Level 7 Post Graduate Diploma in Engineering (9210-02)

Qualification handbook for centres

www.cityandguilds.com
March 2012
Version 1.1 (July 2012)

About City & Guilds

City & Guilds is the UK's leading provider of vocational qualifications, offering over 500 awards across a wide range of industries, and progressing from entry level to the highest levels of professional achievement. With over 8500 centres in 100 countries, City & Guilds is recognised by employers worldwide for providing qualifications that offer proof of the skills they need to get the job done.

City & Guilds Group

The City & Guilds Group includes City & Guilds, ILM (the Institute of Leadership and Management, which provides management qualifications, learning materials and membership services), City & Guilds NPTC (which offers land-based qualifications and membership services), City & Guilds HAB (the Hospitality Awarding Body), and City & Guilds Centre for Skills Development. City & Guilds also manages the Engineering Council Examinations on behalf of the Engineering Council.

Equal opportunities

City & Guilds fully supports the principle of equal opportunities and we are committed to satisfying this principle in all our activities and published material. A copy of our equal opportunities policy statement is available on our website.

Copyright

Publications

City & Guilds publications are available from our website or from our Publications Sales department, using the contact details shown below.

Every effort has been made to ensure that the information contained in this publication is true and correct at the time of going to press. However, City & Guilds' products and services are subject to continuous development and improvement and the right is reserved to change products and services from time to time. City & Guilds cannot accept liability for loss or damage arising from the use of information in this publication.

City & Guilds
1 Giltspur Street
London EC1A 9DD
T +44 (0)844 543 0000
F +44 (0)20 7294 2413
www.cityandguilds.com
centresupport@cityandguilds.com

Level 7 Post Graduate Diploma in Engineering (9210-02)

Qualification handbook for centres

www.cityandguilds.com
March 2012
Version 1.1 (July 2012)

Version and date	Change detail	Section
1.1 July 2012	Added information regarding 'Incorporated Engineer and Chartered Engineer registration'	1.3

City & Guilds

Skills for a brighter future

www.cityandguilds.com

Contents

City & Guilds

Skills for a brighter future

www.cityandguilds.com

1 Introduction to the qualifications

This document contains the information that centres need to offer the following qualification:

Qualification title and level	**Level 7 Post Graduate Diploma in Engineering**
City & Guilds qualification number	9210-02
Last registration date	31.05.2016
Last certification date	31.05.2019

Qualification title and level	City & Guilds qualification number	Last registration date	Last certification date
Level 7 Post Graduate Diploma in Civil Engineering	9210-02	31.05.2016	31.05.2019
Level 7 Post Graduate Diploma in Electrical Engineering	9210-02	31.05.2016	31.05.2019
Level 7 Post Graduate Diploma in Electronic and Telecommunication Engineering	9210-02	31.05.2016	31.05.2019
Level 7 Post Graduate Diploma in Information Technology	9210-02	31.05.2016	31.05.2019
Level 7 Post Graduate Diploma in Mechanical Engineering	9210-02	31.05.2016	31.05.2019

Introduction to this qualification handbook

Centres are advised that the content of this qualification handbook is subject to changes as a result of the review of the units by the UK professional engineering institutions.

Introduction to this programme

The Graduate and Post Graduate Diplomas in Engineering have been developed for those undergoing training or employed in Civil, Electrical/Electronic, Telecommunication and Mechanical Engineering, and Information Technology areas of work. The qualifications aim to reflect the international nature of the knowledge and skills and activities needed for different countries or cultures.

These qualifications are the City & Guilds successor qualifications to the Engineering Council examinations (9107 series).

Flexible alternative route to career success as a professional engineer

These qualifications provide a flexible and alternative method of satisfying the academic requirements of professional institutions or continued professional development (CPD) for learners already in employment, or those looking to change their career who did not have an opportunity (or chose not to) gain an accredited degree.

Learners will normally attend formal courses of study at City & Guilds approved centres in preparation for the examinations and assessments. Learners may take as few or as many subjects as they wish each year.

The qualification has three main professional groupings. These are Civil, Electrical (contains three pathways of Electrical, Electronic and Telecommunication and Information Technology) and Mechanical Engineering.

Why choose these qualifications?

- They have been designed to meet the UK-SPEC requirements and to be recognised by the UK professional engineering institutions
- Registration as a professional engineer is the assurance that a person has received education and training which meets the UK and international professional standards
- Possession of specialist qualifications is often regarded by employers as an advantage when applying for employment
- It is a sign of commitment to a code of professional conduct and ensures the achievement of best practice
- Universities, upon application, may accept the Graduate Diploma and Post Graduate Diploma as entry into MSc programmes
- They can be used as a progression route by holders of certain City & Guilds IVQs and other comparable qualifications
- Learners can study at their own pace with a choice of subjects according to their own expertise and intended future direction
- The modular system parallels the systems used in most universities
- There is no academic penalty applied by City & Guilds for repeating a paper
- Learners can incorporate studies into their lifelong learning plan (Continuous Professional Development - CPD)
- Holders of IEng or CEng may apply for the City & Guilds senior Awards of LCGI, CGCI and MCGI.
- International recognition - City & Guilds qualifications are widely accepted around the world as a benchmark for workplace excellence.

Note: It is recommended that learners have achieved the City & Guilds Level 6 Graduate Diploma in Engineering or equivalent before enrolling on the Level 7 Post Graduate Diploma in Engineering.

Guidelines for the Post Graduate Diploma

The Level 7 Post Graduate Diploma in Engineering is set at the standard of the final (fourth) year of a British MEng degree course. It is advised that the Level 7 Post Graduate Diploma in Engineering consist of 1500 Notional Hours (total learning hours including the Guided Learning Hours and self study/research).

The subject combinations and assessments required for the various Post Graduate Diplomas are set out below. For details of project, practical and laboratory work, please refer to a separate assessment guidance documentation.

Learners must be registered for Post Graduate Diploma at the beginning of the course in order for practical and project work to be accepted.

Learners may repeat papers as many times as they wish. However, some professional institutions may count repeated attempts against an application for professional registration. It will not, however, count against successful completion of the Post Graduate Diploma requirements.

It should be noted that some professional institutions may impose constraints on the time taken to complete the Post Graduate Diploma.

1.1 Qualification structure

Level 7 Post Graduate Diploma in Civil Engineering
To achieve the Level 7 Post Graduate Diploma in Civil Engineering candidates must successfully complete **two** "Mandatory" plus **three** "Pathway Mandatory" and any **three** "Optional" units.

City & Guilds unit number	Practical assignment number (if applicable)	Unit title	Compulsory/ optional for full qualification
Unit 200		Engineering Analysis	Mandatory
Unit 201		Construction Engineering and Management	Pathway Mandatory
Unit 202		Environmental Engineering	Pathway Mandatory
Unit 203		Computational Mechanics Using Finite Element Method	Pathway Mandatory
Unit 204		Geotechnical Engineering	Optional
Unit 205		Built Environment 1	Optional
Unit 206		Structural Design	Optional
Unit 207		Fluid Mechanics and Coastal Engineering	Optional
Unit 208		Built Environment 2	Optional
Unit 111	611	Structural Analysis	Optional
Unit 138		Quality and Reliability Engineering	Optional
Unit 229		Project 2	Mandatory

The practical assignments are carried out during the learning programme (and are internally marked) and should be finished by the date of the written examinations so that the results can be sent to City & Guilds.

To receive this award the candidate must complete practical assignment 229, plus an appropriate practical assignment for the chosen optional unit (611). Please see a separate assessment guidance document for details.

Level 7 Post Graduate Diploma in Electrical Engineering

To achieve the Level 7 Post Graduate Diploma in Electrical Engineering candidates must successfully complete **two** "Mandatory" plus **three** "Pathway Mandatory" and any **three** "Optional" units

City & Guilds unit number	Unit title	Compulsory/ optional for full qualification
Unit 200	Engineering Analysis	Mandatory
Unit 209	Power System Economics and Planning	Pathway Mandatory
Unit 210	High Voltage Engineering	Pathway Mandatory
Unit 211	Fields and Network Theory	Pathway Mandatory
Unit 213	Digital System Design	Optional
Unit 215	Modern Control Systems	Optional
Unit 217	Power Electronics	Optional
Unit 218	Internet Technologies	Optional
Unit 219	Computer System Engineering	Optional
Unit 229	Project 2	Mandatory

The practical assignments are carried out during the learning programme (and are internally marked) and should be finished by the date of the written examinations so that the results can be sent to City & Guilds.

To receive this award the candidate must complete practical assignment 229. Please see a separate assessment guidance document for details.

Level 7 Post Graduate Diploma in Electronic and Telecommunication Engineering

To achieve the Level 7 Post Graduate Diploma in Electronic and Telecommunication Engineering learners must successfully complete **two** "Mandatory" plus **three** "Pathway Mandatory" and any **three** "Optional" units.

City & Guilds unit number	Unit title	Compulsory/ optional for full qualification
Unit 200	Engineering Analysis	Mandatory
Unit 212	Data Communication	Pathway Mandatory
Unit 213	Digital System Design	Pathway Mandatory
Unit 214	Telecommunication Systems Engineering	Pathway Mandatory
Unit 215	Modern Control Systems	Optional
Unit 216	RF and Microwave Engineering	Optional
Unit 217	Power Electronics	Optional
Unit 218	Internet Technologies	Optional
Unit 219	Computer System Engineering	Optional
Unit 229	Project 2	Mandatory

The practical assignments are carried out during the learning programme (and are internally marked) and should be finished by the date of the written examinations so that the results can be sent to City & Guilds.

To receive this award the learner must complete practical assignment 229. Please see a separate assessment guidance document for details.

Level 7 Post Graduate Diploma in Information Technology

To achieve the Level 7 Post Graduate Diploma in Information Technology learners must successfully complete **two** "Mandatory" plus **six** "Pathway Mandatory" units.

City & Guilds unit number	Unit title	Compulsory/ optional for full qualification
Unit 200	Engineering Analysis	Mandatory
Unit 211	Fields and Network Theory	Pathway Mandatory
Unit 212	Data Communication	Pathway Mandatory
Unit 214	Telecommunication Systems Engineering	Pathway Mandatory
Unit 216	RF and Microwave Engineering	Pathway Mandatory
Unit 218	Internet Technologies	Pathway Mandatory
Unit 219	Computer System Engineering	Pathway Mandatory
Unit 229	Project 2	Mandatory

The practical assignments are carried out during the learning programme (and are internally marked) and should be finished by the date of the written examinations so that the results can be sent to City & Guilds.

To receive this award the learner must complete practical assignment 229.
Please see a separate assessment guidance document for details.

Level 7 Post Graduate Diploma in Mechanical Engineering

To achieve the Level 7 Post Graduate Diploma in Mechanical Engineering learners must successfully complete **two** "Mandatory" plus **three** "Pathway Mandatory" and any **three** "Optional" units

City & Guilds unit number	Unit title	Compulsory/ optional for full qualification	Barred combinations
Unit 200	Engineering Analysis	Mandatory	
Unit 220	Computational Mechanics Using FEM	Pathway Mandatory	
Unit 221	Heat and Mass Transfer	Pathway Mandatory	
Unit 222	Mechanical Engineering Design	Pathway Mandatory	
Unit 223	Mechatronics	Optional	
Unit 224	Dynamics of Mechanical Systems	Optional	
Unit 225	Advanced Manufacturing Technology	Optional	
Unit 226	Design and Operation of Marine Vehicles	Optional	Cannot be used if Units 227 or 228 were chosen
Unit 227	Automobile Engineering	Optional	Cannot be used if Units 226 or 228 were chosen
Unit 228	Aerospace Engineering	Optional	Cannot be used if Units 226 or 227 were chosen
Unit 229	Project 2	Mandatory	

The practical assignments are carried out during the learning programme (and are internally marked) and should be finished by the date of the written examinations so that the results can be sent to City & Guilds.

To receive this award the learner must complete the following practical assignment 229. Please see a separate assessment guidance document for details.

1.2 Opportunities for progression

On completion of the qualification learners may progress into employment or to the following City & Guilds qualifications:

- Relevant higher level qualifications

1.3 Incorporated Engineer and Chartered Engineer Registration

The City & Guilds Graduate and Postgraduate Diplomas in Engineering have been developed to provide a flexible route to career success as a professional engineer. City & Guilds is working with the UK's leading professional institutions to ensure that the qualifications are aligned with the requirements for Incorporated Engineer (Graduate Diploma) and Chartered Engineer (Postgraduate Diploma) registration from holders of the following City & Guilds qualifications.

The Institution of Engineering and Technology (IET) welcomes applications from holders of the following City & Guilds qualifications:

City & Guilds Graduate Diplomas for Incorporated Engineer (IEng) registration:
- Graduate Diploma in Electrical Engineering
- Graduate Diploma in Electronic and Telecommunication Engineering
- Graduate Diploma in Information Technology.

City & Guilds Postgraduate Diplomas for Chartered Engineer (CEng) registration:
- Postgraduate Diploma in Electrical Engineering
- Postgraduate Diploma in Electronic and Telecommunication Engineering
- Postgraduate Diploma in Information Technology.

IET and City & Guilds are working together to ensure the qualifications are aligned with the registration requirements for Incorporated Engineer (for the Graduate Diploma) and Chartered Engineer (for the Postgraduate Diploma).

The Institution of Mechanical Engineers (IMechE) welcomes applications from holders of the following City & Guilds qualifications:
- City & Guilds Graduate Diploma in Mechanical Engineering for Incorporated Engineer (IEng) registration
- City & Guilds Postgraduate Diploma in Mechanical Engineering for Chartered Engineer (CEng) registration.

IMechE and City & Guilds are working together to ensure the qualifications are aligned with the registration requirements for Incorporated Engineering (for the Graduate Diploma) and Chartered Engineer (for the Postgraduate Diploma), which will be considered individually by the Institution's Academic Assessment Committee.

The Institution of Civil Engineers (ICE) welcomes applications from holders of the following City & Guilds qualifications:
- City & Guilds Graduate Diploma in Civil Engineering for Incorporated Engineer (IEng) registration
- City & Guilds Postgraduate Diploma in Civil Engineering for Chartered Engineer (CEng) registration.

ICE and City & Guilds are working together to ensure the qualifications are aligned with the registration requirements for Incorporated Engineering (for the Graduate Diploma) and Chartered Engineer (for the Postgraduate Diploma), which will be considered individually by the Institution's Academic Qualifications Panel.

The register of Chartered Engineers (CEng) and Incorporated Engineers (IEng) is held by the Engineering Council, the UK regulatory body for the engineering profession. The Engineering Council sets and maintains the internationally recognised standards of professional competence and ethics that govern the award and retention of these titles.

To become professionally qualified, candidates must be a member of a licensed professional engineering institution, who will act as the awarding body for their registration. IET, IMechE and ICE are the three largest licensed professional engineering institutions in the UK, allowed to assess candidates for inclusion on their register of professional engineers.

1.4 Qualification support materials

City & Guilds also provides the following publications and resources specifically for this qualification:

Description	How to access
Qualification handbook	**www.cityandguilds.com**
Assessment guidance documents	**www.cityandguilds.com**
Recording forms	**www.cityandguilds.com**

2 Centre requirements

This section outlines the approval processes for centres to offer this qualification and any resources that centres will need in place to offer the qualification including qualification-specific requirements for centre staff.

Approval

Existing centres who wish to offer this qualification must use the standard Qualification Approval Process.

To offer this qualification, new centres will need to gain both centre and qualification approval. Please refer to the Centre Guide – 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.

2.1 Resource requirements

Physical resources and site agreements

Centres need to ensure they have all the necessary equipment to carry out all parts of the qualification. If there are no facilities for realistic working environment, centres are advised to develop links with local industry to provide opportunities for hands on experience.

Human resources

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

- be technically competent 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 must never internally verify their own assessments.

Project Supervisor requirements

Project Supervisors must hold a qualification one level above that which is being assessed. They may work within the centre or be from a different centre provided that they have the relevant qualifications/experience.

2.2 Learner entry requirements

Acceptance on to the Post Graduate Diploma course is through possession of a relevant City & Guilds Graduate Diploma or holding a BEng (Honours) accredited by a local or UK professional body.

Acceptance of other local qualifications would be subject to City & Guilds checks and approval. Please contact your local City & Guilds branch office for more details.

The current list of qualifications accepted as entry is available on request from your local branch office.

Other legal considerations

Centres must ensure that all legal requirements specific to the engineering industry in their country are adhered to.

3 Course design and delivery

3.1 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, 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.

3.2 Recommended delivery strategies

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualification before designing a course programme.

Centres may design course programmes of study in any way which:

- best meets the needs and capabilities of their learners
- satisfies the requirements of the qualification
- includes extra topics that meet local needs, if appropriate
- combines theory and practical activities, as appropriate

When designing and delivering the course programme, centres might wish to incorporate other teaching and learning that is not assessed as part of the qualification. This might include the following:

- literacy, language and/or numeracy
- personal learning and thinking
- personal and social development

- employability

Where applicable, this could involve enabling the learner to access relevant qualifications covering these skills.

3.3 Certification

Learners who successfully complete the required assessments within the qualification will receive a certificate listing all units achieved.

4 Assessment

4.1 Summary of assessment methods

For this qualification, learners will be required to complete the following assessments:

- **one written** assignment for **each** unit
- **one practical** assignment for **chosen** optional units (please refer to individual units for indication if practical assignments are required)
- a practical project**.**

4.2 Assessment types

Dated entry exam – the written test which will take place on fixed dates scheduled by City & Guilds

Practical assignments/projects – these assessments will be carried out at the approved centre on dates chosen by the centre

Assessments must be carried out according to City & Guilds International Directory of Examinations and Assessments. Please refer to the Directory for the most up-to-date information.

4.3 Grading

The written question papers are graded pass/merit/distinction. The practical assignments and projects are graded pass/fail. The overall units are graded pass/fail, and the overall qualification is also graded pass/fail.

4.4 Recording forms

Recording forms are available on the City & Guilds website.

Although it is expected that new centres will use these forms, centres may devise or customise alternative forms, which must be approved for use by the external verifier, before they are used by learners and assessors at the centre.

Amendable (MS Word) versions of the forms are available on the City & Guilds website.

4.5 Recognition of prior learning (RPL)

Recognition of Prior Learning (RPL) recognises the contribution a person's previous experience could contribute to a qualification.

RPL is allowed and is also sector specific.

This page is intentionally blank

5 Units

Availability of units

The units for this qualification follow.

Structure of units

The units in this qualification are written in a standard format and comprise the following:

- City & Guilds reference number
- title
- level
- introduction
- unit aim
- prerequisites
- learning outcomes titles
- guided learning hours
- information on assessment
- learning outcomes which are comprised of a number of assessment criteria
- notes for guidance.

Summary of units

City & Guilds unit number	Title
Unit 111	Structural Analysis
Unit 138	Quality and Reliability Engineering
Unit 200	Engineering Analysis
Unit 201	Construction Engineering and Management
Unit 202	Environmental Engineering
Unit 203	Computational Mechanics Using Finite Element Method
Unit 204	Geotechnical Engineering
Unit 205	Built Environment 1
Unit 206	Structural Design
Unit 207	Fluid Mechanics and Coastal Engineering
Unit 208	Built Environment 2
Unit 209	Power System Economics and Planning
Unit 210	High Voltage Engineering
Unit 211	Fields and Network Theory
Unit 212	Data Communication
Unit 213	Digital System Design
Unit 214	Telecommunication Systems Engineering

Unit 215	Modern Control Systems
Unit 216	RF and Microwave Engineering
Unit 217	Power Electronics
Unit 218	Internet Technologies
Unit 219	Computer System Engineering
Unit 220	Computational Mechanics Using FEM
Unit 221	Heat and Mass Transfer
Unit 222	Mechanical Engineering Design
Unit 223	Mechatronics
Unit 224	Dynamics of Mechanical Systems
Unit 225	Advanced Manufacturing Technology
Unit 226	Design and Operation of Marine Vehicles
Unit 227	Automobile Engineering
Unit 228	Aerospace Engineering

Unit 111 Structural Analysis

Level: **6**

Introduction

This unit is intended to extend the learner's knowledge by analysing complicated engineering components and to determine stresses, strain and deflections under more varied load conditions.

Unit aim

The aim of this unit is to develop further knowledge on elastic and plastic analysis and design of more complex structures. On the successful completion of this unit the learner should have sufficient knowledge and skills to analyse and design structures in a civil engineering design office.

Learning outcomes

There are **two** learning outcomes to this unit. The learner will:

1. Perform elastic and plastic analysis of structures
2. Explain basics of design, define loads and design steel structures
3. Demonstrate the use of computer software in stress analysis and design of structural members

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour written examination plus satisfactory completion of the prescribed practical and laboratory work. The assessments will be carried out separately.

