

# Level 6 Graduate Diploma in Engineering (9210-01)

Qualification handbook for centres



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November 2011  
Version 2.1 (July 2012)

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

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<b>Version and date</b>	<b>Change detail</b>	<b>Section</b>
2.0 Nov 2011	Amendments Unit 111 Outcome 2 and the 'notes for guidance'	Unit 111
2.1 July 2012	Added information regarding 'Incorporated Engineer and Chartered Engineer registration'	1 Introduction

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# 1 Introduction

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

<b>Qualification title and level</b>	<b>City &amp; Guilds qualification number</b>	<b>Registration and certification</b>
Level 6 Graduate Diploma in Civil Engineering	9210-01	
Level 6 Graduate Diploma in Electrical Engineering	9210-01	
Level 6 Graduate Diploma in Electronic and Telecommunication Engineering	9210-01	Consult the Walled Garden/Online Catalogue for last dates
Level 6 Graduate Diploma in Information Technology	9210-01	
Level 6 Graduate Diploma in Mechanical Engineering	9210-01	

## Introduction to this programme

The Graduate and Post Graduate Diplomas in Engineering have been developed for those undergoing training or those employed in Civil, Electrical or Mechanical Engineering. 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.

## Guidelines for the Graduate Diploma

The Level 6 Graduate Diploma in Engineering is set at the standard of the final (third) year of a British BEng (Honours) degree course. It is advised that the Level 6 Graduate Diploma in Engineering consist of 1800 Notional Hours (total learning hours including the Guided Learning Hours and self study/research).

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

Learners must be registered for the 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 Graduate Diploma requirements.

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



## Qualification structure

To achieve the **Level 6 Graduate Diploma in Civil Engineering** learners must successfully complete **3 Mandatory** plus **4 Pathway Mandatory** and any **4 Optional** units.

City & Guilds unit	Practical assignment number (if applicable)	Unit title	Compulsory/ optional for full qualification
100		Engineering mathematics	Mandatory
101		Management for engineers	Mandatory
102	602	Mechanics of solids and basic structural analysis	Pathway Mandatory
103	603	Hydraulics and hydrology	Pathway Mandatory
104	604	Engineering surveying	Pathway Mandatory
105	605	Soil mechanics and engineering geology	Pathway Mandatory
106	606	Building engineering	Optional
107	607	Quantity surveying	Optional
108	608	Highway engineering	Optional
109	609	Irrigation engineering	Optional
110	610	Water and waste engineering	Optional
111	611	Structural analysis	Optional
139		Project 1	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 assignments 139, 602-605, plus appropriate practical assignments for the chosen optional units (606-611). Please see a separate assessment guidance document for details.

To achieve the **Level 6 Graduate Diploma in Electrical Engineering** learners must successfully complete **3 Mandatory** plus **4 Pathway Mandatory** and any **4 Optional** units.

<b>City &amp; Guilds unit</b>	<b>Practical assignment number (if applicable)</b>	<b>Unit title</b>	<b>Compulsory/ optional for full qualification</b>
100		Engineering mathematics	Mandatory
101		Management for Engineers	Mandatory
112	612	Circuits and waves	Pathway Mandatory
114	614	Electrical energy system	Pathway Mandatory
115	615	Electrical machines and drives	Pathway Mandatory
116	616	Electronics and telecommunications	Pathway Mandatory
118	618	Communication systems	Optional
121		Computer networks	Optional
123		Computer architecture and operating systems	Optional
124		Database management	Optional
127		Software engineering	Optional
136	636	Control systems	Optional
139		Project 1	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 assignments 139, 612, 614-616, plus appropriate practical assignments for the chosen optional units (618, 636). Please see a separate assessment guidance document for details.

To achieve the **Level 6 Graduate Diploma in Electronic and Telecommunication Engineering** learners must successfully complete **3 Mandatory** plus **4 Pathway Mandatory** and any **4 Optional** units.

<b>City &amp; Guilds unit</b>	<b>Practical assignment number (if applicable)</b>	<b>Unit title</b>	<b>Compulsory/ optional for full qualification</b>
100		Engineering mathematics	Mandatory
101		Management for engineers	Mandatory
112	612	Circuits and waves	Pathway Mandatory
113	613	Electrical machines and electrical energy system fundamentals	Pathway Mandatory
117	617	Electronic systems	Pathway Mandatory
118	618	Communication systems	Pathway Mandatory
119		Wireless and mobile communication	Optional
121		Computer networks	Optional
123		Computer architecture and operating systems	Optional
125		Signals and systems	Optional
127		Software engineering	Optional
136	636	Control systems	Optional
139		Project 1	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 assignments 139, 612, 613, 617, 618, plus appropriate practical assignments for the chosen optional units (636). Please see a separate assessment guidance document for details.

To achieve the **Level 6 Graduate Diploma in Information Technology** learners must successfully complete **3 Mandatory** plus **4 Pathway Mandatory** and any **4 Optional** units.

<b>City &amp; Guilds unit</b>	<b>Practical assignment number (if applicable)</b>	<b>Unit title</b>	<b>Compulsory/ optional for full qualification</b>
100		Engineering mathematics	Mandatory
101		Management for engineers	Mandatory
119		Wireless and mobile communication	Optional
120		Computer programming and information systems	Optional
121		Computer networks	Pathway Mandatory
122		Web design and applications	Optional
123		Computer architecture and operating systems	Optional
124		Database management	Pathway Mandatory
126		Information management	Pathway Mandatory
127		Software engineering	Pathway Mandatory
136	636	Control systems	Optional
139		Project 1	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 139 plus appropriate practical assignments for the chosen optional units (636). Please see a separate assessment guidance document for details.

To achieve the **Level 6 Graduate Diploma in Mechanical Engineering** learners must successfully complete **3 Mandatory** plus **4 Pathway Mandatory** and any **4 Optional** units.

<b>City &amp; Guilds unit</b>	<b>Practical assignment number (if applicable)</b>	<b>Unit title</b>	<b>Compulsory/ optional for full qualification</b>	<b>Barred combinations</b>
100		Engineering mathematics	Mandatory	
101		Management for engineers	Mandatory	
128	628	Applied thermodynamics	Pathway Mandatory	
129	629	Fluid mechanics	Pathway Mandatory	
130	630	Mechanics of machines and strength of materials	Pathway Mandatory	
131	631	Materials	Pathway Mandatory	
132	632	Manufacturing technology	Optional	Cannot be used if Unit 133 was chosen
133		Analysis and design of manufacturing technology	Optional	Cannot be used if Unit 132 was chosen
134	634	Hydraulics and hydraulic machines	Optional	
135	635	Mechanics of solids	Optional	
136	636	Control systems	Optional	
137	637	Electro techniques	Optional	
138		Quality and reliability engineering	Optional	
139		Project 1	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 assignments 139, 628-631 plus appropriate practical assignments for the chosen optional units (632, 634-637). Please see a separate assessment guidance document for details.

## Opportunities for progression

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

- Level 7 Post Graduate Diploma in Engineering
- Relevant higher level qualifications

## 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.

## Qualification support materials

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

<b>Description</b>	<b>How to access</b>
Qualification handbook	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
Assessment guidance documents	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
Recording forms	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>

## 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.

### 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.

#### Learner entry requirements

Acceptance on to the Graduate Diploma course is through possession of a relevant City & Guilds Advanced Technician Diploma or Higher National Diploma, or equivalent qualification. 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

### 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 are 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.

### 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.

### Certification

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

## 4 Assessment

### Summary of assessment methods

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

- **one written** paper 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.

### 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.

### 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.

### 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.

### 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.

## 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
- 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 number	Title
100	Engineering mathematics
101	Management for engineers
102	Mechanics of solids and basic structural analysis
103	Hydraulics and hydrology
104	Engineering surveying
105	Soil mechanics and engineering geology
106	Building engineering
107	Quantity surveying
108	Highway engineering
109	Irrigation engineering
110	Water and waste engineering
111	Structural analysis
112	Circuits and waves
113	Electrical machines and electrical energy system fundamentals
114	Electrical energy system
115	Electrical machines and drives
116	Electronics and telecommunications
117	Electronic systems

<b>City &amp; Guilds number</b>	<b>Title</b>
118	Communication systems
119	Wireless and mobile communication
120	Computer programming and information systems
121	Computer networks
122	Web design and applications
123	Computer architecture and operating systems
124	Database management
125	Signals and systems
126	Information management
127	Software engineering
128	Applied thermodynamics
129	Fluid mechanics
130	Mechanics of machines and strength of materials
131	Materials
132	Manufacturing technology
133	Analysis and design of manufacturing technology
134	Hydraulics and hydraulic machines
135	Mechanics of solids
136	Control systems
137	Electro techniques
138	Quality and reliability engineering

**Level:** 6

## Introduction

This unit is about advanced mathematical techniques and their applications as required by practicing engineers.

## Unit aim

The unit aim is to equip the learner with the mathematical expertise required to function as a professional engineer.

## Learning outcomes

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

1. Solve engineering problems using mathematical methods
2. Solve engineering problems using numerical methods
3. Solve engineering problems using statistical methods

## 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 paper.

The learner is expected to have knowledge of Mathematics including Statistics and Probability ie the City & Guilds 6165-30-075/175 or 8030-227 or 2565-03-047 or relevant HND or equivalent.

# Unit 100      Engineering mathematics

## Assessment Criteria

### **Outcome 1      Solve engineering problems using mathematical methods**

The learner can:

1. Express functions of 2 or 3 variables in terms of other variables.
2. Find Taylor series expansions.
3. Determine both constrained and unconstrained maxima and minima.
4. Solve problems involving vector calculus: Gauss' law, Green's theorem, Stokes' theorem.
5. Employ vector calculus to simple applications.
6. Apply simple applications from field theory.
7. Solve problems involving complex variable theory: analytic functions, Cauchy-Riemann equations, poles, zeros and residues, conformal transformations.
8. Apply Laplace transform methods to the solution of differential equations; transfer functions, convolution theorem.
9. Apply Z-transform methods to the solution of difference equations and discrete systems.
10. Solve second order partial differential equations by separation of variables including the use of Fourier series.

### **Outcome 2      Solve engineering problems using numerical methods**

The learner can:

1. Solve sets of linear equations: Gauss – Seidel and Jacobi methods matrix factorisation methods.
2. Solve numerical optimisation problems; direct search method, simple gradient methods.
3. Determine matrix Eigen values and Eigen vectors; direct and inverse iteration, shift of origin.
4. Solve simple systems of ordinary differential equations using Eigen value analysis.
5. Apply the above to vibration problems.
6. Solve initial value problems for ordinary differential equations numerically: Taylor series, Runge-Kutta method, Simple linear multi-step methods, convergence and stability, coupled ordinary differential equations.
7. Solve boundary value problems for ordinary differential equations numerically.
8. Use simple finite difference methods to solve partial differential equations.
9. Solve initial value problems for partial differential equations numerically; explicit and implicit procedures, simple ideas on errors and stability.
10. Solve boundary value problems for partial differential equations numerically; direct solution of finite difference equations, iterative solution of finite difference equations.

### **Outcome 3      Solve engineering problems using statistical methods**

The learner can:

1. Solve problems using Binomial, Poisson and Normal distributions to include; probability of defects in production, errors in observation.
2. Test samples to make statistical decisions;  $\chi^2$ , t-tests, regression.
3. Use Markov chains.
4. Apply the above to queuing theory.

# Unit 100      Engineering mathematics

Notes for guidance

## Test specification for written paper Engineering Mathematics Unit 100

This examination paper is of three hours duration with nine (09) questions set in three parts. Learners must answer five (05) questions with at least one from each part.

The examination will cover the knowledge specifications.

Topics	Approximate % examination weighting
Mathematical methods	40
Numerical methods	30
Statistical methods	30

### The requirement to achieve overall success for this unit is:

Written examination    Pass/Merit/Distinction

**Level:** 6

## Introduction

This unit deals with management principles, organisational structures, performance measurement, management of technology and control issues of particular relevance to engineers and technologists in management.

## Unit aim

The aim is to provide engineers and technologists with an understanding of management principles, organisational structures, performance measurement, management and control of technology, and develop the awareness of the learner to the broader functions of management.

## Learning outcomes

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

- 1 Describe managerial functions, roles and responsibilities
- 2 Recognise the issues, difficulties and problems facing management and how to address them
- 3 Develop an appreciation of economics, financial accounting and financial management, and understand engineering management, in relation to other managed activities, such as quality, finance, accounting, legal, marketing, sales, purchasing, logistics, and personnel
- 4 Appreciate and use of tools for planning and decision making process

## 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 paper.

Learners are expected to hold a relevant engineering qualification at the City & Guilds Advanced Technician Diploma, HND or equivalent level.



# Unit 101 Management for engineers

## Assessment Criteria

### **Outcome 1 Describe managerial functions, roles and responsibilities**

The learner can:

1. Recognise the nature of organisations: - types of business, business objectives, strategy and policy and legal requirements of business.
2. Recognise the impact of technology on society.
3. Describe the structures, functions and roles within contemporary business organisations.
4. Describe the structures, functions and roles within contemporary business organisations.
5. Prepare financial reports, budgets, costings, accounts and project appraisals.
6. Explain roles of management and skills required for management: - leadership, motivation, team working, team building and personal management.
7. Prepare plans for professional development and career advancement.
8. Develop an understanding of professional issues in management.
9. Develop an understanding of the generic issues in project management environments.
10. Recognise classical techniques for project management.
11. Control resource scheduling, budgeting and cost.
12. Perform risk assessment in project management.
13. Investigate human factors and team issues in project management.
14. Present and analyse business data (descriptive statistics not statistical inference).
15. Use decision analysis techniques; decision trees, EMV, EVPI.
16. Assess the value of information.
17. Develop an understanding of optimisation principles, LP formulation, and graphic solutions.
18. Use simulation principles for analysing business problems.
19. Use forecasting techniques for the development of the organisation.

### **Outcome 2 Recognise the issues, difficulties and problems facing management and how to address them**

The learner can:

1. Recognise management issues within and across business functions: marketing and sales, managing the design and product development process, procurement, purchasing and supply chain management, human resource management and development, job design and work organisation, productivity and work measurement, performance measurement, continuous improvement, knowledge and information management.
2. Recognise issues facing organisations: - ethics and corporate responsibility, health and safety at work, legal requirements, environmental issues, and International business.

