QUALIFICATION HANDBOOK

Level 3 Diploma Engineering (IVQ) (2850-85/86/87/88/89/90)

City & Guilds

October 2015 Version 2.0

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Qualification at a glance

Subject area	Engineering
City & Guilds number	2850
Age group approved	16+
Entry requirements	Level 3
Assessment	Online multiple choice Assignment Dated entry written exam
Fast track	Required
Support materials	Centre handbook Assessment pack Smartscreen
Registration and certification	Consult the Walled Garden/Online Catalogue for last dates

Title and level	City & Guilds	Accreditation number
Level 3 Diploma in Engineering - Welding	2850-85	600/0882/9
Level 3 Diploma in Engineering Fabrication	2850-86	600/0882/9
Level 3 Diploma in Engineering Fabrication and Welding	2850-87	600/0882/9
Level 3 Diploma in Engineering Maintenance, Installation and Commissioning	2850-88	600/0882/9
Level 3 Diploma in Engineering Mechanical Manufacturing Engineering	2850-89	600/0882/9
Level 3 Diploma in Engineering Electrical and Electronic Engineering	2850-90	600/0882/9

Version and date	Change detail	Section
1.1 Mar 2015	Corrected unit number errors in structure information	**Structure**
V2 October 2015	Unit 351 replaced by Units 361 and 362	**Structure Assessment Units**
	Unit 353 – range amended in Outcomes 1.04, 3.05	**Unit 353**
	Unit 354 – range amended in Outcomes 1.03 Additional Guidance added for Outcome 3	**Unit 354**
	Unit 355 – range amended in Outcomes 1.02, 2.02, 3.01, 3.02, 3.04, 3.05, 3.06, 3.07, 4.05 Additional Guidance amended for Outcome 3	**Unit 355**
	Unit 356 – range amended range in outcomes 1.04, 1.06, 2.01, 4.03	**Unit 356**
	Unit 357 - Range amended in Outcomes 1.01, 1.03, 2.01, 2.03, 2.04, 2.06, 3.04 Addition Guidance added for Outcome 3	**Unit 357**
	Amend range in Outcomes 1.02, 2.05, 3.02, 3.04, 4.01	**Unit 358**
	Test specifications updated	**Unit 353-358 361-362**

Contents

1 Introduction

This document tells you what you need to do to deliver the qualification:

Area	Description
Who is the qualification for?	This certificate is aimed at learners who: • intend to follow an Apprenticeship or Advanced Modern Apprenticeship programmes • wish for career progression within engineering • wish to develop the skills learnt from other qualifications
What does the qualification cover?	It allows learners to learn, develop and practise the basic introductory skills required for employment and/or career progression in the engineering sector.
What opportunities for progression are there?	It allows learners to progress into employment or to the following City & Guilds qualifications: • Higher Level Engineering qualifications
This qualification replaces	2565 -02 Level 3 IVQ Technician Diploma in Engineering 8030-22 Level 3 IVQ Technician Diploma in Electrical and Electronic Engineering

2 Structure

To achieve the **Level 3 Diploma in Engineering - Welding**, learners must achieve **27** credits from (301, 302 , 353) plus a minimum of **27** credits from (310-312, 330, 361-362, 336-338) of which **9** credits must come from (310-312).

Unit reference number	City & Guilds unit number	Unit title	Credit value	GLH
Mandatory				
Y/503/0334	301	Engineering health and safety	9	80
D/503/0433	302	Engineering principles	9	80
D/503/0335	353	Principles of welding	9	80
Optional				
F/503/0344	310	Manual metal arc welding of materials	9	80
R/503/0347	311	MIG welding of materials	9	80
D/503/0349	312	TIG welding of materials	9	80
A/503/0424	330	Organising and managing engineering	9	80
H/503/0353	336	MIG welding of aluminium	9	80
Y/503/0351	337	TIG welding of aluminium	9	80
K/503/0354	338	Flux-cored arc welding materials	9	80
K/503/0449	361	Advanced mathematics and science *Advanced mathematics test*	9	80
	362	Advanced mathematics and science *Advanced science test*		

To achieve the **Level 3 Diploma in Engineering - Fabrication**, learners must achieve **27** credits from (301-302, 354) and a minimum of **27** credits from (313-316, 330, 361-362) of which a minimum **9** credits must come from (313 - 316)

Unit reference number	City & Guilds unit number	Unit title	Credit value	GLH
Mandatory				
Y/503/0334	301	Engineering health and safety	9	80
D/503/0433	302	Engineering principles	9	80
H/503/0336	354	Principles of fabrication	9	80
Optional				
F/503/0375	313	Platework fabrication of materials	9	80
A/503/0374	314	Sheet metalwork fabrication of materials	9	80
J/503/0376	315	Fabrication and erection of structural steelwork	9	80
Y/503/0379	316	Pattern development for fabrication	9	80
A/503/0424	330	Organising and managing engineering operations	9	80
K/503/0449	361	Advanced mathematics and science *Advanced mathematics test*	9	80
	362	Advanced mathematics and science *Advanced science test*		

To achieve the **Level 3 Diploma in Engineering – Fabrication and Welding**, learners must achieve **27** credits from (301, 302, 355) plus a minimum of **27** credits from (310-316, 330,351,336-338) 310-312) of which a minimum of **9** credits must come from (310- 316)

Unit reference number	City & Guilds unit number	Unit title	Credit value	GLH
Mandatory				
Y/503/0334	301	Engineering health and safety	9	80
D/503/0433	302	Engineering principles	9	80
K/503/0337	355	Principles of fabrication and welding	9	80
Optional				
F/503/0344	310	Manual metal arc welding of materials	9	80
R/503/0347	311	MIG welding of materials	9	80
D/503/0349	312	TIG welding of materials	9	80
F/503/0375	313	Platework fabrication of materials	9	80
A/503/0374	314	Sheet metalwork fabrication of materials	9	80
J/503/0376	315	Fabrication and erection of structural steelwork	9	80
Y/503/0379	316	Pattern development for fabrication	9	80
A/503/0424	330	Organising and managing engineering operations	9	80
H/503/0353	336	MIG welding of aluminium	9	80
Y/503/0351	337	TIG welding of aluminium	9	80
K/503/0354	338	Flux-cored arc welding materials	9	80
K/503/0449	361	Advanced mathematics and science *Advanced mathematics test*	9	80
	362	Advanced mathematics and science *Advanced science test*		

To achieve the **Level 3 Diploma in Engineering - Maintenance, Installation and Commissioning**, learners must achieve **27** credits from (301-302, 356) and a minimum of **27** credits from (317-322, 330, 332, 351) of which a minimum of **9** credits must come from (317-322).

Unit reference number	City & Guilds unit number	Unit title	Credit value	GLH
Mandatory				
Y/503/0334	301	Engineering health and safety	9	80
D/503/0433	302	Engineering principles	9	80
M/503/0338	356	Principles of engineering maintenance, installation and commissioning	9	80
Optional				
R/503/0381	317	Maintenance of machine systems	9	80
D/503/0383	318	Maintenance of utility systems	9	80
H/503/0384	319	Maintenance of plant services	9	80
T/503/0390	320	Maintenance of hydraulic Systems	9	80
R/503/0395	321	Maintenance of pneumatic systems	9	80
K/503/0435	322	Power generation systems and ancillary equipment	9	80
A/503/0424	330	Organising and managing engineering operations	9	80
R/503/0428	332	Mechatronics systems principles and fault finding	9	80
K/503/0449	361	Advanced mathematics and science *Advanced mathematics test*	9	80
	362	Advanced mathematics and science *Advanced science test*		

To achieve the **Level 3 Diploma in Engineering - Mechanical Manufacturing Engineering**, learners must achieve **27** credits from (301-302, 357) and a minimum of **27** credits from (323-330, 361-362) of which a minimum of **9** credits must come from (323-327)

Unit reference number	City & Guilds unit number	Unit title	Credit value	GLH
Mandatory				
Y/503/0334	301	Engineering health and safety	9	80
D/503/0433	302	Engineering principles	9	80
T/503/0339	357	Principles of mechanical manufacturing engineering	9	80
Optional				
T/503/0437	323	Machining materials by turning	9	80
M/503/0436	324	Machining materials by milling	9	80
A/503/0438	325	Machining materials by grinding	9	80
D/503/0416	326	CNC machining of materials	9	80
M/503/0419	327	Detailed fitting of materials	9	80
H/503/0420	328	Maintenance of electrical equipment and systems	9	80
M/503/0422	329	Produce drawings using CAD	9	80
A/503/0424	330	Organising and managing engineering operations	9	80
K/503/0449	361	Advanced mathematics and science *Advanced mathematics test*	9	80
	362	Advanced mathematics and science *Advanced science test*		

To achieve the **Level 3 Diploma in Engineering - Electrical and Electronic Engineering**, learners must achieve **27** credits from (301-302, 358) the mandatory units and a minimum of **27** credits from (328, 330, 332-335, 361-362) of which a minimum 9 credits must come from (328, 332 - 335)

Unit reference number	City & Guilds unit number	Unit title	Credit value	GLH
Mandatory				
Y/503/0334	301	Engineering health and safety	9	80
D/503/0433	302	Engineering principles	9	80
K/503/0340	358	Principles of electrical & electronic engineering	9	80
Optional				
H/503/0420	328	Maintenance of electrical equipment and systems	9	80
A/503/0424	330	Organising and managing engineering operations	9	80
R/503/0428	332	Mechatronics systems principles and fault finding	9	80
R/503/0431	333	Computer automated and robotic systems principles and control	9	80
Y/503/0432	334	Power supply, and analogue and digital circuit principles and fault	9	80
H/503/0434	335	Electronic power control principles and practice	9	80
K/503/0449	361	Advanced mathematics and science *Advanced mathematics test*	9	80
	362	Advanced mathematics and science *Advanced science test*		

3 Centre requirements

Approval

Centres wishing to offer City & Guilds qualifications must be approved:

- new centres must apply for centre and qualification approval. Please refer to the *Centre Manual – Delivering International Qualifications* for further information. Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualification before designing a course programme.
- existing City & Guilds' centres will need to get specific qualification approval to run these awards and to submit a QAP form.

City & Guilds reserves the right to suspend an approved centre, or withdraw its approval from an approved centre to conduct City & Guilds' qualifications for reasons of debt, malpractice or for any reason that maybe detrimental to the maintenance of authentic, reliable and valid qualifications or that may prejudice the name of City & Guilds.

Resource requirements

Centre staffing

Staff delivering this qualification must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the areas for which they are delivering training and/or have experience of providing training. This knowledge must be at least to the same level as the training being delivered
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training.

Centre staff may undertake more than one role, eg tutor and assessor or internal verifier, but cannot internally verify their own assessments.

Physical Resources

Centres wishing to use this qualification must review this handbook and ensure that they have the staff and access to sufficient equipment in the centre or workplace so that learners have the opportunity to cover all of the activities of the qualification. It is acceptable for a centre to use specifically designated areas within a centre if the learner does not have a work placement. Where facilities do not exist for realistic practical work, it is strongly recommended that centres develop links with local organisations to provide opportunities for hands on experience.

Internal quality assurance

Approved centres must have effective quality assurance systems to ensure optimum delivery and assessment of qualifications. Full information is provided in the *Centre manual – Delivering international qualifications*.

Centres are responsible for internal quality assurance, and City & Guilds is responsible for external quality assurance.

International standards and rigorous quality assurance are maintained by the use of:

- City & Guilds externally set and externally marked examinations for the mandatory unit.
- City & Guilds activities, delivered and assessed by the centre according to externally set evidence requirements
- internal (centre) quality assurance
- City & Guilds external verification.

To meet the quality assurance criteria for this qualification, the centre must ensure that the following internal roles are undertaken:

- Assessment Manager
- Tutor/Assessor
- Internal Verifier Co-ordinator (for larger centres)
- Internal Verifier
- Examinations Secretary
- Invigilator

Full details and guidance on the internal and external quality assurance requirements, procedures and roles, are provided in *Centre manual – Delivering international qualifications* together with full details of the tasks, activities and responsibilities of quality assurance staff.

In order to fully support learners, centres are required to retain original copies of learners' assessment and internal verification records for **three** years after certification.

The following is a summary of the key roles involved in the successful implementation and assessment of the qualification. (Please refer to the *Centre manual – Delivering international qualifications* for further information).

The role of the Internal Verifier (IV) is to ensure that:

- they liaise with City & Guilds personnel
- there are adequate resources, both staff and materials
- the work of all personnel contributing to the delivery and assessment of the programme is sampled by a range of methods which should include sampling the observation checklist, learner training plans and multiple choice quiz responses
- records of all sampling activities are monitored and maintained
- where several members of staff are involved in the delivery/assessment of the qualification, that there is a consistent interpretation of the requirements through standardisation activities and that these are documented
- all staff carrying out delivery and assessment are familiar with and understand the qualification requirements
- an appropriate referral policy is in place
- an appropriate appeals procedure is in place
- learner evidence is clearly organised and accessible to the Internal and Qualification consultant
- relevant records and pro formas are completed, maintained and retained for the purposes of Internal and External Verification along with the record of course delivery form.

The role of the Tutor/Assessor is to:

- plan, manage, deliver and assess the qualification using the City and Guilds materials provided
- ensure availability of technical support for ICT equipment
- ensure that each learner is aware of the assessment requirements throughout their programme of learning
- provide guidance and support to learners on the assessment and evidence requirements for the qualification
- ensure that the assessment and evidence requirements have been met by the learner
- observe learners' delivered sessions
- facilitate the multiple choice quiz and mark learner responses
- complete relevant records and pro formas.

All staff should participate in appropriate Continuous Professional Development (CPD), to keep up to date with the delivery of the qualification and their role.

External quality assurance

External quality assurance for the qualifications will be provided by the usual City & Guilds external verification process and reported on using relevant documentation to provide a risk analysis of individual centre assessment and verification practice.

Continuing professional development (CPD)

Centres must support their staff to ensure that they have current knowledge of the occupational area, that delivery, mentoring, training, assessment and verification is in line with best practice, and that it takes account of any national or legislative developments. All teaching and assessment must take place in the English language and centres must support their staff in this.

Learner entry requirements

No specific prior qualifications, learning or experience are required for learners undertaking the qualification. However, centres will need to make an initial assessment of each learner to ensure that the level of the scheme is appropriate. The nature of both the learning and assessment required for the qualification is such that learners will need basic literacy and numeracy skills: i.e. the ability to read and interpret written tasks and to write answers in a legible and understandable form in the English language. Learners will also need to be able to organise written information clearly and coherently, although they will not be assessed for spelling or grammatical accuracy unless this is part of the assessment criteria.

There are no restrictions on entry for this award. City & Guilds recommend that learners should not enter for a qualification of the same level and the same content as that of a qualification they already hold.

Age restrictions

City & Guilds cannot accept any registrations for candidates under 16 as these qualifications are not approved for under 16s.

4 Delivering the qualification

Initial assessment and induction

Centres will need to make an initial assessment of each learner prior to the start of their programme to ensure they are entered for an appropriate type and level of qualification.

The initial assessment should identify:

- any specific training needs the learner has, and the support and guidance they may require when working towards their qualification. This is sometimes referred to as diagnostic testing.
- any units the learner has already completed, or credit they have accumulated which is relevant to the qualification they are about to begin.

City & Guilds recommends that centres provide an induction programme to ensure the learner fully understands the requirements of the qualification they will work towards, their responsibilities as a learner, and the responsibilities of the centre. It may be helpful to record the information on a learning contract.

All teaching and assessment for this qualification must take place in the English language.

Support materials

The following resources are available for this qualification:

Description	How to access
Assignment guide for centres	www.cityandguilds.com
Assignments (310 to 330 and 332-338)	www.cityandguilds.com (password protected)
SmartScreen	www.smartscreen.co.uk

Recording documents

Learners and centres may decide to use a paper-based or electronic method of recording evidence.

City & Guilds endorses several ePortfolio systems, including our own, **Learning Assistant**, an easy-to-use and secure online tool to support and evidence learners' progress towards achieving qualifications. Further details are available at: **www.learningassistant.com**.

5 Assessment

The mandatory core units 301 Engineering health and safety and 302 Engineering principles are assessed by a City & Guilds online multiple-choice assessment. The remaining 'Principles of' units are assessed by a dated entry written exam paper. All other units are assessed by assignment which contains practical and knowledge tasks.

The practical aspect of the assignments are centre devised with guidance provided by City & Guilds, confirmation that the centre devised practical aspect is acceptable is required from the City & Guilds Qualification consultant. The knowledge aspect of the assignments (short-answer questions) is provided by City & Guilds. As assignments are designed to sample practical activities, it is essential that the centres ensure that candidates cover the content of the whole unit.

Assessment components are graded (Pass, Merit, Distinction). A pass is the achievement level required for the knowledge and understanding in an IVQ and generally represents the ability to follow instructions and procedures. Merit and distinction represent increasing levels of ability to adapt to changing circumstances and to independently resolve problems.

Summary of assessment requirements

For these qualifications, candidates will be required to complete the following assessments:

- **one** online test for **each** mandatory unit
- **one** dated entry written exam for **each** 'Principles of' unit
- **one** assignment for **each** chosen optional unit
- if choosing unit Advanced mathematics and science, **one** dated entry written exam**.**

City & Guilds provides the following assessments:

Unit	Title	Assessment method	Where to obtain assessment materials
301	Engineering health and safety	Online multiple-choice assessment The assessment covers all of the outcomes.	City & Guilds Walled Garden
302	Engineering principles	Online multiple-choice assessment The assessment covers all of the outcomes.	City & Guilds Walled Garden
310	Manual Metal Arc welding of materials	Assignment 2850-310 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
311	MIG welding of materials	Assignment 2850-311 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
312	TIG welding of materials	Assignment 2850-312 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
313	Platework fabrication of materials	Assignment 2850-313 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
314	Sheet metalwork fabrication of materials	Assignment 2850-314 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
315	Fabrication and erection of structural steelwork	Assignment 2850-315 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com

Unit	Title	Assessment method	Where to obtain assessment materials
316	Pattern development for fabrication	Assignment 2850-316 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
317	Maintenance of machine systems	Assignment 2850-317 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
318	Maintenance of utility systems	Assignment 2850-318 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
319	Maintenance of plant services	Assignment 2850-319 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
320	Maintenance of hydraulic systems	Assignment 2850-320 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
321	Maintenance of pneumatic systems	Assignment 2850-321 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
322	Power generation systems and ancillary equipment	Assignment 2850-322 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com

Unit	Title	Assessment method	Where to obtain assessment materials
323	Machining materials by turning	Assignment 2850-323 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
324	Machining materials by milling	Assignment 2850-324 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
325	Machining materials by grinding	Assignment 2850-325 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
326	CNC machining of materials	Assignment 2850-326 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
327	Detailed fitting of materials	Assignment 2850-327 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
328	Maintenance of electrical equipment and systems	Assignment 2850-328 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
329	Produce drawings using CAD	Assignment 2850-329 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com

Unit	Title	Assessment method	Where to obtain assessment materials
330	Organising and managing engineering operations	Assignment 2850-330 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
332	Mechatronics systems principles and fault finding	Assignment 2850-332 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
333	Computer automated and robotic systems principles and control	Assignment 2850-333 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
334	Power supply, and analogue and digital circuit principles and fault	Assignment 2850-334 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
335	Electronic power control principles and practice	Assignment 2850-335 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
336	MIG welding of aluminium	Assignment 2850-336 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
337	TIG welding of aluminium	Assignment 2850-337 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com

Unit	Title	Assessment method	Where to obtain assessment materials
338	Flux-cored arc welding materials	Assignment 2850-338 The assessment covers the practical activities for all outcomes and will also sample underpinning knowledge to verify coverage of the unit. Centre devised assignment, internally marked, externally verified.	cityandguilds.com
353	Principles of welding	Dated entry written exam paper 2850-354	cityandguilds.com
354	Principles of Fabrication	Dated entry written exam paper 2850-354	cityandguilds.com
355	Principles of fabrication and welding	Dated entry written exam paper 2850-355	cityandguilds.com
356	Principles of engineering maintenance, installation and commissioning	Dated entry written exam paper 2850-356	cityandguilds.com
357	Principles of mechanical manufacturing engineering	Dated entry written exam paper 2850-357	cityandguilds.com
358	Principles of electrical and electronic engineering	Dated entry written exam paper 2850-358	cityandguilds.com
361*	Advanced maths test	Dated entry written exam paper 2850-361	cityandguilds.com
362*	Advanced science test	Dated entry written exam paper 2850-362	cityandguilds.com

* Learners must pass both Unit 361 and Unit 362 to achieve K/503/0449 – Advanced Mathematics and Science

Time constraints

The following time constraints must be applied to the assessments of this qualification:

- Each assignment has specific time constraints; please refer to the individual assignments. Centre staff should guide learners to ensure excessive evidence gathering is avoided. Centres finding that assignments are taking longer, should contact the Qualification consultant for guidance
- All assignments must be completed and assessed within the learner's period of registration. Centres should advise learners of any internal timescales for the completion and marking of individual assignments.

Assessment strategy

Test specifications for the online multiple-choice assessment and the dated entry written exam papers will be available online in March 2013. Dated entry examinations will take place in June and December.

Test specifications

The test specifications for the online multiple-choice assessments are below:

Test: 2850-353 Principles of welding
Duration: 180 minutes

Outcome	No. of Qs	%
1. Understand the fundamentals of welding	4	20
2. Know how to apply welding symbols to joint preparations	3	15
3. Understand the affects of distortion and residual stresses due to welding	4	15
4. Understand the metallurgical effects of welding	5	20
5. Know how to determine the integrity of welded joints	8	30
Total	**24**	**100**

Test: 2850-354 Principles of fabrication
Duration: 180 minutes

Outcome	No. of questions	%
1. Know how to classify common materials used in fabrication engineering	6	27
2. Know how to determine the bending and rolling allowances for fabricated forms and the principles of shearing	5	25
3. Understand the difference between different non-thermal joining methods	7	25
4. Understand different methods used for finishing fabricated components	4	23
Total	**22**	**100**

Test: 2850-355 Principles of fabrication and welding
Duration: 180 minutes

Outcome	No. of questions	%
1. Understand how to classify common materials used in fabrication engineering	6	23
2. Know how to apply welding symbols to joint preparations	3	17
3. Know different non-thermal joining methods	7	22
4. Understand the affects of distortion and residual stresses due to welding	4	16
5. Know how to determine the integrity of welded joints	6	22
Total	**26**	**100**

Test: 2850-356 Principles of engineering maintenance, installation and commissioning

Duration: 180 minutes

Outcome	No. of questions	%
1. Understand how to plan maintenance, installation and commissioning activities	8	34
2. Know how to install and commission instruments and components	4	20
3. Understand how to evaluate methods to overcome friction and corrosion	5	26
4. Know how to evaluate connection methods	3	20
Total	**20**	**100**

Test: 2850-357 Principles of mechanical manufacturing engineering

Duration: 180 minutes

Outcome	No. of questions	%
1. Understand how to determine the alignment of machine tools	4	25
2. Know how to differentiate between methods of power transmission in machine tools	6	25
3. Understand how to evaluate the application of CNC to machine tools.	5	25
4. Understand the maintenance requirements of machine tool systems	5	25
Total	**20**	**100**

Test: 2850-358 Principles of electrical and electronic engineering

Duration: 180 minutes

Outcome	No. of Qs	%
1. Understand electrical supply systems, protection and earthing	4	22
2. Understand the function of electrical and electronic components	8	35
3. Know how to carry out electronic measurement	5	23
4. Understand functions of electrical machines	3	20
Total	**20**	**100**

Test: 2850-361 Advanced mathematics

Duration: 120 minutes

Outcome	No. of Qs	%
1. Be able to perform calculations involving indices, logarithms and algebra	2	16
2. Be able to perform calculations using trigonometry	3	32
3. Be able to perform calculations using calculus	3	32
4. Be able to perform calculations involving statistics	2	20
Total	**10**	**100**

Test: 2850-362 Advanced science

Duration: 120 minutes

Outcome	No. of Qs	%
1. Be able to determine stress, strain and elasticity of materials	0[1]	0[1]
2. Be able to solve problems involving kinematics	2	16
3. Be able to solve problems involving dynamics	2	16
4. Be able to solve problems involving bending beams	2	26
5. Be able to solve problems involving fluids	2	22
6. Be able to demonstrate the effects of electromagnetism and alternating current	2	20
Total	**10**	**100**

[1] Learning Outcome 1 is assessed together with the questions for Learning Outcomes 4

6 Units

Structure of units

These units each have the following:

- City & Guilds reference number
- unit reference number (URN)
- title
- level
- credit value
- guided learning hours
- endorsement by a sector or other appropriate body
- unit aim
- information on assessment
- learning outcomes which are comprised of a number of assessment criteria
- notes for guidance.

Unit 301 Engineering health and safety

URN:	**Y/503/0334**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with the requirements that are essential to enable engineering activities to be carried out safely and effectively. It includes dealing with statutory and organisational requirements in accordance with approved regulations, codes of practice and procedures. It covers responsibilities relating to accident reporting and the identification of hazards and risks

Learning outcome
The learner will: 1. understand compliance with statutory health and safety regulations and organisational requirements
Assessment criteria
The learner can: 1.1 describe the health and safety **regulations** applicable to engineering operations 1.2 explain **employers' responsibilities** to maintain health and safety 1.3 describe essential **operator and bystander** health and safety requirements 1.4 explain the Reportable Diseases and Dangerous Occurrences Regulations **(RIDDOR)** relevant to engineering 1.5 explain the procedures for **reporting accidents** 1.6 explain how the **management of health and safety** regulations are implemented 1.7 state the roles, responsibilities and powers of **health and safety personnel** 1.8 explain the sources of health and safety literature/advice and how to access it 1.9 describe how to carry out a **risk assessment** identifying potential health hazards 1.10 state the general rules for the observance of **safe practices.**

Range
Regulations: Health and Safety at Work etc. Act, Control of Substances Hazardous to Health Regulations (COSHH), Provision and Use of Work Equipment Regulations (PUWER), Electricity at Work Regulations, Control of Major Accident Hazards Regulations (COMAH), Control of Noise at Work Regulations, Lifting Operations and Lifting Equipment Regulations (LOLER) **Employers' responsibilities:** safe: place of work, plant and equipment, system of work, working environment, methods of handling, storing and transporting goods and materials reporting of accidents (RIDDOR), information, instruction, training and supervision of employees, a health and safety policy **Operator and bystander**: Personal Protective Equipment (PPE), Respiratory Protective Equipment (RPE)' secure areas **Reporting accidents:** summary of accident, name of victim(s), summary of events prior to accident, details of witnesses, information on injury or loss sustained, conclusions, recommendations, supporting material (photographs, video), diagrams, date, signature of person(s) responsible for report **Management of Health and Safety:** including the four C's of positive health and safety (Competence, Control, Co-operation, Communication) **Health and safety personnel:** Health and Safety Advisors, Health and Safety Representatives, Health and Safety Executive Inspectors, Environmental Health Officers **Risk assessment:** potential hazards, slippery or uneven surfaces, spillages, scrap or waste material, inflammable materials, faulty or missing machine guards, faulty electrical connections or damaged cables, material ejection, pressure and stored energy, unshielded processes, volatile and toxic materials, dust and fumes, contaminants and irritants, materials handling and transportation, working at heights **Safe practices**: be alert, maintain personal hygiene, protect yourself and other people, know emergency procedures, report all hazards

Learning outcome
The learner will: 2. understand compliance with statutory environmental regulations and organisational requirements
Assessment criteria
The learner can: 2.1 describe the differences between the **human and environmental conditions** leading to accidents in the workplace and the means of controlling them 2.2 describe the Environmental Management Systems Standard ISO 14001 in terms of the engineering industry 2.3 describe the implementation of **environmental legislation** as it applies to engineering industries 2.4 identify health and safety **signs** and explain their purpose

Range
Human and environmental conditions: **Causes of accidents** **Human**: lack of management control, carelessness; improper behaviour and dress; lack of training, supervision and experience; fatigue; drug-taking and alcohol intake, **Environmental**: unguarded or faulty machinery or tools; inadequate ventilation; untidy, dirty, overcrowded workplace; inadequate lighting **Controlling methods** Eliminate the hazard, replace the hazard with something less dangerous, guard the hazard, personal protection, health and safety education and publicity **Environmental legislation:** Environmental Protection Act, Pollution Prevention and Control Act, Clean Air Act, Radioactive Substances Act, Controlled Waste Regulations, Dangerous Substances and Preparations and Chemicals Regulations, Hazardous Waste Regulations **Signs:** warning, prohibition, mandatory, information, fire

Learning outcome
The learner will: 3. know how to implement accident and emergency procedures
Assessment criteria
The learner can: 3.1 explain the need for the provision of **first aid** treatment 3.2 explain the **health and safety procedures** that prevent injury or discomfort to skin, eyes, hands and limbs 3.3 explain the appropriate **emergency action** to be taken in cases of electric shock 3.4 explain precautions to be taken to avoid **electric shock** 3.5 explain the causes of **asphyxiation** and the appropriate emergency action to be taken 3.6 state what is meant by a dangerous occurrence and hazardous malfunction 3.7 describe the procedures to be followed the event of the sounding of an **emergency alarm** 3.8 describe methods of **fire prevention.**

Range
First aid: location of facilities, location of qualified first aiders **Health and safety procedures**: personal hygiene, skin protection and care, care of eyes, use of eye and face protectors which are to current EN specifications, use of respirators, dangers of hair and loose clothing getting caught in machinery, means of avoiding such dangers, benefits and use of protective clothing, use of safety guards, screens and fences **Emergency action:** isolate electrical supply, removal from electricity supply, basic resuscitation procedures **Electric shock**: hazards arising from the use of electrical equipment, general health and safety rules: checking and inspection of cables, leads and plugs; earthing; problems associated with the use of portable equipment; use of reduced voltage equipment; health and safety training; warning signs and notices; isolation procedures **Asphyxiation:** confined working space, inadequate ventilation **Emergency alarm**; evacuation system, escape routes, assembly points (reporting to assembly points, not to return until authorised) **Fire prevention**: risk assessments, methods of controlling fires, fire procedures, adhering to fire safety legislation

Learning outcome
The learner will: 4. understand safe working practices and procedures
Assessment criteria
The learner can: 4.1 describe the range of Personal Protective Equipment (PPE) available and relate its use to the operations that will be undertaken 4.2 explain use of Respiratory Protective Equipment (**RPE**) when undertaking tasks involving exposure to hazardous substances and the range available 4.3 describe how to carry out a risk assessment for using mechanical lifting equipment 4.4 state the requirements of the Lifting Operations and Lifting Equipment Regulations (**LOLER**) 4.5 explain the health and safety rules for the use of mechanical lifting equipment 4.6 explain the purpose and methods of use of **accessories** to lifting gear 4.7 describe the Manual Handling Operations Regulations as they apply to engineering industries 4.8 explain the necessity of a permit to work procedure 4.9 explain the necessity of 'lock-off' procedures 4.10 state the procedures used to notify/report hazards to **appropriate people** 4.11 state situations in which it is unadvisable or unsafe to **work in isolation.**

Range
RPE: chemicals and solvents, fumes, dust or harmful particulates, heat **Accessories:** hooks, slings, eyebolts, shackles, chains, rings, special-to- purpose equipment, rules for the use of slings **Appropriate people:** supervisors, health and safety advisors, health and safety representatives, fire marshals, works/site rescue team **Work in isolation:** in confined spaces, above ground or in trenches, in close proximity to unguarded machinery, when a fire risk exists, with toxic or corrosive substances, on site

Unit 301 Engineering health and safety

Supporting information

Guidance

Fire prevention: fire risk assessments, causes of fire, fire prevention, spread of fire, methods of controlling fires, conditions required for combustion and extinction, the fire triangle, fire procedures (fire drills, fire fighting equipment for different types of fires, extinguishers (types classification for types of fire), automatic equipment, adhering to fire safety legislation)

LOLER: as a general rule loads over 20kg need powered lifting gear, never exceed the maximum safe working load (SWL) indicated on the equipment and the accessories, avoid shock loading the lifting equipment, swinging and twisting, estimate the centre of gravity, position the lifting hook above the centre of gravity of the load to maintain an even balance, avoid pushing or pulling the load to adjust the balance, do not transport loads over the heads of people or walk under a load, do not leave a load hanging unnecessarily and, in any event, have someone to watch over it, always lower the load gently into position; make sure it will not move once the lifting equipment is removed, check date of equipment tests

Accessories: hooks (materials, design and certification) slings (materials, design and certification, the importance of the angle at the top, forces in the legs proportional to the angle at the top, design and construction of rope slings [natural and man-made fibres, steel wire slings]), eyebolts (design and construction to published standards, use when lifting engines, gearboxes, the importance of ensuring that the eyebolt shoulder is screwed flush to face of component) shackles (design and construction to published standards, the importance of SWL for different sizes) chains (design and construction; the importance of regular checking and testing to avoid failure from damage and metal fatigue) rings (design and construction to published standards; importance of use with slings and chains), special-to-purpose equipment (use for lifting special equipment, regular lifting eg oil drums, production components) rules for the use of slings (never bend around sharp corners and edges and avoid overbending, use of protective covers on corners of loads, never twist or kink the sling never use a worn or damaged sling, always observe the safe working load (SWL))

Unit 302 Engineering principles

URN:	**D/503/0433**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with those engineering principles that enhance the performance of engineering operations. This includes the extraction, interpretation and use of a range of technical information sources. It includes the use of basic calculations and engineering science that enables the candidate to better understand the behaviour and properties of engineering materials in order that appropriate materials may be selected to satisfy specifications. The identification and application of quality control measures that are relevant to engineering activities are also covered.

Learning outcome
The learner will: 1. know how to interpret engineering information
Assessment criteria
The learner can: 1.1 explain the relevance of **engineering information** 1.2 describe the difference between the **abbreviations and notation** used on various standard engineering drawings, circuit diagrams or piping layouts 1.3 interpret the information that can be extracted from **reference charts, tables, graphs and BS EN standard** 1.4 explain the use of CAD systems to produce engineering drawings 1.5 explain the use of databases and spreadsheets to display information 1.6 explain the basic principles of **document control** 1.7 interpret **drawings, dimensioning and labelling** 1.8 describe how to use charts, tables, graphs and BS EN standards 1.9 describe how to extract information from drawings 1.10 describe how to use engineering drawings to produce material lists 1.11 describe how to use engineering drawings to determine quality requirements

Range
Engineering information: BS EN standards, instruction manuals, technical handbooks, tables, charts (including: flow, Gantt, tally), graphs (including histograms, scatter diagrams), Ishikawa diagrams (fishbone diagrams or cause-and-effect diagrams), data sheets, text books and reference materials, computer applications **Abbreviations and notation:** symbols and abbreviations, application to: engineering drawings, machining, welded joints, circuit diagrams and piping layouts **Reference charts, tables, graphs and BS EN standards:** tapping sizes and threads, feeds and speeds, cable sizing, PIN configurations, component ratings, welding symbols, machining symbols and tolerances, piping components **Drawings, dimensioning and labelling**: projections (orthographic [first angle, third angle], isometric [including exploded], oblique); reference points, lines, edges and surfaces, continuous dimensions, baseline dimensions

Learning outcome
The learner will: 2. know how to differentiate between common engineering materials
Assessment criteria
The learner can: 2.1 describe the difference between a range and form of **supply of materials** commonly used in engineering 2.2 describe the difference between **characteristics** of metallic and non-metallic materials used in engineering 2.3 describe how carbon and alloying elements affect the properties of carbon and low alloy steels 2.4 describe how **heat treatments** can affect the properties of carbon and low alloy steels 2.5 explain the causes of **corrosion** in materials 2.6 state the **defects** that can occur in materials/products and explain the importance of controlling them 2.7 select materials to meet specifications requirements in a typical engineering environment

Range
Supply of materials: ferrous metals (low, medium and high carbon steels; low alloy steels; stainless steels; cast irons), non-ferrous metals (aluminium and aluminium alloys, copper, brass, bronze, nickel, lead, titanium), non-metallic (hard and soft woods, composites, plastics: thermoplastic, thermosetting), ceramics, reinforcing materials (glass fibre, carbon fibre, aramid fibre) **Characteristics:** selection of materials for engineering applications, strength, rigidity, temperature stability (heat resistance, thermal conductivity, electrical conductivity and insulation), wear resistance, acoustic absorption, shock absorption, corrosion resistance, influence of physical properties of materials on processing techniques (cutting, forming, joining), identification of engineering materials (colour, surface texture, appearance, density, magnetic/non-magnetic, spark test) **Heat treatments**: iron-carbon thermal equilibrium diagram, annealing, normalising, hardening, tempering **Corrosion:** pitting, intergranular, galvanic, leaching, oxidation **Defects**: critical, major, minor or non-critical

Learning outcome
The learner will: 3. know how to perform engineering calculations
Assessment criteria
The learner can: 3.1 express numerical solutions to a **degree of accuracy** that is appropriate to the value being calculated 3.2 use a calculator to raise a number to a power and determine square roots 3.3 use formulae to complete **transpositions** and solve problems 3.4 use **algebraic expressions** 3.5 plot and interpret **straight line graphs** 3.6 apply Pythagoras' Theorem 3.7 explain how to use **Sine, Cosine and Tangent** to solve typical engineering problems 3.8 define density and relative density and solve related problems using formula 3.9 define **moments of a force** and **solve related problems using formula** 3.10 define **work, power and energy** and solve related problems using formula 3.11 define **friction** and solve related problems using formula 3.12 describe the relationship between **temperature** changes and changes in length 3.13 define types of **heat** and solve related problems using formula.

