aspects of the design, such as how to select suitable bearings.

Copies of lecture slides will be uploaded to Moodle. Lecture recordings will be available via Panopto/Review.

Additional reference material (catalogues, component information, stress concentration factors) are also available on Moodle, which you will use as part of your design and analysis.

2.4 Communication and feedback on this unit

All announcements will be made via email.

Where is the best place to find information and ask different kinds of question?

- First, please check if your question is answered in this document (try the search!). Then have a search in the Moodle forums to check if anyone has already asked the same question.
- Ask **questions about CAD** on the Moodle CAD forum.
- Ask **questions about organisation or the exercise** on the Moodle Q&A forum. This way we can make sure that everyone receives the same information, where appropriate.
- For **questions about your design choices,** discuss them ideally in the studio sessions with the tutors, or at other times via the Moodle Q&A forum.
- For other matters which aren't suitable for asking on Moodle, email me directly (rcl38@bath.ac.uk).

Tip

You can change your Moodle notification settings if you don't want to receive an email every time someone posts in a forum.

Please use the appropriate channel; due to the number of groups, unfortunately I cannot discuss details of your design or analysis via email and you may not receive a timely response. Of course, you are welcome to get in touch about other matters where you need to speak to me directly.

Finally, please note that technical advice will be given by tutors based on their experience and interpretation of the key issues. *These will probably vary from person to person!* Although it can sometimes be frustrating, it is part of the nature of design that there is no one right answer. The key thing is to listen and think about (and perhaps ask about) their underlying rationale, then decide for yourself what to do.

3 Design brief 2024

Your task:

> Design a speed-reduction transmission shaft sub-assembly for a custom fork-lift for use in a stone quarry near Bath, to meet the requirements set out below.

3.1 Context

Concrete is a very widely used construction material, but one which comes with high carbon emissions. Researchers in the Department of Architecture and Civil Engineering at the University of Bath are exploring how engineers could instead use more traditional, low-carbon materials such as natural stone blocks. The area around Bath has a long history of stone quarrying, and several quarries are still active (Figure 3.1).

Figure 3.1: An underground stone quarry near Bath.

To extract stone blocks, the quarry face is cut into suitably sized blocks using a grid of stone-saw cuts, and the back face of the blocks are fractured to free them. They are then removed using a specially designed forklift.

To increase production capacity, the quarry would like purchase additional machines to lift the blocks. A new design is being developed using electric motors and a novel drive configuration. Your design assignment forms part of the new model being developed.

3.2 Sub-assembly arrangement

The overall design of the new forklift has been completed. Your task is to develop a detailed design for the transmission shaft sub-assembly, within the constraints and requirements which have already been set.

The forks of the forklift are driven up and down by a chain mechanism, which is driven by an electric induction motor, as shown in Figure 3.2. The forks should move at 0.1 m/s while lifting a total load of 1 tonne (that is, the load on each fork lifting chain can be assumed to be half of this). The motor can be configured to operate at speeds up to 30 rpm. The machine components should be capable of operating for 12 hours per day, every day for 10 years before replacement.

