QUALIFICATION HANDBOOK

Level 5 Advanced Technician Diploma in Mechanical Engineering (9209-11)

March 2018 Version 6.2

City & Guilds

Qualification at a glance

Subject area	**Engineering**
City & Guilds number	9209
Age group approved	18+
Entry requirements	To take this qualification, learners should have achieved the 9209 Level 4 Diploma in Engineering or a suitable equivalent.
Assessment	• Assignments: externally set by City & Guilds, internally marked by centres, externally verified. • Dated entry written exam papers
Fast track	N/A
Support materials	• Centre handbook • Assessment pack • Assessor guidance • Sample exam questions • Online tutor and learner support material (Smartscreen)
Registration and certification	Consult the Walled Garden/Online catalogue for last dates

Title and level	GLH	TQT	City & Guilds number	Accreditation number
Level 5 Advanced Technician Diploma in Mechanical Engineering	500	750	9209-11	601/5553/X

Amendments made to the document

Document version and date	Change detail	Section
November 2014 v1.1	NLH added Entry requirements	Individual units Entry requirements
January 2015 v1.3	Age 18+ UAN added Unit title 505 QAN added	Page 2 and Section 3 Individual units Section 5 Page 2
April 2015 v2	Updates to some learning outcomes and assessment criteria and updated range Test specification information Question paper resources if applicable	Individual units Assessment
	Test Specifications amended (505, 513, 514, 516, 517)	Assessment
	Range amendment to 513 LO 1.1	Units
	Supporting information updated LO5	
November 2016 v3	Test Specification amendments 505, 514, 515, 518	Assessment
October 2017 v6.1	Added TQT details	**Qualification at a glance, Structure**
March 2018 v6.2	Clarification	Entry Requirements

Contents

1 Introduction

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

In the table below is an outline of this qualification at a glance.

Area	Description
Who is this the qualification for?	This Advanced Technician Diploma is aimed at learners who • wish to gain employment as an advanced Engineering Technician • wish to progress into higher level Engineering qualifications • intend to advance into third year of a selected university engineering degree programme. It also aims to contribute to recognition by professional institutions.
What does this qualification cover?	It allows learners to learn, develop and practise the advanced skills required for employment, career progression or university progression in the engineering sector. It will also allow learners to build their knowledge of the principles of mathematics, science and technologies that underpin engineering.
Who did we develop the qualification with?	Please refer to our recognition list on our website.
What opportunities for progression are there?	It allows learners to progress into employment, university or to the following City & Guilds qualifications: • 9210-01 Level 6 Graduate Diploma in Engineering or other equivalent City & Guilds qualifications.

2 Structure

To achieve the **Level 5 Advanced Technician Diploma in Mechanical Engineering**, learners must achieve all **6** mandatory units and a minimum of **2** optional units.

City & Guilds unit number/UAN	Unit title	GLH	NLH
Mandatory units			
Unit 513 L/506/9292	Advanced engineering mathematics	85	200
Unit 514 R/506/9293	Analysis of the mechanics of fluids	73	150
Unit 515 D/506/9328	Applied thermodynamics	73	150
Unit 516 H/506/9329	Mechanics of solids	64	150
Unit 517 Y/506/9330	Properties of materials for engineering applications	78	150
Unit 518 H/506/9332	Dynamics of machine systems	62	150
Optional units			
Unit 503 Y/506/9280	Engineering project	20	200
Unit 504 D/506/9264	Project management	50	150
Unit 505 D/506/9281	Instrumentation and control systems	89	150
Unit 519 D/506/9331	Modelling engineering designs	45	150

Total Qualification Time

Total Qualification Time (TQT) is the total amount of time, in hours, expected to be spent by a Learner to achieve a qualification. It includes both guided learning hours (which are listed separately) and hours spent in preparation, study and assessment.

Title and level	GLH	TQT
Level 5 Advanced Technician Diploma in Mechanical Engineering	500	750

3 Centre requirements

Approval

If there is no fast track approval for this qualification, existing centres who wish to offer this qualification must use the **standard** Qualification Approval Process.

Resource requirements

Physical resources and site agreements

The equipment, systems and machinery must meet industrial standards and be capable of being used under normal working conditions.

Centre staffing

Staff delivering this qualification must be able to demonstrate that they meet the relevant occupational expertise requirements, i.e. they should be occupationally competent or technically knowledgeable in the areas for which they are delivering training with experience of providing training. This knowledge must be to the same level as the training being delivered

Trainers must also

- hold or be working towards a recognised training qualification
- 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, e.g. tutor and assessor or internal quality assurer, but cannot internally verify their own assessments.

Assessors and Internal Quality Assurer

Assessors

Although not specifically required for this qualification, City & Guilds recommends that Assessors hold, or are working towards, the relevant Level 3 TAQA qualification, covering the assessment types required for this qualification. Further information about the City & Guilds TAQA qualification can be found at **www.cityandguilds.com**. Assessors must be able to demonstrate clear experience in assessing learning and understand City & Guilds' quality assurance requirements. They must also have the required industry certification and experience as outlined above.

Internal Verifiers / Internal Quality Assurers

Although not specifically required for this qualification, City & Guilds recommends that Internal Verifiers / Internal Quality Assurers hold, or are working towards, the Level 4 TAQA qualification. Further information about the City & Guilds TAQA qualification can be found at **www.cityandguilds.com**. Internal Verifiers / Internal Quality Assurers must be able to demonstrate clear experience in quality assurance processes and understand City & Guilds' specific quality assurance requirements. They must also have the required industry certification and experience as outlined above.

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.

Learner entry requirements

Learners should already hold a Level 4 Diploma in Engineering or equivalent in order to complete the qualification satisfactorily.

Age restrictions

City & Guilds cannot accept any registrations for learners under 18 years of age.

4 Delivering the qualification

Initial assessment and induction

An initial assessment of each learner should be made before the start of their programme to identify:

- if the learner has any specific training needs
- support and guidance they may need when working towards their qualification
- any units they have already completed, or credit they have accumulated which is relevant to the qualification
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme so the learner fully understands the requirements of the qualification, their responsibilities as a learner, and the responsibilities of the centre. This information can be recorded on a learning contract.

Support materials

The following resources are available for this qualification:

Description	How to access
Sample exam questions	**www.cityandguilds.com**
Sample schemes of work	**www.smartscreen.co.uk**
Further reading /links	**www.cityandguilds.com**
Equipment lists	**www.cityandguilds.com**
Recognition lists	**www.cityandguilds.com**

5 Assessment

Units 503, 504 and 519 are assessed by assignments set by City & Guilds, internally marked by centres and externally verified. These assignments are graded Pass, Merit and Distinction.

All the remaining units are assessed by dated entry written paper, which are also graded Pass, Merit and Distinction. Exam dates are available on the Catalogue and Walled Garden.

The assessments have all been developed with input from experts in the industry.

Please refer to the Assessor Guidance on **www.cityandguilds.com** for general assessment guidance for this qualification.

Summary of assessment requirements

To achieve this qualification, candidates will be required to complete the following assessments successfully:

- **one** dated entry written exam for **each** mandatory unit 513, 514, 515, 516, 517 and 518
- **one** dated written exam for **each** chosen optional unit assessed by dated written exam
- **one** assignment for **each** chosen optional unit assessed by assignment.

