

SQA Advanced Unit Specification

General information for centres

Unit title: Measurement Systems 1

Unit code: HV67 47

Unit purpose: This Unit is designed to enable candidates to gain knowledge and understanding of a range of pressure, level, temperature and flow measurement systems. The Unit will also allow the candidate to develop knowledge and skills in calibrating a measurement system.

On completion of the Unit candidates should be able to:

- 1 Explain the performance parameters of measurement systems.
- 2 Explain the principle of operation of pressure measurement systems.
- 3 Explain the principle of operation of level measurement systems.
- 4 Explain the principle of operation of temperature measurement systems.
- 5 Explain the principle of operation of flow measurement systems.
- 6 Calibrate a measurement system.

Credit points and level: 2 SQA Credits at SCQF level 7: (16 SCQF credit points at SCQF level 7*).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates.*

Recommended prior knowledge and skills: Access to this Unit will be at the discretion of the centre and the following recommendations are for guidance only. Candidates should have a basic knowledge of process measurement and control engineering. This may be evidenced by the possession of Higher Process Measurement or Higher Process Control or NQ units in Measurement and Control or NC Measurement and Control or NC Multidisciplinary Engineering.

Core Skills: There are opportunities to develop the Core Skills of Written Communication (Writing), Written Communication (Reading), Using Graphical Information, Problem Solving (Critical Thinking) and Working with Others at SCQF level 5 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

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Assessment: The assessment for Outcome 1 in this Unit should be assessed by one assessment paper. This paper should be taken by candidates as one single assessment that should last one hour. The assessment paper should be composed of a suitable balance of short answer, restricted response questions. This assessment should be conducted under controlled, supervised conditions.

Outcomes 2, 3, 4 and 5 in this Unit should each be assessed by a separate assignment in which candidates are asked to explain the principle of operation of a range of measurement systems. The candidate's response to the assessments for Outcomes 2, 3 and 4 should be a minimum of 1,000 words per assignment with each assignment being completed in three hours. The candidate's response to the assessment for Outcome 5 should be a minimum of 1500 words and should be completed in four hours.

Outcome 6 in this Unit should be assessed by an assignment in which candidates are asked to calibrate a measurement system and produce a report on the calibration. Candidates should complete the assignment in four hours.

The assessments for Outcomes 1, 2, 3, 4 and 5 should be carried out at the end of the delivery of each Outcome. The assignment for Outcome 6 should be carried out at the end of the delivery of the Unit.

It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to pass the Unit.

Unit specification: statement of standards

Unit title: Measurement Systems 1

Unit code: HV67 47

The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Explain the performance parameters of measurement systems

Knowledge and/or skills

- ◆ Accuracy of a measurement system
- ◆ Sensitivity of a measurement system
- ◆ Resolution of a measurement system
- ◆ Hysteresis of a measurement system
- ◆ Response time of a measurement system
- ◆ Gain of a measurement system

Evidence Requirements

The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on the six knowledge and/or skills shown above.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each knowledge and/or skill by showing that the candidate is able to:-

- ◆ explain the accuracy of a measurement system
- ◆ explain the sensitivity of a measurement system
- ◆ explain the resolution of a measurement system
- ◆ explain the hysteresis of a measurement system
- ◆ explain the response time of a measurement system
- ◆ explain the gain of a measurement system

Evidence should be generated through assessment undertaken in controlled, supervised conditions.

Assessment guidelines

Assessment should be conducted under closed-book conditions and as such candidates must not be allowed to bring handouts, notes or textbooks to the assessment.

The assessment for Outcome 1 should be assessed by one question paper. This paper should be taken by candidates as one single assessment that should last one hour.

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Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

This assessment should be conducted under controlled, supervised conditions.