### **Outcome 3    Develop an appreciation of economics, financial accounting and financial management, and understand engineering management, in relation to other managed activities, such as quality, finance, accounting, legal, marketing, sales, purchasing, logistics, and personnel**

The learner can:

1. Explain the following:

Economics

- a. The Theory of consumer behaviour
- b. Theory of Production
- c. Concepts of different types of costs and Cost Functions

Managerial Economics (Micro)

The economic way of thinking –

- a. The economic approach
- b. Supply, Demand and the market process
- c. Demand Forecasting

Market Structures:

- a. Market equilibrium –perfect competition
- b. Monopoly and monopolistic competition
- c. Duopoly and Oligopoly
- d. Public Goods and Market failure.
- e. Pricing & Price Determination Basic concepts

Trade

- a. Basic concepts of Balance of payments.
- b. Business cycles.
- c. Basic concepts of IS-LM models
- d. Effectiveness of Monetary & Fiscal Policy
- e. Keynesian Economic theory versus Classical Economic theory.
- f. Theories of consumption function. (Basic Concepts)

International economics and comparative systems:

- a. Economic growth & Measurement
- b. Economic Development & Sustainable Development
- c. Financing Development
- d. Gains from International Trade
- e. Trade & Economic development
- f. International Finance and Foreign Exchange Market

Financial Accounting and Financial Management

Financial Accounting

Introduction – Theory and Transactions

- a. Basic Accounting Concepts
- b. Generally Accepted accounting Principles (GAAP)

Financial statements

- a. Income Statement
- b. Balance Sheet
- c. Cash Flow Statements
- d. Common Size Statements

Preparation of Final Accounts

- a. Trading and Profit and Loss Account
- b. Balance Sheet
- c. Treatment of Outstanding and Prepaid Expenses
- d. Treatment of Bad Debts

e. Treatment of Depreciation

f. Other Adjustments

Financial Management

a. Fundamental concepts of financial management, goals of the Firm

b. Nature of financial management

c. Financial planning

d. Organisation of the finance function

Basic Financial Concepts

Time value of money

a. Techniques of Financial Analysis

b. Fund flow statement

c. Cash flow statement

Financial Statement Analysis

a. Ratio analysis

b. Common size statements

Budgets And Budgetary Control

a. Procedure in preparing budgets

b. Budgets reports

c. Functional budgets

d. Cash budgets

e. Master budget

f. Fixed and flexible budgets

g. Zero based budgeting

h. Performance budgeting

Marginal Costing And Break Even Analysis

a. Marginal cost equations

b. Cost volume profit relationship

c. Break even analysis

d. Marginal costing vs absorption costing

2. Prepare financial reports, budgets, costings, accounts and project appraisals

3. Management, the direction of employees and other resources to achieve objectives; Labour management, specifically, in planning, organising, leading and controlling of the operative functions of personnel.

## **Outcome 4    Appreciate and use of tools for planning and decision making process**

The learner can:

Explain the following:

1. Decision Making

a. Decision making under certainty and uncertainty

b. Make or buy decisions

c. Accept or reject decisions

d. Differential cost analysis

e. Shut down decision

f. Pay off Matrices

g. Decision Trees

h. Other Techniques

2. Forecasting

a. Sales and Revenue forecasting

b. Technological Forecasting

c. Other types of forecasting techniques

3. Planning
  - a. Linear Programming – Graphical and Simplex method
  - b. Simulations
  - c. PERT
  - d. CPM
  - e. Others
  - f. Network Analysis
  - g. Project planning
  - h. Strengths and weaknesses of Planning tools
4. SWOT analysis
5. Investment appraisal
6. Inventory Control
7. Probability and Decision making
8. Project Management covering project outcomes, cost and time estimation, project planning, communications, critical path analysis, reviews, contract law, standards, document control

# Unit 101 Management for engineers

## 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 examination will cover knowledge specifications.

Topics	Approximate % examination weighting
Understand managerial functions, roles and responsibilities, and organisational behaviour	25
Recognise the issues, difficulties and problems facing management and how to address them	25
Develop an appreciation of economics, financial accounting and financial management, and understand engineering management, in relation to other managed activities, such as quality, finance, accounting, legal, marketing, sales, purchasing, logistics, and personnel.	25
Appreciate and use of tools for planning and decision making process	25

### The requirement to achieve overall success for this unit is:

Written examination

Pass/Merit/Distinction

### Unit guidance

Deliver using case studies and group projects.

**Level:** 6

### Introduction

This unit is intended to teach the learner the basics of the elastic and plastic behaviour of engineering components and to determine stresses, strain and deflections under various load conditions. It is also intended to lay a foundation for analysis and design of structures by teaching the basic concepts of Equilibrium, Stability and Indeterminacy criteria, the functional requirements of structures and the analysis of statically determinate/indeterminate structures.

### Unit aim

The aim of this unit is to provide the concepts governing elastic and plastic analysis and design of structures. On the successful completion of this unit the learner should have sufficient knowledge and skills to analyse and design simple structures in a civil engineering designs office.

### Learning outcomes

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

1. Calculate stresses, strain and deflections in simple structural members under given load conditions
2. Perform elastic analysis of simple structural components
3. Explain stability and instability
4. Demonstrate the use of simple computer software used in stress analysis

### Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** 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 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 ie as per the City & Guilds Advanced Technician Diploma 6165-30-073/173 or relevant HND or other equivalent.

# Unit 102                      Mechanics of solids and basic structural analysis

## Assessment Criteria

### Outcome 1      Calculate stresses, strain and deflections in simple structural members under given load conditions

The learner can:

1. Explain the purpose and function of structures, types of structures and describe types of supports.
2. Identify types of loads and calculate their magnitudes.
3. Use **Mohr's Circle** to determine **stresses** on inclined planes and combined bending torsion and axial loading.
4. Determine shear force and bending moment, bending stress and shear stress distribution in beams.
5. Explain Basic Structural Concepts, describe **Static Indeterminacy**.
6. Determine shear stress and twist of circular solid sections, thin walled sections and simple open sections.

#### Range

**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.

**Deflection** – the displacement of a point on a structure under load

**Mohr's Circle** – a two dimensional graphical representation of the state of stress at a point

**Static Indeterminacy** - static equilibrium equations are insufficient for determining the internal forces and reactions on a structure and additional methods must be adopted

### Outcome 2      Perform elastic analysis of simple structural components

The learner can:

1. Explain and determine Work and Complementary work; **Virtual Work; Strain Energy**.
2. Describe Basic Energy Theorems.
3. Use virtual forces in obtaining displacements.
4. Use virtual displacements in obtaining equilibrium equations.
5. Apply the principle of minimum potential energy.
6. Use analytical or graphical methods for beam analysis, derive **shear force** and **bending moment** diagrams and deflections for simply supported beams and cantilevers.
7. Analyse statically determinate and statically indeterminate structures by calculating forces for pin jointed frames, beams, rigid jointed frames and arches.
8. Derive displacements of statically determinate and indeterminate structures; pin jointed frames, beams, rigid jointed frames and arches.
9. Generate **influence lines** for statically determinate and indeterminate structures; pin jointed frames, beams, rigid jointed frames and arches.

#### Range

**Elastic Analysis** - examination of structures or materials based on their reaction to stresses in stretching or bending elastically.

**Virtual Work** - is the work resulting from either virtual forces acting through a real displacement or real forces acting through a virtual displacement. A principle used in statics to solve equilibrium problems.

**Strain Energy** - The external work done on an elastic member in causing it to distort from its unstressed state is transformed into strain energy which is a form of potential energy.

**Bending Moment** - A bending moment exists in a structural element when a moment is applied to the element so that the element bends. Moments and torques are measured as a force multiplied by a distance eg kilonewton-meters (KN•m).

**Shear Force** - The force transverse to a beam at a given section tending to cause it to shear at that section. It is equal to the algebraic sum of all the vertical forces on either side of the section.

**Influence line** – is a graphical representation of the variation of a function (such as the shear, reaction or bending moment) at a specific point on a beam, truss or other structure caused by a unit load placed at any point along the structure (ie a moving load).

### **Outcome 3 Explain stability and instability**

The learner can:

1. Investigate Structures and Equilibrium, General principles of criteria of **elastic stability** (neutral, stable, unstable etc).
2. Analyse stability of **struts and columns**.
3. Apply **Euler load** to determine buckling for pin-ended struts and other end conditions.
4. Investigate the effects of initial curve, lateral load and eccentric load on structures/beams/columns.
5. Investigate **lateral torsional buckling** of beams.

#### **Range**

**Elastic stability** – the elastic state of a loaded system beyond which elastic instability can occur, including lateral buckling of members subjected to bending and/or compression.

**Struts and columns** – structural components designed to operate principally under compression loading.

**Euler load** – the axial compression load that a member can carry without buckling, calculated by a method derived by Euler.

**Lateral torsional buckling** – occurs where lateral buckling is accompanied by torsional deformation of the loaded component.

### **Outcome 4 Demonstrate the use of simple computer software used in stress analysis**

The learner can:

1. Use software packages for simple design calculations.

#### **Range**

**Stress analysis** - process of calculation determining the stress in materials and structures subjected to loads.



# Unit 102            Mechanics of solids and basic structural 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 knowledge specifications:

<b>Topics</b>	<b>Approximate % examination weighting</b>
Mechanics of Solids	30
Basic Structural Analysis	70

## The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

Pass in Practical work requires satisfactory achievement of all competencies (refer to Unit 102 record sheet).

## Unit guidance

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

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

**Level:** 6

### Introduction

This unit is about the principles and processes involved in fluid mechanics, hydraulics and engineering hydrology.

### Unit aim

The aim of the unit is to provide/develop understanding of flow situations in fluid mechanics and hydraulics and explain aspects of engineering hydrology. It also aims to enable the identification of problems and how to devise solutions.

### Learning outcomes

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

1. Identify and process solutions for problems in fluid mechanics, pipe flow, rotodynamic machines and open channel flow
2. Analyse hydrological data and design engineering applications that involves aspects of engineering hydrology

### 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 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.

The learner is expected to have knowledge of fluid at rest and in motion, at the level of City & Guilds Advanced Technician Diploma in the Construction Unit 6165-30-073, relevant HND or other equivalent.

# Unit 103      Hydraulics and hydrology

## Assessment Criteria

### **Outcome 1      Identify and process solutions for problems in fluid mechanics, pipe flow, rotodynamic machines and open channel flow**

The learner can:

1. Determine fluid continuity and solve problems using Bernoulli's equation.
2. Apply energy and momentum principles in an engineering context.
3. Assess free and forced vortex flow.
4. Assess steady flow in pipes in respect of:
  - a pipe friction
  - b velocity distributions
  - c laminar and turbulent flows in smooth and rough pipes
  - d Poiseuille's law
  - e Darcy's law
5. Examine the relationship between friction factor, Reynolds number and relative roughness.
6. Examine local losses in pipe systems due to friction.
7. Analyse pipe networks using Hardy Cross method and Cornish method.
8. Determine the reasons for unsteady pipe flow in respect of:
  - a frictionless incompressible behaviour
  - b frictionless compressible behaviour
  - c surge tanks
9. Describe the one-dimensional theory of:
  - a pumps
  - b turbines
10. Classify pumps and turbines.
11. Assess pumps and turbines with respect to:
  - a characteristics
  - b specific speed
  - c cavitations
12. Select a pump for a range of pipe systems.
13. Assess steady flow in an open channel using Chezy and Manning equations.
14. Design non-erodible channels.
15. Recognise the effect of sediment transportation in open channels.
16. Analyse gradual varied non-uniform flow in channels.
17. Apply energy and momentum principles to rapidly varied flow in open channels in respect of:
  - a hydraulic structures
  - b short channel transitions
  - c thin weirs
  - d flow gauging structures
  - e hydraulic jump
18. Derive formulae using dimensional analysis.
19. Investigate the criteria, parameters and scales for physical models of:
  - a hydraulic structures.
  - b rivers etc.
20. Ascertain the relative merits of physical and mathematical models.

## **Outcome 2    Analyse hydrological data and design engineering applications that involves aspects of engineering hydrology**

The learner can:

1. Describe the hydrological cycle; rainfall, runoff.
2. Describe river gauging systems and flow measurements.
3. Use unit hydrographs.
4. Assess flood and drought forecasting.
5. Assess storage and flood control reservoirs, mass curves and reservoir flood routing.
6. Analyse groundwater flow.

# Unit 103            Hydraulics and hydrology

## Notes for guidance

### Test specification for written paper

This examination is of three hours duration with a total of nine (09) questions in two sections. Learners must answer five (05) with at least two (02) questions from each section.

The examination will cover knowledge specifications:

<b>Topics</b>	<b>Approximate % examination weighting</b>
Hydraulics	60
Hydrology	40

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

### Introduction

This unit is about the fundamental survey techniques required for various civil engineering applications including buildings, irrigation systems, roads, railways and tunnels.

### Unit aim

The unit aims to develop understanding of advanced theories of surveying and modern surveying techniques and procedures used in engineering surveying applications.

### Learning outcomes

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

1. Understand the error types, random, systematic and gross; know their source and how to manage them
2. Carry out a range of survey types using modern equipment and technology, and taking due regard of accuracy, precision and errors
3. Analyse survey data accurately and reliably using standard convention
4. Apply survey methods to industrial 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, **60** hours practical work and the remainder independent study. This 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.

The learner is expected to have sound knowledge of the related materials at the level of City & Guilds Advanced Technician Diploma in Construction Unit 6165-30-061 or relevant HND or other equivalent. This includes the practical aspects of setting out of works and a detailed understanding of the techniques used in surveying and setting out and their purpose.

# Unit 104      Engineering surveying

## Assessment Criteria

### **Outcome 1      Understand the error types, random, systematic and gross; know their source and how to manage them**

The learner can:

1. Explain the meaning and purpose of engineering surveying.
2. Understand the principles of measurement.
3. Recognise errors in measurement.
4. Establish precision and accuracy limits in surveys.
5. Eliminate mistakes and systematic errors in measurement.
6. Recognise random errors and understand the general laws of probability.
7. Apply corrections for measurements.

### **Outcome 2      Carry out a range of survey types using modern equipment and technology, and taking due regard of accuracy, precision and errors**

The learner can:

1. Use, theodolite, total station and GPS together with any associated software and be able use the instruments to produce reliable data in three dimensions.
2. Set out conventionally shaped structures or works including buildings, drainage, earthworks and highways works, using appropriate techniques
3. Use electronic total station instruments.
4. Carry out triangulation surveys in respect of :
  - a networks
  - b selection of stations
  - c base line measurements and corrections
  - d angle measurements and corrections
5. Make adjustments for triangulation figures.
6. Explain the fundamental principles of levelling in respect of:
  - a. test and adjust levelling instruments
  - b. levelling techniques
  - c. reciprocal levelling
  - d. trigonometrical levelling
  - e. earth curvature and refraction
  - f. acceptable limits of errors in levelling
  - g. digital levels
  - h precise levelling
7. Measure distance by taping and electromagnetic methods:
  - a. fundamental Electronic Distance Measurement (EDM) theory
    - i errors
    - ii calibration
  - b. correction and reduction of measured distances to National Grid distance
8. Appraise developments in EDM.
9. Explain the principles of photogrammetry in surveying.
10. Interpolate measurements from aerial photographs.

11. Assess stereoscopic viewing and parallax.
12. Explain the principles of Geodetic survey.
13. Carryout geodetic control surveys including precise traversing, triangulation and levelling.
14. Use Global Positioning Systems (GPS) in surveying in respect of:-
  - a. user, space and control segments
  - b. overviews of the applications of
    - i signals and codes
    - ii static and kinematic applications of GPS
    - iii real time and post processed solutions
15. Appraise recent developments in GNSS engineering surveying instrumentation and techniques, including laser scanning.

### **Outcome 3 Analyse survey data accurately and reliably using standard convention**

The learner can:

1. Handle data involving:
  - a. angles
  - b. bearings
  - c. co-ordinates.
2. Produce computations involving National Grid rectangular co-ordinates.
3. Define True North and Grid North.
4. Determine local scale factors, convergence of meridians and other parameters by:
  - a. approximations
  - b. precise methods.
5. Correlate both surface and underground surveys to the National Grid.
6. Make Bowditch adjustment of traverses.
7. Appraise engineering survey networks.

### **Outcome 4 Apply survey methods to industrial applications**

The learner can:

1. Implement dimensional control in engineering constructions by setting out horizontal, transition and vertical curves:
  - a. on the surface
  - b. in tunnelling
2. Select equipment for construction surveys.
3. Apply horizontal and vertical control.
4. Identify sources of error in surveys.
5. Monitor deformation and subsidence.
6. Survey tunnels:-
  - a. direction control
  - b. gyro-theodolite observations and computations
  - c. laser instruments for alignment and setting out
7. Determine areas from plan measurements by:
  - a. co-ordinates
  - b. cross-sections.
8. Use general volume and earthwork formulae.
9. Construct and use mass-haul diagrams.