Learners are expected to possess knowledge of the mathematics required for calculations by holding a relevant City & Guilds Advanced Technician Diploma or relevant HND or other equivalent.

Outcome 1 Perform elastic and plastic analysis of structures

Assessment Criteria

The learner can:

1. Explain **superposition** of **actions** and displacements; explain limits to the principle of superposition; compatibility; linearity of load deflection relationship.
2. Explain and apply **Theorem of three moments** in simple applications.
3. Describe slope deflection equations and perform simple applications.
4. Describe **moment distribution** methods and perform simple applications.
5. Analyse **stress** and **strain** including two dimensional problems in rectangular and polar co-ordinates.
6. Analyse **statical indeterminacy** of structures; perform force methods of structural analysis and use matrix methods.
7. Analyse **kinematic indeterminacy** of structures; use **displacement methods** of structural analysis and **matrix methods**.
8. Analyse frames and beams using procedures applied to **plastic collapse** of simple steel frames and **continuous beams**.
9. Apply **plastic analysis** to reinforced concrete slabs.

Range

Elastic analysis- examination of structures or materials based on their reaction to stresses in stretching or bending elastically.
Plastic analysis – the analysis of structures beyond the elastic limits of behaviour, used to calculate actual failure loads which are generally greater than loads calculated by elastic methods.
Superposition – the total effect of two or more load systems on a structure is the sum of the effects caused by each load system individually.
Actions – loads on a structure
Theorem of three moments – the mathematical relationship between the bending moments at three consecutive supports along a loaded continuous beam
Moment distribution – a method used to establish bending moments in statically indeterminate beams and frames
Stress- a measure of the forces acting on or in a deformable body, measured as the average force per unit area of a surface on or in the body on which the forces act.
Strain – a measure of the deformation of an element under applied stresses.
Statical indeterminacy- static equilibrium equations are insufficient for determining the internal forces and reactions on a structure and additional methods must be adopted
Kinematic indeterminacy – the degree of kinematic indeterminacy is the number of joint displacements which are not known when applying the stiffness method of analysis
Displacement method – see matrix method
Matrix method – (of structural analysis) uses mathematical matrices to solve multiple simultaneous equations based on stiffness of members, forces acting on the structure and displacements at joints. This enables member forces and moments to be calculated. Sometimes referred to as direct stiffness method, or displacement method.
Plastic collapse – occurs when sufficient plastic hinges form within a structure to forma failure mechanism
Continuous beam – A beam having several spans in one straight line; generally having at least three supports

Outcome 2 Explain basics of design, define loads and design steel structures

Assessment Criteria

The learner can:

1. Differentiate between **ultimate and serviceability limit states** in limit state method of design adopted in standards for design of structures.
2. Identify load paths in a structure.
3. Evaluate design loads on the structural elements for the different limit states.

Range

Dead load – permanent load due to self weight of structure and those elements supported by the structure
Imposed load – load which can periodically be applied or removed in the short, medium or long term, eg loads from weight of people seated in an auditorium, or the loads due traffic on a bridge or car park structure.
Wind load – load on a structure due to wind pressures
Characteristic load – load which unlikely to be exceeded during the life of the structure
Ultimate limit state – a structure satisfies this condition when it does not collapse under maximum factored loading conditions
Serviceability limit state –relevant criteria to be satisfied include deflection and vibration criteria and control of crack widths which can affect the comfort of building occupants, appearance and performance of surface finishes.

Outcome 3 Demonstrate the use of computer software in stress analysis and design of structural members

Assessment Criteria

The learner can:

1. Use software packages for stress calculations and design.

Unit 111 Structural Analysis

Notes for guidance

Test specification for written paper

This examination is of three hours duration with a total of seven (07) questions. Learners must answer any five (05) questions.

The examination will cover knowledge specifications:

Topic sections	Approximate % examination weighting
Perform elastic and plastic analysis of structures	70
Explain basics of design, define loads and design steel structures	30

The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

Unit guidance

Wherever possible, theoretical teaching sessions should be combined with tutorial worked example sessions and related assignment work matching real life scenarios.

Wherever possible, learners should be given the opportunity to experience simple stress strain relationships in structural elements by experiment, assessment being made of learner laboratory reports.

It is recommended that reliance is not placed entirely on the use of BS449, and that a limit state approach (BS5950 and/or Eurocode 3) is adopted in the teaching of steelwork design where appropriate.

Unit 138 Quality and Reliability Engineering

Level: **6**

Introduction

Quality is the degree to which performance of goods and services meets expectations, whereas the reliability is the probability that a system or component performs its intended function for a specified interval under stated conditions. This unit is about the design process that leads to reliable systems with built-in quality. It enables measurement of effectiveness and repeatability.

Unit aim

The aim of this unit is to develop knowledge and understanding of artefact quality, reliability, safety, and maintainability by measurement and planning.

Learning outcomes

There are **three** learning outcomes to this unit. The learner will:

1. Understand the importance of quality and reliability
2. Use methods for measuring and improving quality and reliability
3. Develop quality and reliability programme plans
4. Adopt Quality Management Systems into organisations

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **90** should be direct taught hours and the remainder for laboratory practical work and independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Learners are expected to possess knowledge of statistics and probability in mathematics as per the City & Guilds Advance Technician Diploma level 2565 or relevant HND or other equivalent.

Outcome 1 Understand the importance of quality and reliability

Assessment Criteria

The learner can:

1. Define:
    a. quality control and assurance
    b. specifications of quality
    c. engineering reliability
2. Explain the principles of Total Quality Control (TQC):
    a. measurement techniques for
        i quality control
        ii improvement
    b. quality Function Deployment
    c. quality Circles and improvement groups
    d. economics of quality
    e. Zero Defects concepts and mistakes proofing
    f. product liability
3. Define reliability, maintainability and availability.
4. Determine reliability specifications.
5. Explain the effects on safety of engineering quality and reliability by:
    a. accident avoidance using
        i design aspects
        ii human factors
    b. risk analysis
    c. event tree analysis
    d. fault tree analysis
    e. redundancy
    f. common mode and common cause failures
    g. reliability block diagrams and risk matrices
    h. quality, environmental, health and safety integration (QUENSH)

Outcome 2 Use methods for measuring and improving quality and reliability

Assessment Criteria

The learner can:

1. State the general principles of metrology.
2. Measure and test:
    a. length
    b. angle
    c. form
    d. surface finish
    e. roundness
    f. gauging
3. Use co-ordinate measuring machines.
4. Undertake on-line inspection and testing using:

a. non-destructive techniques
b. vision systems
c. electrical, mechanical and radiological methods

5. Inspect and evaluate the quality of raw materials:
   a. for purchasing purposes
   b. use supplier evaluation and rating methods
6. Use statistical methods for quality and reliability:
   a. acceptance sampling
   b. control charts
   c. tests of significance and confidence limits
   d. sampling schemes
   e. Seven Quality Tools
   f. and determine control system choice

Outcome 3 Develop quality and reliability programme plans

Assessment Criteria

The learner can:

1. Assess designs for reliability and safety:
   a. institute reliability and safety development programmes
   b. implement testing and evaluate failure modes by
      i statistical analysis
      ii physical characteristics
      iii test design
2. Assess testing and evaluate failure modes using:
   a. Weibull hazard and probability plotting
   b. Lognormal probability plotting
   c. Duane analysis
   d. accelerated testing
3. Investigate the economics of reliability process improvement and the consequences of catastrophic failure.
4. Develop checklists for plant design and installation.
5. Explain Failure Mode, Effect and Criticality Analysis (FMECA) for:
   a. design
   b. process
   c. system
6. Explain availability, maintainability and life cycles when referring to reliability and safety.
7. Understand the application of designed experimentation:
   a. sources of extent of variability
   b. process optimisation
      i improvement by monitoring
      ii improvement by rectification
8. Apply the following to the above:
   a. Exploratory Data Analysis
   b. design of experiments
   c. Analysis of Variance (ANOVA)
   d. Taguchi methods
9. Apply data, collection systems, information feedback and control:
   a. fault detection and trend control

b. automated testing systems
    i design
    ii application
c. expert systems for fault diagnosis in process plant
d. condition monitoring techniques

Outcome 4 Adopt Quality Management Systems into organisations

1. Need for quality management and Quality Management Principles
2. ISO 9000 Family for Quality Management standards
3. Selection of relevant ISO Standard
4. Implementing and Maintaining Quality Management Systems based on ISO 9000
5. Maintaining the benefits and Continual Improvements

Unit 138 Quality and Reliability Engineering

Notes for guidance

Test specification for written paper

This examination paper is of three hours duration with nine (09) questions. Learners must answer any five (05) questions.

The examination will cover knowledge specifications:

Topics	Approximate % examination weighting.
Importance of quality and reliability	30
Methods for measuring and improving quality and reliability	30
Quality and reliability programme plans	40

The requirement to achieve overall success for this unit is:

Written examination Pass/Merit/Distinction

Note “Practical work” is not required for this unit.

Unit guidance

Use Case Studies for delivery.

Unit 200 Engineering Analysis

Level: **7**

Introduction

This unit is about the advanced techniques needed to analyse systems in various engineering disciplines. The unit provides the advanced knowledge required to solve partial differential equations, optimise engineering systems, apply random processes and spectral analysis, and undertake statistical analysis of engineering systems and processes.

Unit aim

The aim of the unit is to enable the learner to apply analytical techniques to engineering systems design and problem solving.

Prerequisites

It is recommended that learners will have competence in mathematics at a level exemplified by the Graduate Diploma unit 9210-01-100 or equivalent

Learning outcomes

There are **four** learning outcomes to this unit. The learner will:

1. Solve engineering problems by applying partial differential equations
2. Apply optimisation techniques to engineering problem solving
3. Use random processes and apply spectral analysis to data filtering and system identification problems
4. Use statistical analysis to solve engineering problems

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. This unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Solve engineering problems by applying partial differential equations

Assessment Criteria

The learner can:

1. Apply partial differential equations in civil, electrical and mechanical engineering systems
2. Classify partial differential equations as parabolic, hyperbolic or elliptical
3. Identify Cartesian, cylindrical and spherical co-ordinate forms
4. Apply analytic solution methods using trial functions, separation of variables (including Bessel and Legendre functions as appropriate), Laplace and Fourier transforms
5. Use finite-difference methods to solve partial differential equations:
   a. approximation of derivatives,
   b. explicit and Crank-Nicholson implicit methods,
   c. numerical stability
6. Apply methods for solving linear equations resulting from finite-difference methods:
   a. direct solution, including Cramer's rule and Gaussian elimination,
   b. iterative methods, including relaxation and Gauss-Seidel methods
7. Solve problems using the method of lines
8. Use the method of characteristics for hyperbolic equations
9. Use the finite-element method at an introductory level

Outcome 2 Apply optimisation techniques to engineering problem solving

Assessment Criteria

The learner can:

1. Describe the characteristics of functions used in optimisation including combinatorial, unimodal and multi-modal functions, single-variable and multi-variable functions, functions with constraints, local and global extremes of functions
2. Formulate and solve constrained optimisation problems by the simplex method of linear programming
3. Use Fibonacci, golden section and Brent's single-variable search methods to solve optimisation problems
4. Apply multi-variable methods to optimisation problems using gradient methods:
   a. steepest descent,
   b. conjugate gradient,
   c. Newton's variable metric techniques
5. Apply the penalty-function method, complex method of Box and the Kuhn-Tucker conditions to functions with inequality constraints
6. Solve optimisation problems by heuristic search methods, random-number generation and objective functions
7. Apply the simulated-annealing method to combinatorial and continuous variable problems
8. Apply genetic algorithms, coding, reproduction and cross-over mutation to solve optimisation problems

Outcome 3 Use random processes and apply spectral analysis to data filtering and system identification problems

Assessment Criteria

The learner can:

1. Describe the role of random processes in the testing and analysis of engineering systems
2. Recognise the engineering applications of random processes in random vibrations, electrical circuits and communications
3. Derive the principal functions used to characterise random processes and the dynamic response of engineering systems
4. Recognise the characteristics of random processes including stationary and non-stationary processes, ergodic processes, probability distributions for single and multiple random variables, auto- and cross-correlation functions, spectral and cross-spectral density
5. Determine the response of engineering systems to stochastic inputs
6. Recognise white noise, wide-band, narrow-band, Gaussian and pseudo-random binary signal (PRBS) noise sources
7. Describe the dynamic characteristics of linear systems using impulse-response functions, convolution integral and frequency response-functions
8. Explain the operation of fast Fourier transform algorithms
9. Describe random input-output relationships for linear systems, power spectra and cross spectra for single-input and two-input systems, coherence functions
10. Describe and compare analogue and digital methods of spectral-density measurement
11. Undertake digital spectral analysis in signal sampling, aliasing, data windows, spectral leakage, frequency smoothing and fast Fourier transform
12. Use fast Fourier transform for power spectra estimates
13. Apply the techniques to data filtering and system identification problems

Outcome 4 Use statistical analysis to solve engineering problems

Assessment Criteria

The learner can:

1. Describe and apply the principles of advanced experimental design to engineering problems.
2. Interpret statistical output results from standard statistical packages and interpret them correctly.
3. Analyse engineering statistics data from an advanced statistical process control and process capability standpoint.
4. Apply appropriate statistical models to reliability data.
5. Analyse reliability problems with appropriate methods, such as fault trees and block diagrams, and provide corrective action solutions based on statistical analysis.

Unit 200 Engineering Analysis

Notes for guidance

Test specification for written paper

This examination is of three hours duration with a total of nine (09) questions. Learners must answer any five (05) questions.

The examination will cover the knowledge specification.

Topics	**Approximate % examination weighting.**
Partial Differential Equations	25
Optimisation Techniques	25
Random Processors and Spectral Analysis	25
Statistical Analysis	25

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit 201 Construction Engineering and Management

Level: **7**

Introduction

This unit is about civil engineering investigation, different construction methods, different construction equipment, and different management techniques for efficient management of construction projects.

Unit aim

The aim of this unit is to equip the learner with the ability to deal with construction and management techniques for the construction of civil engineering works.

Prerequisites

It is recommended that learners have achieved unit 9210-01-101 'Management for Engineers'.

Learning outcomes

There are **six** learning outcomes to this unit. The learner will:

1. Undertake investigation work, mobilise construction sites and manage construction materials
2. Select the most appropriate construction methods for given works
3. Allocate the appropriate machinery and equipment for work items and prepare maintenance programmes
4. Explain techniques related to preparation, transport, placing and compaction of concrete mixes and perform testing of concrete
5. Use appropriate construction planning and monitoring techniques for managing construction sites
6. Ensure quality in construction and use 'safety' in construction activities

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for practical work, projects and independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour written examination paper.

Outcome 1 Undertake investigation work, mobilise construction sites and manage construction materials

Assessment Criteria

The learner can:

1. Carry out site investigation techniques required for determining foundation conditions.
2. Mobilise a construction site and provide facilities according to requirements.
3. Prepare a site for construction activities, manage materials and stores, maintain records and returns

Outcome 2 Select the most appropriate construction methods for given works

Assessment Criteria

The learner can:

1. Gather information from 'specifications' to select relevant construction methods for specific items of work.
2. Select most appropriate methods and techniques for earth excavation, dewatering, shoring, sheet piling, ground water control, dredging, earth compacting, road construction.
3. Select most appropriate methods for rock excavation by blasting, understand drilling patterns, use of explosives.
4. Select piles according to classifications, and install by pile driving, in-situ construction.
5. Select methods for demolition and recycling of works.
6. Select methods for construction of earth dams and coffer dams, temporary works.

Outcome 3 Allocate the appropriate machinery and equipment for work items and prepare maintenance programmes

Assessment Criteria

The learner can:

1. Select soil excavation and earthmoving equipment as per work item.
2. Select earth compaction equipment as per work item.
3. Select hauling and hoisting equipment as per work item.
4. Select pumping equipment as per work item.
5. Select drilling and blasting equipment, vibrators and breakers.
6. Select power sources for construction operations.
7. Prepare maintenance programmes and carry out maintenance work.

Outcome 4 Explain techniques related to preparation, transport, placing and compaction of concrete mixes and perform testing of concrete

Assessment Criteria

The learner can:

1. Explain Mix Design including aggregate batching.
2. Explain concrete properties, perform tests on concrete, and compare with standards.
3. Perform Mix designs according to BS 5328.
4. Perform batching and mixing, transport, pumping and placing, compaction, curing and finishing.
5. Explain properties of hardened concrete, water resistance, water proofing of concrete structures.
6. Prepare pre-cast/ pre-stressed concrete production methods.
7. Prepare formwork and scaffolding: typical, basics of slipform, vibratory etc. .

Outcome 5 Use appropriate construction planning and monitoring techniques for managing construction sites

Assessment Criteria

The learner can:

1. Explain 'Project Management' for civil engineering projects meeting cost, quality and time requirements.
2. Identify activities for building and civil engineering projects.
3. Select appropriate planning techniques; bar charts, detail work programmes, CPM network schedules, line of balance schedules.
4. Schedule resources and perform smoothening of resources.
5. Maintain progress control and perform cost monitoring

Outcome 6 Ensure quality in construction and use 'safety' in construction activities

Assessment Criteria The learner can:

1. Demonstrate an understanding of the principles of management, the work of pioneers and founders of management. Their evolution and application in modern day practice
2. Understand the role of professions/disciplines in project teams and the management principles appropriate to organisations within the industry
3. Demonstrate an understand the application of management techniques to organisations, work planning control of human resources
4. Demonstrate a knowledge and understanding of the industries markets and activities
5. Ensure quality during construction and perform tests for quality.
6. Supervise work to ensure quality control and quality assurance.
7. Ensure safety during construction and adhere to Labour Regulations.

Unit 201 Construction Engineering and Management

Notes for guidance

Test Specification for written paper

This examination is of three hours duration with a total of nine (09) questions. Learners must answer any five (05) questions.

The examination will cover the knowledge specifications:

Topic	Approximate % examination weighting
Mobilisation and site management	10
Construction methods and equipment	30
Concrete in construction	20
Construction planning and monitoring techniques	30
Safety in construction	10

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

For today's competent construction professional manager there is a greater need to understand the environment in which his industry is operating, its restraints and opportunities. A strong theoretical understanding of how to read this environment will greatly assist.

Use of a live project that the learner can associate helps to give context to the study

Incorporating group working in assignments helps to identify management as essentially team working

Unit 202 Environmental Engineering

Level: **7**

Introduction

This unit introduces the environment, the range of problems faced by the environment, basic environmental regulations and risk assessment. It is expected that this knowledge will help to make a candidate confident to make decisions addressing the issues of environment.

Unit aim

The unit aims to develop an understanding of the environment, the range of problems faced by the environment and the various methods of handing those problems. Also it aims to buildup the appreciation for the importance of the management of the environment with a good knowledge in primary regulations and computation of possible risks.

Prerequisites

It is recommended that learners have achieved the Graduate Diploma unit 103 “Hydraulics and Hydrology”.

Learning outcomes

There are **three** learning outcomes to this unit. The learner will:

1. Appreciate and understand the range of activities within the field of environmental engineering and know their multidisciplinary nature
2. Understand the approaches for assessment and treatment for quality of water, air and solid waste
3. Know the role of regulations and risk assessment in environmental engineering and know the primary environmental regulations

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** hours would be direct taught hours, **30** hours laboratory practical work and the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Appreciate and understand the range of activities within the field of environmental engineering and know their multidisciplinary nature

Assessment Criteria

The learner can:

1. Describe the environment
   a. structure and function of ecosystems
   b. cycles of water, energy and material balances
2. Explain basic chemical, biological, and physical concepts used in the environmental problems
   a. organic chemistry: aliphatic, aromatic and heterocyclic compounds; carbohydrates, amino acids, proteins and lipids
   b. microbiology: structure, classification, metabolism, function and environmental significance of micro-organisms; role of micro-organisms in environmental engineering
   c. physical, chemical and biological indicators of environmental and ecosystem status
3. Identify the types of pollution and their impacts
   a. types of waste produced by human activities: domestic, urban, industrial and agricultural waste
   b. organic pollution, dissolved oxygen, nutrients, eutrophication
   c. ground water / soil contamination
   d. global warming.

