T-LEVELS | Institute for Apprenticeships & Technical Education

T Level Technical Qualification in Science

Employer-set project (ESP)

Metrology Sciences

Project brief

v1.2: Specimen assessment materials
20 November 2023
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NCFE CACHE

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Contents

Guidance for students

Student instructions

- read the project brief and the task guidance carefully before starting your work
- you must work independently and make your own decisions on how to approach the tasks within the employer-set project (ESP). Ideally your work should:
  - be in an Arial font 12pt, within standard border sizes, however you may choose to hand write your work. If you choose to hand write your work, this should be in black ink
  - clearly show where sources have been used to support your own ideas and opinions
  - clearly reference all sources used to support your own ideas and opinions
  - reference any quotations from websites
- you must clearly name and date all of the work that you produce during each supervised session
- you must hand over all of your work to your tutor at the end of each supervised session
- you must not work on the assessment in between supervised sessions

Student information

This employer-set project will assess your knowledge, understanding and skills from across the core content of the qualification.

In order to achieve a grade for the core component, you must attempt both of the external examinations and the ESP. The combined marks from these assessments will be aggregated to form the overall core component grade (A* to E and U). If you do not attempt one of the assessments or fail to reach the minimum standard across all assessments, you will receive a U grade.

Your tutor will explain how the assessment time is broken down per task and will confirm with you if individual tasks need to be completed across multiple sessions.

At the end of each supervised session, your tutor will collect all ESP assessment materials before you leave the room. You must not take any assessment material outside of the room (such as via a physical memory device). You must not upload any work produced to any platform that will allow you to access materials outside of the supervised sessions (including email).

You can fail to achieve marks if you do not fully meet the requirements of the task, or equally if you are not able to efficiently meet the requirements of the task.

Plagiarism

Plagiarism may result in the external assessment task being awarded a U grade. For further guidance, refer to your student handbook - plagiarism in external assessment and the maladministration and malpractice policy located at www.qualhub.co.uk.

Presentation of work

- any work not produced electronically must be agreed with your tutor, the evidence you produce should be scanned and submitted as an electronic piece of evidence
- all your work should be clearly labelled with the relevant task number and your student details and be legible (for example front page and headers)
- electronic files should be given a clear file name for identification purposes (see tasks for any relevant naming conventions)
- all pages of your work should be numbered in the format 'Page X of Y', where X is the page number and Y is the total number of pages
- you must complete and sign the external assessment cover sheet (EACS) and include it at the front of your assessment task evidence
- you must submit your evidence to the tutor at the end of each session

Introduction

Which metrology system will you choose?

There is a range of inexpensive, hand-held measuring devices available that are all relatively simple in use, that can be used to investigate the size of objects. Callipers, micrometers and height gauges are a few examples. However, metrology has evolved rapidly in the last decade, the technology has developed, and we can now produce smaller and more precise components than ever before. The question is, has the technology used to measure and quality check these components kept up?

3D scanning was introduced to the world in the 1960's and companies are now starting to transition away from these simple handheld devices onto the use of 3D systems for more complex processes due to their increased accuracy for complex parts and shapes.

All of this, however, comes with an added cost, and does the higher cost always mean higher accuracy and more time saving as advertised, or does mechanical metrology still have a place in the 21st century?

Your brief

Bearing shaft and housing/hole fit

There are 2 parts shown in the technical drawing provided. The bearing shaft, and the bearing hole, sometimes called the housing. The shaft is inserted into the house to allow movement, while reducing friction between moving parts.

A suitable shaft and housing fit are essential to provide sufficient movement in a desired area. It is important for the fit to be tight, as a loose fit means that bearings can begin to creep or move, which is an unintended movement, which can cause damage to the part, as well as reduce functionality. When a fit is too tight, the bearing will have a loss in efficiency, as well as other problems.

It is therefore important to measure the intricate parts of the bearing shaft and housing as accurately as possible for the bearing to function effectively and have the correct amount of movement.

You are required to research the best methods and equipment that could be used to measure these parts based on criteria such as:

- accuracy
- precision
- accessibility
- measurement strategy
- uncertainty
- interpretation of results
- temperature
- time
- cost

You must complete the following steps:

- researching
- producing a plan for investigation

- analysing and evaluating the effectiveness of the investigation
- reporting on your findings
- reflecting on the process

Complete the tasks below to guide you through these steps.