# Unit 104      Engineering surveying

## 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 five (05) questions selecting at least one (01) question from Section A, one (01) each from Section C and D, and one (01) from Section B.

The examination will cover knowledge specifications:

Topics	Approximate % examination weighting
Theory of Errors	10
Survey Methods	40
Data Management	30
Industrial Applications	20

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

### Unit guidance

To develop the skills needed to become a competent Civil Engineer the learner must be able to practise all of the techniques involved. It is essential that they can access a wide range of equipment to be able to develop their abilities. It is also important that learners work in groups small enough to enable them all to gain practical hands-on experience. Assessment should address all aspects including individual practical skills.

**Level:** 6

### Introduction

This unit is intended to teach the basic and intermediate concepts involved in Soil Mechanics, Engineering properties of soils and some of their fundamental applications in Geotechnical Engineering.

This unit also introduces 'Engineering geology' in relation to Geotechnical Engineering.

### Unit aim

The aim of this unit is to provide the learner with the fundamentals of Soil Mechanics, Physical Geology and Engineering Geology in relation to engineering investigations.

### Learning outcomes

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

1. Explain the composition of the Earth, classify different soils and identify the parameters used to model the behaviour of saturated and unsaturated soils, and their relevance to engineering properties
2. Describe the concepts in Engineering Geology
3. Explain the role of the Engineering Geologist in relation to sub-surface investigations in civil engineering

### 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 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 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 related Properties of Engineering Materials ie as per the City & Guilds Advanced Technician Diploma 6165-30-073 and 173 or relevant HND or other equivalent.

# Unit 105 Soil mechanics and engineering geology

## Assessment Criteria

### Outcome 1 Explain the composition of the Earth, classify different soils and identify the parameters used to model the behaviour of saturated and unsaturated soils, and their relevance to engineering properties

The learner can:

1. Introduce the materials of soil and rock as constituent parts of planet Earth and explain the structure of the Earth's crust.
2. Classify soils based on Unified Soil Classification System using ASTM method; Visual soil classification: Classification of coarse, fine grained soils, peat using ASTM method.
3. Perform particle size analysis, determine Atterberg limits and associated indices.
4. Explain and determine stresses in soil formations: Inter granular stress, pore water pressure, principle of effective stress, total and effective stress distribution.
5. Explain and determine the Compaction Characteristics of Soils: Water content-dry density, compactive effort, Standard and modified Proctor compaction, field compaction, relative compaction, specifications related to compaction work.
6. Demonstrate the Settlement Characteristics of Soils by introduction to, Compression index, pre-consolidation pressure, coefficient of compressibility, Time-rate settlement: Dissipation of pore-water pressure with time, coefficient of consolidation.
7. Describe Flow through Soil: Heads and one dimensional flow, laminar flow through porous media and Darcy's law, Constant and falling head permeability tests, well pumping.
8. Define Shear Strength of Soils: Stresses at a point, Mohr-Coulomb failure criterion, and Mohr's circle approach, Laboratory determination of Shear strength and stress-strain behaviour of soils. Laboratory simulation of field conditions.
9. Describe methods of field determination of Shear strength and stress-strain behaviour of soils: Vane shear, Standard Penetration Test.
10. Explain earth pressures exerted by Soils: Rankine states of active and passive plastic equilibrium of soils.

### Outcome 2 Describe the concepts in Engineering Geology

The learner can:

1. Outline the basics of Physical Geology; age of the planet, geological time, Plate tectonics, tectonic dislocations: deformation of solid bodies, foliation folds, faults, lineations, fracturing, and joints, (Introduction).
2. Outline an introduction to **mineralogy**. The physical and chemical properties of the more common **rock** and soil forming minerals. Their genesis and classification, association and mode of occurrence.
3. Describe the process of **weathering**; types of weathering, erosion of rocks, transportation and deposition, Laterite and residual soils, geological work of flowing surface water, underground water, sea, lakes, swamps and wind.
4. Briefly outline Magmatism: causes of Magmatism, Volcanism and types of volcanoes, Formation of igneous rocks and their classification, structure, texture and occurrence, Formation of sedimentary rocks and their classification, texture and occurrence, Metamorphism: Types of metamorphism. Metamorphic rocks, their classification, texture and occurrence.
5. Give an Introduction to Geology locally; **geological** mapping and aerial photographs, engineering geologic mapping.

6. Outline the basics of Geodynamics; engineering geodynamics and their impacts on evaluation of engineering geological conditions, counter measures against destructive action
  - a. Coastal, reservoir erosion,
  - b. Erosion processes of rivers.
  - c. Formation of marshes, construction on marshes or marshy land.
  - d. Landslides, stability analysis of various types of land slides, controlling land slides.
  - e. Rock falls, engineering evaluation of conditions of a rock fall.
  - f. Earthquakes; frequency of earthquakes, energy and intensity, depth of focus, seismic zoning and earthquake proof construction.
7. Outline the basics of **Hydrogeology (Geohydrology)**; Distribution of water in the Earth's crust, Classification of water in the lithosphere, types of aquifers, characteristics of aquifers, influence of rocks and sediments on ground water.

### **Range**

**Rock types** - Igneous, Metamorphic and Sedimentary

**Mineralogy** - common rocks and soils

**Weathering** - physical and chemical

**Geological Features** - faults ,folds ,discontinuities etc

**Geodynamics** - Earth movements and causes

**Hydrogeology** - water presence, its movements and effects on rocks and soils

### **Outcome 3 Explain the role of the Engineering Geologist in relation to sub-surface investigations in civil engineering**

The learner can:

1. Identify, plan and implement engineering geological (geotechnical) **investigation** methods; Exploratory drilling methods, coring, sampling, logging of cores, trial pits and exposures.
2. Carry out Field and laboratory tests analysing results and interpretation for bridges, road, pipeline and tunnel alignments, building sites.
3. Identify Geophysical methods used in geotechnical engineering geological investigations; Seismic survey, magnetic survey, electric survey (resistivity method) and gravity survey.
4. Discuss the suitability of rock and soils etc. for construction industry as a construction material; clay, aggregates, road stones, rubble, rock fill.

### **Range**

Site **Investigation** - sampling and testing in situ and laboratory techniques integrating knowledge of rock and soil type. Techniques and limitations

# Unit 105            Soil mechanics and engineering geology

## 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 minimum two (2) questions from section A and minimum three (3) questions from section B.

The examination will cover knowledge specifications:

<b>Topics</b>	<b>Approximate % examination weighting</b>
Soil Mechanics	50
Engineering Geology	50

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

### Unit guidance

Throughout the module the learner should be able to learn through a combination of practical sessions, experiments, demonstrations, taught and tutorial sessions complemented by well focussed guided learning. The learner's technical numeracy needs to be developed in learning outcome 1 by practising analysis of experimental results and other numerical examples.

**Level:** 6

### Introduction

This unit is intended to teach the learner about design aspects of buildings; an introduction to the management of the design phase and the identification, design and provision of required services.

### Unit aim

The aim of this unit is to provide an overall view of the building process from inception to end of detail design stage. It gives an introduction to the architectural, structural, building utility services, and electro- mechanical engineering.

### Learning outcomes

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

1. Identify the stages of building projects and explain how to manage the design phase of buildings serving specific functions
2. Describe the different elements of the building
3. Understand the design and application of the building utility services
4. Adopt the 'value engineering' concept

### 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 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 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 construction materials and their properties ie as per the City & Guilds Advanced Technician Diploma 6164-30-072 and 172 or relevant HND or other equivalent.

# Unit 106 Building engineering

## Assessment Criteria

### Outcome 1 Identify the stages of building projects and explain how to manage the design phase of buildings serving specific functions

The learner can:

1. Identify a 'Building Project', prepare the 'Outline Plan of Work' and outline the **Project Management** concept.
2. Describe the different types of buildings serving specific functions.
3. Outline the Client requirements, prepare a **design brief**, identify the stages of the **design phase** and functions of the building design team.
4. Discuss architectural design considerations in conjunction with **structural design considerations**.
5. Prepare a design with specific reference to disabled persons.

#### Range

**Project management** - the discipline of planning, organizing, securing and managing resources to bring about the successful completion of specific project goals and objectives

**Design brief** – the statement defining the objectives to be achieved by the design process

**Design phase** – the period in a project during which the design process is carried out

**Structural design considerations** - the design aspects of the project influenced by structural engineering requirements

### Outcome 2 Describe the different elements of the building

The learner can:

1. Describe the functions of different **foundations** and analyse **earthwork** requirements.
2. Describe different forms of **partitioning** including brickwork and plastering requirements.
3. Identify the requirement and design doors and windows.
4. Describe different types of flooring and finishes.
5. Design roofing according to specified requirements.
6. Design means of draining water from roofs, gutters and down pipes, chains.

#### Range

**Foundations** – the engineering elements constructed in the ground which support the superstructure of a building

**Earthwork** – any excavation, filling, levelling or re - profiling of the ground in a building or engineering project

**Partitioning** – in this context the elements of a building subdividing the building space into rooms. Usually a term used to describe non load-bearing walls.

### Outcome 3 Understand the design and application of the building utility services

The learner can:

1. Assess the requirement for water provision, identify the source, purify where necessary, and design the **distribution**, house connections and plumbing, **sanitary connections** and fixtures.
2. Design waste **water, sewerage and storm water** disposal methods; describe house drainage systems and drainage installations for small building schemes.
3. Design **on-site sanitation facilities** for buildings; refuse disposal methods.
4. Analyse effects on the environment and manage waste and pollution.
5. Define wiring regulations and design simple electricity supplies for buildings.
6. Describe the fundamental rules for safety; shock protection; inspection and testing procedure, methods of fire prevention and protection; Security systems.
7. Design elevators, escalators.

#### Range

**Distribution** – piped system for the distribution of water

**Sanitary connections** – the standardised connection systems used to connect sanitary pipework from washbasins, w.c's etc.

**Waste water, sewerage and storm water** – wastewater generally comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. **Sewerage** -the physical infrastructure of pipes etc. used to convey sewage from its origin to the point of eventual treatment or disposal. **Sewage** is correctly the subset of wastewater that is contaminated with faeces

**On-site sanitation facilities** – where sewage cannot be removed from site by piped system methods such as cess pits, septic tanks and other on site sanitation units can be installed.

### Outcome 4 Adopt the 'value engineering' concept

The learner can:

1. Define life cycle costs.
2. Prepare maintenance schedules.
3. Use value management.
4. Assess **environmental impact** and take necessary preventive measures.

#### Range

**Life cycle costs** – all costs associated with constructing and maintaining a built facility throughout its anticipated life span.

**Maintenance schedules** – those schedules listing and anticipating all planned maintenance for a facility including all aspects of the building, its external works, all plant and equipment and its finishes fixtures and fittings.

**Value management** – methods for defining and maximizing value for money

**Environmental impact** - the possible positive or negative impact that a proposed project may have on the environment



# Unit 106 Building 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 five (05) questions.

The examination will cover knowledge specifications:

Topics	Approximate % examination weighting
Building process from inception to end of detail design stage	80
Management of the Design	20

### 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 project scenario sessions, problem solving discussions and related group assignment work

**Level:** 6

## Introduction

This unit is intended to teach the learner about managing the cost of buildings including an introduction to the management of contracts.

## Unit aim

The aim of this unit is to provide adequate knowledge of the basics of Quantity Surveying.

## Learning outcomes

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

1. Identify the role of the Quantity Surveyor in planning and cost control
2. Make measurements using standard Principles of Measurement and prepare Bills of Quantities
3. Explain use of technical specifications for building construction and estimate the cost of projects
4. Define relevant legal requirements, building and environmental regulations
5. Explain types of contract and basics of administering a contract
6. Explain contract documents and construction procurement procedures

## 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 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 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 Drawing practice, Auto Cad Design and Building Engineering ie as per the City & Guilds Advanced Technician Diploma 6165-30-071 and 171 or relevant HND or other equivalent.

# Unit 107                      Quantity surveying

## Assessment Criteria

### **Outcome 1      Identify the role of the Quantity Surveyor in planning and cost control**

The learner can:

1. Define the time value of money, interest, inflation, discounting, depreciation and taxes.
2. Explain the need for and advantages in cost planning and illustrate with simple examples the impact of feasibility studies, planning and design, on cost.
3. Explain the process of cost control during the 'Design' stage, client preferences and the design brief.
4. Explain the importance and management of cost and quality at project implementation stages.
5. Define **tender documents** including BoQ and Contract based on BoQ, Design and Construct.
6. Define Responsibilities of QS.
7. Select relevant contract documents; describe the possible discrepancies in contract documents, and the necessity for Coordinated Project Information.

#### **Range**

**Tender documents** - BQ's drawings, specification, preliminaries, site investigation survey and their relationship to the construction contract

### **Outcome 2      Make measurements using standard Principles of Measurement and prepare Bills of Quantities**

The learner can:

1. Prepare Taking off sheets, use conventional mensuration techniques.
2. Explain the necessity for Standardising Methods of Measurement.
3. Make Measurement to Standard Methods of Measurement:
  - a. Substructure
  - b. Surveying and Levelling, Site clearing
  - c. Site Investigation
  - d. Earthwork
  - e. Types of Foundations
  - f. Measurement of Excavation, Earthwork and Sub-structure
4. Make Measurement to Standard Methods of Measurement
  - a. Concrete Superstructure
5. Make Measurement to Standard Methods of Measurement
  - a. Masonry structures and panels
6. Make Measurement to Standard Methods of Measurement
  - a. Timber and Steel Roof structures
7. Make Measurement to Standard Methods of Measurement – Superstructure II
  - a. Floor
  - b. Finishes
  - c. Woodwork, Doors, Windows, Partitions, Ceilings
  - d. Glazing, Painting
8. Make Measurement to Standard Methods of Measurement, (RC)
  - a. Water supply, Plumbing
  - b. Drainage

### **Outcome 3 Explain use of technical specifications for building construction and estimate the cost of projects**

The learner can:

1. Explain the Necessity for Specifications as an attribute of material and workmanship quality, Performance specifications, Prescriptive specifications, Minimum requirements in relation to durability and required life.
2. Perform Price Analysis; Material costs, Transport, wastage, (price escalation), Labour, production rates (norms and man hours), wages, casual/permanent, insurance, provident fund, Trades, sub-contracts, Schedule of rates.
3. Perform price analysis; Plant and Equipment; capital costs, usage, maintenance and servicing costs, Depreciation, Costing, Safety, Insurance, Employer's liability insurance, Fire Insurance, Material costs, Transport, wastage, (price escalation), Labour, man hours, wages, casual and permanent, provident fund, Trades, sub-contracts, Overheads, Break-even and profit.
4. Explain an 'Estimate' and the need for different types of estimates, carry out basic calculations illustrating estimates.
5. Differentiate between estimating and costing and explain their use at each of the successive design stages, implementation and settlement/accounting.

### **Outcome 4 Define relevant legal requirements, building and environmental regulations**

The learner can:

1. Explain the impact of the judicial system on construction.
2. Explain the need for Building Regulations, Environmental Law.
3. Explain the impact of Land and Property Law on construction.
4. Explain tort.

### **Outcome 5 Explain types of contract and basics of administering a contract**

The learner can:

1. Discuss the essential aspects of the different types of contracts, their effects on quality, time and cost.
2. Describe the essential contract conditions.
3. Explain price escalations and describe the action needed.
4. Explain the need for Bid Bond and the Performance Bond.
5. Briefly describe the different types of disputes (client-consultant, client-contractor) that could arise.
6. List and describe the essential data required for preparation of Valuations, application for payments, variation orders, claims.
7. Explain the process of record keeping of weather, material, plant and human resources.
8. Explain Change Management; prepare application for payments, valuations for interim and final certificates, variation orders, construction claims.
9. Explain the final accounting process.