Outcome 2 Understand the approaches for assessment and treatment for quality of water, air and solid waste

Assessment Criteria

The learner can:

1. Explain the approaches for the assessment and protection of water quality in rivers, lakes and groundwater.
2. Explain the basic engineering approaches to drinking water treatment.
   a. drinking water standards
   b. control of water-borne diseases
   c. components of standard water treatment plant
   d. rural and small scale treatment systems including rainwater harvesting
   e. advanced water treatment: activated carbon filters, ion exchange, micro-filtration, reverse osmosis
3. Explain the basic engineering approaches to wastewater treatment.
   a. characteristics of domestic, urban and industrial wastewater
   b. conventional and simplified sewage systems
   c. principles of operation and design guidelines of anaerobic, aerobic treatment methods, tertiary treatment
   d. disposal of sludge, disposal and re-use of treated wastewater
   e. industrial wastewater treatment
4. Identify the primary air pollutants, their sources and environmental behaviour.
   a. sources of air pollution

b. air quality measurements
c. impacts and control of air pollution
d. layers of atmosphere, ambient vs. stratospheric ozone, greenhouse effect, greenhouse gases, ozone depletion, global warming

5. Identify the processes of handling and disposal of solid, hazardous and industrial wastes
   a. characteristic of solid waste from different sources
   b. collection of solid waste
   c. waste reduction: re-use, recycling
   d. disposal of solid waste: composting, digestion, landfills, incineration

Outcome 3 Know the role of regulations and risk assessment in environmental engineering and know the primary environmental regulations

Assessment Criteria

The learner can:

1. Explain the environmental objectives and standards
   a. standards of ambient air and water quality
   b. emission standards for liquid and gaseous pollutants
2. Describe the different aspects of environmental management
   a. methods of environmental management – legal/regulatory, policy, economic incentives, market manipulations
   b. community awareness and participation
   c. environment laws and regulations
   d. environmental impact assessments
3. Explain the risk of natural disasters
   a. statistical analysis of extreme rainfall and river flows
   b. rainfall intensity-duration –frequency and depth-area-duration analysis
   c. flood flows

Unit 202 Environmental Engineering

Notes for guidance

Test specification for written paper

This is a written examination paper of three hours duration giving a total of eight (08) questions. The learners must answer five (05) questions.

The examination paper covers the knowledge specification:

Topic	Approximate % examination weighting
Basics of environmental engineering	20
Assessment and treatment processes	40
Environmental regulations and risk	40

The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction

Unit 203 Computational Mechanics Using Finite Element Method

Level: **7**

Introduction

This unit is about the fundamental principles of the Finite Element Method as applied to civil engineering

Unit aim

The aim of this unit is for the learner to develop a sound foundation in Finite Element Analysis

Prerequisites

It is recommended that learners hold a pass in the 9210 Civil Engineering Graduate Diploma to ensure knowledge of mathematics including numerical methods for the solution of systems of equations. Knowledge of Mechanics of Materials and Engineering Analysis is preferable.

Learning outcomes

There are **four** learning outcomes to this unit. The learner will:

1. Apply and solve constitutive equations used in Finite Element Analysis
2. Apply strain-displacement formulations used in Finite Element Analysis
3. Define material behaviour within Finite Element Analysis
4. Use computer software for analysis

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for practical work and independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour written examination paper.

Outcome 1 Apply and solve constitutive equations used in Finite Element Analysis

Assessment Criteria

The learner can:

1. Use linear finite difference methods.
2. Generate strain displacement relationships, shape functions and element stiffness matrices.
3. Demonstrate the application of local-global coordinate transformations.
4. Demonstrate application of boundary conditions, constraints and loads.
5. Define equivalent nodal forces for body forces, concentrated loads, and distributed loads.
6. Employ finite element analysis
    a. discretisation
    b. types of elements
    c. relationship between nodal forces, nodal displacements, and stiffness matrix.
7. Obtain stiffness matrix using one-dimensional quadratic elements, displacement functions, shape functions, principle of virtual work.
8. Form global stiffness matrix and load vectors.
9. Determine stresses from primary unknown nodal displacements

Outcome 2 Apply strain-displacement formulations used in Finite Element Analysis

Assessment Criteria

The learner can:

1. Formulate strain-displacement for 1st order elements; constant strain triangle, bilinear quadrilateral.
2. Formulate strain-displacement for 2nd order elements; linear strain triangle, quadratic quadrilateral.
3. Theory and analysis of thin plates and membrane theory of thin shells.
4. Use Jacobian n-point Gausse quadrature numerical integration to form element stiffness matrices and equivalent nodal forces.
5. Solve linear and non-linear systems using Gaussian elimination, Gausse-Siedel iteration and Relaxation techniques.
6. Determine convergence and completeness requirements

Outcome 3 Define material behaviour within Finite Element Analysis

Assessment Criteria

The learner can:

1. Recognise degrees of material behaviour.
2. Define material behaviour using Young's moduli, shear moduli, Poisson's ratio and thermal expansion coefficients.
3. Define various types of non linear materials used in construction

Outcome 4 Use computer software for analysis

Assessment Criteria

The learner can:

1. Analyse a frame structure using a computer package and compare results obtained manually using Force method/Displacement method

Unit 203 Computational Mechanics Using Finite Element Method

Notes for guidance

Test Specification for written paper

This examination is of **three** hours duration giving a total of **seven** (07) questions. Learners must answer any **five** (05) questions.

The examination will cover the knowledge specifications:

Topic	Approximate % examination weighting
Applying and solving constitutive equations used in Finite Element Analysis	40
Strain displacement formulations and solution algorithms	40
Material behaviour within finite element analysis	20

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

Whilst the theoretical studies are important, and mathematical support may be required in the form of tutorial sessions, some freelance time should be allowed for learners to make use of appropriate software.

Unit 204 Geotechnical Engineering

Level: **7**

Introduction
This unit deals with the geotechnical conditions which affect the design of load bearing foundations and earth retaining structures. It also includes geotechnical engineering involved in the conservation, preservation and protection of existing structures.

Unit aim
The unit aims to develop understanding of the behaviour of soils and rocks and the interaction between the ground and any structures founded on it.

Prerequisites
It is recommended that learners have achieved the Graduate Diploma Unit 105 Soil "Mechanics and Engineering Geology".

Learning outcomes
There are **three** learning outcomes to this unit. The learner will:
1. Analyse soils and rocks
2. Investigate stress states in natural and manmade situations
3. Determine appropriate foundations and earth retaining structures

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** hours would be direct taught hours, **30** hours laboratory practical work and the remainder for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Analyse soils and rocks

Assessment Criteria

The learner can:

1. Conduct stress analysis within a soil mass and determine pressure distribution due to foundation loads.
2. Assess the effect of settlement on stress distribution.
3. Analyse the settlement of granular soils.
4. Investigate the settlement of clays: immediate, consolidation, secondary settlement.
5. Investigate the rate of settlement of clays.
6. Investigate the effects of vertical drains on settlement.
7. Describe the engineering behaviour of principle rock types.
8. Undertake testing methods appropriate to rock types.
9. Analyse rock masses: description, classification, behaviour.
10. Undertake rock masses mapping.
11. Implement discontinuity analysis: translational failures, toppling failures, rotational failures.
12. Analyse rock anchoring designs.
13. Describe the principle methods of excavations in rock.
14. Analyse rock supporting systems during excavations.

Outcome 2 Investigate stress states in natural and manmade situations

Assessment Criteria

The learner can:

1. Analyse lateral earth pressures and stress status in natural and manmade situations: banks, retaining walls and piling.
2. Analyse the effects of pore water pressures and uniform surcharges.
3. Design soil retaining walls.
4. Assess the effectiveness of cantilever and anchored sheet pile walls.
5. Assess the effectiveness of ground anchors.
6. Use graphical and mathematical techniques to solve problems involving water flow in soils.
7. Investigate soil compressibility: fundamentals consolidation, normal and over consolidated soils, pre-consolidation pressure, primary and secondary consolidation.
8. Solve consolidation settlement problems using calculations.
9. Investigate soil slopes: principle concept, methods of analysis, and effects of water.

Outcome 3 Determine appropriate foundations and earth retaining structures

Assessment Criteria

The learner can:

1. Determine the bearing capacity of foundations: shallow and deep.
2. Determine foundation types: pads, rafts, buoyant, basements, piled and strip.
3. Determine ultimate and allowable bearing capacities of types of foundations.

4. Analyse the problems associated with foundation deformation and its effect on building.
5. Undertake foundation geotechnical analysis.
6. Determine necessary ground treatments: drainage and dewatering, exclusion techniques, soil stabilisation/modification, cement and lime stabilisation, reinforcement, geotextiles.
7. Determine field application and equipment for ground treatments.
8. Assess the need for grout and grouting of rocks and soils.
9. Explain the environmental aspects of geotechnical processes.

Unit 204 Geotechnical Engineering

Notes for guidance

Test specification for written paper

This examination is of **three** hours duration with a total of **seven** (07) questions. Learners must answer any **five** (05) questions.

The examination will cover knowledge specifications:

Topic	Approximate % examination weighting
Soils and rocks	30
Stress states	30
Foundations and earth retaining structures	40

The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction

Unit guidance

Throughout the module the learner should be able to learn through a combination of taught and tutorial sessions as well as design sessions focussed around case studies or if possible actual projects. They should be familiar with working with uncertain ground conditions and develop their skill in becoming proficient in the selection of appropriate design parameters from site investigation reports and similar. They should be aware of the need to select foundation types not just to suit their engineering performance but also consider issues such as cost, location, sustainability and environmental sensitivities.

Unit 205 Built Environment 1

Level: **7**

Introduction
This unit is about the engineering principles applied to the design and specification of the internal environment experienced by occupants of habitable space.

Unit aim
The unit aims to develop understanding of the thermal, visual, aural and air quality needs of occupied spaces and hence specify optimum conditions for occupied space.

Prerequisites
It is recommended that learners hold a pass of the compulsory subjects at the Graduate Diploma level

Learning outcomes
There are **three** learning outcomes to this unit. The learner will:
1. Specify optimum thermal conditions for occupied space
2. Specify optimum lighting conditions for occupied space
3. Specify optimum sound conditions for occupied space

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours and the remainder for design work and independent study. The unit may be carried out on a full time or part time basis

Assessment
This unit will be assessed by means of one three hour written examination.

Outcome 1 Specify optimum thermal conditions for occupied space

Assessment Criteria

The learner can:

1. Assess heat transmission through building shells.
2. Assess methods of reducing heat gains and cooling loads.
3. Assess the effect of ventilation in occupied spaces.
4. Assess heating systems in occupied spaces
5. Assess the transmission of vapour through building shells.

Outcome 2 Specify optimum lighting conditions for occupied space

Assessment Criteria

The learner can:

1. Assess the flow of natural light through fenestration and its distribution by reflection.
2. Assess the properties of glazing materials.
3. Assess the effects of blinds and curtains.
4. Assess the psychological and physiological impact of daylight in interiors.
5. Control glare from windows and roof lights.
6. Assess daylight performance.
7. Describe visual perception functions.
8. Apply Gestalt laws of perception of patterns and shapes.
9. Assess the nature of light.
10. Determine the relationship between V and P and light output.
11. Assess the effect on visual performance of illuminance.
12. Determine the nature and components of glare.
13. Use statistical data on availability of daylight.
14. Apply lighting units and laws of illumination.
15. Assess the production of visible, thermal and discharge radiation associated with light sources.
16. Select artificial lighting sources which are appropriate to the conditions.
17. Assess the energy consumption of lighting in buildings
18. Determine the positioning of lighting in domestic and industrial buildings.
19. Measure artificial light values.

Outcome 3 Specify optimum sound conditions for occupied space

Assessment Criteria

The learner can:

1. Assess the transmission of sound through building shells of various construction designs and materials.
2. Assess the attenuation of sound through walls, floors and ceilings.

3. Assess the acoustic properties of enclosed space.
4. Use design criteria for the internal aural environment.
5. Determine the sound absorption properties of building materials.
6. Assess noise and vibration attenuation generated externally and within.
7. Investigate methods of improving the acoustics in enclosed spaces.
8. Assess the physical damage of noise on occupants of buildings
9. Check noise levels.

Unit 205 Built Environment 1

Notes for guidance

Test Specification for written paper

This examination is of **three** hours duration with a total of **seven** (07) questions. The learners must answer any **five** (05) questions.

The examination will cover the knowledge specifications:

Topic	Approximate % examination weighting
Optimum thermal conditions for occupied space	30
Optimum lighting conditions for occupied space	40
Optimum sound conditions for occupied space	30

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit 206 Structural Design

Level: **7**

Introduction

This unit is about methods of structural design of masonry, timber, steel, reinforced concrete structures and pre-stressed concrete elements to current standards. The unit covers the methods to determine loads and forces on structural elements and the structural action of common building materials.

Unit aim

The aim of this unit is for the learner to develop the ability to investigate the behaviour of steelwork, reinforced concrete, timber and masonry in buildings. It is intended that the learner should understand the concepts in structural design, material options, construction methods, idealisation and analysis of structures, use of computers for design, loading on structures; gravity, wind, etc.

Prerequisites

It is recommended that learners have achieved the Graduate Diploma unit 111 "Structural Analysis"

Learning outcomes

There are **four** learning outcomes to this unit. The learner will:

1. Design steelwork elements, their support and connections in buildings
2. Design and detail reinforced concrete elements in buildings
3. Design and detail structural masonry and timber elements in buildings
4. Use the British Codes of Practice for loading and design

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours and the remainder for design work and independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour written examination.

Outcome 1 Design steelwork elements, their support and connections in buildings

Assessment Criteria

The learner can:

1. Determine the capacity of steel structural tension members, compression members and beams
2. Design structural elements in frames and trusses
3. Design plate girders
4. Design bolted and welded connections in steel structures

Outcome 2 Design and detail reinforced concrete elements in buildings and bridges

Assessment Criteria

The learner can:

1. Design and detail reinforced concrete elements:
   - **simply supported** and **continuous beams** of different sections that are **singly or doubly reinforced**
   - 'short' columns subjected to axial and moment loading;
   - one way and two way spanning slabs
2. Design and detail staircases
3. Design and detail foundations.

Range

detailing – in this context , the detailing of steel reinforcing bars to be included in the reinforced concrete elements. This includes preparing information to schedule lengths, spacings, diameters, shapes and locations of reinforcing bars.

simply supported beams – beams which have no continuity with, and are independent of, their simple vertical supports.

continuous beam – a beam having several spans in one straight line; generally having at least three supports

singly reinforced – the concrete element requires reinforcing bars to act in tension , in the section of the element under tension due to bending.

doubly reinforced – the concrete element requires reinforcing bars to act in tension, in the section of the element under tension due to bending, and also requires reinforcing bars to act in compression in the section of the element under compression due to bending.

Outcome 3 Design and detail structural masonry and timber elements in buildings

Assessment Criteria

The learner can:

1. Analyse load transfer and evaluate stresses in walls for the design of masonry walls.
2. Determine design loads for load-bearing brickwork and blockwork for vertical loading.
3. Design masonry panels for **lateral loading**
4. Design solid timber beam and column sections.
5. Design timber trusses
6. **Design built-up members**, **glued-laminated** members

Range

lateral loading – wind loading or soil pressure on masonry wall panels (and other structural elements)
retaining wall – a wall which resists the lateral pressure of soil from higher ground, where a change in ground level is required.
built-up members – timber structural elements such as beams or columns which are built up from plywood and/or solid timber sections by gluing, screwing and/or bolting to make larger, stronger composite sections.
glue laminated– large timber sections which are built up by gluing many smaller pieces of timber together to form long span beams, columns and frames.

Outcome 4 Use the British Codes of practice for loading and design

Assessment Criteria

The learner can:

1. Use codes of practice to aid design.
2. Extract relevant information from codes of practice.
3. Check designs and design calculations against codes of practice.

Unit 206 Structural Design

Notes for guidance

Test Specification for written paper

This examination is of **three** hours duration and is structured in **three** parts (A, B and C) giving total of **seven** (07) questions.

Learners must answer **four** (04) questions in total by selecting at least **one** question from each section.

The examination will cover the knowledge specifications:

Topic	Approximate % examination weighting
Reinforced concrete elements	35
Steelwork elements	35
Structural masonry and timber elements	30

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

Wherever possible, theoretical teaching sessions should be combined with tutorial worked example sessions and related assignment work relating to real life scenarios

Wherever possible, learners should be given the opportunity to experience load testing and deflection measurement of structural elements by experiment.

Unit 207 Fluid Mechanics and Coastal Engineering

Level: **7**

Introduction

This unit encompasses the principles of fluid mechanics and theories on ocean waves, coastal sediment transportation and design aspects required for applications of coastal engineering.

Unit aim

The unit aims to develop understanding in the advanced principles of fluid mechanics and theories and principles necessary for coastal engineering constructions and management.

Prerequisites

It is recommended that learners have achieved Graduate Diploma unit 103 “Hydraulics and Hydrology”.

Learning outcomes

There are **three** learning outcomes to this unit. The learner will:

1. Use advanced theories and principles involved in motion of fluid
2. Identify the different aspects of formation and propagation of ocean waves and the associated physical processes
3. Design and manage coastal engineering applications

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** hours would be direct taught hours, **30** hours laboratory practical work and the remainder for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination.

Outcome 1 Use advanced theories and principles involved in motion of fluid

Assessment Criteria

The learner can:

1. Assess fluid stream functions and velocity potential functions for a
    a. uniform stream
    b. source
    c. sink
    d. doublet and point vortex
    e. combination of above
2. Assess factors affecting
    a. boundary layer transmission
    b. boundary layer separation and wake formation
3. Investigate the drag force on single particles in fluid
4. Calculate fluid
    a. drag coefficient
    b. Reynolds number
    c. terminal velocity
5. Assess lamina flow between plates.

Outcome 2 Identify the different aspects of formation and propagation of ocean waves and the associated physical processes

Assessment Criteria

The learner can:

1. Recognise the coastal engineering terminology
2. Identify different types of coastal engineering problems and solutions
3. Derive small amplitude wave theory
4. Describe wave shoaling, refraction, diffraction and reflection
5. Describe wave breaking, long shore current
6. Explain wave measurement and wave spectra
7. Determine design wave condition
8. Explain tides
9. Describe different aspects of coastal sediment transport
    a. near-bottom boundary layer
    b. bed forms
    c. sediment transform by breaking and non-breaking waves
    d. beach profile change, closure of estuaries
    e. coastal erosion and accretion, control of erosion.

Outcome 3 Design and manage coastal engineering applications

Assessment Criteria

The learner can:

1. Estimate design parameters of revetments, groynes, breakwaters, harbours and anchorages
2. Investigate the criteria, parameters and scales for physical models of
   a. coasts
   b. harbours
3. Discuss coastal management strategies

Unit 207 Fluid Mechanics and Coastal Engineering

Notes for guidance

Test specification for written paper

This written examination is of **three** hours duration with a total of **seven** (07) questions in two sections, A and B. The learners must answer **five** (05) questions selecting at least **one** (1) question from section A and **two** (2) questions from Section B.

The examination paper covers the knowledge specification:

	Topic	**Approximate % examination weighting**
Section A	Fluid Mechanics	40
Section B	Wave motion and physical processes	40
	Coastal engineering applications	20

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit 208 Built Environment 2

Level: **7**

Introduction

This unit is a continuation of Unit 205 and it expands on the engineering principles applied to the design and specification of the internal environment experienced by occupants of habitable space.

Unit aim

The unit aims to develop understanding by the learner of solar effects, weather and climate on the performance of environmental installations.

Prerequisites

It is recommended that learners hold a pass of the compulsory subjects at Graduate Diploma level plus Unit 205 of the Post Graduate Diploma.

Learning outcomes

There are **three** learning outcomes to this unit. The learner will:

1. Assess the impact of external environmental conditions on occupied spaces
2. Assess the fire hazards exhibited in buildings and develop fire plans and fire detection systems
3. Relate functional requirements of buildings to the environment

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours and the remainder is for design work and independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour written examination paper.

Outcome 1 Assess the impact of external environmental conditions on occupied spaces

Assessment Criteria

The learner can:

1. Determine the composition of solar radiation.
2. Determine the heat generated by sunlight and daylight.
3. Use statistics to estimate the availability of daylight.
4. Use climatology statistics for estimating annual and diurnal temperature variations and mean temperatures.
5. Assess national and local climate conditions.
6. Interpret meteorological information in the derivation of external building design data.
7. Assess atmospheric pollution and pollution sources.

Outcome 2 Assess the fire hazards exhibited in buildings and develop fire plans and fire detection systems

Assessment Criteria

The learner can:

1. Check the fire resistant properties of building materials using technical specifications or applying standard tests.
2. Assess fire and smoke detection systems and alarm systems.
3. Assess the dangers of ignition and explosion of gases and dusts.
4. Determine explosive limits.
5. Assess the fire ignition risks of open flame, static electricity, electric arcs and spontaneous combustion.
6. Assess and select appropriate fire protection systems and the positioning of individual components.

