T Level Technical Qualification in Science

Occupational specialism assessment (OSA)

Metrology Sciences

Assignment 3

Mark scheme

v1.2: Specimen assessment materials
September 2021
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Contents

Task 1

PO1, PO2 and PO3

Marking allocations	Marks
All 3 missing symbols have been correctly drawn. Must have all 3 symbols correct to be awarded 1 mark (0 marks for having 2 correct).	1
All 3 missing geometric characteristics have been correctly labelled. Must have all 3 symbols correct to be awarded 1 mark (0 marks for having 2 correct).	1
All 3 missing tolerance types have been correctly labelled. Must have all 3 symbols correct to be awarded 1 mark (0 marks for having 2 correct).	1
Length labelled as 0.50955 incorrectly (example 1). Must be corrected to 0.59055.	1
Length labelled as 0.50955 line has been drawn too far (example 1). Must be identified and redrawn correctly or error corrected in another suitable way.	1
Length labelled as 0.59055+0.003937 (example 1) has incorrect symbol. Must be corrected to ±.	1
Circle labelling is shown as 7x (example 1). Must be corrected to 8x.	1
Circle labelling showing O instead of the correct diameter symbol (example 1). Must be corrected with correct diameter symbol.	1
Upper left circle has been drawn with incorrect alignment (example 2). Must be drawn in correct position or error corrected in another suitable way.	1
Circle labelling has line missing (example 2). This must be drawn correctly.	1
Circle labelling has been rounded to 0.197 (example 2). This must be corrected to 0.19685.	1
Labelling B and C are inconsistent across the diagrams. Must be corrected so they are consistent.	1
Total marks	12