Outcome 2

Explain the principle of operation of pressure measurement systems

Knowledge and/or skills

- ◆ Principle of operation of a capacitance pressure sensor
- ◆ Principle of operation of a strain gauge pressure sensor
- ◆ Principle of operation of a resonant pressure sensor
- ◆ Principle of operation of a piezo-electric pressure sensor
- ◆ Principle of operation of a magnetic pressure sensor
- ◆ Principle of operation of an optical pressure sensor

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this Outcome four out of six knowledge and/or skills items should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of six knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:-

- ◆ explain, with the aid of a sketch, the principle of operation of a process pressure measurement system that includes a capacitance pressure sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process pressure measurement system that includes a strain gauge pressure sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process pressure measurement system that includes a resonant pressure sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process pressure measurement system that includes a piezo-electric pressure sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process pressure measurement system that includes a magnetic pressure sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process pressure measurement system that includes an optical pressure sensor

Evidence should be generated through an assignment undertaken in open book conditions.

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Assessment guidelines

The assessment of this Outcome should take the form of an assignment. The time allocation for the assignment is three hours (including class time). The candidate's response to the assignment should be a minimum of 1,000 words.

It is essential that centres ensure that evidence generated is the candidate's own work.

Outcome 3

Explain the principle of operation of level measurement systems

Knowledge and/or skills

- ◆ Principle of operation of a hydrostatic head level sensor
- ◆ Principle of operation of a displacer level sensor
- ◆ Principle of operation of a capacitance level sensor
- ◆ Principle of operation of an ultrasonic level sensor
- ◆ Principle of operation of a radar level sensor
- ◆ Principle of operation of an optical level sensor

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this Outcome four out of six knowledge and/or skills items should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of six knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ explain, with the aid of a sketch, the principle of operation of a process level measurement system that includes a hydrostatic head level sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process level measurement system that includes a displacer level sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process level measurement system that includes a capacitance level sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process level measurement system that includes an ultrasonic level sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process level measurement system that includes a radar level sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process level measurement system that includes an optical level sensor

Evidence should be generated through an assignment undertaken in open book conditions.

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Assessment guidelines

The assessment of this Outcome should take the form of an assignment. The time allocation for the assignment is three hours (including class time). The candidate's response to the assignment should be a minimum of 1,000 words.

It is essential that centres ensure that evidence generated is the candidate's own work.

Outcome 4

Explain the principle of operation of temperature measurement systems

Knowledge and/or skills

- ◆ Principle of operation of a thermocouple
- ◆ Principle of operation of a resistance thermometer
- ◆ Principle of operation of an infra-red thermometer
- ◆ Principle of operation of a pyrometer
- ◆ Principle of operation of a filled system thermometer
- ◆ Principle of operation of a thermistor

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this Outcome four out of six knowledge and/or skills items should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of six knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:-

- ◆ explain, with the aid of a sketch, the principle of operation of a process temperature measurement system that includes a thermocouple
- ◆ explain, with the aid of a sketch, the principle of operation of a process temperature measurement system that includes a resistance thermometer
- ◆ explain, with the aid of a sketch, the principle of operation of a process temperature measurement system that includes an infra-red thermometer
- ◆ explain, with the aid of a sketch, the principle of operation of a process temperature measurement system that includes a pyrometer
- ◆ explain, with the aid of a sketch, the principle of operation of a process temperature measurement system that includes a filled system thermometer
- ◆ explain, with the aid of a sketch, the principle of operation of a process temperature measurement system that includes a thermistor.

Evidence should be generated through an assignment undertaken in open book conditions.

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Assessment guidelines

The assessment of this Outcome should take the form of an assignment. The time allocation for the assignment is three hours (including class time). The candidate's response to the assignment should be a minimum of 1,000 words.

It is essential that centres ensure that evidence generated is the candidate's own work.