Outcome 3 Relate functional requirements of buildings to the environment

Assessment Criteria

The learner can:

1. Develop building designs to Clients' briefs or user requirements.
2. Determine the functions of buildings and building performance for domestic, social, commercial and industrial buildings.

Unit 208 Built Environment 2

Notes for guidance

Test Specification for written paper

This examination is of **three** hours duration with a total of **seven** (07) questions. The learners must answer any **five** (05) questions.

The examination will cover knowledge specifications:

Topic	Approximate % examination weighting
Impact of external environmental conditions on occupied spaces	40
Fire hazards and fire detection systems	40
Functional requirement of buildings	20

The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction

Unit 209 Power System Economics and Planning

Level: **7**

Introduction

This unit is about methods and models used for planning, operation and economical analysis of power systems. The course mixes computational techniques and reliability analysis.

Unit aim

The aim of the unit is to provide basic concepts as well as analysis and optimisation techniques underlying reliability assessment of electric power systems and planning techniques**.**

Prerequisites:

It is recommended that learners have achieved the Graduate Diploma Electrical Engineering option or equivalent in order to register for this unit.

Learning outcomes

There are **three** learning outcomes to this unit. The learner will:

1. Analyse and evaluate an electric power system for load forecasting and generation planning and reliability
2. Analyse and evaluate an electric power system for transmission, substation and distribution planning and reliability
3. Execute production costing analysis and long term generation expansion plans in a deregulated environment

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Analyse and evaluate an electric power system for load forecasting and generation planning and reliability

Assessment Criteria

The learner can:

Load forecasting

1. Explain the reasons and importance of use of load forecasting.
2. Describe factors effecting load forecasting.
3. Identify and explain the load growth characteristic.
4. Use the different types of load forecasting methods: extrapolation, co-relation techniques.
5. Compare the load forecasting techniques.
6. Use forecasting techniques for energy forecasting, peak load forecasting, reactive load forecasting, monthly, annual and total forecasting.

Generation planning (operation and expansion) and reliability

7. Explain the objectives and factors effecting generation planning.
8. Describe the generation technology options (Hydro, Thermal, diesel, gas, combined cycle etc).
9. Describe short term planning, medium term planning and long term planning.
10. Sketch and explain the characteristics of thermal unit.
11. Describe criteria for economic dispatch of generating power between thermal units.
12. Calculate economic dispatch of power between thermal units.
13. Consider the transmission losses for economic dispatch between the units.
14. Explain the operation planning of hydropower systems.
15. Explain the maintenance scheduling.
16. Describe the technology options and their performance in long term generation planning.
17. Identify the environmental impacts.
18. Define reliability of generation systems.
19. Explain the measures of reliability in generation systems.
20. Consider the reliability constrain for generation planning (outage rate, scheduled outages, loss of energy).
21. Calculate loss of load probability, loss of load expectation and energy not served probability.
22. Explain real power control and frequency stability of generator.
23. Calculate the power contribution of generating stations using droop characteristics.

Outcome 2 Analyse and evaluate an electric power system for transmission, substation and distribution planning and reliability

Assessment Criteria

The learner can:

Transmission planning

1. Explain the importance and need of transmission planning.
2. Use engineering model for transmission planning.
3. Identify the network reconfiguration.
4. Explain the criteria for selection of voltage levels for overhead lines and underground cables.
5. Explain the reactive power compensation and voltage reliability.

6. Describe single contingency and double contingency.
7. Identify the line routing.
8. Use the transmission systems planning criteria for the planning.
9. Explain the use of HVDC links and interconnection systems.
10. Consider the environmental and reliability constrains in transmission planning.

Substation planning

11. Identify the types of substations.
12. Explain how to select sites for substations.
13. Describe functions of various elements of substations.
14. Explain the different types of bus bar arrangements used in substations and their area of use.
15. Explain the reliability constrains of substations and switching systems.
16. Describe general failure rates and duration for outages

Distribution systems and sub-transmission planning

17. Distinguish urban and rural electrification.
18. Explain distribution network design for urban areas.
19. Calculate voltage drop and power loss.
20. Explain the details of different feeder arrangement.
21. Describe the methods of loss optimisation and voltage regulation in distribution systems.
22. Analyse distribution system reliability with and without back-up supply

Outcome 3 Execute production costing analysis and long term generation expansion plans in a deregulated environment

Assessment Criteria

The learner can:

Electricity pricing and demand side management

1. Explain the electricity pricing policy.
2. Describe the different types of tariff used.
3. Calculate cost of electricity using tariffs.
4. Explain the metering policy.
5. Calculate long run and short run marginal costs.
6. Explain how to use demand side management as a tool for power systems planning.
7. Evaluate and implement demand side management projects.

Restructuring of Electric utility

8. Describe the practice in worldwide for restructuring of electrical utility.
9. Explain the types of models used for restructuring.
10. Explain the evaluation of non-utility generation into the system transmission wheeling.

Unit 209 Power System Economics and Planning

Notes for guidance

Test specification for written paper

This examination is of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The written examination will cover knowledge specifications:

Topics	**Approximate % Examination weighting.**
Load forecasting	15
Generation planning (operation and expansion) and reliability	20
Transmission planning	15
Substation planning	10
Distribution systems and sub-transmission planning	15
Electricity pricing and demand side management	15
Restructuring of Electric utility	10

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Level: 7

Introduction
This unit deals with high voltage engineering and related industrial applications. The unit is compulsory for Electrical Engineering learners.

Unit aim
The aim of this unit is to provide electrical engineering learners with sound knowledge of high voltage phenomena, technology, generation and measurement.

Prerequisites
It is recommended that learners have achieved the Graduate Diploma in Electrical Engineering specialisation including passes in Unit 114- Electrical Energy Systems and Unit 115 – Electrical Machines and Drives.

Learning outcomes
There are **five** learning outcomes to this unit. The learner will:
1. Explain breakdown mechanism of gases, solid and liquid
2. Explain lightning phenomena
3. Explain transient voltages and their propagation characteristic
4. Explain high voltage measurement techniques
5. Explain production and operation of high voltage impulse generators and generation of high voltage for testing

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Explain breakdown mechanism of gases, solid and liquid

Assessment Criteria

The learner can:

Breakdown of gases

1. Describe ionisation processes in gas discharges.
2. Explain the electron Avalanche Mechanism (Townsend Breakdown Process) and mathematical model of it.
3. Determination of Townsend's Coefficients.
4. Explain breakdown of electronegative gases.
5. State Paschen's law.
6. Describe streamer mechanism.
7. Explain the factors affecting the breakdown voltage in a vacuum gap.
8. Sketch and explain time-lag characteristic.
9. Explain mechanism of formation of corona.
10. Calculate power loss due to corona.
11. Describe safety and health aspects relating to the breakdown of gases

Breakdown of solid insulation

12. Describe electro-mechanical breakdown and breakdown due to internal discharges.
13. Explain how deteriorations due to internal discharges occur.
14. Explain surface flashover and essential components for occurring.
15. Explain thermal and electro-chemical breakdown.

Breakdown of liquid insulation

16. Explain the commercial liquids.
17. Explain breakdown due to gaseous insulations and relationship electric field with permittivity.
18. Explain breakdown due to liquid globules and calculation of critical field strength.
19. Describe safety and health aspects relating to the breakdown of liquids

Outcome 2 Explain lightning phenomena

Assessment Criteria

The learner can:

1. Explain the mechanism of lightning.
2. Describe the breakdown process in lightning.
3. Explain the methods of protection of overhead transmission lines against lightning.
4. Calculate the shielding angle of earth wire.
5. Identify the area of attraction of transmission systems to lightning.
6. Explain the effect of lightning to phase-conductor and earth wire.

Outcome 3 Explain transient voltages and their propagation characteristic

Assessment Criteria

The learner can:

1. Write the differential equations for current and voltage of a transmission line.
2. Derive expressions for surge impedance and velocity of propagation.
3. Describe reflection of traveling wave at a junction.
4. Use Bewley lattice diagram for voltage calculation of over voltages.
5. Calculate reflected and transmitted voltage and current waves at T-junction.

Outcome 4 Explain high voltage measurement techniques

Assessment Criteria

The learner can:

1. Explain how electrostatic voltmeter and sphere gap method are used to measure high voltages with relevant sketches and equations.
2. Describe indirect methods of high voltage measurement: transformer ratio, resistive potential divider, capacitive potential divider and matching potential divider.
3. Use the Klydonograph for the measurement of surges.
4. Use the high voltage Schering Bridge for the purpose of measurement of capacitance and loss tangent.
5. Explain how corona detector is used for the detection of internal discharge.
6. Explain the use of oscilloscope for the measurement of dielectric loss.

Outcome 5 Explain production and operation of high voltage impulse generators and generation of high voltage for testing

Assessment Criteria

The learner can:

High voltage impulse generators

1. Explain how single and double exponential waveforms are produced.
2. Calculate α and β from resistance and capacitance value.
3. Define wavefront and wavetail times for the practical waveforms.
4. Explain how wavefront and wavetail are controlled.
5. Explain uncontrolled and controlled operation of impulse generator.
6. Sketch Marx impulse and Goodlet impulse generator circuits.

High voltage generation for testing

7. Explain generation of high voltage for testing of insulators.
8. Describe the use of cascade arrangement of transformers and resonant transformers for the generation of high alternative voltages.
9. Describe the use of electrostatic generators (Van de Graeff) for the generation of high dc voltages.
10. Explain the use of rectifier circuits, voltage multiplier circuit and Cockroft-Walton circuit for the generation of high dc voltages.

Unit 210 High Voltage Engineering

Notes for guidance

Test specification for written paper

This examination is of **three** hours duration with a total of **eight** (08) questions. Learners must answer any **five** (05) questions.

The written examination will cover knowledge specifications:

Topics	**Approximate % examination weighting.**
Explain breakdown mechanism of gases, solid and liquid	20
Explain lightning phenomena	20
Explain transient voltages and their propagation characteristic	20
Explain high voltage measurement techniques	20
Explain production and operation of high voltage impulse generators and generation of high voltages for testing	20

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit 211 Fields and Network Theory

Level: **7**

Introduction

This unit is about fields and network theories that are used to solve electrical networks both linear and non-linear. The unit discusses advanced methods to solve the networks.

Unit aim

The aim of this unit is to provide a detailed study of electromagnetic field and network theory, providing the learner with sufficient knowledge to evaluate any complex network.

Prerequisites

It is recommended that learners have achieved the Graduate Diploma including Unit 112 - Circuits and Waves.

Learning outcomes

There are **seven** learning outcomes to this unit. The learner will:

1. Solve and analyse the linear networks
2. Solve and analyse the non-linear networks
3. Demonstrate knowledge in network theories
4. Solve problems on electric fields in dielectrics
5. Solve problems on magnetic fields in ferromagnetic materials
6. Describe the motion of charged particles in electric and magnetic fields
7. Illustrate the use of numerical techniques in electromagnetic problems

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Solve and analyse the linear networks

Assessment Criteria

The learner can:

1. Formulate equations using nodal analysis.
2. Formulate equations using mesh analysis.
3. Solve linear circuits using mesh and nodal methods.
4. Solve sparse matrices and sparsity programming.

Outcome 2 Solve and analyse the non-linear networks

Assessment Criteria

The learner can:

1. Use the companion model for the steady state analysis of non-linear circuits.
2. Use the companion model for the transient analysis of non-linear circuits.

Outcome 3 Demonstrate knowledge in network theories

Assessment Criteria

The learner can:

1. Formulate incidence matrix for circuits.
2. State the Tellegen's Theorem.
3. Explain the use of Tellegen's theorem for the design of filters.
4. Use of Tellegen's Theorem in sensitivity analysis.
5. State Thevenin's and Norton's theorem.
6. Describe idea about attenuators and their types.

Outcome 4 Solve problems on electric fields in dielectrics

Assessment Criteria

The learner can:

1. Review Maxwell's equations on electromagnetic fields.
2. Identify boundary conditions related to electromagnetic fields.
3. Develop Laplace's equation and Poisson's equation.
4. Develop the concepts of electric dipoles and electric polarisation.
5. Develop knowledge of electrical images of charged conductors due to earth.

Outcome 5 Solve problems on magnetic fields in ferromagnetic materials

Assessment Criteria

The learner can:

1. Develop the concepts of magnetic dipoles and dipole moment.
2. Describe magnetic properties of paramagnetic, diamagnetic and ferromagnetic materials, magnetisation curves, hysteresis, permanent magnets and demagnetisation.
3. Identify magnetic circuits and perform calculations of different properties of magnetic circuits.

Outcome 6 Describe the motion of charged particles in electric and magnetic fields

Assessment Criteria

The learner can:

1. Describe the concept of electron acceleration using electric fields.
2. Describe vertical and horizontal deflection of electrons due to electromagnetic fields.
3. Describe the cathode ray oscilloscope and particle accelerators.

Outcome 7 Illustrate the use of numerical techniques in electromagnetic problems

Assessment Criteria

The learner can:

1. Use Finite Difference Method to solve Laplace's equation in rectangular coordinates to obtain approximate solutions to potential and intensity of electric fields.
2. Use Method of Moments to examine the charge distribution along a charged wire.

Unit 211 Fields and Network Theory

Notes for guidance

Test specification for written paper

This examination is of **three** hours duration with a total of **eight** (8) questions in two sections, A and B. Learners must answer **five** (05) questions with at least two from each section.

The written examination will cover knowledge specifications:

Topics	Approximate % examination weighting.
Solve and analyse the linear networks	15
Solve and analyse the non-linear networks	15
Demonstrate knowledge in network theories	20
Electric fields in Dielectrics	15
Magnetic fields in Ferromagnetic materials	15
Electron Ballistics	10
FDM and MOM	10

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit 212 Data Communication

Level: **7**

Introduction
This unit is about fundamental concepts of computer networking architectures, algorithms, implementations and data communication technology.

Unit aim
The unit aims to develop the knowledge of the key elements of data communication systems, communication protocols, data transmission modes and the management of computer networks.

Prerequisites
It is recommended that learners have achieved the Graduate Diploma in Electronic and Telecommunication specialisation including Unit 121 Computer networks and Unit 123 Operating systems.

Learning outcomes
There are **four** learning outcomes to this unit. The learner will:
1. Identify Wired Broadband Networking Technologies
2. Identify High Speed LANs
3. Describe MAN Technologies and Network Management Concepts
4. Identify Broadband Wireless Access Technologies

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Identify Wired Broadband Networking Technologies

Assessment Criteria

The learner can:

1. Explain broadband technology options
2. Identify xDSL Technologies
3. Identify WDM and DWDM Technologies

Outcome 2 Identify High Speed LANs

Assessment Criteria

The learner can:

1. Compare and contrast different LAN Technologies such as IEEE 802 LAN standards.
2. Differentiate between Ethernet, Fast Ethernet, Gigabit Ethernet, 10Gb Ethernet
3. Describe the problem of channel allocation in the LAN segments and their solutions
4. Describe structured cabling for high speed LANs.

Outcome 3 Describe MAN Technologies and Network Management Concepts

Assessment Criteria

The learner can:

1. Describe Metro Ethernet protocol
2. Explain the function of FDDI
3. Identify Network Management Techniques and Tools
4. Describe concepts of a Network Operation Center (NOC)

Outcome 4 Identify Broadband Wireless Access Technologies

Assessment Criteria

The learner can:

1. Wireless Protocols (WiFi, WiMax)
2. Cellular Mobile access method; eg. HSPA
3. Power-line carrier communication

Unit 212 Data Communication

Notes for guidance

Test specification for written paper

This examination is of **three** hours duration with **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications:

Topic	Approximate % examination weighting.
Wired Broadband Network Technologies	25
High speed LANs	25
Ethernet in WANs	25
Broadband Wireless Access Technologies	25

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit 213 Digital System Design

Level: **7**

Introduction:
This unit is about the principles underlying digital systems.

Unit aim:
The unit aims to equip the learner with knowledge of digital system design.

Prerequisites:
It is recommended that learners have achieved the Graduate Diploma in Electronics and Telecommunication specialisation and should have knowledge of analogue and digital electronic circuits.

Learning outcomes
There are **six** learning outcomes to this unit. The learner will:

1. Describe the role of Hardware Description Language in the evolution of Digital System Design
2. Demonstrate skills in Hardware Description Language that facilitate rapid prototyping of digital systems
3. Design sequential systems using RTL based approach
4. Describe different approaches available for processor design
5. Identify the key stages in designing a processor
6. Describe different forms of Memory Design

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination.

Outcome 1 Describe the role of Hardware Description Language in the evolution of Digital System Design

Assessment Criteria

The learner can:

1. Review the traditional design methodologies in Digital Systems – combinational and sequential.
2. Identify the need for a Hardware Description Language
3. Describe the essential features of a chosen Hardware Description Language
4. Recognise the capability of Hardware Description Language to represent a Digital System at different levels
5. Apply the rules of the chosen Hardware Description Language to represent simple digital systems.

Outcome 2 Demonstrate skills in Hardware Description Language that facilitate rapid prototyping of digital systems

Assessment Criteria

The learner can:

1. Formalise the representation of digital systems
2. Remove technology dependence from digital systems description
3. Describe circuit specifications using hardware description languages
4. Speeding up the design cycle
5. Use HDL packages

Outcome 3 Design sequential systems using RTL based approach

Assessment Criteria

The learner can:

1. Describe RTL based design
2. Explain data paths and controllers
3. Analysis of a given digital system for RTL based implementation
4. Design complex digital systems using RTL

Outcome 4 Describe different approaches available for processor design

Assessment Criteria

The learner can:

1. Identify the processor as an ideal but complex digital system that can be fully represented by Hardware Description Language
2. Describe features of RISC architecture
3. Describe pipelining, register windows and register renaming

Outcome 5 Identify the key stages in designing a processor

Assessment Criteria

The learner can:

1. Identify instruction set architecture
2. Describe hardwired and microprogramming approaches to processor design
3. Represent the designed processor using HDL.

Outcome 6 Describe different forms of Memory Design

Assessment Criteria

The learner can:

1. Identify the critical role Memory plays in Processor based Systems
2. Describe RAM, ROM, EPROM, SRAM, DRAM
3. Describe memory cells and memory organisation,
4. Identify cache memory design and memory interfacing

Unit 213 Digital System Design

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specification:

Topic	**Approximate % examination weighting.**
Use of HDL	20
RISC architecture	20
Processor design	20
Memory design	20
RTL based sequential approach for system design	20

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit 214 Telecommunication Systems Engineering

Level: **7**

Introduction:
This unit provides an in-depth study of telecommunication systems and networks.

Unit aim:
The aim of the unit is to equip the learner with knowledge of the core network, transmission and switching and access networks of modern telecommunication systems.

Prerequisites:
It is recommended that learners have achieved the Graduate Diploma in the Electronic and Telecommunication specialisation including Unit 118 Communication Systems.

Learning outcomes
There are **six** learning outcomes to this unit. The learner will:

1. Describe basics of communication networks
2. Identify core network, transmission, switching and routing techniques
3. Describe optical fibre communication systems
4. Describe mobile communication systems
5. Describe satellite communication systems
6. Identify access technologies

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Describe basics of communication networks

Assessment Criteria

The learner can:

1. Describe the network hierarchy: LAN, WAN, Nationwide networks and International networks.
2. Explain network topologies: Bus, Star and Ring.
3. Identify terminal equipment.
4. Identify access networks: plain old telephone service twin pair and dial up access, mobile access and cable TV access.

Outcome 2 Identify core network, transmission, switching and routing techniques

Assessment Criteria

The learner can:

1. Understand line and radio transmission.
2. Explain the evolution of signalling systems, CCITT no.7 signalling system.
3. Understand digital transmission and multiplexing techniques: PCM, PDH, SDH/SONET and WDM.
4. Describe transmission technologies: X.25, frame relay, ATM, IP based networks.
5. Explain convergence of technologies: voice and video on packet switching networks, integrated networks, applications in multimedia communications and MPLS.

Outcome 3 Describe optical fibre communication systems

Assessment Criteria

The learner can:

1. Describe the propagation characteristics of signals through optical fibres: dispersion and attenuation.
2. Describe optical sources, detectors, fibre amplifiers and other components.
3. Determine noise, impulse and frequency responses.
4. Estimate bandwidth of optical systems.
5. Describe WDM systems.
6. Develop optical fibre system link budget.

Outcome 4 Describe mobile communication systems

Assessment Criteria

The learner can:

1. Recognise the implications of service requirements on system design in a mobile environment.
2. Determine cell and cluster sizes in cellular mobile systems.
3. Explain radio wave propagation in the mobile environment.
4. Analyse modulation, speech and channel coding for GSM systems, 3G systems and UMTS systems.
5. Analyse data and appreciate network layer principles of GSM systems and UMTS systems.