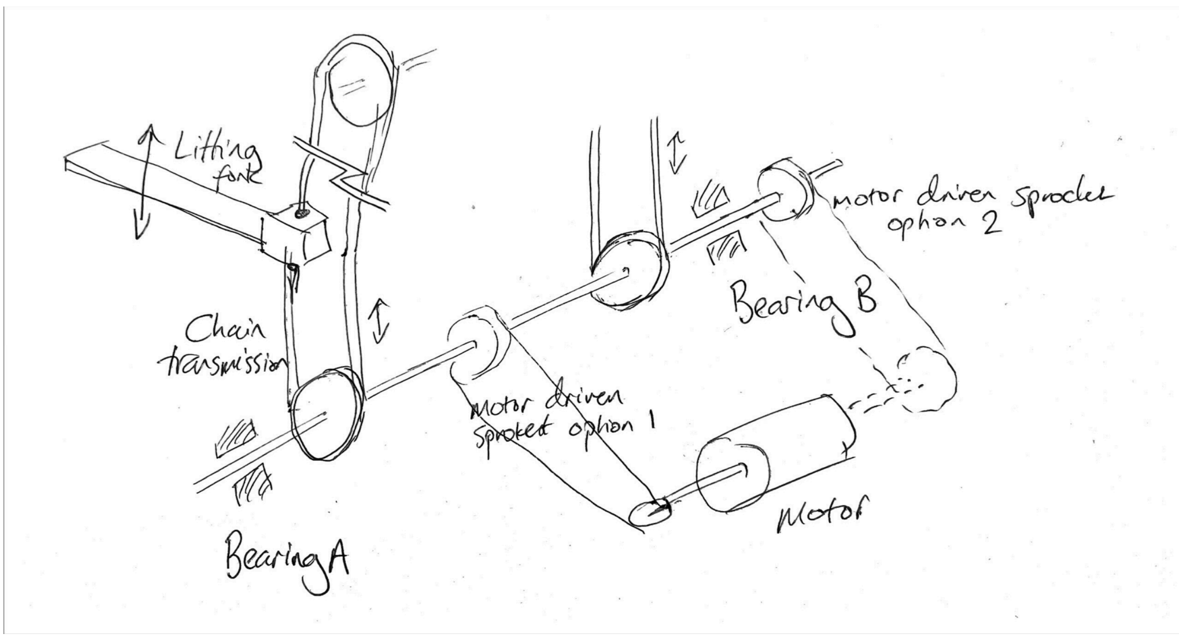

Figure 3.2: Overall sketch of sub-assembly arrangement

There are several options for how the components are arranged along the shaft. Two possible positions for the motor chain drive are shown in Figure 3.3. In addition, it is possible to swap the positions of Bearing B and the right-most motor chain drive position.

The scope of your sub-assembly includes:

- A chain drive transmission, to transfer power from the motor to the shaft and control the speed and torque;
- Two deep-groove ball bearings, to support and locate the shaft and allow it to rotate with low friction, with suitable mountings;

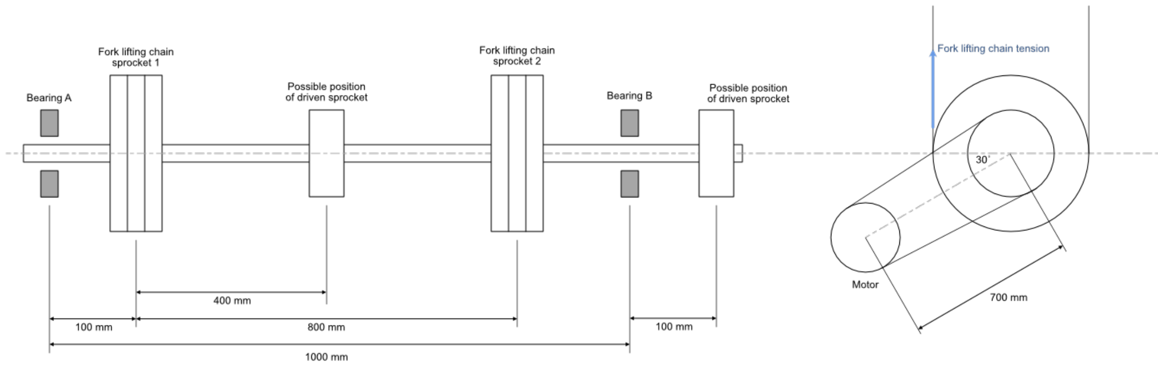

Figure 3.3: Side view and end view of sub-assembly, showing the location of the electric motor and the chains which lift the forks. The motor may be mounted with its shaft at either end, driving the shaft at either point 1 or point 2. Tolerances on the axial dimensions are ±20 mm, tolerances on the shaft/motor centre distances are ±50 mm.

- The shaft itself, with a custom geometry including shoulders, keyseats and circlip grooves to locate components and transmit torque; and
- Additional components (circlips and keys) needed to assemble the components onto the shaft.

The selection of the large chains supporting the forks has already been made: 31.75mm pitch, triplex BS chains, which may be driven by sprockets on the shaft with a maximum diameter of 220mm. On the other hand, the chain drive transmission between the motor and the shaft is your concern.

The supporting structure for the bearing housings and motor is not your concern; assume these can be mounted to the chassis of the forklift at any location which does not interfere with the operation of your design. You should however specify a suitable off-the-shelf bearing housing or bearing unit, or include a simple design for one.