Outcome 5

Explain the principle of operation of flow measurement systems

Knowledge and/or skills

- ◆ Principle of operation of an ultrasonic flow meter
- ◆ Principle of operation of a turbine flow meter
- ◆ Principle of operation of a vortex flow meter
- ◆ Principle of operation of pitot tube
- ◆ Principle of operation of a differential pressure flow sensor
- ◆ Principle of operation of a Coriolis flow meter
- ◆ Principle of operation of a thermal mass flow meter
- ◆ Principle of operation of an electromagnetic flow meter

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this Outcome five out of eight knowledge and/or skills items should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of five out of eight knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all five items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ explain, with the aid of a sketch, the principle of operation of a process flow measurement system that includes an ultrasonic flow meter
- ◆ explain, with the aid of a sketch, the principle of operation of a process flow measurement system that includes a turbine flow meter
- ◆ explain, with the aid of a sketch, the principle of operation of a process flow measurement system that includes a vortex flow meter
- ◆ explain, with the aid of a sketch, the principle of operation of a process flow measurement system that includes a pitot tube
- ◆ explain, with the aid of a sketch, the principle of operation of a process flow measurement system that includes a differential pressure flow sensor
- ◆ explain, with the aid of a sketch, the principle of operation of a process flow measurement system that includes a Coriolis flow meter

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- ◆ explain, with the aid of a sketch, the principle of operation of a process flow measurement system that includes a thermal mass flow meter
- ◆ explain, with the aid of a sketch, the principle of operation of a process flow measurement system that includes an electromagnetic flow meter

Evidence should be generated through an assignment undertaken in open book conditions.

Assessment guidelines

The assessment of this Outcome should take the form of an assignment. The time allocation for the assignment is four hours (including class time). The candidate's response to the assignment should be a minimum of 1,500 words.

It is essential that Centres ensure that evidence generated is the candidate's own work.

Outcome 6

Calibrate a measurement system

Knowledge and/or skills

- ◆ Setting up calibration equipment
- ◆ Calibration of a measurement system
- ◆ Documentation of the calibration procedures

Evidence Requirements

This is a practically based Outcome and all of the knowledge and/or skills items above should be assessed. The evidence should be presented in response to a practical assignment in which the candidate is set the task of calibrating a pressure, level, temperature or flow measurement system and producing a report on the calibration.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each knowledge and/or skill by showing that the candidate is able to:

- ◆ Set up calibration equipment for either a pressure, level, temperature or flow measurement system
- ◆ Calibrate a measurement system such that the zero and span are adjusted correctly
- ◆ Produce a report on the calibration that includes the following:
 - a sketch of the equipment used to perform the calibration
 - a description of the method used to perform the calibration
 - a table of the calibration results
 - a graph of the input/output response of the calibrated system
 - a conclusion on the results of the calibration

Candidates should be provided with suitable equipment to enable them to perform a calibration on either a pressure, level, temperature or flow measurement system.

Candidates should have access to relevant notes and reference material for the calibration equipment.

Centres should provide candidates with details of the required report format that should include, as a minimum, the items listed under Evidence Requirements bullet point three. If they so desire, candidates should be permitted to use software packages to produce documentation for their reports.

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While candidates are not required to produce reports under controlled, supervised conditions, centres should make every reasonable effort to ensure that reports are candidate's own work.

Assessment guidelines

The assessment of this Outcome should take the form of an assignment and be carried out at the end of the delivery of the Unit. The time allocated for the practical assignment, including the writing of the report, is approximately four hours in total. It is recommended that centres develop checklists to support the assessment requirements for each of the knowledge and/or skills items.

It is essential that centres ensure that evidence generated is the candidate's own work.

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Administrative information

Unit code:	HV67 47
Unit title:	Measurement Systems 1
Superclass category:	RA
Original date of publication:	November 2017
Version:	01

History of Changes:

Version	Description of change	Date

Source: SQA

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Unit specification: support notes

Unit title: Measurement Systems 1

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 80 hours.

Guidance on the content and context for this Unit

This Unit has been written in order to allow candidates to develop knowledge, understanding and skills in the following areas:

- 1 Explain the performance parameters of measurement systems.
- 2 Explain the principle of operation of pressure measurement systems.
- 3 Explain the principle of operation of level measurement systems.
- 4 Explain the principle of operation of temperature measurement systems.
- 5 Explain the principle of operation of flow measurement systems.
- 6 Calibrate a measurement system.