Diagram 1

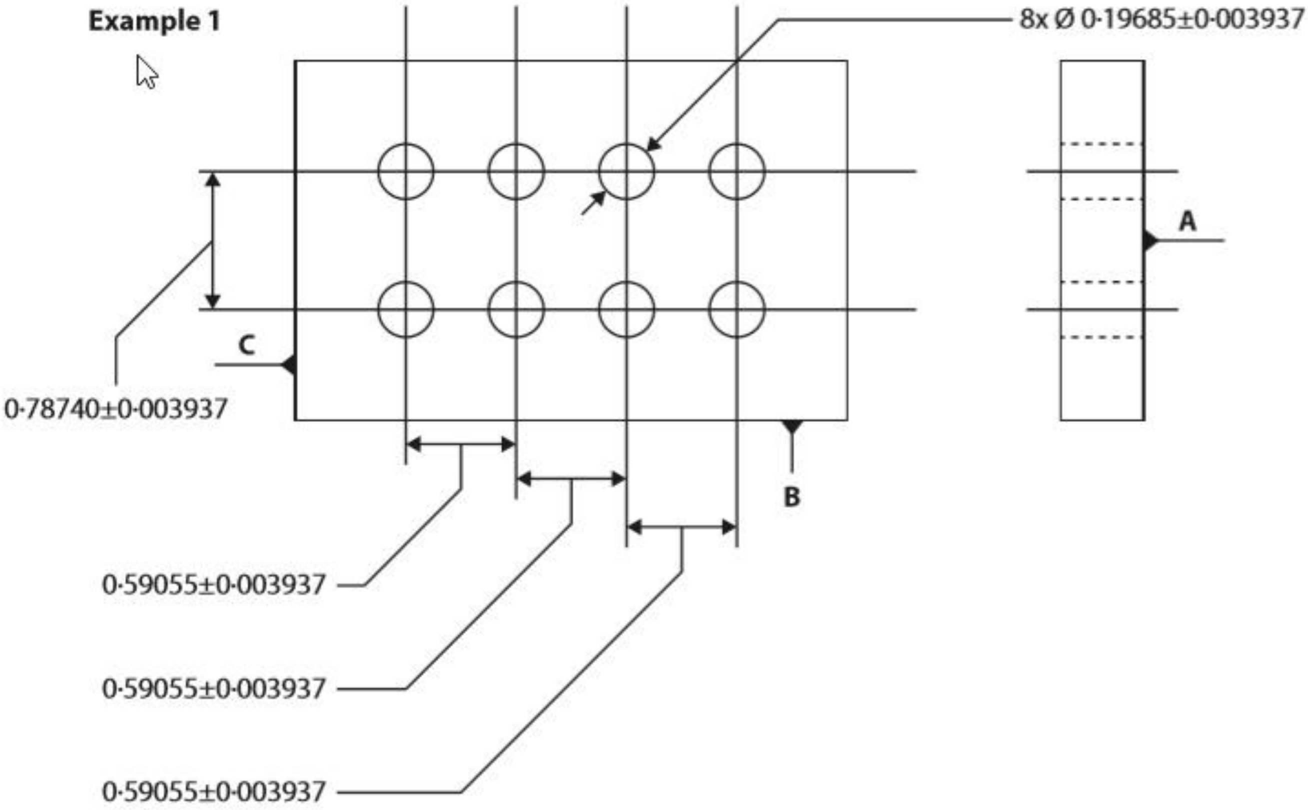
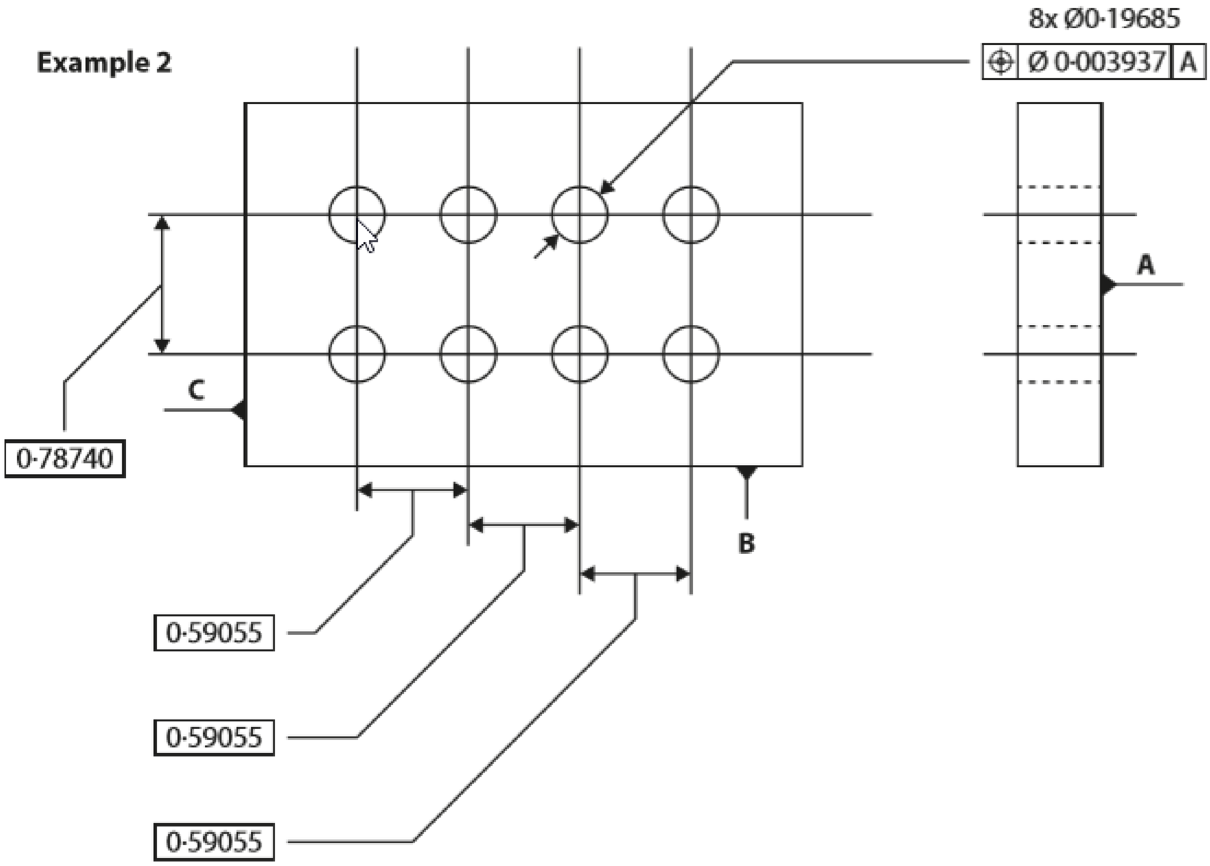

Example 1
8x Ø 0·19685±0·003937
A
C
B
0·78740±0·003937
0·59055±0·003937
0·59055±0·003937
0·59055±0·003937

Diagram 2



Content mapping:

K1.20: How to apply best practice principles in measurement

K1.26: The correct terminology for measurement in metrology

K1.27: The impact of using incorrect terminology when communicating about measurement

K1.29: The international system of units (SI)

K1.34: The most relevant sources to use to extract measurement requirements

K1.38: The role of scientific metrology, industrial metrology and legal metrology

K1.39: The roles of different organisations that support metrology practices

K1.40: How metrology can play a role in a range of industries

K1.41: The considerations to make when interpreting customer requirements

K1.47: Why it is important to remain up to date with developments in metrology

K3.4: How to review the measurement data obtained against measurement requirements