City & Guilds provides the following assessments:

Unit	Title	Assessment method	Where to obtain assessments
Mandatory units			
9209-513	Advanced engineering mathematics	Dated entry written exam paper 9209-513	Sample exam questions on www.cityandguilds.com
9209-514	Analysis of the mechanics of fluids	Dated entry written exam paper 9209-514	Sample exam questions on www.cityandguilds.com
9209-515	Applied thermodynamic s	Dated entry written exam paper 9209-515	Sample exam questions on www.cityandguilds.com
9209-516	Mechanics of Solids	Dated entry written exam paper 9209-516	Sample exam questions on www.cityandguilds.com
9209-517	Properties of materials for engineering applications	Dated entry written exam paper 9209-517	Sample exam questions on www.cityandguilds.com
9209-518	Dynamics of machine systems	Dated entry written exam paper 9209-518	Sample exam questions on www.cityandguilds.com
Optional units			
9209-503	Engineering project	Assignment 9209-503 This assignment covers all the learning outcomes in this unit. Assignment set by City & Guilds, internally marked, externally verified	www.cityandguilds.com
9209-504	Project management	Assignment 9209-504 This assignment covers all the learning outcomes in this unit. Assignment set by City & Guilds, internally marked, externally verified	www.cityandguilds.com
9209-505	Instrumentation and control systems	Dated entry written exam paper 9209-505	Sample exam questions on www.cityandguilds.com
9209-519	Modelling engineering designs	Assignment 9209-519 This assignment covers all the learning outcomes in this unit. Assignment set by City & Guilds, internally marked, externally verified	www.cityandguilds.com

Unit assessment overview

Assignments

The following tables are designed to offer a summarised overview of how the tasks in each assignments demonstrate achievement of the assessment criteria in the units.

Unit 503 Engineering project

Task	Description	Assessment Criteria	Task duration	Grading	Weighting per task
1	Identify and be able to research workplace problems. Produce project plans and proposals for improvements or developments *(demonstrate effective and appropriate communication skills)*	1.1, 1.2, 2.1, 2.2, 2.3	6 hours	P / M / D / X	1
2	Source information, concepts and principles relevant to engineering problems *(Apply underlying concepts and principles of their area of study to address an identified engineering problem or issue)*	3.1, 3.2	5 hours	P / M / D / X	1
3	Select project methods to address objectives *(Evaluate different approaches to the problem or issue identified)*	4.1, 4.2, 4.3	4 hours	P / M / D / X	1
4	Execute the project *(Initiate and use strategies to address an identified engineering issue)*	5.1, 5.2, 5.3, 5.4	4 hours	P / M / D / X	1

Unit 504 Project management

Task	Description	Assessment Criteria	Task duration	Grading	Weighting per task
1	Report: The Principles of Project Management	1.1, 1.2, 2.1, 3.1, 3.2, 3.3, 4.1	4 hours	P / M / D / X	1
2	Research Task: Project Management Case Study	2.2, 2.3, 2.4, 2.5, 2.6. 2.7, 4.2	6 hours	P / M / D / X	1

Unit 519 Modelling engineering designs

Task	Description	Assessment criteria	Task duratio n	Grading	Weighting per task
1	Drawing task: Creating engineering drawings and modelling engineering design	1.1, 1.2, 4.1, 2.1, 2.2, 2.3, 3.1, 3.2, 1.3, 4.2, 4.3, 5.1, 5.2, 5.3	18 hours	P / M / D / X	1

Dated entry written exam papers

Test specifications for the dated entry written exam papers are included here.

Test specifications

The way the knowledge is covered by each test is laid out in the tables below:

Test: 9209-505 Instrumentation and control systems

Duration: 3 hours

Grading: Pass/Merit/Distinction

Unit	Outcome		Number of questions	%
505	1.	understand instrumentation sensors for measurement	4	310
	2.	understand instrumentation systems	1	11
	3.	be able to mathematically model parts of a physical control system	3	30
	4.	understand the stability of a control system	2	19
	5.	be able to design stable feedback control systems	1	9
		Total	**11**	**100**

Test: 9209-513 Advanced engineering mathematics

Duration: 3 hours

Grading: Pass/Merit/Distinction

Unit	Outcome		Number of questions	%
513	1.	be able to use matrix algebra to solve engineering problems	2	18
	2.	be able to use vectors methods to solve engineering problems	1	12
	3.	be able to use calculus to solve engineering problems	5	42
	4.	be able to apply numerical analysis to solve engineering problems	2	28
		Total	**10**	**100**

Test: 9209-514 Analysis of the mechanics of fluids

Duration: 3 hours

Grading: Pass/Merit/Distinction

Unit	Outcome	Number of questions	%
514	1. understand principles of fluid mechanics	2	27
	2. understand the mechanics of flowing fluids	5	60
	3. understand available performance of incompressible fluid turbo-machines	1	13
	Total	**8**	**100**

Test: 9209-515 Applied thermodynamics

Duration: 3 hours

Grading: Pass/Merit/Distinction

Unit	Outcome	Number of questions	%
515	1. understand the thermodynamic principles of engineering power and refrigeration cycles	3	43
	2. understand how the design of compressible fluid turbo-machines affects performance	1	14
	3. understand the performance of internal combustion engines	2	29
	4. understand the performance of reciprocating compressors	1	14
	Total	**7**	**100**

Test: 9209-516 Mechanics of solids

Duration: 2.5 hours

Grading: Pass/Merit/Distinction

Unit	Outcome	Number of questions	%
516	1. understand the behaviour of solids under elastic loading	4	34
	2. understand the behaviour of elastically loaded structures	3	45
	3. understand the nature of failure modes under plastically loaded conditions	3	21
	Total	**10**	**100**

Test: 9209-517 Properties of materials for engineering applications

Duration: 3 hours

Grading: Pass/Merit/Distinction

Unit	Outcome		Number of questions	%
517	1.	understand the atomic theory of the structure of engineering materials	3	27
	2.	understand the changes in the properties of metals as a result of further processing	3	16
	3.	understand the application of non-ferrous metals and their alloys	2	16
	4.	understand how properties affect the application of composite materials	1	9
	5.	understand the relationship between the physical properties of materials and their behaviour	5	32
		Total	**14**	**100**

Test: 9209-518 Dynamics of machine systems

Duration: 3 hours

Grading: Pass/Merit/Distinction

Unit	Outcome		Number of questions	%
518	1.	understand the kinematics of mechanisms	2	26
	2.	understand the dynamics of machines	2	26
	3.	understand the need for machine balancing	2	20
	4.	understand the vibration of machines	2	28
		Total	**8**	**100**

Question paper resources

The following examinations papers will require resource materials as listed below.

Unit no.	Required source material (required on day of exam)	City & Guilds or third party	Cost if third party	How to access
505	Laplace Transforms	City & Guilds	n/a	**www.cityandguilds.com** Copies will be provided with exam question answer booklets. It is recommended to print a copy from the **9209 webpage** to use throughout the course.
513	Mathematical formulae and Laplace Transforms	City & Guilds	n/a	**www.cityandguilds.com** Copies will be provided with exam question answer booklets. It is recommended to print a copy from the **9209 webpage** to use throughout the course.
514	Moody chart	City & Guilds	n/a	Copies will be provided with exam question answer booklets, where applicable.
515	Rogers and Mayhew Thermodynamic properties of fluids, SI units, **5th edition**	Third party	£10	From the internet or through the centre's usual textbook sources. (It is important that it is the 5th edition as it contains data on the refrigerant 134a which is used in all new refrigeration systems.)
	Refrigeration and Air tables	City & Guilds	n/a	**www.cityandguilds.com** Copies will be provided with exam question answer booklets. It is recommended to print a copy from the **9209 webpage** to use throughout the course.