Range
Degree of accuracy: correct to three significant figures, correct to two decimal places, express a decimal fraction in standard form, express tolerance in terms of limits of size **Transpositions**: involving addition, subtraction, multiplication and division in any combination using a maximum of three terms, for example Ohm's Law solve problems: substitution of known values **Algebraic expressions:** represent numerical quantities using symbols, apply laws of precedence in the use of precedence (BODMAS) **Straight line graphs**: determining suitable scales from given data, defining and correctly labelling axes, determine the gradient, determine the intercept, prove the law of the straight line graph is $y = mx + c$ **Sine, Cosine and Tangent**: state their ratios for angles up to 90°, determine their values for given angles up to 90°, solve simple problems **Moments of a force:** define and apply the 'Principle of Moments', define the meanings of the terms 'torque' & 'couple' **Solve problems**: associated with levers and couples work, power and energy define work done in terms of force and distance moved **Work, power and energy:** explain what is meant by energy; state that the unit of energy is the joule (J), the unit of power is the watt (W) and the unit of work is the joule (J); define power in terms of voltage/current and work done per second, perform calculations for work, power and energy **Friction:** definition, explain coefficient of friction, explain how friction can be reduced, select materials that will rotate, or slide together with low frictional value, perform calculations for friction **Temperature:** define coefficient of expansion, solve numerical problems to determine the change in length due to temperature. **Heat:** define: specific heat capacity, specific latent heat (fusion, evaporation) solve numerical problems associated with specific heat capacity, specific latent heat of fusion, specific latent heat of evaporation

Learning outcome
The learner will: 4. understand quality control in engineering.
Assessment criteria
The learner can: 4.1 state what is meant by the term **quality** and apply quality to contexts/perceptions 4.2 define the terms **inspection and quality control** 4.3 explain the principles of **quality control and inspection** 4.4 explain the need for materials and components, **inward inspection** and correct documentation 4.5 state the function of an incoming raw materials inspection department 4.6 explain the need for **validating and calibrating** test and measuring equipment 4.7 explain how to **check equipment is approved** for use and how to take appropriate action to return/report equipment that has passed its approval date 4.8 explain the use of engineering standards in determining the fitness of purpose of items/equipment used in engineering production, construction and maintenance

4.9	describe the appropriate **action** to take when required standards of performance are not met
4.10	explain limits of authority in respect of re-working, adjusting or scrapping a component/product
4.11	explain the need to inform a responsible person of the variation from the stated standard
4.12	state the need to document all actions agreed upon and taken
4.13	explain the importance of **quality records** and the type of inspection records needed
4.14	explain the purpose of the ISO 9000 series of standards
4.15	describe how to complete quality documents/records of work carried out and record test/inspection results
4.16	interpret results from quality measurements and compare them with stated parameters
4.17	make recommendations whether to re-work, adjust or scrap items/components that do not meet required standards.

Range
Quality: components, products or services being fit for purpose, customer expectation, product, component or service reliability, the need for interchangeability with regard to supplying spare parts, product life cycle **Quality control and inspection**: inspection: covering the examination, measurement, testing and judgement of a product for conformation to a predetermined requirement i.e. fitness for purpose, quality control: activities embracing all stages of manufacture from initial design, raw material and finished products, principles of inspection (random sampling, sampling frequency) **Inward inspection**: dimensional accuracy, correct documentation for incoming goods/materials, importance of release and advice notes, faults that may arise in documentation and storage of incoming goods, methods of checking for faults in documentation, spot checks, random checks; sampling (quarantine inspection) in terms of: importance of release and advice notes, the reason for clear, identification of materials with relevant batch numbers, procedures to be followed before batch material is released into stores in accordance with storage recommendations – tests to be applied, identification of acceptance/rejection criteria and the recording procedures involved, remedial action to be taken when components/materials prove defective **Validating and calibrating:** need for regular and controlled calibration and validation of measuring equipment, need for traceable records of calibration checks, use of international standards **Check equipment is approved**: Equipment such as: torque wrenches, lifting equipment, pressure gauges, micrometers, vernier instruments **Action:** re-work, adjust, scrap **Quality records:** record all test results, record all inspections carried out, procedures to be taken upon completion of task (place into stores, pass it to another department, mark it for re-work, adjust, mark it for scrap or salvage

Unit 302 Engineering principles

Supporting information

Guidance

Document control: where documents are obtained from, how distribution and use of documents is controlled, the relevance of document issue numbers, document approval and authorisation procedures, procedure to be adopted if documents are lost or damaged
Characteristics: selection of materials for engineering applications, strength, rigidity, temperature stability (heat resistance, thermal conductivity, electrical conductivity and insulation), wear resistance, acoustic absorption, shock absorption, corrosion resistance, influence of physical properties of materials on processing techniques (cutting, forming, joining), identification of engineering materials (colour, surface texture, appearance, density, magnetic/non-magnetic, spark test), explain the factors influencing the choice of materials (properties, cost, testing of materials (non-destructive: visual, penetrant [dye and fluorescent], magnetic particle [dye and fluorescent], radiography, ultrasonic; destructive: tensile, shear, hardness [Brinell, Vickers, Rockwell], toughness [Charpy, Izod], creep, fatigue, bending.

Unit 310 Manual metal arc welding of materials

URN:	**F/503/0344**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit sets out the requirements for manual metal arc welding in a modern engineering environment, in terms of what needs to be achieved by the candidate, ie: welding a series of challenging joint configurations across in a wide range of positions that are compliant to welding procedure specifications. The unit is concerned with the technology and practices involved in the application of manual metal arc welding. The unit is demanding in terms of technological content and the complexity of the welding that candidates are expected achieve. The unit is broadly divided into health and safety, welding equipment, welding consumables (i.e. electrodes) and the practicalities of producing a welded joint in relation to a welding procedure specification (WPS) and a quality specification.

Learning outcome
The learner will: 1. be able to apply safe working practices to manual metal arc welding
Assessment criteria
The learner can: 1.1 apply the health and safety **regulations** relevant to welding 1.2 assess **hazards and risks** in a welding environment and recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards 1.3 follow safe working practices

Range
Regulations: Health and Safety at Work etc. Act, COSHH, PUWER (scope within the welding environment), RIDDOR, Management of Health and Safety at Work Regulations, Personal Protective Equipment At Work Regulations, Noise at Work Regulations **Hazards and risks:** fume, fire, electricity, arc radiation, hot metal/slag **Safe working practices:** safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance

Learning outcome
The learner will: 2. be able to prepare equipment for performing manual metal arc welding
Assessment criteria
The learner can: 2.1 list the range of **welding equipment** available 2.2 describe the functions of welding equipment 2.3 prepare welding equipment for a range of given applications

Range
Welding equipment: power sources, transformer/rectifier, inverter, generator, measurement of electrical output and continuity, methods of current regulation, power source characteristics,, leads, electrode holders, return clamps, ancillary equipment

Learning outcome
The learner will: 3. be able to perform manual metal arc welding operations to meet welding procedure specification requirements
Assessment criteria
The learner can: 3.1 critically compare **welding consumables** for a range of given applications 3.2 differentiate between welding consumables by their classification 3.3 produce complex welded joints in a range of positions in accordance with procedure specification (**WPS**) parameters 3.4 **restore work areas** to a clean and safe condition on completion of welding operation

Range
Welding consumables: electrode coverings to current BS EN standard (strength and elongation properties, impact properties, chemical composition, type of the covering, recovery rate and current type, welding positions, hydrogen content of the deposit), electrode coverings (cellulosic, rutile, basic, iron powder, composition, applications, baking requirements, hydrogen content, determination of electrode efficiency), function of coverings (facilitates arc striking, stabilises and directs the arc, assists control of the size and frequency of filler metal globules/droplets, protects filler metal from atmospheric contamination

during transfer, protects deposited metal from contamination, provides appropriate weld contour, prevents rapid cooling of weld metal [thermal blanket effect], provides a flux for the molten pool to remove oxides and impurities, supplies additional metal to weld pool [including alloying elements], core wire composition (carbon steel, low alloy steel, stainless steel, non-ferrous metals, cast iron), electrode coverings to current AWS standard (strength and elongation properties, position, usability, suffix)
WPS: welding process, parent metal, consumables, pre welding activities (cleaning, edge preparation, assembly, pre-heat), welding parameters, welding positions (EN ISO 6947 – PA, PB, PC, PD, PE, PF, PG), number and arrangement of runs to fully fill/weld joints, electrode sizes for joint thicknesses, techniques used when welding with electrodes (cellulosic, rutile, basic, iron powder), electrical conditions required (type of current, alternating [a.c.], direct [d.c.], electrode polarity (positive, negative), welding current ranges, voltage (open circuit, arc), control of heat input, interpass/run cleaning/back gouging methods, post welding activities (slag removal, spatter removal, wiring brushing, removal of excess weld metal where required), post-weld heat treatment (normalising, stress relief)

Learning outcome
The learner will: 4. be able to evaluate welded joints for welding procedure specification conformance
Assessment criteria
The learner can: 4.1 explain the implications of quality specifications used to determine the **integrity of welded joints** 4.2 **visually evaluate** welded joints for conformance 4.3 prepare and **destructively test** joints to evaluate sub-surface for conformance

Range
Integrity of welded joints: classification of defects, quality specification (BS EN 25817 – arc welded joints in steel – guidance on quality levels for imperfections), methods of avoiding, rectification methods **Visually evaluate**: use of visual techniques, lighting, low powered magnification, fillet weld gauges, dye penetrant testing, preparation for inspection, qualitive (defect levels, appearance), quantitive (extent, size, dimensional accuracy) **Destructively test**: nick-break (fracture), macroscopic examination (x5) bend tests (butt welds, side, face, root), methods of preparation for testing

Unit 310 Manual metal arc welding of materials

Supporting information

Guidance

Regulations: Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to welding process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors renderPersonal Protective Equipment (PPE) provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels)

Hazards and risks: fume (composition, visible particulate, invisible gaseous, risks to health, control measures to reduce exposure, extraction [background, local, natural ventilation, e.g. on-site, air-fed headshields, respirator, breathing apparatus, monitoring the effectiveness of control measures), fire (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), electricity (shock, fire, burns, methods of avoiding shock hazards, emergency procedures in the event of an electric shock, function of protection devices, earthing, workpiece, plant), arc radiation (visible light, infra-red, ultra-violet, effects, protection (Personal Protective Equipment (PPE), screening, warnings [verbal, notices], hot metal/slag (methods of avoiding)

Welding equipment: power sources (output [alternating current [a.c.], direct current [d.c.], transformer [function, winding ratio, input/output ratio, construction], transformer/rectifier [function, operation, construction {diodes, thyristors} function of smoothing capacitors], inverter [function, operation, construction], generator [fuel driven, motor driven, function, operation, construction], rated output [duty cycle]), measurement of electrical output and continuity (voltage – use of voltmeter/multi-meter, current – use of ammeter/shunts/coils, continuity – use of continuity tester/ohmmeter), methods of current regulation (tapped reactor, moving core, moving coil, moving shunt, saturable reactor, variable resistance), power source characteristics (volt/ampere graph, drooping characteristic, constant current output), leads used (welding, return, earth, construction, rated output [duty cycle]), electrode holders (types, fully insulated, partially insulated), return clamps (types, clamping mechanisms), ancillary equipment (angle grinders, chipping hammer, wire brushes, hammer and chisel)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

Unit 311 MIG welding of materials

URN:	**R/503/0347**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit sets out the requirements for metal inert gas (MIG) welding in a modern engineering environment, in terms of what needs to be achieved by the candidate, ie: welding a series of challenging joint configurations across in a wide range of positions that are compliant to welding procedure specifications. The unit is concerned with the technology and practices involved in the application of MIG welding. The unit is demanding in terms of technological content and the complexity of the welding that candidates are expected achieve. The unit is broadly divided into health and safety, welding equipment, welding consumables (i.e. electrodes) and the practicalities of producing a welded joint in relation to a welding procedure specification (WPS) and a quality specification

Learning outcome
The learner will: 1. be able to apply safe working practices to MIG welding
Assessment criteria
The learner can: 1.1 apply the **health and safety regulations** relevant to welding 1.2 assess **hazards and risks** in a welding environment and recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards 1.3 follow **safe working practices**

Range
Health and safety r**egulations:** Health and Safety at Work etc. Act, COSHH, Management of Health and Safety at Work Regulations, Personal Protective Equipment at Work Regulations, Noise at Work Regulations **Hazards and risks:** fume, fire, electricity, arc radiation, hot metal, hazards associated with the storage, handling and use of pressurised gas cylinders **Safe working practices:** safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance cylinders (safe storage conditions, safe handling/moving, safe use)

Learning outcome
The learner will: 2. be able to prepare equipment for performing MIG welding
Assessment criteria
The learner can: 2.1 list the range of **welding equipment** available 2.2 describe the functions of welding equipment 2.3 prepare the welding equipment for a range of given applications 2.4 prepare the welding **shielding gases** for a range of given applications

Range
Welding equipment: power sources, inverter , generator, rated output, measurement of electrical output and continuity, relationship between wire feed speed control and welding current, power source characteristics, function of induction, return, earth, construction, rated output, welding guns, contact tip, return clamps, wire feed control, ancillary equipment **Shielding gases:** cylinders, manifold systems, regulators (fixed, single-stage, two-stage), gas flow meters, gas tubes and connectors, use of solenoid valves, heaters for CO2

Learning outcome
The learner will: 3. be able to perform MIG welding operations to meet welding procedure specification requirements
Assessment criteria
The learner can: 3.1 critically compare **welding consumables** for a range of given applications 3.2 differentiate between **welding consumables** by their classification 3.3 produce complex welded joints in a range of positions in accordance with welding procedure specification (WPS) parameters 3.4 **restore work areas** to a clean and safe condition on completion of welding operation

Range
Welding consumables: *Electrode wires:* BS EN 440: Welding consumables: wire electrodes and deposits for gas shielded metal arc welding of non alloy and fine grain steels, classification: (sizes [diameters, reel sizes available], strength and elongation of the weld metal, impact properties of the weld metal, chemical composition of the weld metal, deoxidisers, function of copper coating, protection of bare wires), non-ferrous metals (types, availability, typical sizes), storage (storage, identification, segregation (classification, size) **Shielding gases:** BS EN 439: Welding consumables: shielding gases for arc welding and cutting, effects of shielding gases/gas mixtures (weld pool/arc area protection, heat input, weld geometry, penetration profile, travel speed, mode of metal transfer), applications for shielding gases/gas mixtures (argon, helium, carbon dioxide, argon/carbon dioxide mixtures, argon/oxygen/carbon dioxide mixtures, argon/oxygen mixtures, helium/argon/oxygen/carbon dioxide mixtures), gas pressure requirements, flow rates for applications **WPS:** welding process, parent metal, consumables, pre welding activities (cleaning, edge preparation, assembly, pre-heat), welding parameters, welding positions (EN ISO 6947 – PA, PB, PC, PD, PE, PF, PG), number and arrangement of runs to fully fill/weld joints, electrode sizes for joint thicknesses, mode of metal transfer (dip [short-circuiting, globular, spray, pulse), electrical conditions required (type of current, direct [d.c.], electrode polarity (positive), wire feed speed ranges, voltage (open circuit, arc), control of heat input, shielding gas (type, flow rate) interpass/run cleaning/back gouging methods, post welding activities (spatter removal, wiring brushing, removal of excess weld metal where required), post-weld heat treatment (normalising, stress relief)

Learning outcome
The learner will: 4. be able to evaluate welded joints for welding procedure specification conformance
Assessment criteria
The learner can: 4.1 explain the implications of quality specifications used to determine the **integrity of welded joints** 4.2 **visually evaluate** welded joints for conformance 4.3 **destructively test** joins to evaluate sub-surface for conformance

Range
Integrity of welded joints: classification of defects, quality specification (BS EN 25817 – arc welded joints in steel – guidance on quality levels for imperfections), methods of avoiding, rectification methods **Visually evaluate**: use of visual techniques, lighting, low powered magnification, fillet weld gauges, dye penetrant testing, preparation for inspection, qualitive (defect levels, appearance), quantitive (extent, size, dimensional accuracy) **destructively test**: nick-break (fracture), macroscopic examination (x5) bend tests (butt welds, side, face, root), methods of preparation for testing

Unit 311 MIG welding of materials

Supporting information

Guidance

Regulations: Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to welding process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render PPE provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels)
Hazards and risks: fume (composition, visible particulate, invisible gaseous, risks to health, control measures to reduce exposure, extraction [background, local, natural ventilation, e.g. on-site, air-fed headshields, respirator, breathing apparatus, monitoring the effectiveness of control measures), fire (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), electricity (shock, fire, burns, methods of avoiding shock hazards, emergency procedures in the event of an electric shock, function of protection devices, earthing, workpiece, plant), arc radiation (visible light, infra-red, ultra-violet, effects, protection [PPE, screening, warnings {verbal, notices}]), hot metal (methods of avoiding), hazards associated with the storage, handling and use of pressurised gas cylinders
Welding equipment: power sources (output direct current [d.c.], transformer/rectifier [function, operation, construction {diodes, thyristors} function of smoothing capacitors], inverter [function, operation, construction], generator [fuel driven, function, operation, construction], rated output [duty cycle]), measurement of electrical output and continuity (voltage – use of voltmeter/multimeter, current – use of ammeter/shunts/coils, continuity – use of continuity tester/ohmmeter), relationship between wire feed speed control and welding current, power source characteristics (volt/ampere graph, flat characteristic, constant voltage output), function of induction (principle, effect, fixed, stepped, variable control, leads used (welding [water cooled, air cooled, harness construction], return, earth, construction, rated output [duty cycle]), welding guns/torches (water cooled, air cooled, construction, types [push, pull, reel-on-gun] swan neck design, pistol design, nozzles [dip, spray], contact tip [functions, material, sizes, clearing a burn-back), return clamps (types, clamping mechanisms), wire feed control (variable speed motor, direct control of wire feed rate, indirect control of welding current, solenoid valves [shielding gas, water], relay for electrical power, jog-feed control, gas purge control) ancillary equipment (angle grinders, wire brushes, linishers, hammer and chisel)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 312 TIG welding of materials

URN:	**D/503/0349**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit sets out the requirements for tungsten inert gas (TIG) welding in a modern engineering environment, in terms of what needs to be achieved by the candidate, ie: welding a series of challenging joint configurations across in a wide range of positions that are compliant to welding procedure specifications. The unit is concerned with the technology and practices involved in the application of TIG welding. The unit is demanding in terms of technological content and the complexity of the welding that candidates are expected achieve. The unit is broadly divided into health and safety, welding equipment, welding consumables and the practicalities of producing a welded joint in relation to a welding procedure specification (WPS) and a quality specification

Learning outcome
The learner will: 1. be able to apply safe working practices to TIG welding
Assessment criteria
The learner can: 1.1 apply the health and safety **regulations** relevant to welding 1.2 assess **hazards and risks** in a welding environment and recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards 1.3 follow **safe working practices**

Range
Regulations: Health and Safety at Work etc. Act, COSHH, Management of Health and Safety at Work Regulations, Personal Protective Equipment at Work Regulations, Noise at Work Regulations **Hazards and risks:** fume, fire, electricity, arc radiation, hot metal, hazards associated with the storage, handling and use of pressurised gas cylinders **Safe working practices:** safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance cylinders (safe storage conditions, safe handling/moving, safe use)

Learning outcome
The learner will: 2. be able to prepare equipment for performing TIG welding
Assessment criteria
The learner can: 2.1 list the range of **welding equipment** available 2.2 describe the functions of welding equipment 2.3 prepare the welding equipment for a range of given applications 2.4 prepare the welding **shielding gases** for a range of given applications

Range
Welding equipment: power sources, direct current [d.c.], transformer, transformer/rectifier, inverter, generator, measurement of electrical output and continuity, methods of current regulation, power source characteristics, torches, collet, collet holder, gas lens, electrodes, return clamps, ancillary equipment **Shielding gases:** cylinders, manifold systems, regulators (fixed, single-stage, two-stage), gas flow meters, gas tubes and connectors, use of solenoid valves

Learning outcome
The learner will: 3. be able to perform TIG welding operations to meet welding procedure specification requirements
Assessment criteria
The learner can: 3.1 critically compare **welding consumables** for a range of given applications 3.2 differentiate between welding consumables by their classification 3.3 produce complex welded joints in a range of positions in accordance with welding procedure specification (WPS) parameters 3.4 explain the effects of the **electrical characteristics** of the TIG welding arc 3.5 **restore work areas** to a clean and safe condition on completion of welding operation

Range
Welding consumables: Electrode wires: BS EN 1668: Welding consumables: rods, wires and deposits for tungsten inert gas welding of non alloy and fine grain steels, classification: BS EN 12072: Welding consumables: wire electrodes, wires and rods for arc welding of stainless and heat-resisting steels., classification: (sizes [diameters, lengths], strength and elongation of the weld metal, impact properties of the weld metal, chemical composition of the weld metal, deoxidisers, function of copper coating, protection of bare wires), non-ferrous metals (types, availability, typical sizes), storage (storage, identification, segregation (classification, size) **Shielding gases**: BS EN 439: welding consumables, shielding gases for arc welding and cutting, effects of shielding gases/gas mixtures (weld pool/arc area protection, heat input, weld geometry, penetration profile, travel speed), applications for shielding gases/gas mixtures (argon, helium, argon/helium mixtures, helium/argon mixtures, argon/hydrogen mixtures, nitrogen, argon/nitrogen mixtures), gas pressure requirements, flow rates for applications **WPS:** welding process, parent metal, consumables, pre welding activities (cleaning, edge preparation, assembly, pre-heat), welding parameters, welding positions (EN ISO 6947 – PA, PB, PC, PD, PE, PF, PG), number and arrangement of runs to fully fill/weld joints, electrode sizes for joint thicknesses, electrode, filler wire, electrical conditions required (type of current, alternating [a.c.] direct [d.c.], electrode polarity (negative), welding current ranges, methods of arc ignition (scratch, high frequency, lift start), shielding gas (type, flow rate, pre-weld gas flow, post-weld gas flow), techniques (including autogenous), control of heat input, interpass/run cleaning/back gouging methods, post welding activities (wiring brushing, removal of excess weld metal where required), post-weld heat treatment (normalising, stress relief) **Electrical characteristics:** effects of types of current (a.c./d.c.) and electrode polarity (d.c.: positive, negative) upon: heat input/distribution, electrode, weld bead profile, penetration; methods of a.c. arc stabilisation (including: square wave); welding current features (pulse current, slope in, slope out) voltage (open circuit, arc)

Learning outcome
The learner will: 4. be able to evaluate welded joints for welding procedure specification conformance
Assessment criteria
The learner can: 4.1 explain the implications of quality specifications used to determine the **integrity of welded joints** 4.2 **visually evaluate** welded joints for conformance 4.3 prepare and **destructively test** joins to evaluate sub-surface for conformance

Range
Integrity of welded joints: classification of defects, quality specification (BS EN 25817 – arc welded joints in steel – guidance on quality levels for imperfections), methods of avoiding, rectification methods **Visually evaluate:** use of visual techniques, lighting, low powered magnification, fillet weld gauges, dye penetrant testing, preparation for inspection, qualitive (defect levels, appearance), quantitive (extent, size, dimensional accuracy) **Destructively test:** nick-break (fracture), macroscopic examination (x5) bend tests (butt welds, side, face, root), methods of preparation for testing

Unit 312 TIG welding of materials

Supporting information

Guidance

Regulations: Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to welding process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render PPE provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels)
Hazards and risks: fume (composition, visible particulate, invisible gaseous, risks to health, control measures to reduce exposure, extraction [background, local, natural ventilation, e.g. on-site, air-fed headshields, respirator, breathing apparatus, monitoring the effectiveness of control measures), fire (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), electricity (shock, fire, burns, methods of avoiding shock hazards, emergency procedures in the event of an electric shock, function of protection devices, earthing, workpiece, plant), arc radiation (visible light, infra-red, ultra-violet, effects, protection [Personal Protective Equipment (PPE), screening, warnings {verbal, notices}]), hot metal (methods of avoiding), hazards associated with the storage, handling and use of pressurised gas cylinders
Welding equipment: power sources (output [alternating current [a.c.], direct current [d.c.], transformer [function, winding ratio, input/output ratio, construction], transformer/rectifier [function, operation, construction {diodes, thyristors} function of smoothing capacitors], inverter [function, operation, construction], generator [fuel driven, motor driven, function, operation, construction], rated output [duty cycle]), measurement of electrical output and continuity (voltage – use of voltmeter/multi-meter, current – use of ammeter/shunts/coils, continuity – use of continuity tester/ohmmeter), methods of current regulation (tapped reactor, moving core, moving coil, moving shunt, saturable reactor, variable resistance), power source characteristics (volt/ampere graph, drooping characteristic, constant current output), leads used (welding [water cooled, air cooled, harness] return, earth, construction, rated output [duty cycle]), torches (types, water cooled air cooled, pencil, construction, connections, contactor/switch, foot pedal/amptrol, back caps [long. medium, short, applications], nozzles [long. medium, short, applications], collet, collet holder, gas lens [construction, effects, benefits, limitations, applications), electrodes (thoriated, zironiated, ceriated, lananathed, compositions, sizes, identification, applications, preparation [grinding: techniques, equipment, health and safety implications {dust, particulates, extraction, radioactivity for thoriated}), return clamps (types, clamping mechanisms), ancillary equipment (angle grinders, linishers, wire brushes, oxide removal, degreasers)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 313 Platework fabrication of materials

URN:	**F/503/0375**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and the underlying process technology required for the fabrication of platework, including bolted and welded fabrications, developed platework, tubular node connection, boxed girder construction and pressure vessels. It covers health and safety aspects of fabrication, necessary planning and template development lay outs, marking out, cutting and forming and joining for the production of platework fabrications.

Learning outcome
The learner will: 1. be able to apply safe working practices to platework fabrication
Assessment criteria
The learner can: 1.1 apply the health and safety **regulations** relevant to welding 1.2 assess **hazards and risks** associated with hot working and recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards 1.3 follow safe working practices

Range
Regulations: Health and Safety at Work etc. Act, COSHH, Management of Health and Safety at Work Regulations, Personal Protective Equipment at Work Regulations, Noise at Work Regulations **Hazards and risks:** hot working (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), arc radiation (visible light, infra-red, ultra-violet, effects, protection (Personal Protective Equipment (PPE), screening, warnings [verbal, notices], hot metal/slag from (thermal cutting process, welding processes, grinding) **Safe working practices:** thermal cutting and welding: safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance

Learning outcome
The learner will: 2. be able to prepare equipment for platework cutting
Assessment criteria
The learner can: 2.1 prepare fabrication **cutting equipment** for a range of given applications 2.2 prepare **thermal cutting equipment** for a range of given applications 2.3 **critically compare** methods of cutting thick plate using thermal and mechanical methods

Range
Cutting equipment: drills (twist drill nomenclature, drilling machines [pedestal, bench, radial arm, portable, hand, electric power, pneumatic]), tank cutters, hole saws, rotary shears (portable shears, nibblers [shear type, punch type, combination shears]), guillotines (mechanical, pneumatic, CNC control, back stops, front stops, guides), universal shearing machine, power punch (including CNC control), cold sawing (circular saws, band saws [vertical, horizontal], reciprocating, friction), portable angle grinders/sanders **Thermal cutting equipment:** oxy-fuel gas cutting (principle, manual cutting of plate and sections, machine cutting of plate, reason for 'three-point' support of plate, control of distortion), electric arc process (plasma-arc, laser cutting) **Critically compare:** cost of equipment, suitability, versatility, accuracy, quality of cut

Learning outcome
The learner will: 3. be able to prepare the equipment for platework forming
Assessment criteria
The learner can: 3.1 prepare fabrication **forming equipment** for a range of given applications 3.2 **critically compare methods of forming** thick plate mechanical methods

Range
Forming equipment: rolling machines (pyramid type, pinch type [three and four pinch], mechanical, angle-ring bending, section rolls), folding machines (horizontal, vertical, double arm folder) press brake (tooling [dies, forming tools], mechanical, electro-hydraulic, up-stroking, downstroking, CNC control), fly press (tooling [dies, forming tools]); methods of spring-back control for bending and folding, tooling design for air bending techniques, specialised tooling for press brake, use of polyurethane block for use with double arm folder, methods of pre-setting plate edges for rolling **Methods of forming**: cylinders, methods of conical and helical rolling, methods of rolling sectional material, stops, guides fitted to aid production; guarding (interlocking devices, fail safe circuits, light guards, gates) **Critically compare**: cost of equipment, suitability, versatility, accuracy, quality of finish

Learning outcome
The learner will: 4. be able to produce fabrications using platework techniques
Assessment criteria
The learner can: 4.1 perform **fabrication assembly** operations to produce square, rectangular and circular forms from thick plate to ± 2.0 mm tolerance 4.2 perform **joining** operations to produce fabricated platework assemblies to ± 2.0 mm tolerance 4.3 **restore work areas** to a clean and safe condition on completion of the operation

Range

Fabrication assembly: transfer of patterns to metal, use of level surfaces for assembling, methods used for alignment (strong backs and wedges, draw cleats/lugs, draw bolts), methods of avoiding twist, methods of controlling distortion, use of stays to maintain shape, use of jigs and fixtures and clamping devices, use of tack bolts and tack welds, care and use of lifting tackle, importance of close contact surfaces, removal of all temporary tack weld and the reinstatement of a good surface.

Joining:

thermal joining techniques: manual metal arc welding, MIG welding, procedures, settings and consumables to produce sound and effective tacking, interpret weld symbols to BS EN 22553, range of joint configuration used in thick platework ('open' square corner joints, lap fillets, tee fillets, cruciform joints, single and double vee butts, welding techniques (single and multi-run, stringer beads and weaving), joint design and welding sequence (weld strength, distortion control, weld economics), jigs and fixtures to aid assembly; manipulators, positioners, rotators to facilitate welding and control distortion/ maintain dimensional accuracy;

mechanical methods of joining: bolting (bolts: [black bolts, high strength friction grip bolts, close tolerance bolts, fitted bolts], bolting requirements [cleanliness of contact surfaces, correct tensioning, hole clearance, tolerances, alignment of holes])

dimensional accuracy: function of a datum line or surface, measuring equipment to check dimensional accuracy, specific tolerances, methods of checking accuracy (dimensions, alignment, form, squareness, freedom from twist and distortion, surface condition)

Unit 313 Platework fabrication of materials

Supporting information

Guidance

Regulations: Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to fabrication process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render Personal Protective Equipment (PPE) provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 314 Sheet metalwork fabrication of materials

URN:	**A/503/0374**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and the underlying process technology required for the fabrication of thin plate, including developed thin plate components, ducting, double curvature work and light sheetmetal fabrication. It covers the health and safety aspects of fabrication work, cutting and forming of sheet metal and the production of fabrications using sheet metalwork techniques, including joining by soldering (soft and hard) and resistance welding (spot, seam and projection)

Learning outcome
The learner will: 1. be able to apply safe working practices to sheet metalwork fabrication
Assessment criteria
The learner can: 1.1 apply the health and safety **regulations** relevant to welding 1.2 assess **hazards and risks** associated with hot working and recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards 1.3 follow safe working practices

Range
Regulations: Health and Safety at Work etc. Act, COSHH, Management of Health and Safety at Work Regulations, Personal Protective Equipment at Work Regulations, Noise at Work Regulations **Hazards and risks:** hot working (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers) **Safe working practices:** safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance

Learning outcome
The learner will: 2. be able to prepare and use equipment and tools for sheetmetal cutting
Assessment criteria
The learner can: 2.1 prepare fabrication **cutting equipment** for a range of given applications 2.2 prepare fabrication **cutting tools** for a range of given applications

Range
Cutting equipment: drills (twist drill nomenclature, drilling machines [pedestal, bench, portable, hand, electric power, pneumatic]), trepanning, tank cutters, hole saws, rotary shears (portable shears, nibblers [shear type, punch type, combination shears]), guillotines (treadle, mechanical, pneumatic, CNC control, back stops, front stops, guides), universal shearing machine, fly press, power punch (including CNC control), portable angle grinders/sanders **Cutting tools**: hand shears (straight, left hand, right hand, universal), bench shears (hand-lever, throatless, corrugated), tinman's hand-level punch

Learning outcome
The learner will: 3. be able to prepare the equipment and tools for sheetmetal forming
Assessment criteria
The learner can: 3.1 prepare fabrication **forming equipment** for a range of given applications 3.2 prepare fabrication **forming tools** for a range of given applications

Range
Forming equipment: jennys (tooling), rolling machines (pyramid type, pinch type, slip rolls, handoperated, mechanical, cone rolls, angle-ring bending), folding machines (box and pan, universal swing-beam, angle bending, simple bench mounted bending), press brake (tooling [dies, forming tools], mechanical, electro-hydraulic, up-stroking, down-stroking, CNC control), fly press (tooling [dies, forming tools]), stretch forming/shrinking machines, vibratory forming machines **Forming tools**: types and sizes of hammers, planishing hammers, stretching hammers, blocking hammers, hollowing hammers, mallets, wedge shaped mallets, wooden blocks, sand bags, range of bench stakes

Learning outcome
The learner will: 4. be able to produce fabrications using sheet metalwork techniques
Assessment criteria
The learner can: 4.1 perform **fabrication techniques** to produce square, rectangular, cylindrical, conical forms (including offsets) and transition pieces from sheetmetal to ± 2.0 mm tolerance 4.2 perform **joining** operations to produce fabricated sheetmetal assemblies to ± 2.0 mm tolerance 4.3 evaluate fabrications for **dimensional accuracy** and fitness for purpose 4.4 **restore work areas** to a clean and safe condition on completion

Range
Fabrication techniques: transfer of patterns to metal/plastics, stiffening techniques (swaging, beading, wired edges [including false], folds, flanging), forms (square, rectangular, cylindrical, conical: offset: square, rectangular, cylindrical, conical; boxed, curved panels, double curvatures, segmental bends), techniques used to produce transition pieces (square to round, round to square, breeches), stretching and shrinking techniques (hand forming, machine forming), hand forming techniques (hollowing, raising, planishing, flanging, double curvature, 'split and weld' methods), wheeling techniques **Joining:** methods of fabrication assembly, use of joints, including self-secured, soldering and hard solder , types of fluxes, heat sources, braze welding, resistance welding processes **Dimensional accuracy:** function of a datum line or surface, measuring equipment to check dimensional accuracy, specific tolerances, methods of checking accuracy (dimensions, alignment, form, squareness, freedom from twist and distortion, surface condition)

Unit 314 Sheet metalwork fabrication of materials

Supporting information

Guidance

Regulations: Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to fabrication process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render Personal Protective Equipment (PPE) provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels)

Joining: methods of fabrication assembly (holding methods, clamping, distortion control methods), use of joints, including self-secured (lap, grooved seam, lock-formed, Pittsburgh lock, panned down, knocked-up, jointing allowances, junctions that require notched corners), soldering and hard solder (brazing) techniques (principles of soldering, benefits and limitations, joint design, preparing the joint, cleaning the joint, types of soft solder [melting points, applications], types of fluxes, heat sources [copper bit, flame, hot plate, furnace, induction, resistance, dip], cleaning the soldered joint), braze welding, resistance welding processes (spot, seam, projection, principles of resistance welding [power source, generation of heat, electrodes [sizes, types, functions, methods of cooling, electrode arms)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

Unit 315 Fabrication and erection of structural steelwork

URN:	**J/503/0376**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and the underlying process technology required for the fabrication and erection of structural steelwork. The unit is broadly divided into structural materials, fixtures and fastenings, structural fabrication, site work and safe working practices during fabrication and on site.