S1.51: Use the correct terminology for measurement in metrology

S1.52: Use different unit systems (SI and non-SI units) and be able to convert between units, using appropriate conversion factors or formulae

S1.56: Access and interpret information and documentation (for example, legislation, ISO and other standards, manuals, specification sheets) to extract measurement requirements to support the measurement task

S1.59: Interpret and review customer requirements from a customer brief and identify relevant factors

S1.60: Summarise key information relating to customer requirements

S3.10: Contribute to the production of reports and other measurement documentation

S3.11: Present data/results in the most appropriate format to meet customer requirements (for example, production of reports and other measurement documentation)

Task 2

PO1, PO2 and PO3

Feature	Marks
Correct characteristic designator for each key feature	1
Correct requirement for each key feature	1
Correct unit identified for each feature	1
Correct upper limit identified for each feature	1
Correct lower limit identified for each feature	1
Suitable equipment selected for each feature	1
Suitable preparation tasks identified for each feature	1
Suitable accuracy/uncertainty considered for each piece of equipment selected	1
Realistic and suitable estimation of preparation tasks for each feature	1
Realistic and suitable estimation of number of measurements for each feature to ensure accurate results	1
Realistic and suitable estimation of time required per measurement	1
Accurate calculation of total time per feature using estimation of preparation time and time per measurement calculation ONLY – estimation of preparation time + (estimated number of measurements x time per measurement)	1 mark for correctly multiplying the number of measurements x time per measurement 1 mark for adding the estimation of preparation time 1 mark for correct calculation **(maximum 3 marks)**
Total columns added up correctly (uncertainty consideration, estimation of prep time, estimation of number of measurements, time per measurement, and total time)	2 marks for adding up all 5 total columns accurately 1 mark only for adding up 4 columns accurately 0 marks for less than 4 columns added correctly **(maximum 2 marks)**
Time per part accurately calculated and rounded to nearest second (total time/100)	1 mark for accurate calculation 1 mark for accurate rounding **(maximum 2 marks)**

Feature	Marks
Total cost calculated accurately and rounded to nearest penny (calculated at £110 per hour)	1 mark for accurate calculation 1 mark for accurate rounding **(maximum 2 marks)**
Cost per part calculated accurately and rounded to nearest penny (total cost/100)	1 mark for accurate calculation 1 mark for accurate rounding **(maximum 2 marks)**
Total marks	22 marks

Notes are not awarded any additional marks, but additional information relating to specific marks may be evident in the notes section, and these should be used as evidence towards the relevant marks. For example, detailed preparation information may be evident in the notes section instead of being written in the table (possibly due to space available).

Content mapping:

K1.6: How the accuracy of measurements is related

K1.7: The concept and purpose of measurement uncertainty

K1.8: The different ways sources of uncertainty can be categorised

K1.9: The difference between repeatability and reproducibility of measurement results

K1.10: The concept of type A and type B evaluations of uncertainty

K1.11: The concept of random and systematic effects

K1.13: The role of measurement uncertainty in conformity assessment

K1.14: The concept of confidence level using k=1 (≈68%), k =2 (≈95%) and k =3 (≈99.7%)

K1.17: Techniques for gaining confidence in measurement

K1.20: How to apply best practice principles in measurement

K1.21: The purpose of an uncertainty budget

K1.22: The components of an uncertainty budget, used to calculate measurement uncertainty

K1.23: Factors that may influence the number of repeated measurements in a measurement task

K1.28: The sources which may be used to calculate maximum permissible error (MPE) of a system

K1.29: The International System of Units (SI)

K1.30: The tools and equipment (and software programs where applicable) and how these are used within the operating principles

K1.33: Why different sample preparation methods are required when preparing an item for measurement

K1.34: The most relevant sources to use to extract measurement requirements

K1.38: The role of scientific metrology, industrial metrology and legal metrology

K1.41: The considerations to make when interpreting customer requirements

K1.45: The importance of quality requirements within the workplace

K1.46: Why further professional development and undertaking continuing professional development (CPD) is important in metrology

K1.47: Why it is important to remain up to date with developments in metrology

K3.4: How to review the measurement data obtained against measurement requirements

S1.52: Use different unit systems (SI and non-SI units) and be able to convert between units, using appropriate conversion factors or formulae

S1.56: Access and interpret information and documentation (for example, legislation, ISO and other standards, manuals, specification sheets) to extract measurement requirements to support the measurement task

S1.59: Interpret and review customer requirements from a customer brief and identify relevant factors