Task 1: literature review

What you have to do

You have been provided with a database containing a range of potentially relevant sources for your research. All the sources are linked to the brief and all outline different equipment and methods available to measure components. Some sources will be more relevant or reliable than others.

Carry out a literature review:

- justify why you have chosen specific sources and rejected others
- your justification should be based on:
    - how reliable you think the source is and why
    - how relevant you think the source is and why

Use an academic referencing technique when citing or referencing literature and state which system you have used at the start of the report.

Add any notes about your work in your project diary. These notes will not be marked. They are to help you to complete task 6 which is a reflective evaluation.

Resources

- NCFE CACHE database
- project diary

Assessment objectives

AO2: Apply core knowledge and skills to the development of a scientific project (18 marks)

AO4: Use English, mathematics, and digital skills as appropriate (4 marks)

Core skills

CS2: Researching

The evidence you have to submit for this task

A literature review, as described in ‘What you have to do’ above.

How the evidence will be assessed

This will be externally marked by examiners.

Time for completion of task 1

3 hours plus 30 minutes for completion of project diary.

Task 2: producing a project plan

What you have to do

Develop a project plan to measure each key feature in the technical drawing, using the sources selected in your literature review. You must use 2 different methods for each feature in order to later compare the methods selected, in order to determine the most suitable method.

The plan must:

- set out your strategies to measure all key features of the component shown in the technical drawing
- include all appropriate risk assessments to ensure the safety of yourself and others who you are working with
- identify the measurement data you need to collect in order to test your strategy
- describe how you will collect this data

Add any notes about your work in your project diary. These notes will not be marked. They are to help you to complete task 6 which is a reflective evaluation.

Resources

- NCFE CACHE database
- literature review (from task 1)
- project diary

Assessment objectives

AO1: Plan your approach to meeting the project brief (12 marks)

AO2: Apply core knowledge and skills to the development of a scientific project (12 marks)

AO4: Use English, mathematics, and digital skills as appropriate (4 marks)

AO5: Realise a project outcome and review how well the outcome meets the brief (8 marks)

Core skills

CS1: Project management

CS2: Researching

CS3: Working with others

CS4: Creativity, innovation

CS6: Communication (written)

The evidence you have to submit for this task

Your project plan.

How the evidence will be assessed

This will be externally marked by examiners.

Time allowed for completion of task 2

3 hours plus 30 minutes for completion of project diary.

Task 3: analysis of data

What you have to do

Due to the limitations of time and resources, you are not required to carry out the investigation you have planned.

Therefore, you have been provided with a raw data pack, obtained from an organisation which developed and carried out a similar plan to solve the same problem. The raw data pack is in the form of a laboratory information management system (LIMs) spreadsheet.

You must:

- analyse the data provided to measure the effectiveness of the organisation's plan
- produce a report of your analysis, to include:
    - presentation of data to enable peer review
    - selection of appropriate statistical techniques
    - application of appropriate statistical techniques
    - justification for your conclusions

Add any notes about your work in your project diary. These notes will not be marked. They are to help you to complete task 6 which is a reflective evaluation.

Resources

- written project plan
- NCFE CACHE LIMs spreadsheet
- project diary

Assessment objectives

AO2: Apply core knowledge and skills to the development of a scientific project (16 marks)

AO3: Select relevant techniques and resources to meet the brief (6 marks)

AO4: Use English, mathematics, and digital skills as appropriate (6 marks)

AO5: Realise a project outcome and review how well the outcome meets the brief (6 marks)

Core skills

CS4: Creativity, innovation

CS5: Problem solving

CS6: Communication (written)

CS7: Reflective evaluation

The evidence you have to submit for this task

Your analysis report including any charts and graphs.

How the evidence will be assessed

This will be externally marked by examiners.

Time allowed for completion of task 3

3 hours plus 30 minutes for completion of project diary.

Task 4: present outcomes and conclusions

What you have to do

(a) Use your report from task 3 to produce an A2 scientific poster.

Your poster must show:

- the issue being addressed/investigated
- a brief summary of the 2 strategies compared
- the results of your analysis, including any graphs and charts
- your conclusions

(b) Present the main points from your poster to your tutor. Your tutor will make observations on your presentation and ask questions if further detail is needed. The presentation will be recorded on video.