Learning outcome
The learner will: 1. be able to apply safe working practices to steelwork fabrication and erection
Assessment criteria
The learner can: 1.1 apply the health and safety **regulations** relevant to welding 1.2 assess **hazards and risks** associated with hot working and recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards 1.3 follow **safe working practices**

Range
Regulations: Health and Safety at Work etc. Act, COSHH, Management of Health and Safety at Work Regulations, Personal Protective Equipment at Work Regulations, Noise at Work Regulations **Hazards and risks:** hot working (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), arc radiation (visible light, infra-red, ultra-violet, effects, protection (PPE, screening, warnings [verbal, notices], hot metal/slag from (thermal cutting process, welding processes, grinding) **Safe working practices:** thermal cutting and welding: safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance

Learning outcome
The learner will: 2. understand how to prepare structural materials for steelwork fabrication
Assessment criteria
The learner can: 2.1 critically compare **structural steels** used in fabrication engineering 2.2 explain the commercial **forms of supply** of materials available 2.3 explain the forms of **pre-fabricated sections** and **fixtures** commercially available

Range
Structural steels: low carbon steel, low alloy steels, high yield alloy steels, weather resistant steels (WR 55 grades); applications, limitations, load bearing capabilities, ease of fabrication (marking out, cutting, joining), density; application for: (access) platforms, decking and walkways, stairways and hooped ladders, handrailings; (support) saddles, brackets and cleats, frameworks, bracings and ties **Forms of supply:** sections (rolled steel angle [RSA] {equal leg, unequal leg}, universal beam [UB], universal column [UC], rolled steel channel [RSC], rolled steel joist [RSJ], tee bar) hollow sections (circular hollow section [CHS], rectangular hollow section [RHS]) plates (plain, non-slip [durbar and chequer], expanded, pierced and punched), flat bars **Pre-fabricated sections:** plate birders, box girders, lattice girders, castellated beams, cambered beams, laced stanchions, battened stanchions, portal frames **Fixtures:** cleats (beam to beam connections, beam to column connections), columns (base plates, end plates, splice plates), gusset plates

Learning outcome
The learner will: 3. be able to perform marking out and cutting operations on structural materials
Assessment criteria
The learner can: 3.1 perform **marking out** operations on structural steelwork to meet specification 3.2 perform **cutting** operations on structural material to meet specification 3.3 **critically compare** methods of cutting structural steelwork using thermal and mechanical methods

Range
Marking out: directly onto steelwork, using templates (types: plate, sections, cleats; application of templates: box, battened, part), datum, centre lines, set out points, avoidance of cumulative error in marking out by the avoidance of string dimensions, non-slip plate (chequer) avoiding 'wrong hand' or 'mirror image' errors, setting out a camber, derive the shapes of bolted gusset plates from standard hole pitch and edge distance **Cutting:** **mechanical**: drills, tank cutters, hole saws, rotary shears, guillotines, universal shearing machine, power punch, cold, portable angle grinders/sanders, reasons for reaming punched holes **thermal**: oxy-fuel gas cutting, electric arc process **Critically compare:** cost of equipment, suitability, versatility, accuracy, quality of cut

Learning outcome
The learner will: 4. be able to produce fabricated steelwork structures
Assessment criteria
The learner can: 4.1 perform **fabrication assembly** operations to produce welded beam to beam connection from structural steelwork to ± 2.0 mm tolerance 4.2 explain the form and applications of **joining methods** used in structural steelwork 4.3 evaluate fabrications for **dimensional accuracy** and fitness for purpose 4.4 perform a trial **erection** of fabricated sections 4.5 tension bolts to the recommended torque 4.6 set out a roof truss and determine which members are struts and which are ties 4.7 **restore work areas** to a clean and safe condition on completion

Range
Fabrication assembly: forming processes (plate rolls [pinch, pyramid], section rolls, beam bender), use of level surfaces for assembling, methods used for alignment (strong backs and wedges, draw cleats/lugs, draw bolts), methods of avoiding twist, methods of controlling distortion, use of stays to maintain shape, use of jigs and fixtures and clamping devices, use of tack bolts and tack welds, care and use of lifting tackle, importance of close contact surfaces, removal of all temporary tack weld and the reinstatement of a good surface, reasons for part assemblies, trial erections and sub-assemblies **Joining methods:** **thermal joining techniques***:* manual metal arc welding, MIG welding, procedures, settings and consumables to produce sound and effective tacking, interpret weld symbols to BS EN 22553, range of joint configuration used in thick steelwork ('open' square corner joints, lap fillets, tee fillets, cruciform joints, single and double vee butts, welding techniques (single and multi-run, stringer beads and weaving), joint design and welding sequence (weld strength, distortion control, weld

economics), jigs and fixtures to aid assembly; manipulators, positioners, rotators to facilitate welding and control distortion/ maintain dimensional accuracy (restraint, welding sequence, presetting) methods of rectifying excessive distortion in welded structures (mechanical force, heat)
mechanical methods of joining*:* bolting – bolts (black, high tensile, high strength friction grip [HSFG], load indicating, close tolerance, torshear), washers (plain, hardened steel, load indicating, taper, tab, anti-vibration), shear connectors, factors that contribute to the quality of bolted connections (cleanliness of surfaces in contact, alignment of holes, correct tensioning [torque wrench, impact wrench]) **Dimensional accuracy:** function of a datum line or surface, measuring equipment to check dimensional accuracy, specific tolerances, methods of checking accuracy (dimensions, alignment, form, squareness, freedom from twist and distortion, surface condition)
Erection: levelling steelwork and steelwork bases, plumbing vertical members, checking alignment, handle, move and lift structural sections safely, use of ancillary equipment used on site to lift, move or adjust the position of steelwork (pulleys, block and tackle, pull-lifts, hydraulic jacks, podger spanners, drifts, wedges, temporary props and bracings, falsework, modification techniques to steelwork on site (misaligned holes, incorrect sized members, maximum thickness of packings, fouling existing steelwork or services), consequences of cutting holes in beams to facilitate service piping or ducting

Unit 315 Fabrication and erection of structural steelwork

Supporting information

Guidance

Regulations: Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to fabrication process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render Personal Protective Equipment (PPE) provided as protection,ineffective or unsafe]), Noise at Work Regulations (action levels)

Cutting:

Mechanical: drills (twist drill nomenclature, drilling machines [pedestal, bench, radial arm, portable, hand, electric power, pneumatic]), tank cutters, hole saws, rotary shears (portable shears, nibblers [shear type, punch type, combination shears]), guillotines (mechanical, pneumatic, CNC control, back stops, front stops, guides), universal shearing machine, power punch (including CNC control), cold sawing (circular saws, band saws [vertical, horizontal], reciprocating, friction), portable angle grinders/sanders, reasons for reaming punched holes *Thermal:* oxy-fuel gas cutting (principle, manual cutting of plate and sections, machine cutting of plate, reason for 'three-point' support of plate, control of distortion), electric arc process (plasmaarc, laser cutting)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 316 Pattern development for fabrication

URN:	**Y/503/0379**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and the underlying process technology required for obtaining flat layouts of 3D forms that can be used for producing templates to mark out the material for fabrication to the required form.

Learning outcome
The learner will: 1. be able to determine lines of intersection
Assessment criteria
The learner can: 1.1 determine lines of intersection using projection 1.2 determine lines of intersection using the principle of the **common central sphere** 1.3 determine lines of intersection using the method of cutting planes 1.4 determine **joint lines of ducts**

Range
Common central sphere: right cylindrical branches onto transformer pieces, oblique cones to right cones, oblique cones to oblique cones, inclined right cylinder branches on right cones on and off centre, cylindrical and rectangular branch intersections onto rectangular hoppers, cylindrical and rectangular branches on spherical, doomed or dished ends **Joint lines of ducts:** where the centre lines lie on centre and in the same plane, a right angled tee piece of equal cross-section, a right angled tee piece of unequal cross-section, junctions of three cylinders

Learning outcome
The learner will: 2. be able to develop patterns using parallel line techniques
Assessment criteria
The learner can: 2.1 apply the **parallel line** method of pattern development 2.2 apply the parallel line method of pattern development to **complex forms**

Range
Parallel line: segmental bends (right cylindrical and oblique), square or rectangular ducts cut obliquely, right cylinders cut obliquely, oblique cylinders cut obliquely **Complex forms:** branch pipes on to boiler, shells, dished ends and domed ends, cylindrical branches onto right and cylindrical segmental bends to include interpenetration of the branch pipe, square and rectangle branches onto right and oblique cones, swan neck transition pieces, rectangle to rectangle in angular planes, transition pieces of apparently twisted sides with openings at right angles and different levels

Learning outcome
The learner will: 3. be able to develop patterns using radial line techniques
Assessment criteria
The learner can: 3.1 apply the **radial line** method of pattern development 3.2 apply the radial line method of pattern development to **complex forms**

Range
Radial line: right cones and frusta, oblique cones and frusta, oblique cones cut by a flat surface, oblique cones cut by a curved surface, two way breeches piece made from right cones, two-way breeches piece made from oblique cones **Complex forms:** right cones in multiple connections of right cylinders and right cones, breeches pieces involving oblique cones, tapered segmental bends ('lobster back bends')

Learning outcome
The learner will: 4. be able to develop patterns using triangulation
Assessment criteria
The learner can: 4.1 apply the **triangulation** method of pattern development 4.2 apply the triangulation method of pattern development to **complex forms**

Range
Triangulation: hoppers based on square or rectangular based pyramids, square or rectangle to round transformers, round to square or rectangle transformers, transformers and hoppers on and off centre, between parallel planes, transformers and hoppers between parallel and non-parallel planes, right cylinders, oblique cylinders, right cones, oblique cones **Complex forms:** rectangular to round off-set transformers on a roof apex, breeches pieces branching from cylindrical main to equal and unequal diameter ducts, rectangular kinked sided hoppers (kinked to produce maximum volume, kinked to produce minimum volume), spiral blade segments by triangulation

Learning outcome
The learner will: 5. be able to produce templates of developed patterns
Assessment criteria
The learner can: 5.1 apply pattern development techniques to prepare **templates** for the marking out of a fabrication 5.2 perform **calculations** to produce dimensions for checking templates 5.3 review and revise layouts to accommodate **material thickness** 5.4 **restore work areas** to clean and safe condition on completion of the operation

Range
Templates: purpose, means of checking, types and applications, use of CAD packages, specialist packages, template production techniques, tools used, materials, information contained on templates, drilling requirements, cutting instructions, assembly reference mark, datum[s] **Calculations:** length of cylinder (πd), angle at the apex of a developed right cone/frustra pattern/half pattern, use of triangles, use of trigonometry, application of the neutral line **Material thickness:** methods of marking out from templates, including: external forms, internal forms, holes, back marks, pitch, use of datums; determine modified set-outs to accommodate plate thickness (application of the neutral line), use of instructions added to templates and patterns produced by the triangulation method enabling them to be used effectively

Unit 316 Pattern development for fabrication

Supporting information

Guidance

Templates: purpose (avoid repetitive measurements, avoid unnecessary material wastage, act as a guide to cutting process[es], means of checking [lengths, angles, shapes, forms], precise method of marking hole positions, reliable means of assuring repeatability), types and applications (pattern development, internal, external, roof truss, gusset, back-marks, hole, bushed, box), use of CAD packages (standard CAD [eg AutoCAD], specialist packages [pattern development software]), template production techniques (template shop/loft, setting out floor), tools used (saws, planes, drills, marking gauge, steel rule, compasses, dividers, trammels, protractor, engineers square, flat (plate) square, straight edge, hammers, centre/dot/nipple punches, chalk line and soft chalk, French chalk, coloured and indelible pencils/crayons), materials (template paper, hardboard, timber, sheetmetal, steel plate), information contained on templates (job/contract number, size/thickness of material, steel section and length, quantity required, bending/folding instructions, orientation [eg 'this side up', 'left side', 'right hand', etc], drilling requirements, cutting instructions, assembly reference mark, datum[s]

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

Unit 317 Maintenance of machine systems

URN:	**R/503/0381**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and the underlying process technology required for the routine maintenance, repair and modifications to all types of manufacturing machine systems. This consists of machine tools: drills, lathes, millers, grinders (precision and off-hand), power saws and boring machines. It includes the mechanical and fluid power features of NC and CNC machines and robots, but not the control systems. It also covers extrusion equipment and presses; filling, bottling and packaging plant and conveying and transfer equipment (but not fork lift trucks and cranes or other mobile devices). Candidates will not usually be expected to know the constructional features of the components of hydraulic, pneumatic or refrigeration systems, or other specialist equipment, only the function of each. However they should be able to apply general engineering principles to identify the causes of a fault and safely carry out any replacements needed to bring the equipment back on line.

Learning outcome
The learner will: 1. understand the function of machine systems
Assessment criteria
The learner can: 1.1 explain the **structural requirements** of a range of common machine systems 1.2 explain the importance of **alignment** in machine systems and methods to achieve it 1.3 explain the methods used to achieve **rotational movement** 1.4 explain the methods used to achieve **linear movement** 1.5 explain the methods used to **change speeds** 1.6 explain the methods used to **control feed speeds** 1.7 classify **coolants and lubricants** applicable to machine systems 1.8 explain the application of **hydraulic and pneumatic systems** to the operation and control of machine systems

Range
Structural requirements: strength, rigidity, stability, control of movement, materials (cast iron, cast steel, steel plate), structures (box column, rib and box bed, fabricated base) **Alignment:** **slideways**: flat, vee, dovetail, cylindrical, comparison of their capabilities, main features, accuracy of movement, means of adjustment, lubrication, protection, friction related to applied loads and surface finish **typical checks**: coaxial alignment between main spindle axis, coaxial alignment between two spindles, alignment of spindle to guideway, squareness of slideways movement, concentricity and end float of spindle, squareness of planes to spindle, setting of guards, stops and automatic safety cut-outs bearings: plain bush (radial, radial and axial) ball (radial, axial, radial and axial) roller (radial, axial, radial and axial) **methods of alignment**: standard tests, straight edge, precision level, autocollimator, reflector and laser, roundness measuring machine **Rotational movement:** flat belts, vee belts, toothed belts, chain drives, correct tensioning belts and chains, friction clutches, dog clutches, gears: worm and wheel, bevel gear, spur, gear nomenclature, gear materials, non-ferrous alloys, calculate simple and compound gear ratios, relationship between torque and power transmitted and the loads on gear teeth, gear box layouts and means of selecting different output speeds, gear defects, hydraulic actuators **Linear movement:** screw and nut (vee, square [including multi-start], ACME, relationship between the lead of a screw and the motion transmitted, engaging screw drives [fixed nuts, split nuts]), rack and pinion, recirculating ball-screw, crank and connecting rod, cams (lift, dwell and types of motion produced) hydraulic actuator **Change speeds:** sliding gears, cone pulleys, clutch operated, infinitely variable, electrical/electronic **Control feed speeds:** sliding gears (Norton gearbox), leadscrew and nut, hydraulic drives **Coolants and lubricants:** types of coolant pump, strainers and

filtration, filters, lubrication of headstock/gearbox assemblies of splash and pressurised feed
Hydraulic and pneumatic systems: hydraulic reservoirs and pumps, actuators (rotary and linear), valves and the methods of operation, pneumatic/hydraulic pressure intensifiers, pneumatic silencers, methods of providing clean, dry air to a machine tool from air mains

Learning outcome
The learner will: 2. be able to prepare for maintenance of machine systems
Assessment criteria
The learner can: 2.1 evaluate type and extent of work to be carried out 2.2 develop a **plan** that includes assessing any risks, securing the area and isolating equipment 2.3 estimate the **tools, materials, equipment and information** that will be needed 2.4 set-up to carry out the maintenance activity

Range
Plan: to include - emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system, procedures for de-pressurising systems and testing them to be in a safe condition, procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination, fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, electrical installations and testing of equipment and appliances according to the IEE and Electricity at Work Regulations: methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities

Learning outcome
The learner will: 3. be able to perform inspections and maintenance tasks
Assessment criteria
The learner can: 3.1 perform **dismantling and assembling** operations to ensure effective operation on completion 3.2 perform **inspections of components** and draw conclusions **regarding** its repair or replacement

Range
Dismantling and assembling: to allow for reassembly, identification of parts (layout of parts), reassemble in correct order for recommissioning of the system. Testing of parts and system to establish effectiveness of repair/replacement.

Learning outcome
The learner will: 4. be able to reinstate machine systems
Assessment criteria
The learner can: 4.1 perform **re-commissioning** operations to brings system on-line and adjust as required until the working requirements have been fully met 4.2 **restore work areas** to a clean and safe condition on completion of maintenance and re-commissioning

Range
Re-commissioning: bring system back on-line and test/trial run to establish full functionality

Unit 317 Maintenance of machine systems

Supporting information

Guidance

Rotational movement: flat belts, vee belts (single and matched sets) toothed belts, chain drives, correct tensioning belts and chains, friction clutches, dog clutches, gears: worm and wheel, bevel gear, spur, gear nomenclature (addendum, dedendum, clearance, diametral pitch, circular pitch, module), gear materials (cast iron alloy steels [including surface hardened], non-ferrous alloys [brass and bronze derivations], plastics), calculate simple and compound gear ratios, relationship between torque and power transmitted and the loads on gear teeth, gear box layouts and means of selecting different output speeds, gear defects (pitting, flaking, scoring and scuffing, likely causes); hydraulic actuators
Hydraulic and pneumatic systems: hydraulic reservoirs and pumps, actuators (rotary and linear), valves and the methods of operation (mechanical, pilot, solenoid, directional control, flow control, pressure control, uni-directional), pneumatic/hydraulic pressure intensifiers, pneumatic silencers, methods of providing clean, dry air to a machine tool from air mains
Plan: to include- emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system (isolating switches, removal of fuses, closing and 'locking off' of valves, removal of valves and blanking of pipes) procedures for de-pressurising systems and testing them to be in a safe condition, procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination (including any special Personal Protective Equipment (PPE) such as breathing apparatus), fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities
Tools, materials, equipment and information: specific implications of statutory regulations, codes of practice related to installing or maintaining systems, special considerations as prescribed by the manufacturer Dismantling and assembling: make identification (witness) marks on components so that they can be correctly reassembled/re-aligned, label and safely store parts that have been removed methods used to avoid distortion and damage to, or leakage from, pipework (disconnecting, aligning, connecting), precautions needed to avoid danger from, or damage to, components whilst installing, dismantling and assembling from: misalignment, use of wrong tools, excessive force, uncontrolled release of springs, scoring of surfaces; protection of dismantled components from contamination (blanking off open ports, use of correct cleaning agents and lint-free cloths), sequence for tightening bolts and applying specified torque, application of lubrication to seals, precautions to be taken when refilling systems with specified oils, methods of safely bleeding systems to eliminate air locks and avoid spillage, how to remove; fit and replace: bearings, seals, springs, circlips, keys, brushes; prepare or

make new gaskets or joints (including preparation of surfaces and/or housings) and repack glands Inspections: bearing surfaces, erosion and pitting, split or worn seals, signs of overheating (discolouration); condition of filters for: signs of metallic or other particles, indications of emulsions or oil deterioration, correctly labelling re-built components for replacement in a system or returning to stores, checking oil for signs of oxidation and acidity, bench testing re-assembled components, pressure testing pipework and pressure vessels, presenting information that can be used to appraise the outcome of a maintenance or installation activity

Re-commissioning: refilling or recharging systems, opening up the system to the sources of pressure, methods to safely drain, bleed and purge systems to avoid undue leakage or contamination, set up and test interlocks, sensors and limit switches, sequence of bringing systems back to the specified working conditions (removal of protective covers and blanks, opening appropriate valves or switches, operating the system under gradually increasing pressures or loads, state the methods of securing pipework and safety fittings (guards, handrails), methods of replacing insulation, lagging and other protective coverings, applying identification markings to different parts of a system (colour identification of pipework to BS 1710, using appropriate and approved codings for electrical connections and components)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 318 Maintenance of utility systems

URN:	**D/503/0383**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and the underlying process technology required for the maintenance and/or installation requirements of utilities systems needed for industrial purposes. These include compressed air, electricity and steam (but not boilers). The unit will cover system layouts and their main components, the selection and use of appropriate tools and equipment, the procedures and techniques involved with safely installing and isolating systems, removing or replacing components, commissioning, or restoring, a system to a fully operative condition.

Learning outcome
The learner will: 1. understand the function of utility systems
Assessment criteria
The learner can: 1.1 explain the nature and behaviour of **air** under pressure 1.2 differentiate between the different types of air **compressor** and their performance 1.3 explain the features of **pipework and systems** used for supplying compressed air 1.4 explain the nature and properties of **steam** under pressure 1.5 explain the nature and effects of **electricity** 1.6 explain the applications of **electrical systems**

Range
Air: compressed air hazards, relationships between force, area and pressure and how to use them for calculations, relationships between volume, temperature and pressure and how to use them for calculations, relationships between volume, temperature and pressure and how to use them for calculations, relative humidity and its relationship with air pressure and temperature **Compressor**: performance capability in terms of pressure and volumetric output of free air delivered (FAD): piston types – single stage and multi-stage, screw, centrifugal, basic component parts and layout of each type of compressor, intercoolers and aftercoolers construction and layout, air receivers (function, associated essential equipment fitted to receivers, legal requirements for installation, inspection and testing), air dryers (absorption, adsorption, refrigerant types [super dryers]) **Pipework and systems** **Air**: factors affecting pressure drops and flow rates and the relationships between these and pipe sizes, how information can be obtained by the use of nomograms, pipework materials and applications, methods of connecting and supporting different forms of pipework with respect to access and vibration, mains layouts – methods of isolating, draining (including slope) and 'take off' arrangements, the costs associated with air leaks, service units – filters, pressure regulators and lubricators **Steam:** hazards, heat transfer principles and the applications to heat exchangers, calculation of heat flows (temperature difference x surface area x heat transfer coefficient), heat content of steam, relationships between pressure and temperature (use of steam tables), types of steam and applications (saturated, dry saturated, superheated) **Pipework and systems – steam:** materials and applications, connecting methods for HP and LP systems, flanged joints (screwed and welded), pipe support systems to allow for expansion and vibration, jointing materials (fibre based, corrugated metallic and spiral wound), lagging and insulation, causes and prevention of water hammer, drainage methods, manual cocks and steam traps, functions and main features of drain coolers, condensers and condensate return systems, types and main features of steam valves used for (system isolation and safety, pressure reduction and control, flow control), uses of LP and exhaust steam for fan heaters, calorifiers and economisers, **Electricity:** meaning of common electrical terms and state their units and relationships as applicable (voltage, current and resistance [Ohm's law], power, voltage and current [relationship between electrical and mechanical power], heating and magnetic effects, a.c. and d.c. voltages differences and applications) **Electrical systems**: electrical supply systems and their applications and limitations (supply from grid, 3 phase 4 wire, single phase, 12V and 24V requirements and uses), types and uses of transformers (fixed and portable), isolating and control methods (isolators and circuit breakers, switchgear and distribution panels, fuses, no-volt release and residual current detectors), methods of electrical distribution, their applications and limitations (cable forms and selection [size, insulation, including IMS and screened], cable protection methods including conduit and armoured, bus bars, extension reels [heating effects on coiled cable]), meters for testing continuity, voltage and resistance

Learning outcome
The learner will: 2. be able to prepare for maintenance of utility systems
Assessment criteria
The learner can: 2.1 evaluate type and extent of work to be carried out 2.2 develop a **plan** that includes assessing any risks, securing the area and isolating equipment 2.3 estimate the **tools, materials, equipment and information** that will be needed 2.4 set-up to carry out the maintenance activity

Range
Plan: to include - emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system, procedures for de-pressurising systems and testing them to be in a safe condition, procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination, fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, electrical installations and testing of equipment and appliances according to the IEE and Electricity at Work Regulations: methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities

Learning outcome
The learner will: 3. be able to perform inspections and maintenance tasks
Assessment criteria
The learner can: 3.1 perform **dismantling and assembling** operations to ensure effective operation on completion 3.2 perform **inspections** of components and draw conclusions regarding its repair or replacement

Range
Dismantling and assembling: to allow for reassembly, identification of parts (layout of parts), reassemble in correct order for re-commissioning of the system. Testing of parts and system to establish effectiveness of repair/replacement. **Inspections:** bearing surfaces, erosion and pitting, split or worn seals, signs of overheating (discolouration); condition of filters for: signs of metallic or other particles, indications of emulsions or oil deterioration, correctly labelling re-built components for replacement in a system or returning to stores, checking oil for signs of oxidation and acidity, bench testing re-assembled components, pressure testing pipework and pressure vessels, presenting information that can be used to appraise the outcome of a maintenance or installation activity, methods of testing electrical equipment/circuitry for insulation and continuity

Learning outcome
The learner will: 4. be able to reinstate utility systems
Assessment criteria
The learner can: 4.1 perform **re-commissioning** operations to brings system on-line and adjust as required until the working requirements have been fully met 4.2 **restore work areas** to a clean and safe condition on completion of maintenance and re-commissioning

Range
Re-commissioning: bring system back on-line and test/trial run to establish full functionality

Unit 318 Maintenance of utility systems

Supporting information

Guidance

Plan: to include- emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system (isolating switches, removal of fuses, closing and 'locking off' of valves, removal of valves and blanking of pipes) procedures for de-pressurising systems and testing them to be in a safe condition, procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination (including any special Personal Protective Equipment (PPE) such as breathing apparatus), fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities

Tools, materials, equipment and information: specific implications of statutory regulations, codes of practice related to installing or maintaining systems, special considerations as prescribed by the manufacturer

Dismantling and assembling: make identification (witness) marks on components so that they can be correctly reassembled/re-aligned, label and safely store parts that have been removed methods used to avoid distortion and damage to, or leakage from, pipework (disconnecting, aligning, connecting), precautions needed to avoid danger from, or damage to, components whilst installing, dismantling and assembling from: misalignment, use of wrong tools, excessive force, uncontrolled release of springs, scoring of surfaces; protection of dismantled components from contamination (blanking off open ports, use of correct cleaning agents and lint-free cloths), sequence for tightening bolts and applying specified torque, application of lubrication to seals, precautions to be taken when refilling systems with specified oils, methods of safely bleeding systems to eliminate air locks and avoid spillage, how to remove; fit and replace: bearings, seals, springs, circlips, keys, brushes; prepare or make new gaskets or joints (including preparation of surfaces and/or housings) and repack glands

Re-commissioning: refilling or recharging systems, opening up the system to the sources of pressure, methods to safely drain, bleed and purge systems to avoid undue leakage or contamination, set up and test interlocks, sensors and limit switches, sequence of bringing systems back to the specified working conditions (removal of protective covers and blanks, opening appropriate valves or switches, operating the system under gradually increasing pressures or loads, state the methods of securing pipework and safety fittings (guards, handrails), methods of replacing insulation, lagging and other protective coverings, applying identification markings to different parts of a system (colour identification of pipework to BS 1710, using appropriate and approved codings for electrical connections and components)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested
parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

Unit 319 Maintenance of plant services

URN:	**H/503/0384**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and the underlying process technology required for the maintenance and/or installation requirements of systems commonly used in industrial plant and premises. These include heating and ventilation, fresh water and waste, low water systems, fuel and gas storage and distribution. The unit will cover system layouts and their main components, the selection and use of appropriate tools and equipment, the procedures and techniques involved with safely isolating systems, removing and replacing components and restoring a system back to a full working condition.

Learning outcome
The learner will: 1. understand the function of plant services
Assessment criteria
The learner can: 1.1 describe the difference between the cold, **hot and process water supply and disposal methods** 1.2 explain the properties and requirements of **fuel oil systems** 1.3 explain the properties and requirements of **gases and supply systems** 1.4 explain the principles of **heating and ventilating systems**

Range
Hot and process water supply and disposal methods: nature of water and the treatments required, storage requirements and methods – including cleansing and testing services, types of water pump, types of valve, pressure control including relief, flow control, pipework requirements, heat exchangers, water sprinkler systems, detector types and testing, storage and settling tanks, arrangements for the disposal of clean and contaminated waters, toxic liquid waste **Fuel oil systems:** fuel characteristics and combustion principles, precautions when storing, handling and supplying fuels, types of fuel pump, types of valve, pressure control, flow control, pipework requirements, identification, protection – lagging and tracing **Gases and supply systems:** gases for fuel and processing applications storage methods and requirements, safe practices for filling and distribution, procedures for evacuating pipework and disposal of contents removed according to current legislation, methods of testing for gas presence and leaks, procedures to be followed when detected gas levels are unsafe, line purging and pressure testing techniques, types of valve used for plant and services equipment **Heating and ventilating systems:** the requirements for acceptable habitability, recommended number of air changes, the relationships between air velocity, ducting area and volume of air delivered using simple calculations or data tables, 'U' values of common construction materials, factors affecting pressure drops and losses in a system; factors affecting pressure drops and losses in a system; specific heat values for air and water and steam; sources of heat into an area, heating and ventilating components and their symbols according to current BS and ISO standards, circulating pumps, heating and cooling units components, fans [centrifugal and axial], the effect of fan speed and power needed for different airflow rates, filtration units, large particle extraction, methods of mounting and fixing; types of pipework and ducting; layouts of hot water central heating systems, layouts of single and double duct systems, monitoring and control of, automatic recorders for the analysis of system operation and efficiency

Learning outcome
The learner will: 2. be able to prepare for maintenance of plant services
Assessment criteria
The learner can: 2.1 evaluate type and extent of work to be carried out 2.2 develop a **plan** that includes assessing any risks, securing the area and isolating equipment 2.3 estimate the **tools, materials, equipment and information** required 2.4 set-up to carry out the maintenance activity

Range
Plan: to include - emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system, procedures for de-pressurising systems and testing them to be in a safe condition, procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination, fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, electrical installations and testing of equipment and appliances according to the IEE and Electricity at Work Regulations: methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities

Learning outcome
The learner will: 3. be able to perform inspections and maintenance tasks
Assessment criteria
The learner can: 3.1 perform **dismantling and assembling** operations to ensure effective operation on completion 3.2 perform **inspections** of components and draw conclusions regarding its repair or replacement

Range
Dismantling and assembling: to allow for reassembly, identification of parts (layout of parts), reassemble in correct order for re-commissioning of the system. Testing of parts and system to establish effectiveness of repair/replacement.

Learning outcome
The learner will: 4. be able to reinstate plant services
Assessment criteria
The learner can: 4.1 perform **re-commissioning** operations to brings system on-line and adjust as required until the working requirements have been fully met 4.2 **restore work areas** to a clean and safe condition on completion of maintenance and re-commissioning

Range
Re-commissioning: bring system back on-line and test/trial run to establish full functionality

Guidance

Hot and process water supply and disposal methods: nature of water and the treatments required (acidic and alkaline – corrosive effects, dissolved solids – effects and softening processes, bacterial content and treatment, un-dissolved solids – erosion), storage requirements and methods – including cleansing and testing services, types of water pump (positive displacement, centrifugal), types of valve (isolating [gate and screw down], pressure control including relief, flow control), pipework requirements (materials, joining methods and fittings by means of flanged and screwed connectors, the use of elbows and tee pieces, identification [to BS 1710], identification and protection – lagging and tracing), heat exchangers (single and multi-pass, calorifiers), water sprinkler systems, detector types and testing, storage and settling tanks, arrangements for the disposal of: clean and contaminated waters, toxic liquid waste

Fuel oil systems: fuel characteristics and combustion principles (air/fuel mixture, flammability and exclusivity, viscosity and flow characteristics, light and heavy types, applications), precautions when storing, handling and supplying fuels (types of tank and content measuring methods, need for barrier walls and spillage trenches, isolating and emergency procedure, warning and information signs and notices), types of fuel pump (positive displacement, centrifugal), types of valve (isolating [gate and screw down], pressure control, flow control), pipework requirements (materials, joining methods and fittings (elbows, 'Y' pieces, tee pieces), identification (to BS 1710), protection – lagging and tracing

Gases and supply systems: gases for fuel and processing applications (propane, acetylene, oxygen, ammonia, nitrogen, argon) storage methods and requirements (identification of cylinders and lines, ventilation, flame proof switches, securing cylinders, security of access), safe practices for filling and distribution, procedures for evacuating pipework and disposal of contents removed according to current legislation, methods of testing for gas presence and leaks, procedures to be followed when detected gas levels are unsafe, line purging and pressure testing techniques, types of valve used for plant and services equipment (isolating [gate and screw down], pressure control, flow control)

Heating and ventilating systems: the requirements for acceptable habitability in terms of temperatures, humidity, airborne particles, fumes, odours and bacterial content; recommended number of air changes for welding shops, general workshops, office blocks, stores and warehouses; the relationships between air velocity, ducting area and volume of air delivered using simple calculations or data tables, 'U' values of common construction materials - wood, bricks, concrete, insulation; factors affecting pressure drops and losses in a system; factors affecting pressure drops and losses in a system; specific heat values for air and water and steam; sources of heat into an area (external from solar radiation, internal from electrical equipment and occupants); heating and ventilating components and their symbols according to current BS and ISO standards (changeover, bypass and isolating valves and their methods of actuation [manual, mechanical, electrical], circulating pumps, heating and cooling units components [including drainage systems], fans

[centrifugal and axial], the effect of fan speed and power needed for different airflow rates, filtration units, large particle extraction [wood chips and similar particulates]; methods of mounting and fixing; types of pipework and ducting (materials for construction and insulation, flange connecting methods, noise reduction baffles); layouts of hot water central heating systems, layouts of single and double duct systems [with heater and cooler elements, etc]; monitoring and control of systems (from a central control point, local sensors and overrides, testing of cooling water sources for bacterial content (legionella), automatic recorders for the analysis of system operation and efficiency

Plan: to include- emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system (isolating switches, removal of fuses, closing and 'locking off' of valves, removal of valves and blanking of pipes) procedures for de-pressurising systems and testing them to be in a safe condition, procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination (including any special Personal Protective Equipment (PPE) such as breathing apparatus), fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities

Tools, materials, equipment and information: specific implications of statutory regulations, codes of practice related to installing or maintaining systems, special considerations as prescribed by the manufacturer

Dismantling and assembling: make identification (witness) marks on components so that they can be correctly reassembled/re-aligned, label and safely store parts that have been removed methods used to avoid distortion and damage to, or leakage from, pipework (disconnecting, aligning, connecting), precautions needed to avoid danger from, or damage to, components whilst installing, dismantling and assembling from: misalignment, use of wrong tools, excessive force, uncontrolled release of springs, scoring of surfaces; protection of dismantled components from contamination (blanking off open ports, use of correct cleaning agents and lint-free cloths), sequence for tightening bolts and applying specified torque, application of lubrication to seals, precautions to be taken when refilling systems with specified oils, methods of safely bleeding systems to eliminate air locks and avoid spillage, how to remove; fit and replace: bearings, seals, springs, circlips, keys, brushes; prepare or make new gaskets or joints (including preparation of surfaces and/or housings) and repack glands

Inspections: bearing surfaces, erosion and pitting, split or worn seals, signs of overheating (discolouration); condition of filters for: signs of metallic or other particles, indications of emulsions or oil deterioration, correctly labelling re-built components for replacement in a system or returning to stores, checking oil for signs of oxidation and acidity, bench testing re-assembled components, pressure testing pipework and pressure vessels, presenting information that can be used to appraise the outcome of a maintenance or installation activity

Re-commissioning: refilling or recharging systems, opening up the system to the sources of pressure, methods to safely drain, bleed and purge systems to avoid undue leakage or contamination, set up and test interlocks, sensors and limit switches, sequence of bringing systems back to the specified working conditions (removal of protective covers and blanks, opening appropriate valves or switches, operating the system under gradually increasing pressures or loads, state the methods of securing pipework and safety fittings (guards, handrails), methods of replacing insulation, lagging and other protective coverings, applying identification markings to different parts of a system (colour identification of pipework to BS 1710, using appropriate and approved codings for electrical connections and components)
Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 320 Maintenance of hydraulic systems

URN:	**T/503/0390**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and the underlying process technology required for the maintenance and/or installation requirements of hydraulic power transmission systems. It involves identifying hydraulic components and their symbols and the interpretation of circuit diagrams. It also covers the procedures and techniques involved with isolating systems safely, the ability to install or rebuild circuits from given information, removing and replacing components in a circuit and restoring a system back to a full working condition it also covers causes of common faults in hydraulic systems. When training rigs are used then a method of safely applying reasonable loads to fully test the operation of a circuit must be provided i.e. not simply that the specified actuator movements are obtained.

Learning outcome
The learner will: 1. understand the function of hydraulic systems
Assessment criteria
The learner can: 1.1 explain the relationships between force, pressure and area and carry out simple calculations 1.2 explain the reasons for pressure drops and losses in a system 1.3 explain the effect of fluid flow rate on actuator speed and power produced 1.4 explain the characteristics of **hydraulic fluids** 1.5 explain the function of **hydraulic components** and their current standard symbols 1.6 describe the difference between the **constructional features** of hydraulic components 1.7 explain the methods used for connecting pipework and hoses and how systems are installed to minimise pressure drops and flow restriction 1.8 describe the selection of components for particular purposes 1.9 explain the **relative positions of components** in a circuit 1.10 explain the possible causes of **common faults**

Range
Hydraulic fluids: viscosity, density and lubricity (including effects of temperature and aeration), flash point and fire resistant forms, purpose of oil additives, causes of deterioration of hydraulic oils, procedures for storing and handling of hydraulic fluids, potential hazards **Hydraulic components:** pumps, gear types, vane types, actuators,, rotary, non-return, pressure, auxiliary components **Constructional features:** types of seals and their applications (static and dynamic), seal materials, compatibility and methods of assembly, methods of mounting and fixing valves and actuators, attachment of connectors and pipework **Relative positions of components:** counterbalance, unloading and offloading, meter-in, meterout and bleed off speed control, sequential operation **Common faults:** slow, erratic and intermittent motion of actuators, lack of specified system pressure, cavitation, overheating of oil

Learning outcome
The learner will: 2. be able to prepare for maintenance of hydraulic systems
Assessment criteria
The learner can: 2.1 evaluate type and extent of work to be carried out 2.2 develop a **plan** that includes assessing any risks, securing the area and isolating equipment 2.3 estimate the **tools, materials, equipment and information** that will be needed 2.4 set-up to carry out the maintenance activity

Range
Plan: to include - emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system, procedures for de-pressurising systems and testing them to be in a safe condition, procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination, fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, electrical installations and testing of equipment and appliances according to the IEE and Electricity at Work Regulations: methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities

Learning outcome
The learner will: 3. be able to perform inspections and maintenance tasks
Assessment criteria
The learner can: 3.1 perform **dismantling and assembling** operations to ensure effective operation on completion 3.2 perform **inspections** of components and draw conclusions regarding its repair or replacement

Range
Dismantling and assembly: to allow for reassembly, identification of parts (layout of parts), reassemble in correct order for recommissioning of the system, Tessting of parts and system to establish effectiveness of repair/replacement.