3.3 Manufacturing capabilities and assumptions

The initial shaft will be manufactured by turning on a lathe. The focus is primarily on the bulk of material removal which will happen by straight turning. Depending on the relevant materials, approximate values for specific cutting energy can be obtained from lecture slides. Alternatively, you can employ other sources and cite them.

You have access to four lathes, but you will have to choose only one to use based on your requirements. Their power ratings are 5 kW, 10 kW, 30 kW and 60 kW.

Assume the lathe spindle rotates at 420 rpm and the tool is travelling at an axial velocity of 220 mm/min. The depth of cut should not exceed 4 mm. You can also assume the machining can be approximated by an orthogonal model of cutting and that the rake and friction angles are equal to 12° and 30° respectively.

The cost of machining (C_m) mostly depends on labour cost rate (L_m) and on various overheads associated with the lathe (maintenance, depreciation, etc). The latter is called the burden rate (B_m) and in this instance is a function of the machine power (P, measured in W) such that:

$$B_m = 40 + \frac{\sqrt{P}}{4} \quad \text{(in £ per hour)}$$

An estimate for the machining cost then is:

$$C_m = T_m(L_m + B_m)$$

where T_m is the total machining time.

3.4 Client priorities

- Since the forklifts are specialist machines and will be only produced in small quantities, standard components should be used where possible.
- Costs of materials and components should be minimised while meeting design requirements.
- Costs of manufacturing time and equipment should be minimised while satisfactorily producing the designed part.
- The carbon footprint (embodied carbon) of the material purchased, and carbon footprint of the energy used for manufacture, should be calculated and reported.
- It should be possible to disassemble and replace the transmission and bearing components if needed, to extend the lifetime of the sub-assembly.

3.5 How to approach the design task

The next section (Chapter 4) recommends the approach to take to complete the design project, leading to the coursework submissions (Chapter 5).

4 Design approach and stages

You have the freedom to explore a variety of potential design options to find a good solution. To do this, you will first need to analyse the problem and come up with alternative options as a group, of which you will individually analyse one in more depth. These individual assessments will then form the basis for your group's choice of final design, and final group coursework submission.

To help you do this, the design assignment is structured into three phases: initial groupwork (W1-W5), individual detailed design analysis (up to W6) and the final group design submission (W7-8).

4.1 Initial group design work (W1-W5)

You will first need to analyse the problem and come up with alternative potential solutions as a group, which you can individually analyse in more depth later (see below). Some parts of the problem are fixed (e.g. overall force and power requirements) and can be completed early on as a group; other calculations will depend on your design choices (e.g. choice of transmission determines loads on the shaft) so will need to be carried out by each team member for their own design option.

By the end of **week 2**, your group should have completed initial analysis of free-body diagrams and initial calculations to understand the loading requirements for your design. By using symbolic notation and setting up calculations using a spreadsheet or code rather than directly calculating results, you can make this work re-usable across different individual analyses.

By the end of **week 4**, your group should have derived a suitable merit index or indices (taking into account your group's objective and constraints) to support an initial screen of materials, and shortlisted some materials you will consider further as your design progresses.

By the end of **week 5** (or earlier), you must have agreed in your groups what individual design options each team member will analyse for their individual analysis (described below).

You should ensure you have a diverse set of design options, considering different choices. There is no hard line between what is a different "design option", and what are different iterations in developing an individual "design option". However, to give guidance, consider these questions to identify different design options (i.e. each member of the group should focus on an option with at least some different answers):

- What size of sprocket is used to drive the fork lifting chains on the shaft?
- What speed ratio, size, type of chain drive is used to transmit power from the electric motor to the shaft?
- Which of the possible motor positions in Figure 3.2 is used?
- Where along the shaft should the largest shoulder be placed?

4.2 Individual analysis of design options (W3-6)

From W3 onwards you will have enough information to begin to analyse your individual design options. The pause in lectures during the W6 reading week creates space for extra studio sessions, which you should use to complete this analysis and development of your chosen design option. While you are encouraged to continue to support each other in your teams, each team member must take responsibility for carrying out their own analysis of a different design option.

Your individual analysis should aim to answer these questions for *your* design option:

- What are the loads and stresses in the shaft? This analysis can be based on your initial group analysis, but made specific to your individual situation (for example, if you have a different transmission, you will have different forces on the shaft).
- What dimensions should the shaft have to avoid failure under load? Where should features such as shoulders and grooves be located?
- Which size of deep-groove ball bearings (DGBBs) are required?
- What other components are needed to assemble the design? How large should they be?
- How will the shaft be manufactured? Quantify key parameters and costs.
- What material will you use for your custom shaft part? The choice should be justified using appropriate materials selection methods.