### **Outcome 6 Explain contract documents and construction procurement procedures**

The learner can:

1. Describe the tender Documents; bonds, guarantees, contract documentation.
2. Explain basic tendering procedures; adopted in government departments, recommended by international funding agencies.
3. Discuss the factors that affect tender pricing.
4. Discuss Technical Evaluation Reports and Award of Contract.

# Unit 107            Quantity surveying

## 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 all three (3) questions in section A and any two (2) questions from section B.

The examination will cover knowledge specifications:

<b>Topics</b>	<b>Approximate % examination weighting</b>
Contractual technical documentation	70
Contractual administration	30

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

### Unit guidance

This unit possesses all the general skills that are needed to become a competent Quantity Surveyor. Skills within the area of Standard Method of Measurement come from repetitive use. To hold interest it is useful to have a whole but simple building to measure, containing as many elements as possible. In this way learners can see over the term of their studies a complete building which may also be used in the estimating section.

**Level:** 6

### Introduction

This unit is intended to teach the learner about the principles of planning and design of traffic control and the principles of design and construction of roads and highways.

### Unit aim

The unit aims to develop/provide the knowledge of collection and analysis of data required for traffic designs and methods of highway construction.

### Learning outcomes

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

1. Apply the principles of traffic planning to design for road safety and traffic control
2. Demonstrate knowledge of highway construction and maintenance

### 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 for 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 written examination plus satisfactory completion of the prescribed practical and laboratory work. The assessments will be carried out separately.

Learners are expected to have knowledge of soil mechanics, at the level of City & Guilds Advanced Technician Diploma 6165-30-073 or relevant HND or other equivalent.

# Unit 108 Highway engineering

## Assessment Criteria

### **Outcome 1 Apply the principles of traffic planning to design for road safety and traffic control**

The learner can:

1. Describe uninterrupted and interrupted traffic flow.
2. Explain measures of traffic volume, vehicle speed, vehicle headway and traffic density and their fundamental relationships.
3. Identify characteristics of traffic flow: urban and rural.
4. Recognise the uses of traffic data.
5. Plan traffic surveys:
  - a. design of field sheets and summary sheets
  - b. selection and training of personnel
6. Recognise features of flow and control measures and analyse data from traffic surveys
7. Describe types of intersections.
8. Recognise the objectives and methods of traffic control
  - a. traffic control between intersections
  - b. traffic control at intersections: priority control, police control, traffic signals
  - c. merits and demerits of traffic control methods
9. Explain traffic signs and carriageway marking:
  - a. classification of signs: regulatory, warning and information
  - b. standards of size, shape and colour
  - c. placement and illumination
  - d. functions and limitations of carriageway marking
  - e. longitudinal and transverse marking
  - f. classes of marking and their dimensions
  - g. night visibility
10. Describe on-street and off street parking layouts and management of parking.
11. Discuss parking surveys: parking supply, parking usage and parking duration surveys.
12. Explain principles of street lighting; purpose, lantern types, arrangement and spacing, mounting, lighting along roads and at intersections.
13. Recognise the importance of road safety and factors contributing to cause accidents: road user, vehicle, road and the environment.
14. Collect and analyse accident data to make proposals for improvement.

### **Outcome 2 Demonstrate knowledge of highway construction and maintenance**

The learner can:

1. Recognise the development in road construction.
2. Demonstrate and apply knowledge of techniques of route planning:
  - a. highway planning procedure: surveys, interpretation of data, master plan and phased implementation
  - b. highway alignment; factors controlling alignment, stages of the process, final location and detailing
  - c. project formulation
  - d. realignment projects.

3. Carry out geometric design of highways taking due regard of all relevant factors:
  - a. design speed
  - b. design year traffic volume
  - c. capacity: level of service and service volumes
  - d. design elements: sight distance, horizontal curvature, super elevation, grades, visibility on vertical curves, cross section elements.
4. Describe the sub-grade stabilisation and compaction and important soil properties.
5. Discuss structural elements of a highway pavement and causes of structural failure in pavements.
6. Discuss the material used in highway constructions:
  - a. aggregates: origin and type, production
  - b. properties of aggregate: shape, texture, gradation, strength, resistance to abrasion etc
  - c. aggregate testing
  - d. aggregate blending
  - e. bituminous road binders: origin and type, production
  - f. forms of bitumen: penetration grade, cutback bitumen, bitumen emulsions
  - g. properties of bitumen: penetration, softening point, viscosity, ductility, flash and fire, durability
  - h. testing of bitumen
  - i. stripping from aggregate
  - j. rubberised bitumen
  - k. bituminous mixes: dense and open graded mixes, properties of asphalt concrete mixes, asphalt concrete mix design
  - l. recycled material for road construction: bituminous materials, green waste, blast furnace and steel slag, plastics, glass etc.
7. Explain highway pavement maintenance.



# Unit 108 Highway 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 selecting at least two (2) from each section.

The examination will cover knowledge specifications:

<b>Topics in two sections</b>	<b>Approximate % examination weighting</b>
Traffic Engineering	40
Highway Engineering	60

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

## Introduction

This unit is about the principles underlying the design, operation and maintenance of irrigation and drainage systems.

## Unit aim

The unit aims to teach the knowledge, applications and design of principles of irrigation systems, irrigation structures and water management.

## Learning outcomes

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

1. Understand the principles of irrigation and drainage systems, field application methods and social and economical impacts
2. Apply the principles of water management to achieve optimum efficiency of irrigation systems
3. Design reservoir capacities and select suitable types of irrigation canals and 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** for hour's laboratory practical/tutorial 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 written examination plus satisfactory completion of the prescribed practical and laboratory work. The assessments will be carried out separately.

The learner is expected to have sufficient knowledge in mathematics ie as per City & Guilds Advanced Technician Diploma 6165 or relevant HND or other equivalent.

# Unit 109      Irrigation engineering

## Assessment Criteria

### **Outcome 1      Understand the principles of irrigation and drainage systems, field application methods and social and economical impacts**

The learner can:

1. Explain irrigation engineering and associated terms.
2. Describe the need for irrigation, sources of irrigation water, (surface water, groundwater and rainfall).
3. Analyse the flow and lift irrigation schemes for their characteristics.
4. Discuss the advantages and disadvantages of irrigation.
5. Describe Cultivation seasons, weather patterns.
6. Describe the historical development and present irrigation schemes as applied locally.
7. Conduct feasibility studies.
8. Evaluate sociological and economical (NPV, IRR etc.) aspects.
9. Describe the field irrigation methods
  - a. surface irrigation: basin, border, furrow, drip etc.
  - b. overhead irrigation: water can, sprinkler etc.
  - c. sub surface irrigation
- 10 Describe the drainage requirement for irrigated lands.
- 11 Recognise the simple theories and methods of drainage.

### **Outcome 2      Apply the principles of water management to achieve optimum efficiency of irrigation systems**

The learner can:

1. Describe soil moisture holding capacities and soil water release curves.
2. Estimate the irrigation water requirement
  - a. land preparation requirement
  - b. crop water requirement: potential evapotranspiration, growth stages and crop factors
  - c. effective rainfall
  - d. losses: farm losses and conveyance losses
3. Differentiate between the application, distribution and conveyance efficiencies.
4. Prepare irrigation schedules encompassing cropping patterns and crop calendar.

### **Outcome 3      Design reservoir capacities and select suitable types of irrigation canals and structures**

The learner can:

1. Explain design considerations of reservoirs storages.
2. Classify dams on their characteristics.
3. Design and maintain canals.
4. Identify and select canal structures appropriate for different purposes depending on their merits, de-merits and hydraulic design considerations
  - a. conveyance structures: siphons, flumes, drops, chute etc.
  - b. regulating structures: checks, check drops, turnouts, cross regulators, head regulators etc.
  - c. protective structures: channel spillways, cross drainage structures etc.
  - d. water measurement structures: Parshall flumes, weirs etc.

5. Control and exclude silt using control measures:
  - a. silt excluder
  - b. silt ejector

# Unit 109            Irrigation 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 five (05) questions selecting at least two questions from each section.

The examination will cover knowledge specifications:

<b>Topics</b>	<b>Approximate % examination weighting</b>
Irrigation systems and methods	30
Water management	30
Irrigation structures	40

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

## Introduction

This unit is about the principles and processes involved in water supply systems and waste water disposal systems.

## Unit aim

The unit aims to develop understanding in the principles of water quality, water and wastewater treatment, water supply systems, wastewater disposal systems, storm water systems and biosolids treatment.

## Learning outcomes

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

1. Identify and understand the principles and processes involved in water supply systems
2. Identify and understand the principles and processes involved in wastewater disposal systems

## 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 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.

The learner is expected to have sufficient knowledge in mathematics and fluid mechanics by holding a relevant City & Guilds Advanced Technician Diploma or relevant HND or other equivalent.

# Unit 110 Water and wastewater engineering

## Assessment Criteria

### Outcome 1 Identify and understand the principles and processes involved in water supply systems

The learner can:

1. Describe **water sanitation and health**.
2. Describe sources of water for water supply:
  - a. **surface water**
  - b. **ground water**: pervious and impervious stratum
  - c. rainwater harvesting
3. Forecast demands for water supply systems:
  - a. average per capita water consumption
  - b. peak domestic water demand
  - c. industrial, commercial and agricultural demands
  - d. design periods
  - e. collection, storage, transmission, treatment and distribution works
4. Recognise the characteristics of surface water and ground water intake structures:
  - a. yields of bored and drilled wells
  - b. feasible discharges
5. Select suitable pumps from different types (displacement, centrifugal, airlift, hydraulic):
  - a. capacities and efficiencies
  - b. operational characteristics
  - c. advantages and disadvantages
6. Assess different types of transmission devices and their effects including strength considerations.
7. Design pipe distribution systems:
  - a. Tree /Dead end systems
  - b. Cycle / ring systems
  - c. Pipe sizes: **Hazen William formula** etc.
  - d. Pipe material and types
  - e. Joints: Bell spigot, flanged, mechanical, plastic
  - f. Characteristics and maintenance of different types of valves and water meters
8. Recognise types of **distribution reservoirs**.
9. Analyse storage and demand.
10. Assess the process of **water treatment**:
  - a. pre-treatment, screening types
  - b. aeration: types and characteristics of aerators
  - c. sedimentation: types and dimension estimates
  - d. coagulation
  - e. filtration: types and characteristics
  - f. disinfection methods: chlorination testing and points of applications
11. Describe **water quality** standards and methods of analysis:
  - a. Chemical reactions
  - b. ionic equilibria
  - c. buffering
  - d. pH

- e. Water pollution criteria
  - f. **BOD**
  - g. **COD**
  - h. Toxicity
  - i. **Eutrophication**
12. Describe methods of locating and accessing ground water sources
  13. Outline influences driving water demand
  14. Differentiate and select appropriate pumps and pumping systems for differing applications

### Range

**Water sanitation and health** – the relationship between effective sanitation and the minimisation of water borne disease. This involves fundamental understanding of water cycles, harvesting, treatment and distribution of potable water.

**Surface water** – water available for use that has been replenished by the natural water cycle and has accumulated in ponds, lakes, streams, rivers and natural reservoirs which is distinct from ground water.

**Ground water** – this is sub-surface water that is distinct from but is an integral part of and is added to by surface water.

**Hazen-Williams formula** - an empirical formula which relates to the flow of water in a pipe with the physical properties of the pipe and the pressure drop caused by friction.

**Distribution reservoir** – storage for treated water capable of supplying water during emergencies and also to help in absorbing the hourly fluctuations in the normal water demand.

**Water treatment** – treatment of raw water in order to bring it up to acceptable, nationally agreed standards for potable water.

**Water quality** – complying with EU standards set out in the drinking water directive, ground water directive, nitrates directive, urban wastewater treatment directive, and the water framework directive.

**BOD (biochemical oxygen demand)** - is a measure of the amount of oxygen needed by microbial action to break down the organic matter in a sample of water.

**COD (chemical oxygen demand)** – is the standard indirect method for the measurement of the quantity of pollutants in a given sample of water.

**Eutrophication** – the gradual accumulation of silt and organic matter in a body of water; pond, lake or inland sea.

## Outcome 2 Identify and understand the principles and processes involved in wastewater disposal systems

The learner can:

1. Differentiate between separate and combined sewerage systems.
2. Assess sewerage systems with respect to design period, flow estimation and quality estimation:
  - a. Rational formula
  - b. Runoff coefficients
  - c. Time of concentration.
3. Determine the requirement of sewer appurtenances:
  - a. Manholes: types, sizes and spacing
  - b. Storm water inlets: types, catchment basins.
4. Select sewer construction materials: types, characteristics.
5. Differentiate between types of waste transmission systems:
  - a. gravity sewers
  - b. self cleansing and slime control
  - c. types of pumping stations and rising mains
  - d. pump types and capacities.



6. Maintain sewerage systems:
  - a. Problems and hazards
  - b. Cleaning equipment and machinery
  - c. Safety equipment.
7. Recognise the importance of sewerage treatment processes:
  - a. Physical treatment processes - screening, sedimentation, filtration,
  - b. chemical treatment processes
  - c. Biological treatment processes - Aerobic and Anaerobic processes.
8. Integrate the physical, chemical and biological processes for wastewater treatment plant design:
  - a. Primary treatment processes
  - b. secondary treatment processes
  - c. tertiary and advanced treatment processes.
9. Describe the Sludge/Biosolids treatment and disposal processes.
10. Describe effluent reuse.
11. Describe methods for the mechanical treatment of wastewater.
12. Explain the role and importance of bio-chemistry in standards of water quality.

# Unit 110 Water and wastewater 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 five (05) questions selecting at least two questions from each section.

The examination will cover knowledge specifications:

<b>Topic sections</b>	<b>Approximate % examination weighting</b>
Water Supply	60
Waste Water	40

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

## Introduction

This unit is intended to extend the knowledge gained in unit 9201-01-102 by analysing more 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 **three** 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 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 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.

# Unit 111      Structural analysis

## Assessment Criteria

### Outcome 1      Perform elastic and plastic analysis of structures

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 form a 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**

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**

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:

<b>Topic sections</b>	<b>Approximate % examination weighting</b>
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 112                      Circuits and waves

**Level:**                      **6**

## **Introduction**

This unit is about electrical circuits and includes electromagnetic fields and waves.

## **Unit aim**

The aim of this unit is to develop sufficient skills and techniques in solving problems with electrical circuits and networks. It also includes problems on electromagnetic fields and waves.

## **Learning outcomes**

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

1. Solve problems involving electrical circuits and networks
2. Solve problems involving electromagnetic field and waves

## **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 laboratory practical work. 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

The learner is expected to have knowledge on basic circuit theory and to know the basic laws of electric and magnetic fields as per the City & Guilds Advanced Technician Diploma 8030-221 or relevant HND or other equivalent.

# Unit 112      Circuits and waves

## Assessment Criteria

### **Outcome 1      Solve problems involving electrical circuits and networks**

The learner can:

- 1 Analyse complex networks excitations.
- 2 Obtain transient and steady state response of a given passive network.
- 3 Formulate matrix equations for mesh and nodal analysis of dc and ac circuits and solve them
- 4 Analyse passive networks using pole-zero patterns.
- 5 Explain Synthesis of LC, RC and LRC networks. Cauer, Foster canonical forms.
- 6 Demonstrate the knowledge of classical filter design: low pass, high pass and band pass.
- 7 Use two- port parameters in two-port network to analyse the filter circuits and networks.
- 8 Simulate ac and dc circuits using simulate software tools.
- 9 Apply Fourier series and Fourier transform power spectra and spectral analysis of wave forms.