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 and to the Assessor Guidance. 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
- all dated entry written exam papers must be sat within the learner's period of registration.

Assessment strategy

City & Guilds provide sample questions for each unit assessed by dated entry written exam paper. The purpose of these sample questions is to provide examples of the type of question that will be set, giving an indication of the breadth and depth of knowledge that is expected. It should be noted that these are sample questions and **not** a full sample question paper.

Dated entry examinations will take place twice a year, in June and November/ December, with the first exam series being November/December 2015.

Recognition of prior learning (RPL)

Recognition of prior learning means using a person's previous experience or qualifications which have already been achieved to contribute to a new qualification.

RPL is not allowed for this qualification.

6 Grade profile

Purpose and use of this qualification grade profile

City & Guilds has taken the decision to grade the individual assessments included in this qualification, and provide a grade associated with each unit. This decision is based on market research with employers and colleges that suggests grading can be of use both as a motivational tool within the learning environment, and also to learners presenting evidence of their skills to prospective employers.

For this reason, the tasks have been developed to extend learners beyond the minimum required for Pass. As a basis for developing the tasks and their related grading criteria, City & Guilds consulted a number of stakeholders to discover what the grades at each level should mean in practice, and how they might be used. The following descriptors are based on that consultation.

The descriptors were used in the development of the task grading criteria and should be used by assessors to understand the intended outcomes of the grading.

They should be referred to during the centre's standardising exercises in addition to the specific grading criteria for the unit to support a consistent understanding of the standard across units, centres and assessors.
The grades achieved by a learner would be considered by universities for subsequent entry into the correct year of a degree programme.

Aims

The Level 4 and 5 Diplomas in Engineering focus on advanced engineering, with a wide choice of units to provide a flexible route to career success as a professional engineer. The qualifications have been developed closely with both industry and the deliverers of learning in order to ensure fitness for purpose.

Both Level 4 and Level 5 for this qualification are presented here to allow comparison and better understanding of progression.

Levels

Level 4

The Level 4 Diplomas in Engineering focus on advanced engineering. The learners will have the potential to fulfil a role within Engineering that requires a high level of responsibility, for example within first level management, requiring the use of personal initiative and critical judgement.

Holders of these qualifications may also be able to advance into the second year of a selected university engineering degree programme.

Level 5

The Level 5 Advanced Technician Diplomas in Engineering focus on advanced engineering. The learner will have the potential to fulfil a role within Engineering that requires a high level of responsibility, for example

leading to middle management and/or project management, requiring the use of personal initiative and critical judgement.

Holders of these qualifications may also be able to advance into the third year of a selected university engineering degree programme.

To take this qualification a learner must first achieve the 9209 Level 4 Diploma in Engineering.

Both levels are also ideal for people wanting to advance as an Engineering technician within the fields of Mechanical Engineering, Electrical and Electronic Engineering, or Civil Engineering.

Delivery of learning

Learning is delivered by approved colleges and training providers in simulated learning environments, not in the workplace. Learners will however have access to real work environments in which to further develop the breadth of their skills and their experience.

Grading

The majority of tasks are graded Pass / Merit / Distinction. Pass reflects the minimum requirements that are expressed in the unit, with Merit and Distinction showing progression in skills and knowledge as well as recognising behaviours important to the industry.

	Pass	Merit	Distinction
Level 4	**Learner:** Capable of making informed decisions, likely to have achieved a grade at Level 3 (Merit / Distinction), starting to have sufficient skills to bring value to the industry, is becoming comfortable with occupational systems and procedures. **Evidence:** Complex tasks may present some challenge, partial attempt at assessment, well defined tasks completed with a level of guidance, able to follow the required process, acceptable skills / knowledge / competence displayed for the industry, can plan, can solve problems. Limited reflection on the outcomes of the task.	**Learner:** Broader understanding of systems and procedures, can work with minimal guidance, determination to resolve issues, taking ownership and responsibility for own learning, desire to progress. **Evidence:** Full attempt at assessment, well defined tasks completed with minimal guidance, able to follow the required process, higher level skills / knowledge / competence displayed for the industry, can plan, can solve problems more effectively and confidently. Sufficient reflection on the outcomes of the task.	**Learner:** High level of understanding and evaluation of overall systems and procedures, showing potential to achieve a higher level of academic study. Has an ability to carry out tasks without guidance and shows own initiative. **Evidence:** Full achievement of assessment completely independently, within the time given, ie efficient use of time. Detailed / in-depth reflection on the outcomes of the task with recommendations for improvement / alternatives.

	Pass	Merit	Distinction
Level 5	**Learner:** Capable of making informed decisions, likely to have achieved a grade at Level 4 (Merit / Distinction), has sufficient skills to bring value to the industry, is fairly comfortable with occupational systems and procedures. **Evidence:** Complex tasks may present some challenge, but most assessments attempted, well defined tasks completed with a level of guidance, able to follow the required process, acceptable skills / knowledge / competence displayed for the industry, can plan, can solve problems. Satisfactory reflection on the outcomes of the task.	**Learner:** Full understanding of systems and procedures, can work with minimal to no guidance, determination to resolve issues, taking ownership and responsibility for own learning, desire to excel. **Evidence:** Full attempt at assessment, well defined tasks completed with minimal guidance, able to follow the required process, higher level skills / knowledge / competence displayed for the industry, can plan, can solve problems more effectively and confidently. Good reflection on the outcomes of the task.	**Learner:** High level of understanding, evaluation and competence in overall systems and procedures, clearly achieving a higher level of academic study. Has an ability to carry out tasks without guidance and shows own initiative. **Evidence:** Full achievement of assessment completely independently, within the time given, ie efficient use of time. Detailed / in-depth reflection on the outcomes of the task with recommendations for improvement / alternatives.

7 Units

Structure of units

These units each have the following:

- City & Guilds reference number
- title
- level
- guided learning hours
- unit aim
- relationship to NOS, other qualifications and frameworks
- endorsement by a sector or other appropriate body
- information on assessment
- learning outcomes which are comprised of a number of assessment criteria
- notes for guidance.

Unit 503 Engineering project

Level:	5
UAN:	Y/506/9280
GLH:	20
NLH:	200
Assessment method:	Assignment
Aim:	The purpose of this unit is to enable learners to • apply underlying concepts and principles of their area of study to address an identified engineering problem or issue • evaluate different approaches to the problem or issue identified • initiate and use strategies to address an identified engineering issue • demonstrate effective and appropriate communication skills.

Learning outcome
The learner will: 1. be able to research engineering problems
Assessment criteria
The learner can: 1.1 **investigate** processes, practices or structures in engineering to identify an area for development 1.2 propose project ideas.

Range
Investigate Methods and techniques of investigation; observation; history records; interviewing; quality of output

Learning outcome
The learner will: 2. be able to set project objectives
Assessment criteria
The learner can: 2.1 identify information required for inclusion in the engineering project proposals 2.2 produce project proposals to **required scope** 2.3 produce project objectives.

Range
Required scope Generate new focussed information about the problem or issue; increase efficiency; improve customer satisfaction; deliver services more effectively; improvements in quality and output; increase organisation competitive edge; opportunities to expand services; more flexibility; other (to be specified in proposal)

Learning outcome
The learner will: 3. be able to source information, concepts and principles relevant to engineering problems
Assessment criteria
The learner can: 3.1 review theories and practices relevant to **engineering project proposal** 3.2 select key **sources of data and information** to support project.