You will need to *make iterative changes* to the design's layout, geometry, material or design details, to achieve a design which meets the essential design requirements, and improves against the design wishes.

By the end of the week, you will submit your results as a "stage-gate" check in the form of an individual technical design file (Section 5.1) – see that page for details of what figures and calculations you should aim to complete.

4.3 Group design selection and documentation (W7-8)

By this point, your team has done the hard work and has analysed a range of design options. You now need to evaluate these options to reach your final group design, and formally present your results in the form of technical drawings and a concise report explaining why this was the best solution.

The report must present the analysis to evidence the reasons for your choices, but this should be largely able to be copied directly from the individual technical design files.

The final group submission (Section 5.2) is due in Week 8.

5 Coursework submissions

There are two submissions elements for this exercise, with staged deadlines, plus Moodle-based quizzes for the “manufacturing toolbox”:

Submission element	**Individual/group**	**Due**	Weight
Stage-gate: technical design file	Individual	Friday W6	–
Final design report & drawings	Group	Thursday W8	97%
Moodle quiz (manufacturing toolbox)	Individual	W9–11	3%

The individual submission acts as a “stage gate”: it is important that all group members have contributed to completing individual analysis of a different design option by this point in the exercise, so the group is in a position to evaluate options and complete the main group coursework submission in W8.

Details about each element are given in Section 5.1 and Section 5.2 below.

5.1 Stage gate: individual technical design file

The individual technical design file should present the analysis and choices you have made in iteratively developing your individual design scheme. The design file should include:

- **Initial loading analysis**
  - Sketch/diagrams showing your chosen arrangement of transmission and bearing components
  - Free-body diagrams of the shaft itself, with explanation of any assumptions made to calculate the loading.
  - Bending moment diagrams and torque diagrams, showing the distribution of loading within the shaft.
  - Data/calculations for the chain drive transmission between the motor and the shaft to show it is suitable for the loading.
- **Spreadsheet showing iterations of shaft geometry and components**

- Include one sheet per iteration. On each sheet, explain briefly what has changed since the previous iteration, including a diagram/sketch of the shaft geometry where appropriate.
  - Each sheet should analyse stresses at key nodes along the shaft, clearly showing stresses and failure conditions.
  - Include a further sheet(s) presenting calculations and data for the bearings and other components to demonstrate their suitability for the loading and geometry.

- **Material selection**
  - A brief description of the materials selection approach taken throughout the design process.
  - An overview of objectives and constraints, and suggested merit index based on these.
  - Appropriate use of merit index with additional constraints, Ashby charts and Granta Edupack to identify some candidate materials for the final iteration.

- **Manufacturing analysis of final iteration**
  - A brief description of the proposed steps involved in manufacturing your design for the shaft.
  - Calculations for the Material Removal Rate, the total machining time (T_m), the power required (P_m), the total machining energy, the maximum cutting force (F_c) and the maximum resultant force on the tool.
  - Calculation of cost of machining for each shaft based on the assumptions in the brief.

The term "technical design file" is used to emphasise that this is **not** be a wordy report, but should consist mostly of figures, diagrams, spreadsheets and key technical details. You should however use headings and subheadings within documents, and comments/text/formatting within spreadsheets, as needed to make it easy to navigate. Include concise descriptions and explanations as needed to make sure that it is clear what you are presenting, and to explain why you made the choices you did.

In your group, you will use each team member's individual technical design file to compare the different candidate designs. Your design files will form appendices to your final group submission. A clear and complete file at this stage will make it easy for your group to arrive at a final design and easy to present your evidence in your main group submission for your choices.

5.2 Group submission: design report & drawings

You will hand in 4 elements as part of the same group submission, via Moodle. They should be submitted as separate files with the names and formats below (filling in *XXX* with your group number).