Outcome 5 Describe satellite communication systems

Assessment Criteria

The learner can:

1. Analyse satellite orbits, look angles and coverage.
2. Analyse transponder and earth station design for geostationary satellites for communication.
3. Analyse propagation and link budgets.
4. Assess digital transmission, modulation and multiple access.
5. Recognise mobile radio applications of satellite systems.
6. Recognise broadband applications of satellite systems.

Outcome 6 Identify access technologies

Assessment Criteria

The learner can:

1. Describe wire-line and wireless network access.
2. Explain FDMA, TDMA, and CDMA and spread spectrum techniques.
3. Develop a comparison of access technologies..

Unit 214 Telecommunication Systems Engineering

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specification:

Topics	**Approximate % examination weighting.**
Basics of communication networks, Core Networks, Transmission and Switching	35
Optical Fibre Communications	10
Satellite Communications	10
Mobile Communications	20
Access Technologies	25

The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction

Unit 215 Modern Control Systems

Level: **7**

Introduction

This unit is about mathematical models in time and frequency domains of control systems and implementation of modern control systems.

Unit aim

The unit aims to equip the learner with knowledge of the fundamentals of control theory and implementation techniques applied to modern control systems.

Prerequisites:

It is recommended that learners have achieved the Graduate Diploma (relevant Electrical specialisation) unit 136 “Control Systems”.

Learning outcomes

There are **eleven** learning outcomes to this unit. The learner will:

1. Identify a general process for designing a control system
2. Review the use of Mathematical models of physical systems to design and analyse control systems.
3. Develop time domain methods of system modelling
4. Develop modelling to include control system characteristics
5. Identify the common time domain specifications
6. Develop methods to analyse and design stable systems
7. Develop the steady-state response of a system
8. Understand the design of compensators
9. Understand the design of controllers utilising state feedback
10. Understand the design of robust control systems
11. Understand the design of digital control systems

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Identify a general process for designing a control system

Assessment Criteria

The learner can:

1. Describe examples of control systems through the course of history.
2. Explain the use of control design strategies for improving manufacturing processes, efficiency of energy use among others.
3. Identify the notion of a design gap and the iterative nature of design to handle the design gap effectively.

Outcome 2 Review the use of Mathematical models of physical systems to design and analyse control systems.

Assessment Criteria

The learner can:

1. Describe the dynamic behaviour using ordinary differential equations with examples.
2. Describe the use of Laplace transform methods to analyse the dynamic behaviour and develop the input–output relations of components and subsystems in the form of transfer functions.
3. Draw signal flow graphs to design and analyse complicated control systems.

Outcome 3 Develop time domain methods of system modelling

Assessment Criteria

The learner can:

1. Develop the time domain state variable model of system modelling.
2. Identify the difference between signal flow graph models and state variable model.

Outcome 4 Develop modelling to include control system characteristics

Assessment Criteria

The learner can:

1. Describe modelling to include sensitivity to model uncertainties, steady-state errors, transient response characteristics to input test signals and disturbance rejection using feedback.
2. Describe the transient performance of a feedback system and how it is improved.
3. Describe how a control system is designed to reduce the impact of disturbance signals.

Outcome 5 Identify the common time domain specifications

Assessment Criteria

The learner can:

1. Identify percent overshoot, settling time, time to peak, time to rise and steady-state tracking error for step and ramp signals to test the response of the control system.
2. Describe the correlation between the system performance and the location of the system transfer function poles and zeros in the s-plane.
3. Develop relationships between the performance specifications and the natural frequency and damping ratio for second order systems

Outcome 6 Develop methods to analyse and design stable systems

Assessment Criteria

The learner can:

1. Describe bound-input, bound-output stability.
2. Use the roots of the characteristic equation of the system transfer function to analyse the stability of the system.
3. Use Routh-Hurwitz method to assess the system stability.
4. Identify the notion of relative stability to characterise the degree of stability.
5. Use the root-locus method to design and analyse feedback systems.
6. Describe the practical techniques of obtaining the root-locus plot and their effective in the design process.
7. Describe the PID controller with three adjustable parameters as a practical controller structure..

Outcome 7 Develop the steady-state response of a system

Assessment Criteria

The learner can:

1. Describe the steady-state response of a system to a sinusoidal input as the frequency is varied.
2. Use the Bode plot for analyzing and designing control systems; use polar plots and log magnitude and phase diagrams.
3. Develop time domain performance measures in terms of the frequency response of the system.
4. Investigate stability of a system using the frequency response methods by developing the gain margin, phase margin and bandwidth in the concept of Bode plots and Nyquist diagrams.
5. Identify the destabilising effect of a stable system due to phase lag introduced by the time delay.

Outcome 8 Understand the design of compensators

Assessment Criteria

The learner can:

1. Develop design techniques in the frequency domain
2. Describe phase-lead and phase-lag control design approaches using root locus plots and Bode diagrams.

Outcome 9 Understand the design of controllers utilising state feedback

Assessment Criteria

The learner can:

1. Describe a system test for controllability and observability.
2. Use Akermann's formula to determine the state variable feedback gain matrix.
3. Describe observer design process and the applicability of Akermann's formula in such situations.
4. Describe optimal control system design.

Outcome 10 Understand the design of robust control systems

Assessment Criteria

The learner can:

1. Describe the root locus method, frequency response method and ITAE method for a robust PID system.

Outcome 11 Design of digital control systems

Assessment Criteria

The learner can:

1. Determine the response of a closed-loop system using a digital computer serving as the compensator.

Unit 215 Modern Control Systems

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications:

Topics	**Approximate % examination weighting.**
Mathematical Models and State Variable Models	30
Feedback Control Systems; characteristics and performance, stability	30
Steady state response to a sinusoidal input signal	20
Robust systems	10
Digital control systems	10

The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction

Unit 216 RF and Microwave Engineering

Level: **7**

Introduction:
This unit is about microwave bands, the unique properties of microwaves and applications in communication systems.

Unit aim:
The aim is to equip the learner with knowledge of transmission lines for microwave systems, passive and active microwave components, microwave antennas and applications.

Prerequisites:
It is recommended that learners have achieved the Graduate Diploma unit 118 “Communication Systems”.

Learning outcomes
There are **seven** learning outcomes to this unit. The learner will:

1. Identify microwave transmission lines
2. Describe microwave circuits using signal flow graphs and characterise passive components
3. Design a microwave transistor amplifier
4. Identify two terminal semiconductor devices useful at RF and microwave frequencies
5. Identify and analyse microwave tubes
6. Identify radiation patterns, directivity, gain, Input impedance of RF and microwave antennas and their uses
7. Describe terrestrial microwave radio systems

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Identify microwave transmission lines

Assessment Criteria

The learner can:

1. Draw the electric and magnetic field lines in twin lines and coaxial lines and identify TEM waves.
2. Describe propagation characteristics of twin lines and coaxial lines using the transmission line equivalent circuit.
3. Identify TEM mode of propagation, propagation constant, characteristic impedance and speed of propagation of electromagnetic waves propagating in free space
4. Describe metal waveguides: TE and TM modes of propagation, electromagnetic field within a rectangular waveguide for different modes, dominant mode, cut-off frequency, cut-off wavelength, free space wavelength, guide wavelength, speed of propagation.
5. Estimate the power carried through the rectangular waveguide by a microwave signal.
6. Describe methods of exciting the dominant mode in a rectangular waveguide.

Outcome 2 Describe microwave circuits using signal flow graphs and characterise passive components

Assessment Criteria

The learner can:

1. Define scattering parameters of a 2-port microwave network and for an n-port network.
2. Draw signal flow graphs for 2-port and 3-port network.
3. Describe the function of common microwave passive components such as isolator, circulator, directional coupler, and T-junctions.
4. Obtain s-parameters that characterise microwave passive components.

Outcome 3 Design a microwave transistor amplifier

Assessment Criteria

The learner can:

1. Draw the signal flow graph for a two port network; power supplied from a source to a load through a transducer
2. Analyse the microwave transistor amplifier using s-parameters
3. Design input and output matching circuits for a transistor amplifier for maximum unilateral power gain
4. Identify the physical structure, characteristics and applications of microwave Si bipolar transistor, GaAs FET, GaAs MESFET, GaAs HEMT and HBT
5. Identify the advantages of MMICs and briefly describe their fabrication techniques

Outcome 4 Identify two terminal semiconductor devices useful at RF and microwave frequencies

Assessment Criteria

The learner can:

1. Analyse the Varactor diode parametric amplifier, Gunn oscillator and IMPATT diode amplifier.
2. Analyse the Tunnel diode and its uses.
3. Analyse the Point Contact Diode, Schottky Diode, Backward Diode and their uses as detectors and mixers.

Outcome 5 Identify and analyse microwave tubes

Assessment Criteria

The learner can:

1. Draw and describe the function of a Magnetron and describe its uses and limitations.
2. Draw and describe the function of a Multi-cavity Klystron and describe its uses and limitations.
3. Draw and describe the function of a Reflex Klystron and describe its uses and limitations.
4. Draw and describe the function of a Travelling Wave Tube and describe its uses and limitations.
5. Describe a Cross Field amplifier and describe its uses and limitations.

Outcome 6 Identify radiation patterns, directivity, gain, Input impedance of RF and microwave antennas and their uses

Assessment Criteria

The learner can:

1. Draw the radiation pattern and obtain the beam-width and estimate the gain of half wave dipole and monopole antennas.
2. Draw the radiation pattern and obtain the beam-width and estimate the gain of Linear arrays.
3. Describe Phased Arrays and feeding mechanisms.
4. Draw the radiation pattern and obtain the beam-width and estimate the gain of a Horn antenna.
5. Draw the radiation pattern of a Helical antenna in different modes.
6. Draw the radiation pattern and obtain the beam-width and estimate the gain of Parabolic Reflector Antenna and feeding mechanisms.
7. Identify the polarisation characteristics of different antennas.

Outcome 7 Describe terrestrial microwave radio systems

Assessment Criteria

The learner can:

1. Identify the basic microwave radio relay system.
2. Identify the equipment required at the terminal stations and at active and passive repeater stations.

3. Explain free space microwave propagation.
4. Describe the effects of atmospheric refraction and estimate the radio horizon.
5. Describe system gain and diversity reception..

Unit 216 RF and Microwave Engineering

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications:

Topics	**Approximate % examination weighting.**
Transmission Lines	10
Passive components	10
Transistor amplifier, Varactor Diode, Gunn Device, IMPATT diode, Tunnel Diode	30
Detector and Mixer diodes	15
Microwave Tubes	15
Microwave Antennas	10
Microwave Terrestrial Systems	10

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

Although professional simulation tools such as Microwave Office are expensive, there are numerous online scripts and calculators, and also the MATLAB RF Toolbox, that could be very useful for analysis and visualisation.

Unit 217 Power Electronics

Level: **7**

Introduction:
This unit is about power electronics and the block that interfaces utility systems with consumer load.

Unit aim:
The aim is for the learner to develop knowledge about power semiconductor switching devices and circuits that work under the guidance of control electronics.

Prerequisites:
It is recommended that learners have achieved the Graduate Diploma including Unit 116 or Unit 117

Learning outcomes
There are **six** learning outcomes to this unit. The learner will:
1. Identify Power Semiconductor Devices
2. Identify power switching, protection and filtering schemes
3. Identify magnetic materials required for transformer cores and filters
4. Analyse and design power conversion systems (techniques / topologies)
5. Analyse and design power supplies
6. Understand converter control of machines

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the rest is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Identify Power Semiconductor Devices

Assessment Criteria

The learner can:

1. Describe the switching behaviour of diodes (fast recovery /ultrafast recovery/ high voltage) and transistors (bipolar power transistors, power darlingtons, power MOSFETs).
2. Refer to the manufactures datasheets and describe the characteristics, typical ratings and applications of the SCRs, power MOSFETs, IGBTs and GTOs.

Outcome 2 Identify power switching, protection and filtering schemes

Assessment Criteria

The learner can:

1. Sketch and describe inductive switching waveforms and calculate switching losses.
2. Perform thermal calculations and thermal management.
3. Design suitable driver circuits (including pulse transformers, optoisolators), filter circuits and protection circuits (snubbers).

Outcome 3 Identify magnetic materials required for transformer cores and filters

Assessment Criteria

The learner can:

1. Select the appropriate magnetic material for the transformer.
2. Select the appropriate magnetic material for the filters
3. Calculate the core area of the ferrite based transformers.
4. Calculate the number of windings and cross section size for ferrite winding cables

Outcome 4 Analyse and design power conversion systems (techniques / topologies)

Assessment Criteria

The learner can:

1. Analyse AC-DC converters (phase-controlled converters):
    a. Explain the operation of half wave and full wave bridge rectifiers in both single phase and three phase converters with un-control, semi control and full control.
    b. Explain the operation of multiple controllers and control of converters.
    c. Analyse source side distortion; perform Fourier analysis of the ac input currents and the calculation of current total harmonic distortion and power factor.
    d. Derive expressions for the average output voltage including the effects of source inductance.

2. Analyse DC-DC converters (choppers, buck and boost converters):
    a. Sketch circuit diagrams, steady-state waveforms, and explain the operation of the buck, boost and buck/boost converters in the continuous and discontinuous conduction modes.
    b. Analyse the Cuk and Bridge type converters.
    c. Derive voltage conversion ratio expressions for each converter, and do the calculations of circuit components and operating conditions.
    d. Describe fly-back and forward converters and half bridge, full bridge and push-pull type converters.
    e. Describe resonance converters with zero voltage switching (ZVS), zero current switching (ZCS) and pseudo resonant switching.
3. Identify switch mode DC-AC converters (inverters):
    a. Analyse self controlled voltage source inverters.
    b. Analyse square wave inverters.
    c. Describe PWM control strategies and implementations.
    d. Analyse current source inverters.
    e. Explain the operation of single and three-phase voltage sourced inverters, including the calculation of waveform harmonics.
4. Direct AC-AC converters (cycloconverters):
    a. Develop the idea of cycloconverter.
    b. Analyse the single phase cycloconverter.
    c. Analyse the three phase cycloconverter.
    d. Describe the three phase/three phase cycloconverter.

Outcome 5 Analyse and design power supplies

Assessment Criteria

The learner can:

1. Describe the application of PWM techniques for Non isolated DC power supplies.
2. Describe the operation of Isolated DC power supplies.
3. Describe the operation of Uninterrupted Power Supplies (UPS).

Outcome 6 Understand converter control of machines

Assessment Criteria

The learner can:

1. Describe Phase-Controlled Converter DC Drives.
2. Describe Pulse width Modulation (PWM) Converter DC Machine Drives.
3. Describe PWM control single phase and three phase induction motor drives.

Unit 217 Power Electronics

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications:

Topic	Approximate % examination weighting.
AC to DC converters	20
DC to DC converters	20
DC to AC inverters	20
AC to AC converters	10
Converter Control of Machines	10
Identify Magnetic Materials	10
Analyse and design power supplies	10

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit 218 Internet Technologies

Level: **7**

Introduction
There is a need for technical professionals who can develop and underpin content development for the web and other emerging platforms. This unit couples in-depth understanding a number of key Internet and Web technologies along with a high level approach to the technological development of web content.

Unit aim
The aim is to equip the learner with an in-depth knowledge of the Technologies of Internet and WWW.

Prerequisites:
It is recommended that learners have achieved the Graduate Diploma of the relevant specialisation including Unit 122 Web Design and Applications.

Learning outcomes
There are **five** learning outcomes to this unit. The learner will:
1. Review basics of the Internet and the World Wide Web
2. Identify the strategies for web development, programming for the web and document creation
3. Identify quality, security and privacy concerns of Internet
4. Describe social and ethical issues connected with the use of Internet
5. Identify emerging technologies and platforms

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Review basics of the Internet and the World Wide Web

Assessment Criteria

The learner can:

1. Describe the evolution of the Internet and the growth of the web.
2. Explain the client-server model.
3. Describe the architecture of the Intranet/Internet/Extranet.
4. Describe access methods: dialup, ISDN, ADSL, cable, LAN, WiFi, WiMax, Mobile and Satellite.
5. Explain the use of a Proxy Server.
6. Describe application areas such as e-commerce, education and entertainment.
7. Describe the process, standards and protocols: URL, TCP/IP, Fixed and dynamic IP addressing, role of DNS, email clients – server and gateways – SMTP, POP3, IMAP and Webmail, FTP, telnet, role of W3C, mobile computing, wireless, 3G, GPS.

Outcome 2 Identify the strategies for web development, programming for the web and document creation

Assessment Criteria

The learner can:

1. Identify domain registration and free vs. commercial hosting solutions for web development.
2. Develop knowledge on server/database replication, backup and archiving, RAID, bandwidth and availability.
3. Identify the methods of interaction between browser and server; HTML forms, GET and POST data.
4. Describe concerns of limiting access with htaccess and htpasswd configuration files.
5. Develop dynamic content using Javascript; manipulate the DOM using Javascript.
6. Develop dynamic content with PHP and interfacing with a database.
7. Validate user inputs using simple pattern matching.
8. Create documents; XML, XHTML 1.0 translational/Strict, XSLT, DTD, CSS (1 and 2), well-formedness and validity.

Outcome 3 Identify quality, security and privacy concerns of Internet

Assessment Criteria

The learner can:

1. Develop testing approaches and strategies to maintain quality of data transmitted through the internet.
2. Identify ISO 9126 characteristics of quality, metrics, quality of service and standards and conformance: W3C, WAI, and CSS.
3. Describe methods of client, server and network risks, attacks, prevention and mitigation.
4. Illustrate integrity, authentication and non-repudiation of data.
5. Describe public and private key encryption, on-the-fly encryption, hashes, the use and limitations of RSA, DES and AES.
6. Develop digital certificates, HTTPS, Steganography and Biometrics.
7. Describe phishing; web profiling, Internet anonymity and identity theft.

Outcome 4 Describe social and ethical issues connected with the use of Internet

Assessment Criteria

The learner can:

1. Identify the social and ethical impact of technologies for controlling web access.
2. Identify the social and commercial consequences of media convergence.
3. Describe the social and economic effects of e-commerce.
4. Describe the ethical and economic implications of accessibility policies and legislation.

Outcome 5 Identify emerging technologies and platforms

Assessment Criteria

The learner can:

1. Describe web services that are possible.
2. Identify file sharing and distribution mechanisms: traditional downloading/uploading, FTP, Bittorrent, P2P networks.
3. Describe streaming media, RSS, IRC, Wiki, Blog, Web Forum, Portals.
4. Identify online connectivity of PDAs, games consoles and mobile phones.
5. Identify wireless connectivity.

Unit 218 Internet Technologies

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **five** (5) questions. Learners must answer any **four** (4) questions**.**

The examination will cover knowledge specifications.

Topic	**Approximate % examination weighting.**
Review of basics of Internet	20
Programming the Web	40
Quality, Security and Privacy	10
Social and ethical issues	10
Emerging Technologies and Platforms	20

The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction

Unit 219 Computer Systems Engineering

Level: **7**

Introduction:
This unit is about the principles underlying the basic operation, analysis and design of high speed digital computer systems.

Unit aim
The aim of the unit is to equip the learner with knowledge on parallel computing, real time operations and embedded systems.

Prerequisites:
It is recommended that learners have achieved the Graduate Diploma relevant specialisation including Unit 123 “Computer Architecture and Operating Systems”.

Learning outcomes
There are **four** learning outcomes to this unit. The learner will:
1. Apply parallel computing techniques/systems
2. Assess the performance of microprocessors in varying situations
3. Manage virtualised Systems
4. Understand and operate real-time systems

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Apply parallel computing techniques/systems

Assessment Criteria

The learner can:

1. Relate the motivation for high performance and parallelism to application areas and relevant technologies.
2. Function at abstraction levels in models of computation, overheads, multiple program counters and multi-threaded execution models.
3. Use parallel languages and compilers; task-parallel programming models; data-parallel programming models.
4. Evaluate memory architecture, memory access times and associated overheads.
5. Restructure for parallel performance; parallelising compilers

Outcome 2 Assess the performance of microprocessors in varying situations

Assessment Criteria

The learner can:

1. Recognise future technological implications, the market place and requirements for mobile coding, JAVA implications, JIT compilation and dynamic optimisation
2. Recognise and investigate the applications of digital signal processors in communications, mobile phone developments, mobile computing and GPS
3. Identify hardware in order to support fault tolerant computing
4. Analyse concurrency and its implications for computer systems architecture
5. Apply the ARM processor three and five stage pipelines and integer processor cores to specific and general cases
6. Utilise architectural extensions for floating point and DSP

Outcome 3 Manage virtualised Systems

Assessment Criteria

The learner can:

1 Describe classic virtual machines
2 Describe paravirtualisation
3 Explain hardware-assisted virtualisation
4 Explain tunneling
5 Build overlay networks
6 Explain file system level virtualisation
7 Explain block level virtualisation
8 Implement virtual machine based distributed computing
9 Manage cloud computing

Outcome 4 Understand and operate real-time systems

Assessment Criteria

The learner can:

1 Implement real-time systems
2 Analyse real-time operating system kernels
3 Manage interrupt task, clock task and base level task
4 Determine exceptions and exception handling and develop techniques for managing overload under fault conditions
5 Use fail-soft techniques and high integrity systems
6 Assess standards for safety critical systems

Unit 219 Computer Systems Engineering

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications.