Range
Engineering project proposal Determined by sector / subject **Sources of data and information** Quantitative and qualitative information; relevant materials; published research

Learning outcome
The learner will: 4. be able to select project methods to address objectives
Assessment criteria
The learner can: 4.1 evaluate the strengths of **methods** in relation to project objectives 4.2 justify selected method(s) used to address project objectives 4.3 identify strategies appropriate to carry out selected method.

Range
Methods Qualitative research (may include interviews; forums; observation; shadowing, research journal articles, books); quantitative research (may include small sample surveys; questionnaires, sector data, organisational data); application / test of a theory; examination / evaluation of a process

Learning outcome
The learner will: 5. be able to execute a project
Assessment criteria
The learner can: 5.1 produce **work plans** to meet objectives 5.2 implement work plans 5.3 review work plan, adjusting timescales and deliverables accordingly. 5.4 prepare a report on the results obtained during project execution

Range
Work plan must • include phases and tasks • include task distribution • include project requirements against objectives • include time constraints • use SMART principles • record objectives in project plan

Unit 503 Engineering project

Supporting information

Guidance

This unit will include a small practical applications-based project with the learner given hands-on control of the project practical activities.

Unit 504 Project management

Level:	5
UAN:	D/506/9264
GLH:	50
NLH:	150
Assessment method:	Assignment
Aim:	The purpose of this unit is to enable learners to develop an understanding of the principles of project management and how projects are set up. Learners will gain an understanding of how to mitigate for risks and develop practical skills in using management tools to monitor and review projects.

Learning outcome
The learner will: 1. understand why organisations use project management.
Assessment criteria
The learner can: 1.1 describe the **principles** of project management 1.2 explain the **benefits** of project management to organisations and individuals.

Range
Principles Business justification; learning from experience; defined roles and responsibilities; manage by stages; manage by exception; focus on products; objectives; constraints; lifecycle **Benefits** Possible benefits will include: Increased efficiency; improved customer satisfaction; organisations may be more effective in delivering services; improvements in quality and output; development opportunities within the project team; increase in an organisation's competitive edge; opportunities to expand services; more flexibility; improved risk assessment

Learning outcome
The learner will: 2. understand how to set up projects.
Assessment criteria
The learner can: 2.1 explain the **considerations** when reviewing project proposals 2.2 explain **how to set clear goals** for projects 2.3 analyse project **resource requirements** 2.4 explain **how roles and responsibilities are allocated** within project teams 2.5 identify project **communication needs** 2.6 assess **possible risks** to successful completion of projects 2.7 explain how to **mitigate** for possible risks.

Range
Considerations Financial viability of the project; time; legal; resource; budget; constraints; dependencies; confidentiality eg restrictions in relation to the Data Protection Act, who has access to data and project documentation **How to set clear goals** Identify stakeholders; identify needs; use SMART principles; record goals in project plans **Resource requirements** Project requirements against goals; time constraints; budget; human resources; training needs; communication needs; IT requirements **How roles and responsibilities are allocated** Use of experts from different areas of the organisation; use of key stakeholders; identify training needs; meeting schedules; timing of reports **Communication needs** Reasons for communication, formal/informal communication; methods of communication; identifying who requires communication eg stakeholders, management, team members **Possible risks** Safety issues; optimistic time and cost estimates; unexpected budget costs; unclear roles and responsibilities; stakeholder needs not sought; changing requirements after the start of the project; new requirements; poor communication; lack of commitment **Mitigate** Health and safety training; regular project review meetings; appropriate communication; training and monitoring

Learning outcome
The learner will: 3. be able to use management tools to maintain, control and monitor projects
Assessment criteria
The learner can: 3.1 describe different **management tools** for monitoring and control of projects 3.2 justify the use of management tools for monitoring and controlling projects 3.3 use management tools to **monitor** projects.

Range
Management tools Progress reports; budget monitoring reports; GANTT charts; Critical Path Analysis; use of relevant and current project software packages. **Monitor** Updating task status; re-scheduling uncompleted tasks; updating project elements.

Learning outcome
The learner will: 4. be able to review projects at all stages
Assessment criteria
The learner can: 4.1 explain **reasons** for reviewing projects after completion 4.2 review projects against original proposals.

Range
Reasons Improve future projects; enables ability to learn from experience; identify key resources for future projects; ensures comparison against achievements to original objectives; highlights any issues eg health and safety, problems, training needs, shortages in terms of resources, increases in costs, allows for the ability to revise and update plans, enables completion of an end of project report.

Unit 504 Project management

Supporting information

Guidance

This unit will be supported by the provision of computer-based project management software and the learner will have the opportunity to use this software to reinforce understanding and help in the application of the project management techniques presented in the unit.

Unit 505 Instrumentation and control systems

Level:	5
UAN:	D/506/9281
GLH:	89
NLH:	150
Assessment Method	Dated Written Paper
Aim:	The purpose of this unit is to extend and deepen learners understanding of instrumentation and control engineering. The recommended pre-requisite is Level 4 unit 428: Electrical principles for mechanical engineers. Through this unit, learners will develop their understanding of advanced instrumentation systems and in particular acquire the mathematical and analytical tools to understand and design control systems.

Learning outcome
The learner will: 1. understand instrumentation sensors for measurement
Assessment criteria
The learner can: 1.1 calculate **parameters** of an orifice plate 1.2 calculate the volumetric flow rate through a venturi nozzle 1.3 calculate parameters of **measurement** tranducers 1.4 analyse the operation of electro-magnetic level sensors 1.5 explain the operating principle of Linear Variable Differential Transformer (LVDT) 1.6 explain how error correction is achieved using a Gray coded angular position encoder 1.7 analyse the different wiring configurations for Resistance Temperature Detectors (RTDs) 1.8 explain how Steinhart-Hart is used for calibrating of thermistor.

Range
Parameters Pressure, volume flow rate, diameter. **Measurement** Level, pressure, temperature, load, displacement

Learning outcome
The learner will: 2. understand instrumentation systems.
Assessment criteria
The learner can: 2.1 analyse the function of **elements** of instrumentation systems 2.2 design a signal conditioning system for a multiple sensor Gray coded input.

Range
Elements Multiplexer, computer, display, sensor, transducer

Learning outcome
The learner will: 3. be able to mathematically model parts of a physical control system
Assessment criteria
The learner can: 3.1 derive the **differential equation** for a **complex physical system** 3.2 derive a differential equation model for an underdamped system using an electrical analogy 3.3 derive the Laplace transformation for a **complex physical system** 3.4 derive the transfer function of a complex linear system.

Range
Differential equation First order, second order **Complex physical system** Mass-spring-damper system, rotational mass, rotational damper, fluid inertia, fluid resistance, RLC circuit

Learning outcome
The learner will: 4. understand the stability of a control system
Assessment criteria
The learner can: 4.1 evaluate the stability of linear feedback systems 4.2 evaluate the stability of linear feed forward systems 4.3 analyse the frequency response of a feedback control system 4.4 explain how the transfer function relates to the operation of three term controllers (PID) 4.5 tune a PID controller using the Ziegler-Nichols methodology.

Learning outcome
The learner will: 5. be able to design stable feedback control systems
Assessment criteria
The learner can: 5.1 design a simple compensated stable control system 5.2 **analyse compensated** stable control systems.

Range
Analyse compensated Series, parallel and external (input/output) by block diagrams, transfer functions.