Add any notes about your work in your project diary. These notes will not be marked. They are to help you to complete task 6 which is a reflective evaluation.

Resources

- your written project plan
- your analysis report
- A2 paper, various coloured markers, scissors, and glue
- IT software/applications to create poster (or parts of) for printing, and printing facilities
- project diary

Assessment objectives

AO2: Apply core knowledge and skills to the development of a scientific project (12 marks)

AO3: Select relevant techniques and resources to meet the brief (6 marks)

AO4: Use English, mathematics, and digital skills as appropriate (4 marks)

AO5: Realise a project outcome and review how well the outcome meets the brief (6 marks)

Core skills

CS4: Creativity, innovation

CS6: Communication (written and verbal)

CS7: Reflective evaluation

The evidence you have to submit for this task

Your scientific poster.

Video recording of presentation.

How the evidence will be assessed

This will be externally marked by examiners using the video recording and the assessor commentary.

Time allowed for completion of task 4

4(a) 3 hours plus 30 minutes for completion of project diary

4(b) 1 hour

Task 5: group discussion

What you have to do

You have been provided with an email for your customer, querying the method you used to measure the parts they have provided.

In your allocated group, discuss the concerns the customer has raised and how it would be best to respond to these concerns. You will need to refer back to your research notes to contribute effectively to the discussion. Take notes during the team discussion of the points and suggestions made.

It is suggested 10 minutes are given over to this at the start of the discussion.

Each group member will then take it in turns to make suggestions and to agree an approach. It is suggested that groups consist of 5 to 10 individuals to allow sufficient time for discussion in 40 minutes.

Take notes during the team discussion of the points and suggestions made.

Following the discussion, students will need to (individually) draft an email to the consumer group to respond to the concerns raised (max 10 minutes).

There is an overall time limit of 1 hour for this task. In this time, students will:

- be asked to read the email from the consumer group in their groups
- be given 10 minutes to familiarise themselves with their literature review, their plan, their data analysis and scientific poster.
- discuss their suggestions for responding to the consumer group
- draft an email to the consumer group to respond to the concerns raised

Note: The group discussion and email you produce will be externally assessed by NCFE.

Student resources required

- your literature review (task 1)
- the experience of developing your project plan (task 2)
- your data analysis and report (task 3)
- your A2 scientific poster and its presentation (task 4)

Tutor resources required

Assessment sheet for tutor commentary.

Video recording equipment.

Assessment objectives

AO2: Apply core knowledge and skills to the development of a scientific project (4 marks)

AO3: Select relevant techniques and resources to meet the brief (2 marks)

AO5: Realise a project outcome and review how well the outcome meets the brief (3 marks)

Core skills

CS3: Working with others

CS5: Problem solving

CS6: Communication (verbal)

The evidence you have to submit for this task

Your recorded discussion.

Your email response to the customer.

How the evidence will be assessed

This will be externally marked by examiners.

Time allowed for completion of task 5

1 hour.

Task 6: reflective evaluation

What you have to do

Write a reflective evaluation of your work. This should be based on:

- your literature review (task 1)
- the experience of developing your project plan (task 2)
- your data analysis and report (task 3)
- your A2 scientific poster and its presentation (task 4)

Your reflections should include:

- an evaluation of your approach to each task, including your chosen tool for analysis
- any changes you would make to your approach to each task

Resources

- your project diary
- your literature review
- your project plan
- your analysis report
- your A2 scientific poster
- reflective evaluation template

Assessment objectives

AO2: Apply core knowledge and to the development of a scientific project (7 marks)

AO3: Select relevant techniques and resources to meet the brief (2 marks)

AO4: Use English, mathematics, and digital skills as appropriate (4 marks)

AO5: Realise a project outcome and review how well the outcome meets the brief (5 marks)

Core skills

CS6: Communication (written)

CS7: Reflective evaluation

The evidence you have to submit for this task

Your written reflective evaluation.

How the evidence will be assessed

This will be externally marked by examiners.