### **Outcome 2      Solve problems involving electromagnetic field and waves**

The learner can:

1. Apply Gauss' law and calculate electric field strength (E) and Electric flux density (D) of different objects such as rod, sphere, disc, plates with the distribution of electric charge.
2. Calculate capacitance of different configurations such as parallel plates, concentric cylinders.
3. Apply Ampere's Circuital law and calculate magnetic field intensity (H) and magnetic flux density (B) to solenoids and toroids.
4. Produce an electric circuit analogue for magnetic circuit and develop the relationship between mmf, flux and reluctance conductor.
5. Calculate capacitance and inductance per unit length of wire pair and coaxial line.
6. Obtain Maxwell's equations in integral and differential forms and obtain wave equation for free space and for a lossy medium for uniform plane wave propagation.
7. Determine the electromagnetic field/wave energy using Poynting Theorem.
8. Explain polarisation of electromagnetic waves; examine reflection and transmission of electromagnetic waves when incident at a boundary.
9. Identify TE and TM mode propagation wave propagation through rectangular metal waveguides; determine the dominant mode; the power transmitted through a rectangular waveguide using the dominant mode and uses of metal waveguides in communications.
10. Draw radiation pattern of antennas; define, directivity, gain, radiation resistance of an antenna; express the far field electric field due to a short dipole, half-wave dipole, monopole, small loop, large loop and draw their radiation patterns; obtain beam-width; express antenna impedance of these antennas.
11. Obtain beam-width, directivity and gain of horn antenna and parabolic reflector antenna and describe feeding methods of parabolic antennas; radiation patterns of uniform linear isotropic arrays; broadside and end-fire arrays and obtain beam-width between first nulls and discuss applications of antenna arrays.



# Unit 112                  Circuits and waves

## Notes for guidance

### Test specification for written paper

This examination paper is of three hours duration structured in two parts (A and B) with five questions in each part giving a total of ten (10) questions. The learners must answer five (05) questions in total by selecting at least one question from each section.

The examination will cover the knowledge specifications:

<b>Topic sections</b>	<b>Approximate % examination weighting</b>
<b>Section A</b>	
Circuit Analysis	15
Synthesis of passive networks	10
Two port networks and filter design	15
Laplace transform	10
Circuit Analysis	15
<b>Section B</b>	
Electric & Magnetic Fields	15
Magnetic circuits	10
Electromagnetic Wave Propagation	10
Antennas	15

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

## Unit 113

# Electrical machines and electrical energy system fundamentals

**Level:** 6

### Introduction

This unit is about the basics of electrical machines and systems.

### Unit aim

The aim of this unit is to provide an understanding of the construction and operating principles of Electrical Machines and Electrical systems.

### Learning outcomes

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

1. Explain construction, operating principles and area of use of transformers, induction motors, and synchronous generators and DC machines
2. Explain the operating principle of main elements involved in power generation, transmission and distribution

### Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **60** 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 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 as per the City & Guilds Advanced Technician Diploma 8030-226 or a relevant HND or other equivalent.

# Unit 113      Electrical machines and electrical energy system fundamentals

## Assessment Criteria

### Outcome 1      Explain construction, operating principles and area of use of transformers, induction motors, and synchronous generators and DC machines

The learner can:

#### Transformers

1. Explain necessity of power transformers in electrical energy systems.
2. Explain main construction features of transformer: shell type, core type.
3. Describe types of windings used in transformers: sandwich, concentric.
4. Describe operating principle of power a transformer.
5. Sketch the equivalent circuit of a transformer.
6. Explain the losses involved in transformers.
7. Sketch the diagrams of winding arrangement and standard connection of transformers.
8. Describe the conditions for parallel operation of transformers.
9. Describe the use of auto transformers and their merits and demerits over two winding transformers.

#### Induction motor

10. Explain two types of inductions motors in use: squirrel cage and wound rotor.
11. Explain how torque is developed on rotor windings of the motor.
12. Express the rotor speed in terms of slip and synchronous speed.
13. Derive an expression for the shaft torque developed.
14. Describe losses in an induction motors.
15. Sketch approximate equivalent circuit for an induction machine.
16. Analysis of induction motor with the help of equivalent circuit.
17. Determine equivalent circuit parameters of induction motor with the help of locked rotor and no load tests.
18. Derive an expression for the electromagnetic torque developed in terms of emf, rotor impedance, synchronous speed and slip.
19. Derive expressions for starting torque and the maximum torque.

#### Synchronous machine

20. Explain the existence of two types of synchronous machines: cylindrical and salient pole synchronous machines.
21. Describe the use of synchronous generators in electrical power stations (hydro, thermal etc).
22. Derive vector equation and sketch vector diagram for cylindrical rotor machine.
23. Explain effect of armature reaction to the excitation voltage of the generator.
24. Sketch the equivalent circuit of a synchronous machine.
25. Derive power angle equation of a synchronous machine connected to an infinite bus.
26. Sketch vector diagram of a synchronous machine connected to an infinite bus.
27. Calculate excitation voltage, current of a generator connected to an infinite bus using vector equations/ diagrams.
28. Explain steady- state and transient stability conditions for synchronous machine (qualitatively).

## **DC Machines**

29. Explain the construction of DC rotating machines.
30. Explain the working principle of different types of DC machines and their area of use: separately excited, self excited (series, shunt and compound).
31. Explain how armature reaction effects to the performance of the machine.
32. Draw the equivalent circuits of types of DC machines and calculate voltage, current and power.
33. Sketch and explain load characteristics of DC generators.
34. Explain the speed control methods of DC motors.
35. Describe area of use of different types of DC motors.

## **Outcome 2 Explain the operating principle of main elements involved in power generation, transmission and distribution**

The learner can:

### **Power generation**

1. Explain the methods of power generation (both conventional and non-conventional): hydro, thermal, nuclear, wind, solar etc.
2. Calculate load factor, diversity factor of load curve.
3. Allocate different types of power stations to cover base, intermediate and peak loads.
4. Describe the methods to improve the load factor of the load curve.

### **Sub-stations**

5. Explain the necessity of power transmission and distribution.
6. Describe types of sub-stations in power system: primary, grid and distribution sub stations.
7. Describe functions of elements of sub-stations: circuit breakers, isolators, instrumental transformers, reactors etc.
8. Explain the area of use of different types of bus-bar arrangements and their merits and demerits: single bus bar, single bus-bar with bus sectionaliser, and single bus bar with transfer bus bar, double bus bar, and mesh arrangement.

### **Switch gear**

9. Explain the difference between mechanical opening and closing of a switch and electrical opening and closing of a switch. Explain electric arc.
10. Explain modes of electric arc extinction: High resistance interruption and low resistance of zero point interruption and current asymmetry and armature reaction on the re-striking voltage.
11. Describe with aid of sketches the arrangement of contacts and arc extinction principles in air blast, air break, vacuum, oil, SF<sub>6</sub> circuit breakers and their merits and demerits.
12. Explain with aid of sketches the operation of the two principle types of construction of isolators: three post, centre post rotating double breaker type and two post single breaker type.

### **Overhead Lines**

13. Explain construction material and line support of over head lines. Calculate sag, span and ground clearance.
14. Describe different types of insulators used in over head lines, compare materials used for insulators. Explain the common methods of overcoming problems, caused by pollution on line insulators.
15. Explain reasons for voltage distribution along the suspension type insulators.
16. Calculate voltage distribution along a string for a given value of unit capacitance and given value of capacitance from pin to earth. Calculate string efficiency.
17. Explain the methods of improving string efficiency.
18. Describe the existence of electrical characteristic of resistance, inductance and capacitance.

### **Underground cables**

19. Identify the principle construction features of underground cables.
20. Identify the material used for the conductor, insulation and sheath of underground cable and describe each part of cable.
21. Explain desirable properties (electrical and mechanical) of material used for the core, insulator and sheath.
22. Determine capacitance of single core cable.
23. Define the six capacitor equivalent circuit of a three core cable.
24. Describe the two methods of grading high voltage cables and discuss their relative merits.

### **Electrical Power Distribution**

25. Describe the three types of distribution systems and their relative advantages and disadvantages.
26. Sketch equivalent circuit for three phase short and medium length lines: Pi, T networks and ABCD parameters.
27. Calculate voltage, current, power loss, power factor for given radial systems using equivalent circuits.
28. Describe the methods of voltage control: series and shunt compensation, static var systems, tap changing transformers.
29. Describe the methods of power factor correction.

# Unit 113      Electrical machines and electrical energy system fundamentals

Notes for guidance

## Test specification for written paper

This examination paper is of three hours duration structured in two parts (A and B) with nine (9) questions in total. The learners must answer five (05) questions by selecting at least one question from each section.

The examination will cover the knowledge specifications.

<b>Topic sections</b>	<b>Approximate % examination weighting</b>
<b>Section A</b>	
Transformers	15
Induction motor	10
Synchronous machine	10
DC Machines	15
<b>Section B</b>	
Power generation	05
Sub –stations	05
Switch gear	10
Overhead Lines	10
Underground cables	10
Electrical Power Distribution	10

### The requirements to achieve overall success for this unit are:

Practical work	Pass
Written examination	Pass/Merit/Distinction

# Unit 114                      Electrical energy systems

**Level:**                      **6**

## **Introduction**

This unit is about the analysis of electrical energy systems.

## **Unit aim**

The aim of this unit is to provide sufficient knowledge and ability to enable confident handling of problems arising in planning, commissioning, operating and maintenance of electrical energy systems.

## **Learning outcomes**

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

1. Explain and analyse the operation and control of electrical energy system under its normal operating condition
2. Explain and analyse abnormal behaviour of electrical energy systems and methods of protection

## **Guided learning hours**

It is recommended that **150** hours should be allocated for this unit of which **60** 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 written examination plus satisfactory completion of the prescribed practical and laboratory work. The assessments will be carried out separately.

The learner is expected to have knowledge on Generation and Supply of Electrical Energy as per the City & Guilds Advanced Technician Diploma 8030-224 or relevant HND or other equivalent.

# Unit 114 Electrical energy systems

## Assessment Criteria

### Outcome 1 Explain and analyse the operation and control of electrical energy system under its normal operating condition

The learner can:

#### Electrical Power Transmission and Distribution

1. Sketch equivalent circuit for three phase short and medium length lines: Pi, T networks and ABCD parameters.
2. Calculate voltage, current, power loss, power factor for short length and medium length lines.
3. Calculate voltage regulation, transmission efficiency and understand effect of load power factor on regulation of transmission efficiency.
4. Describe the methods of voltage control: series and shunt compensation, static var systems, tap changing transformers.
5. Calculate propagation constant, characteristic impedance, wave length of long length transmission line.
6. Calculate voltage, current, reactive power along the long length transmission line using hyperbolic equations.

#### Power flow calculations

1. Identify the different types of buses in electrical systems.
2. Calculate power flow using iterative methods: Gauss -Zeidel and Newton Raphson methods.
3. State the merits and demerits of each method.
4. Explain the different modification of Newton Raphson method and their effect.
5. Explain the modern techniques of load flow analysis.

#### Power System control

1. Explain Generator control.
2. Describe active power and frequency control.
3. Describe reactive power and voltage control.
4. Explain the control characteristic of hydro, thermal nuclear wind and other different categories of power plant.

### Outcome 2 Explain and analyse abnormal behaviour of electrical energy systems and methods of protection

The learner can:

#### Analysis and fault calculations

1. Explain the concept of per unit system.
2. Select suitable values for the independent base quantities and derive base values for the remaining quantities and calculate per unit values.
3. Explain why the base values on either sides of transformer are generally different.
4. Calculate the base values and hence per unit values on power system containing transformers.
5. Calculate the fault current for symmetrical three phase short circuit.
6. Calculate the fault MVA and fault levels in power system.
7. Calculate the sequence component impedance matrix from the phase component impedance matrix.



8. Draw the sequence networks for different winding connections for given generator and transformers.
9. Draw the sequence network for a given transmission system.
10. Identify different types of unbalanced faults and write down the basic equations for unbalanced faults.
11. Calculate unsymmetrical fault currents with and without fault impedance.

### **Stability in electrical systems**

12. Write swing equation of synchronous generator.
13. Explain transient stability and steady state stability.
14. Write power angle equation for simple systems for the pre-fault, during the fault and post fault situations.
15. Calculate critical clearing angle and critical clearing time for single machine systems using equal area criteria.

### **Protection of power systems**

16. Explain protective relaying, protective zones, back-up protection, selectivity and reliability.
17. Classify relays by type, by time of operation and actuating quantities.
18. Distinguish between relay unit, protective scheme and protective system.
19. Explain the basic concepts protection of generators, transformers and transmission lines.
20. Perform simple calculations involving current transformers and potential transformers.
21. Carry out calculations involving in over current protection, distance protection and differential protection.

# Unit 114 Electrical energy systems

## 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 written examination will cover the knowledge specifications:

<b>Topics</b>	<b>Approximate % examination weighting</b>
Electrical Power Transmission and Distribution	20
Power flow calculations	15
Power System control	10
Analysis and fault calculations	20
Stability in electrical systems	15
Protection of power systems	20

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

### Introduction

This unit is about Electrical Machines and Drives.

### Unit aim

The aim of this unit is the study of electrical machines and drives and introduces the concepts governing the common types of machines, their characteristics and peculiarities. On completion of this unit, a learner will be capable of carrying out the selection, commissioning and maintenance of common electrical machines and drives.

### Learning outcomes

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

1. Explain the general theory of electrical machines
2. Explain operating principle, characteristics and area of use of synchronous, induction, DC, stepper and reluctance machines
3. Explain the general issues that are common to all drive 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 laboratory practical work. 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

Learners are expected to possess knowledge as per the City & Guilds Advanced Technician Diploma 8030-226 Electrical Plant and Equipment or relevant HND or other equivalent.

# Unit 115      Electrical machines and drives

## Assessment Criteria

### **Outcome 1      Explain the general theory of electrical machines**

The learner can:

1. Explain the main design parameters and their relation to machine performance.
2. Explain concentrated windings, magneto-motive force, working and leakage flux and flux density and mmf distribution of electrical machines.
3. Determine electric and magnetic loading.
4. Derive output power equations for ac and dc machines.
5. Explain the factors affecting the size of machine.
6. Describe the difference between geometrical and electrical angle.
7. Calculate flux per pole, induced emf of concentrated fully pitched windings distribution factor.
8. Explain the advantages of double layer windings over single layer windings.