Unit 505 Instrumentation and control systems

Supporting information

Evidence requirements:

1.3 Each 'measure' should be assessed each time.

Guidance

This unit will be supported by the provision of laboratory equipment to demonstrate and evaluate the operation of measurement and control systems.

This unit contains advanced mathematical concepts and should not be attempted without thorough background knowledge of the necessary mathematical theory.

Unit 513 Advanced engineering mathematics

Level:	5
UAN:	L/506/9292
GLH:	85
NLH:	200
Assessment method:	Dated written paper
Aim:	The purpose of this unit is to enable learners to develop knowledge and understanding of advanced mathematical techniques and be able to apply analytical skills to the solution of engineering problems. The knowledge and skills developed are used by other units in the qualification and they also provide a sound basis for extending the study of engineering to a higher level if desired. On completion of this unit, learners will be able to: • use matrix algebra methods to describe and solve engineering problems • use vector methods of analysis to solve engineering problems • use advanced methods of calculus to model and solve engineering problems • use numerical analysis techniques to solve engineering problems

Learning outcome
The learner will: 1. be able to use matrix algebra to solve engineering problems.
Assessment criteria
The learner can: 1.1 perform **operations** in matrix algebra 1.2 evaluate the determinants of a matrix 1.3 solve simultaneous equations using **matrix methods** 1.4 **obtain the inverse** of a square matrix 1.5 apply matrix algebra to solve engineering problems described by sets of simultaneous equations.

Range
Operations Sums, differences, multiplication by a scalar constant, product; transpose of a matrix, identity matrix, eigenvalues and eigenvectors of a matrix **Matrix methods** Cramer's rule, Gaussian elimination **Obtain the inverse** By formula, by row transformations

Learning outcome
The learner will: 2. be able to use vectors methods to solve engineering problems.
Assessment criteria
The learner can: 2.1 perform **operations** with vectors 2.2 solve engineering problems using vectors.

Range
Operations Vector addition, scalar multiplication; obtain scalar and vector products of two vectors; obtain the vector equation of a line and a plane

Learning outcome
The learner will: 3. be able to use calculus to solve engineering problems
Assessment criteria
The learner can: 3.1 evaluate **partial derivatives** for a function of several variables 3.2 use **series expansions** to obtain approximations of a function 3.3 obtain a **Fourier series** description for functions of a single variable 3.4 obtain Laplace transforms for simple **functions** 3.5 obtain the inverse Laplace transforms for simple **functions** 3.6 obtain **integrals** of simple functions and application to areas, volumes, centroids and moments of inertia 3.7 solve **ordinary differential equations**.

Range
Partial derivatives First- and second-order partial derivatives; the chain rule for partial derivatives, total differential; gradient, divergence, curl **Series expansions** Taylor, Maclaurin **Function** Simple algebraic, trigonometric and exponential **Fourier Series** Sine series, cosine series; series defined over any finite interval **Functions** Defined in the interval (-π, π); odd and even functions **Functions** Algebraic, trigonometric and exponential functions; Heaviside function, Dirac delta function; Evaluation by partial fractions **Integrals** Indefinite, definite, standard **Ordinary differential equations** First order (variables separable; exact equations; linear equations using an integrating factor), second order (initial and boundary value problems; complementary functions and particular integrals)

Learning outcome
The learner will: 4. be able to apply numerical analysis to solve engineering problems
Assessment criteria
The learner can: 4.1 evaluate the inaccuracy of calculations that use **approximate numbers** 4.2 use numerical **iterative methods** to find the roots of a function 4.3 apply **numerical methods of integration and interpolation** to **engineering variables** 4.4 apply **numerical methods** for the solution of **ordinary differential equation models** of engineering systems 4.5 apply **numerical methods** to the solution of partial differential equation models of engineering systems.

Range
Approximate numbers Decimal places; rounding down and up; significant figures **Iterative methods** Bisection method; Secant method; Newton's/Newton-Raphson method **Numerical methods of integration and interpolation** Trapezoidal rule; Simpson's rule; Newton polynomial **Engineering variables** Areas, volumes, centres of gravity, moments of inertia **Numerical methods** Euler and improved Euler; Taylor series; Runge-Kutta **Ordinary differential equation models** Initial value problems **Numerical methods** Forward, backward and central finite difference methods for partial differential equations; solution of sets of linear equations by Jacobi iterative method; Gauss-Seidel iterative method

Unit 513 Advanced engineering mathematics

Supporting information

This unit will be supported by the provision of computer-based mathematical software and the learner will have the opportunity to use this software to reinforce understanding of the analysis techniques presented in the unit and assist in skills development.

1.2 Determinants

evaluate minors and cofactors; apply rules for simplifying determinants.

1.4 Inverse of a square matrix

matrix form of simultaneous equations; singular and non-singular matrices; the characteristic equation; eigenvalues and eigenvectors; obtain the inverse of a square matrix by formula or by row transformations.

1.5 Gaussian elimination: the augmented matrix; systematic elimination in the augmented matrix by row transformations

3.2 use of L'Hopital's rule for function evaluation

3.4 and 3.5 using tables of Laplace transforms

3.6 rules and techniques for the integration of functions

3.7 complementary function using the D-operator; particular integral using trial functions; response to sinusoidal inputs; resonance; solution of equations using Laplace transforms.

4.1 use of partial derivatives to estimate calculation errors in formulae caused by inaccuracies in measurements.

Unit 514 Analysis of the mechanics of fluids

Level:	5
UAN:	R/506/9293
GLH:	73
NLH:	150
Assessment method:	Dated written paper
Aim:	The unit provides for study of the principles of fluid mechanics and associated properties of fluids. It aims to develop knowledge, understanding and analysis skills to enable learners to solve problems in engineering applications of fluid mechanics and to support fluid system design and performance. On successful completion learners will be able to: • apply basic fluid mechanics. • apply the mechanics of flowing fluids. • determine the performance of incompressible fluid turbo-machines.

Learning outcome
The learner will: 1. understand principles of fluid mechanics.
Assessment criteria
The learner can: 1.1 derive **conservation equations** of fluid mechanics 1.2 explain the **kinematics** of fluid motion 1.3 explain **viscosity** of flowing fluids 1.4 apply dimensional analysis to flowing fluids.

Range
Conservation equations Continuity; momentum; energy **Kinematics** Streamlines, streamtubes, particle paths, streak lines; irrotational and rotational flows; circulation; vorticity **Viscosity** Stress-strain relations for Newtonian and non-Newtonian fluids

Learning outcome
The learner will: 2. understand the mechanics of flowing fluids
Assessment criteria
The learner can: 2.1 analyse inviscid fluid flows 2.2 evaluate the **effects** of viscosity in fluid **flows** 2.3 analyse **laminar flow** of incompressible fluids using boundary layer theory 2.4 explain boundary layer transition 2.5 analyse the **turbulent flow** of incompressible fluids 2.6 explain boundary layer separation 2.7 analyse **steady incompressible fluid flow** in pipes 2.8 analyse **steady compressible fluid flow** in pipes.