Topic	Approximate % examination weighting.
Parallel computing	25
Microprocessors in varying situations	25
Virtualised systems	25
Real-time systems	25

The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction

Unit 220 Computational Mechanics Using FEM

Level: 7

Introduction
This unit is about the basic principles upon which the Finite Element Method (FEM) is based and how FEM could effectively be used to understand the behaviour and response of mechanical systems to external effects such as heat, stress, shock, etc.

Unit aim
The aim of this unit is to equip the learner with a sound foundation in Finite Element Analysis and the knowledge and skills needed to apply FEM in solving a broad variety of physical problems that illustrate its principles which are not complicated by the geometry of the problem under consideration.

Prerequisites
It is recommended that learners have achieved the Graduate Diploma in Mechanical Engineering to include a thorough knowledge of Mathematics, particularly the application of numerical methods for the solution of systems of equations. The learner is also expected to have a good knowledge of core Mechanical Engineering subjects required for the design of machine elements.

Learning outcomes
There are **five** learning outcomes to this unit. The learner will:
1. Develop finite element equations to model engineering problems and analyse them
2. Formulate and apply strain-displacement relationships used in Finite Element Analysis
3. Define behaviour of material in Finite Element Analysis
4. Apply solution algorithms and interpret results
5. Apply FEM for the analysis of special cases

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **90** would be direct taught hours while the rest is for laboratory practical work and independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Develop finite element equations to model engineering problems and analyse them

Assessment Criteria

The learner can:

1. Develop a mathematical model of the system.
2. Apply local-global co-ordinate transformations.
3. Apply boundary conditions, constraints and loads.
4. Define equivalent nodal forces for:
    a. body forces
    b. concentrated loads
    c. distributed loads
    d. thermal loads
5. Form global stiffness matrix and load vectors

Outcome 2 Formulate and apply strain-displacement relationships used in Finite Element Analysis

Assessment Criteria

The learner can:

1. Develop strain-displacement formulas for 1st-order elements:
    a. constant strain triangle
    b. bilinear quadrilateral
2. Develop strain-displacement formulas for 2nd-order elements:
    a. linear strain triangle
    b. quadratic quadrilateral
    c. Serendipity family of elements
    d. Isoparametric elements
3. Use Jacobian n-point Gauss quadrature numerical integration to form element stiffness matrices and equivalent nodal forces.
4. Analyse simple beam elements:
    a. Timoshenko modified beam element
    b. biplanar frame element
5. Analyse plate and shell elements.
6. Use interface elements for geometric non-linearities and crack-tip elements for fracture problems.

Outcome 3 Define behaviour of material in Finite Element Analysis

Assessment Criteria

The learner can:

1. Recognise degrees of material behaviour:
    a. isotropic
    b. transversely isotropic
    c. orthotropic
    d. fully anisotropic
2. Define material behaviour using:
    a. Young's moduli
    b. shear moduli
    c. Poisson's ratios
    d. thermal expansion coefficients
3. Define various types of non-linear materials:
    a. elasto-plastic
    b. Drucker-Prager
    c. foam
    d. rubber
    e. soil

Outcome 4 Apply solution algorithms and interpret results

Assessment Criteria

The learner can:

1. Solve linear and non-linear systems using:
    a. Gaussian Elimination Gauss-Seidel iteration relaxation techniques
    b. Gauss-Seidel iteration
    c. Relaxation techniques
2. Determine convergence and completeness requirements.
3. Determine inter-element compatibility using the patch test.
4. Interpret the quality of results using:
    a. element quality test
    b. discretisation error
    c. global measures of error
    d. h-refinement
    e. p-refinement.

Outcome 5 Apply FEM for the analysis of special cases

Assessment Criteria

The learner can:

1. Analyse special case applications:
    a. axisymmetric
    b. plane stress
    c. plane strain
    d. dynamic
    e. thermal.

Unit 220 Computational Mechanics Using FEM

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **nine** (9) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications.

Topic	Approximate % examination weighting.
Constitutive equations used in Finite Element Analysis (FEA).	20
Strain-displacement formulations used in FEA	20
Material behaviour within Finite Element Analysis.	15
Obtaining solutions and interpreting results.	20
Application of FEM to special cases.	20

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

At least one commercial finite element packages such as Ansys/Solidworks/COSMOS to be utilised in the learning process and used in the demonstration of the learning outcomes.
Significant mathematical support will be required with extensive use of tutorial sessions, especially in small groups. Teaching should be augmented by use of appropriate software

Unit 221 Heat and Mass Transfer

Level: **7**

Introduction

This unit is about heat transfer and mass transfer operations occurring in closed and open systems and their applications.

Unit aim

The aim of this unit is to provide the learner with the knowledge and competence required to understand and analyse heat transfer and mass transfer systems employed in industrial processes.

Prerequisites

It is recommended that learners have achieved the Graduate Diploma in Mechanical specialisation including Unit 128 “Applied Thermodynamics”.

Learning outcomes

There are **three** learning outcomes to this unit. The learner will:

1. Evaluate heat transfer and mass transfer rates in simple geometries
2. Predict heat and mass transfer coefficients in flowing systems using correlations appropriate for both forced and free convection
3. Analyse the performance of heat exchangers, wetted-wall columns, packed towers, plate columns, humidification and drying equipment, and evaporators

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **90** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Evaluate heat transfer and mass transfer rates in simple geometries

Assessment Criteria

The learner can:

1. Perform material and energy balances.
2. Determine steady-state heat transfer by conduction through:
    a. slabs
    b. compound walls
    c. cylinders
3. Determine unsteady-state conduction in homogeneous solids.
4. Determine heat transfer by convection:
    a. natural convection
    b. heat transfer in fluids
    c. film and overall heat transfer coefficients
    d. forced convection
        i. inside pipes
        ii. outside pipes
        iii. around tube bundles
        iv. fins
5. Determine heat transfer by radiation:
    a. Laws of radiant heat transfer
    b. radiation from gases
    c. geometric factors
    d. absorptivity
    e. flame temperature and furnace design
6. Analyse heat transfer involving change of phase.
7. Explain and calculate:
    a. condensation on vertical and horizontal surfaces
        i. filmwise
        ii. dropwise
    b. nucleate and film boiling
    c. critical heat flux
8. Analyse vaporisation and evaporators involving:
    a. natural circulation
    b. forced circulation
    c. surface effects
    d. evaporators with single and multiple effects.

Outcome 2 Predict heat and mass transfer coefficients in flowing systems using correlations appropriate for both forced and free convection

Assessment Criteria

The learner can:

1. Define mass transfer as a transport process.
2. Apply Fick's law.
3. Determine molecular diffusivity.
4. Analyse steady-state molecular diffusion.
5. Determine film and penetration theory of mass transfer.
6. Explain diffusion:
    a. eddy diffusivity
    b. boundary layer diffusivity
7. Analyse mass transfer in two-phase fluid systems:
    a. counter-current flow
    b. co-current flow
8. Analyse coefficients of mass transfer:
    a. film
    b. overall
9. Determine mass transfer between fluids and solids.
10. Explain the fundamentals of continuous separation processes:
    a. operating and equilibrium lines
    b. multistage and differential-contact separation
    c. concepts of theoretical stage
    d. stage efficiency and transfer units
11. Analyse simultaneous heat and mass transfer:
    a. relationship between heat, mass and momentum transfer
    b. jH and jD factors
    c. psychometry
12. Analyse humidification and dehumidification:
    a. direct contact water and gas cooling
    b. air-conditioning
    c. drying

Outcome 3 Analyse the performance of heat exchangers, wetted-wall columns, packed towers, plate columns, humidification and drying equipment, and evaporators

Assessment Criteria

The learner can:

1. Appraise heat exchangers:
    a. type of construction
    b. mean temperature difference
    c. effectiveness and number of transfer units

2. Assess the economic factors of heat exchange systems:
    a. design of main types
    b. costing
3. Appraise the application of mass transfer processes:
    a. distillation
        i. design
        ii. transfer process
    b. absorption
        i. design
        ii. transfer process
    c. extraction
        i. design
        ii. transfer process

Unit 221 Heat and Mass Transfer

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications.

Topic	Approximate % examination weighting.
Evaluate heat transfer and mass transfer rates in simple geometries	35
Predict heat and mass transfer coefficients in flowing systems using correlations appropriate for both forced and free convection.	30
Analyse the performance of heat exchangers, wetted-wall columns, packed towers, plate columns, humidification and drying equipment, and evaporators	35

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

This will require some support for the mathematical elements and teaching should include a high proportion of tutorial sessions devoted to problem solving. Where possible the practical element should be increased to cover different systems, e.g. different types of heat exchanger etc.

Unit 222 Mechanical Engineering Design

Level: **7**

Introduction

This unit is about application of principles of mechanics of machines, materials science, and other subject areas relevant to the design of components and complete machines that must meet prescribed functional requirements. Synthesis and analysis is a major part of a machine design project.

Unit aim

The aim of this unit is to equip the learner with knowledge and skills of designing safe machine components and mechanical systems for an intended function. The learner is required to use the knowledge gained in studying several core engineering subjects of strength of material, mathematics and mechanics of machines in this work.

Prerequisites

It is recommended that learners have achieved Graduate Diploma in Mechanical Engineering specialisation.

Learning outcomes

There are **seven** learning outcomes to this unit. The learner will:

1. Understand the traditional design procedure depending on the design problem, and influence of information technology in the design process
2. Decide correct material and its properties for the item to be designed and understand manufacturing considerations in design
3. Practice principles that help designing against static, impact and fluctuating loads and understand modes of failures
4. Design mechanical components and power transmission systems commonly used in machines.
5. Design fasteners, couplings and joints, thick and thin cylinders
6. Design spur gears, helical gears, worm and wheel, bevel gears and gear trains for a given situation
7. Analyse failures in mechanical system and design or modify mechanical systems

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** would be direct taught hours while the remainder is for independent study and practical work. The unit may be carried out on a full time or part time basis.

Assessment

It is recommended that **150** hours should be allocated for this unit of which **100** would be direct taught hours while the remainder is for independent study.

Outcome 1 Understand the traditional design procedure depending on the design problem, and influence of information technology in the design process

Assessment Criteria

The learner can:

1. Explain the traditional design procedure and the design phases involved and appreciate the influence of information technology in design.
2. Identify design considerations of machine elements and machines.
3. Safety factors – selection of a numerical value:
   a. Reasons to have safety factors
   b. High and low safety factors
   c. Reliability and interference theory of reliability distribution
4. Use computer technology for the process of design and design-documentation
5. Identify uses of **CAD** software with other software, such and Computer Aided Engineering (AIE), Finite Element Analysis (FEA), Computer Aided Manufacturing and Computer Numerical Control (CNC) machines.

Range

Computer Aided Design (CAD): is the use of a wide range of computer-based tools that assist engineers in their design activities. CAD is used throughout the engineering process from conceptual design and layout, through detailed engineering and analysis of components to definition of manufacturing methods.

Outcome 2 Decide correct material and its properties for the item to be designed and understand manufacturing considerations in design

Assessment Criteria

The learner can:

1. Identify the correct material required for a machine component:
   a. Mechanical properties on ferrous and non-ferrous materials
   b. Use of alternative materials
   c. Application of heat treatment methods to obtain desirable properties
2. Explain manufacturing considerations:
   a. Types of fits
   b. Systems of fits and **tolerances**
   c. Selection of fits
   d. Tolerances and manufacturing methods
   e. Selective assembly
   f. Surface roughness
   g. Population combination
3. Decide suitable surface finish methods and prevention of corrosion.

Range

Absolute tolerance: use the worst-case maximum or minimum values of dimensions and tolerances to calculate the maximum and minimum distance (clearance or interference) between two features or parts.

Outcome 3 Practice principles that help designing against static, impact and fluctuating loads and understand modes of failures

Assessment Criteria

The learner can:

1. Design machine components against:
a. Static loads
b. Impact loads
c. Fluctuating loads
d. Vibration
2. Explain:
a. Theories of failure
b. Creep
c. Stress concentration
d. Basic concepts in fracture mechanics
e. Shaft deflections

Outcome 4 Design mechanical components and power transmission systems commonly used in machines.

Assessment Criteria

The learner can:

Analyse strengths under given loading conditions and design or/and select the following items:

1. Levers
2. Springs
3. Power transmission shafts and axles
4. Clutches and brakes
5. Belt drives
6. Rope drives
7. Chain drives
8. Power screws
9. Rolling element bearings
10. Sliding bearings
11. Splines
12. Flywheels
13. Seals and circlips

Outcome 5 Design fasteners, couplings and joints, thick and thin cylinders

Assessment Criteria

The learner can:

Design:

1. Riveted joints
2. Welded joints
3. Bolted joints
4. Cotter and knuckle joints
5. Keys and couplings
6. Thick and thin cylinders, pipes and tubes

Outcome 6 Design spur gears, helical gears, worm and wheel, bevel gears and gear trains for a given situation

Assessment Criteria

The learner can:

1. Design from the stand point of strength, wear and dynamic load the following gears:
    a. Spur gears
    b. Helical gears
    c. Worm and wheel
    d. Bevel gears
2. Calculate and design simple gear trains for a given speed ratio and power requirement.
3. Explain gear dynamics.

Outcome 7 Analyse failures in mechanical system and design or modify mechanical systems

Assessment Criteria

The learner can:

1. Give consideration of simple mechanical systems consisting of several mechanical elements, analyse the stresses induced under given loads.
2. Design or modify components
3. Design or modify mechanical systems to suit engineering applications.

Unit 222 Mechanical Engineering Design

Notes for guidance

Test specification for written paper

This is a written examination paper of **four** hours duration with a total of **seven** (7) questions. Learners must answer question number 1 (compulsory) and any **three** (3) other questions. Question 1 carries 55 marks and the remainder 15 each.

The examination will cover knowledge specifications.

Topic	**Approximate % examination weighting.**
Be conversant with the traditional design procedure depending on the design problem, and influence of information technology in the design process	10
Decide correct material and its properties for the item to be designed and understand manufacturing considerations in design.	20
Practice principles that help designing against static, impact and fluctuating loads and understand modes of failures	10
Design mechanical components and power transmission systems commonly used in machines.	20
Design fasteners, couplings and joints; thick and thin cylinders.	20
Design of spur gears, helical gears, worm and wheel, bevel gears and gear trains for a given situation.	10
Analyse failures in mechanical system and design or modify mechanical systems	10

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

Solving problems is the most efficient way to understand this module in conjunction with assignments and mini projects. Video clips presentation for some of the topics will help the learners to have a better understanding.

Unit 223 Mechatronics

Level: 7

Introduction

This unit is about an integrated approach for engineering graduates to adopt an interdisciplinary way to the design, manufacture and maintenance of a wide range of engineering products and processes. It is mainly integration of mechanical engineering, electronic engineering, electrical engineering, computer technology and control engineering.

Unit aim

The aim of this unit is for the learner to acquire a mix of skills in mechanical engineering, electronics and computing which is necessary for them to comprehend and design Mechatronics systems and to become capable of operating and communicating across the range of engineering disciplines that form Mechatronics.

Prerequisites

It is recommended that learners have achieved the Graduate Diploma in Mechanical Engineering specialisation including Units 136 and 137.

Learning outcomes

There are **six** learning outcomes to this unit. The learner will:

1. Identify basic elements of a Mechatronics system
2. Interpret system drawings and design simple systems including pneumatic and hydraulic, mechanical and electrical actuation systems
3. Devise models for mechanical, electrical, fluid and thermal systems, rotational-translational, electro-mechanical and hydraulic-mechanical systems; model dynamic systems, derive system transfer functions and determine and analyse frequency response as well as predict behaviour of systems
4. Understand and use digital logic, and its applications
5. Describe basic structure of microprocessors, use programme languages, identify interface requirements, describe basic structure of PLCs, describe communication systems, and recognise the techniques used to identify faults
6. Identify traditional and Mechatronics solutions to design problems

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **100** would be direct taught hours while the remainder is for laboratory practical work and independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Identify basic elements of a Mechatronics system

Assessment Criteria

The learner can:

1. Appreciate what Mechatronics is about with comprehension of various elements of control systems such as open-loop, closed-loop and sequential and recognise the need for models of systems in order to predict their behaviour.
2. Describe the sensors and transducers with their applications.
3. Explain signal conditioning with principle of digital signal processing and principle of pulse-modulation
4. Explain data presentation systems with measurement system loading:
    a. Meters
    b. Analogue chart recorders
    c. Oscilloscopes
    d. Visual display units
    e. Printers
    f. Data loggers
    g. Principles of magnetic recording
    h. Principles of displays and LED seven-segment and dot matrix displays.

Outcome 2 Interpret system drawings and design simple systems including pneumatic and hydraulic, mechanical and electrical actuation systems

Assessment Criteria

The learner can:

1. Interpret system drawing and design simple systems for sequential control systems involving valves and cylinders.
2. Explain the principles of process control valves their characteristics and sising.
3. Evaluate mechanical systems involving linkages, cams, gears, ratchet and pawl, belt and chain drives and bearings.
4. Explain and evaluate operational characteristics of electrical actuation systems particularly relays, solid-states switches (thyristors, bipolar, transistors and MOSFETs, solenoid actuates systems, dc motors, ac motors and steppers).

Outcome 3 Devise models for mechanical, electrical, fluid and thermal systems, rotational-translational, electro-mechanical and hydraulic-mechanical systems; model dynamic systems, derive system transfer functions and determine and analyse frequency response as well as predict behaviour of systems

Assessment Criteria

The learner can:

1. Devise models from basic building blocks for mechanical, electrical, fluid and thermal systems.
2. Devise models for rotational-translational, electro-mechanical and hydraulic-mechanical systems.
3. Model dynamic systems by means of differential equations and determine the response of first-and second-order systems to simple inputs.
4. Define the transfer function and determine the response of systems to simple inputs by its means using Laplace transforms, and identify the effect of pole location on transient response.
5. Analyse frequency response of systems subject to sinusoidal inputs, plot and interpret Bode plots and use such plots for system identification.
6. Predict the behaviour of systems with proportional, integral, derivative, proportional lus integral, proportional plus derivative and PID control.
7. Explain such modes of control can be realised with operational amplifiers and digital controllers and controller settings determined.
8. Explain velocity feedback and adaptive control.

Outcome 4 Understand and use digital logic and its applications

Assessment Criteria

The learner can:

1. Use binary, octal, hexadecimal and binary coded decimal number systems.
2. Explain how numbers can be signed with twos complement method of handling negative numbers.
3. Explain the advantage of Gray code and describe parity method of error detection.
4. Recognise the symbols and Boolean representation of, write truth tables for and use in applications, the logic gates of AND, OR, NOT, HAND, NOR and XOR.
5. Use Boolean algebra to simplify Boolean expressions and present them in the form of sums of products or product of sums.
6. Use Karnaugh maps to determine the Boolean expressions to represent the truth tables.
7. Explain the operation of decoders.
8. Explain how flip-flops can be used in control systems.
9. Explain fuzzy logics and fuzzy control.

Outcome 5 Describe basic structure of microprocessors, use programme languages, identify interface requirements, describe basic structure of PLCs, describe communication systems, and recognise the techniques used to identify faults

Assessment Criteria

The learner can:

1. Explain the basic structure of microprocessor system and architecture of common microprocessors and how they can be incorporated into a microprocessor system.
2. Explain the basic structure of microcontroller and the architecture of commonly encountered microcontrollers and how their basic registers are used to carry out tasks.
3. Explain how programmes can be developed using flow charts or pseudocode.
4. Use Assembly and C languages to write programmes.
5. Identify interface requirements and how they can be realised.
6. Explain how interrupts are used with microcontrollers.
7. Explain the function of peripheral interface adapters and program them for particular situations.
8. Explain asynchronous communications interface adapters.
9. Describe basic structure of PLCs and programme PLCs,; Develop programmes involving timers, relays, counters, shift registers, master relays, jumps and data handling.
10. Describe commonly used communication interfaces:
    a. RS-232
    b. Centronics
    c. IEEE-488
    d. Personal computer buses
    e. VXIbus
    f. FCbus
11. Recognise the techniques used to identify faults in microprocessor-based systems, including both hardware and software.
12. Explain the use of emulation and simulation.
13. Explain how fault finding can be developed with PLC systems..