Group submission element	Filename	File format
Technical design report	SD*XXX*-report.pdf	PDF
Appendices (individual technical design files)	SD*XXX*-appendix-*NAME.xxx*	PDF / XLSX
Component drawing of shaft	SD*XXX*-drawing-shaft.pdf	PDF
Sub-assembly drawing	SD*XXX*-drawing-assembly.pdf	PDF

5.2.1 Technical design report

Your technical design report is the main place that you explain your design process, analysis and outcomes: the purpose is to use the evidence you have collected to reach a final design, and document it clearly. It should contain copies of diagrams, analysis and results from your individual technical design files, as needed to help explain, or summarised versions of them, but it should not contain all the details: treat the individual design files as appendices where you can direct the reader to find details if needed.

5.2.1.1 Report structure

Your report should contain the following sections:

- **Brief introduction**:
  - Summarise briefly your understanding of the design requirements and objectives, and what you will show in this report.
- **Design options**
  - Give the context: what design options did your group decide to focus on, and why? What are the key *differences* between options? Conversely, what is the *same* between options (and why did you decide it was less important to consider different options for these aspects)?
  - Explain what your design options are like; use diagrams to illustrate and tables to summarise as appropriate (e.g. sketches of transmission arrangement, different approaches to material choice etc).
  - Show the solutions for each option (summarise the iterative changes made in each case, and show using diagram(s)/tables what the final design looked like and what components were finally used)
- **Material selection** (this section marked by Dr Roscow):

- Overview of the materials selection approach used throughout the design process with an explanation of relevant merit index/indices used. Objectives, constraints and free variables should be correctly identified.
- Relevant Ashby Charts demonstrating how merit indices have been used at different stages of the design process to aid with initial screening and ranking of candidate materials.
- Additional constraints should be added based on other design considerations (loading analysis, geometry, manufacturing, working environment, expected lifetime) and supported by relevant calculations.
- A single material should be identified that satisfies the design requirements. This selection should be justified with the aid of merit index calculations and unstructured information available through Granta Edupack.

- **Manufacturing considerations** (this section marked by Dr Loukaides):
  - Summarise the individual manufacturing analysis results for each design option, and compare the outcomes.
  - How does the machining cost depend on the required surface quality? Produce a suitable plot to describe this.
  - What additional costs would you consider in practice?
  - How would you use transformative processes to improve manufacturing of the subassembly? Identify two relevant transformative manufacturing processes and explain the benefits and constraints they would introduce (in under 200 words).

- **Evaluation of design options, and final design**:
  - Compare and discuss the solutions – using the evidence from your appendices and previous sections – in relation to the design requirements.
  - Based on this, propose a final design.

- **Appendices**:
  - Include a copy of the individual technical design file for each design option as an appendix
  - No need to embed this within the main report, separate files uploaded to Moodle for appendices are fine.

Your report must meet the following requirements and advice:

- Maximum 2500 words of content. Words in the title, summary, table of contents, references, captions and appendices do not count towards this total. You must indicate the word count on the title page.

- Include a summary (approx 100-200 words) before the start of the main report. The point of the summary is to summarise (!) briefly the whole report. It should include 1-2 sentences for each part of the report. It is different from the introduction: the summary needs to give spoilers for the whole report including what you did and what the conclusions are, whereas the introduction is just setting the scene and structure at the beginning.

- Apply the standards of good report writing: make sure figures and text are well formatted and easy to read; use structure and headings to help guide your reader through the report; caption figures/tables and refer to them in the text; write as simply and briefly as possible while still getting across your message; reference your sources of information and figures.
- You do **not** need to reproduce details of the analysis and component selection steps which you have already included in your individual technical design files / appendices. The report should include the *results* of your analysis (to support your evaluation and explanation as you compare the options and propose a final design), but if the reader wants to verify how you arrived at these results, they can refer to your appendices.

See Appendix B for further advice on what to include in the technical report.

5.2.2 Technical drawings

Two drawings are required to show your final design:

- A completely dimensioned single part (component) drawing of the shaft; and
- An assembly drawing, with Parts List, of the final design arrangement.

See Appendix A for further advice on what to include in technical drawings.

5.2.3 Group submission assessment criteria

The marking criteria are given in a separate document on Moodle.

5.3 Use of GenAI

This coursework is a “Type B” assessment: the use of GenAI is allowed for specific purposes, and is optional (you are not required to use it).