This Unit is at SCQF level 7 and has been devised as a mandatory Unit within the SQA Advanced Certificate/Diploma in Measurement and Control Engineering. However this does not preclude the use of this Unit in other awards where award designers feel this to be appropriate.

In designing this Unit, the Unit writer has identified the range of topics that they would expect to be covered by lecturers. The writer has also given recommendations as to how much time should be spent on each Outcome. This has been done to help lecturers decide what depth of treatment should be given to the topics attached to each of the Outcomes. While it is not mandatory for centres to use this list of topics, it is recommended that they cover them.

A list of topics for each Outcome is given below.

Outcome 1

Explain the performance parameters of measurement systems (6 hours)

- ◆ Accuracy
- ◆ Sensitivity
- ◆ Resolution
- ◆ Hysteresis
- ◆ Response time
- ◆ Gain

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Outcome 2

Explain the principle of operation of pressure measurement systems (16 hours)

- ◆ Different types of pressure including
 - vacuum
 - gauge
 - absolute
 - differential
 - atmospheric
- ◆ Capacitive types of pressure sensors
- ◆ Strain gauge types of pressure sensors
- ◆ Resonant wire pressure sensors
- ◆ Piezo-electric pressure sensors
- ◆ Magnetic pressure sensors
- ◆ Optical pressure sensors
- ◆ Pressure switches
- ◆ Transmission signals from pressure transmitters including
 - 4-20mA
 - fieldbus
 - wireless
 - HART (Highway Addressable Remote Transducer)

Outcome 3

Explain the principle of operation of level measurement systems (16 hours)

- ◆ Hydrostatic head level sensors
- ◆ Displacer level sensors
- ◆ Capacitance level sensors
- ◆ Ultrasonic level sensors
- ◆ Radar level sensors
- ◆ Optical level sensors
- ◆ Effects of process parameters on the measurement method
- ◆ Transmission signals from level transmitters including
 - 4-20mA
 - fieldbus
 - wireless
 - HART (Highway Addressable Remote Transducer)

Outcome 4

Explain the principle of operation of temperature measurement systems (16 hours)

- ◆ International Practical Temperature Scale 1990 (ITS-90) including the fixed points of temperature (triple points and freezing points)
- ◆ Planck radiation law
- ◆ Thermocouples
- ◆ Resistance thermometers
- ◆ Infra-red thermometers

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- ◆ Pyrometers
- ◆ Filled system thermometers
- ◆ Thermistors
- ◆ Programmable and isolated two wire transmitters
- ◆ Use of standard tables for thermocouples and resistance thermometers
- ◆ Temperature compensation
- ◆ Reference temperatures
- ◆ Transmission signals from temperature transmitters including
 - 4-20mA
 - fieldbus
 - wireless
 - HART (Highway Addressable Remote Transducer)

Outcome 5

Explain the principle of operation of flow measurement systems (18 hours)

- ◆ Definitions of volumetric and mass flow
- ◆ Temperature and pressure compensation in flow measurement
- ◆ Mass flow computers
- ◆ Fiscal metering
- ◆ Ultrasonic level transmitters (Doppler and transit time)
- ◆ Coriolis flow meters
- ◆ Thermal mass flow meters
- ◆ Turbine flow meters
- ◆ Vortex flow meters
- ◆ Pitot tubes
- ◆ Differential pressure methods of flow measurement (orifice plate, Venturi tube)
- ◆ Electromagnetic flow meters
- ◆ Transmission signals from flow transmitters including
 - 4-20mA
 - fieldbus
 - wireless
 - HART (Highway Addressable Remote Transducer)

Outcome 6

Calibrate a measurement system (8 hours)

- ◆ Calibration methods for pressure measurement systems
- ◆ Calibration equipment for pressure measurement systems including
 - digital manometers
 - portable pressure indicators for gauge, absolute and differential pressure
 - pressure calibrators
 - bench pressure standards and pressure calibrators
 - precision pressure pumps
 - loop calibrators
 - multi-function calibrators