Learning outcome
The learner will: 4. be able to reinstate hydraulic systems
Assessment criteria
The learner can: 4.1 perform **re-commissioning** operations to bring system on-line and adjust as required until the working requirements have been fully met 4.2 **restore work areas** to a clean and safe condition on completion of operation

Range
Re-commissioning: bring system back on-line and test/trial run to establish full functionality

Unit 320 Maintenance of hydraulic systems

Supporting information

Guidance

Hydraulic fluids: viscosity, density and lubricity (including effects of temperature and aeration), flash point and fire resistant forms, purpose of oil additives, causes of deterioration of hydraulic oils (chemical changes due to oxidation overheating, contamination by suspended solids and moisture, incorrect storage conditions), procedures for storing and handling of hydraulic fluids, potential hazards (toxicity, harmful effects on skin)

Hydraulic components: BS 2917, ISO 1219-1; pumps (piston types [axial, radial and variable delivery – swash plate], gear types [internal and external], vane types [fixed and variable capacity]); actuators (linear – single acting, double acting, telescopic and differential [ram] type cylinders] uncushioned and cushioned forms], rotary – [hydraulic motors] piston and sliding vane types; valves and their methods of actuation [manual, mechanical, electrical and pilot] (rotary and spool directional control valves – 2/2, 3/2, 4/2, 5/2 and 4/3 [including all neutral position variants of 3 position types], non-return [plain and pilot operated], pressure control – pressure regulating and relief [simple and compound], flow control – simple restrictors, uni-directional and pressure compensated types, modular [stacker] and cartridge valve assemblies, identification of valve ports using current systems [PABT and numeric]); auxiliary components (reservoirs, accumulators, pressure intensifiers, filters)

Plan: to include - emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system (isolating switches, removal of fuses, closing and 'locking off' of valves, removal of valves and blanking of pipes) procedures for de-pressurising systems and testing them to be in a safe condition (including reservoirs and storage vessels), procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination (including any special PPE such as breathing apparatus), fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, electrical installations and testing of equipment and appliances according to the IEE and Electricity at Work Regulations: methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities

Tools, materials, equipment and information: specific implications of statutory regulations, codes of practice related to installing or maintaining systems, special considerations as prescribed by the manufacturer

Dismantling and assembling: make identification (witness) marks on components so that they can be correctly reassembled/re-aligned, label and safely store parts that have been removed methods used to avoid distortion and damage to, or leakage from, pipework (disconnecting, aligning, connecting), precautions needed to avoid danger from, or damage to, components whilst installing, dismantling and assembling from: misalignment, use of wrong tools, excessive force, uncontrolled release of springs, scoring of surfaces; protection of dismantled components from contamination (blanking off open ports, use of correct cleaning agents and lint-free cloths), sequence for tightening bolts and applying specified torque, application of lubrication to seals, precautions to be taken when refilling systems with hydraulic oil, methods of safely bleeding systems to eliminate air locks and avoid spillage, procedures for charging gas filled accumulators

Inspections: bearing surfaces, erosion and pitting (e.g. of gear teeth or vane edges), split or worn seals, signs of overheating (discolouration); condition of filters for: signs of metallic or other particles, indications of emulsions or oil deterioration, correctly labelling re-built components for replacement in a system or returning to stores, checking oil for signs of oxidation and acidity, bench testing re-assembled components, pressure testing pipework and pressure vessels, presenting information that can be used to appraise the outcome of a maintenance or installation activity

Re-commissioning: refilling or recharging systems, opening up the system to the sources of pressure, methods to safely drain, bleed and purge systems to avoid undue leakage or contamination, set up and test interlocks, sensors and limit switches, sequence of bringing systems back to the specified working conditions (removal of protective covers and blanks, opening appropriate valves or switches, operating the system under gradually increasing pressures or loads, state the methods of securing pipework and safety fittings (guards, handrails), methods of replacing insulation, lagging and other protective coverings, applying identification markings to different parts of a system (colour identification of pipework to BS 1710, using appropriate and approved codings for electrical connections and components)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 321 Maintenance of pneumatic systems

URN:	**R/503/0395**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and the underlying process technology required for the maintenance and/or installation requirements of pneumatic power transmission systems. It involves identifying pneumatic components and their symbols and the interpretation of circuit diagrams. It also covers the procedures and techniques involved with isolating systems safely, the ability to install or rebuild circuits from given information, removing and replacing components in a circuit and restoring a system back to a full working condition and causes of common faults in pneumatic systems. When training rigs are used then a method of safely applying reasonable loads to fully test the operation of a circuit must be provided i.e. not simply that the specified actuator movements are obtained.

Learning outcome
The learner will: 1. understand the function of pneumatic systems
Assessment criteria
The learner can: 1.1 explain the relationships between force, pressure and area and carry out simple calculations 1.2 explain the use of nomograms for pipe selection 1.3 explain the reasons for **pressure drops** and losses in a system 1.4 explain the effect of fluid flow rate on actuator speed and power produced 1.5 explain the changes in energy throughout a system 1.6 explain the function of **pneumatic components** and their current standard symbols 1.7 describe the difference between the **constructional features** of pneumatic components 1.8 explain the methods used for **connecting pipework** and hoses and how systems are installed to minimise pressure drops and flow restriction 1.9 describe the selection of components for particular purposes 1.10 explain the **relative positions of components** in a circuit 1.11 explain the possible causes of **common faults** 1.12 explain the application of circuits with **electro pneumatic** operation

Range
Pressure drops: leaks, changes in temperature, venting, etc. **Pneumatic components**: actuators, rotary, rotary and spool directional control valves, non-return, pressure control, simple restrictors and by-pass forms, two pressure and shuttle valves [OR and AND logic], quick exhaust, impulse generators, identification of valve ports using current systems; auxiliary components **Constructional features**: types of seals and their applications (static and dynamic), seal materials, compatibility and methods of assembly, methods of mounting and fixing valves and actuators **Connecting pipework:** attachment of connectors and pipework to components, types of pipework and connecting methods (rigid, flexible and push-in), factors for efficient and safe routing of pipes to minimise pressure drops and flow restriction **Relative positions of components**: components needed for particular purposes and their relative positions in a circuit to obtain speed control and sequential operation, reasons for held (maintained) signals and methods of overcoming this problem for circuits requiring up to three group cascade layouts **Common faults:** slow, erratic and intermittent motion of actuators, lack of specified system pressure **Electro pneumatic:** types of sensor or contact (induction, magnetic, reed switches), relays, rotary switches; principles of programmable logic controllers (PLCs) using a 'black box' treatment only; basic the programming methods and the need for requiring feedback signals

Learning outcome
The learner will: 2. be able to prepare for maintenance of pneumatic systems
Assessment criteria
The learner can: 2.1 evaluate type and extent of work to be carried out 2.2 develop a **plan** that includes assessing any risks, securing the area and isolating equipment 2.3 estimate the **tools, materials, equipment and information** that will be needed 2.4 set-up to carry out the maintenance activity

Range
Plan: to include - emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system, procedures for de-pressurising systems and testing them to be in a safe condition, procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination, fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, electrical installations and testing of equipment and appliances according to the IEE and Electricity at Work Regulations: methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities

Learning outcome
The learner will: 3. be able to perform inspections and maintenance tasks
Assessment criteria
The learner can: 3.1 perform **dismantling and assembling** operations to ensure effective operation on completion 3.2 perform **inspections** of components and draw conclusions regarding its repair or replacement

Range
Dismantling and assembling: to allow for reassembly, identification of parts (layout of parts), reassemble in correct order for re-commissioning of the system, testing of parts and system to establish effectiveness of repair/replacement

Learning outcome
The learner will: 4. be able to reinstate pneumatic systems
Assessment criteria
The learner can: 4.1 perform **re-commissioning** operations to brings system on-line and adjust as required until the working requirements have been fully met 4.2 **restore work areas** to a clean and safe condition on completion of operation

Range
Re-commissioning: refilling or recharging systems, opening up the system to the sources of pressure, methods to safely drain, bleed and purge systems to avoid undue leakage or contamination, set up and test interlocks, sensors and limit switches, sequence of bringing systems back to the specified working conditions (removal of protective covers and blanks, opening appropriate valves or switches, operating the system under gradually increasing pressures or loads, state the methods of securing pipework and safety fittings (guards, handrails), methods of replacing insulation, lagging and other protective coverings, applying identification markings to different parts of a system (colour identification of pipework to BS 1710, using appropriate and approved codings for electrical connections and components)

Unit 321 Maintenance of pneumatic systems

Supporting information

Guidance

Pneumatic components: BS 2917, ISO 1219-1: actuators (linear – single acting, double acting, telescopic and differential [ram] type cylinders] uncushioned and cushioned forms], rotary – [air motors] piston and sliding vane types; valves and their methods of actuation [manual, mechanical, electrical and pilot], rotary and spool directional control valves [including all neutral position variants of 5/3 position types], non-return [plain and pilot operated], pressure control – pressure regulating and relief, flow control – simple restrictors and by-pass forms, two pressure and shuttle valves [OR and AND logic], quick exhaust, impulse generators, identification of valve ports using current systems; auxiliary components (reservoirs, accumulators, pressure intensifiers, filters, silencers,)

Plan: to include - emergency shut down and evacuation procedures for the work, methods of isolating the equipment or system (isolating switches, removal of fuses, closing and 'locking off' of valves, removal of valves and blanking of pipes) procedures for de-pressurising systems and testing them to be in a safe condition (including reservoirs and storage vessels), procedure for draining oil or other such substances and their safe and legitimate disposal, spillage and contamination (including any special Personal Protective equipment (PPE) such as breathing apparatus), fire, personal injury, disposal of toxic waste and other such substances as defined by COSHH and Environmental Protection Acts, working at heights and in confined spaces, electrical installations and testing of equipment and appliances according to the IEE and Electricity at Work Regulations: methods of lifting, supporting, or otherwise making system components safe, how the work to be undertaken may interact with or affect other systems or production facilities

Tools, materials, equipment and information: specific implications of statutory regulations, codes of practice related to installing or maintaining systems, special considerations as prescribed by the manufacturer

Dismantling and assembling: make identification (witness) marks on components so that they can be correctly reassembled/re-aligned, label and safely store parts that have been removed methods used to avoid distortion and damage to, or leakage from, pipework (disconnecting, aligning, connecting), precautions needed to avoid danger from, or damage to, components whilst installing, dismantling and assembling from: misalignment, use of wrong tools, excessive force, uncontrolled release of springs, scoring of surfaces; protection of dismantled components from contamination (blanking off open ports, use of correct cleaning agents and lint-free cloths), sequence for tightening bolts and applying specified torque, application of lubrication to seals, precautions to be taken when refilling systems with hydraulic oil, methods of safely bleeding systems to eliminate air locks and avoid spillage, procedures for charging gas filled accumulators

Inspections: bearing surfaces, erosion and pitting (e.g. of gear teeth or vane edges), split or worn seals, signs of overheating (discolouration); condition of filters for: signs of metallic or other particles, indications of emulsions or oil deterioration, correctly labelling re-built components for replacement in a system or returning to stores, checking oil for signs of oxidation and acidity, bench testing re-assembled components, pressure testing pipework and pressure vessels, presenting information that can be used to appraise the outcome of a maintenance or installation activity

Re-commissioning: refilling or recharging systems, opening up the system to the sources of pressure, methods to safely drain, bleed and purge systems to avoid undue leakage or contamination, set up and test interlocks, sensors and limit switches, sequence of bringing systems back to the specified working conditions (removal of protective covers and blanks, opening appropriate valves or switches, operating the system under gradually increasing pressures or loads, state the methods of securing pipework and safety fittings (guards, handrails), methods of replacing insulation, lagging and other protective coverings, applying identification markings to different parts of a system (colour identification of pipework to BS 1710, using appropriate and approved codings for electrical connections and components)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 322 Power generation systems and ancillary equipment

URN:	**K/503/0435**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with power generation and associated systems, in terms of: planning and preparation, components, carrying out inspections, maintenance and installation tasks and commissioning the system

Learning outcome
The learner will: 1. be able to identify the components and features of utilities
Assessment criteria
The learner can: 1.1 identify the components and sub-systems needed for **power generation** units from drawings that use standard symbols 1.2 identify the **function of the essential components** needed for power generation plant or sub-systems 1.3 select **components** or equipment to meet specified functions in terms of required volumes (fuel, air and steam), pressures and temperatures using manufacturers' catalogues or other data

Range
Power generation: principles of combustion of hydrocarbon fuels and the products of combustion, need for the correct proportions of air and fuel for complete combustion, ways in which energy forms can be achieved (chemical to heat, heat to mechanical, kinetic to mechanical); principles and factors affecting heat transfer by conduction, convection and radiation, basic four stroke, two stroke cycle for spark, compression ignition (CI) systems, valve timing diagrams (for all types) defining lead, lag and overlap, ignition and combustion requirements [obtaining the correct air pressures and temperatures, uniform mixtures of air and fuel in the required proportions, effects of incorrect mixtures, use of pressure/volume and crank angle/pressure diagrams to show the stages in combustion process]

Function of the essential components: general layouts of the following types of engine: on-line, vee, methods of supplying air to IC engines, main features of electrical systems

Components : parts of cooling water supply systems, water treatment for preventing scaling, corrosion and freezing, relationship between pressure and boiling point and resultant danger, parts of lubricating systems, splash methods of lubricating cylinder walls and valve mechanisms, types of oil and grease used specifically for IC engines, starting methods for IC engines, general construction details of reciprocating IC engines, bearing types and application, ball and roller solid bush, split bearings, principles and construction of turbines, stages of a gas turbine engine and the associated components, compressor-blade materials, changes in air pressure and temperatures, compression chambers, power take off arrangements, control methods for safe and efficient running, dispersal methods for exhaust gases in accordance with current regulations and good practice, stages of steam turbines and the associated components, control nozzle arrangements, speed governing and overspeed trips, exhaust steam arrangements and condensers, materials used for different components and power units and the reasons for their selection, possible causes of corrosion in IC engines, possible causes of commonly observed symptoms related to IC engines

Learning outcome
The learner will: 2. be able to plan and prepare for the maintenance or installation operation
Assessment criteria
The learner can: 2.1 evaluate the type and **extent of work** to be carried out 2.2 describe how **current legislation** and codes of practice relate to the given tasks 2.3 carry out a **risk assessment** by listing the procedures and requirements for setting up safe working conditions 2.4 select manufacturers information, related records, circuit diagrams and other necessary data 2.5 check availability of materials, tools and equipment and prepare requisitions or works orders as required 2.6 assemble all tools, materials and other equipment required

Range
Extent of work: layout, function of components and operational features of the pneumatic system to be installed or maintained (special considerations as prescribed by the manufacturer, methods of lifting, supporting or otherwise making system components safe, work to be undertaken may interact with or affect other systems or production facilities) **Current legislation**: specific implications of Statutory regulations, Codes of practice related to installing or maintaining steam generating systems, disposal of toxic waste and other substances as defined by COSHH and environmental protection acts, pressure systems and portable gas containers and working at heights and in confined areas legislation **Risk assessment:** methods of isolating the equipment or system (isolating switches, removal of fuses, closing or locking off of valves, removal of valves and blanking of pipes, procedures for de-pressurising systems and testing them to be in a safe condition, procedures for draining oil and other substances and their safe and legitimate disposal, need for providing equipment to deal with spillage and contamination (including any special Personal Protective Equipment (PPE) such as breathing apparatus), fire and personal injury, emergency shut down and evacuation procedures for the work area

Learning outcome
The learner will: 3. be able to carry out inspections and general maintenance tasks
Assessment criteria
The learner can: 3.1 carry out an **inspection** **3.2 diagnose system faults and rectify components** 3.3 **reassemble** system following repair

Range
Inspection: on power generation equipment or system **Inspection:** methods used to avoid distortion and damage to, or leakage from, pipework (disconnecting, aligning, connecting), precautions needed to safely and effectively dismantle components, make identification (witness)marks on components so they can be correctly re assembled or re-aligned, label and safely store parts that have been removed, precautions needed to avoid danger from, or damage to, components whilst installing, dismantling and assembling from misalignment, use or wrong tools or excessive force, uncontrolled release of springs and scoring of surfaces; protect dismantled components from contamination (blanking off open ports, use of correct cleaning agents and lint free cloths) **Diagnose system faults and rectify components**: rectify by repair or replace, essential points to be checked when inspecting pneumatic components (bearing surfaces, erosion and pitting, split or worn seals, signs of overheating (colour changes), condition of filters for signs of metallic or other particles, indications of emulsions or oil deterioration.

Re-assembly: procedures for re-assembling components to avoid damage using the approved sequence for tightening bolts and applying specified torque and the application of lubrication to seals, need for correctly labelling re-built components for replacement in a system or returning to stores, checking oil for signs for oxidation and acidity, bench testing re-assembled components, pressure testing pipework and pressure vessels, precautions to be taken when refilling systems with hydraulic oil, methods of safely bleeding systems to eliminate air locks and avoid spillage, procedures for charging gas filled accumulators, present information that can be used to appraise the outcome of a maintenance or installation activity

Learning outcome
The learner will: 4. be able to commission or re-commission the system
Assessment criteria
The learner can: 4.1 bring the system **online and adjust** as required until the working parameters have been fully met 4.2 **restore the work area** to a clean and safe condition on completion of maintenance or installation 4.3 identify **hazardous substances** that may have been used or discovered during the work and give the approved method of disposal for each such substance 4.4 describe the reasons for **handing over** the system to the authorised persons 4.5 complete a report on the action taken

Range
Online and adjust: precautions to be taken when refilling or recharging the systems and opening up the system to the sources of pressure, methods of safely draining, bleeding and purging systems to avoid undue leakage or contamination, set up and test interlocks, sensors and limit switches, removal of protective covers and blanks, opening appropriate valves or switches, operating the system under gradually increasing pressure or loads, **Hazardous substances:** materials used that are classified as hazardous and those that can be recycled, **Handing over:** necessity for, and methods of, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, need to let all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area. Work termination documents or reports that may be required are completed and passed on to an authorised person, procedure for terminating any 'permits to work'.

Unit 322 Power generation systems and ancillary equipment

Supporting information

Guidance

Function of the essential components: general layouts of the following types of engine (in-line, vee, engine capacity in terms of bore, stroke and number of cylinders, meaning of torque and its relationship with engines speed and power produced, factors affecting the efficiency of power generating systems, systems for supplying fuels to power units (from storage point to engine, by carburettors, venture, throttle control, main and idling jets, injection pumps, injectors [types and spray patterns] gas flow regulating valves]) methods of supplying air to IC engines (normally aspirated, under pressure [supercharged and turbo-charged[,construction and positioning of chargers, need for correct operating procedures to avoid damage during start up and shut down, air filtration [wet and dry types]), main features of electrical systems (coil ignition and components-switch, coil, condensers, contact breakers, distributors, spark plug types, suppressors, magneto-rotating armature, rotating magnet, contact breakers and mechanisms, a.c. alternators and generators and including voltage regulators, d.c. batteries-checking of condition and recharging).

Components : parts of cooling water supply systems (closed circulation via heat exchangers [radiators], pump types, temperature control methods [thermostats], water treatment for preventing scaling, corrosion and freezing, relationship between pressure and boiling point and resultant dangers), parts of lubricating systems – (pressurised: pump types, filters, pressure control and warning systems, oil coolers), splash methods of lubricating cylinder walls and valve mechanisms, types of oil and grease (and additives) used specifically for IC engines, starting methods for IC engines (electric, compressed air, hydraulic, manual, starting aids, volatile gas injection, heater plugs, excess fuel [choke], decompression devices), general construction details of reciprocating IC engines (cylinder blocks and heads [use wet and dry liners], crankshafts and bearing arrangements, cam shafts and valve timing arrangements, piston assemblies [gudgeon pins and types of piston ring], bearing types and application, ball and roller solid bush, split bearings [white metalled and shell types], principles and construction of turbines (rotor and stator blade configurations, blade shapes-impulse and reaction types-multi staging, methods of attaching blades onto rotor discs, need to allow for expansion of gases and steamand gas), stages of a gas turbine engine and the associated components, compressor-blade materials, changes in air pressure and temperatures, compression chambers (materials, fuel injection and mixing arrangements [primary and secondary], internal and external combustion zones, blade materials, attachment methods [including shrouding], power take off arrangements (reduction gearing), control methods for safe and efficient running (acceleration control units, steady speed governors, overspeed and temperature trips, use of exhaust gases to preheat air inlet to combustion zones), dispersal methods for exhaust gases in accordance with current regulations and good practice, stages of steam turbines and the associated components,

control nozzle arrangements), speed governing and overspeed trips, exhaust steam arrangements and condensers, materials used for different components and power units and the reasons for their selection, possible causes of corrosion in IC engines (cooling water, condensation, reactions with combustion products, requirements and checks needed for standard maintenance and installation routines associated with the components and systems listed, possible causes of commonly observed symptoms related to IC engines (smoke from exhaust, overheating, knocking or pinking, misfiring or loss of power, excessive consumption [of fuel or oil])

Restore the work area: methods of securing pipework and safety fittings (guards, handrails), methods of replacing insulation, lagging or other protective coverings, identification markings to different parts of a system: colour identification of pipework to BS1710; using appropriate and approved codings for electrical connections and components

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 323 Machining materials by turning

URN:	**T/503/0437**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with the underlying process of machine alignment and producing complex components whilst following safe working practices. The unit is designed to enable candidates to carry out a full alignment test and record the results, produce internal and external tapers, measure angles and inspect with taper gauges, cut internal and external multi start threads, form profiles and identify cutting tool shapes and describe the materials

Learning outcome
The learner will: 1. be able to carry out alignment tests and machine to required dimensions
Assessment criteria
The learner can: 1.1 perform **safety checks** 1.2 use inspection **equipment** to perform full **alignment tests** 1.3 explain the functions and layout of the **headstock** gearbox 1.4 **machine by turning** to required dimensions

Range
Safety checks: risk assessment, inspect equipment prior to test, lock-off system. re-instatement procedures, Personal Protective Equipment (PPE), manual handling, emergency stops, COSHH requirements (lubricants, cutting fluids, cleaning materials) **Equipment**: mandrills (headstock, tailstock) dial test indicators (lever, plunger) precision levels (spirit [vee grooved base], square block), straight edge, **Alignment tests**: headstock, tailstock, bed, guideways, centres **Headstock:** shafts, gear clusters, ratios, gear systems (shaft [drive, driven, lay], gears [straight, involute, rack], lubrication systems [drip, splash, pump]) system of lubrication, calculations (geometric gear progression [including produce graph], spindle speeds for each gear ratio) **Machining by turning:** external, internal, faces, recesses, undercuts, between centres, parting off, drilling holes (centre drilling, pilot drilling, through holes, blind holes, flat bottom holes), reamed holes, bored holes, chamfers, parting off, knurling, types of chip produced (continuous [materials, prevention, hazards], discontinuous [materials]), relationship between feed rate and depth of cut and the effect on material removal rate

Learning outcome
The learner will: 2. be able to produce self-holding and quick release tapers
Assessment criteria
The learner can: 2.1 use **workholding** devices when setting up for turning operations 2.2 perform turning operations to produce self-holding and quick-release **tapers** to BS EN ISO 286 and surface finish 1.6 m 2.3 explain methods of **manufacture** 2.4 evaluate tapers using engineers' blue, measuring and gauging **inspection** techniques

Range
Workholding: between centres, faceplate, catch plates and carriers, collets, magnetic and pneumatic devices, mandrels, steadies, fixtures, spigots, bar feed, purpose **Tapers:** morse, international, boring tools and holders, drills (twist, core), reaming (purpose, types [machine, chucking, taper], nomenclature, accessories [extension sockets, reduction sleeves, machine tapers, floating reamer]) **Manufacture:** form tool, compound slide, offset tailstock, taper turning attachment **Inspection:** measure/gauge internal and external tapers (taper plug gauge, taper ring gauge), engineers' blue, gauge blocks, sine bar and surface table/plate

Learning outcome
The learner will: 3. be able to produce single and two start threads
Assessment criteria
The learner can: 3.1 identify different standard **thread forms** 3.2 perform **grinding** operations to produce cutting tools to match methods of thread cutting 3.3 perform **lathe setting** operations to produce internal and external two-start **threads** 3.4 produce multi-start threads to medium fit specification 3.5 **evaluate** threads against the specification

Range
Thread forms: metric (course, fine, special) unified (course, fine) British Standard (whitworth, fine, B.A.) square, acme **Grinding:** tool grinder, profile, high speed steel, stellite **Lathe setting**: on centre, square using gauge, half included angle, pitch movement (compound slide, rotate spindle) **Threads:** internal, external, cutting (plunge, half included angle, chasers), calculate depth of flank angle, sine bar gauge blocks, surface plate/table, precision balls, depth micrometer **Evaluate:** three wire, thread measuring machine, shadow graph projector, thread profile gauge, contour gauge, thread measuring (effective diameter, major diameter, minor diameter)

Learning outcome
The learner will: 4. be able to differentiate between cutting methods
Assessment criteria
The learner can: 4.1 describe **tool and tip shape** 4.2 perform calculations to determine the cutting speeds in relationship to **tool material** and **material** being cut 4.3 perform calculations to determine **cutting** speeds and feeds 4.4 describe form, oblique and orthogonal **cutting** 4.5 diagnose any **problems** encountered

Range
Tool and tip shapes: solid bits, brazed tips and inserts (disposable), indexable tip tool shapes (square, triangular, diamond, round), tool holding (clamp and cap screw, pin and wedge, pin and lever, screwed, single post, quick-change tool post, four way tool post) **Tool material**: high speed steel, alloyed carbon steel, stellite, tungsten and ceramic carbides, diamond, temperature charges tool materials, tool geometry (clearance, rake [positive, negative]), chip breakers, tip tool colour coding **Materials**: range of carbon steels, cast iron, aluminium, copper and copper alloys calculations: speed formula, feed in millimetres per revolution, factors affecting choice of cutting speed (work material being cut, cutting tool material, type of cutting operation, surface finish required, type of cutting fluid), factors affecting choice of feed (finish required, rate of material removal, type of cutting tool material, power of machine, type of cutting operation) **Cutting:** rake and clearance angles for form tool, cutting and feed forces (tangential, feed, back, calculate the forces acting on a cutting tool) types of cutting (oblique, orthogonal), types and properties of cutting fluid (aqueous, oil-type, chemical, synthetic, gases) **Problems:** oversize/undersize components (tool wear, slackness in slides, deflection), inconsistency of product shape (deflection, clamping, stops, alignment of fixtures), vibration (condition of machine, tooling, set- up, speeds and feeds), surface damage to component (blunt tools, clamping)

Unit 323 Machining materials by turning

Supporting information

Guidance

Workholding: between centres (centres and sleeves: dead, running, live) faceplate (hold work directly on plate, hold work via a fixture, balancing) catch plates and carriers, chucks (three jaw, hard jaws, soft jaws, four jaw [normal reverse, regular shapes, irregular shapes, balancing), collets (parallel, expanding), magnetic and pneumatic devices, mandrels (plain, expanding), steadies (fixed, travelling), fixtures, spigots, bar feed, purpose (locate workpiece, restrain workpiece against cutting forces)

Assessment Guidance

Outcome 3 - Thread should be retained to ensure that the thread is not produced with a die and finished with a die-nut.

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 324 Machining materials by milling

URN:	**M/503/0436**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with the underlying process used in producing complex components whilst following safe working practices and using advanced milling operations to a high level of precision. The unit is designed to enable candidates to set and operate a universal dividing head, carry out differential indexing, establish spindle speeds and feeds for individual operations, machine multiple faces in a single pass, mill straight and curved gears.

Learning outcome
The learner will: 1. be able to prepare for milling operation
Assessment criteria
The learner can: 1.1 explain the range, type and capabilities of **milling machines** available 1.2 explain the **checks** required prior to machining 1.3 define cutting speed as relative speed between tool point and work surface 1.4 explain the factors affecting choice of **cutting speed** 1.5 define and calculate **feed rates** 1.6 critically compare the types and properties of **cutting fluid** 1.7 explain the **relationship between rotation of cutter and feed direction** 1.8 describe the range, setting, methods of use and characteristics of **workholding** methods and devices 1.9 explain the types and applications of **spindle held cutters** 1.10 explain the types and applications and methods of securing of **other cutters** 1.11 explain the **tool geometry** of milling cutter

1.12 explain the factors to be considered for effective production of **components**

1.13 explain the possible production **problems** encountered and possible remedies

1.14 perform milling machine set up to meet component and production specifications

1.15 perform relevant alignment checks and check machine for defects

1.16 produce a speeds and feeds table

1.17 set required speeds and feeds

1.18 prepare and mount cutting tools for complex milling operations

Range

Milling machines: horizontal, vertical, universal, construction, parts, applications, reasons for the choice of milling machine type; horizontal milling operations: milling flat surfaces (horizontal, vertical), production of slots, slitting thin plate, gang milling, straddle milling, cutting keyways, gear cutting; vertical milling operations: milling flat surfaces (horizontal, vertical), production of slots (tee, dovetail), sunk and recessed surfaces, keyway cutting, including woodruff

Checks: safety switches, interlock devices, emergency stops, guarding, alignment tests (table, vertical spindle/quill), operating and care procedures (methods of starting, stopping, including emergency stop procedure)

Cutting speed: work material being cut, cutting tool material, type of cutting operation, type of cutter, surface finish required, type of cutting fluid required, calculate cutting speeds for milling

Feed rates: cut/tooth, table feed rate (mm/min), calculate feed, formula (feed/tooth x number of teeth x rev/min); factors affecting choice of feed rate: finish required, rate of material removal (type of cutting tool material, power of machine), type of cutting operation being carried out, type of cutter; calculate feed rates for milling

Cutting fluid: types (aqueous, oil-type, chemical, synthetic), purpose (provision of lubrication at tool point, absorption and removal of heat from the cutting zone, maintaining clean cutting zone, washing away chips

Relationship between rotation of cutter and feed direction: up-cut milling, down-cut milling,

Workholding: clamping work to machine table, machine vice, tilting table, sine table, rotary table, angle plate, vee blocks, dividing head [plain and universal] (methods of workholding, indexing calculations [simple, compound, differential and angular]), fixtures; purpose (locate workpiece, restrain workpiece against cutter forces); potential movement of the workpiece along and around the x, y, and z axes of the machine

Spindle held cutters: face mills, inserted blade

Other cutters: drills, parallel and taper shank, machine reamers, machine taps, boring tools

Tool geometry: factors affecting penetration of material by cutting edge (hardness of cutting tool material in relation to material being cut, sharpness of cutter, wedge form of cutter); angle of wedge shape and their function and terminology (rake angle: positive, negative, neutral), clearance angles; relationship between depth of cut and feed rate and effect on material removal rate

Effective production of components: correct sequence of machining operations to maximise production, eliminating unnecessary tool changes, eliminate unnecessary materials handling (fixtures, stops and guides), adjust parameters to improve quality and production efficiency **Problems:** oversize/undersize products (tool wear, slackness in slides,
deflection), inconsistency of product shape (deflection, clamping, stops, alignment of fixtures), vibration (condition of machine, tooling, set-up, speeds and feeds), surface damage of component (blunt tools, clamping), product schedules not being met

Learning outcome
The learner will: 2. be able to machine components using a universal dividing head
Assessment criteria
The learner can: 2.1 select and set **workholding** devices square and central to cutter and set adjustable angle plate to prescribed angle 2.2 set-up **universal dividing head** for differential milling operations 2.3 perform **calculations** the indexing movement and gearing required 2.4 produce machined holes and slots around an external diameter 2.5 produce machined **gears** and cutter teeth around an external diameter 2.6 machine arcs and angles, to within specified dimensions and measure accuracy to ± 0.1mm, angular ± 1° and surface finish 1.6m 2.7 produce machined teeth on the peripheral of **bevelled blanks** 2.8 apply milling machine **equipment** to complex machining operations 2.9 apply **milling cutters** and perform complex machining operations to BS EN ISO286, angles ± 0.5° and surface finish 1.6m 2.10 perform **inspection** of components to determine the level of accuracy by measuring and gauging

Range
Workholding devices: rotary table (indexing, scales (rotary, vernier), swizzle vice, angle plate (fixed and adjustable), methods of securing and centralising work **Universal dividing head**: 40:1 **Calculations**: simple and differential indexing **Gears:** straight and curved teeth for gear wheels and teeth for cutters, straight, involute, splined hafts, serrated shafts **Bevelled blanks:** end of shaft and/or bored **Equipment:** tailstock, chuck, catch plate mandrel dial test indicator and base **Milling cutters**: end mills, slot drills, angle cutters and drills **Inspection**: external micrometers (0 -25, 25-50 and 50-150mm), internal micrometer, vernier callipers & protractor, surface texture gauges, gauge blocks, sine bar

Learning outcome
The learner will: 3. be able to machine components by reaming and boring
Assessment criteria
The learner can: 3.1 set up **machines and equipment** to perform reaming and boring operations 3.2 check and reset machines **alignment** 3.3 apply **cutting tools** to complex machining operations 3.4 mount cutters prior to multi facet milling in a single pass 3.5 produce precision holes by boring and reaming to within H8 3.6 perform **inspection** of components to determine the level of accuracy by measuring and gauging

Range
Machines and equipment: vertical, horizontal, universal, off-set boring head **Alignment:** table, spindle **Cutting tools:** reamers (machine, chucking, stub, shell, boring heads) **Inspection:** internal micrometer, depth micrometer, vernier callipers & protractor, surface texture gauges, gauges: plug, sine bar (construction, size, calculations)

Learning outcome
The learner will: 4. be able to reinstate the work area
Assessment criteria
The learner can: 4.1 explain the health and safety and environmental legislations for waste disposal, and implications of not following legal requirements 4.2 explain the importance of **maintaining the safety and cleanliness** of machinery, tools equipment and the work area 4.3 explain the correct procedures for dealing with waste materials 4.4 explain the potential problems that may occur during restoring the work area and actions to be taken 4.5 explain the actions to be taken in the event of a **spillage** 4.6 **restore work area** after machining operations

Range
Maintaining the safety and cleanliness: isolate machines, manual cleaning, machine assisted cleaning, use and correct storing of cleaning agents, identify and label products, inspection of components, tools and equipment on the completion of work, sort items into reusable, rework and waste, clean and store Personal Protective Equipment (PPE) **Spillage**: barriers and safety signs, use of personal protective equipment, aids to containment and prevention of spillage reaching watercourse, aides for cleaning, who should be notified

Guidance

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 325 Machining materials by grinding

URN:	**A/503/0438**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with the underlying process of producing high quality surface textures on a range of components by grinding whilst following safe working practices. The unit is designed to enable candidates to carry out a range of surface grinding operations safely, carry out a range of cylindrical grinding operations both internally and externally, set and operate a tool and cutter grinding machine to re-grind milling cutters, lathe tools, test, inspect and replace abrasive wheels and carry out an inspection of surface texture.

Learning outcome
The learner will: 1. understand how to perform manufacturing operations safely on grinding machines
Assessment criteria
The learner can: 1.1 explain the **training requirements** for removal and changing of abrasive wheels 1.2 describe the methods of **inspection and testing** abrasive wheels for damage 1.3 explain the wheel **marking** system 1.4 explain the **characteristics** of abrasive wheels

Range
Training requirements: reference to Provision and Use of Work Equipment Regulations, appointed person responsibilities, mandatory signs, Personal Protective Equipment (PPE), guarding, manual handling **Inspection and testing**: safety checks (wheel speed, spindle speed, visual, ring test), safety factors (centrifugal stress, operating stress [heat, mechanical]), machine checks (oil levels [wheelhead, workhead], lubrication points), ensure no end play in spindle, security of pipes and couplings, safety devices and interlocks are working, emergency stops, alignment , traverse stops are functional, guards in position and secure, type and care of cutting fluids (purpose: absorption and carry away heat from the cutting zone, rapid cooling, maintain clean cutting zone, flood contact zone, remove dust and particles), filtering system for the cutting fluid, dust extraction equipment (purpose and function, checking, removal of waste), care of grinding wheels **Marking**: types (1, 2, 3, 4, 5, 6, 11, 12, 13, 27, 27A)abrasives (aluminium oxide, silicon carbide, cubic boron nitride [CBN]), grain size, grade, structure and bond, wheels larger than Ø80 mm (rpm, dimensions, specifications) wheels less than Ø80 mm (colour coded stripes, expiry date), factors affecting wheel selection (material to be ground, amount of material to be removed, arc/area of contact, type and condition of machine, wheel and work speeds, dry or wet cutting **Characteristics:** cutting action, hazards (bursting wheel, flying particles, abrasive burns)

Learning outcome
The learner will: 2. be able to perform manufacturing operations to produce precision finishes using surface grinding
Assessment criteria
The learner can: 2.1 perform **surface grinding operations to produce precision flat and parallel surfaces** 2.2 use **workholding devices** when setting up for grinding operations 2.3 evaluate the **dimensional accuracy** to BS EN ISO 286 and 0.2m surface texture 2.4 perform wheel **balancing**, truing and dressing operations 2.5 describe the possible **faults** in grinding wheels and ways of rectifying them

Range
Surface grinder: horizontal spindle, vertical spindle, need for dust extraction, feed systems, determination of wheel and work speeds, reason for 'sparkout', reasons for the 'warm up' period, settings **Workholding**: magnet chuck,table, magnet blocks, double sided tape, direct clamping, vices, fixtures, purpose **Surface grinding:** dry grinding, wet grinding, guards (wheel, table), machine movements and methods of setting (wheel, table) **Dimensional accuracy**: co-ordinate measuring machine, micrometers (external) surface measuring machine and charts **Balancing:** false spindle, balancing stand compound slide, dressing (diamond, stone) **Faults:** wheel chatter, rough finish, wheel loading, short wheel life, effects of heat when grinding, possible problems and remedies

Learning outcome
The learner will: 3. be able to perform manufacturing operations to produce precision finishes using cylindrical grinding
Assessment criteria
The learner can: 3.1 perform external and internal grinding operations using a cylindrical grinder to produce precision parallel and tapered bores and shafts 3.2 use **workholding devices** when setting up for grinding operations 3.3 evaluate the **dimensional accuracy** to BS EN ISO 286 and 0.2 • m surface texture 3.4 perform wheel **mounting**, balancing, truing and dressing operations 3.5 **restore work areas** to a clean and safe condition on completion

Range
Cylindrical grinder: machine parts, drive pin, face plate, table traverse stops, guarding, table, grinding fluids **Workholding:** between centres, faceplate, carriers, chucks, collets, spigots, **External and internal grinding**: centralising, work setting, setting table traverse stops, steady rests, steady rest shoes, guarding, nomograms, effects of arc area contact, **Dimensional accuracy:** co-ordinate measuring machine, micrometers (external, internal) surface measuring machine and charts **Mounting:** handling and storage of wheels, truing and dressing (fixed installation diamond, portable diamond), wheel balancing (parallel ways, overlapping discs), hub flanges, effects of an unbalanced wheel, function and construction of control wheel,

Learning outcome
The learner will: 4. be able to perform tool and cutter grinding operations
Assessment criteria
The learner can: 4.1 perform safe operation of **tool and cutter grinders** to re-grind lathe tools and milling cutters 4.2 explain the **tool geometry** nomenclature for lathe tools and milling cutters 4.3 **calculate** the off set for different angles

Range
Tool and cutter grinders: machine parts (wheel head, cutter head, stub arbor, setting gauge, tailstock, tool rest), wheel dressing (off-hand), principle parts (grinding wheel, control wheel, work rest blade), directional movements (grinding wheel, control wheel, work), types of feed (through, how feed is accomplished, work rest, in, end) **Tool geometry:** range of lathe tools and milling cutter, collet held and arbour mounted, methods of grinding (milling cutters, linear setting, angular setting) clearance angles (primary, secondary), addition equipment: gauges, tooth rest, and cutter heads **Calculate:** linear setting to obtain clearance angle

Unit 325 Machining Materials by Grinding

Supporting information

Guidance

Surface grinder: horizontal spindle (reciprocating table, down feed and cross traverse, rotary table, down feed and cross traverse), vertical spindle (reciprocating table and down feed, rotary table and down feed), need for dust extraction, feed systems (table – reciprocating and cross, wheel), determination of wheel and work speeds, reason for 'sparkout', reasons for the 'warm up' period, settings (traverse stops, centres, rests, guides, control wheel)

Workholding: magnet chuck (truing of surface), table, magnet blocks, double sided tape, direct clamping, vices, fixtures, purpose (restrain workpiece against wheel force, locate workpiece)

Faults: wheel chatter (true wheel, increase feed, use softer grade) rough finish (finer grit wheel, use harder grade, increase work traverse) wheel loading (use coarser grit, dress wheel, increase work traverse), short wheel life, effects of heat when grinding (expansion/dimensional accuracy, overheating/wheel life and additional costs) possible problems and remedies (over and undersize components: wheel wear, slackness inslides deflection; inconsistency of component shape: deflecting and stops; vibration: condition of machine, set up, speeds and feeds; surface finish of component: wheel fault and clamping)

Cylindrical grinder: machine parts (work head, tailstock, table, wheel head [external internal), feed systems (table, wheel head), drive pin, face plate, table traverse stops, guarding (external wheels, internal wheels), table, grinding fluids (cooling, chip and dust removal, non-corrosive, supply [pump, flow control, filtration])

External and internal grinding: centralising (work head, tailstock), work setting (between centres, three jaw self centring chuck), setting table traverse stops, steady rests, steady rest shoes, guarding (external wheels, internal wheels, table), nomograms (work head speed, table traverse speed), effects of arc area contact,

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 326 CNC machining of materials

URN:	**D/503/0416**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and knowledge necessary to successfully machine by Computer Numerical Control (CNC), it includes part-programming, preparation of the machine, selection and the preparing of the required methods of workholding, the selection and the correct mounting of tooling. It also covers the operations required and safe working practices to complete the machining operations.