S3.10: Contribute to the production of reports and other measurement documentation

Task 3

PO1, PO2, PO3 and PO4

Metrology measurement plan

Band	Mark	Descriptor
4	16–20	The student has provided a plan that: • evaluates all methods for measurement, inspection and recording • clearly explains processes used • gives relevant and well reasoned justifications throughout • identifies all major hazards with reference to technical and legal requirements • explains, in detail, realistic recommendations on how to mitigate all risks and environmental factors • classifies all equipment correctly • uses relevant industry standard terminology throughout **Note:** Please note that the uncertainty budget is marked separately, see the marking grid below this one.
3	11–15	The student has provided a plan that: • explains the processes used for measurement, inspection and recording • uses relevant and realistic reasoning throughout • identifies most major hazards with reference to technical and legal requirements • describes recommendations on how to mitigate key risks and environmental factors • classifies all equipment with some, but minimal, error • uses relevant industry standard terminology with some, but minimal, error
2	6–10	The student has provided a plan that: • describes most processes used for measurement, inspection and recording in some detail, but insufficient to reliably replicate • identifies some major hazards with reference to technical and legal requirements • identifies how to mitigate some risks and environmental factors • attempts to classify some equipment with some patterns of error • attempts to use relevant industry standard terminology with some patterns of error

Band	Mark	Descriptor
1	1–5	The student has provided a plan that: • identifies some processes used for measurement, inspection and recording, giving limited details • identifies some major hazards • lists some basic mitigation of some risks and environmental factors, although these may be based on common sense or general assertions rather than occupational knowledge in context • attempts to classify some equipment with consistent error • attempts to use relevant industry standard terminology with consistent error
0	0	No creditworthy material as described in bands 4 to 1.

PO1, PO2 and PO4

Uncertainty calculation within the plan

Band	Mark	Descriptor
3	7–9	The student has: • explained their consideration of uncertainty in measurement in detail, giving detailed reference to the equipment and the environment, for example, vibration, debris, dust, background light, temperature and humidity, type of workshop (metrology lab) • explained in detail realistic recommendations for mitigating possible uncertainty risks • demonstrated both type A and type B uncertainty in the uncertainty budget calculation and explained the outcome
2	4–6	The student has: • described their consideration of uncertainty in measurement, which is basic, but relevant to the equipment and the environment, for example, vibration, debris, dust, background light, temperature and humidity, type of workshop (metrology lab) • described some relevant suggestions for mitigating possible uncertainty risks • demonstrated both type A and type B uncertainty in the uncertainty budget calculation
1	1–3	The student has: • listed their considerations of uncertainty in measurement in limited detail which is somewhat relevant to some of the equipment and the environment, for example, vibration, debris, dust, background light, temperature and humidity, type of workshop (metrology lab) • attempted to identify suggestions to mitigate uncertainty risks, but these may be unrealistic or based on common sense/general assertions rather than occupational knowledge in context
0	0	No creditworthy material as described in bands 3 to 1.

Indicative content

- environmental factors like vibration, debris, dust, background light, temperature and humidity might affect measurement and need to be addressed
- any parts and measuring setup would need to soak after cleaning and deburring, so all specimens and equipment are at the same temperature
- general health and safety such as maintaining a clean dry floor and clear walkways to prevent slips, trips and falls should be discussed, as well as the working environment, should display screen equipment (DSE) be used
- specific safety considerations, such as the sharp nature of the parts and much of the equipment
- back lighting and excess heat or cold to be avoided
- students to show awareness of different pieces of equipment available for measurement and the strengths and limitations of their selection
- the student should decide how many times they sample a dimension to reduce uncertainty. Some features require far more than 2x sampling to determine taper and out of round faults – students need to be aware that some pieces of equipment do not meet specific uncertainty ratio for tight tolerances

- accurate drawing and geometric dimensioning and tolerance interpretation
- creation of a plan/working instruction for equipment and measurement
- uncertainty of equipment and budget calculations included (no measurement is complete without an uncertainty evaluation)
- reference to repeatability, calibration, tractability in measurement activity such as:
    - measurement repeatability
    - uncertainty and minimum number of measurements for each dimension for each item, for example, is it planned to take 1 linear measurement across the diameters, or 2, or several, or a proposal to record the min/max or both measurements
- to include sampling methods, number of samples, equipment used, how each piece of equipment is calibrated and how to overcome environmental factors – this must be completed for all features
- risks include, for example, using safe practices for handling of equipment, removing trip hazards, orderly setup of workstations
- the plan clearly explains the processes used, for example, without reference to other sources and can be used reliably to replicate the measurement
- use of comparisons as the basis for their justifications, for example, I have selected equipment X because it has a lower uncertainty than equipment Y