### **Outcome 2      Explain operating principle, characteristics and area of use of synchronous, induction, DC, stepper and reluctance machines**

The learner can:

#### **Synchronous machine**

1. Explain the basic difference between two types of synchronous machines: cylindrical and salient rotor synchronous machines.
2. Explain the armature reaction of a synchronous machine.
3. Describe the necessity of two axis theory to analysis salient pole machines.
4. Derive vector equation and sketch vector diagram for both cylindrical and salient pole machines machine.
5. Derive equations for power and torque of synchronous generator (cylindrical and salient pole).
6. Calculate excitation voltage, current of a generator connected to an infinite bus.
7. Describe the control of active and reactive power of synchronous generator.
8. Explain the procedure adapted for synchronisation of generator.
9. Calculate load sharing of parallel operating generators.
10. Construct an operating chart for cylindrical synchronous generator.
11. Explain saturated and unsaturated reactance of synchronous machine and their experimental determination.
12. Determine leakage reactance by the Potier method.
13. Explain the slip test.
14. Describe the events following a three-phase short circuit on unloaded synchronous machine.
15. Describe qualitatively transient reactance's (transient, sub-transient and steady state) of synchronous generator.
16. Explain the layout of salient pole and cylindrical rotor windings.
17. Explain the Fourier analysis of mmf produced by the rotor windings.
18. Explain the advantages in short pitching a coil
19. Calculate pitch factor for a given harmonic.
20. Select synchronous machine for a given application
21. Solve problems related to operation and maintenance of synchronous machines
22. Explain common faults associated with synchronous machines

## **Induction motors**

23. Explain how electrical energy input is converted to mechanical energy in an induction motor.
24. Explain the difference between two types of induction motors: squirrel cage and wound rotor machines.
25. Explain how force is exerted on the rotor conductor
26. Explain what is meant by slip of induction motor.
27. Express the rotor speed in terms of slip and synchronous speed.
28. Explain electromagnetic field interaction in induction machine
29. Develop an expression for the shaft torque developed
30. Describe losses in an induction motors.
31. Sketch 'exact equivalent circuit' and 'approximate equivalent' for an induction machine.
32. Analysis of induction motor with the help of equivalent circuit.
33. Determine equivalent circuit parameters of induction motor with the help of locked rotor and no load tests.
34. Derive an expression for the electromagnetic torque developed in terms of emf, rotor impedance, synchronous speed and slip.
35. Derive expressions for starting torque and the maximum torque.
36. Draw the characteristic of induction motor and explain those characteristic.
37. Explain the methods of starting three phase induction motor.
38. Explain the speed control of induction motor by varying frequency and pole pair number.
39. Explain the differences between the motoring, generating and braking modes of operation of three phase induction machines.
40. Derive the torque versus speed curve for the induction for all three modes of generation.
41. Select three phase induction motor for a given application
42. Solve problems related to operation and maintenance of three phase induction motors
43. Explain common faults associated with three phase induction motors

## **Single phase induction motors**

44. Explain the operating principles of single-phase induction machine.
45. Explain the starting and running performance of single-phase induction machine.
46. Determine the value of capacitance for the maximum torque.
47. Explain the area of use of single-phase induction motors.
48. Select single phase induction motor for a given application
49. Solve problems related to operation and maintenance of single phase induction motors
50. Explain common faults associated with single phase induction motors

## **DC machines**

51. Explain the construction of DC rotating machines.
52. Derive an expression for the emf generated in DC machine.
53. Explain how armature reaction effects to the performance of the machine.
54. Explain the working principle of different types of DC machines and their area of use: separately excited, self excited (series, shunt and compound).
55. Draw the equivalent circuits of types of DC machines and calculate voltage, current and power of the machine.
56. Explain the operation of DC machines in two modes: generation and motor.
57. Sketch the performance characteristics of DC machine as generator.
58. Derive expression for torque and speed developed by the motor.
59. Explain the starting methods and sketch speed-torque characteristic of DC motors.
60. Select DC machine for a given application
61. Solve problems related to operation and maintenance of DC machines
62. Explain common faults associated with DC machines

### **Stepper and reluctance motors**

63. Explain the basic principle involved in the mechanism of the operation.

64. Explain the use and application.

### **Outcome 3 Explain the general issues that are common to all drive systems**

The learner can:

1. Explain load characteristic of common applications.
2. List the transducers use in a drive.
3. Explain the principles of closed loop control.
4. Sketch circuit diagram and explain operating principles of single –phase and three-phase bridge rectifiers, dual converters, self commutated dc-dc converts and dc-ac converters.
5. Explain the steady state operation of separately excited dc motors fed by rectifiers.
6. Sketch a thyristor full-wave and half-controlled bridge rectifier controller capable of providing armature voltage control of a shunt motor and explain its operation.
7. Derive relationship between mean output voltage of a bridge, the ac supply voltage and firing angle for the controller in.
8. Explain how the speed of speed of wound rotor induction motor by adding resistance to the rotor circuit.
9. Sketch the schematic circuit diagram for induction motor control incorporating a rectifier-thyristor inverter unit to provide regenerative feedback for slip power-recovery and explain its operation.

# Unit 115 Electrical machines and drives

## 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.

<b>Topics</b>	<b>Approximate % examination weighting</b>
General theory of Electrical Machines	10
Synchronous machine	20
Induction motors	20
DC machines	20
Stepper and reluctance motors	10
General issues that are common to all drive systems	20

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

## Introduction

This unit is about the principles underlying the basic operation, analysis and design of electronic circuits and basic principles of telecommunications and telecom systems.

## Unit aim

The unit aims to develop the knowledge of semiconductor devices, power supplies, low frequency signal amplifiers, oscillators, digital logic circuits and logic families. The unit is also aimed to develop an understanding of communication principles and systems.

## Learning outcomes

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

1. Describe the basic principles and application of semiconductor devices
2. Analyse, design and apply analogue circuits
3. Analyse, design and apply digital circuits
4. Demonstrate an overview of electronic communications
5. Explain the principles and functions of a telecommunication network and its basic components
6. Describe different communication 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 laboratory practical work. 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

The learner is expected to have knowledge of conductors, semiconductors, insulators, and electric circuits and some knowledge of common electronic devices and electronic communications as per the City & Guilds Advanced Technician Diploma 8030-022 and 225 or the relevant HND or other equivalent.



# Unit 116      Electronics and telecommunications

## Assessment Criteria

### **Outcome 1      Describe the basic principles and application of semiconductor devices**

The learner can:

1. Describe the basic principles underlying the rectifier diode, zener diode, light emitting diode, photo diode, varactor diode, schottky diode and their uses.
2. Describe the physical operation of a bipolar junction transistor (BJT) and its use as an amplifier and a switch.
3. Analyse BJT operating conditions, cut-off and saturation, small signal behaviour and the hybrid-model, the switching properties, BJT as a diode, emitter coupled pair, power ratings.
4. Explain the basic principles underlying a FET; JFET and MOSFET, enhancement and depletion models of MOSFET.
5. Apply an FET as a resistance, as a switch, as an amplifier and to use the small signal FET models.

### **Outcome 2      Analyse, design and apply analogue circuits**

The learner can:

1. Analyse biasing circuits of BJT and FET.
2. Develop transistor small signal ac equivalent circuits.
3. Design small signal amplifiers circuits involving bipolar transistors and field effect transistors and explain the effect of coupling and bypass capacitors.
4. Develop amplifier circuits involving cascade connections and Darlington connections.
5. Apply the high frequency hybrid-model.
6. Develop circuits involving differential amplifiers.
7. Describe the structure and operation of operational amplifiers and their frequency response and slew rate.
8. Analyse and develop operational amplifier applications: as an adder, integrator, and differentiator.
9. Design feedback amplifiers to meet gain, stability and bandwidth criteria.
10. Apply design principles of sinusoidal waveform oscillators using RC, LC and crystals.
11. Develop circuits using monostable and astable multivibrators, Schmitt trigger circuits, square and triangular wave generators, sweep and staircase generators and voltage control oscillators.
12. Analyse the operation of Class A, AB, B and C power amplifier circuits in terms of power output, efficiency and distortion effects.
13. Develop rectifier circuits, regulated power supplies, switching regulators and switch mode power supplies.

### **Outcome 3      Analyse, design and apply digital circuits**

The learner can:

1. Describe the functions of logic gates and the use them in IC form.
2. Identify the merits and demerits of TTL and CMOS logic families.
3. Apply Boolean algebra and Karnaugh maps for reduction techniques.
4. Design combinational logic circuits having up to four variables.
5. Design half and full adders, code converters, comparators, decoders, encoders and multiplexers.

6. Implement combinational logic functions using programmable read only memory (PROM), programmable logic array (PLA) and programmable array logic (PAL) structures.
7. Apply state diagrams and tables, simple state reduction methods and excitation tables.
8. Analyse and design sequential logic circuits using RS, JK and D type flip flops.
9. Analyse, synthesise and design shift registers and counters.
10. Describe the structure, and operation of common forms of analogue-to-digital and digital-to-analogue converters.

#### **Outcome 4 Demonstrate an overview of electronic communications**

The learner can:

1. Describe basic concepts related to communication systems.
2. Identify analogue and digital signals.
3. Identify types of communication channels.
4. Describe the effect of bandwidth and noise on signals.
5. Describe the radio spectrum and wave propagation.
6. Explain different methods of analogue and digital modulation.

#### **Outcome 5 Explain the principles and functions of a telecommunication network and its basic components**

The learner can:

1. Describe multiplexing and demultiplexing hierarchies for high speed networks.
2. Identify different transmission lines, characteristics and their uses.
3. Identify transmission, switching and access networks of a telecommunication network.
4. Identify broadcast and switched networks.
5. Describe access networks.
6. Describe transmission lines: copper wire pair, coaxial wire, metal wave guide, multiplexing and demultiplexing hierarchies.
7. Explain types of antennas and propagation for radio communication systems.

#### **Outcome 6 Describe different communication systems**

The learner can:

1. Describe Radio and TV broadcast systems.
2. Describe the telephone network.
3. Describe the computer network.
4. Describe the Internet.
5. Identify microwave terrestrial systems and satellite links.
6. Describe the fibre optic network.
7. Describe the features of a cellular mobile communication system.

# Unit 116                      Electronics and telecommunications

## Notes for guidance

### Test specification for written paper

This examination paper is of three hours duration and is structured in two parts (A and B) with five questions in each part giving a total of ten (10) questions. The learners must answer five (05) questions in total by selecting at least one question from each section.

The examination will cover knowledge specifications.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Section A	
Semiconductor Devices	10
Analogue Circuits	20
Digital Circuits	20
Section B	
Electronic Communication	15
Telecommunication Network	20
Different communication systems	15

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

## Introduction

This unit is about the principles underlying the basic operation, analysis and design of electronic circuits and systems.

## Unit aim

The unit aims to develop knowledge in respect of semiconductor devices, power supplies, low frequency signal amplifiers, oscillators, digital logic circuits and logic families.

## Learning outcomes

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

1. Describe the operation and application of semiconductor devices
2. Analyse, design and apply analogue circuits and systems
3. Analyse, design and apply digital circuits and 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 laboratory practical work. 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.

The learner is expected to have knowledge of conductors, semiconductors, insulators, and electric circuits as per the City & Guilds Advanced Technician Diploma 8030-225 or relevant HND or other equivalent.

# Unit 117      Electronic systems

## Assessment Criteria

### **Outcome 1      Describe the operation and application of semiconductor devices**

The learner can:

1. Explain the principles underlying a p-n junction diode, zener diode, varactor diode, light emitting diode, photo diode and Schottky diode and their uses.
2. Describe the operation of a bipolar junction transistor (BJT).
3. Analyse BJT operating conditions, cut-off and saturation, small signal behaviour and the hybrid-model, the switching properties, BJT as a diode, emitter coupled pair, power ratings.
4. Explain the physical features of a FET; JFET and MOSFET, enhancement and depletion models of MOSFET.
5. Apply an FET as a resistance, as a switch, as an amplifier and to use the small signal FET models.
6. Develop awareness of the Ebers-Moll model and semiconductor fabrication techniques.

### **Outcome 2      Analyse, design and apply analogue circuits and systems**

The learner can:

1. Analysis of biasing of the BJT and FET circuits.
2. Develop transistor small signal ac equivalent circuits.
3. Develop small signal amplifiers circuits involving bipolar transistors and field effect transistors.
4. Explain the effect of coupling and bypass capacitors.
5. Develop amplifiers circuits involving, cascade connections and Darlington connections.
6. Apply the High Frequency hybrid-model of BJT.
7. Develop circuits involving differential amplifiers.
8. Estimate the dynamic response of amplifiers: Bode diagrams and step response.
9. Describe the structure and operation of operational amplifiers and their frequency response and slew rate.
10. Analyse and develop operational amplifier applications: as an adder, integrator, and differentiator.
11. Analyse first and second order active filters, logarithmic and exponential amplifiers, and analogue multipliers using opamps.
12. Use feedback amplifiers: feedback topologies, effects of negative feedback on gains and impedance levels; frequency response and distortion noise, stability and compensation.
13. Design feedback amplifiers to meet gain, stability and bandwidth criteria.
14. Design passive and active filters.
15. Apply design principles of sinusoidal waveform oscillators using RC, LC and crystals.
16. Describe the amplitude and frequency stabilisation of waveform generators.
17. Describe, analyse and design circuits using monostable and astable multivibrators, Schmitt trigger circuits, square and triangular wave generators, sweep and staircase generators and voltage control oscillators.
18. Describe the operating principles of phase locked loop (PLL) and designing circuits using PLLs.
19. Analyse the operation of Class A, AB, B and C power amplifier circuits in terms of power output, efficiency and distortion effects.
20. Design rectifier circuits, regulated power supplies, switching regulators and switch mode power supplies.

### **Outcome 3    Analyse, design and apply digital circuits and systems**

The learner can:

1. Implement simple combinational circuits using logic gates in integrated circuit form.
2. Identify the merits and demerits of different logic families, TTL, ECL, NMOS, and CMOS.
3. Apply Boolean theorems, reduction techniques and Karnaugh maps.
4. Design combinational logic circuits having up to five variables.
5. Design half and full adders, code converters, comparators, decoders, encoders and multiplexers.
6. Implement combinational logic functions using programmable devices: read only memory (PROM), programmable logic array (PLA) and programmable array logic (PAL) structures and microcontrollers (PIC).
7. Apply state diagrams and tables, simple state reduction methods and excitation tables.
8. Analyse and design sequential logic circuits using RS, JK and D type flip flops.
9. Analyse, synthesise and design shift registers and counters.
10. Apply simple concepts of sampling and multiplexing for data acquisition.
11. Describe the structure, operation and make speed/cost comparisons for common forms of analogue-to-digital and digital-to-analogue converters.

# Unit 117            Electronic systems

## 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 knowledge specifications:

<b>Topics</b>	<b>Approximate % examination weighting</b>
Semiconductor Devices	25
Analogue Circuits	35
Digital Circuits	40

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

### Introduction

This unit is about the principles underlying the operation of communication systems and their components.

### Unit aim

The unit aims to develop the knowledge and understanding of modern communication systems including transmission, switching and access networks with emphasis on digital communications.

### Learning outcomes

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

1. Describe the basic aspects of a telecommunication network
2. Demonstrate an understanding of modern digital communication systems
3. Demonstrate knowledge of the principles of digital transmission, line coding and modulation
4. Demonstrate knowledge of elementary information theory and describe principles of source coding and error control coding
5. Demonstrate knowledge of communication system noise and link budgets

### 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 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 written examination plus satisfactory completion of the prescribed practical and laboratory work. The assessments will be carried out separately.

The learner is expected to have knowledge of mathematical methods and statistics as per the City & Guilds Advanced Technician Diploma in the Telecommunication units 27130-022 and 023 or relevant HND or other equivalent.



# Unit 118      Communication systems

## Assessment Criteria

### **Outcome 1      Describe the basic aspects of a telecommunication network**

The learner can:

1. Describe the historical development of telecommunications services.
2. Compare and contrast the advantages and disadvantages of line and radio transmission.
3. Identify the advantages of digital communications compared with analogue communications.
4. Describe and compare the transmission characteristics of twisted pair, coaxial cable and optical fibre transmission lines.
5. Describe and compare the dominant propagation mechanisms, noise processes and nominal ranges of different bands of the radio spectrum, signal fading.
6. Describe a range of telecommunication network applications.
7. Distinguish between broadcast and switched networks.
8. Distinguish between LANs, MANs and WANs.
9. Describe a range of network structures and represent them, where appropriate, using a connection matrix.
10. Explain what is meant by the transmission system, the switching system and the signalling system of a network.
11. Explain the network switching philosophies: circuit switching, message switching and packet switching.
12. Explain what is meant by the terms, core network and access network.
13. Explain the principle of layered network architecture.
14. Describe the ISO-OSI 7-layer model of a communications system.
15. Describe the use of repeaters, bridges, routers and gateways to extend and interconnect networks.
16. Describe the structure of a national PSTN.