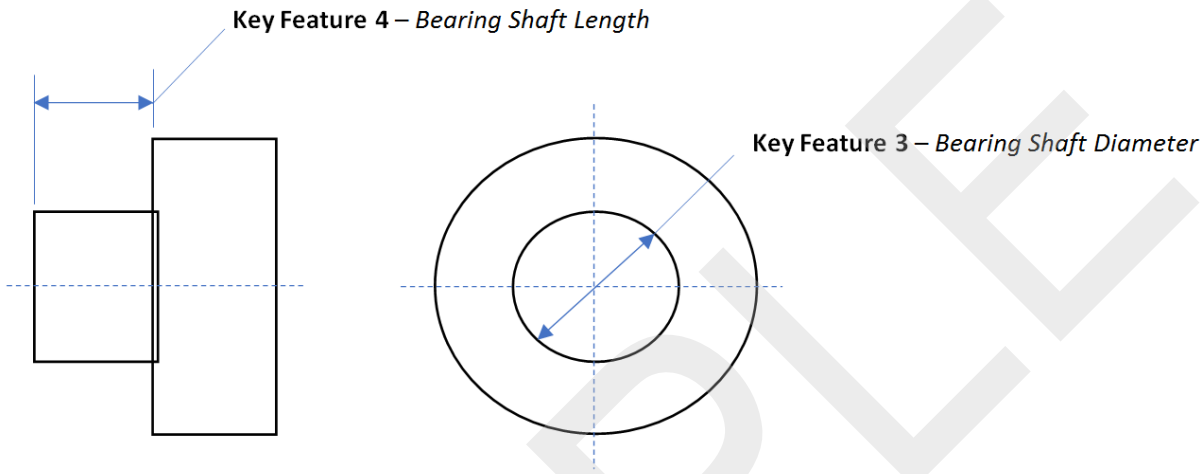
Time allowed for completion of task 6

2 hours.

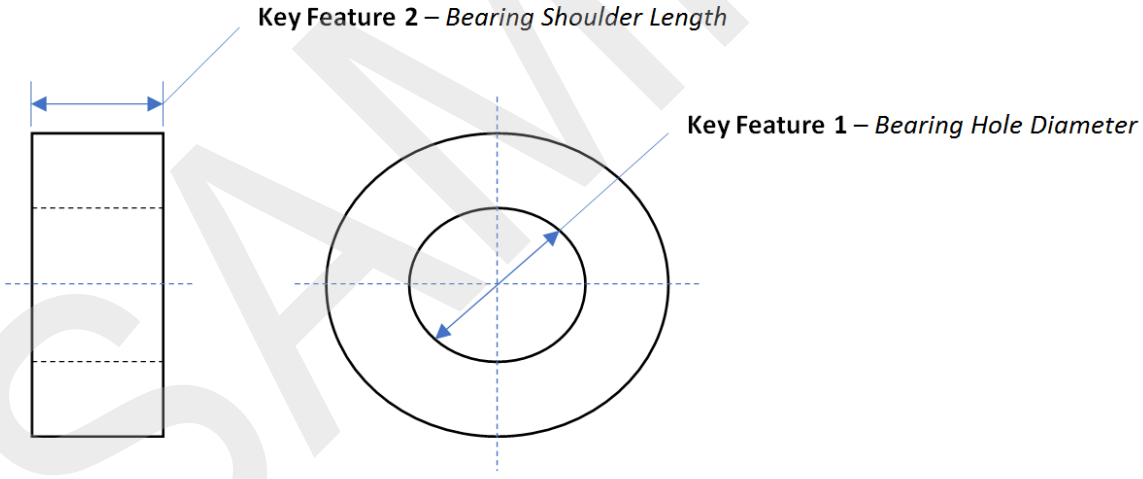
Appendix 1: technical drawing

The shaft (part 1) is designed to fit into the bearing hole (part 2) so that it has a clearance fit when key features 3 and 4 are manufactured to the tolerances. In addition, the tolerances for key features 2 and 4 must allow the shaft to float within the bearing in order to maintain even wear on both parts.