Learning outcome
The learner will: 1. be able to produce CNC part-programs
Assessment criteria
The learner can: 1.1 interpret engineering component drawings to determine CNC part-programming requirements 1.2 explain the principles of computer numerical control as the control of machine movements and management functions through coded instructions 1.3 explain the **types of program format** 1.4 explain the meaning of the **part programming terms** 1.5 select a suitable datum to the component to be machined 1.6 describe the factors to be considered when **planning** a part program 1.7 produce tables of co-ordinate dimension taken from specified datum positions in the form of **part program** operation sheets 1.8 produce an **instruction set** to machine and engineering component to size 1.9 explain **tool geometry** requirements for effective material removal 1.10 calculate **speeds and feeds** for CNC machine tools 1.11 explain the importance of modifying feed rates when profiling internal and external radii 1.12 explain the constant surface speed mode for turning operations

1.13	explain the benefits of using tool nose radius compensation for turning operations
1.14	explain circular interpolation and arc programming commands
1.15	apply **trigonometry** to calculate component cutter path co-ordinates
1.16	describe different programming formats including ISO word address and other formats used by Fanuc, Heidenhain and other controllers
1.17	describe word address, conversational and graphical programming

Range

Types of program format: fixed sequence/block, word address
Part-programming terms: character, word, block, modal and non-modal functions

Planning: component material, dimensions and tolerances, required surface finish, appropriate datum settings, roughing and finishing operations, grouping of similar operations, relevant canned cycles, loops, macros and subroutines, workholding methods to give accurate location and secure (CNC milling: direct clamping, vices, fixtures, devices modified for CNC operations; CNC turning: three jaw chucks, including the use of soft jaws, four jaw chucks, collets)

Part program: work material, work datum position, workholding requirements, tooling requirements including pre-setting data, sequence of operations, miscellaneous functions

Instruction set: factors to be considered when planning safe tool paths to ensure: operator safety, collisions with component and workholding equipment are avoided, safe work and tool changing positions are specified, defined areas to prevent collisions, cutter diameter compensation for milling operations, assigned canned cycles, user-defined canned cycles, translation and transformation commands for: mirror imaging, rotation, scaling, datum offset; canned cycles for turning operations

Tool geometry: milling cutters, turning tools, characteristics and applications, principles of mounting/clamping systems

Speeds and feeds: spindle speed (define cutting speed as relative linear speed between work surface and tool point, use cutting tool manufacturers data for work/tool combinations allowing for: type of cutting operation, surface finish requirements, use of coolant); feed rate (define feed rate as distance moved per minute (mm/min) or distance moved per revolution (mm/rev), use of manufacturers feed rate data allowing for: type of cutting operation, surface finish requirements, cutting tool geometry, work/tool material combinations, delicacy of work piece and workholding method

Trigonometry: Pythagoras' theorem, trigonometric ratios, sine rule

Learning outcome
The learner will: 2. be able to set-up CNC machine tools
Assessment criteria
The learner can: 2.1 use the precautions to be taken to prevent accidents when setting and operating CNC machines 2.2 explain the potential hazards when setting and operating CNC machines input part-program 2.3 **input data** to CNC machine controls 2.4 **check that** guards, interlocking devices and fail safe mechanisms are operating 2.5 set work datums and tool length offset values 2.6 describe the characteristics of preset and qualified tooling 2.7 describe the advantages of performing a **trial run**

Range
Input data: manual data input, portable systems, direct computer link, via data storage devices **Trial run:** (dummy run) finding any unwanted rapid tool movements, make adjustments to speeds and feeds, adjustments to compensate for errors, reduce unnecessary tool movements, rearrange the machining sequence; methods of editing the part program: manual data input (MDI), off line using a text editor

Learning outcome
The learner will: 3. be able to produce parts using CNC machine tools
Assessment criteria
The learner can: 3.1 produce block diagrams showing the elements of open and closed loop control systems 3.2 produce line diagrams to identify primary and secondary **axes of motion** for vertical and horizontal spindle CNC machines indicating positive and negative movement 3.3 compare work and tool holding/changing systems on CNC machine tools 3.4 explain the principles of **tooling** systems, libraries and monitoring 3.5 explain the function of **workholding and setting devices** used on CNC machine tools 3.6 explain the **construction and operation** of CNC machine tools and recognise the importance to accurate performance in milling and turning 3.7 explain problems of **swarf removal** and the methods used to overcome them 3.8 differentiate between different types of **machine control** and the application to which they are suited 3.9 use the precautions to be taken to prevent accidents when setting and operating CNC machines

3.10 explain the potential **hazards** when setting and operating CNC machines input part-program

3.11 check that, guards, interlocking devices and fail safe mechanisms are operating

3.12 prove part programs to check for program errors and edit to achieve optimum production performance

3.13 explain the importance of **optimising production** during program proving

3.14 produce suitable components to required specifications

3.15 inspect finished component against specifications

Range

Axes of motion: X Y and Z conventions used for primary axis motion for various CNC machine configurations; U V and W conventions used for secondary axis motion for various CNC machine configurations; A B and C conventions used for rotation about the primary axes

Tooling: systems: preset, qualified, modular cutting unit, tool adapter; libraries: tool identification, geometry, offset values, speed, feed and tool life data; monitoring: sensing devices and electronic probes – tool life and cutting conditions, tool breakage detection, tool offset measurements, tool identification, torque variations, acoustic emissions

Workholding and setting devices: conventional workholding devices modified to suit CNC operation; positioning work datum relative to machine datum, the need for zero shift controls and how they are used, the use of air and hydraulic workholding devices for gripping delicate components; methods of setting workholding devices accurately relative to machine slide movements

Construction and operation: structural requirements: strength, rigidity, vibration damping; correct alignment, feedback transducers, re-circulating ball and leadscrew; operating principles of linear and rotary transducers used in CNC systems, differences between open and closed loop control systems (positional feedback, drive method)

Swarf removal: volume produced, conveyor systems, slant bed design, cutting fluid reclamation

Machine control: typse: point to point control, linear (paraxial)control, continuous path control; applications: point to point drilling and tapping operations, linear profiles and slots, curved profiles and slots

Hazards: tool collisions, swarf/chips, rapid movement of machine parts and tooling, entrapment, etc.; avoidance using machine over-ride controls, hazards when using the constant surface speed function on CNC lathes, location and function of emergency stop and program stop controls, guards, interlocking devices and fail safe mechanisms

Optimising production: adjusting speeds and feeds to give maximum metal removal rates considering: surface finish requirements, tool life requirements; reducing unnecessary tool movements; rearranging the machining sequence; adjustments to compensate for errors and tool wear (tool offsets and length offset values, cutter radius/diameter compensation)

Learning outcome
The learner will: 4. be able to reinstate the work area.
Assessment criteria
The learner can: 4.1 **restore the work area** to agreed requirements 4.2 describe the difference between waste and reusable or recyclable materials 4.3 explain the actions to be taken in the event of a **spillage**

Range
Restore the work area: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identifying and recording finished work, manual cleaning machine tools, machine assisted cleaning, use and storage of cleaning agents, labelling/identifying products, inspecting components, tools and equipment on completion of work, cleaning and storing personal protection equipment

Unit 326 CNC machining of materials

Supporting information

Guidance

Part program: work material, work datum position, workholding requirements, tooling requirements including pre-setting data, sequence of operations [part program] (X, Y, Z, dimensional information, machine management information [preparatory functions: rapid movement, time dwell, zero shift, feed rates, absolute/incremental dimensions, inch/metric units]; miscellaneous functions [end of program, spindle forward/reverse, tool change, coolant on/off]; speeds and feeds; tooling requirements)

Instruction set: factors to be considered when planning safe tool paths to ensure: operator safety, collisions with component and workholding equipment are avoided, safe work and tool changing positions are specified, defined areas to prevent collisions (safe zone, warning zone, prohibited zone); cutter diameter compensation for milling operations, assigned canned cycles (role and benefits; milling: circular interpolation, rectangular/circular pocket milling, slot mill; drilling: drill, drill and dwell, deep hole drilling); user-defined canned cycles (role and benefits; loops, macros, subroutines); translation and transformation commands for: mirror imaging, rotation, scaling, datum offset; canned cycles for turning operations (stock removal in turning, stock removal in facing, thread cutting, peck drilling in Z axis)

Restore the work area: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identifying and recording finished work, manual cleaning machine tools, machine assisted cleaning, use and storage of cleaning agents, labelling/identifying products, inspecting components, tools and equipment on completion of work, cleaning and storing personal protection equipment

Unit 327 Detailed fitting of materials

URN:	**M/503/0419**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and knowledge that are essential for detailed fitting being carried out safely and efficiently. It includes the preparation of equipment, materials, service supplies, works areas, together with production and quality requirements.

Learning outcome
The learner will: 1. be able to determine tooling and equipment requirements
Assessment criteria
The learner can: 1.1 follow **safe working practices** and procedures when carrying out maintenance activities 1.2 explain the **hazards** associated with bench fitting activities 1.3 interpret information from **engineering drawings** 1.4 identify the **tools and equipment** required to undertake a bench fitting activity 1.5 describe the functions of **equipment and systems** 1.6 explain the **factors affecting accuracy** 1.7 explain the forces exerted on pins and keys

Range
Safe working practices: wearing appropriate protective clothing and equipment (overalls, safety footwear, eye protection, hearing protection, use of barrier cream), maintaining a clean and tidy work area, preparing the work area, leaving the work area in a safe and clean condition, risk assessments **Hazards**: handling of coolants and cutting oils/compounds, misuses of tools, use of damaged or badly maintained tools **Engineering drawings:** dimensional, geometrical, materials **Tools and equipment:** marking out, hand tools, measuring instruments, gauges, dial test indicators, surface finish/texture, cutting and shaping, scrapers, levers and pullers, drills, taps, use of charts for selecting tapping sizes and dies, reamers, forms of power supply, powered hand tools, forming equipment, guillotines, folders **Equipment and systems:** bearings, bushes and seals; shafts and couplings; pins and keys; power transmission and pulley mechanisms; fabrications and castings; gaskets; locking devices; springs; linkages/rollers **Factors affecting accuracy**: environmental, equipment, human **Forces exerted on pins and keys:** axial, radial, shear

Learning outcome
The learner will: 2. be able to prepare to perform detailed fitting operations
Assessment criteria
The learner can: 2.1 explain the purpose of **workholding** 2.2 describe the different types and features of **machines** 2.3 explain the meaning and applications of different **threads** 2.4 explain the purpose of **reaming holes** 2.5 explain the purpose of **scraping** 2.6 explain the purpose of **shafts and plain bearings** 2.7 explain the type, construction and purpose of **ball and roller bearing systems** 2.8 identify the different **type of seals** 2.9 explain the purpose of **flanges** 2.10 explain the purpose of **gear assemblies** 2.11 explain the purpose of **transmission systems** 2.12 explain the type, construction and purpose of **cylinders/actuators and auxiliary components** 2.13 critically compare **types of pump** available 2.14 critically compare **types of valve** available 2.15 explain the type, construction and purpose of auxiliary components 2.16 prepare to produce assemblies by detailed fitting

Range
Workholding: locate work, restrain the forces exerted by the tool, workholding devices **Machines:** bench/pillar drills, portable drills (mains operated, battery, pneumatic) grinding machines (bench, angle) **Threads**: terms: pitch and lead, left and right hand threads, single and multi-start; applications: fastening device, transmit motion; manual methods cutting threads: internal taps, internal special taps and thread inserts, external dies, external solid die nuts **Reaming holes**: parallel through, blind, tapered **Scraping:** flat surfaces, bearings **Shafts and plain bearings**: correct clearances, checking clearance, lubrication and methods of distribution **Ball and roller bearing systems:** factors influencing cleanliness, classes of fit (inner race fits tightly on shaft, outer race slides into housing, inner and outer races both tightly fitting), types of self-alignment bearings, distinguish between thrust bearings designed to take: axial loads only, axial and radial loads; tools used for fitting ball and roller bearings (drifts, special spanners, extractors), inspecting bearings for faults (pitting, crazing, discolouration, assessment of the necessity for replacement); sealing bearing assemblies lubricated by grease or lubricating oils (felt and synthetic rubber ring seals, minimum machined clearance between bearing housing and shaft, labyrinth seals) **Type of seals**: metallic, non-metallic, combination of metallic and non-metallic; selection: applications, temperature and pressure, speed of moving parts, replacement period and corrosion **Flanges**: faces clean and flat, checking 'O' rings or gaskets for size, shape and depth/condition of recesses, tightening flange bolts in the correct sequence **Gear assemblies**: how to obtain: contact area of tooth surfaces, alignment of gear faces, tooth surface clearance; methods of obtaining positive clearance **Transmission systems**: tensioning belt/pulley systems, tensioning chain/sprocket systems **Cylinders/actuators and auxiliary components**: single acting, double acting, auxiliary components: reservoirs, accumulators, filters **Types of pump:** gear, vane, piston **Types of valve**: manual, mechanical, pilot, directional control values spool and rotary, non-return, pressure control, flow control

Learning outcome
The learner will: 3. be able to perform detailed fitting operations
Assessment criteria
The learner can: 3.1 use **workholding** devices safely 3.2 use drilling and grinding machines to shape material safely **3.3 sharpen tools by grinding** 3.4 produce and apply internal and external **threads** for engineering uses 3.5 produce **reamed holes** 3.6 apply **scraping** technique to flat surfaces and bearings 3.7 assemble **component parts and sub systems** 3.8 isolate equipment 3.9 check **accuracy of components** against specification

Range
Workholding: locate work, restrain the forces exerted by the tool, workholding devices **Sharpen tools by grinding:** cold chisels, twist drills **Machines:** bench/pillar drills, portable drills (mains operated, battery, pneumatic) grinding machines (bench, angle) **Threads:** manual methods cutting threads: internal taps, internal special taps and thread inserts, external dies, external solid die nuts **Reamed holes**: parallel through, blind, tapered **Scraping**: flat surfaces, bearings **Component parts and sub systems** **shafts and bearings**: methods of obtaining clearances by: filing, scraping, shimming; checking clearance: feeler gauges, dial test indicator (DTI), lead wire, lubrication **ball and roller bearings**: cleanliness: personal cleanliness hands, tools and work surfaces, cleaning journals and housings prior to fitting, retaining bearings in protective wrapping until required; methods of positioning by: pressing into the housing, tapping, heating and sliding onto the shaft, cooling; use tools for fitting ball and roller bearings, inspect bearings for faults, seal bearing assemblies lubricated by grease or lubricating oils **seals**: metallic, non-metallic, combination of metallic and non-metallic; selection: applications, temperature and pressure, speed of moving parts, replacement period and corrosion **flanges:** faces clean and flat, checking 'O' rings or gaskets for size, shape and depth/condition of recesses, tightening flange bolts in the correct sequence **gear assemblies:** contact area of tooth surfaces, alignment of gear faces, tooth surface clearance; methods of obtaining positive clearance by: increasing the centre distance between gears, reducing tooth profile one gear, reducing tooth thickness of both gears; fitting gears on shafts: press fit, push fit **transmission systems:** methods of tensioning belt/pulley systems, tensioning chain/sprocket systems

cylinders/actuators: single acting, double acting

pumps: gear, vane, piston, auxiliary components: reservoirs, accumulators, filters

valves: methods of activation: manual, mechanical, pilot, directional control values spool and rotary, non-return, pressure control, flow control

isolating equipment: removal of fuses from electrical prime movers, disconnect drive shaft, closing and locking-off valves, closing auxiliary supplies, drain down pipework

Accuracy of components: factors affecting accuracy: misalignment of work and measuring equipment, parallax error

Learning outcome
The learner will: 4. be able to reinstate the work area
Assessment criteria
The learner can: 4.1 **restore the work area** to agreed requirements 4.2 identify **waste and reusable or recyclable materials** 4.3 explain the actions to be taken in the event of a spillage

Range
Waste and reusable or recyclable materials: types of waste produced, storage and waste removal, disposal methods (recycling, solid waste, liquid waste) **Actions to be taken in the event of a spillage:** barriers and safety signs, use of personal protection equipment, aids to containment and prevention of spillage reaching the watercourse, aides for cleaning, who should be notified

Unit 327 Detailed fitting of materials

Supporting information

Guidance

Tools and equipment: marking out (scribers, scribing block, punches [centre and dot], surface plate/table, angle plate, parallels and vee blocks) hand tools (files, screwdrivers, hammers and mallets, spanners (open-ended, socket sets, ring, torque wrenches), measuring instruments (rules, inside and outside calipers, protractor, micrometers (external, depth), verniers (height gauge, protractor, callipers), gauges (feeler, blocks/slip, radius, thread) dial test indicators, surface finish/texture (comparison plates, tactile machines), cutting and shaping (saws [hand, mechanical], scrapers, levers and pullers, drills (high speed steel [HSS] carbide tips drill speed tables, cutting speed formula [cutting speed = πdN/1000]), taps (spiral flute, straight flute [taper, second, bottoming], use of charts for selecting tapping sizes) and dies (circular split, rectangular loose, solid die nut, pipe thread), reamers (hand, taper), forms of power supply (230V, 110V, pneumatic, battery), powered hand tools (drills, screwdrivers, angle grinders, saws), forming equipment (bench folders, fly press), guillotines, folders

Equipment and systems: bearings, bushes and seals; shafts and couplings; pins and keys; power transmission and pulley mechanisms (gears, chains and sprockets, belts and pulleys); fabrications and castings; gaskets; locking devices; springs; linkages/rollers

Factors affecting accuracy: misalignment of work and measuring equipment, parallax error; affects of temperature variation upon: measuring, joining by co-efficient of expansion/contraction

Component parts and sub systems

Shafts and bearings: methods of obtaining clearances by: filing, scraping, shimming; checking clearance: feeler gauges, dial test indicator (DTI), lead wire, lubrication Ball and roller bearings: cleanliness: personal cleanliness hands, tools and work surfaces, cleaning journals and housings prior to fitting, retaining bearings in protective wrapping until required; methods of positioning by: pressing into the housing, tapping, heating and sliding onto the shaft (oil bath or electrically), cooling; use tools for fitting ball and roller bearings (drifts, special spanners, extractors), inspect bearings for faults (pitting, crazing, discolouration, assessment of the necessity for replacement); seal bearing assemblies lubricated by grease or lubricating oils (felt and synthetic rubber ring seals, minimum machined clearance between bearing housing and shaft

Transmission systems: methods of tensioning belt/pulley systems (idler pulleys, adjustment of the centres between shafts, hinged mounted pulleys), tensioning chain/sprocket systems (idler wheel, adjustment of sprocket by set screws)

Restore the work area: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identifying and recording finished work, isolate machines, manual cleaning machine tools, machine assisted cleaning, use and storage of cleaning agents, labelling/identifying products, inspecting components, tools and equipment on completion of work, cleaning and storing Personal Protection Equipment (PPE)

Unit 328 Maintenance of electrical equipment and systems

URN:	**H/503/0420**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	The unit is concerned with basic electrical theory and electrical components associated with the maintenance of electrical equipment. The candidate will understand the operations necessary for the planning and carrying out of maintenance in an industrial and commercial environment.

Learning outcome
The learner will: 1. understand the components and features of electrical systems
Assessment criteria
The learner can: 1.1 explain **electrical system components** and units in conjunction with system drawings 1.2 explain the **function of electrical components** and the way in which they can be assembled 1.3 identify **components and systems** to meet required functions

Range
Function of electrical components: electromagnets, magnetic materials, iInductors capacitors, electrolytic capacitors, discharge resistors, semi-conductor devices, diodes, thyristor and triac, half and full wave rectification, heat sinks, smoothing circuits, single thyristor circuits, transformers. **Components and systems** containment systems, Busbar systems, underfloor ducting, rising mains, steel wire armoured (SWA) and Mineral Insulated Copper cable (MICC), circuit breakers switches, fuses, isolators supply systems, earthing arrangements TT, TN-S, TN-C-S, lightning protection, no-volt releases, residual current devices. d.c machines ratings, insulation and enclosures. d.c. generators excitation and voltage control. d.c motors, series, shunt & compound, alternating current machines, types- induction and synchronous, construction-cylindrical and salient pole, power factor correction equipment,single phase motors, series universal, split phase induction start, capacitor start, capacitor start and run, motor starters and motor speed controllers test equipment, insulation resistance testers, low resistance ohmmeters, wattmeters, earth loop impedance and prospective short circuit testers tachometers and stroboscopes.

Learning outcome
The learner will: 2. be able to plan and prepare for the maintenance operation
Assessment criteria
The learner can: 2.1 evaluate the **extent of work** to be carried out 2.2 describe the current legislation and codes of practice relating to electrical equipment and systems 2.3 carry out a **risk assessment** by listing the procedures and requirements for setting up safe working conditions 2.4 analyse manufacturers' information, related work records, circuit diagrams and other necessary **data** 2.5 identify **tools and equipment** 2.6 prepare works orders or requisitions

Range
Extent of work: area, safety requirements, equipment, barriers and enclosures, notification of personnel and other workers, Personal Protective Equipment (PPE) **Legislation**: Electricity at Work Regulations, IEE Wiring Regulations, GS 38 **Risk assessment**: method statements, safe isolation procedure, Permit to Work **Data:** manufacturers data, catalogues, internet, component data sheets, availability and assemble of materials, company stores, wholesalers and component suppliers. **Tools and equipment**: hand and power tools, battery operated drills, safety checks.

Learning outcome
The learner will: 3. be able to carry out monitoring and inspection of maintenance work
Assessment criteria
The learner can: 3.1 carry out **inspection** 3.2 conduct **diagnosis** and carry out repairs 3.3 complete maintenance record

Range
Inspection: on equipment or systems. e.g. visual inspection of plant, cables and containment **Diagnosis and carry out repairs – on faulty system and/or components** e.g. Faults to lighting, plant containment and other components. Motors and Generators, safe dismantling, recording of faults, install range of electrical systems. containment of oils and greases, protection and storage of parts, wear due to corrosion, erosion and pitting, worn seals, removal and fitting bearings, seals, springs, circlips, manufacture and fitting of gaskets, bench testing of components , maintenance records.

Learning outcome
The learner will: 4. be able to re-commission the system and restore the work area.
Assessment criteria
The learner can: 4.1 **re commissions the system** and adjust as required to working parameters 4.2 **restore work area** to a clean and safe condition upon completion of maintenance 4.3 classify **hazardous substances** and the state the approved method of disposal 4.4 produce a **report** to record the actions taken during hand over

Range
Re commission system: safety before re-energising, check all systems in place and re-set, prescribed start up procedures, electrical, mechanical and pneumatic/hydraulic checks. **Hazardous substances:** oils, greases, cleaning agents, solvents, insulation, adhesives, fillers, packing, lagging. **Report**: complete maintenance schedules, clear permits to work and sign off, diaries, materials used, record likely future requirements, update maintenance schedule, hand over to authorised personnel.

Unit 328 Maintenance of electrical equipment and systems

Supporting information

Guidance

Restore work area. Return reusable materials to store, clean and check tools, return tools to store/storage.

Unit 329 Produce drawings using CAD

URN:	**M/503/0422**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop the skills and knowledge in computer aided design (CAD), in terms of producing 2D and 3D drawings, including the use of 3D modelling methods. Although most of the commands referred to are generic and would apply to all CAD systems, some terms may be specific to one particular application (eg AutoCAD). Where this is the case an equivalent alternative application commands may be appropriate

Learning outcome
The learner will: 1. be able to set-up to produce CAD drawings
Assessment criteria
The learner can: 1.1 explain the function of **hardware** components used for CAD which are unique to CAD 1.2 explain the function of **data input devices** used in CAD 1.3 explain the function of **data output devices** used in CAD 1.4 explain CAD **software requirements** 1.5 evaluate methods of **data storage** and make recommendations for their use 1.6 explain the reasons for backup files and saving drawings at regular intervals 1.7 describe the role of drawings in communicating technical information 1.8 critically **compare CAD** systems with manual draughting methods 1.9 explain the purpose of prototype drawings and how they are used 1.10 set drawing aids 1.11 create layers 1.12 set drawing limits to suit component dimensions 1.13 set suitable drawing parameters 1.14 use main menu drawing commands to produce a variety of different shapes 1.15 create, save and load a range of library drawings.

Range
Hardware: effects of hardware specifications on efficiency of the system, processor type and speed, available RAM, video processor card, VDU resolution and screen size, size of hard disk drive **Data input devices**: keyboard, mouse, digitising tablet and puck, light pen, scanning, touch pad, track ball, CAD functions (command input, cursor movement, selecting menu items, picking points) **Data output devices**: VDU, printers, plotters, transfer data to a computer-aided manufacturing (CAM), principles of CAD/CAM **Software requirements**: memory allocation, driving input and output devices, CAD software, graphics creation, manipulation, manipulation, editing, storage, user software, customising menus and parameter, symbols library, macros, applications software including: parts listing, costing, stress analysis; operating system functions: create directories (folders), organise the contents of directories, locate, copy, delete and rename files **Data storage**: hard disk drive, CD ROM, CD RW, DVD ROM, DVD RW, USB storage devices, other storage media (eg. Internet), maintaining careful filing systems for manual reference and data storage (creation and maintenance of manual reference files for ease of access, index system for storage of disks), methods of restricting user access using passwords where required **Compare CAD**: speed of drawing creation, checking and editing, ease of creating modified revisions, quality and consistency of finished drawing, memory facility, storage and retrieval of finished drawings, cost, compatibility with CAM systems

Learning outcome
The learner will: 2. be able to produce 2D CAD drawings
Assessment criteria
The learner can: 2.1 set drawing **parameters** on the CAD system 2.2 explain the reasons for using structured **layers** and how they are created 2.3 explain the function of the **commands** used in producing 2D CAD drawings 2.4 produce 2D CAD drawings that contain essential **technical information** 2.5 apply standard **conventions** to 2D CAD drawings 2.6 differentiate between absolute, relative (incremental) and polar co-ordinate systems 2.7 differentiate between world and user co-ordinate systems 2.8 review and revise 2D CAD drawings by **editing** and manipulating graphical data 2.9 produce **text** on 2D CAD drawings 2.10 import and position library items onto 2D CAD drawings 2.11 apply conventions relating to **dimensioning** to 2D CAD drawings

2.12 apply the conventions for **cross-hatching** areas to 2D CAD drawings 2.13 save drawings using appropriate file names 2.14 load and edit existing drawings 2.15 evaluate the process of producing a 2D CAD drawing and recommend improvements to the process

Range
Parameters: limits to suit component dimensions and paper size, drawing aids to draw entities accurately (grid spacing, snap interval, object snap mode, orthogonal mode, units benefits and limitations of using the drawing aids) **Layers:** apply meaningful names, assign line types, assign colours, control the visibility of layers **Commands:** line, polyline, circle, arc, polygon, rectangle, ellipse, doughnut, erase (single entities, multiple entities) **Technical information:** projection type (pictorial: isometric, oblique; orthographic: first angle, third angle) units, scale, shape, size including tolerance, surface finish, number off, material requirements, special treatments, **Conventions:** BS 8888, types of line, representation of common features **Editing:** zoom in/zoom out, pan, erase, copy, mirror, offset, move, array (rectangular and polar), trim, extend, scale, stretch, break, fillet, chamfer, modify properties (line type, colour, layer) **Text:** position, font style, font height, rotation **Dimensioning:** linear, aligned, angular, diameters, radii, leader, tolerances, limits, methods of edit existing dimensions, baseline, continuous, associative dimensions **Cross-hatching:** simple and complex **areas,** pre-defined hatch patterns, user defined hatch patterns, application to cross-sectioning

Learning outcome
The learner will: 3. be able to produce 3D CAD drawings
Assessment criteria
The learner can: 3.1 explain the role of detail and assembly drawings 3.2 critically compare the 3D CAD drawing **visual representation** methods available 3.3 explain the function of the **commands** used in producing 3D CAD drawings 3.4 produce 3D CAD drawings that contain essential technical information 3.5 review and revise 3D CAD drawings by editing and manipulating graphical data 3.6 apply the shading and rendering to 3D CAD drawings 3.7 save drawings using appropriate file names 3.8 load and edit existing drawings

Range
Visual representation: isometric projection, wire frame modelling, extruded forms, solid modelling (B-REP, CGS, hybrid) surface modelling, parametric and variational geometry **Commands:** line, polyline, circle, arc, polygon, rectangle, ellipse, doughnut, erase (single entities, multiple entities), extrude, revolve, 3D primitives (box, cuboid, sphere, cylinder, cone, torus, wedge), combine primitives using Boolean operations (addition, union, join, subtraction, cut, intersection), surfacing commands, shade, hide, render, rotate, camera, 3D views, 3D viewports (multiple views), model space, paper space

Learning outcome
The learner will: 4. be able to produce hard copies of CAD drawings
Assessment criteria
The learner can: 4.1 **print/plot** hard copies of different sized CAD drawings 4.2 print/plot hard copies of modified CAD drawings 4.3 critically compare types of printer/plotter available 4.4 import drawings into **presentation** software for demonstration purposes 4.5 transfer CAD data to a computer-aided manufacturing Computer Aided Manufacturing (CAM) system

Range
Print/plot: print/plot command, printer/plotter configuration settings, device selection, paper size (A4, A3, etc.), paper orientation (portrait, landscape) paper source, print quality, pen assignments where appropriate, display parameters, extents, limits, view, window, text resolution, units, scale, rotation and origin, print preview **Presentation:** produce a presentation that fulfils one or more of the following criteria: o demonstrates the stages of the drawing process o shows the capabilities of the engineering item drawn presents the item from a sales and marketing perspective

Unit 330 Organising and managing engineering operations

URN:	**A/503/0424**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to develop an understanding of the principles of organisation and management and the ways in which engineering activities can be efficiently planned and implemented. It covers the topics: relationships between installation, production and maintenance operations, the necessity for good planning in order to provide an efficient and cost effective service and why good recording processes are needed and how data is collected, used to forecast and/or solve problems. The unit also covers the main sources of labour and physical resources and developing good relationships with all levels of personnel and the ways in which their duties need to be carried out. The candidate is not expected to have an in-depth understanding of all engineering activities and strategies but should be familiar with the events/terminology that they will come into contact with during normal working conditions

Learning outcome
The learner will: 1. be able to organise engineering activities
Assessment criteria
The learner can: 1.1 explain the **organisational structures** employed in engineering 1.2 describe the function of **engineering sections** 1.3 explain the procedures for organising and running **meetings**

Range
Organisational structures: roles and responsibilities, lines of communication, decision making and implementation procedures, types of organisation chart **Engineering sections**: installation, production, maintenance **Meetings:** duties of the chair and secretary

Learning outcome
The learner will: 2. be able to schedule engineering activities
Assessment criteria
The learner can: 2.1 explain the factors that need to be considered when planning **operations** 2.2 explain the need for reviewing production and maintenance procedures at regular intervals in order to ensure maximum efficiency and economy 2.3 prepare flow and Gantt (bar) charts for planning, scheduling and checking on progress 2.4 produce worksheets or job cards for typical engineering tasks 2.5 explain the need for establishing priorities and the most effective **sequences of operations** 2.6 explain how **modification, repair or replace** policies are determined 2.7 explain how **reliability** can be achieved and production targets maintained

Range
Planning: obtaining specialist tools and equipment, personnel requirements (existing staff, specialist skills available and possible training needs, temporary [sub contract, casual], contingencies and overtime), items that must be considered when preparing contracts (working conditions and health and safety implications, supervisory and legal responsibilities, penalties for non compliance with conditions, insurance cover), provision of materials and spares, effects on other departments or changes to working practices (permanent or temporary), estimation of time needed for different activities **Operations:** production, maintenance or installation **Sequences of operations**: Critical Path Analysis (CPA) and/or Performance Evaluation and Review Techniques (PERT) principles (using examples but without necessarily carrying out an analysis), contingency plans for: inclement conditions, shortage of materials or staff, equipment failure **Modification, repair or replace:** plant history records, manufacturer's recommendations, changes in production output, age of plant or equipment, technological changes **Reliability**: good maintenance, identification of recurring problems or faults, initiating or modifying new procedures, updating systems, equipment and machinery

Learning outcome
The learner will: 3. be able to analyse the costs associated with engineering installation, production and maintenance
Assessment criteria
The learner can: 3.1 analyse the cost-related information needed when **estimating/budgeting** for an **activity** 3.2 estimate the cost of an **activity** 3.3 estimate the **total life cycle costs** of machinery 3.4 describe the difference between **direct and indirect costs** 3.5 compare production performance, maintenance or installation costs using cost analysis 3.6 use bar and/or pie charts to identify the optimum levels of production or maintenance costs 3.7 explain how commonly used cost ratios are employed to determine the value of maintenance 3.8 evaluate the significant importance on costs of machinery and items held in stores as indicated by a Pareto analysis 3.9 explain the relationship between capital expenditure and depreciation for plant and equipment 3.10 explain the need to manage stock levels in stores for economic and efficient operation and production

Range
Estimating/budgeting: extent of the task(s), time allowed for completion, the skills and experience of personnel to be involved, machinery, equipment, materials and spares that will be needed, purchase or hire of specialist equipment **Activity:** production, maintenance or installation **Total life cycle costs:** design features, maintenance, expected length of serviceable use, disposal value or costs that may be incurred during decommissioning and dismantling **Direct and indirect costs:** direct costs (materials, labour [company employed and sub-contract], overheads [rent, rates, taxes, energy consumption]), indirect costs (organisation and management, lost production, depreciation of equipment, training)

Learning outcome
The learner will: 4. be able to apply research methods to assist the installation, production or maintenance process
Assessment criteria
The learner can: 4.1 describe the implications of using **computers** to access records and product information 4.2 explain how feedback data can be used to improve planning and scheduling 4.3 collect data and use it to report on installation, production or

maintenance requirements

4.4 identify **the information required to determine the prime cause of a fault or production problem**

4.5 produce an algorithm to help trace a fault or production problem

4.6 explain the importance of collecting and recording information following the failure of equipment or machinery for calculation of Mean Time Between (or To) Failures (MTBF and MTTF)

4.7 evaluate available data to decide whether to repair or replace equipment

Range

Computers: increased number of access points, ease of updating, wide range of information available (including access to Internet), appropriate siting and cost of installation, maintaining security of data and limiting access to authorised persons only, training of personnel, automatic data collection and recording methods for controlling operations

Information required to determine the prime cause of a fault or production problem: to include detailed knowledge of the principles of the plant and equipment, observed and measured data, information obtained from operators, history of the equipment, details of changes in running conditions or modifications made, information from suppliers or manufacturers

Unit 330 Organising and managing engineering operations

Supporting information

Guidance

Engineering sections: installation (site preparation, installing new or modified equipment and systems, commissioning machinery and systems), production (preparation of drawings and specifications, ensuring that appropriate machinery, manpower and materials are available, producing work allocations and rotas to ensure efficient operation, dealing with production problems and shortages), maintenance (carrying out routine servicing schedules, repair and replacement following breakdowns, monitoring and performance testing of machinery, equipment and systems)

Meetings: duties of the chair (preparation of agendas, allocating personnel to deliver agenda items, conduct and control meetings), duties of the secretary (arrange time, venue and catering requirements, take minutes during meeting, produce finalised minutes and distribute to concerned persons

Unit 332 Mechatronics systems principles and fault finding

URN:	**R/503/0428**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with pneumatic, hydraulic, mechanical and electrical actuation systems. The topics covered will enable the candidate to interpret diagrams, explain the operation of circuits and systems and be able to identify and test electrical and mechanical components. The candidate will also be able to perform diagnostic checks on prepared (simple) systems, and make deductions from the results of these checks which lead to a correct fault diagnosis.