You may use it for:

- Generating ideas for design options (but make sure they are valid for this problem)
- Helping you to perform calculations (but make sure they are correct)
- Producing diagrams and images (but make sure they are clear, correct, and relevant)
- Summarising information
- Editing and rewriting text

When using GenAI, you must:

- Check any calculations yourself, and show how you have done this (using test cases, known solutions, etc)
- Ensure that material generated by AI is sufficiently specific to your particular case. It is easy to use AI to generate plausible but vague discussion; this design coursework should be specific and relate directly to the details of *your* design.
- Acknowledge and reference material produced by GenAI, as described below.

You may *not* use GenAI in this assignment to:

- Perform calculations without showing how you know they are correct
- Generate designs, results, calculations, choices, decisions or conclusions where you cannot explain how they came about and why they are there.

In other words, you may use GenAI to *help you* in the design process, but not to avoid going through and taking responsibility for any step of the process.

5.3.1 Appropriate GenAI tools and platforms

The University's supported GenAI tool is Microsoft CoPilot (formerly Bing Chat). When using CoPilot ensure you are logged in using your Bath email address as this safeguards your user data.

When using GenAI, you must not upload information to the platform which may contain private data (e.g. information provided to you by a company) or upload any of your tutor's work unless expressly permitted.

To ensure equity between students, you must only use GenAI platforms and tools for your assessment that are freely available.

5.3.2 Acknowledging and referencing GenAI

You must ensure that you acknowledge and reference your use of GenAI appropriately. For more information about the University's approach to the use of GenAI, and advice on acknowledging your use of it, see the Library website.

References

A Advice on technical drawings

Engineering drawings are, in most cases, the definitive outcome of any design project. They can show how the design problem has been solved, how something will work, and how it is assembled and operated. They should clearly contain all information need for a technician to obtain the materials for your design, manufacture the custom shaft, and assemble it together with the other components you have selected.

Here are some notes on preparing technical drawings. Remember also to refer back to what you learned last year, and make use of studio sessions to get feedback on draft drawings.

Drawings should be at a suitable scale and paper size; given the amount of detail to get across here, this is likely to be A2. They must be created on CAD. Do annotate the drawings and use scrap views.

A.1 Sub-assembly drawings

- Assembly drawings must be complete and accurate.
- Orthogonal projections (third angle) are always required. These must show sufficient details of bearings, locations, mountings, etc. to inform the reader on the assembly arrangements. In some cases, an isometric view can be useful to illustrate the complete assembly in three dimensions.
- Drawing scales should always be clearly stated, and follow the normal conventions described in BS 8888.
- A complete Parts List is essential. Where parts from suppliers are used, the manufacturer and part codes must be specified correctly.
- Use explanatory notes, local detail views, and section views to explain the assembly. Notes should be concise and precise: the drawings are the primary means of design communication, and notes are only to be used to support the explanation of the design.
- Don't forget that sections (general and local) are incredibly powerful at showing what is going on.

A.2 Detail part drawings

- Detail drawings must show all dimensions, tolerances, surface finishes, and any other information related to the manufacture of that part. This level of detail is essential, since this drawing would normally be the only source of information for a technician to make the part in a workshop.
- Details such as keyways probably need at least two views.
- Explanatory notes and local details/sections are useful to explain key features.
- Think about how you choose to dimension features, so that dimensions relate to how the feature would be made, and/or show the relationships which are actually important.

B Advice on the technical report

This section gives further advice on writing the group technical report described in Section 5.2.1.

B.1 Advice on discussing design options

A design may succeed in not failing, while still not being a "good" design. For example, an extremely heavy shaft would be unlikely to fail under load, but would not be a "good" design from the point of view of cost, embodied carbon, ease of installation, etc. To show that your design is a "good" design you will want to show how you have iterated your design and considered a range of possible solutions, with your final design representing a reasonable trade-off between the options you have considered.

The point of this report is therefore to give your client insight into the advantages and disadvantages of different design options. By doing this, you should convince them that you have tried to produce a "good" design by considering different options, not just jumping to the first thing that seemed to work.

Make reference to the design requirements, and be *specific* when discussing design options! You should have plenty of specific analysis and results from your individual technical design files – use them.

B.2 Advice on discussing manufacturing

As with Design, Manufacturing choices rarely have one correct answer. Most often Production Engineers are trying to balance conflicting constraints. Your responses should primarily be used to demonstrate you understand the constraints and how your choices affect the final product and the business of producing it.

Some of the questions in the brief are specific and quantitative, but others are open-ended and acceptable answers can differ significantly between groups. In the absence of specific data students should make and state their own assumptions.