Part 1: shaft



Part 2: bearing



Key feature number	Feature type	Feature size and tolerance
1	Hole diameter	18 mm to 18.018 mm
2	Length	13 mm +/- 0.3 mm
3	Shaft diameter	17.980 mm to 17.993 mm
4	Length	13 mm +/- 0.3 mm

Appendix 2: literature list

National Physical Laboratory Good Practice Guide No. 40 – Callipers and micrometers

National Physical Laboratory Good Practice Guide No. 80 – Fundamental Good Practice in Dimensional Metrology

National Physical Laboratory Good Practice Guide No. 118 – A Beginner's Guide to Measurement

https://www.npl.co.uk/resources/gpgs/all-gpgs

Mitutoyo Quick Guide to Precision Measuring Instruments

www.bowersgroup.co.uk/bore-gauging?gclid=Cj0KCQjwy8f6BRC7ARIsAPIXOjiZwoSREXoVRq1D9uNM_v08wG8iHSOuvpjdVcWrCpBIbMI9u9kHeV0aAnrwEALw_wcB

www.tesatechnology.com/en-us/home/

www.thearchitectsguide.com/blog/best-laser-measuring-tools

www.thedrive.com/reviews/29267/best-laser-measuring-tools

Gosavi, A. and Cudney, E., (2012). Form errors in precision metrology: a survey of measurement techniques. **Quality Engineering**, **24**(3), pp.369-380.

Ritter, M., Hemmleb, M., Sinram, O., Albertz, J. and Hohenberg, H., (2004), July. A versatile 3D calibration object for various micro-range measurement methods. In **Proceedings XXth ISPRS Congress Istanbul** (Vol. 25, pp. 696-701).

www.qualitymag.com/articles/92738-metrology-methods-compared-on-1-identical-part

Liu, Z., Zhu, J., Yang, L., Liu, H., Wu, J. and Xue, B., (2013). A single-station multi-tasking 3D coordinate measurement method for large-scale metrology based on rotary-laser scanning. **Measurement Science and Technology**, **24**(10), p.105004.

Jones, C.W. and O'Connor, D., (2018). A hybrid 2D/3D inspection concept with smart routing optimisation for high throughput, high dynamic range and traceable critical dimension metrology. **Measurement Science and Technology**, **29**(7), p.074004.

www.cmmmagazine.com/metrology/mitutoyo%E2%80%99s-new-miscan-system-probes-the-smallest-detail/

www.cmmmagazine.com/metrology/large-area-3d-optical-metrology-system-s-wide/

www.metrology.news/ensuring-tools-and-molds-produce-perfect-parts-with-3d-scanning/

www.metrology.news/redefining-quality-control-with-ai-powered-visual-inspection/

www.aerotech.com/media/2954110/ca0916a-test-and-measurement-group-web.pdf

www.hunker.com/12276796/list-of-measuring-tools-for-length

www.technologyuk.net/science/measurement-and-units/measuring-length.shtml

www.metrology.news/cmm-ensures-inspection-equipment-precision/

Sadeghian, H., Van den Dool, T.C., Crowcombe, W.E., Herfst, R.W., Winters, J., Kramer, G.F.I.J. and Koster, N.B., (2014), April. Parallel, miniaturized scanning probe microscope for defect inspection and review. In **Metrology,**

Inspection, and Process Control for Microlithography XXVIII (Vol. 9050, p. 90501B). International Society for Optics and Photonics.

www.metrology.news/portable-metrology-continues-its-march-onto-the-manufacturing-floor/

Rolls Royce Guide to Dimensional Measurement Equipment – Version 3.3 November 2015

Rolls Royce Guide to Dimensional Measurement Equipment Capability Charts – Version 1.0 September 2015

Appendix 3: customer email

While we appreciate your experience within the industry and how you have kept up to date with new technologies in metrology, we do have some concerns about the accuracy of the methods you used during the inspection and we feel that some of the parts are not the dimensions as reported in the results.

We would therefore appreciate if you could review the methods used with your colleagues to see if there is a more accurate way of inspecting these parts to ensure that all of the parts are fit for purpose and let us know how you arrived at the decision you did. If you think there any other alternative methods available that might be more suitable, could you please recommend those for us to consider using in future.

Document information

The T Level Technical Qualification is a qualification approved and managed by the Institute for Apprenticeships and Technical Education.

Owner: Head of Assessment Design

Change History Record

Version	Description of change	Approval	Date of Issue
v1.0	Post approval, updated for publication.		January 2021
v1.1	NCFE rebrand.		September 2021
v1.2	Sample added as a watermark	November 2023	20 November 2023