Learning outcome
The learner will: 1. understand the principles of the 'Total Engineering Approach' to production systems
Assessment criteria
The learner can: 1.1 classify the basic **building blocks** of industrial systems 1.2 explain, with the aid of block diagrams, the **architecture** of various types of industrial systems 1.3 describe the differences between the **features** of conventional and mechatronic systems

Range

Building blocks: typical input devices, prime movers, gearing, controllers, typical output devices

Architecture: controller, correction element, process, outputs, logical sequence of events, construct block diagrams

Features: centralised control or distributed control, hard wiring or networks, sequence control or intelligent individual control, relay logic *or* software programming, plant maintenance or predictive maintenance

Learning outcome
The learner will: 2. be able to apply the principles of typical sensors
Assessment criteria
The learner can: 2.1 interface contact and non-contact **sensors** into a control system. 2.2 explain the operation and application of **sensors** 2.3 explain typical connections and tuning arrangements for **sensors** 2.4 explain the action and importance of **signal conditioning systems** 2.5 explain the importance of **terms** applied to sensors used in an industrial system

Range
Sensors: micro switch, snap action limit switch, wobble stick, pressure mat, positively guided safety switch, inductive proximity, capacitive proximity, optical proximity, light curtain, thermocouple, strain gauge differential pressure, impeller flow, encoder (incremental and absolute), resolver **Signal conditioning systems:** voltage to current, current to voltage, pressure to voltage, pressure to current, analogue to digital, digital to analogue, frequency to voltage, frequency to current, sink to source, source to sink **Terms:** sensitivity, repeatability, resolution, dead band, alignment, compatibility, cross talk, grounding, calibration

Learning outcome
The learner will: 3. be able to apply the principles of pneumatic, hydraulic, mechanical and electrical actuation systems
Assessment criteria
The learner can: 3.1 design and implement **control and actuation systems** 3.2 explain the operation and application of each part of a **pneumatic power system** 3.3 explain the operation and application of **valves** employed in **pneumatic systems** 3.4 explain the operation and application of **actuators** employed in pneumatic systems 3.5 explain the operation and application of each part of a **hydraulic power system** 3.6 explain the operation and application of **valves** employed in **hydraulic systems** 3.7 explain the operation and application of **actuators** employed in hydraulic systems 3.8 classify **symbols** used in pneumatic, hydraulic, mechanical and electrical actuation systems 3.9 explain the operation and application of each part of a **mechanical system**

3.10 explain the operation and application of each part of a **electrical system**
3.11 explain the application of **components** in a fieldbus network

Range
Control and actuation systems: pneumatic, hydraulic, electrical
Pneumatic power system: prime mover (i.e., motor), compressor (i.e., two stage reciprocating), silencer, filter, pressure relief valve, cooler, filter and water trap, air receiver, pipe work distribution system
Valves - pneumatic systems:
directional control valves (DCV) – spool, 3/2, 4/2, 5/2, directly operated, pilot operated, solenoid operated, poppet
directional valves – one way, one way restrictor return
pressure control valves – pressure regulating, pressure limiting, pressure sequence, **proportional**
process control valves – pneumatic diaphragm actuator, linear contoured, equal; **percentage**
actuators:
linear actuators – single acting, double acting, fluid muscle, tandem, multi position, stick slip
rotary actuators – use of linear actuator to produce rotation, vane-type semi-rotary, vane motor
Hydraulic power system: prime mover (i.e., motor), pump, non return valve, pressure relief valve, accumulator (i.e. bladder-type), sump, hydraulic oil, pipe work distribution system and return
Valves - hydraulic systems:
directional control valves (DCV) – spool, 3/2, 4/2, 5/2, directly operated, pilot operated, solenoid operated, poppet
directional valves – one way, one way restrictor return
pressure control valves – pressure regulating, pressure limiting, pressure sequence, proportional
Symbols: flow path, flow shut-off, initial connections, push button operation, lever operation, roller operation, plunger operation, spring operation, solenoid operation, pedal operation, pilot operation, 2/2 valve, 3/2 valve, 4/2 valve, 5/2 valve, non return valve, pressure limiting valve, regulator, pressure source, exhaust, filter, single acting cylinder, double acting cylinder, rotary actuator
Mechanical system: prismatic motion, revolute motion, sliding joints, revolving joints, force amplification (i.e., levers), change of speed (i.e., gears), transfer of rotation (i.e., belts and chains), types of motion (i.e., quick return mechanism), cams and cam followers, change of direction (i.e., bevel and worm gear), linear to revolute / revolute to linear (i.e., rack and pinion), bearings (i.e., plain roller needle and ball)
Electrical system:
switching devices – *push buttons, relays, thyristor, triac, solid state relay*
solenoid devices
motors – *series d.c., shunt d.c., separately excited d.c., stepper, servo, single phase induction, three phase induction*
motor control – *basic d.c. motor speed control (i.e., inverter drive), basic induction motor speed control (i.e., inverter drive), basic stepper motor controllers, basic servo motor controllers*

***Components**: benefits over hard wired systems, communications interface to control system, basic requirements of wiring medium (i.e. CAT 5, grounding), types of distributed input / output modules (i.e., digital, analogue)*

Learning outcome
The learner will: 4. be able to apply the principles of embedded control
Assessment criteria
The learner can: 4.1 write simple expressions to describe **logic instructions**. 4.2 explain the function of the main **components** in Programmable Logic Controller (PLC) architecture 4.3 explain **Ladder Logic programming** as used in PLC programming 4.4 explain the content of simple programs written using Ladder Logic programming 4.5 explain the function of the main **components** in Programmable Interface Controller (PIC) architecture 4.6 apply the content of programs written for simple **programme languages** PIC programming 4.7 explain the operation of **embedded control systems** 4.8 explain the logical function of **logic gates**

Range
Logic instructions: simple instructions to describe input/output conditions, correct terminology **Components (PLC):** control unit, programming device, input/output modules, memory, system clock, use block diagrams to aid description **Ladder Logic programming:** basic instructions, examine if open/closed, output, latched output, bit / flag instructions, timers, counters **Components (PIC):** Central Processing Unit (CPU), analogue to digital converter (ADC), input / output ports, communication port, timers, memory, system clock, block diagrams to aid description **Programme Languages:** *low level assembly language* - RISC (Reduced Instruction Set Computing) high *level language* - requiring a compiler (i.e., Basic) e.g simple robot arm movements **Embedded control systems:** dedicated controllers, slave controllers **Logic gates:** And, Or, ExOr, Not, Nand, Nor

Learning outcome
The learner will: 5. be able to carry out fault finding on pneumatic, hydraulic, mechanical and electrical actuation systems
Assessment criteria
The learner can: 5.1 diagnose simple faults on **control and actuation systems** 5.2 explain **methods** of fault location 5.3 explain the operation and applications of **test instruments** 5.4 explain safe isolation procedures for **systems** 5.5 evaluate the effects of faulty or inefficient **pneumatic systems** and **hydraulic systems**.

Range
Control and actuation systems: pneumatic, hydraulic, electrical **Methods:** half split method, input to output/output to input, component/unit substitution, component/unit response, visual inspection, consideration of symptoms, pressure monitoring **Test instruments:** signal injector, logic probe, multimeter, signal sources (i.e., 4 mA – 20 mA), data logger **Systems:** electrical power, electrical control, pneumatic radial, pneumatic ring, hydraulic **Pneumatic systems:** cost of producing, lost air, environmental effects **Hydraulic systems:** dangers of pressurised liquids, environmental effects

Unit 333 Computer automated and robotic systems principles and control

URN:	**R/503/0431**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with automated and robotic systems. It covers the operation of various types of control systems, open and closed loop control, robotic drive systems, effective robot tooling design, basic robotic control and programming tasks, plc applications in integrated control environments and analysis techniques for various modes of control for automation systems

Learning outcome
The learner will: 1. understand the architecture and uses of computer automated and robotic systems
Assessment criteria
The learner can: 1.1 explain the **architecture** of computer based automation systems 1.2 explain **variable names** used in computer based automation systems 1.3 explain the significance and use of mathematical modelling of system components and the concept of transfer functions 1.4 explain the basic **physical construction** of a robotic system 1.5 explain **movements** and **joints** in robotic systems 1.6 classify **robotic arms** 1.7 explain **wrist design** features 1.8 explain the factors which determine the **choice of end effectors** 1.9 classify **types of robot** for different applications 1.10 obtain **characteristic responses** for simple control and robotic systems 1.11 describe the **benefits** and possible **implications** of using an automated control system

1.12 explain the **design considerations** in relation to implementation of a robotic system 1.13 explain the **physical layouts** for robotic systems 1.14 explain robot/automation **safety aspects** relating to both machines and personnel.

Range
Architecture: process, inputs, outputs, energy source, measurement system, controller, feedback loops **Variable names:** controlled variable, manipulated variable, measurement variable, disturbance variable, error, set-point controller output **Physical construction:** jointed manipulator, end effector, controller, programming unit **Movements:** arm sweep, shoulder swivel, elbow extension, X plane (width movement), Y plane (height movement), Z plane (depth movement), roll, pitch, yaw, prismatic, revolute, symbols for prismatic and revolute joints, six degrees of freedom **Joints:** prismatic, revolute, symbols for prismatic and revolute joints **Robotic arms:** Cartesian, cylindrical, polar, jointed arm, SCARA (Selective Compliance Assembly Robot Arm), partial spherical (pendulum), multiple joint (spline) **Wrist design:** three revolute degrees of freedom, accuracy of end effecter manipulation **Choice of end effectors:** vacuum, stepper motor driven, specialist design **Types of robot:** programmable manipulator, pick and place, loading and unloading, production **Characteristic responses:** input/output, effect of variables **Benefits:** increased productivity, improved quality, increased efficiency, improved safety, convenience, power assistance, repeatability, accuracy, speed, use in hazardous areas **Implications:** effect on jobs, capital costs, variable costs, available space, maintenance costs, loss of production due to failures, upgrade costs, safety **Design considerations:** **planning** – personnel involved, application, feasibility review **development** – task, part presentation, handling equipment, process machines, quality control process **mock-up & testing** – commissioning, de-bugging, trial runs, quality control checks **installation** – pilot production runs, parallel running with manual cells, final implementation **Physical layouts:** radial layout, in-line track mounted, in-line fixed **Safety aspects:** category B, category 1, category 2, category 3, category 4, operator competence, operator training, emergencies

Learning outcome
The learner will: 2. understand the operation of various types of control systems
Assessment criteria
The learner can: 2.1 describe the difference between **control system types** 2.2 explain **classifications** of control systems 2.3 explain the operation of **digital and analogue motion control systems** 2.4 evaluate the relationship between **functions** in a motion control system

Range
Control system types: regulatory/following, numerical/ servo/sequential **Classifications:** **set-point changes** – infrequent change – regulatory system, frequently changed – following system **industry found in** – processing – process control, continuous system, batch system **part manufacturing** – machine control – numerical control systems, robotic control systems **category of controller or control** – Programmable Logic Controller, event sequenced control, time sequenced control, industrial, controller **Digital motion control system:** set-point, gain, output signal, feedback devices, actuator types, error codes **Analogue motion control system:** rectification, d.c. bus, chopping circuit, output section **Functions:** frequency/speed, speed/torque, switching frequency/noise

Learning outcome
The learner will: 3. be able to apply open and closed loop control systems
Assessment criteria
The learner can: 3.1 explain the **requirements** and **true value inputs** of a measurement system 3.2 classify **signal conditioning** in measurement systems 3.3 explain **input transducer** circuit arrangements and operations 3.4 explain the principles of **damping** in open and closed loop systems 3.5 explain the **actions** and meaning of **terms and expressions** of open and closed loop systems 3.6 apply **formulae** to derive controller output 3.7 describe the difference between **integral and derivative control** 3.8 explain the basic principles of **output analysis** 3.9 **build and analyse circuits** on open and closed loop control systems

Range
Requirements: reliability, repeatability, range (reproducibility), sensitivity, stability, response time, rise time, settling time, steady state, desired value, loading effects/errors **True value inputs:** measurement system, measured value of variable output **Signal conditioning:** voltage to voltage, voltage to current, frequency to voltage, resistance to voltage **Input transducer:** transducer action, analogue input interfaces, digital input interfaces, signal conditioning circuits, calibration procedures **Damping:** under-damped, over-damped, critical damping **Actions:** system block diagrams, reliability, repeatability, range (reproducibility), sensitivity, stability, response time, rise time, settling time, steady state, desired value, loading effects / errors **Terms and expressions:** two step control, continuous control, proportional band, dead band, off-set, hysteresis, Proportional gain (Kp), Derivative gain (Kd), Integral gain (Ki) **Formulae:** controller output = Kp(error + Ki x integral of error + Kd x derivative of error), output = kp(e+ki$\int$e + kd de/dt) **Integral and derivative control (statements):** integral control is a controller output that is proportional to the integral to the error with respect to time, derivative control is a controller output that is proportional to the rate of change of the error with respect to time **Output analysis:** *input signals* – stepped, ramped, sinusoidal *measuring equipment* – PC-based data logger, storage scope **Build and analyse circuits:** configure inputs, analyse outputs, simulated analysis, system tuning using tables / charts

Learning outcome
The learner will: 4. be able to use transducers in control and robotic systems
Assessment criteria
The learner can: 4.1 explain typical **applications** for sensors employed in control and robotic systems 4.2 interpret and use technical information contained in manufacturers data sheets relating to **thermocouples, pt100devices, proximity sensors, tacho generators and differential pressure devices** 4.3 classify digital, analogue, safety and internal and external sensors 4.4 explain actions and calibration of **actuators** 4.5 explain common **connection types** used with transducers 4.6 explain the **connection of proximity switches** in parallel and series to achieve Boolean Logic external to a controller 4.7 explain technologies required for circuits that operate in areas of high radio frequency interference, and electromagnetic interference (**RFI/EMI**) 4.8 explain the **connection of devices** to proximity sensors 4.9 explain **sensor power supply** considerations 4.10 set up sensors 4.11 set up actuators

4.12 select an appropriate sensor for a given application 4.13 wire a selection of transducers with different connection types into a control system 4.14 wire proximity switches to obtain AND and OR functions 4.15 wire proximity switches in sink and source mode

Range
Applications: measuring machine parameters for robot control loops, determining the position of objects in 3-D space, adjusting the robot control for the environment, detecting and preventing failures, detecting and avoiding collisions, monitoring the interaction with the environment, monitoring the environmental changes / temperature, inspecting the final product **Thermocouple and pt100 devices:** zero, range, span, junction compensation, type **pt100 devices:** zero, range, span **Proximity sensors:** **types** - inductive, capacitive, optical **information** – sensing range, material tuning, required output (sink source), switching capability, banking capability **Tacho generators:** **devices** – resolvers, encoders **information** – setting volts / rpm, setting of volts / mm, setting of data sequence **Differential pressure devices:** **devices** – turbine, strain gauge, piezo electric, ultrasonic **information** – resistive bridge trimming, trimming of volts / seconds, trimming of power level **Digital sensors:** limit switch, proximity switch, photo electric switch, Hall effect switch, float switch, ultrasonic switch **Analogue sensors:** temperature sensor, flow switch, load cell, laser, pressure transducer, vision system **Safety sensors:** gate plug, light curtain, safety mat **Internal and external sensors:** **internal** – potentiometer, LVDT's, synchros, resolvers, optical encoders, load cells, photoelectric **external** – proximity, limit switch, optical systems, Hall effect switch, ultrasonic switch **Actuators:** proportional valves – trimming of input signals, span, zero **servo motors** – setting of absolute datum optical sensor / drive to stall, deriving maximum holding torque Connection types: 2 wire d.c. & a.c. – normally open (NO) contact, normally closed (NC) contact, **grounding connections, residual load current** **3 wire d.c.** – transistor switched outputs (NPN & PNP types), normally open, normally closed **4 wire d.c**. – transistor switched outputs (NPN & PNP types), normally open/closed **Connection of proximity switches**: parallel and series connection (benefits and limitations), parallel connection using 2 wire technology, parallel connection using 3 wire technology, series connection using 2

wire technology, series connection using 3 wire technology

RFI/EMI: need for screening, need for short cable lengths, segregation of data and power conductors, power supply filtering, limit error signals at source

Connection of devices: controllers, relays, display elements, current consumption considerations, load resistance considerations, sensor current considerations, transient protection

Sensor power supply: switch-on spikes, supply voltage ripple, stabilisation

Learning outcome
The learner will: 5. be able to use robotic drive systems
Assessment criteria
The learner can: 5.1 explain common methods used to **power** robotic systems 5.2 explain the configuration and operation of typical **robotic control** and **drive systems** 5.3 explain the operation of, and give applications for, **transmission systems** 5.4 use suitable **actuators** in a robotic control system

Range
Power: fluid, pneumatic, electrical, production of compressed air (pneumatic power), production of compressed fluid (hydraulic power) **Robotic control systems:** control element, actuator, transmission element, load, sensor, feedback, comparator **Robotic drive systems:** pneumatic cylinder single acting, pneumatic cylinder double acting, hydraulic cylinder double acting, pneumatic rotary actuator, hydraulic rotary actuator, electro-mechanical solenoid, spool valve, stepper motor **Transmission systems:** spur gears, helical gears, straight bevel gears, spiral bevel gears, worm gears, rack and pinion, ball and roller screws, pulley drives and tendons, linkages, bearings **Atuators:** pneumatic, hydraulic, electric, reasons for choice

Learning outcome
The learner will: 6. be able to apply effective robot tooling design
Assessment criteria
The learner can: 6.1 explain **component design considerations** with regard to component automation 6.2 explain the **application, operation** and **limitations** of end effectors 6.3 apply suitable end effectors

Range
Component design considerations: symmetry, datum's, tangling, feeding, insertion, alignment **Application:** welding, grinding, painting, gripper and effector, vacuum, clamp, intelligent hand **Operation:** vacuum cup, pneumatic gripper, servo controlled gripper, intelligent hand **Limitations:** rated payload and gripper mass, force required to accelerate and decelerate payload (F = ma), force required to change payload direction, clamping force, co-efficient of friction between gripper and part

Learning outcome
The learner will: 7. be able to apply basic robotic control and programming tasks
Assessment criteria
The learner can: 7.1 use **programming tools** employed in robotic systems 7.2 explain **online and offline programming** considerations 7.3 produce robot program designs utilising **flow charts** and **block diagrams** 7.4 explain the use of kinematic and isometric diagrams to relay information relating to a robot system 7.5 explain the relationship and interaction between **control systems** 7.6 explain **performance specifications** for robots 7.7 explain **safety implications** of combined discipline systems

Range
Programming tools: control pendants, software, simulation **On-line programming:** axis limit control, point to point, contouring, line tracking **Off-line programming:** safety, 3D visualisation of a robot arm, need for computing ability, specialist programming language, absolute and incremental co-ordinates, trouble shooting, planning, communication between CAD and CAM systems (Computer Aided Drawing/Computer Aided Manufacture) **Flow charts:** symbols, labelling, inputs **Block diagrams:** layout, process, sequence **Control systems:** robot, motion **Performance specifications:** payload, normal and maximum, static and rated, static and dynamic, repeatability, speed, limit on certain motion, weight restrictions **Safety implications:** verification of inputs, collision detection, working envelope

Learning outcome
The learner will: 8. be able to perform plc applications in integrated control environments
Assessment criteria
The learner can: 8.1 explain the function of the **component parts** of PLC architecture 8.2 explain **programming languages** used to program PLCs 8.3 explain programming device **communications configuration** methods 8.4 explain the characteristics and methods of configuring different types of **interface module** 8.5 perform **simple operations** on a PLC controlled system

Range
Component parts: control unit, programming device, input / output modules, memory **Programming languages:** industrial standard languages, IEC 61131-3, statement list, structured text, function block, sequential function chart, basic instructions in Ladder Logic, examine in open / closed, output, latched output, bit / flag instructions, timers, counters, move and logic, arithmetic and compare **Communications configuration:** upload programmes from a PLC, modify programmes both online and offline, test programmes and re-evaluate operation, use software and hardware to troubleshoot problems in a PLC based control system, document and save programmes **Interface module:** digital I/O, analogue, remote I/O, RFID (Radio Frequency Identification) scanning systems, bar code readers, camera vision systems **Simple operations:** programming using Ladder Logic, communications configuration, PLC programme download/upload tests, PLC programme modification, interface module configuration, e.g programme a robot arm to carry out a simple task

Learning outcome
The learner will: 9. be able to use analysis techniques for various modes of control for automation systems
Assessment criteria
The learner can: 9.1 describe methods used to describe **sequential processes** 9.2 explain the principles of **control modes** used in automation systems 9.3 explain the characteristics of automation systems employing combinations of control modes 9.4 explain **methods** used to optimise/tune the response of a control system for various types of control mode 9.5 explain methods used to **analyse the response** of a control system to determine the levels of stability in a system 9.6 carry out simple **analysis operations** on a PLC controlled system

Range
Sequential processes: **time driven – statem**ent algorithm, timing diagrams **event driven** – ladder diagrams, Boolean expressions, sequential function charts, state diagrams, process timing diagrams **Control modes:** proportional (P), integral (I), derivative (D), combinations (PI and PID) **Methods:** process reaction curve, ultimate cycling method,, self tuning adaptive controllers **Analyse the response:** Bode diagrams for phase and gain, phase and gain margins **Analysis operations:** program simple time/event driven processes using a PLC as the controller, tune simple control systems, frequency response check for various modes of control wire proximity switches in sink and source mode e.g , a frequency response check for various modes of control

Learning outcome
The learner will: 10. be able to integrate computer based operator interfaces
Assessment criteria
The learner can: 10.1 explain the main **elements, features and functions** of PC based (SCADA) systems 10.2 explain software **data linking standards** used to exchange data between software applications 10.3 explain methods used to link real I/O to PC based applications via **database objects** 10.4 explain the use of **functions and features** available with HMI systems 10.5 explain the main features and functions of **system interfaces** 10.6 configure **control interfaces** on PLC based control systems.

Range
Elements, features and functions: linked animated graphics, PC control of system functions, display and logging of system errors, need for archiving of process errors, alarm functions of variable priority, display of process trends in various graphical formats **Data linking standards:** dynamic data exchange (DDE), object linking and embedding (OLE) **Database objects:** I/O PLC based, HMI (human machine interface) based **Functions and features:** function key control, touch screen controls, communication links available with typical systems, creation of graphical objects and configuring links to PLC and SCADA based systems **System interfaces:** PC based operator, HMI based **Control interfaces:** SCADA or HMI, graphical interface to include control / animation / alarming / archiving / trends, data exchange link between software applications

Unit 334 Power supply, and analogue and digital circuit principles and fault

URN:	**Y/503/0432**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with d.c. power supplies, analogue circuits including amplifiers and oscillators, and digital circuits including logic families, sequential logic, and digital transmission systems. The topics covered will enable the candidate to interpret circuit diagrams, explain the operation of circuits, produce waveform diagrams for given points in a circuit, and be able to identify and test electronic components. The candidate will also be able to perform circuit and diagnostic checks on prepared boards, and make deductions from the results of these checks which lead to a correct fault diagnosis.

Learning outcome
The learner will: 1. understand power supply circuits to component level
Assessment criteria
The learner can: 1.1 explain the operation of low voltage dc **power regulator circuits** 1.2 explain the **key components**, and the **operation** of, a switch mode power supply (SMPS) 1.3 evaluate the **advantages and disadvantages** of SMPS compared with series and shunt regulator circuits 1.4 explain principles of **fault location** in power supply circuits

Range
Power regulator circuits: series regulator, shunt regulator, voltage doubler, dc-dc converter, inverters, feedback control for voltage/current regulation, over-current protection circuits, safety critical components **Key components:** d.c. input, power switching, chopper control, start-up, feedback, d.c. output generation, safety critical components, rf suppression components, transient suppression components **Operation:** power switching, chopper control, start-up, feedback, over-voltage protection, over-current protection, stand-by mode, d.c. output generation, expected waveforms and voltages **Advantages and disadvantages:** efficiency, circuit complexity, physical size, heat output, current output capabilities, factors determining choice of PS **Fault location:** recognise symptoms, relate symptoms to fault conditions, expected changes in waveforms and voltages for given fault conditions, use of dummy loads, typical adjustment methods

Learning outcome
The learner will: 2. understand analogue circuits to component level
Assessment criteria
The learner can: 2.1 explain the operation of single and multi-stage **bipolar transistor voltage amplifiers** 2.2 explain the different **classes and modes of operation** of bipolar transistor circuits 2.3 explain how to obtain **response plots** for amplifier circuits 2.4 explain the operation of **MOSFET amplifier, transistorised power amplifier** and operational amplifier circuits 2.5 explain the meaning of **common terms** relating to **operational amplifiers** 2.6 state the conditions for oscillation in **amplifier circuits** 2.7 explain the operation of **common oscillator circuits** and **555 timer circuits** 2.8 apply **fault location to component level** using appropriate test instruments

Range
Bipolar transistor voltage amplifiers: common circuit arrangements, inter-stage coupling, typical component values, effects of collector load resistor value on voltage gain, effects of negative feedback (both a.c. and d.c.), expected waveforms and voltages, causes and effects of distortion **Classes and modes of operation:** A, AB, B, C, common emitter, common base, common collector (emitter follower) **Response plots:** frequency response, bandwidth measurement (@ -3dB), voltage gain **MOSFET amplifier:** common circuit arrangements, typical component values, expected waveforms and voltages **Transistorised power amplifier:** Class A bipolar, Class B transformerless push-pull, MOSFET designs, need for a.c. and d.c. feedback, integrated circuit types **Operational amplifier circuits:** common circuit arrangements, feedback circuits, 'virtual earth', inverting input, non-inverting input, integrator differentiator, differential amplifier, comparator, Schmitt trigger, high / low pass filters **Common terms:** drift, offset, slew **Conditions for oscillation:** effects of positive feedback, feedback factor **Common oscillator circuits:** crystal, ceramic resonator, RC phase shift, Wien bridge, LC, VCO (voltage controlled oscillator) using PLL (phase locked loop), expected waveforms and voltages **555 timer circuits:** astable, monostable, deriving a sawtooth output **Fault location to component level:** identification of fault area from fault symptoms, visual inspection, half split method, input to output/output to input, component substitution, choice of suitable test instrument(s) for a given fault condition, tests are appropriate to the fault condition, correct setup of test instruments, correct interpretation of results, recording results of applied tests, correct diagnosis of defective component(s)

Learning outcome
The learner will: 3. understand digital electronics and data transmission systems
Assessment criteria
The learner can: 3.1 classify common **logic device encapsulations** 3.2 explain **common terms** used with digital electronics 3.3 classify and compare devices in **logic families** 3.4 explain the operation of logic devices using waveform diagrams 3.5 connect bistable logic devices to produce **counting and dividing circuits** 3.6 explain the operation of synchronous and asynchronous **integrated counters** 3.7 explain the effects of mechanical switch / relay **contact bounce** on logic circuits 3.8 explain the principles of **Time Division Multiplexing (TDM)** 3.9 critically compare digital **encoding methods** employed in data transmission systems

3.10 critically compare **transmission medium** for data transmission employing TDM 3.11 explain **error detection and correction** techniques employed in digital systems

Range
Logic device encapsulations: device numbering, type of packaging, pinout numbering **Common terms:** supply voltages, supply current, high level input voltage, low level input voltage, noise margin, input and output currents, rise and fall times, propagation delay, power dissipation, absolute maximum ratings, fan in/fan out **Logic families:** 4000 Series, 74LS Series, 74HC Series, 74HCT Series, 74AHC Series **Logic devices:** JK bistable, D-Type bistable, Master–Slave JK bistable **Counting and dividing circuits:** modulo-n dividers, up/down counters, associated timing diagrams and waveforms **Integrated counters:** decade counters, modulo-n counters, modulo-n dividers, ring counters, twisted ring, shift registers, associated timing diagrams and waveforms **Contact bounce:** causes, effects on circuit operation, methods for suppression (de-bounce circuits) **Time Division Multiplexing (TDM):** sampling, sampling rate, multiplexing, demultiplexing **Encoding methods:** RZ (Return to Zero) encoding, NRZ (Non Return to Zero) encoding, Manchester code, Gray code, BCD (Binary Coded Decimal) **Transmission medium:** copper cable, fibre-optic cable **Error detection and correction:** parity check, CRC (Cyclic Redundancy Check)

Learning outcome
The learner will: 4. be able to find faults on digital circuits and data transmission systems
Assessment criteria
The learner can: 4.1 **assemble, test** and **find** faults on digital circuits 4.2 explain common causes of **failure of integrated circuits (IC's)** during use and servicing 4.3 explain **methods for preventing IC damage** by electrostatic discharge during assembly/servicing 4.4 explain the uses and limitations of **test equipment** in relation to logic circuits 4.5 explain **fault finding techniques**

Range
Assemble, test and find faults : effects of floating inputs, output loading effects, input drive options, connect circuits via a fibre-optic link, use of TDM to transmit multiple signals across a single transmission path, use of logic tutors to investigate circuit operation and verify Data Sheet information, circuits using JK and D-type bistable ICs, integrated shift registers employing ICs such as 74XX194, integrated synchronous and asynchronous modulo-n counters employing ICs such as 74XX74 / 74XX112 / 74XX193 / 74XX380, switch bounce, locate faults in digital equipment such as combinational logic circuits/synchronous and asynchronous counters, shift registers, bistables/remote controls/D-A and A-D converters/7 segment displays **Failure of ICs during use:** incorrect supply voltages, electrostatic discharge (ESD), lightning strike, excessive heat, mechanical vibration **Failure of ICs during servicing:** incorrect orientation when fitting / replacing, poor soldering techniques, insertion/removal whilst power is applied, shorting of pins during measurements, electrostatic discharge (ESD) **Methods for preventing IC damage:** storage/transportation of ICs, non-static floor coverings / work surfaces, non-static clothing, wrist/heel straps, conductive matting **Test equipment:** multimeter, logic probe and clip, logic pulser, logic analyser, current tracer, signature tracer, oscilloscope **Fault finding techniques:** visual inspection, consideration of symptoms, half split method, input to output / output to input, component substitution, recording results of applied tests

Unit 335 Electronic power control principles and practice

URN:	**H/503/0434**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit is concerned with the basic principles of three phase mains power, power electronic components, the electronics employed in process control and automation systems, and basic customer care. The topics covered will enable the candidate to interpret circuit diagrams, explain the operation of circuits, and perform tests on circuits. The candidate will also be able to carry out simple PLC programming, and describe methods of customer care

Learning outcome
The learner will: 1. understand power electronics principles and circuits
Assessment criteria
The learner can: 1.1 explain the principles of a **3-phase mains electricity** supply 1.2 explain typical **functions** for low voltage 3-phase power supplies 1.3 explain the wiring configurations for typical 3-phase **power connectors** 1.4 explain the operation of **3-phase rectification** circuits 1.5 explain the operation of, and applications for, **heavy current components** 1.6 use methods for testing heavy current components 1.7 describe applications for low voltage/heavy current **switched mode power supplies** 1.8 explain controlled **a.c. power transmission systems** employed in localised power networks 1.9 explain the operation of **Uninterruptible Power Supplies (UPS)**

Range
3-phase mains electricity: 3-phase 4 wire output from a substation, line to line and phase voltages, graphical representation of 3-phase waveforms, star and delta connections, typical applications for 3-phase supplies **Functions:** reduced PSU output ripple, increased efficiency **Power connectors:** IEC60309 connector, 3-phase + earth, 3-phase + neutral + earth **3-phase rectification:** half wave, full wave, input/output waveform relationships for rectifier circuits, output ripple, ripple frequency **Heavy current components:** capsule thyristors, thyristor/diode modules, triacs, capsule rectifier diodes, stud mount rectifier diodes, fast diode modules, power insulated gate FETs (IGFETs), insulated gate bipolar transistors (IGBTs), insulated gate commutated thyristors (IGCTs) **Switched mode power supplies:** single phase, three phase **a.c. power transmission systems:** Flexible a.c. Transmission Systems (FACTS), Uninterruptible Power Supplies (UPS) **Uninterruptible Power Supplies** (**UPS):** on-line UPS, off-line UPS

Learning outcome
The learner will: 2. be able to process control and transducers
Assessment criteria
The learner can: 2.1 describe common **control methods** 2.2 describe **common terms** used in control systems 2.3 describe the operation of **block diagrams** for systems used in process control 2.4 explain the operation of **transducers and sensors** employed in control systems 2.5 explain the operation of **feedback** as employed in control systems 2.6 locate faults in systems listed in block diagrams

Range
Control methods: On/Off, proportional derivative (PD), proportional integral derivative (PID) **Common terms:** critical damping, stability, proportional band, dead band, transport lag **Block diagrams:** micro-controller based linear control system, temperature control systems, speed control systems, position control systems, fluid control systems, gas flow control systems **Transducers and sensors:** analogue output, digital output, digitally encoded output, signal conditioners, temperature, motion sensors, rotary encoders, optical transducers, displacement transducers, image sensors, proximity sensors, fluid/gas flow transducers **Feedback:** positive, negative, voltage derived series applied, voltage derived shunt applied, current derived series applied, current derived shunt applied

Learning outcome
The learner will: 3. be able to apply motor drive systems
Assessment criteria
The learner can: 3.1 explain typical applications for d.c. motors employing different **methods of excitation** 3.2 explain typical applications for different types of **a.c. motor** 3.3 select suitable motors for tasks where particular **characteristics** are required 3.4 explain and illustrate the operation of motor **speed control systems** 3.5 explain the operation of **stepper motors** and their drive systems 3.6 measure values to determine **characteristics** of motor drive systems

Range
Methods of excitation: series, shunt, split field, permanent magnet **a.c. motor:** capacitor start induction run single phase, three phase induction with d.o.l. starting, synchronous three-phase **Characteristics:** constant torque, high speed, low speed, low maintenance, precise positional control **Speed control systems:** a.c. motor, d.c. motor **Stepper motors:** permanent magnet, variable reluctance, hybrid **Characteristics:** feedback signals, start/running currents, torque/speed characteristics

Learning outcome
The learner will: 4. be able to program industrial automation systems
Assessment criteria
The learner can: 4.1 explain the operation of **programmable logic controllers (PLCs)** 4.2 classify **PLC inputs and outputs** 4.3 explain briefly the operation of **field device networking protocols** 4.4 write **programs for PLCs** using ladder diagrams 4.5 program a PLC to perform an operation in response to a sensor input.

Range
Programmable logic controllers (PLCs): PLC as a system, PLC as a part of an automated production system **PLC inputs:** **instruction inputs** – keypads, selector switches **sensor inputs** – limit switches, proximity switches, photosensors **PLC outputs:** **low current** – small solenoid valves, motors, electromagnetic clutches **high current** – large solenoid valves, three-phase motors **indicators** – pilot lamps, digital display **Field device networking protocols:** Actuator Sensor Interface (AS-Interface, or ASi), Profibus **Programs for PLCs:** standard ladder diagram symbols, logic functions, latching, timers, markers, counters, shift registers

Unit 336 MIG Welding of aluminium

URN:	**H/503/0353**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit sets out the requirements for metal inert gas (MIG) welding of aluminium and aluminium alloys in a modern engineering environment, in terms of what needs to be achieved by the candidate, ie: welding a series of challenging joint configurations across in a wide range of positions that are compliant to welding procedure specifications. The unit is concerned with the technology and practices involved in the application of MIG welding of aluminium and aluminium alloys. The unit is demanding in terms of technological content and the complexity of the welding that candidates are expected achieve. The unit is broadly divided into health and safety, welding equipment, welding consumables (i.e. electrodes) and the practicalities of producing a welded joint in relation to a welding procedure specification (WPS) and a quality specification.