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- ◆ Calibration methods for level measurement systems
- ◆ Calibration methods for temperature measurement systems
- ◆ Calibration equipment for temperature measurement systems including
 - dry block calibrators
 - reference temperature generators
 - water baths
 - sand baths
- ◆ Calibration methods for flow measurement systems including
 - volumetric
 - gravimetric
 - pipe provers

Unit assessment

Question paper for Outcome 1	1 hour
Assignment for Outcome 2	3 hours
Assignment for Outcome 3	3 hours
Assignment for Outcome 4	3 hours
Assignment for Outcome 5	4 hours
Practical based assignment for Outcome 6	4 hours

Guidance on the delivery and assessment of this Unit

This Unit has been designed to incorporate sufficient time to allow the lecturer to teach, in a student centred way, different methods of measuring pressure, level, temperature and flow.

Outcome 1 must be delivered first since it contains knowledge that is required for the other five Outcomes. The content of Outcomes 2, 3, 4 and 5 means that they are not a direct follow on to each other and hence they could be delivered in any order. Outcome 6 should be delivered at the end of the Unit.

Due to the range of topics covered in each Outcome it is recommended that each Outcome is assessed at the end of the delivery for that Outcome.

Details on approaches to assessment are given under Evidence Requirements and Assessment Guidelines under each Outcome in the SQA Advanced Unit specification: statement of standards section. It is recommended that these sections be read carefully before proceeding with assessment of candidates.

Opportunities for developing Core Skills

There are opportunities to develop the Core Skills of Written Communication (Writing), Written Communication (Reading), Using Graphical Information, Problem Solving (Critical Thinking) and Working with Others at SCQF level 5 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support. With regard to assessment, planning would be required of the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that relevant assessment were conducted under controlled, supervised conditions.

Arrangements would need to be made to ensure that the candidate could practically demonstrate that they can calibrate a measurement system. This could involve the candidate attending the Centre to carry out the practical work. Alternatively, special arrangements could be made for the candidate to demonstrate the practical work to a designated, responsible person local to the candidate.

For information on open learning, please refer to *SQA guide assessment and quality assurance of open and distance learning (A1030, Feb 2001)*.

Equality and inclusion

This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

General information for candidates

Unit title: Measurement Systems 1

This Unit has been designed to provide you with the knowledge and skills that will enable you to understand the operation of a range of pressure, level, temperature and flow measurement systems.

In Outcome 1 you will learn about the performance parameters of measurement systems.

In Outcome 2 you will learn about different methods of measuring pressure. This will include learning about the basic construction and the principle of operation of different types of pressure measurement systems.

In Outcome 3 you will learn about different methods of measuring level. This will include learning about the basic construction and the principle of operation of different types of level measurement systems.

In Outcome 4 you will learn about different methods of measuring temperature. This will include learning about the basic construction and the principle of operation of different types of temperature measurement systems.

In Outcome 5 you will learn about different methods of measuring flow. This will include learning about the basic construction and the principle of operation of different types of flow measurement systems.

In Outcome 6 you will learn about how to calibrate a measuring system. This will include learning about the equipment that is required to carry out the calibration and the procedures that are used to calibrate a measurement system.

The formal assessment for this Unit will consist of a question paper for Outcome 1 and five assignments for Outcomes 2, 3, 4, 5 and 6.

The assessment paper for Outcome 1 will last one hour and will be carried out under closed-book conditions in which you will not be allowed to take notes, handouts, textbooks, etc into the assessment.

The assignments for Outcomes 2, 3, 4 and 5 will assess your competence in explaining the operation of a range of measurement systems. The assignments for Outcomes 2, 3 and 4 should each be a minimum of 1,000 words and should be completed in three hours. The assignment for Outcomes 5 should be a minimum of 1,500 words and be completed in four hours.

The assignment for Outcome 6 will assess your practical skills since you will be required to calibrate either a pressure, level, temperature or flow measurement system and produce a report on the calibration. This assignment should be completed in four hours.

You will have access to relevant notes, handouts and textbooks when carrying out the assignments for Outcomes 2, 3, 4, 5 and 6.