Outcome 6 Identify traditional and Mechatronics solutions to design problems

Assessment Criteria

The learner can:

1. Identify solutions to design problems from the traditional and Mechatronics point of view and design Mechatronics systems.
2. Recognise and use of embedded systems.
3. Design Mechatronics solutions to problems.

Unit 223 Mechatronics

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **seven** (7) questions. Learners must answer question number one (1) and any other **three** (3) questions. Question one (1) carries 40 marks and the remainder 20 marks each.

The examination will cover knowledge specifications.

Topic	**Approximate % examination weighting.**
Outcome 1: Identify basic elements of a Mechatronics system, and Outcome 2: Interpret system drawings and design simple systems including pneumatic and hydraulic, mechanical and electrical actuation systems.	20
Outcome 3: Devise models for mechanical, electrical, fluid and thermal systems, rotational-translational, electro mechanical and hydraulic-mechanical systems; model dynamic systems, derive system transfer functions and determine and analyse frequency response., and predict behaviour of systems.	20
Outcome 4: Understand and use digital logic and it applications.	20
Outcome 5: Describe basic structure of microprocessors, use programme languages, identify interface requirements, describe basic structure of PLCs, describe communication systems, recognise the techniques use to identify faults.	20
Outcome 6: Identify traditional and Mechatronics solutions to design problems.	20

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit 224 Dynamics of Mechanical Systems

Level: 7

Introduction

This unit equips learners to solve real-world problems and make future advances in mechanisms, manipulators, and robotics. This subject covers Motion analysis and dynamic modelling of systems of particles and rigid bodies in three-dimensional motion and digital control systems. It focuses on the modelling of a diverse range of dynamic systems and the design of controllers that will cause these systems to behave in the desired manner.

Unit Aim

This unit aims to lay a strong foundation of relevant theoretical concepts, so that the learner is able to analyse and solve problems in dynamics, kinetics and kinematics of rigid bodies in three dimensional space, model mechanical system in vibration. The unit also aims to expose the learner to the advanced concepts of control systems.

Prerequisites

It is recommended that learners have achieved the Graduate Diploma in Mechanical Engineering including Unit 100 Mathematics and Unit 136 Control systems.

Learning outcomes

There are **seven** learning outcomes to this unit. The learner will:

1. Understand kinematics of particle, particle dynamics, the use of energy methods for single and system of particle and momentum and moment of momentum of particles and Kinematics and kinetics of rigid bodies (2D and 3D).
2. Understand energy and Momentum for rigid bodies and Dynamics of general rigid body in motion (2D and 3D).
3. Understand mechanical vibration with single, two and multi degree of freedom vibration.
4. Understand Lagrange's Equations in generalised coordinates and its applications in impulse, momentum, and forced and damped vibration.
5. Understand non-Linear Vibration.
6. Understand analysis and control non-linear systems.
7. Understand modern control systems.

Guided learning hours

It is recommended that **150** hours should be allocated for this unit, of which **100** would be direct taught hours, while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Understand kinematics of particle, particle dynamics, the use of energy methods for single and system of particle and momentum and moment of momentum of particles and Kinematics and kinetics of rigid bodies (2D and 3D).

Assessment Criteria

The learner can:

Evaluate and solve problems in the following topics:

1. Velocity and acceleration with rectangular and cylindrical coordinates, path variables.
2. Particle dynamics.
3. Energy methods for particles and a system of particles.
4. Method of momentum for particles.
5. Translation and rotation of rigid bodies, Chasles' theorem.
6. Vector fixed in a moving reference and applications of fixed vector concept.
7. General relationship between time derivatives of a vector for different references.
8. Relationship between velocities for different references and acceleration for different references.
9. Mass Moment of Inertia and Inertia Tensor.
10. Moment of Momentum and Euler's Equation of Motion.
11. Translational, rotational and combined motion of the two.
12. Balancing of multi-cylinder engines.
13. Static equilibrium, Newton's laws, and calculation of reaction and internal forces

Outcome 2 Understand energy and Momentum for rigid bodies and Dynamics of general rigid body in motion (2D and 3D).

Assessment Criteria

The learner can:

Evaluate and solve problems in the following topics:

1. Kinetic energy of a rigid body in different motion
2. 2D and 3D situations
3. Work and Energy relations
4. Impulse momentum and angular momentum
5. Euler's equation of momentum
6. Application of Euler's momentum equation to 3D situation
7. Three dimensional motion about a fixed point
8. Conservation of energy
9. Conservation of linear and angular momentum

Outcome 3 Understand mechanical vibration with single, two and multi degree of freedom vibration.

Assessment Criteria

The learner can:

1. Analyse single degree of vibration with undamped and damped with free and force vibration; solve complex problems.
2. Explain oscillatory systems with multi degree of freedom, analyse system with two degree of freedom and solve problems in respect Vibration Transmission and Isolation.
3. Analyse torsional vibration and vibration of multi rotor systems single rotor system, multi rotor systems, torsionally equivalent shaft, vibrations of geared systems, Holzer Analysis.
4. Explain Tranverse vibration and whirling of shafts,
    a. A Rayleigh's Method
    b. Dunkerley's Method
    c. Influence Coefficient Method
5. Explain the mobility method and apply it to solve problems
6. Solve problems with periodic functions as the forcing function.
7. Explain motion for systems which have Continuously Distributed Masses and Elasticity
8. Explain second order differential equations

Outcome 4 Understand Lagrange's Equations in generalised coordinates and its applications in impulse, momentum, and forced and damped vibration.

Assessment Criteria

The learner can:

Explain the following topics:

1. Generalised Lagrange's Equation
2. Lagrange's Equations for Impulse and momentum
3. Lagrange's Equations for categories of mechanical vibration
4. Solve problems applying Lagrange's Equations.

Outcome 5 Understand non-Linear Vibration.

Assessment Criteria

The learner can:

Solve non-linear models using

1. Analytical methods
2. Graphical methods

Outcome 6 Understand analysis and control non-linear systems.

Assessment Criteria

The learner can:

Evaluate and solve problems in the following topics:

1. Properties of non-linear systems
2. Techniques for analyzing non-linear systems
3. Control design techniques for non-linear systems

Outcome 7 Understand modern control systems.

Assessment Criteria

The learner can:

1. Explain the design level of control systems with more emphasis on digital control systems and other topics which are not covered in Unit 136 at the Graduate Diploma level.

Unit 224 Dynamics of Mechanical Systems

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications.

Topic	Approximate % examination weighting.
Kinematics of particle, particle dynamics, the use of energy methods for single and system of particles, momentum and moment of momentum of particles and kinematics and kinetics of rigid bodies.	20
Energy and Momentum for rigid bodies and Dynamics of a general rigid body in motion.	20
Mechanical vibration and with single, two and multi degree of freedom vibration.	30
Lagrange's Equation and its applications to forces and damped vibration Non-Linear Vibration Analysis and control non-linear systems Modern controls systems	30

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

Learners should have access to laboratory experiments to practically investigate the topics covered in this module theoretically. Part of the final mark should be based on laboratory activities and lab reports. Solving problems is the most efficient way to understand this module. Video clips presentation for some of the topics will help the learners to have a better understanding.

Unit 225 Advanced Manufacturing Technology

Level: **7**

Introduction
This unit is about modern technologies used in manufacturing systems and processes.

Unit aim
The aim of this unit is to equip learners with the knowledge and skills required for the integration of the design of a product, its manufacture and associated commercial considerations. The learner will be able to choose the most appropriate technology for a manufacturing system.

Prerequisites
It is recommended that learners have achieved the Graduate Diploma in Mechanical Engineering.

Learning outcomes
There are **four** learning outcomes to this unit. The learner will:
1. Assess product design for most suitable manufacturing processes
2. Apply modern technologies to the manufacture of products
3. Determine process parameters for given conditions
4. Apply modern manufacturing strategies in various industries

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **90** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Assess product design for most suitable manufacturing processes

Assessment Criteria

The learner can:

1. Assess the implication of design on:
   a. traditional manufacturing methods
   b. modern advanced manufacturing methods
2. Correlate the interrelationship between design, component manufacture and product assembly.
3. Analyse production machining systems.
4. Analyse constraints affecting system performance.
5. Determine and analyse manufacturing systems operating parameters.
6. Assess performance, accuracy and quality requirements.

Outcome 2 Apply modern technologies to the manufacture of products

Assessment Criteria

The learner can:

1. Determine the most appropriate machining processes and techniques to product manufacture:
   a. material removal rate
   b. surface finish
   c. accuracy
   d. economics
2. Apply reverse engineering with regard to:
   a. rapid modelling (prototyping)
   b. concept modelling
   c. functional prototyping
3. Analyse data generation from models.
4. Apply time compression technologies to manufacturing..

Outcome 3 Determine process parameters for given conditions

Assessment Criteria

The learner can:

1. Assess the performance of high-speed machining techniques with regard to:
   a. material removal rate
   b. surface finish requirements
   c. accuracy
   d. economic considerations
2. Assess the effect of tool manufacture, materials and coatings on:
   a. performance
   b. tool life

c. component quality
3. Determine optimum cutting tool performance in high precision machining techniques:
   a. micro-machining
   b. three and five axis machining
   c. “single-hit” machining
4. Integrate machining techniques for increased production flexibility.
5. Assess and apply industrial lasers technology:
   a. cutting
   b. welding
   c. surface treatments
   d. in-process sensing systems
   e. automation
6. Assess the influence of machining systems on the accuracy and surface generation of components (metrology) using:
   a. in-line and off-line measurements
   b. contact and non-contact technologies
   c. co-ordinate measuring systems

Outcome 4 Apply modern manufacturing strategies in various industries

Assessment Criteria

The learner can:

1. Evaluate manufacturing processes and apply them to a minimum of two of the following:
   a. mechanical production applications
   b. aeronautical engineering applications
   c. chemical engineering applications
   d. automobile engineering applications
2. Assess the economic considerations of advanced manufacturing:
   a. product redesign
   b. manufacturing facilities
   c. time to market
   d. workforce training

Unit 225 Advanced Manufacturing Technology

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **eight** (8) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications.

Topic	Approximate % examination weighting.
Assess product design for most suitable manufacturing processes	25
Apply modern technologies to the manufacture of products	25
Determine process parameters for given conditions	25
Apply modern manufacturing strategies in various industries	25

The requirements to achieve overall success for this unit are:

Written examination Pass

Unit 226 Design and Operation of Marine Vehicles

Level: 7

Introduction

This unit is about the process of design of marine vehicles, including ships and offshore units and their propulsion and auxiliary systems. It also includes the dynamic behaviour of marine vehicles subjected to a variety of external and internal excitations plus materials and joining techniques in the marine environment.

Unit aim

The aim of this unit is to equip the learner with the knowledge and analytical skills required for working in a marine engineering related work environment.

Prerequisites

It is recommended that learners have achieved the Graduate Diploma in Mechanical Engineering including Unit 131 Materials and Unit 129 Fluid Mechanics

Learning outcomes

There are **four** learning outcomes to this unit. The learner will:

1. Determine appropriate dimensions, masses, propulsive power and auxiliary systems for a marine vehicle to satisfy a set of requirements
2. Analyse the operational dynamics of marine vehicles and verify their acceptability against appropriate criteria
3. Appreciate properties of common materials used for manufacturing marine vehicles and techniques for joining these materials
4. Describe the effects of economic, regulatory and safety considerations on the characteristics of marine vehicles

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **90** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Determine appropriate dimensions, masses, propulsive power and auxiliary systems for a marine vehicle to satisfy a set of requirements

Assessment Criteria

The learner can:

1. Recognise and apply components of the design process.
    a. iteration
    b. synthesis
    c. optimisation
2. Assess owner's requirements and prepare specifications.
3. Review preliminary ship design methods and determine dimensions for mass limited and space governed designs:
    a. mass groups
    b. capacity
    c. stability
    d. powering estimations
4. Assess the limitations of basis ship and regression based methods.
5. Select form coefficients and position of Longitudinal Centre of Buoyancy (LCB).
6. Use computer aided ship design software for:
    a. hull generation
    b. curve fitting
    c. fairing
7. Incorporate structural requirements in the design of marine vehicles:
    a. understand longitudinal strength calculations
    b. appreciate the influence of longitudinal strength considerations on various ship types
    c. recognise limitations on length/depth ratio
8. Appreciate torsional strength problems in:
    a. bulk carriers
    b. container ships
9. Assess offshore vehicle design including the naval architecture of principal types of offshore vehicle with particular reference to stability.
10. Select main and auxiliary power systems taking account of thermodynamic cycles and other characteristics of the prime movers, singly and in combination:
    a. diesel
    b. steam
    c. gas turbines
    d. electric motors
11. Match machinery to:
    a. vessel operational profile
    b. hull resistance
    c. propeller
12. Assess methods of waste energy recovery:
13. Assess electrical plant:
    a. load distribution
    b. management
    c. control of electric propulsion
14. Assess the design and operation of control systems 3-term controllers.
15. Appraise fuel and lubricating oil management:
    a. specification

b. quality
c. purchase and storage
d. testing and treatment

16. Describe the combustion process for oil.

Outcome 2 Analyse the operational dynamics of marine vehicles and verify their acceptability against appropriate criteria

Assessment Criteria

The learner can:

1. Analyse wave and sea states:
    - a properties of regular waves
    - b characteristics of irregular waves
    - c long and short crested seas
    - d properties of sea spectra
    - e definition of sea state
    - f encounter spectra
2. Analyse rigid body motions leading to natural frequencies:
    - a simple uncoupled solutions for
        - i roll
        - ii pitch
        - iii heave
    - b added mass and damping terms
    - c magnification factor
    - d phase relationships
    - e curves of extinction
3. Analyse response amplitude operators:
    - a definition
    - b determination by experiment
    - c application of strip theory
4. Analyse ship motion spectra.
5. Investigate operational conditions of marine vehicles in relation to:
    - a human tolerance limits
    - b speed loss in waves
    - c slamming
    - d wetness
    - e drilling and helicopter restrictions
6. Analyse motion reduction systems:
    - a passive
    - b active
7. Explain marine vehicle maneuvering:
    - a steering and turning
    - b angle of heel while turning
    - c rudder types and steering gear
    - d stopping
    - e dynamic positioning systems
8. Analyse marine vehicle vibrations:

a types of vibration experienced by
  i hull girder
  ii local structure
  iii systems
  iv rudders
  v shafts
  vi brackets
  vii machinery
b sources of excitation
  i waves
  ii propellers
  ii machinery
c prevention and cure
  i resonance avoidance
  ii damping
  iii effect of local stiffening

9. Estimate the natural frequencies of free-free beams:
   a virtual mass
   b shear and rotational effects
   c energy
   d deflection
   e approximate methods for fundamental vertical mode
   f higher modes

Outcome 3 Appreciate properties of common materials used for manufacturing marine vehicles and techniques for joining these materials

Assessment Criteria

The learner can:

1. Review currently available materials for marine vehicles
   a steels
   b light alloys

2 Appraise fabrication and joining techniques
   a weldability
   b types of weld
   c weld testing
   d detrimental effects of welding on fatigue life

Outcome 4 Describe the effects of economic, regulatory and safety considerations on the characteristics of marine vehicles

Assessment Criteria

The learner can:

1. Evaluate the criteria governing the economic operation of marine vehicles:
   a required freight rate
   b et present value
   c yield
   d permissible price
2. Evaluate the economic factors influencing selection of:
   a ship size
   b ship speed
   c machinery
   d type
3. Appreciate the role of IMO, government agencies and classification societies in the regulatory and statutory aspects of, for example, crew accommodation, fire protection and life saving appliances.
4. Appreciate the role of safety management systems and outline reliability concepts.
5. Describe environmental management related to marine vehicles:
   a statutory regulations
   b strategies to manage
   c. solid discharges
   d. liquid discharges
   e. gaseous discharges.

Unit 226 Design and Operation of Marine Vehicles

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **nine** (9) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications:

Topic	Approximate % examination weighting.
Determine appropriate dimensions, masses, propulsive power and auxiliary systems for a marine vehicle to satisfy a set of requirements.	35
Analyse the operational dynamics of marine vehicles and verify their acceptability against appropriate criteria	35
Appreciate properties of common materials used for manufacturing marine vehicles and techniques for joining these materials	10
Describe the effects of economic, regulatory and safety considerations on the characteristics of marine vehicles.	20

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

The teaching should make extensive use of real world examples and case studies to relate theory to practice. The learning outcomes give detailed content for which contextual judgement needs to be made as to the depth of study required for a given cohort of students depending on the type of shipbuilding extent locally.

Unit 227 Automobile Engineering

Level: 7

Introduction
This unit deals with mechanical, hydraulic, pneumatic, electrical, electronic, software and safety engineering aspects as applied to the design, manufacture and operation of road transport vehicles and their respective engineering subsystems. The unit focuses on the design and manufacture of automobiles and their component parts, as well as on the integration of components into an automotive system.

Unit aim
The aim of the unit is to equip the learner with the theoretical knowledge required to understand components, subsystems and systems and the integration of these into a complete vehicle. This will enable the learner to confidently handle vehicle problems and will provide a strong foundation for the development of the learner's career as an automotive designer and engineer.

Prerequisites
It is recommended that learners have achieved the Graduate Diploma in Mechanical Engineering.

Learning outcomes
There are **eight** learning outcomes to this unit. The learner will:
1. Understand vehicle structure and body design focusing on light and heavy vehicles
2. Understand constructional details of petrol and diesel engines and their operations
3. Understand the suspension system
4. Understand power transmission from engine to wheels, steering, and braking systems
5. Understand vehicle ventilation, air conditioning systems and other features that bring passenger comfort
6. Understand safety and ergonomics observed in vehicle design
7. Understand automotive electronics and use of computers and software in traction control, engine control, antilock brake system, active suspension and power steering, and safety and performance
8. Explain environmental impact of the automobile with fossil fuels and focusing on electric (EV), hybrid electric (HEV, powered by both an ICE and electric motor) and Fuel Cells Vehicles (FCV) as a means by which to reduce greenhouse gases and fuel consumption

Guided learning hours
It is recommended that **150** hours should be allocated for this unit of which **100** would be direct taught hours while the remainder is for independent study. The unit may be carried out on a full time or part time basis.

Assessment
This unit will be assessed by means of one three hour examination paper.

Outcome 1 Understand vehicle structure and body design focusing on light and heavy vehicles

Assessment Criteria

The learner can:

Explain the following:

a. Integral body construction
b. The structure of body and chassis of common different vehicles
c. Trailer and caravan crowbar couplings
d. Methods of mountings of various units to the chassis
e. Chassis lubrication systems
f. Vehicle body aerodynamics and commercial vehicle aerodynamic fundamentals

Outcome 2 Understand constructional details of petrol and diesel engines and their operations

Assessment Criteria

The learner can:

Explain the following:

a. General principles of heat engines
b. Engine balance, constructional details of the engine
c. Six-, eight- and twelve-cylinder engines
d. Sleeve valve and special engines
e. Diesel injection equipment and systems
f. Distributor type pumps
g. Some representative diesel engines
h. The two-stroke engine
i. Carburetion, some representative carburettors
j. Petrol injection systems
k. Induction manifold design
l. Emission control
m. Fuel pumps and engine intake air conditioning
n. Turbo charging and supercharging
o. Fuels and their combustion
p. Friction, lubricants and lubrication
q. Engine cooling systems
r. Electric propulsion
s. Alternative power units
t. Bearings, gearing, chains and belt drives
u. Engine lubrication.