Range
Inviscid fluid flows Flows resulting from simple combinations of a uniform stream, source, sink, doublet and point vortex; flow around a circular cylinder with circulation and its pressure distribution and lift force **Effects** Boundary layer concept, vortices, **Flows** Laminar and turbulent flows wakes, viscous drag **Laminar flow** Displacement and momentum thicknesses; skin-friction coefficient; the drag on a flat plate **Turbulent flow** Power law and logarithmic velocity distribution; laminar sub-layer; skin friction on a flat plate; effects of surface roughness, necessity of turbulence modelling **Steady incompressible fluid flow** The relationship between friction factor, Reynolds number and relative roughness (Moody chart) and use of the Darcy-Weisbach equation **Steady compressible fluid flow** Stagnation pressure, temperature and density; subsonic flow; isentropic flow of a perfect gas in ducts of varying cross-sectional area in terms of Mach number; choked flow; supersonic flow; formation of a normal shock in a convergent-divergent nozzle

Learning outcome
The learner will: 3. understand available performance of incompressible fluid turbo-machines
Assessment criteria
The learner can: 3.1 evaluate the design performance of **incompressible fluid turbo-machines** using one-dimensional analysis 3.2 evaluate practical turbo-machine operating **conditions**.

Range
Incompressible fluid turbo-machines Centrifugal, axial and mixed-flow machines; **Conditions** Net positive-suction head (NPSH); flow, head and power coefficients; specific speed; optimum pump operation

Unit 514 Analysis of the mechanics of fluids

Supporting information

Guidance

1.4 dimensional analysis

geometric, kinematic and dynamic similarity in fluid flow; Buckingham - theorem; derivation of the principal dimensionless numbers for fluid flow, Reynolds, Euler, Froude, Mach numbers; pressure, lift and drag coefficients; roughness ratio.

2.1 Euler and Bernoulli equations of motion; the stream function and velocity potential function in steady, two-dimensional flows.

Unit 515 Applied thermodynamics

Level:	5
UAN:	D/506/9328
GLH:	73
NLH:	150
Assessment method:	Dated written paper
Aim:	The unit provides for study of the application of thermodynamic principles and thermodynamic properties of fluids to a range of power systems and refrigeration systems. It aims to develop knowledge, understanding and analysis skills that enable learners to evaluate the performance of such systems and also to support the design of the systems. On successful completion learners will be able to: • apply thermodynamic principles to engineering power and refrigeration cycles. • perform design calculations for compressible fluid turbo-machines. • determine the practical performance of internal combustion engines. • determine the practical performance of reciprocating compressors.

Learning outcome
The learner will: 1. understand the thermodynamic principles of engineering power and refrigeration cycles.
Assessment criteria
The learner can: 1.1 analyse the thermodynamic performance of **steam-turbine power cycles** 1.2 analyse the thermodynamic performance of **combined heat and power cycles** 1.3 analyse the thermodynamic performance of **gas turbine power cycles** 1.4 analyse the thermodynamic performance of **vapour-compression cycles**.

Range
Steam turbine power cycles Rankine cycle; Rankine cycle with superheating; Rankine cycle with reheating; Rankine cycle with regenerative feed heating; effects of isentropic efficiency; thermal efficiency **Combined heat and power cycles** Back-pressure turbine cycle; pass-out turbine cycle; combined heat and power (CHP) cycle; thermal efficiency **Gas turbine power cycles** Joule (Brayton) cycle; overall cycle performance (with intercooling; reheating; heat exchange); effects of isentropic efficiency; thermal efficiency **Vapour compression cycles** Refrigeration cycles, heat pump cycles; coefficient of performance (CoP)

Learning outcome
The learner will: 2. understand how the design of compressible fluid turbo-machines affects performance
Assessment criteria
The learner can: 2.1 explain how the **characteristics** of compressible fluid turbo-machines affect performance 2.2 evaluate the **performance** of compressible fluid turbo-machines using one-dimensional analysis.

Range
Characteristics Axial- and radial-flow turbines; axial- and radial-flow compressors; impulse and reaction stages; leakage losses **Performance** Sources of internal losses; overall, single stage and polytropic efficiencies; reheat factor

Learning outcome
The learner will: 3. understand the performance of internal combustion engines
Assessment criteria
The learner can: 3.1 analyse the performance of **air-standard cycles** 3.2 explain **factors** affecting the performance of **internal-combustion engines** 3.3 evaluate the **practical performance** of **internal-combustion engines** 3.4 compare air-standard cycles and practical internal-combustion engine performance.

Range
Air-standard cycles Otto, Diesel, Sterling **Factors** Ignition timing, induction, exhaust, supercharging **Internal-combustion engines** Spark-ignition; compression-ignition; **Practical performance** Output power, speed, mean effective pressure, specific fuel consumption

Learning outcome
The learner will: 4. understand the performance of reciprocating compressors
Assessment criteria
The learner can: 4.1 analyse the **ideal performance** of reciprocating compressors 4.2 evaluate the **practical performance** of reciprocating **compressors**.

Range
Ideal performance Volumetric efficiency; isothermal and isentropic efficiencies; multi-stage compression; intercooling. **Practical performance** Effects of using non-return valves; input power required; volumetric efficiency; volumetric flow rate; free air delivered **Compressors** Single and double acting compressors

Unit 515 Applied thermodynamics

Supporting information

Evidence requirements

3.2 must be performance of an actual engine.
4.2 must be actual measured performance.

Guidance

3.2, 4.2 actual live performance.

Unit 516 Mechanics of solids

Level:	5
UAN:	H/506/9329
GLH:	64
NLH:	150
Assessment method:	Dated written paper
Aim:	The purpose of this unit is to extend and deepen learners understanding of the theory of elastic and plastic loading of materials. The learner will be able to apply this theory to different types of structures and analyse the effect of different types of loading upon the structure or structural component. Through this unit, learners will develop their understanding of modes of failure including fatigue, stress rupture and creep. Learners will apply the understanding they develop to analyse and solve problems related to loading.

Learning outcome
The learner will: 1. understand the behavior of solids under elastic loading.
Assessment criteria
The learner can: 1.1 explain the relationship between the **primary elastic constants for isotropy** 1.2 explain the significance of elastic constants in different **types of materials** 1.3 explain the concept of stress components in complex stress cases 1.4 explain and apply Mohr's circle to combined loading 1.5 explain the operating principle of a strain gauge 1.6 explain the application of Euler's buckling theory 1.7 calculate the tensile hoop stress in thin rings and cylinders rotating at constant angular velocity 1.8 calculate the stresses at any radius r in a disc of uniform thickness rotating with a constant angular velocity ω rad/s 1.9 explain how finite element modelling can be applied in the analysis of structures 1.10 determine the principal stresses and angles for a given loading case. 1.11 determine **conditions** for the stability of a **column** using Euler's buckling theory.

Range
Primary elastic constants Young's modulus {E}; Shear modulus{G}; Bulk modulus {K}; Poisson's ratio {v} **Types of materials** Isotropic solids, anisotropic solids **Conditions** Pin conditions, free conditions, built-in end conditions **Column** Circular, solid and hollow cross sections. Pinned, free and built-in end conditions.

Learning outcome
The learner will: 2. understand the behavior of elastically loaded structures.
Assessment criteria
The learner can: 2.1 calculate the second moment of area of various beam cross-sections 2.2 select values of second moment of areas for standard beams 2.3 calculate the bending and shear stresses in a beam 2.4 calculate the deflection of a beam using double-integration method 2.5 calculate bending and shear stresses in a composite beam 2.6 calculate deflection of a composite beam using double-integration method 2.7 analyse a truss **structure**

Range
Structure Truss, redundant member

Learning outcome
The learner will: 3. understand the nature of failure modes under plastically loaded conditions
Assessment criteria
The learner can: 3.1 analyse an engineering component subject to **fatigue loading** 3.2 analyse an engineering component involving **creep** 3.3 describe viscoelasticity in an engineering component 3.4 analyse an engineering component involving **fracture mechanics** 3.5 analyse an engineering component involving **yield criteria**.