Learning outcome
The learner will: 1. be able to apply safe working practices to MIG welding
Assessment criteria
The learner can: 1.1 apply the health and safety **regulations** relevant to welding 1.2 assess **hazards and risks** in a welding environment and recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards 1.3 follow **safe working practices**

Range
Regulations: Health and Safety at Work etc. Act, COSHH, Management of Health and Safety at Work Regulations, Personal Protective Equipment at Work Regulations, Noise at Work Regulations **Hazards and risks:** fume, fire, electricity, arc radiation, hot metal,, hazards associated with the storage, handling and use of pressurised gas cylinders **Safe working practices:** safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance cylinders (safe storage conditions, safe handling/moving, safe use)

Learning outcome
The learner will: 2. be able to prepare equipment for performing MIG welding of aluminium and aluminium alloys
Assessment criteria
The learner can: 2.1 list the range of **welding equipment** available 2.2 describe the functions of welding equipment 2.3 prepare the welding equipment for a range of given applications 2.4 prepare the welding **shielding gases** for a range of given applications

Range
Welding equipment: power sources, inverter , generator, rated output, measurement of electrical output and continuity, relationship between wire feed speed control and welding current, power source characteristics, function of induction, return, earth, construction, rated output, welding guns, contact tip, return clamps, wire feed control, ancillary equipment **Shielding gases:** cylinders, manifold systems, regulators (fixed, single-stage, two-stage), gas flow meters, gas tubes and connectors, use of solenoid valves, heaters for CO_2

Learning outcome
The learner will: 3. be able to perform MIG welding operations to meet welding procedure specification requirements
Assessment criteria
The learner can: 3.1 critically compare **welding consumables** for a range of given applications 3.2 describe the difference between welding consumables by their classification 3.3 produce complex welded aluminium and aluminium alloy joints in a range of positions in accordance with welding procedure specification (WPS) parameters 3.4 **restore work areas** to a clean and safe condition on completion of welding operation

Range
Welding consumables: **Electrode wires:** BS EN ISO 18273:– Welding consumables. Wire electrodes, wires and rods for welding of aluminium and aluminium alloys, classification: (sizes [diameters, lengths], strength and elongation of the weld metal, chemical composition of the weld metal, storage, identification, segregation (classification, size), application to aluminium alloy groups (1000 – 7000 series) **Shielding gases:** BS EN 439: Welding consumables. Shielding gases for arc welding and cutting, effects of shielding gases/gas mixtures (weld pool/arc area protection, heat input, weld geometry, penetration profile, travel speed, mode of metal transfer), applications for shielding gases/gas mixtures (argon, helium, argon/helium mixtues, helium/argon mixtures), benefits and limitations, gas pressure requirements, flow rates for applications **WPS:** welding process, parent metal, consumables, pre welding activities (cleaning [including scraping, filing, abrasives, stainless steel wire brushing, degreasing, chemical etching and associated care in use], edge preparation, assembly, pre-heat – relation to thickness, effect upon fusion, material composition]), welding), welding parameters, welding positions (EN ISO 6947 – PA, PB, PC, PD, PE, PF, PG), number and arrangement of runs to fully fill/weld joints, electrode sizes for joint thicknesses, mode of metal transfer (spray, pulse, synergic pulse), electrical conditions required (type of current, direct [d.c.], electrode polarity (positive), wire feed speed ranges, voltage (open circuit, arc), control of heat input input (preheat temperatures and methods of application), shielding gas (type, flow rate) interpass/run cleaning/back gouging methods, post welding activities (spatter removal, wiring brushing, removal of excess weld metal where required), post-weld heat treatment (normalising, stress relief)

Learning outcome
The learner will: 4. be able to evaluate welded joints for welding procedure specification conformance
Assessment criteria
The learner can: 4.1 explain the implications of quality specifications used to determine the **integrity of welded joints** 4.2 **visually evaluate** welded joints for conformance 4.3 prepare and **destructively test** joints to evaluate sub-surface for conformance

Range
Integrity of welded joints: classification of defects, quality specification (BS EN ISO 10042 – Welding, arc-welded joints in aluminium and its alloys, quality levels for imperfections), methods of avoiding, rectification methods **Visually evaluate:** use of visual techniques, lighting, low powered magnification, fillet weld gauges, dye penetrant testing, preparation for inspection, qualitative (defect levels, appearance), quantitative (extent, size, dimensional accuracy) **Destructively test**: nick-break (fracture), macroscopic examination (x5) bend tests (butt welds, side, face, root), methods of preparation for testing

Unit 336 MIG Welding of aluminium

Supporting information

Guidance

Regulations: Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to welding process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment at Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render Personal Protective Equipment (PPE) provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels)

Hazards and risks: fume (composition, visible particulate, invisible gaseous, risks to health, control measures to reduce exposure, extraction [background, local, natural ventilation, e.g. on-site, air-fed headshields, respirator, breathing apparatus, monitoring the effectiveness of control measures), fire (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), electricity (shock, fire, burns, methods of avoiding shock hazards, emergency procedures in the event of an electric shock, function of protection devices, earthing, workpiece, plant), arc radiation (visible light, infra-red, ultra-violet, effects, protection [PPE, screening, warnings {verbal, notices}]), hot metal (methods of avoiding), hazards associated with the storage, handling and use of pressurised gas cylinders

Welding equipment: power sources (output direct current [d.c.], transformer/rectifier [function, operation, construction {diodes, thyristors} function of smoothing capacitors], inverter [function, operation, construction], generator [fuel driven, function, operation, construction], rated output [duty cycle]), measurement of electrical output and continuity (voltage – use of voltmeter/multi-meter, current – use of ammeter/shunts/coils, continuity – use of continuity tester/ohmmeter), relationship between wire feed speed control and welding current, power source characteristics (volt/ampere graph, flat characteristic, constant voltage output), function of induction (principle, effect, fixed, stepped, variable control, leads used (welding [water cooled, air cooled, harness construction], return, earth, construction, rated output [duty cycle]), welding guns/torches (water cooled, air cooled, construction, types [push, pull, reel-on-gun] swan neck design, pistol design, nozzles [dip, spray], contact tip [functions, material, sizes, clearing a burn-back), return clamps (types, clamping mechanisms), wire feed control (variable speed motor, direct control of wire feed rate, indirect control of welding current, solenoid valves [shielding gas, water], relay for electrical power, jog-feed control, gas purge control) ancillary equipment (angle grinders, wire brushes, linishers, hammer and chisel)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 337 TIG Welding of aluminium

URN:	**Y/503/0351**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit sets out the requirements for tungsten inert gas (TIG) welding of aluminium and aluminium alloys in a modern engineering environment, in terms of what needs to be achieved by the candidate, ie: welding a series of challenging joint configurations across in a wide range of positions that are compliant to welding procedure specifications. The unit is concerned with the technology and practices involved in the application of TIG welding of aluminium and aluminium alloys. The unit is demanding in terms of technological content and the complexity of the welding aluminium and aluminium alloys that candidates are expected achieve. The unit is broadly divided into health and safety, welding equipment, welding consumables and the practicalities of producing a welded joint in relation to a welding procedure specification (WPS) and a quality specification.

Learning outcome
The learner will: 1. be able to apply safe working practices to TIG welding
Assessment criteria
The learner can: 1.1 apply the health and safety **regulations** relevant to welding 1.2 assess **hazards and risks** in a welding environment and recommend safety precautions, procedures and Personal protective Equipment (PPE) to overcome hazards 1.3 follow **safe working practices**

Range
Regulations: Health and Safety at Work etc. Act, COSHH, Management of Health and Safety at Work Regulations, Personal Protective Equipment at Work Regulations, Noise at Work Regulations **Hazards and risks:** fume, fire, electricity, arc radiation, hot metal, hazards associated with the storage, handling and use of pressurised gas cylinders **Safe working practices:** safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance cylinders (safe storage conditions, safe handling/moving, safe use)

Learning outcome
The learner will: 2. be able to prepare equipment for performing TIG welding of aluminium and aluminium alloys
Assessment criteria
The learner can: 2.1 list the range of **welding equipment** available 2.2 describe the functions of welding equipment 2.3 prepare the welding equipment for a range of given applications 2.4 prepare the welding **shielding gases** for a range of given applications

Range
Welding equipment: power sources, direct current [d.c.], transformer, transformer/rectifier, inverter, generator, measurement of electrical output and continuity, methods of current regulation, power source characteristics, torches, collet, collet holder, gas lens, electrodes, return clamps, ancillary equipment **Shielding gases:** cylinders, manifold systems, regulators (fixed, single-stage, two-stage), gas flow meters, gas tubes and connectors, use of solenoid valves

Learning outcome
The learner will: 3. be able to perform TIG welding operations to meet welding procedure specification requirements
Assessment criteria
The learner can: 3.1 critically compare **welding consumables** for a range of given applications 3.2 differentiate between welding consumables by their classification 3.3 produce complex welded joints in a range of positions in accordance with welding procedure specification (WPS) parameters 3.4 explain the effects of the **electrical characteristics** of the TIG welding arc 3.5 **restore work areas** to a clean and safe condition on completion of welding operation

Range

Welding consumables:

Electrode wires:

BS EN ISO 18273:– Welding consumables: wire electrodes, wires and rods for welding of aluminium and aluminium alloys, classification (sizes [diameters, lengths], strength and elongation of the weld metal, chemical composition of the weld metal, storage, identification, segregation (classification, size), application to aluminium alloy groups (1000 – 7000 series)

Shielding gases:

BS EN 439: Welding consumables: shielding gases for arc welding and cutting, effects of shielding gases/gas mixtures (weld pool/arc area protection, heat input, weld geometry, penetration profile, travel speed), applications for shielding gases/gas mixtures (argon, helium, argon/helium mixtures, helium/argon mixtures), benefits and limitations, gas pressure requirements, flow rates for applications

WPS: welding process, parent metal, consumables, pre welding activities (cleaning [including scraping, filing, abrasives, stainless steel wire brushing, degreasing, chemical etching and associated care in use], edge preparation, assembly, pre-heat – relation to thickness, effect upon fusion, material composition]), welding), welding parameters, welding positions (EN ISO 6947 – PA, PB, PC, PD, PE, PF, PG), number and arrangement of runs to fully fill/weld joints, electrode sizes for joint thicknesses, electrode, filler wire, electrical conditions required (type of current, alternating [a.c.] direct [d.c.], electrode polarity (positive), welding current ranges, methods of arc ignition (scratch, high frequency, lift start), shielding gas (type, flow rate, pre-weld gas flow, post-weld gas flow), techniques, control of heat input (preheat temperatures and methods of application), interpass/run cleaning/back gouging methods, post welding activities (wiring brushing, removal of excess weld metal where required), post-weld heat treatment (normalising, stress relief)

Electrical characteristics: effects of types of current (a.c./d.c.) and electrode polarity (d.c.: positive, negative) upon: heat input/distribution, electrode, weld bead profile, penetration; methods of a.c. arc stabilisation and maintenance (including: square wave); welding current features (pulse current, slope in, slope out) voltage (open circuit, arc)

Learning outcome

The learner will:

4. be able to evaluate welded joints for welding procedure specification conformance

Assessment criteria

The learner can:

4.1 explain the implications of quality specifications used to determine the **integrity of welded joints**

4.2 **visually evaluate** welded joints for conformance

4.3 prepare and **destructively test** joints to evaluate sub-surface for conformance

Range
Integrity of welded joints: classification of defects, quality specification (BS EN ISO 10042 – welding, arc-welded joints in aluminium and its alloys, quality levels for imperfections), methods of avoiding, rectification methods **Visually evaluate:** use of visual techniques, lighting, low powered magnification, fillet weld gauges, dye penetrant testing, preparation for inspection, qualitive (defect levels, appearance), quantitive (extent, size, dimensional accuracy) **Destructively test**: nick-break (fracture), macroscopic examination (x5) bend tests (butt welds, side, face, root), methods of preparation for testing

Unit 337 TIG Welding of aluminium

Supporting information

Guidance

Regulations: Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to welding process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render Personal Protective Equipment (PPE) provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels)

Hazards and risks: fume (composition, visible particulate, invisible gaseous, risks to health, control measures to reduce exposure, extraction [background, local, natural ventilation, e.g. on-site, air-fed headshields, respirator, breathing apparatus, monitoring the effectiveness of control measures), fire (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), electricity (shock, fire, burns, methods of avoiding shock hazards, emergency procedures in the event of an electric shock, function of protection devices, earthing, workpiece, plant), arc radiation (visible light, infra-red, ultra-violet, effects, protection [PPE, screening, warnings {verbal, notices}]), hot metal (methods of avoiding), hazards associated with the storage, handling and use of pressurised gas cylinders

Welding equipment: power sources (output [alternating current [a.c.], direct current [d.c.], transformer [function, winding ratio, input/output ratio, construction], transformer/rectifier [function, operation, construction {diodes, thyristors} function of smoothing capacitors], inverter [function, operation, construction], generator [fuel driven, motor driven, function, operation, construction], rated output [duty cycle]), measurement of electrical output and continuity (voltage – use of voltmeter/multi-meter, current – use of ammeter/shunts/coils, continuity – use of continuity tester/ohmmeter), methods of current regulation (tapped reactor, moving core, moving coil, moving shunt, saturable reactor, variable resistance), power source characteristics (volt/ampere graph, drooping characteristic, constant current output), leads used (welding [water cooled, air cooled, harness] return, earth, construction, rated output [duty cycle]), torches (types, water cooled air cooled, pencil, construction, connections, contactor/switch, foot pedal/amptrol, back caps [long. medium, short, applications], nozzles [long. medium, short, applications], collet, collet holder, gas lens [construction, effects, benefits, limitations, applications), electrodes (thoriated, zironiated, ceriated, lananathed, compositions, sizes, identification, applications, preparation [grinding: techniques, equipment, health and safety implications {dust, particulates, extraction, radioactivity for thoriated}), return clamps (types, clamping mechanisms), ancillary equipment (angle grinders, linishers, wire brushes, oxide removal, degreasers)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 338 Flux-cored Arc welding materials

URN:	**K/503/0354**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit sets out the requirements for flux-cored arc welding in a modern engineering environment, in terms of what needs to be achieved by the candidate, ie: welding a series of challenging joint configurations across in a wide range of positions that are compliant to welding procedure specifications. The unit is concerned with the technology and practices involved in the application of flux-cored arc welding. The unit is demanding in terms of technological content and the complexity of the welding that candidates are expected achieve. The unit is broadly divided into health and safety, welding equipment, welding consumables (i.e. electrodes) and the practicalities of producing a welded joint in relation to a welding procedure specification (WPS) and a quality specification

Learning outcome
The learner will: 1. be able to apply safe working practices to flux-cored arc welding
Assessment criteria
The learner can: 1.1 apply the health and safety **regulations** relevant to welding 1.2 assess **hazards and risks** in a welding environment and recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards 1.3 follow **safe working practices**

Range
Regulations: Health and Safety at Work etc. Act, COSHH, PUWER (scope within the welding environment), RIDDOR, Management of Health and Safety at Work Regulations, Personal Protective Equipment At Work Regulations, Noise at Work Regulations **Hazards and risks:** fume, fire, electricity, arc radiation, hot metal/slag **Safe working practices:** safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance cylinders (safe storage conditions, safe handling/moving, safe use

Learning outcome
The learner will: 2. be able to prepare equipment for performing flux-cored arc welding
Assessment criteria
The learner can: 2.1 list the range of **welding equipment** available 2.2 describe the functions of welding equipment 2.3 prepare the welding equipment for a range of given applications 2.4 prepare the welding **shielding gases** for a range of given applications

Range
Welding equipment: power sources, transformer/rectifier, inverter, generator, measurement of electrical output and continuity, methods of current regulation, power source characteristics, leads, electrode holders, return clamps, ancillary equipment **Shielding gases:** cylinders, manifold systems, regulators (fixed, single-stage, two-stage), gas flow meters, gas tubes and connectors, use of solenoid valves, heaters for CO2

Learning outcome
The learner will: 3. be able to perform flux-cored arc welding operations to meet welding procedure specification requirements
Assessment criteria
The learner can: 3.1 critically compare **welding consumables** for a range of given applications 3.2 differentiate between welding consumables by their classification 3.3 produce complex welded joints in a range of positions in accordance with welding procedure specification **(WPS)** parameters 3.4 **restore work areas** to a clean and safe condition on completion of welding operation

Range
Welding consumables: **Electrode wires:** BS EN 756: Welding consumables, solid wires, solid wire-flux and tubular cored electrode-flux combinations for submerged arc welding of non-alloy and fine grain steels, classification: (sizes [diameters, reel sizes available], strength and elongation of the weld metal, impact properties of the weld metal, chemical composition and types of flux core (rutile, basic, metal-cored, self-shielded, gas-shielded) **Shielding gases:** BS EN 439: Welding consumables: shielding gases for arc welding and cutting, effects of shielding gases/gas mixtures (weld pool/arc area protection, heat input, weld geometry, penetration profile, travel speed, mode of metal transfer), applications for shielding gases/gas mixtures (carbon dioxide, argon/carbon dioxide mixtures, argon/oxygen/carbon dioxide mixtures), gas pressure requirements, flow rates for applications **WPS**: welding process, parent metal, consumables, pre welding activities (cleaning, edge preparation, assembly, pre-heat), welding parameters, welding positions (EN ISO 6947 – PA, PB, PC, PD, PE, PF, PG), number and arrangement of runs to fully fill/weld joints, electrode sizes for joint thicknesses, mode of metal transfer (dip [short-circuiting, globular, spray, pulse), electrical conditions required (type of current, direct [d.c.], electrode polarity (positive or negative depending upon the wire), wire feed speed ranges, voltage (open circuit, arc), control of heat input, shielding gas (type, flow rate) interpass/run cleaning/back gouging methods, post welding activities (spatter removal, wiring brushing, removal of excess weld metal where required), post-weld heat treatment (normalising, stress relief)

Learning outcome
The learner will: 4. be able to evaluate welded joints for welding procedure specification conformance
Assessment criteria
The learner can: 4.1 explain the implications of quality specifications used to determine the **integrity of welded joints** 4.2 **visually evaluate** welded joints for conformance 4.3 **destructively test** joins to evaluate sub-surface for conformance

Range
Integrity of welded joints: classification of defects, quality specification (BS EN 25817 – arc welded joints in steel – guidance on quality levels for imperfections), methods of avoiding, rectification methods **Visually evaluate:** use of visual techniques, lighting, low powered magnification, fillet weld gauges, dye penetrant testing, preparation for inspection, qualitive (defect levels, appearance), quantitive (extent, size, dimensional accuracy) **Destructively test:** nick-break (fracture), macroscopic examination (x5) bend tests (butt welds, side, face, root), methods of preparation for testing

Unit 338 Flux-cored Arc welding materials

Supporting information

Guidance

Regulations: Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to welding process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment at Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render Personal Protective Equipment (PPE) provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels)

Hazards and risks: fume (composition, visible particulate, invisible gaseous, risks to health, control measures to reduce exposure, extraction [background, local, natural ventilation, e.g. on-site, air-fed headshields, respirator, breathing apparatus, monitoring the effectiveness of control measures), fire (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), electricity (shock, fire, burns, methods of avoiding shock hazards, emergency procedures in the event of an electric shock, function of protection devices, earthing, workpiece, plant), arc radiation (visible light, infra-red, ultra-violet, effects, protection [PPE, screening, warnings {verbal, notices}]), hot metal/slag (methods of avoiding), hazards associated with the storage, handling and use of pressurised gas cylinders

Welding equipment: power sources (output direct current [d.c.], transformer/rectifier [function, operation, construction {diodes, thyristors} function of smoothing capacitors], inverter [function, operation, construction], generator [fuel driven, function, operation, construction], rated output [duty cycle]), measurement of electrical output and continuity (voltage – use of voltmeter/multi-meter, current – use of ammeter/shunts/coils, continuity – use of continuity tester/ohmmeter), relationship between wire feed speed control and welding current, power source characteristics (volt/ampere graph, flat characteristic, constant voltage output), function of induction (principle, effect, fixed, stepped, variable control, leads used (welding [water cooled, air cooled, harness construction], return, earth, construction, rated output [duty cycle]), welding guns/torches (water cooled, air cooled, construction, types [push, pull, reel-on-gun] swan neck design, pistol design, nozzles [dip, spray], contact tip [functions, material, sizes, clearing a burn-back), return clamps (types, clamping mechanisms), wire feed control (variable speed motor, direct control of wire feed rate, indirect control of welding current, solenoid valves [shielding gas, water], relay for electrical power, jog-feed control, gas purge control) ancillary equipment (angle grinders, wire brushes, linishers, hammer and chisel)

Restore work areas: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work)

BSI standards can be accessed at http://shop.bsigroup.com/en/

Unit 353 Principles of welding

URN:	**D/503/0335**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to understand the underlying principles that enable effective welding to take place, without focusing on specific welding processes. Welding metallurgy, the physical science of welding, weld symbols, joint design, distortion, defects and testing: non-destructive (NDT) and destructive (mechanical) are included.

Learning outcome
The learner will: 1. understand the fundamentals of welding
Assessment criteria
The learner can: 1.1 explain the characteristics of an **electric arc** used for welding purposes 1.2 explain the purpose of **electrode coverings** used for welding purposes 1.3 explain the **effects** of fluxes and electrode coverings/cores upon welding processes 1.4 explain the purpose of **shielding gases** used for welding purposes

Range
Electric arc: voltage distribution across the arc, heat generation at the cathode and anode, arc characteristics (alternating current [a.c.], direct current [d.c.]), effects and influence of magnetic fields, factors that influence metal transfer (surface tension, gravity, electromagnet [Lorentz] force, hydrodynamic forces due to gas flow, pinch effect **Electrode coverings:** rutile, basic, cellulosic, iron powder **Effects:** facilitates arc striking, stabilises and directs the arc, assists control of the size and frequency of filler metal globules/droplets, protects filler metal from atmospheric contamination during transfer, protects deposited metal from contamination, provides appropriate weld contour, prevents rapid cooling of weld metal (thermal blanket effect), provides a flux for the molten pool to remove oxides and impurities,

supplies additional metal to weld pool

Shielding gases: tungsten inert gas (TIG) welding, Metal Active Gas (MAG) welding metal inert gas (MIG) welding, gases (argon, helium), inert gas mixtures (CO_2, Ar/CO_2, $Ar/O_2/CO_2$, $Ar/He/O_2/CO_2$, Ar/O_2, Ar/H_2, N_2, Ar/N_2) [where: Ar = argon, He = helium, O_2 = oxygen, H_2 = hydrogen, N_2 = nitrogen, CO_2 = carbon dioxide]; influence of shielding gases (protection from gases in the atmosphere, composition of atmosphere, arc characteristics, mode of metal transfer, penetration, weld bead profile, speed of welding, wetting/undercutting tendency, cleaning action, weld metal mechanical properties

Learning outcome
The learner will: 2. know how to apply welding symbols to joint preparations
Assessment criteria
The learner can: 2.1 describe the difference between the **features** of welded joints 2.2 describe how to apply BS EN 22553 to **types of joints** 2.3 describe how to apply **weld dimensions** to weld symbols

Range
features: face, toes, root, HAZ (heat affected zone), convex fillet profile, concave fillet profile, mitred fillet profile, root face, root gap, root radius ('U' butt profile), land ('U' butt profile), bevel angle, included angle, weld width, throat thickness, leg length(s), fusion zone (depth of fusion), excess weld metal, penetration, fusion line (boundary) **Types of joints:** Welded, brazed and soldered joints — symbolic representation on drawings, symbols for the communication of the designation of welded joints; types of joint (butt, tee, lap, corner); types of weld preparation (square butt [open], square butt [closed], flanged butt, single-vee butt, double-vee butt, single 'U' butt, double 'U' butt, fillet, single-bevel butt, double-bevel butt, single 'J' butt, double 'J' butt, spot, seam, projection, surfacing, plug, edge, surface, inclined, fold); application of types of weld preparation (arrow line, reference line, identification line, symbol, non-symmetrical welds, symmetrical welds); supplementary and complimentary symbols (finished flush by grinding, finished flush by machining, convex, concave, backing [sealing] run, permanent backing strip, removable backing strip, toes blended smoothly, peripheral welds, field or site welds, numerical indication of welding process [EN 24063 — Welding, brazing, soldering and braze welding of metals — nomenclature of processes and reference numbers for symbolic representation on drawings] **Weld dimensions:** leg length, throat thickness, fillet welds, square butt welds, root gaps, intermittent fillet welds, staggered intermittent fillet welds

Learning outcome
The learner will: 3. understand the affects of distortion and residual stresses due to welding
Assessment criteria
The learner can: 3.1 explain the **reasons for distortion** due to welding 3.2 classify **types of distortion** 3.3 explain the methods of **distortion control** 3.4 explain the methods of **distortion rectification** 3.5 explain the **residual stress** effects of welding

Range
Reasons for distortion: uneven expansion and contraction, degree of restraint **Types of distortion:** longitudinal, transverse, angular, buckling, bowing, dishing, twisting **Distortion control:** presetting, pre-bending, weld sequencing, skip welding, back-stepping, balanced welding, intermittent welding, tack welding, pre and post weld heat treatment, joint design, chills, restraint (clamping, jigs, back-to-back assembly) **Distortion rectification:** mechanical methods (peening, jacking, pressing, bending, rolling, hammering, planishing); thermal methods (use of heat strips, use of heat triangles); combination of mechanical and thermal methods (hot working) **Residual stress:** causes (restraint due to uneven expansion and contraction [natural], restraint due to distortion control methods [clamping, jigs, back-to-back assembly, balanced welding]), effects (pattern across joint cross-section [areas of tension, areas of compression], influence upon mechanical properties in service), stress relieving methods (normalising, thermal stress relief)

Learning outcome
The learner will: 4. understand the metallurgical effects of welding
Assessment criteria
The learner can: 4.1 explain the **heat distribution** during welding 4.2 explain the **effects of heat** due to welding 4.3 explain the relationship between the iron-carbon (Fe-C) **thermal equilibrium diagram** for plain carbon steels and welded joints 4.4 explain the reasons for **cracking** due to welding 4.5 explain the effects of **dilution** on fully fused joints in dissimilar metals.

Range
Heat distribution: thermal gradients, heat flow, weld thermal cycle, effects upon the structure of the weld metal, effects upon the structure of the parent metal (heat-affected zone [HAZ], HAZ sub-zones [overheated, refining, transition] **Effects of heat**: temperature, methods of heat production (electric arc, electrical resistance, combustion), determination of heat input during arc welding (J/s, [k]J/mm), pre and post weld heat treatment, stress relief, methods of temperature measurement (pyrometer, temperature indicating crayons), means of heat transfer/loss (conduction, convection, radiation) **Thermal equilibrium diagram**: influence of percentage carbon content in iron, influence of temperature, upper critical point, lower critical point, eutectoid, relationship to heat treatment processes, relationship to weld and HAZ **Cracking**: cold-cracking due to hydrogen in steels, definition, conditions necessary for cold cracking, influence of hydrogen, influence of stresses, influence of susceptible microstructure, methods of avoiding, reheat cracking, definition, types of steels sensitive to reheat cracking, reheat cracking due to heat treatment, reheat cracking due to multi-pass welding **Dilution**: determine the amount of dilution in a weld deposit, factors affecting dilution, welding procedure, methods of reducing dilution, use of solid phase welding processes

Learning outcome
The learner will: 5. know how to determine the integrity of welded joints.
Assessment criteria
The learner can: 5.1 classify the types of weld defects (EN 26520) 5.2 explain the application of **visual examination** methods to welded joints 5.3 explain the application of **penetrant testing** methods to welded joints 5.4 explain the application of **magnetic particle testing** methods to welded joints 5.5 explain the application of **radiography** methods to welded joints 5.6 explain the application of **ultrasonic testing** methods to welded joints 5.7 explain the application of **mechanical testing** methods to welded joints 5.8 explain the methods of **container testing.**

Range
Weld defects: cracks (longitudinal, transverse, edge, HAZ, crater, centreline, fusion zone, underbead), lack of fusion (root, side wall, inter-run), porosity (scattered, cluster, isolated pore, root, blow holes, worm holes), piping (craters), solid inclusions (slag, copper, tungsten, oxide), lack of penetration, undercut, oxidation, excessive weld metal (including penetration), underfill, concavity, overlap, burn-through, possible causes, remedial action
Visual examination: applications, requirements (equipment, personnel) benefits, limitations
Penetrant testing: dye, fluorescent, test procedure, applications, equipment requirements, limitations
Magnetic particle testing: magnetic flow (types of magnet [horseshoe, yoke]), current flow (a.c. [skin effect], d.c., types of magnetisation [prods, bar, coil, tubular, kettle element]), test procedure, applications, equipment requirements, benefits, limitations
Radiography: sources of radiation (x-ray, gamma ray), principle, applications, equipment requirements, benefits, limitations, radiation hazards (effects of radiation on the human body, radiation monitoring, personal monitoring, radiation enclosures, precautions for site radiography), radiographic techniques (plate, pipe [single wall – single image {including panoramic}, double wall – single image, double wall – double image [ellipse, superimposed])
Ultrasonic testing: applications, procedure, applications, equipment requirements (ultrasonic testing set [cathode ray tube {oscilloscope}, controls, calibration], probes [normal, angle, probe index, selection criteria, beam spread, far zone, near zone, dead zone], leads, calibration blocks, couplant), benefits, limitations, techniques (thickness testing, lamination testing, transmission method, reflection method), determination of geometry (beam angle, skip distance), procedures for reporting and recording flaws in welded components
Mechanical testing: impact tests (izod, charpy), bend tests (root, face, side), tensile (determination of tensile strength, determination of yield stress, determination of percentage elongation, transverse, all weld metal, tensile/shear [application to lap joints, application to double lap joints]), fracture (nick break), macro examination (specimen preparation, magnification), micro examination (specimen preparation, magnification), hardness surveys (weld zone, HAZ, parent metal, location of indents, testing methods (Vickers, Brinell, Rockwell), testing of spot welded joints (peel test, tensile/shear, cross tensile, 'U' tensile, twist or torsion
Container testing: hydraulic pressure, pneumatic pressure, by filling, by immersion, health and safety considerations

Unit 353 Principles of welding

Supporting information

Guidance

Electrode coverings: processes manual metal arc (MMA) welding, types of covering (rutile, basic, cellulosic, iron powder)

Cracking: cold-cracking due to hydrogen in steels, definition, conditions necessary for cold cracking, influence of hydrogen (sources of hydrogen, control of hydrogen in the deposited weld metal) influence of stresses (nature of stresses, methods of avoiding) influence of susceptible microstructure (nature, methods of avoiding), cracking mechanism in the weld metal and the HAZ, effect of preheating, use of stainless steel weld metal; lamellar tearing, definition, causes (through thickness properties, inclusions) methods of avoiding (influence of joint design, bead sequence, influencing factors [manganese/sulphur ratio, copper content, oxygen content, depth to width ratio of the weld, crack susceptibility); reheat cracking, definition, types of steels sensitive to reheat cracking, reheat cracking due to heat treatment, reheat cracking due to multi-pass welding

Dilution: determine the amount of dilution in a weld deposit, factors affecting dilution, welding procedure (welding process, welding technique), methods of reducing dilution (buttering, control of heat input [including welding current {use of small electrodes at low current, allowing the work to cool between runs/layers, fast travel speed, avoiding the use of pre-heat (not always possible), careful selection of welding process}], use of solid phase welding processes

Unit 354 Principles of fabrication

URN:	**H/503/0336**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to understand the underlying principles that apply to the selection of materials and mechanical joining processes used in fabrication, without focusing on specific fabrication disciplines. Included is fabrication materials, allowances for bending and rolling, the principles of shearing, joining using non-thermal methods and finishing

Learning outcome
The learner will: 1. know how to classify common materials used in fabrication engineering
Assessment criteria
The learner can: 1.1 critically compare **materials** from a range found in fabrication engineering 1.2 explain the commercial **forms of supply** of materials available 1.3 state the criteria used for the **selection** of materials for a given application 1.4 explain the different material **structures** 1.5 explain the variation in properties that result from different types of **metallic structures** 1.6 explain the requirements for the **heat treatment** of metals

Range
Materials: metallic (low-carbon steel, low alloy steels, high yield steels, austenitic stainless steels, clad and coated materials [galvanised steel, tin plated steel, plastic coated steel, clad steels, anodised aluminium], aluminium/aluminium alloys, copper/copper alloys, titanium/ titanium alloys), polymers (thermoplastics, thermosetting), composites (glass fibre, carbon fibre, aramid fibre) **Forms of supply:** sheet, plate, section (RSJ, channel, column, beam, tee, angle (equal leg, unequal leg), hollow section (square, rectangular, round [tubular]), pipe, fibre reinforcing materials (FRP) **Selection**: strength/weight ratio, resistant properties (heat, corrosion, wear), cost, weldability, malleability, unit cost **Structures:** crystalline, chain molecules, amorphous **Metallic structure**s: fine grained structure, coarse grained structure, effect of grain size upon working properties **Heat treatment:** annealing (steels, stainless steels, non-ferrous metals), normalising of steels, hardening of steels, tempering of steels, precipitation hardening of aluminium alloys

Learning outcome
The learner will: 2. know how to determine the bending and rolling allowances for fabricated forms and the principles of shearing
Assessment criteria
The learner can: 2.1 explain the **mechanics of bending** 2.2 define the term **neutral line** 2.3 explain the purpose of **bending allowances** and apply bending allowance formulas 2.4 explain the purpose of **rolling allowances** and apply rolling allowance formulas 2.5 calculate the included angle of patterns of right cones using formula 2.6 explain the **principles of shearing**

Range
Mechanics of bending: tensile stresses, compressive stresses, neutral plane, springback, compensation for springback **Neutral line:** principle, application to bending and rolling **Bending allowances:** definition, radius of bend, application (thin sheet materials, thick plate materials, pipe, circular forms, 'U' bends, right-angle bends, non-right-angle bends, compound forms) **Rolling allowances:** definitions (diameter of cylinder, length/height of cylinder, circumference of cylinder), application (circular cylinders, elliptical cylinders, taking into account material thickness, determination of the length of presetting required to avoid 'flats' when rolling **Principles of shearing:** shear angle, rake angle, clearance, shearing action (area under shear, shear force required), mechanical advantage of lever system for hand-operated shears (bench, hand), principle of moments for lever system for hand-operated shears (bench, hand), piercing and blanking (area under shear, shear force required)

Learning outcome
The learner will: 3. understand the difference between different non-thermal joining methods
Assessment criteria
The learner can: 3.1 classify **bolting** methods from a range found in fabrication engineering 3.2 classify **mechanical fastenings** applied to thin plate fabrication engineering 3.3 explain the reasons for and the methods available to protect metal surfaces prior to and after assembly 3.4 classify **joint configurations** from a range found in fabrication engineering 3.5 explain the **benefits of using jigs and fixtures** 3.6 explain the use of **adhesive bonding** in the joining of fabricated assemblies 3.7 calculate **joining allowances**

Range
Bolting: black bolts, high strength friction grip (HSFG), close tolerance bolts, fitted bolts, load indicating bolts, torshear, importance of cleanliness of contact surfaces, correct tensioning, hole diameters, tolerances and alignment of holes to produce satisfactory bolted connections **Mechanical fastenings:** bolts, captive nuts, studs, self-tapping screws, special thin plate fastenings, solid and tubular rivets, blind rivets (pop rivets) **Joint configurations:** self secured, lap joints, flanged joints, thermal/mechanical bonded, grooved seams, double grooved seams, knocked up, panned down, slip joints, flexible joints, threaded joints **Benefits of using jigs and fixtures:** position of component(s), joint alignment, mass production/repetitive work, distortion control/dimensional accuracy, economy of operation **Adhesive bonding:** methods available (heat activated, solvent activated, impact activated), preparation of surfaces, applications, health and safety considerations **Joining allowances:** joints joined by: riveting, bolting, adhesive bonding

Additional guidance
Materials supplied with protective layers, preventing damage during fabrication and transportation. Protection against contamination, surface damage, corrosion and arcing during welding. **Flexible joints:** hinges, rubber, interface, universal joints, expansion joints, expansion hoops

Learning outcome
The learner will: 4. understand different methods used for finishing fabricated components
Assessment criteria
The learner can: 4.1 explain the methods of removal of **surface contaminants** prior to finishing 4.2 explain the common **causes of corrosion** and degradation of common engineering materials 4.3 classify the methods of **corrosion prevention** or retardation commonly found in fabrication engineering 4.4 classify the **methods of application** for common surface coatings 4.5 evaluate the **merits and suitability** of purpose of the various surface preparations and protections.

Range
Surface contaminants: for: scale, oxide, slag, excessive build up and weld metal penetration, spatter
Causes of corrosion: oxidation of ferrous materials, direct chemical attack on metals, electrolytic corrosion, conditions and regions that can be conducive to corrosive activity (bi-metallic joints, immersed in aqueous solutions, adjacent to changes in grain structure [heavily worked material-stress corrosion], surface flaws, increased temperature)
Corrosion prevention: painting, cladding with corrosion and/or heat resistant materials, cladding with plastics, metallic coatings, cathodic protection, anodic protection, fouling and anti-fouling coatings, corrosion inhibitors
Methods of application: painting (brush, dip, spray), metallic coatings (metal spraying, hot dip galvanising, electroplating)
Merits and suitability: cost, portability, functional effectiveness (influence upon: environmental performance, application of surface coatings, aesthetic appeal, material selection)

Unit 355 Principles of fabrication and welding

URN:	**K/503/0337**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to understand the underlying principles of fabrication and welding, without focusing on specific fabrication disciplines or welding processes. Fabrication materials, joining using non- thermal methods, weld symbols, joint design, distortion, weld defects and testing: non-destructive (NDT) and destructive (mechanical) are included.