Content mapping

K1.1: The concept of measurement

K1.2: How metrology is defined

K1.4: The definition of measurement standards

K1.5: The use of measurement standards in the calibration of measuring equipment when planning scientific measurements

K1.6: How the accuracy of measurements is related

K1.7: The concept and purpose of measurement uncertainty

K1.8: How most sources of uncertainty can be categorised

K1.9: The difference between repeatability and reproducibility of measurement results

K1.10: The concept of type A and type B evaluations of uncertainty

K1.11: The concept of random and systematic effects

K1.13: The role of measurement uncertainty in conformity assessment

K1.14: The concept of confidence level using k=1 (≈68%), k=2 (≈95%) and k=3 (≈99.7%)

K1.15: How an unbroken chain of comparisons, directly related to SI units, ensures confidence in results

K1.16: The links within a traceability chain

K1.17: Techniques for gaining confidence in measurement

K1.18: The purpose of measurement instruments

K1.19: The differences between automated and manual measuring instruments

K1.20: How to apply best practice principles in measurement

K1.21: The purpose of an uncertainty budget

K1.22: The components of an uncertainty budget, used to calculate measurement uncertainty

K1.23: Factors that may influence the number of repeated measurements in a measurement task

K1.24: Factors that may influence the sampling strategy

K1.25: The difference between validation and verification of scientific measurement equipment

K1.26: The correct terminology for measurement in metrology

K1.27: The impact of using incorrect terminology when communicating about a measurement

K1.28: The sources which may be used to calculate maximum permissible error (MPE) of a system

K1.30: The tools and equipment (and software programs where applicable) used within the operating principles

K1.31: The considerations when deciding on the most appropriate equipment and tools to be used

K1.32: The advantages and limitations of different commercially available equipment and instrumentation used within the operating principles

K1.33: Why different sample preparation methods are required when preparing an item for measurement

K1.35: The purpose of planning a task in metrology

K1.36: How environmental conditions such as temperature, vibration, humidity and lighting can affect both the measuring equipment and the item to be measured, and hence the data collected

K1.37: General approaches to dealing with environmental conditions

K1.39: The roles of different organisations that support metrology practices

K1.42: How to mitigate risk, using control measures

K1.43: The hierarchy of written standards and their application in a metrology environment

K1.44: The importance of following SOPs when carrying out measurement tasks

K1.45: The importance of quality requirements within the workplace

K1.46: Why further professional development and undertaking continuing professional development (CPD) is important in metrology

K2.1: The purpose of validation or verification techniques for measuring equipment

K2.2: The purpose of calibrating and testing metrology equipment

K2.3: How to check the current calibration

K2.4: Why it is important to follow the correct escalation route if an instrument’s calibration status is not identifiable, or if the instrument is clearly out of calibration

K3.1: The stages of processing raw data

K3.3: Why the following are used to interrogate and critically analyse measurement data

K3.4: How to review the measurement data obtained against measurement requirements

K4.1: How to recognise when measuring equipment is operating incorrectly

K4.3: The considerations to make when measuring equipment is in need of repair

S1.48: Make informed decisions about the needs of the measurement task

S1.49: Determine the design of the measurement plan

S1.50: Read a simple uncertainty budget for a measurement task and use it

S1.51: Use the correct terminology for measurement

S1.53: Select appropriate tools/equipment/instrumentation (with any associated software) when planning for a specific measurement task

S1.54: Provide reasoned decisions for the selection of equipment and instrumentation when planning for a specific measurement task

S1.55: Plan any specific preparation methods needed on the item to be measured

S1.57: Create a measurement plan

S1.58: Plan and record how to deal with potential environmental conditions

S1.63: Identify relevant regulatory procedures and standards required for the measurement task

S1.64: Document in the measurement plan the ISO standards and the specific quality requirements needed for the measurement task

S3.7: Assess repeatability and reproducibility of measurements to determine any variation within the data and establish a degree of confidence

S3.11: Present data/results in the most appropriate format to meet customer requirements (for example, production of reports and other measurement documentation)

S4.5: Discuss measurement results and issues with peers to determine when issues need to be escalated

Performance outcome grid

Task	PO1	PO2	PO3	PO4	Total
1	4	2	6	0	12
2	14	2	6	0	22
3	10	4	5	10	29
Total marks	28	8	17	10	63
% weighting	44.4%	12.7%	27.0%	15.9%	100%

Document information

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	Post approval amendments (Institute reference: ODSR_S_015 - ODSR_S_018)		February 2021
v1.2	NCFE rebrand.		September 2021