Outcome 3 Understand the suspension system

Assessment Criteria

The learner can:

Understand and explain:

a. Suspension geometry and suspension roll centres
b. Body roll stability analysis and antiroll bars and roll stiffness
c. Rubber spring bumps
d. Axle and axle beam locations of light and heavy vehicles
e. Suspension design considerations and different suspension designs including air suspension
f. Hydro pneumatic automatic height correction
g. Variable rate leaf suspension systems
h. Tandem and tri-axle bogies
i. Electronic controlled pneumatic suspension systems

Outcome 4 Understand power transmission from engine to wheels, steering, and braking systems

Assessment Criteria

The learner can:

Explain the following:

1. Clutch fundamentals
   a. Representative friction clutches and their design and operation
   b. Clutch actuating mechanisms (manual, hydraulic, etc.)
2. Manual gear boxes and overdrives, setting gear ratios, lubrication:
   a. Hydrokinetic fluid couplings and torque converters, efficiency and torque capacity
   b. Fluid friction couplings
   c. Torque conversion and torque converters, multistage hydrokinetic torque converters
   d. Semi and fully automatic transmission
   e. Fundamentals of hydraulic transmission control and gear selection control, automatic transmission with electronic-hydraulic control
   f. Continuous variable pulley and belt transmission
   g. Properties of transmission fluids
3. Transmission bearings and constant velocity joints:
   a. Final drive transmission
   b. Crown wheel and pinion and axle adjustments
   c. Differential locks and skid reducing differentials
   d. Double reductions axles and two speed axles
   e. Four wheel drive arrangement
   f. Electro-hydraulic limited slip differential
4. Wheels and tyres:
   a. Tyre grip when braking and accelerating
   b. Traction control
   c. Traction and braking properties, tyre material and tread design, cornering properties
   d. Vehicle steady state directional stability
   e. Tyre marking identification

f. Wheel balancing

5. Steering System:
   a. Steering gear mechanism designs
   b. Steering geometry and wheel alignment
   c. Power assisted steering speed sensitive rack and pinion
   d. Steering linkage mechanisms, ball and socket joints
   e. Variable ratio rack and pinion
   f. Rack and pinion electric power assisted steering
6. Brake Systems:
   a. Brake shoe and pad fundamentals, shoe expanders and adjusters
   b. Disk brakes and pad support arrangements
   c. Dual braking systems
   d. Apportioned braking
   e. Antilock Brake System
   f. Brake servos and pneumatic operated brake systems for trucks and trailers
   g. Air operated power brakes
   h. Vehicle retarders
   i. Electro-pneumatic brakes

Outcome 5 Understand vehicle ventilation, air conditioning systems and other features that bring passenger comfort

Assessment Criteria

The learner can:

Explain the following:

a. Air conditioning and refrigeration
b. Ventilation system
c. Heating systems
d. Other passenger comfort considerations

Outcome 6 Understand safety and ergonomics observed in vehicle design

Assessment Criteria

The learner can:

Explain the following:

a. Design of seats and controls
b. Passenger safety

Outcome 7 Understand automotive electronics and use of computers and software in traction control, engine control, antilock brake system, active suspension and power steering, and safety and performance

Assessment Criteria

The learner can:

Explain the following:

a. Engine starter motors
b. Alternators
c. Battery Charging systems
d. Lighting systems
e. Power shutter operation
f. All electric drives
g. Electronic control systems, sensors and transducers for controlling of brakes, suspension steering, engine, traction, GPS, communications and safety
h. Use of computers and software to overall control.

Outcome 8 Explain environmental impact of the automobile with fossil fuels and focusing on electric (EV), hybrid electric (HEV, powered by both an ICE and electric motor) and Fuel Cells Vehicles (FCV) as a means by which to reduce greenhouse gases and fuel consumption

Assessment Criteria

The learner can:

Explain the following:

a. Alternative power devices
b. Hybrid electric vehicles
c. Full cell vehicles
d. Emission control

Unit 227 Automobile Engineering

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **nine** (9) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications.

Topic	Approximate % examination weighting.
Understand vehicle structure, body design focusing on light and heavy vehicles.	10
Understand and explain constructional details of petrol and diesel engines and engines and their operations.	20
Understand suspension system.	10
Understand power transmission from engine to wheels,	20
Understand vehicle ventilation, air conditioning system and other features that bring passenger comfort.	10
Understand safety and ergonomics observed in vehicle design	10
Understand automotive electronics and use of computers and software in traction control, engine control, antilock brake system, active suspension and power steering, and safety and performance.	10
Explain environmental impact of the automobile with fossil fuels and focusing on electric (EV), hybrid electric (HEV, powered by both an ICE and electric motor) and Fuel Cells Vehicles (FCV) as a means by which to reduce greenhouse gases and fuel consumption.	10

The requirements to achieve overall success for this unit are:

Written examination Pass/Merit/Distinction

Unit guidance

Delivery should offer access to typical vehicles and all components of such vehicle, including body, engines, transmission, electrical components and systems and hydraulic components and systems. These should be in an environment compatible with learning and teaching, but also with a hands-on approach.

Unit 228 Aerospace Engineering

Level: 7

Introduction

Aerospace engineering deals with the design and manufacture of aircraft or spacecraft structures, craft guidance systems, control and navigations systems, developing tools for communication and finally the production of the aircraft or spacecraft. Each of these areas of aerospace engineering is crucial for efficient functioning of the aircraft or spacecraft. Therefore, aerospace engineering imparts knowledge to aspiring aerospace engineers in each of these areas.

Unit aim

The aim of this unit is to equip the learner with foundation knowledge and skills required in aerospace engineering. Further study will be required in order to develop the knowledge required to be competent in designing aerospace vehicles.

Prerequisites

It is recommended that learners have achieved the Graduate Diploma in Mechanical Engineering.

Learning outcomes

There are **nine** learning outcomes to this unit. The learner will:

1. Understand the basic aerospace engineering principles and how an aero engine works and their significance.
2. Conduct a realistic analysis of any simplified gas turbines or jet engines and have knowledge and understanding of structural components of aerospace crafts and their behaviour, load carrying capacity, loading and performance envelope, etc.
3. Develop analytical capability towards analysis and assessment of structures.
4. Understand basic avionic systems, including radar, navigation and aircraft vision systems.
5. Understand the fundamentals of the performance of fixed-wing aircraft, develop skills required to formulate and solve representative performance problems, and understand the basics of aircraft stability.
6. Develop the ability to understand qualitatively and to predict quantitatively the flow over an aerofoil at all speeds.
7. Have a good understanding of Flight Dynamics/Flight Control Systems principles and how to apply them to solve related problems.
8. Understand broad Fundamentals of Rocket and Missiles and Rocket Propulsion
9. Manipulate aircraft design software

Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **90** would be direct taught hours while the rest is for independent study. The unit may be carried out on a full time or part time basis.

Assessment

This unit will be assessed by means of one three hour examination paper.

Outcome 1 Understand the basic aerospace engineering principles and how an aero engine works and their significance.

Assessment Criteria
The learner can:
Explain the following:
1. Basic Concepts:
The solar system - Reference frames and coordinate systems - The celestial sphere -The ecliptic – Motion of vernal equinox - Sidireal time - Solar time - Standard time - The earth's atmosphere.

2. The General N-Body Problem;
The Many body problems - Lagrange - Jacobi identity - The circular restricted three body problem – Libration points - Relative Motion in the N-body problem - The two - body problem - Satellite orbits – Relations between position and time - Orbital elements.

3. Satellite Injection and Satellite Orbit Perturbations;
General aspects of satellite injections - Satellite orbit transfer - Various cases - Orbit deviations due to injection errors - Special and general perturbations - Cowell's Method - Encke's method - Method of variations of orbital elements - General perturbations approach.

4. Interplanetary Trajectories Ballistic Missile- Trajectories;
Two-dimensional interplanetary trajectories - Fast interplanetary trajectories - Three dimensional interplanetary trajectories - Launch of interplanetary spacecraft - Trajectory about the target planet. The boost phase - The ballistic phase - Trajectory geometry - Optimal flights - Time of flight - Re-entry phase - The position of the impact point - Influence coefficients.

5. Materials for Spacecraft;
Space environment - Peculiarities -Effect of space environment on the selection of materials of spacecraft.

6. Aeroengine Basics;
Different types of aero engines, their profiles and how they function
Aeroengine accessories
Helicopter engines and its function

Outcome 2 Conduct a realistic analysis of any simplified gas turbines or jet engines and have knowledge and understanding of structural components of aerospace crafts and their behaviour, load carrying capacity, loading and performance envelope, etc.

Assessment Criteria

The learner can:

Explain the following:

1. Fundamentals of gas turbine engines:

Illustration of working of gas turbine engine - The thrust equation - Factors affecting thrust - Effect of pressure, velocity and temperature changes of air entering compressor - Methods of thrust augmentation – Characteristics of turboprop, turbofan and turbojet - Performance characteristics. Impulse and reaction blading of gas turbines - Velocity triangles and power output - Elementary theory Vortex theory - Choice of blade profile, pitch and chord - Estimation of stage performance – Limiting factors in gas turbine design - Overall turbine performance - Methods of blade cooling - Matching of turbine and compressor - Numerical problems.

2. Subsonic and supersonic inlet flow for jet engines

Internal flow and Stall in Subsonic inlets - Boundary layer separation - Major features of external flow near a subsonic inlet - Relation between minimum area ratio and eternal deceleration ratio - Diffuser performance - Supersonic inlets - Starting problem in supersonic inlets - Shock swallowing by area variation – External deceleration - Modes of inlet operation.

3. Combustion Chambers and nozzles

Classification of combustion chambers - Important factors affecting combustion chamber design – Combustion process - Combustion chamber performance - effect of operating variables on performance - Flame tube cooling - Flame stabilisation - Use of flame holders - Numerical problems.

Theory of flow in isentropic nozzles - Convergent nozzles and nozzle choking - Nozzle throat conditions - Nozzle efficiency - Losses in nozzles - Over expanded and under-expanded nozzles - Ejector and variable area nozzles - Interaction of nozzle flow with adjacent surfaces - Thrust reversal.

4. Compressors

Principal of operation of centrifugal compressor - Work done and pressure rise - Velocity diagrams – Diffuser vane design considerations - Concept of prewhirl - Rotating stall - Elementary theory of axial flow compressor - Velocity triangles - degree of reaction - Three dimensional flow - Air angle distributions for free vortex and constant reaction designs - Compressor blade design - Centrifugal and Axial compressor performance

Outcome 3 Develop analytical capability towards analysis and assessment of structures.

Assessment Criteria

The learner can:

Explain the following:

1. Statically determinate beams and statically indeterminate beams and frames

Double integration and moment area methods, Conjugate beam method, Principle of superposition, Beams of constant strength, Composite beams. Clapeyron's three moment equation method, Moment distribution method.

2. Application of Energy Methods for Aircraft Structures

Castigliano's theorem, Maxwells ' reciprocal theorem, Unit load method, Application to beams, trusses, frames, rings, etc.

3. Columns and beam columns

Columns with various end conditions, column curves, Columns with initial curvature, with eccentric loading, South well plot, short column formulae like Rankine's Johnsons, etc. Energy method. Various loading and end conditions.

4. Unsymmetrical Bending

Stresses in beams of unsymmetrical sections

5. Shear flow in open sections and shear flow in closed sections

Thin walled beams, Concept of shear flow, shear centre, Elastic axis. With one axis of symmetry, with wall effect and ineffective in bending, unsymmetrical beam sections.

Bredt - Batho formula, Single and multi-cell structures. Approximate methods. Shear flow in single and multicell structures under torsion. Shear flow in single and multicell under bending with walls effective and ineffective.

6. Buckling of Platges

Rectangular sheets under compression, Local buckling stress of thin walled sections, Crippling stresses by Needham's and Gerard's methods, Thin walled column strength. Sheet stiffener panels. Effective width, Inter rivet and sheet wrinkling failures.

7. Stress Analysis of Wings and Fuselage

Procedure - Shear and bending moment distribution for semi cantilever and other types of wings and fuselage, thin webbed beam. With parallel and non parallel flanges, Shear resistant web beams, Tension field web beams (Wagner's).

Outcome 4 Understand basic avionic systems, including radar, navigation and aircraft vision systems.

Assessment Criteria

The learner can:

Explain the following:

1. Basics In and Introduction to Avionic Syste4ms

Need for avionics in civil and military aircraft and space systems - Integrated avionics and weapon systems - Typical avionics subsystems, design, technologies.

Communication systems - Navigation systems - Flight control systems - Radar-
Electronic Warfare — Utility systems Reliability and maintainability - Certification.

2. Principles of Digital Systems
Digital computers - Microprocessors - Memories

3. Digital Avionics Architecture
Avionics system architecture - Databases - MIL - STD - 1553B - ARINC - 420 - ARINC - 629.

4. Flight Decks and Cockpits
Control and display technologies: CRT, LED, LCD, EL and plasma panel - Touch screen - Direct voice input (DVI) - Civil and Military Cockpits: MFDS, HUD, MFK, HOTAS..

Outcome 5 Understand the fundamentals of the performance of fixed-wing aircraft, develop skills required to formulate and solve representative performance problems, and understand the basics of aircraft stability.

Assessment Criteria
The learner can:
Explain the following:

1. Steady light and gliding and climbing flight
Steady level flight, Thrust/power, available and required with altitude. Estimation of maximum level flight speed, conditions for minimum drag and minimum power required.
Maximum range, Minimum rate of skin a glide, Shallow angles of climb, Rates of climb, time to climb and ceilings, Glide hodograph.

2. Performance problems
Range and endurance of jet and propeller type of airplanes. Estimation of take-off and landing distances. High lift devices, Use of thrust augmentation and reverse thrust.

3. Turning performances
Bank angle and load factor, Limitations on turn, Pull up and push over, the v-n diagram.

4. Propellers
Froude momentum and blade element theories, Propeller co-efficients, use of propeller charts, performance of fixed and variable pitch propellers.

Outcome 6 Develop the ability to understand qualitatively and to predict quantitatively the flow over an aerofoil at all speeds.

Assessment Criteria

The learner can:

Explain the following:

1. Aircraft Performance

Streamlined and bluff bodies, Aerofoil Characteristics, Pressure distribution round circular cylinder and aerofoils, Aerofoil classification and different designs of aerofoils.

2. Drag of Bodies

Types of drag, Effects of Reynold's number on skin friction and pressure drag, Drag reduction of airplanes. Momentum theory of finite wings, Induced drag, Chrodwise and spanwise pressure distributions. Aspect ratio, Camber and planform characteristics drag polar. Lift on aerofoils

Outcome 7 Have a good understanding of Flight Dynamics/Flight Control Systems principles and how to apply them to solve related problems.

Assessment Criteria

The learner can:

Explain the following:

1. Aircraft Stability and Control

a. Basics in stability and control

Degrees of freedom of a system, Static and dynamic stability. Need for stability in an airplane, Purpose of controls, inherently and marginally stable airplanes.

b. Static longitudinal and static lateral stability

Stick Fixed: Basic equations of equilibrium, Stability criterion, Wing and tail moments, Effects of fuselage and nacelles, Effects of c.g.location, Power effects, Stabiliser setting and c.g.location, Elevator effects, Stick fixed neutral point. Stick Free: Hinge moment coefficients, Stick free neutral point symmetric manoeuvres, Stick force gradients and stick force per g. Aerodynamic balancing of control surfaces.

Dihedral effect, coupling between rolling moment and yawing moment, adverse yaw, Aileron power, Aileron reversal. Weathercocking effect, Rudder requirements. One engine inoperative conditions, Rudder lock.

c. Dynamic longitudinal stability

Equations of motion, Stability derivatives, Routh's discriminant, solving the stability quartic, Phugoid motion, Factors affecting the period and damping.

d. Dynamic lateral and directional stability

Dutch roll and spiral instability Auto rotation and spin, Two control airplane.

Outcome 8 Understand broad Fundamentals of Rocket and Missiles and Rocket Propulsion

Assessment Criteria

The learner can:

Explain the following:

1. Fundamentals of rocket propulsion

Operating principle - Specific impulse of a rocket - internal ballistics - Rocket nozzle classifications – Rocket performance considerations - Numerical problems.

Operating principle - Subcritical, critical and supercritical operation - Combustion in ramjet engine – Ramjet performance - Sample ramjet design calculations - Introduction to scramjet - Preliminary concepts in supersonic combustion - Integral ram - rocket - Numerical problems.

Electric rocket propulsion - Ion propulsion techniques - Nuclear rocket - Types -Solar sail - Preliminary Concepts in nozzle less propulsion.

2. Rocket and Missiles

Ignition system in rockets - Types of igniters - Igniter design considerations - Design consideration of liquid rocket combustion chamber, injector propellant feed lines, valves, Propellant tanks outlet and helium Pressurised and turbine feed systems - Propellant slosh and propellant hammer - Elimination of geysering effect in missiles - Combustion system of solid rockets.

3. Chemical Rockets

Solid propellant rockets - Selection criteria of solid propellants - Important hardware components of solid rockets - Propellant grain design considerations - Liquid propellant rockets - Selection of liquid propellants – Thrust control in liquid rockets - Cooling in liquid rockets - Limitations of hybrid rockets - Relative advantages of liquid rockets over solid rockets - Numerical problems.

4. Aerodynamics of rockets and missiles

Airframe components of rockets and missiles - Forces acting on a missile while passing through atmosphere - Classification of missiles - Method of describing aerodynamic forces and moments - Lateral aerodynamic moment - Lateral Damping moment and longitudinal moment of a rocket - Lift and drag forces – Drag estimation - body upwash and downwash in missiles - rocket dispersion - Numerical problems.

5. Rocket motion in free space and gravitational field

One dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields - Description of vertical, inclined and gravity turn trajectories - Determination of range and altitude Simple approximations to burnout velocity.

6. Staging and controls of rocket missiles

Rocket vector control - Methods - Thrust termination - SITVC - Multistaging of rockets - Vehicle optimisation - Stage separation dynamics - Separation techniques.

7. Materials for rockets and missiles

Selection of materials - Special requirements of materials to perform under adverse conditions..

Outcome 9 Manipulate aircraft design software

Assessment Criteria

The learner can:

1. Demonstrate hands on experience using computer software for aerodynamic, stability and structures, and performance modeling of aircrafts.
2. Apply CFD analysis to solving 3D Aero Dynamic flows and thermal modelling focused on solving multimode heat transfer problems, from underhood thermal flows to air conditioning and heating air flows in aircraft environmental control systems.

Unit 228 Aerospace Engineering

Notes for guidance

Test specification for written paper

This is a written examination paper of **three** hours duration with a total of **nine** (9) questions. Learners must answer any **five** (5) questions.

The examination will cover knowledge specifications.

Topic	Approximate % examination weighting.
Have a broad understanding of basic aerospace engineering principles and how aeroengine works and their significance.	12
Conduct a realistic analysis of any simplified gas turbines or jet engines have a knowledge and understanding of structural components of aerospace crafts and their behaviour, load carrying capacity, loading and performance envelope, etc	11
Develop analytical capability towards analysis and assessment of structures	11
Understand basic avionic systems, including radar, navigation and aircraft vision systems	11
Understand the fundamentals of the performance of fixed-wing aircraft, develop skills required to formulate and solve representative performance problems, and understand the basics of aircraft stability.	11
Develop the ability to understand qualitatively and to predict quantitatively the flow over an aerofoil at all speeds.	11
Have a good understanding of Flight Dynamics/Flight Control Systems principles and to equip them to solve related problems.	11
Understanding of Fundamentals of Rocket and Missiles and Rocket Propulsion	11
Manipulate aircraft design software	11

The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction

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 learners
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Frequently asked questions.

Ensuring quality contains updates and good practice exemplars for City & Guilds assessment and policy issues. Specifically, the document contains information on:

- Management systems
- Maintaining records
- Assessment
- Internal verification and quality assurance
- External verification.

Access to Assessment and Qualifications provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for learners who are eligible for adjustments in assessment.

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

- ***Walled Garden***
  Find out how to register and certificate learners on line
- ***Qualifications and Credit Framework (QCF)***
  Contains general guidance about the QCF and how qualifications will change, as well as information on the IT systems needed and FAQs
- ***Events***
  Contains dates and information on the latest Centre events
- ***Online assessment***
  Contains information on how to register for GOLA assessments.

City & Guilds

Skills for a brighter future

www.cityandguilds.com

Useful contacts

UK learners **General qualification information**	**T: +44 (0)844 543 0033** **E: learnersupport@cityandguilds.com**
International learners General qualification information	T: +44 (0)844 543 0033 F: +44 (0)20 7294 2413 E: **intcg@cityandguilds.com**
Centres Exam entries, Registrations/enrolment, Certificates, Invoices, Missing or late exam materials, Nominal roll reports, Results	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: **centresupport@cityandguilds.com**
Single subject qualifications Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 F: +44 (0)20 7294 2404 (BB forms) E: **singlesubjects@cityandguilds.com**
International awards Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: **intops@cityandguilds.com**
Walled Garden Re-issue of password or username, Technical problems, Entries, Results, GOLA, Navigation, User/menu option, Problems	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: **walledgarden@cityandguilds.com**
Employer Employer solutions, Mapping, Accreditation, Development Skills, Consultancy	T: +44 (0)121 503 8993 E: **business_unit@cityandguilds.com**
Publications Logbooks, Centre documents, Forms, Free literature	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413

If you have a complaint, or any suggestions for improvement about any of the services that City & Guilds provides, email: feedbackandcomplaints@cityandguilds.com

Published by City & Guilds
1 Giltspur Street
London
EC1A 9DD
T +44 (0)844 543 0000
F +44 (0)20 7294 2413
www.cityandguilds.com

City & Guilds is a registered charity established to promote education and training