### **Outcome 2      Demonstrate an understanding of modern digital communication systems**

The learner can:

1. Describe the purpose of sampling and anti-aliasing, quantisation/reconstruction filtering, pulse code modulation/decoding, source coding/decoding, encryption/deciphering, error control coding/decoding, multiplexing/demultiplexing, line coding/decoding, pulse shaping/matched filtering, bandpass modulation/demodulation, multiple access, equalisation in relation to digital communications processes.
2. Apply the knowledge of the mathematical and geometrical representation of baseband and modulated signals for analysis and design of communication systems.
3. Explain the principle of Spread Spectrum and analyse the error performance of DS-SS and FH-SS systems under jamming and broadband noise.
4. Describe the principle and challenges of multicarrier modulation, mitigation of subcarrier fading and discrete implementation of orthogonal frequency division multiplexing (OFDM).

### **Outcome 3 Demonstrate knowledge of the principles of digital transmission, line coding and modulation**

The learner can:

1. Apply Nyquist's sampling theorem.
2. Convert analogue-to-digital conversion process into sampling, quantisation and pulse code modulation.
3. Describe the process and significance of quantisation.
4. Explain what is meant by quantisation noise.
5. Calculate signal to quantisation-noise ratios (SNQR) for signals with uniform pdf.
6. Explain the advantages of PCM.
7. Estimate the signal-to-noise ratio (SNR) of a demodulated PCM signal.
8. Describe the process and non-linear quantisation and companding.
9. Identify and quantify the benefits of A-law of companding.
10. Describe centre point detection (CPD) as applied in simple baseband receivers and calculate the bit error ratio (BER) for a baseband CPD system in the presence of Gaussian noise.
11. Explain what is meant digital signal regeneration and describe how it is achieved.
12. Calculate the effect of error accumulation over multi-hop links using linear amplifiers or regenerative repeaters between hops.
13. Describe the purpose and requirements of a line code and identify the general properties of unipolar, polar, dipolar and bipolar (AMI) line codes.
14. Distinguish between return-to-zero and non-return-to-zero line codes.
15. Describe HDB3, CMI and nBmT line codes.
16. Explain the purpose of band-pass modulation.
17. Describe the basic binary forms of digital modulation: - amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK) and sketch example waveforms, spectra and constellation diagrams for each of the binary modulation schemes.
18. Show how each ASK, FSK and PSK signals could be generated in principle.

### **Outcome 4 Demonstrate knowledge of elementary information theory and describe principles of source coding and error control coding**

The learner can:

1. Summarise elementary information theory and define the basic measures of information (bits, nats and hartleys), explain and define entropy, redundancy and transmission (or code) efficiency and apply measures of information, entropy, redundancy and transmission efficiency to simple numerical problems.
2. Explain the purpose and principles of source coding and implement a Huffman code.
3. Describe source coding for speech, music (Hi-Fi), facsimile, pictures (JPEG) and video (MPEG).
4. Define channel capacity (Shannon-Hartley law) and comment on the limiting factors of channel capacity (error rate due to noise and bit rate due to bandwidth) with the possible trade-off between these factors.
5. Explain the purpose and principles of error control coding and define Hamming distance and codeword weight.
6. Explain the principles of  $(n, k)$  block codes and the use of parity check digits, the error detection and correction capability of a code and implementation of nearest neighbour and syndrome decoding of a block code.
7. Explain what is meant by a cyclic code and, in particular, the special case of a Hamming code and the significance of interleaving.

## **Outcome 5 Demonstrate knowledge of communication system noise and link budgets**

The learner can:

1. Explain what is meant by additive noise, white noise and Gaussian noise.
2. Explain origin and characteristics of shot noise.
3. Distinguish between internal and external receiver noise.
4. Define noise temperature and noise figure and convert freely between the two.
5. Calculate the overall noise temperature and noise figure of a system comprising multiple subsystems connected in cascade.
6. Explain the origin of the dominant antenna noise at different frequencies explain and define antenna directivity, gain and effective area.
7. Explain what is meant by antenna noise temperature and sketch the typical noise temperature of a high gain antenna as a function of frequency for low and high elevation angles.
8. Explain and define spreading loss, free-space path loss, flat earth path loss and interference patterns due to ground reflection.
9. Construct simple microwave or millimetre-wave link budgets for point-to-point terrestrial links.
10. Describe what is meant by multipath fading and diversity reception in the context of a radio link.
11. Explain the principles of optical fibre transmission, propagation of signal through fibres, problem of dispersion and attenuation, optical sources, detectors and amplifiers.
12. Construct simple optical fibre link budgets.

# Unit 118                      Communication systems

## 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 the knowledge specifications.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Basic aspects of a communication network	20
Digital transmission, line coding and modulation	30
Information theory and describe principles of source coding and error control coding	30
System noise and link budgets	20

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

## Introduction

This unit is about the principles underlying the operation of wireless communication systems and their components.

## Unit aim

The unit aims to develop knowledge and understanding of wireless communications with emphasis on cellular mobile systems.

## Learning outcomes

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

1. Describe wireless access systems and cellular mobile systems
2. Describe radio wave propagation in fixed and mobile environments
3. Describe basics of multiple access including FDMA and TDMA of wireless access networks
4. Develop knowledge of the functioning of cellular mobile systems
5. Develop knowledge of wireless network standards

## 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 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 written examination paper.

The learner is expected to have knowledge of electronic communications and mathematical methods as per the City & Guilds Advanced Technician Diploma in the Telecommunication units 2730-022 and 023 or relevant HND of other equivalent.

# Unit 119      Wireless and mobile communications

## Assessment Criteria

### **Outcome 1      Describe wireless access systems and cellular mobile systems**

The learner can:

1. Explain the design of radio systems and their basic functionality.
2. Illustrate point-to-point (PTP) and point-to-multipoint (PMP) radio communication.
3. Calculate radio system range and reliability.
4. Describe applications of fixed wireless access.
5. Explain the basics of cellular mobile technology.

### **Outcome 2      Describe radio wave propagation in fixed and mobile environments**

The learner can:

1. Identify path loss in free space radio wave propagation.
2. Identify the propagation loss problems associated in fixed and mobile environments.
3. Describe statistical fading models and illustrate multipath fading, shadowing and 'large-scale' path loss models.
4. Identify narrow band and wideband fading models.
5. Review performance of digital modulation schemes over wireless channels.

### **Outcome 3      Describe basics of multiple access including FDMA and TDMA of wireless access networks**

The learner can:

1. Describe direct sequence spread spectrum (DS-SS), frequency hopping spread spectrum (FH-SS) systems.
2. Illustrate ISI and Narrow band interference rejection and code design.
3. Explain diversity in DS-SS systems, Rake Receiver.
4. Describe CDMA Systems including an interference analysis for broadcast and multiple access channels.

### **Outcome 4      Develop knowledge of the functioning of cellular mobile systems**

The learner can:

1. Describe the principles and operations of cellular mobile networks.
2. Explain the methods of multiple Access; FDMA, TDMA, Spatial reuse.
3. Analyse co-channel interference.
4. Perform a capacity analysis with spectral efficiency.
5. Estimate the capacity of cellular CDMA networks.
6. Describe hard and soft hand off strategies.

### **Outcome 5      Develop knowledge of wireless network standards**

The learner can:

1. Describe the 2G cellular wireless systems; GSM and IS-95 standards.
2. Describe the 3G wireless systems: UMTS & CDMA 2000 standards and specifications.

# Unit 119 Wireless and mobile communications

## Notes for guidance

### Test specification for written paper

This is a written examination paper lasting three hours with nine questions. Learners must answer any five questions.

The examination will cover knowledge specifications:

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Basic aspects of wireless access and cellular mobile systems	20
Radio wave propagation in fixed and mobile environments	20
Wireless access networks	25
Cellular mobile systems	20
Wireless network standards	15

### 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 120

# Computer programming and information systems

**Level:** 6

### Introduction

This unit is about the principles of computer programming and focuses on the critical, personal and organisational issues of the management of information systems (MIS).

### Unit aim

The aim of the unit is to provide/develop knowledge in order to be able to analyse, solve, design and code real-life problems using C language. In addition this unit also provides an overview of management of information systems in the business world.

### Learning outcomes

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

1. Develop an understanding of the basic concepts of computing
2. Learn the methodology of problem solving
3. Develop skills in programming using C language
4. Develop knowledge of basic computer hardware, software, and data concepts of a computer based information management system
5. Develop awareness of critical issues faced by the MIS profession, including international information flow, legal and ethical issues, privacy and security of data
6. Problem solving and managerial decision making skills using information systems and information technology

### 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 laboratory practical work. 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.

The learner is expected to have knowledge of computer programming as per the City & Guilds 7267-301 Unit or relevant HND or other equivalent.



# Unit 120      Computer programming and information systems

## Assessment Criteria

### **Outcome 1      Develop an understanding of the basic concepts of computing**

The learner can:

1. Draw a block diagram of a computer and identify components of a computer system.
2. Describe the hardware and software aspects of a computer.
3. Explain the categories of an operating system and applications - booting, installing and uninstalling software, software piracy and software terminologies.
4. Describe applications of computers and their role of information technology.
5. Explain the **history** of the internet and internet services.

#### **Range**

#### **History**

Original computer/terminal model, moving to the PC / local storage model, moving to the Internet / cloud computing model

### **Outcome 2      Learn the methodology of problem solving**

The learner can:

1. Illustrate problem solving techniques; the concept of a computer program.
2. Describe the program development cycle; algorithms and design.
3. Draw flow charts.
4. Develop program control structures.
5. Describe **types** and generation of programming languages.
6. Develop algorithms for simple problems.

#### **Range**

#### **Types**

Assembler/machine code, compiled, object-oriented abstracted languages

### **Outcome 3      Develop skills in programming using C language**

The learner can:

1. Write a simple program in C language.
2. Describe operators and expressions.
3. Describe Input and Output Functions: - Simple computational problems and decision making.
4. Use control statements; branching, looping, nested control structures, switch, break, continue, and 'go to' statements.
5. Write programs for problems using control structures.

#### **Outcome 4    Develop knowledge of basic computer hardware, software, and data concepts of a computer based information management system**

The learner can:

1. Describe IT infrastructure of information management systems.
2. Describe foundations of business intelligence: databases and information management.
3. Describe **methods** of telecommunications, the internet and wireless technology for high speed data transfer.

#### **Range**

#### **Methods**

Modem-based, LANs, WANs and wireless networks

#### **Outcome 5    Develop awareness of critical issues faced by the MIS profession, including international information flow, legal and ethical issues, privacy and security of data**

The learner can:

1. Describe management and the networked enterprise.
2. Describe information systems in global business today.
3. Explain global e-business - how businesses use information systems.
4. Describe ethical and social issues in information systems.
5. Describe methods of securing information systems.
6. Establish the business value of systems and managing change.

#### **Outcome 6    Problem solving and managerial decision making skills using information systems and information technology**

The learner can:

1. Develop Information Systems.
2. Explain methods of project management.
3. Establish the business value of systems and managing change.
4. Describe methods of managing global systems.

# Unit 120 Computer programming and information systems

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 knowledge specifications.

Topics	Approximate % examination weighting.
Basic concepts of computing	10
Problem solving	20
Programming using C language	20
Basic computer hardware, software, and data concepts of a computer based information management system	20
Critical issues faced by the MIS profession, including international information flow, legal and ethical; privacy and security of data	15
Problem solving and managerial decision making skills using information systems and information technology	15

### The requirement to achieve overall success for this unit is:

Written examination Pass/Merit/Distinction

Note 'Practical work' is not required for this unit.

**Level:** 6

## Introduction

This unit is about the design and analysis of computer communication networks.

## Unit aim

The aim of this unit is to give an understanding of the principle of network protocols, structures, standard and services mainly concentrating on wired networks but with a mention of wireless where relevant.

## Learning outcomes

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

1. Describe the basic concepts of a computer network and differentiate between network topologies, types of networks and layered architecture
2. Explain the client/server model and key application layer protocols
3. Learn sockets programming and implementation client/server programs
4. Describe the basics of error detection including parity, checksums, and CRC
5. Describe key protocols for multimedia networking
6. Familiarise themselves with current topics such as security, network management, management instrumentation, and/or other topics

## 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 laboratory practical work. 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.

Learners are expected to have elementary knowledge of probability for engineers, basic knowledge of computer organisation, C language programming and computer operating systems as per City & Guilds award 7267-503 or relevant HND or other equivalent.

# Unit 121 Computer networks

## Assessment Criteria

### **Outcome 1 Describe the basic concepts of a computer network and differentiate between network topologies, types of networks and layered architecture**

The learner can:

1. Explain the basic concepts of a computer network.
2. Differentiate between different network topologies, types of networks.
3. Describe multiple access protocols (collision and token based). IEEE 802.3 Ethernet.
4. Describe the features of the layered architecture of networks.
5. Explain the functioning of Switching, Bridging and Routing.
6. Describe the Internet, its delays and quality of service.

### **Outcome 2 Explain the client/server model and key application layer protocols**

The learner can:

1. Describe the application layer features.
2. Explain client-server as a key model.
3. Identify and differentiate between the protocols, Web, HTTP, FTP, SMTP, POP3, and DNS.
4. Describe peer-to-peer file sharing networks.

### **Outcome 3 Learn sockets programming and implementation client/server programs**

The learner can:

1. Perform Sockets programming in C and implement a simple client-server program.
2. Perform a simple web server implementation.
3. Describe how to carry out a reliable data transfer.
4. Describe TCP and UDP semantics and syntax and perform a TCP RTT estimation.
5. Describe the principles of congestion control; efficiency and fairness, reactive and proactive.

### **Outcome 4 Describe the basics of error detection including parity, checksums, and CRC**

The learner can:

1. Describe methods of Error detection (parity, checksum, and CRC).
2. Describe ATM. Media, signal strength, and data encoding.
3. Describe wireless and cellular networks.

### **Outcome 5 Describe key protocols for multimedia networking**

The learner can:

1. Describe the concepts of streaming video and voice and protocols: RTP, SIP, H.323, RSVP, IntServ, and DiffServ.
2. Describe QoS issues related to streaming.
3. Differentiate between main protocols used for streaming.

**Outcome 6 Familiarise themselves with current topics such as security, network management, management instrumentation, and/or other topics**

The learner can:

1. Describe Symmetric and public key cryptography. Authentication. Firewalls. VPNs.
2. Explain network management tools; SNMP. MRTG tool.

# Unit 121 Computer networks

## 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 knowledge specifications.

Topics	Approximate % examination weighting.
Basic concepts of a computer network and differentiate between network topologies, types of networks and layered architecture	15
Client/server model and key application layer protocols.	20
Sockets programming and implementation of client/server programs.	10
Basics of error detection including parity, checksums, and CRC.	15
Key protocols for multimedia networking	20
Security, network management, management instrumentation, and other topics.	20

### The requirement to achieve overall success for this unit is:

Written examination

Pass/Merit/Distinction

**Note:** Practical work is not required for this unit.

**Level:** 6

### Introduction

This unit is designed to introduce the most common methods of adding useful, interactive and dynamic elements to web development. The unit also focuses on building web applications using latest internet application development techniques.