Range
Fatigue loading Crack growth using Paris' Law, Life factors using Miner's rule, S-N curves **Creep** Elevated temperature, stress rupture curves **Fracture mechanics** Linear elastic fracture mechanics (LEFM), elasto-plastic fracture mechanics (EPFM), notches, cracks, stress intensity factor, strain energy release rate **Yield criteria** Plastic yielding, Tresca and von Mises criteria, pressure-dependency

Unit 516 Mechanics of solids

Supporting information

Guidance

This unit will be supported by the provision of computer-based finite element analysis software and the learner will have the opportunity to use this software to reinforce understanding and assist with the application of finite element analysis techniques to practical problems.

Also, this unit will be supported by the provision of laboratory equipment to evaluate stress and deflection in simple components and structures when subjected to complex loading to enable the learner to verify the predictions of elastic theory.

3.2 use stress rupture curve for selected material.

Unit 517 Properties of materials for engineering applications

Level:	5
UAN:	Y/506/9330
GLH:	78
NLH:	150
Assessment method:	Dated written paper
Aim:	The purpose of this unit is to enable learners to develop knowledge and understanding of the effects that material properties have on the choice of materials for engineering applications. On completion of this unit, learners will understand • the atomic structure of engineering materials • the effects of additional processing on the properties of metals • the engineering applications of non-ferrous metals and their alloys • the engineering applications of composite materials • how the behaviour of a material is affected by the physical properties of the material.

Learning outcome
The learner will: 1. understand the atomic theory of the structure of engineering materials.
Assessment criteria
The learner can: 1.1 explain the influence of atomic bonding on the properties of engineering materials 1.2 explain the effect of temperature change on the microstructure of plain carbon steels 1.3 explain the **processes** by which polymer molecules are formed 1.4 explain the influence of crosslinking on the **mechanical properties** of polymers 1.5 compare the cell structure of wood with a long chain polymer 1.6 explain how the molecular structure of glass affects its properties.

Range
Processes Addition process, condensation process **Mechanical properties** Stiffness, strength.

Learning outcome
The learner will: 2. understand the changes in the properties of metals as a result of further processing
Assessment criteria
The learner can: 2.1 analyse the effect of **thermo-mechanical treatments** on the microstructure of plain carbon steels 2.2 explain the effect of cooling rates on the grain structure of different types of cast iron 2.3 analyse the effect of chilling upon cast iron 2.4 explain how alloying affects the mechanical properties of cast iron 2.5 explain the effect of **alloying elements** on the mechanical properties of alloy steels 2.6 explain the **surface hardening treatment** processes 2.7 explain how nitriding improves the surface hardness of nitralloy steels 2.8 explain how processing of stainless steel affects its properties 2.9 explain the role played by niobium in stabilising stainless steels against weld decay.

Range
Thermo-mechanical treatments Work hardened, quenching, flame hardening, induction hardening, case hardening, hardening **Alloying elements** Nickel, chromium, molybdenum, manganese, cobalt, niobium, titanium, vanadium, boron, combination

Surface hardening treatment Carburising, casehardening, nitriding
Learning outcome
The learner will: 3. understand the application of non-ferrous metals and their alloys
Assessment criteria
The learner can: 3.1 evaluate different **methods** of metallic protective **coatings** 3.2 evaluate the engineering **applications** of copper and its alloys 3.3 evaluate the engineering applications of aluminium and its alloys in different **forms** 3.4 evaluate the application of wrought and cast **processes** on aluminium alloys 3.5 explain the British Standards classification of aluminium alloys 3.6 represent **structural changes** of aluminium-copper alloys on a heat treatment graph 3.7 analyse the effect on tensile strength of the precipitation treatment of a duralumin type aluminium alloy.

Range
Methods Electrochemical scale, electrolytic corrosion, Sacrificial anode, cathode, anodising, electroplating, phosphating, surface hardness and corrosion resistance **Coatings** Zinc, tin, copper, chrome **Applications** Commercial grades, tubing, conductor, plain bearings **Forms** Sheet, strip, plate, extrusion, rod, tube **Processes** Sand cast, gravity die cast, pressure die cast **Structural changes** Resulting from heat treatment and ageing

Learning outcome
The learner will: 4. understand how properties affect the application of composite materials
Assessment criteria
The learner can: 4.1 explain the difference in ultimate tensile strength of a single glass fibre produced in different **conditions** 4.2 analyse the role of the glass fibres in **glass reinforced products** 4.3 evaluate the **mechanical properties** of different **types of glass** from design tables 4.4 compare the suitability of different **fibres** for composite material products.

Range
Conditions Laboratory, commercial production **Glass reinforced products** Matrix, uniaxial **Mechanical properties** Ultimate tensile strength, compressive strength, density **Types of glass** E glass, R glass, D glass, C glass, S glass **Fibres** Aramid fibre (Kevlar), carbon fibre

Learning outcome
The learner will: 5. understand the relationship between the physical properties of materials and their behavior
Assessment criteria
The learner can: 5.1 analyse the adverse effects of production **processes** on materials 5.2 analyse the effects of in service **conditions** imposed on a material 5.3 compare multiphase structural steels with micro-alloyed high strength low alloy (HSLA) steels 5.4 evaluate stress-strain graphs of different **materials** 5.5 explain the importance of stress concentrations in different **conditions** 5.6 explain the concept of fracture mechanics 5.7 describe the effect of **manufacturing defects** on the brittle fracture failure of ceramic products 5.8 describe remedies for reducing **manufacturing defects** that could lead to brittle fracture failure in ceramic products 5.9 explain the mechanisms by which stress corrosion cracking can occur in polymeric materials 5.10 explain the gradual degradation of polymeric materials caused by environmental factors

Range
Processes Rolling, extrusion, forging, deep drawing **Conditions** Fatigue, creep, tensile strength under critically elevated and low temperature, environmental stress cracking, ultraviolet, microorganisms, acids, alkalis, pollution **Materials** TRIP, DP and HSLA steels **Conditions** Sudden changes in section, incorrect surface finish specifications, manufacturing defects **Manufacturing defects** Microscopic flaws, microcracks, internal pores, atmospheric contaminants, thermal expansion

Unit 517 Properties of materials for engineering applications

Supporting information

Evidence requirements

LO3: from a time temperature graph (AC3.7)

Guidance

1.2 Using the iron carbon equilibrium diagram.

LO2: learners are expected to demonstrate their understanding of the properties of the materials and not be constrained by a specific list.

3.6 aluminium-copper alloy of the duralumin type with up to 6% copper content (heat treatment graph).

4.1A.A.Griffith's flaw hypothesis.

5.6 Griffith's criterion, Irwin's modification, elastic strain energy.

Lo 5 **Industry standard procedures -** British Standard, CEN-CENELEC, ASMI, API, IET

Unit 518 Dynamics of machine systems

Level:	5
UAN:	H/506/9332
GLH:	62
NLH:	150
Assessment method:	Dated written paper
Aim:	The unit provides for study of the application of engineering dynamics principles to machine system design and analysis. It aims to develop knowledge, understanding and analysis skills that enable learners to evaluate the performance of machine systems from a dynamics point of view and also provide support for the design of machine systems. On successful completion learners will understand: • the kinematics of mechanisms • the dynamics of machines • the need for machine balancing • the vibration of machines

Learning outcome
The learner will: 1. understand the kinematics of mechanisms
Assessment criteria
The learner can: 1.1 explain **kinematic modelling** of simple mechanisms 1.2 evaluate velocities in kinematic **mechanisms** by **graphical analysis** 1.3 evaluate the accelerations in kinematic **mechanisms** by **graphical analysis** 1.4 evaluate the **motions** in kinematic mechanisms by mathematical analysis.