Learning outcome
The learner will: 1. understand how to classify common materials used in fabrication engineering
Assessment criteria
The learner can: 1.1 critically compare **materials** from a range found in fabrication engineering 1.2 explain the commercial **forms of supply** of materials available 1.3 state the **criteria** used to select materials for a given application 1.4 explain the different material **structures** 1.5 explain the variation in properties that result from different types of **metallic structures** 1.6 explain the requirement for the **heat treatment** of metals

Range
Materials: metallic (low-carbon steel, low alloy steels, high yield steels, austenitic stainless steels, clad and coated materials [galvanised steel, tin plated steel, plastic coated steel, clad steels, anodised aluminium], aluminium/aluminium alloys, copper/copper alloys, titanium/ titanium alloys), polymers (thermoplastics, thermosetting), composites (glass fibre, carbon fibre, aramid fibre) **Forms of supply:** sheet, plate, section (RSJ, channel, column, beam, tee, angle (equal leg, unequal leg), hollow section (square, rectangular, round [tubular]), pipe, fibre reinforcing materials (FRP) **Criteria:** strength/weight ratio, resistant properties (heat, corrosion, wear), cost, weldability, formability, machinability, appearance, availability **Structures:** crystalline, chain molecules, amorphous **Metallic structures:** fine grained structure, coarse grained structure, effect of grain size upon working properties **Heat treatment:** annealing (steels, stainless steels, non-ferrous metals), normalising of steels, hardening of steels, tempering of steels, precipitation hardening of aluminium alloys

Learning outcome
The learner will: 2. know how to apply welding symbols to joint preparations
Assessment criteria
The learner can: 2.1 describe the difference between **features** of welded joints 2.2 describe how to apply BS EN 22553 to **types of joints** 2.3 describe how to apply **weld dimensions** to weld symbols

Range
Features: face, toes, root, HAZ (heat affected zone), convex fillet profile, concave fillet profile, mitred fillet profile, root face, root gap, root radius ('U' butt profile), land ('U' butt profile), bevel angle, included angle, weld width, throat thickness, leg length(s), fusion zone (depth of fusion), excess weld metal, penetration, fusion line (boundary) **Types of joint:** Welded, brazed and soldered joints — symbolic representation on drawings, symbols for the communication of the designation of welded joints; types of joint (butt, tee, lap, corner); types of weld preparation (square butt [open], square butt [closed], flanged butt, single-vee butt, double-vee butt, single 'U' butt, double 'U' butt, fillet, single-bevel butt, double-bevel butt, single 'J' butt, double 'J' butt, spot, seam, projection, surfacing, plug, edge, surface, inclined, fold); application of types of weld preparation (arrow line, reference line, identification line, symbol, non-symmetrical welds, symmetrical welds); supplementary and complimentary symbols (finished flush by grinding, finished flush by machining, convex, concave, backing [sealing] run, permanent backing strip, removable backing strip, toes blended smoothly, peripheral welds, field or site welds, numerical indication of welding process [EN 24063 — Welding, brazing, soldering and braze welding of metals — nomenclature of processes and reference numbers for symbolic representation on drawings]. **Weld dimensions:** leg length, throat thickness, fillet welds, square butt welds, root gaps, intermittent fillet welds, staggered intermittent fillet welds

Learning outcome
The learner will: 3. know different non-thermal joining methods
Assessment criteria
The learner can: 3.1 classify **bolting** methods from a range found in fabrication engineering 3.2 classify **mechanical fastenings** applied to thin plate fabrication engineering 3.3 explain the reasons for and the methods available to protect metal surfaces prior to and after assembly 3.4 classify **joint configurations** from a range found in fabrication engineering 3.5 explain the **benefits of using jigs and fixtures** 3.6 explain the use of **adhesive bonding** in the joining of fabricated assemblies 3.7 calculate **joining allowances**

Range
Bolting: black bolts, high strength friction grip (HSFG), close tolerance bolts, fitted bolts, load indicating bolts, torshear, importance of cleanliness of contact surfaces, correct tensioning, hole diameters, tolerances and alignment of holes to produce satisfactory bolted connections **Mechanical fastenings:** bolts, captive nuts, studs, self-tapping screws, special thin plate fastenings, solid and tubular rivets, blind rivets (pop rivets) **Joint configurations:** self secured, lap joints, flanged joints, thermal/mechanical bonded, grooved seams, double grooved seams, knocked up, panned down, slip joints, flexible joints, threaded joints **Benefits of using jigs and fixtures:** position of component(s), joint alignment, mass production/repetitive work, distortion control/ dimensional accuracy, economy of operation **Adhesive bonding:** methods available (heat activated, solvent activated, impact activated), preparation of surfaces, applications, health and safety considerations **Joining allowances:** self-secured joints, joints joined by: riveting, bolting, adhesive bonding

Additional guidance
Protect Metals – materials supplied with protective layers, preventingdamage during fabrication and transportation. Protection against contamination, surface damage, corrosion and arcing during welding. **Flexible joints –** hinges, rubber, interface, universal joints, expansion joints, expansion hoops

Learning outcome
The learner will: 4. understand the affects of distortion and residual stresses due to welding
Assessment criteria
The learner can: 4.1 explain the **reasons for distortion** due to welding 4.2 classify **types of distortion** 4.3 explain the methods of **distortion control** 4.4 explain the methods of **distortion rectification** 4.5 explain the **residual stress** effects of welding

Range
Reasons for distortion: uneven expansion and contraction, degree of restraint **types of distortion:** longitudinal, transverse, angular, buckling, bowing, dishing, twisting **Distortion control:** presetting, pre-bending, weld sequencing, skip welding, back-stepping, balanced welding, intermittent welding, tack welding, pre and post weld heat treatment, joint design, chills, restraint (clamping, jigs, back-to-back assembly) **Distortion rectification:** mechanical methods (peening, jacking, pressing, bending, rolling, hammering, planishing); thermal methods (use of heat strips, use of heat triangles); combination of mechanical and thermal methods (hot working) **Residual stress: (Definition – stresses locked in after the original cause of stress has been removed)** causes (restraint due to uneven expansion and contraction [natural], restraint due to distortion control methods [clamping, jigs, back-to-back assembly, balanced welding]), effects (pattern across joint cross-section [areas of tension, areas of compression], influence upon mechanical properties in service), stress relieving methods (normalising, thermal stress relief)

Learning outcome
The learner will: 5. know how to determine the integrity of welded joints.
Assessment criteria
The learner can: 5.1 classify the types of **weld defects** (EN 26520) and identify possible causes and remedial action 5.2 explain the application of **visual examination** methods to welded joints 5.3 explain the application of **penetrant testing** methods to welded joints 5.4 explain the application of **magnetic particle testing** methods to welded joints 5.5 explain the application of **radiography** methods to welded joints 5.6 explain the application of **ultrasonic testing** methods to welded joints 5.7 explain the application of **mechanical testing** methods to welded joints 5.8 explain the methods of **container testing**

Range
Weld defects: cracks (longitudinal, transverse, edge, HAZ, crater, centreline, fusion zone, underbead), lack of fusion (root, side wall, inter-run), porosity (scattered, cluster, isolated pore, root, blow holes, worm holes), piping (craters), solid inclusions (slag, copper, tungsten, oxide), lack of penetration, undercut, oxidation, excessive weld metal (including penetration), underfill, concavity, overlap, burn-through, possible causes, remedial action **Visual examination:** applications, requirements (equipment, personnel) benefits, limitations **Penetrant testing:** dye, fluorescent, test procedure, applications, equipment requirements, limitations **Magnetic particle testing:** magnetic flow (types of magnet [horseshoe, yoke]), current flow (a.c. [skin effect], d.c., types of magnetisation [prods, bar, coil, tubular, kettle element]), test procedure, applications, equipment requirements, benefits, limitations **Radiography:** sources of radiation (x-ray, gamma ray), principle, applications, equipment requirements, benefits, limitations, radiation hazards (effects of radiation on the human body, radiation monitoring, personal monitoring, radiation enclosures, precautions for site radiography), radiographic techniques (plate, pipe [single wall – single image {including panoramic}, double wall – single image, double wall – double image [ellipse, superimposed]) **Ultrasonic testing:** applications, procedure, applications, equipment requirements (ultrasonic testing set [cathode ray tube {oscilloscope}, controls, calibration], probes [normal, angle, probe index, selection criteria, beam spread, far zone, near zone, dead zone], leads, calibration blocks, couplant), benefits, limitations, techniques (thickness testing, lamination testing, transmission method, reflection method), determination of geometry (beam angle, skip distance), procedures for reporting and recording flaws in welded components

Mechanical testing: impact tests (izod, charpy), bend tests (root, face, side), tensile (determination of tensile strength, determination of yield stress, determination of percentage elongation, transverse, all weld metal, tensile/shear [application to lap joints, application to double lap joints]), fracture (nick break), macro examination (specimen preparation, magnification), micro examination (specimen preparation, magnification), hardness surveys (weld zone, HAZ, parent metal, location of indents, testing methods (Vickers, Brinell, Rockwell), testing of spot welded joints (peel test, tensile/shear, cross tensile, 'U' tensile, twist or torsion

Container testing: hydraulic pressure, pneumatic pressure, by filling, by immersion, health and safety considerations)

Unit 355 Principles of fabrication and Welding

Supporting information

Guidance

Types of joint: Welded, brazed and soldered joints — symbolic representation on drawings, symbols for the communication of the designation of welded joints; types of joint (butt, tee, lap, corner); types of weld preparation (square butt [open], square butt [closed], flanged butt, single-vee butt, double-vee butt, single 'U' butt, double 'U' butt, fillet, single-bevel butt, double-bevel butt, single 'J' butt, double 'J' butt, spot, seam, projection, surfacing, plug, edge, surface, inclined, fold); application of types of weld preparation (arrow line, reference line, identification line, symbol, non-symmetrical welds, symmetrical welds); supplementary and complimentary symbols (finished flush by grinding, finished flush by machining, convex, concave, backing [sealing] run, permanent backing strip, removable backing strip, toes blended smoothly, peripheral welds, field or site welds, numerical indication of welding process [EN 24063 — Welding, brazing, soldering and braze welding of metals — Nomenclature of processes and reference numbers for symbolic representation on drawings]

Unit 356 Principles of engineering maintenance, installation and commissioning

URN:	**M/503/0338**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement	This unit is endorsed by SEMTA.
Aim	This unit enables the candidate to understand the underlying principles that apply to all commonly used processes and elements that are essential to most maintenance, installation and commissioning activities. It takes into account the fact that some industries and organisations employ engineering personnel that perform both of these activities, whereas others, particularly specialist contractors for installation and commissioning, may only cover a limited range. The content of this unit can be applicable to both situations as it is considered essential for all candidates to have a wide range of engineering knowledge and experience. It covers the maintenance, installation and commissioning requirements, including equipment and lubrication that are commonly associated with the maintenance, installation and commissioning of plant and machinery and the ways in which they are used or applied. Candidates are not expected to have an in- depth understanding of all maintenance and installation and commissioning strategies, but they should become familiar with the events, terminology and practices that they will need as part of their normal work.

Learning outcome
The learner will: 1. understand how to plan maintenance, installation and commissioning activities
Assessment criteria
The learner can: 1.1 explain the reasons for carrying out **maintenance activities** 1.2 explain the methods and **procedures** necessary to make an area safe 1.3 describe the contents of a **maintenance plan** 1.4 explain how to carry out **installation activities** 1.5 describe the contents of a **report** completed following maintenance or installation activities 1.6 describe the difference between **symptoms and the causes of faults**

Range
Maintenance activities: upholding or improving safety standards, maintaining production output at the required levels and quality, maximising the useful working life of engineering assets, increasing production efficiency (reduction of rejected work or downtime), activities include: carrying out routine servicing schedules or planned preventative maintenance, repair and replacement following breakdowns, monitoring and performance testing **Procedures:** using barriers and/or tapes, placing warning signs in appropriate positions, informing any persons who may be affected, isolating power or pressure sources, obtaining official clearance (permit to work), cleaning work areas after spillage, leakage or contamination (absorbent substances, detergents and solvents, approved waste disposal methods) **Maintenance plan:** tools and equipment, materials and spares (minimising downtime [avoid loss of production, avoid poor customer relations {internal and external}], wage overheads), estimate the length of time needed for maintenance **Installation activities**: installing machinery and systems into new sites or locations, replacement of machinery and equipment following or extending facilities, monitoring and performance testing, factors to consider: site conditions and locations, storage of parts and materials, tools and equipment, provision of services – gas, communication, electricity, compressed air, water and drainage, minimising disruption to adjacent work areas, how to estimate the length of time needed for the installation and commissioning **Report:** work undertaken, location(s), dates/times (commencement, completion and handover), parts and consumables used, test data, permit to work or certification references **Symptoms and the causes of faults:** **Diagnostic and fault location techniques:** fault location techniques (half-split, input-to-output, function testing, unit substitution, equipment self-diagnostics).evaluation using sensory information, diagnostic techniques, fault location techniques. **Aids:** manuals, flow charts, troubleshooting guides, maintenance records, barcodes, catalogue numbers.

Additional guidance
Diagnostic and fault location techniques: evaluation using sensory information (sight, sound, smell, touch), diagnostic techniques (fault reports, visual checks, measurement, movement and alignment checks, testing).

Learning outcome
The learner will: 2. know how to install and commission instruments and components
Assessment criteria
The learner can: 2.1 explain the applications of **instruments** used for testing and monitoring the condition of systems and machinery 2.2 explain the methods used to **set-up and align components** 2.3 describe how to perform installation and commissioning operations of instruments and/or components

Range
Instruments: terms: range, sensitivity, response, accuracy, repeatability, analogue and digital signals, transducers and amplifiers; pressure: manometers, Bourdon tube based instruments; temperature: expansion types, electrical resistance types and thermocouples, thermal paints and crayons; flow: direct (bellows and piston types), inferential (rotameters, venturi and orifice plates, and turbine types); rate and speed: tachometers (mechanical and electrical), stroboscopes, pulse counters; content: direct (dipsticks and sight glasses), indirect (load cells and electrical transducers); electrical multimeters (Ohmmeters, insulation resistance testers); vibration, data recorders; need for regular calibration of instruments and the methods used; methods of mounting instruments and the ways in which they can be protected from: external damage or unauthorised interference, excess loads and surges (use of snubbers and reservoirs), heat and vibration **Set-up and align components:** straight edges and squares, feeler gauges and test indicators, plumb lines and spirit levels, taut wire, optical and laser based instruments

Learning outcome
The learner will: 3. understand how to evaluate methods to overcome friction and corrosion
Assessment criteria
The learner can: 3.1 explain the nature of surfaces and the effects of these on **friction** 3.2 explain the purpose of **lubrication** to reduce the effects of friction 3.3 explain the **nomenclature** used to describe lubricant properties 3.4 evaluate types of **oils** and **greases** for given applications 3.5 explain the nature and causes of **corrosion** and methods of minimising the effects

Range
Friction: actual surface contact area (on 'peaks') and hence causes of 'cold welding', surface wear (breaking of 'peaks'), generation of heat, forces required to overcome friction (static and dynamic); reducing the adverse effects by use of: low friction materials, material combinations that control wear to only one of the two contacting elements, partial lubrication, full film lubrication **Lubrication**: hydrodynamic wedge principle – requirements: bearing types and design, clearances, points of oil admission; lubrication methods: total loss, recirculatory (construction and component parts of reservoirs, filtration methods and positioning, heat exchangers, pressure controls and warning devices), splash, grease guns and nipples, self lubricating (cast iron and impregnated metals) **Nomenclature:** viscosity, viscosity index, emulsions, foaming, compatibility (with other oils, seals and bearing material), pour and flash points, additives **Oils:** mineral, animal and vegetable, synthetic; properties (load, temperature) environmental considerations, reasons for deterioration (excess heat, oxidation, contamination, breakdown of structure due to prolonged overloading, poor storage conditions) **Greases**: the base (matrix), lubricants, methods of application, including the need to prevent over-packing and churning **Corrosion:** types: oxidation, electrolytic; methods of minimising effects: selection of materials to suit conditions, insulation of dissimilar metals, use of sacrificial anodes, use of protective coatings, paint, galvanising and anodising, plating and coating; methods of releasing corroded nuts (release and penetrating oils, application of heat, nut splitters or similar techniques)

Learning outcome
The learner will: 4. know how to evaluate connection methods
Assessment criteria
The learner can: 4.1 explain the purposes of **bearings** and their applications 4.2 explain the methods available for **removal and fitting** of bearings 4.3 explain the purposes of **threaded joints** and their applications

Range
Bearings: plain bearings, roller bearings, ball bearings, shielded and sealed forms of roller and ball **Removal and fitting:** onto shafts and into housings **Threaded joints:** thread forms (pitch and lead, major and root diameters, truncation), identification using screw pitch gauges and charts, applications, methods of insertion and extraction of studs, dealing with sheared studs (extractors, drilling and re-tapping), use of shield anchor bolts (rawlbolts) and ragbolts for masonry and concrete (hole preparation and fitting, health and safety aspects in relation to reinforced concrete)

Additional guidance
Bearings: plain bearings (materials used [including non-ferrous alloys, non-metallic], split and solid forms and their housing methods, shell and white-metalled types), roller bearings (cylindrical, tapered, double row, spherical, needle), ball bearings (single row deep groove and angular contact, double row deep groove and angular contact, self-aligning), shielded and sealed forms of roller and ball bearings **Removal and fitting**: methods of removing and fitting bearings (special extractors and mandrels, hand (mandrel) and hydraulic presses, appropriate lubricants or grease

Unit 356 Principles of engineering maintenance, installation and commissioning

Supporting information

Guidance

Bearings: plain bearings (materials used [including non-ferrous alloys, non-metallic], split and solid forms and their housing methods, shell and white-metalled types), roller bearings (cylindrical, tapered, double row, spherical, needle), ball bearings (single row deep groove and angular contact, double row deep groove and angular contact, self-aligning), shielded and sealed forms of roller and ball bearings

Removal and fitting: methods of removing and fitting bearings (special extractors and mandrels, hand (mandrel) and hydraulic presses, appropriate lubricants or grease

Unit 357 Principles of mechanical manufacturing engineering

URN:	**T/503/0339**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to understand the underlying principles that apply to all common machine tool systems, covering: the alignment of machine tools, power transmission, an evaluation of the application of CNC to machine tools and the understanding of maintenance requirements for machine tool systems. Within the unit candidates are expected to prepare a maintenance programme, prepare a lubrication chart, produce a CNC part-programme and critically compare CNC machining to non-CNC machining.

Learning outcome
The learner will: 1. understand how to determine the alignment of machine tools
Assessment criteria
The learner can: 1.1 describe the range of **machine tools** available in terms of size, capacity, accuracy and production capability 1.2 explain the **structural requirements** of a range of common machine tools 1.3 explain the common methods of **mounting** machine tools 1.4 explain the importance of **alignment** in machine tools and methods to achieve it

Range
Machine tools: lathes (centre), milling machines (vertical), drilling machines (pedestal, radial arm, multi- spindle, special purpose), grinding machines (surface [horizontal spindle], cylindrical [plain, universal]), electro machining (electrodischarge machining [EDM] {ram feed, wire feed}, ultrasonic machining [USM], electrochemical machining [ECM], computer numerical control (CNC). Presses (gap, flywheel). Die casting machines (hot and cold chamber)

Structural requirements: strength, rigidity, stability, control of movement, materials (cast iron, cast steel, steel plate), structures (box column, rib and box bed, fabricated base)

Mounting: cork pad, adjustable mounting, rag bolt, expanding bolt

Alignment:

slideways: flat, vee, dovetail, cylindrical, comparison of their capabilities, main features, accuracy of movement, means of adjustment, lubrication, protection

stick-slip: definition, recirculating ball leadscrews, hydrostatic slides typical checks: coaxial alignment between main spindle axis, coaxial alignment between two spindles, alignment of spindle to guideway, squareness of slideways movement, concentricity and end float of spindle, squareness of planes to spindle, setting of guards, stops and automatic safety cut-outs

bearings: plain bush (radial, radial and axial) ball (radial, axial, radial and axial) roller (radial, axial, radial and axial)

methods of alignment: standard tests, straight edge, precision level, autocollimator and reflector, roundness measuring machine

Additional information
Sand casting

Learning outcome
The learner will: 2. know how to differentiate between methods of power transmission in machine tools
Assessment criteria
The learner can: 2.1 explain the methods used to achieve **rotational movement** 2.2 explain the methods used to achieve **linear movement** 2.3 explain the methods used to **change speeds** 2.4 explain the methods used to **control feed speeds** 2.5 explain the methods used to control feeds and speeds of **hydraulic components** on machine tools 2.6 explain the application of **pneumatic systems** to the operation and control of machine tools

Range
Rotational movement: belt drives (flat, vee and tooth), gears, hydraulic actuators, pneumatic, stepper motors **Linear movement**: screw and nut (vee, square [including multi-start], ACME, relationship between the lead of a screw and the motion transmitted, engaging screw drives [fixed nuts, split nuts]), rack and pinion, recirculating ball-screw, crank and connecting rod, cams (lift, dwell and types of motion produced) hydraulic actuator **Change speeds**: sliding gears, cone pulleys, infinitely variable, electrical/electronic **Control feed speeds:** sliding gears (Norton gearbox), leadscrew and nut, hydraulic drives, electrical / electronic **Hydraulic components**: variable capacity pump, filter, pressure gauge, pressure relief valve, directional control valve, actuator, signal elements, one way flow control valve, differential cylinders, meter in, meter out, bleed off, pressure control valves, sequence valves, electrical and electro- magnetic control systems (switching devices, solenoids, interlock systems, timing shafts and cams, coded information), advantages and limitations of hydraulic actuation and control, common defects which may occur on a hydraulic system **Pneumatic systems**: variable output compressor, service unit, pressure gauge, signal elements, directional control valves, actuator, supply air throttling, exhaust air throttling, pressure reducing valve, pressure operated valves, time delay valve, electrical and electro-magnetic control systems (switching devices, solenoids, interlock systems, timing shafts and cams, coded information), advantages and limitations of pneumatic actuation and control, common failures which may occur on a pneumatic system

Learning outcome
The learner will: 3. understand how to evaluate the application of CNC to machine tools
Assessment criteria
The learner can: 3.1 explain the **operating principles** of computer numerically controlled machine tools 3.2 describe how to produce a **part-programme** to demonstrate the relative work/tool movement of a CNC machine tool 3.3 describe how to prove the part-programme using simulation software 3.4 **critically compare** CNC machine tools against non-CNC machine tools 3.5 describe how to evaluate **cutting tools materials** for given applications (CNC and non-CNC)

Range
Operating principles: open loop system, closed loop system, control systems (closed loop servo motors and associated transmission, stepper motors and associated transmission), types and function of position transducers (rotary type, optical gratings), digital control **Part-programme:** co-ordinate positioning (absolute, incremental), use of sub routines, macros and canned cycles, role of CADCAM **Critically compare:** production (mass, flow, batch, single items/ job), ease of programming, repeatability, prototypes, skill levels and other factors **Cutting tools materials**: high carbon steel (HCS), high speed steel (HSS) tungsten carbide, ceramic

Learning outcome
The learner will: 4. understand the maintenance requirements of machine tool systems
Assessment criteria
The learner can: 4.1 describe the differences between **types of maintenance** carried out on machine tools 4.2 describe a **maintenance programme** for a typical machine tool 4.3 describe what would be included in a **lubrication chart** for a typical machine tool workshop 4.4 classify **coolants and lubricants** applicable to machine tool systems 4.5 classify the methods of application for common surface coatings 4.6 explain the **commissioning/maintenance procedures** carried out on machine tools

Range
Types of maintenance: running, preventive, breakdown, routine **Maintenance programme:** inspection, lubrication, adjustment, rectification, overhaul **Lubrication chart:** machine designation, types of lubricant, quantities of lubricant, frequency **Coolants and lubricants**: types of coolant pump, strainers and filtration methods (including separating tanks and magnetic drum), filters, lubrication of headstock/gearbox assemblies of splash and pressurised feed (lead and feed screws, separation of coolant from lubricants in the lathe cross slides/carriage assemblies) **Commissioning/maintenance procedures**: checks, operational function, compare checks and operational functions with manufacturers' or production departments requirements, complete reports and job sheets, submit report

Unit 357 Principles of mechanical manufacturing engineering

Supporting information

Guidance

Rotational movement: flat belts, vee belts (single and matched sets) toothed belts, chain drives, correct tensioning belts and chains, friction clutches, dog clutches, gears: worm and wheel, bevel gear, spur, gear nomenclature (addendum, dedendum, clearance, diametral pitch, circular pitch, module), gear materials (cast iron alloy steels [including surface hardened], non-ferrous alloys [brass and bronze derivations], plastics), calculate simple and compound gear ratios, relationship between torque and power transmitted and the loads on gear teeth, gear box layouts and means of selecting different output speeds, gear defects (pitting, flaking, scoring and scuffing, likely causes); hydraulic actuators

Commissioning/maintenance procedures: checks (alignment and levels, electrical power supplies/insulation, safety switches/devices and interlocking, security of pipes and couplings, oil levels), operational function (run at light load: check, oil temperature, oil pressure, cooling/coolant system as appropriate; run at full load and carry out the same checks again), compare checks and operational functions with manufacturers' or production departments requirements, complete reports and job sheets (work carried out to commission/restore machine tool to operational condition, complete maintenance schedule, report and recommendation on system condition), submit report

Unit 358 Principles of electrical & electronic engineering

URN:	**K/503/0340**
Level:	Level 3
Credit value:	9
GLH:	80
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA.
Aim:	This unit enables the candidate to understand the underlying principles that apply across electrical and electronics engineering. The unit covers supply systems, protection and earthing, electronic measurement, functions of electrical machines, transformers and switchgear and electronic components and circuits

Learning outcome
The learner will: 1. understand electrical supply systems, protection and earthing
Assessment criteria
The learner can: 1.1 explain electricity **supply systems** 1.2 explain the function of **transformers** and switchgear 1.3 explain the purpose of **earthing systems** 1.4 explain **protection systems**

Range
Supply systems: from generation to utilisation, generation, transmission and distribution voltages, star and delta connections, single and 3 phase power. **Transformers**: principle of operation, input, output and losses, transformer rating in kVA, auto transformer; LV & HV switchgear. **Earthing systems:** human safety, overvoltage protection (lightning, etc.) **Protection systems**: short circuits, overloads, earth leakage, fuses, circuit breakers. residual current devices, residual current breakers (RCDs) with overload (RCBO)

Learning outcome
The learner will: 2. understand the function of electrical and electronic components
Assessment criteria
The learner can: 2.1 apply basic electrical **units** 2.2 describe **resistors** 2.3 describe **magnetism** and magnetic circuits 2.4 describe **inductance** and inductive components 2.5 describe **capacitors** and capacitance 2.6 describe graphically inductance and capacitance when connected to **d.c. supplies** 2.7 state the effects of resistance, inductance and capacitance connected to an **a.c. circuit** 2.8 describe **semiconductor** devices 2.9 describe **electronic circuits** and components including applications

Range
Units: energy, current, charge, voltage, power & resistance **Resistors:** resistance depends upon dimensions, material and temperature, resistivity Ohms law, series and parallel d.c circuits. **Magnetism:** fields and flux paths, relationship between flux, area and flux density **Inductance:** inductors as wound components, self and mutual induction, Lenz's law, force on a conductor **Capacitors**. electric field and stress, dielectrics, potential difference charge and capacitance, construction and types, series parallel connections. **d.c. supplies**: C & L connected to d.c circuits, series circuits, charge and discharge, time constants. **a.c. circuit**: R,L & C in a.c circuits. R,L & C in series / parallel, power, power factor, kW, kVA & kVAr **Semiconductor devices**: action of semiconductor devices, thyristors, bridge rectifiers, smoothing circuits. **Electronic circuits**: function of amplifier, oscillator, filter, power supply, application of common components, photocell, photodiode etc.

Learning outcome
The learner will: 3. know how to carry out electronic measurement
Assessment criteria
The learner can: 3.1 describe how to use **multimeters** to measure current, voltage and resistance 3.2 describe how to use **oscilloscopes** in different modes 3.3 describe how to use electronic instruments for **component testing** and prepared circuits 3.4 describe how to use electronic instruments as **signal sources** for prepared circuits 3.5 describe the use of **computers** in component testing.

Range
Multimeters: auto range, data capture and transfer, correct range settings. **Oscilloscopes:** use to carry out a range of tests and measurements, real time and storage. Advantages and disadvantages of oscilloscopes. **Component testing**: transistors, a series RLC circuit: a resistor, inductor and capacitor (L,C & R), power gain or loss in dB, voltage/current gain. **Signal sources**: signal generators, function generators (include sine wave, square wave and saw tooth), signal injection probes **Computers**: diagnostic information, technical information, websites, use and function as digital multimeter, oscilloscope, spectrum analyser

Learning outcome
The learner will: 4. understand functions of electrical machines
Assessment criteria
The learner can: 4.1 describe the principles of rotating **electrical machines** 4.2 describe the function of **3 phase induction motors** 4.3 describe the function of **single phase** a.c motors

Range
Electrical machines: a.c and d.c generators, interdependence of frequency, speed, pole pairs, EMF and field strength. d.c motor, synchronous and asynchronous machines, rotating magnetic field **3 phase induction motors**: cage rotor, wound rotor. **Single phase**: Series Universal, split phase, permanent capacitor, capacitor start/ run

Unit 361* Advanced mathematics and science

URN:	K/503/0449*
Level:	3
Credit value:	9*
GLH:	80*
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA
Aim:	This unit enables the candidate to develop the skills in and understanding of mathematics and science to facilitate progression onto awards that require a Level 3 mathematics and science component. It is primarily aimed at those candidates who wish to progress to higher education and has been applied to practical engineering principles of mathematics topics.

***** Unit 361 should be taken in conjunction with Unit 362. Learners must complete both units to achieve K/503/0449. Units 361 and 362 have a combined credit value of 9 and GLH of 80.

Learning outcome
The learner will: 1. be able to perform calculations involving indices, logarithms and algebra
Assessment criteria
The learner can: use **powers and roots** to solve problems use **logarithms** to solve problems use **number bases** to solve problems use **algebra** to solve problems

Range
Powers and roots: meanings of the terms: base, index, power, root and reciprocal; $a^0 = 1, a^{-n} = \frac{1}{a^n}$, $a^{\frac{1}{n}} = \sqrt[n]{a}$ Evaluate: $a^m \times a^n, \left(ans = a^{(m+n)}\right) \frac{a^m}{a^n}, (ans = a^{(m-n)})\ (a^m)^n, (ans = a^{mn})$ Express decimal fractions in standard form, solve algebraic problems involving transposition of terms with indices. **Logarithms:** define a logarithm as a power applied to a base number, logarithms to the base 10, logarithms to the base 'e' stating its application, logarithms to simplify calculations. **Number bases:** application of binary and hexadecimal numbering systems in data transmission, storage and programming, calculations using binary and hexadecimal numbers, conversions of numbers between denary, binary and hexadecimal bases. **Algebra:** algebraic and graphical methods to solve simultaneous and quadratic equations, define the roots of an equation, simple arithmetic and geometric series, factorial notation for combinations and permutations.

Learning outcome
The learner will: 2. be able to perform calculations using trigonometry
Assessment criteria
The learner can: 2.1 perform calculations involving trigonometric ratios for the four quadrants 2.2 apply the Sine Rule $a/sinA = b/sinB = c/sinC$ to practical problems 2.3 apply the Cosine Rule ($a^2 = b^2 + c^2 - 2bcCosA$) to practical problems 2.4 plot graphs of the functions $y = Rsin(t + \theta) and\ y = Rcos(t + \theta)$ 2.5 perform calculations to solve problems involving **areas** 2.6 differentiate between different **trigonometric identities** 2.7 explain that a complex number is a combination of 'j' notation and a rational number 2.8 explain the graphical represent **vector quantities** and **polar quantities**

Range
Areas: non right-angled triangles, angles between lines, true length of lines, true angle between planes **Trigonometric identities:** $\tan\theta = \frac{\sin\theta}{\cos\theta}$, $\cot\theta = \frac{1}{\tan\theta}$, $\sec\theta = \frac{1}{\cos\theta}$, $\operatorname{cosec}\theta = \frac{1}{\sin\theta}$ **Vector quantities**: complex numbers, modulus, argument **Polar quantities**: complex numbers, argand diagrams, rotating vector, polar to cartesian form and vice-versa

Learning outcome
The learner will: 3. be able to perform calculations using calculus
Assessment criteria
The learner can: 3.1 apply the rules of **differentiation** 3.2 apply Simpson's Rule to the calculation of areas of irregular sections 3.3 apply the rules of **integration** 3.4 perform calculations that apply differentiation to problems such as velocity and acceleration 3.5 perform calculations involving maxima and minima to determine the minimum material required to produce a regular-shaped square or circular container of maximum volume 3.6 perform calculations that apply integration to problems such as summation of irregular areas, volumes of revolution, centroid of area and second moment of area.

Range
Differentiation: products, quotients, function of a function and algebraic expressions (polynomial expressions, exponential expressions, simple trigonometrical functions(Sin, Cos and Tan only)), calculations involving a second derivative **Integration:** polynomial expressions, exponential expressions, simple trigonometric functions, integration by substitution, integration by parts

Learning outcome
The learner will: 4. be able to perform calculations involving statistics
Assessment criteria
The learner can: 4.1 calculate the **mean and standard deviation** for a sample of engineering components 4.2 perform estimates of failure rates of engineering artefacts or systems 4.3 define probability 4.4 define dependent and independent events, addition and multiplication laws of probability, permutations and combinations applied to probability, normal probability distribution, confidence limits and statistical testing

Range
Mean and standard deviation: gather and collate data from various sources and solve problems involving: frequency distributions (mean, median, mode, standard deviation), extrapolated data, interpolated data, use a calculator to perform statistical calculations.

Unit 362* Advanced mathematics and science

URN:	K/503/0449*
Level:	3
Credit value:	9*
GLH:	80*
Endorsement by a sector or regulatory body:	This unit is endorsed by SEMTA
Aim:	This unit enables the candidate to develop the skills in and understanding of mathematics and science to facilitate progression onto awards that require a Level 3 mathematics and science component. It is primarily aimed at those candidates who wish to progress to higher education and has been applied to practical engineering principles of mathematics topics.

***** Unit 362 should be taken in conjunction with Unit 361. Learners must complete both units to achieve the K/503/0449. Units 361 and 362 have a **combined** credit value of 9 and GLH of 80.

Learning outcome
The learner will: 1. be able to determine stress, strain and elasticity of materials
Assessment criteria
The learner can: 1.1 perform **tensile tests** on a range of materials and determine Young's Modulus for each material 1.2 perform **shearing tests** and determine the modulus of rigidity of materials

Range
Tensile tests: direct stress, direct strain, elastic limit, yield stress, tensile strength, breaking point, Modulus of Elasticity, factor of safety, calculations comparing the properties of different materials. **Shearing tests:** shear stress, shear strain, Modulus of Rigidity, Poisson's ratio, calculations comparing the properties of different materials.

Learning outcome
The learner will: 2. be able to solve problems involving kinematics
Assessment criteria
The learner can: 2.1 define velocity and acceleration 2.2 solve practical problems involving bodies in **linear motion** and trajectories 2.3 use **vector diagrams** to determine achieved tracks and relative velocities

Range
Velocity and acceleration: velocity as a vector quantity that is the rate of change of distance with respect to time, area under a velocity/time curve represents the distance travelled, acceleration is the rate of change of velocity with time, area under an acceleration/time curve represents velocity **Linear motion**: solve problems for linear and rotary motion both graphically and using the formulae **Vector diagrams**: velocities of bodies subjected to linear motion (ships in tides, aircraft in winds).

Learning outcome
The learner will: 3. be able to solve problems involving dynamics
Assessment criteria
The learner can: 3.1 explain Newton's Laws of Motion 3.2 define acceleration due to gravity as 9.81 ms-2 3.3 define that 1 newton is the force required to accelerate a mass of 1 kg at the rate of 1 ms-2 3.4 solve practical problems involving accelerating/decelerating masses both graphically and using the formulae f = ma 3.5 define momentum as the product of mass and velocity 3.6 solve practical problems involving colliding bodies by calculation 3.7 use calculations to find the moment of inertia of disks and rimmed flywheels 3.8 define radius of gyration 3.9 define potential energy and solve practical problems involving P.E = mgh 3.10 explain the relationship between work done in raising a body to potential energy 3.11 define linear and angular kinetic energy in terms of $(mv^2)/2$ and $(m^2w^2)/2$ 3.12 solve energy conversion problems both graphically and using formulae 3.13 solve problems associated with stored energy both graphically and

Learning outcome
The learner will: 4. be able to solve problems involving bending beams
Assessment criteria
The learner can: 4.1 construct shear force and bending moment diagrams for simply supported beams and cantilevers 4.2 perform calculations to determine **maximum bending moments** 4.3 define units of second moment of area as m4 4.4 solve problems associated with the stresses produced in bending beams 4.5 compare the resistance in bending of tee, 'I' and channel beam cross-sections

Range
Maximum bending moments: point loads, uniformly distributed loads, combinations of point and uniformly distributed loads, identify points of contraflexure, assumptions made in calculating stress due to bending.

Learning outcome
The learner will: 5. be able to solve problems involving fluids
Assessment criteria
The learner can: 5.1 define **Boyle's law** 5.2 define **Charles' law** 5.3 define the combined gas laws 5.4 solve practical **gas law problems** by calculation 5.5 solve practical **fluid flow rate problems** by calculation

Range
Boyles' law: At constant temperature, the volume of a given mass of gas is inversely proportional to its pressure **Charles' law:** At constant pressure, the volume of the gas is directly proportional to absolute temperature **Gas law problems:** Boyle's law, Charles' law, combined gas laws Fluid flow problems: velocity of flow, volume flow rate, mass flow rate, continuity equation for an incompressible liquid.

Learning outcome
The learner will: 6. be able to demonstrate the effects of electromagnetism and alternating current
Assessment criteria
The learner can: 6.1 demonstrate the effect of a magnetic field on a current carrying conductor 6.2 demonstrate the effect of a magnetic field on a moving conductor 6.3 apply Fleming's Left-hand Rule to establish the direction of the force on a current flowing at right angles to the direction of a magnetic field 6.4 perform calculations to determine the magnitude of the force on a current flowing at right angles to a magnetic field using the formula F = B.I./ 6.5 explain the practical applications of **force exerted on a current in a magnetic field** 6.6 define **Faraday's law** of electromagnetic induction 6.7 explain the practical applications of **electromagnetic induction**

Range
Force exerted on a current in a magnetic field: electric motor, moving coil loudspeaker **Faraday's law:** effect of moving a conductor across a magnetic field, calculate the value of an induce E.M.F. **Electromagnetic induction**: electric generator, eddy-current brake, method of generating an alternating electro-motive force (EMF), sketch the graph of instantaneous conductor EMF against angular position of coil, define the period and frequency of an alternating current

Appendix 1 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to **http://www.cityandguilds.com/Provide-Training/Centre-Support**.

Our Quality Assurance Requirements encompasses all of the relevant requirements of key regulatory documents

Regulatory Arrangements for the Qualifications and Credit Framework (2008)

and sets out the criteria that centres should adhere to pre and post centre and qualification approval.

The **homepage** section of the City & Guilds website also contains useful information such on such things as:

Walled Garden: how to register and certificate learners on line

Events: dates and information on the latest Centre events

Online assessment: how to register for e-assessments.

Centre manual – Delivering International Qualifications contains detailed information about the processes which must be followed and requirements which must be met for a centre to achieve 'approved centre' status, or to offer a particular qualification. Specifically, the document includes sections on:

The centre and qualification approval process and forms

Assessment, verification and examination roles at the centre

Registration and certification of learners

Non-compliance

Complaints and appeals

Equal opportunities

Data protection

Management systems

Maintaining records

Assessment

Internal and External quality assurance

Frequently asked questions.

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Useful contacts

International learners and centres General qualification information	Please contact your regional office. Details can be found at **www.cityandguilds.com** or alternatively E: **intcg@cityandguilds.com**

If you have a complaint, or any suggestions for improvement about any of the services that we provide, email: feedbackandcomplaints@cityandguilds.com

About City & Guilds

As the UK's leading vocational education organisation, City & Guilds is leading the talent revolution by inspiring people to unlock their potential and develop their skills. We offer over 500 qualifications across 28 industries through 8500 centres worldwide and award around two million certificates every year. City & Guilds is recognised and respected by employers across the world as a sign of quality and exceptional training.

City & Guilds Group

The City & Guilds Group operates from three major hubs: London (servicing Europe, the Caribbean and Americas), Johannesburg (servicing Africa), and Singapore (servicing Asia, Australia and New Zealand). The Group also includes the Institute of Leadership & Management (management and leadership qualifications), City & Guilds Land Based Services (land-based qualifications), the Centre for Skills Development (CSD works to improve the policy and practice of vocational education and training worldwide) and Learning Assistant (an online e-portfolio).

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