Range
Kinematic modelling Reference frames; degrees of freedom; rigid body links, revolute and prismatic joints; kinematic chains; planar kinematic mechanisms; translation; rotation; general motion; relative motion **Mechanisms** Four-bar linkage; crank and rocker; drag link; slider-crank; scotch yoke; quick-return **Graphical analysis**

Instantaneous centres; relative velocities; velocity and acceleration diagrams **Motions** Displacement; velocity; acceleration

Learning outcome
The learner will: 2. understand the dynamics of machines
Assessment criteria
The learner can: 2.1 analyse the operation of a **gear train** in a machine 2.2 analyse the **forces** in machines 2.3 analyse the **torques** in machines 2.4 **analyse** the operation of a flywheel in a machine.

Range
Gear train Simple; compound; epicyclic; dynamics of gear trains **Forces** Gravitational; inertial; pressure; frictional **Torque** Input; output **Analysis** Function of a flywheel in a machine; cyclic torque diagram for a machine; energy analysis of a flywheel

Learning outcome
The learner will: 3. understand the need for machine balancing
Assessment criteria
The learner can: 3.1 analyse **balancing of rotating masses** in a machine 3.2 analyse **balancing of reciprocating masses** in a machine.

Range
Balancing of rotating masses Static balancing; dynamic balancing; single out-of-balance mass; several masses in one transverse plane; masses in different transverse planes **Balancing of reciprocating masses** Slider-crank mechanism; primary out-of-balance forces; secondary forces; treatment of the connecting-rod; single reciprocating mass; Lanchester balancer; several masses in an in-line multi-cylinder engine

Learning outcome
The learner will: 4. understand the vibration of machines
Assessment criteria
The learner can: 4.1 explain the **causes of vibration** in a simple machine system 4.2 analyse a **system with one degree of freedom** 4.3 analyse the normal modes of **vibration** in a **system with two degrees** of **freedom** 4.4 analyse **torsional vibration** of a **multi-mass system** using Holzer's method 4.5 evaluate **methods for reducing vibration** in a machine.

Range
Causes of vibration Sources of vibration excitation; degrees of freedom; free vibration; natural frequency; resonance; forced vibration; damped vibration **System with one degree of freedom** Spring/mass system; shaft/flywheel system; critical damping **Vibration** Forced, Free **System with two degrees of freedom** Two-Spring/two-mass systems (Horizontal, Vertical), double pendulum systems **Torsional vibration** of a **multi-mass system** Two inertia systems, Multiple inertia systems (Rotating shafts carrying discs, flywheels, pulley systems and gears) **Methods for reducing vibration** Reducing harmonic forces; vibration isolation; additional damping; dynamic absorber

Unit 518 Dynamics of machine systems

Supporting information

Guidance

This unit could be supported by the provision of laboratory equipment to evaluate the effects of out-of-balance rotating masses in a simple shaft and flywheel assembly.

Unit 519 Modelling engineering designs

Level:	5
UAN:	D/506/9331
GLH:	45
NLH:	150
Assessment method:	Assignment
Aim:	The purpose of this unit is to enable learners to demonstrate an understanding of 3D CAD systems and parametric modelling. Learners will understand the benefits of using 3D CAD, its application in the workplace, and its role in the preparation and presentation of mechanical engineering designs. Learners will also use a variety of methods to analyse design optimisation.

Learning outcome
The learner will: 1. be able to use parametric modelling in the production of 3D parts
Assessment criteria
The learner can: 1.1 create **2D & 3D Sketches** with the CAD Environment 1.2 create **3D Models** using a range of **Feature Commands** 1.3 create 3D Models using **Table Driving formulas** 1.4 demonstrate **Design Intent** in the creation of 3D Models 1.5 export 3D CAD Models for **CNC, 3D Printing or Laser/Plasma Cutting**

Range
2D & 3D Sketches; 3D Models Drawing Tools, Constraints; Solid Geometry, Sheet Metal **Feature Commands** Extrude, Revolve, Loft, Fillet, Chamfer, Shell, Sweep, Work Planes, Patterns, Bend, face, Flange **Table Driving formulas** Families of parts & assemblies from spread sheets **Design Intent** Plane Selection, Feature Relationships **CNC, 3D Printing or Laser/Plasma Cutting** DXF, IGES, STL, VRML, HPGL, STEP

Learning outcome
The learner will: 2. be able to produce 3D working assemblies
Assessment criteria
The learner can: 2.1 create **3D Assemblies using Modelled Parts** and **Content Libraries** 2.2 create**3D Functional Assemblies** using correct **constraining procedures** 2.3 create**3D Exploded Assemblies** to demonstrate the **assembly/disassembly process**

Range
3D Assemblies using Modelled Parts Multiple part models **Content Libraries** Nuts, Bolts, Screws, Washers, Bearings **3D Functional Assemblies** Rotary and Linear Motion **constraining procedures** Flush, Parallel, Joint **3D Exploded Assemblies** Presentation Files **assembly/disassembly process** Putting the assembly together or taking apart

Learning outcome
The learner will: 3. be able to create drawings
Assessment criteria
The learner can: 3.1 create**2D drawings of individual parts** for manufacture to **BS8888** 3.2 Create **2D Assembly Drawings** to BS8888

Range
2D drawings of individual parts Orthographic, Sections, Break Outs, Detail **BS8888** Templates, Line Types, Dimensioning, View Layouts, Metric units **2D Assembly Drawings** General Assembled view, Exploded Assembly view, BOM

Learning outcome
The learner will: 4. be able to produce rendered images and animations
Assessment criteria
The learner can: 4.1 create **rendered images** of parts and assemblies 4.2 create **animations** of **assembly/disassembly processes** 4.3 create animations of **assembly functionality**

Range
Rendered Images Photo Realistic, Lighting, Environment **Animations** e.g. MP4, avi files **Assembly/Disassembly Processes** Exploding & reassembling **Assembly Functionality** Rotary & Linear Motion, Gears, Chains, Sprockets

Learning outcome
The learner will: 5. be able to analyse 3D CAD models
Assessment criteria
The learner can: 5.1 carry out finite element analysis on 3D Models 5.2 carry out design optimisation & sustainability analysis on 3D designs 5.3 carry out computational fluid dynamics analysis on 3D Models

Range
Finite Element Analysis Forces, Loads, Stress, Deformation, Deflection **Design Optimisation** Material Selection, Manufacturing Capabilities, User Requirements, End of Life, Product Use, Raw Material Extraction **Computational Fluid Dynamics** Internal & External Flow, Heat Transfer, Liquids & Gases

Unit 519 Modelling engineering designs

Supporting information

Guidance

This unit will be supported by the provision of computer-based 3-D CAD solid modelling software and finite element analysis software to enable the learner to develop 3-D models of practical components and perform an analysis of the 3-D CAD models for strength and stiffness when subjected to various loading conditions.

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 the **Centres and Training Providers homepage** on **www.cityandguilds.com**.

Centre Guide – 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 candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Frequently asked questions.

Useful contacts

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

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