### Unit aim

This aim of this unit is to provide the learner with an in-depth knowledge of web design and web applications development including useful, interactive and dynamic elements.

### Learning outcomes

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

1. Describe web applications architecture and web programming
2. Create web pages using HTML and CSS
3. Add interactivity to web pages using JavaScript
4. Create server-side programming using PHP
5. Develop XML applications by programming the SAX and DOM API's

### 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 laboratory practical work. 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.

Learners are expected to have computer programming ability as per the City & Guilds award 7267-522 or relevant HND or other equivalent.



# Unit 122      Web design and applications

## Assessment Criteria

### **Outcome 1      Describe web applications architecture and web programming**

The learner can:

1. Describe the Client-Server, N-Tier and P2P architecture of web applications.
2. Identify the role of middleware in web applications.
3. Explain the various components on the web server stack: network/transport, messaging, description, and discovery.
4. Configure and run the Apache web server on Windows or Linux platforms.
5. Install and connect PHP to Apache server.
6. Revise basic syntax of PHP.
7. Describe web related features of PHP.

### **Outcome 2      Create web pages using HTML and CSS**

The learner can:

1. Describe the structure of a HTML page using various HTML tags.
2. Modify the presentation of information of a given HTML page by adding images and various formatting.
3. Create web pages with inter-page and intra-page links.
4. Describe programming concepts of CSS language.
5. Create a web page using HTML and CSS.

### **Outcome 3      Add interactively to web pages using JavaScript**

The learner can:

1. List client-side scripting languages.
2. Explain programming concepts and data types in JavaScript.
3. Identify the object-oriented concepts used by JavaScript.
4. Identify the document object model (DOM) of a HTML document and access different components using JavaScript.
5. Explain event handling in JavaScript.
6. Use JavaScript to create a simple web page with dynamic content.
7. Create a web page including forms and use JavaScript to validate fields.

### **Outcome 4      Create server-side programming using PHP**

The learner can:

1. Explain server-side programming and programming languages.
2. Explain programming concepts and data types in PHP language.
3. Identify object-oriented concepts in PHP.
4. Use PHP to process a HTML form.
5. Identify useful functions in PHP.
6. Create sessions in a PHP-based website.
7. Connect to a MySQL database using PHP.

## **Outcome 5    Develop XML applications by programming the SAX and DOM API's**

The learner can:

1. Describe the XML framework and how it relates to existing web technology including HTML.
2. Identify the distinction between presentation and content on the web and how it can be addressed using XML.
3. Describe the distinction between well-formedness and validity, DTD's and Schema, XPointer and Xlink.
4. Use style sheet technology and the XSL.
5. Describe how XML document structure can be accessed using the SAX and DOM API's.

# Unit 122      Web design and applications

## 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 knowledge specifications.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Web applications architecture	20
Web pages using HTML and CSS	20
Interactive web pages using JavaScript	20
Server-side programming using PHP	20
XML applications by programming the SAX and DOM API's	20

### The requirement to achieve overall success for this unit is:

Written examination

Pass/Merit/Distinction

**Note:** Practical work is not required for this unit.

**Level:** 6

**Introduction**

This unit is about the computer as a digital system and the operating systems used for operation. Since most practical operating systems are written in C-based languages, this course will use C.

**Unit aim**

The aim of the unit is to develop an understanding of the operation of computer operating systems.

**Learning outcomes**

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

1. Read and understand C language and construct intermediate level C programs
2. Describe the basic principles behind the design of modern computer systems
3. Describe the functions of the major components of an operating system
4. Develop familiarity with graphical and command-line operating 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 rest is for independent study and laboratory practical work. 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.

Learners are expected to be familiar with the concepts gates, symbolic logic, assembly language, and basic computer architecture as per the City & Guilds 7261/7267 awards or relevant HND of other equivalent.

# Unit 123 Computer architecture and operating systems

## Assessment Criteria

### **Outcome 1 Read and understand C language and construct intermediate level C programs**

The learner can:

1. Describe operators and expressions in C language
2. Describe Input and Output Functions: Simple computational problems and decision making
3. Use control statements; branching, looping, nested control structures, switch, break, continue, 'go to' statements
4. Write programs in C, using an environment such as Visual Studio, Code: Blocks/GCC

### **Outcome 2 Describe the basic principles behind the design of modern computer systems**

The learner can:

1. Describe the Computer structure: processor, memory, I/O, secondary storage, buses, clocks, sequential operation, Fetch-Execute cycle.
2. Describe Data representation: Binary and hex integer representations and conversions, Fixed-length arithmetic, 2's complement representation, IEEE FP representation, analogue versus digital.
3. Illustrate Memory organisation: Addresses, Memory organisation into bytes, words, longs, memory-mapped I/O.
4. Describe the processor or CPU: Simple internal structure, registers, program counter etc., The execution cycle.
5. Describe Instructions: The CPU instruction set syntax and semantics, Addressing modes, Encoding and decoding.
6. Explain Data Structures: Stacks, queues and linked lists, The stack and stack frame for supporting parameters, local variables, and recursion.
7. Describe Simple I/O: Handling simple devices: the interface and the peripheral, Device registers and polling, Interrupts and interrupt hardware, interrupt vectors.
8. Describe More complex devices: Programmable devices, Block-mode devices, DMA: system structure and operation.
9. Describe Magnetic and Optical Storage: Basic bit storage, Tapes and disks: structure and operation of discs, Organisation of disc blocks into files.
10. Describe Performance enhancements: Pipelining, caches memory, RISC vs CISC architectures, superscalar architectures, VLIW, multi-threaded and trace-based architectures.
11. Describe Micro-controllers: Role: low cost, low power, small size computer systems, I/O systems.

### **Outcome 3 Describe the functions of the major components of an operating system**

The learner can:

1. Comprehend the basic concepts on which the stored-program computer is built.
2. Comprehend computer hardware management & Abstraction.
3. Describe process management.
4. Describe Memory management: Paging, page tables, MMUs, Page faults, associative page table caches, multi-threading.
5. Describe multi-tasking (Pre-emptive and Co-operative).

6. Differentiate between the different types of parallel architectures.
7. Recognise some of the drawbacks, limitations, advantages, and disadvantages of the different computer architectures.
8. Demonstrate familiarity with assembly language, and basic computer architecture.

#### **Outcome 4    Develop familiarity with graphical and command-line operating systems**

The learner can:

1. Develop familiarity with a command-line operating system (eg DOS).
2. Develop familiarity with a graphical user interface (GUI) operating system (eg Windows).
3. Develop familiarity with Unix having the option of using either command-lines or GUIs.

# Unit 123 Computer architecture and operating systems

## 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 knowledge specifications.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
C language programming	20
Principles behind the design of modern computer systems	30
Functions of the major components of an operating system	30
Graphical and command-line operating systems	20

### The requirement to achieve overall success for this unit is:

Written examination Pass/Merit/Distinction

**Note:** Practical work is not required for this unit.

**Level:** 6

## Introduction

This unit is about database and file management systems.

## Unit aim

The aim of the unit is to provide the learner with an in-depth knowledge of database analysis, design and implementation of principles.

## Learning outcomes

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

1. Understand a database management system
2. Understand relational data model
3. Manipulate data using Relational Algebra
4. Manipulate data using SQL
5. Explain data views and data security
6. Understand the design process of a database
7. Understand data storage and access and manipulate query processing techniques
8. Demonstrate transaction processing techniques of database systems
9. Determine designs for distributed databases
10. Understand database objects using ODMG and SQL-2003

## 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

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

Learners are expected to have computer programming ability as per the City & Guilds awards 7261/7267 awards or relevant HND or other equivalent.



# Unit 124 Database management

## Assessment Criteria

### **Outcome 1 Understand a database management system**

The learner can:

1. Describe the role of database system.
2. Describe the evolution of database systems and the limitations of the conventional file management system.
3. Describe the three-schema architecture for database and explain the difference between conceptual, external and physical schemes.
4. Describe the functions of a database administrator.

### **Outcome 2 Understand relational data model**

The learner can:

1. Explain the historical development of database management systems.
2. Define the terms: Relation, Attribute, Tuple, Domain, Instance, Cardinality, degree and Schema.

### **Outcome 3 Manipulate data using Relational Algebra**

The learner can:

1. List the operations of relational algebra and show how they can be used to create new relations from existing relations.
2. Formulate solutions to specify types of queries in relational algebra.

### **Outcome 4 Manipulate data using SQL**

The learner can:

1. Define a relational database scheme in SQL.
2. Explain the basic elements in the structure of an SQL information schema.
3. Formulate SQL queries of varying complexity.
4. Insert, update and delete in a relational database through SQL commands.

### **Outcome 5 Explain data views and data security**

The learner can:

1. Define the view concept in database systems.
2. Formulate data views in SQL.
3. Define limitations in updating views.
4. Define the concept of in view materialisation.
5. Describe the types of security and threats to database systems.
6. Define discretionary access control.
7. Define mandatory access control.
8. Explain security issues in statistical database systems.

## **Outcome 6 Understand the design process of a database**

The learner can:

1. Describe the steps in the database development cycle and their interrelationships.
2. Demonstrate how frequent needs of information in business can be addressed by using data modelling techniques.
3. Map conceptual model into relational schema.

## **Outcome 7 Understand data storage and access and manipulate query processing techniques**

The learner can:

1. Explain basics of physical file structures used in databases.
2. Outline how file access system methods are used in database systems.
3. Evaluate execution strategies and apply optimisation techniques.
4. Identify tuning and physical design issues of database systems.

## **Outcome 8 Demonstrate transaction processing techniques of database systems**

The learner can:

1. Analyse transaction schedules.
2. Apply concurrency control techniques.
3. Apply database recovery techniques.

## **Outcome 9 Determine designs for distributed databases**

The learner can:

1. Describe distributed database architecture.
2. Produce designs for distributed database systems.
3. Recognise different categories of distributed database systems.
4. Infer query processing in a distributed environment.

## **Outcome 10 Understand database objects using ODMG and SQL-2003**

The learner can:

1. Present an overview of the object model of ODMG.
2. Explain object-relational systems and their features in SQL-2003.

# Unit 124 Database 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 knowledge specifications.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Relational data model and manipulating data using relational algebra and SQL, Data views and data security	30
Design process of a database, data storage, access and manipulate query processing techniques	25
Transaction processing techniques of database systems	15
Distributed databases	15
Database objects using ODMG and SQL-2003	15

### The requirement to achieve overall success for this unit is:

Written examination

Pass/Merit/Distinction

**Note:** Practical work is not required for this unit.

**Level:** 6

## Introduction

This unit is about electrical signals and systems. It introduces continuous and discrete time signals in the time domain and frequency domain which is essential for a learner specialising in telecommunications.

## Unit aim

The aim of this unit is to develop knowledge and understanding of such notions as the transient and the steady state response of a system, stability, and causality etc.

## Learning outcomes

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

1. Describe continuous and discrete time signals in the time and frequency domains; and translate freely between the domains
2. Analyse linear time invariant continuous and discrete time systems and evaluate the effect of transmission through a linear system

## 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 using MATLAB software. 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.

Learners are expected to have knowledge of mathematics, electrical and electronic circuits as per the City & Guilds 8030/7261 Advanced Technician Diplomas or relevant HND or other equivalent.

# Unit 125      Signals and systems

## Assessment Criteria

### **Outcome 1      Describe continuous and discrete time signals in the time and frequency domains; and translate freely between the domains**

The learner can:

1. Recognise and distinguish between periodic and non-periodic signals; deterministic and random signals; and transient and non-transient signals.
2. Use analytical formulae to represent common periodic and transient signals in time and frequency domains.
3. Translate simple signals between time and frequency domains using the Fourier series and Fourier transform.
4. Translate signals between time and frequency domains using tables of Fourier series, Fourier transforms and Fourier transform theorems.
5. Relate and calculate power spectra and autocorrelation functions of signals.

### **Outcome 2      Analyse linear time invariant continuous and discrete time systems and evaluate the effect of transmission through a linear system**

The learner can:

- 1 Describe how physical are modelled by linear systems.
- 2 Describe impulse, impulse response and convolution.
- 3 Describe the effect of a linear system using frequency response and impulse response, especially in the context of pulse transmission.
- 4 Explain the relationship between different responses such as frequency, impulse etc.
- 5 Describe the origin, effects and mitigating techniques for loss, amplitude distortion and phase and group delay.
- 6 Discuss applications of linear system models in electrical and communication systems.

# Unit 125      Signals and systems

## 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 knowledge specifications.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Signals	50
Linear Systems	50

### 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

It would be vital to provide a good range of practise problems, with facilities for learners to test their own understanding. MATLAB is the a standard software, available to learners at a reasonable price and well suited to classroom and home study.

**Level:** 6

### Introduction

This unit is about the critical, personal and organisational issues of the management of information systems (MIS)

### Unit aim

This unit is aimed at providing the essential knowledge and understanding of information systems in the business world in order to equip the learner to manage them efficiently.

### Learning outcomes

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

1. Demonstrate an understanding of the significance of information technology/systems activities
2. Explain the relationships between business strategy and IT/IS strategy
3. Identify and evaluate the options concerning the position of IT/IS in the organisation
4. Identify and utilise appropriate models to gain a better understanding of IT/IS in the organisation and its future applications
5. Apply the investment techniques appropriate to the appraisal and control of IT/IS
6. Analyse risks involved in disseminating information and security issues

### 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 laboratory practical work. 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.

Learners are expected to have knowledge and understanding of computer programming as per the City & Guilds 7267-041 award or relevant HND or other equivalent.

# Unit 126 Information management

## Assessment Criteria

### **Outcome 1 Demonstrate an understanding of the significance of information technology/systems activities**

The learner can:

1. Explain the case for strategic management if IT/IS- as a resource; IT expenditure patterns, pervasiveness and critically of IT/IS.
2. Describe IT/IS as a strategic weapon; stakeholders; problems of information management.

### **Outcome 2 Explain the relationships between business strategy and IT/IS strategy**

The learner can:

1. Identify IT/IS and strategic advantages and strategy formulation for IT/IS.
2. Develop conceptual models for identifying strategic IT/IS opportunities and applications, eg stage hypotheses, applications portfolio, strategic grid, critical success factors.

### **Outcome 3 Identify and evaluate the options concerning the position of IT/IS in the organisation**

The learner can:

1. Analyse the importance and the contribution of IT/IS for the organisation.
2. Review major decisions to be taken with regard to deployment of IS/IT resources - eg right sizing, end-user computing, outsourcing, business process re-engineering.

### **Outcome 4 Identify and utilise appropriate models to gain a better understanding of IT/IS in the organisation and its future applications**

The learner can:

1. Management of IT/IS investment - issues related to information value and IT/IS value.
2. Management of IT/IS costs and benefits; review of traditional and recent investment appraisal techniques; risk in IT/IS projects.

### **Outcome 5 Apply the investment techniques appropriate to the appraisal and control of IT/IS**

The learner can:

1. Structure and control of IT/IS activities- location in the organisation; organisation of the IS/IT department; steering committees; IT/IS director; spending patterns; appraisal of IS/IT projects; responsibility accounting for IT/IS projects.

### **Outcome 6 Analyse risks involved in disseminating information and security issues**

The learner can:

1. Analyse the risks involved in disseminating information.
2. Develop security measures to be taken for to minimise risks.



# Unit 126 Information 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 knowledge specifications.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
IT/IS strategy and options for an organisation.	20
Models of IT/IS in an organisation and its applications.	30
Investment techniques to the appraisal and control of IT/IS.	30
Risks in disseminating information and security issues	20

### 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 127      Software engineering

**Level:**                **6**

## **Introduction**

This unit is about the principles and processes of designing and building complex software systems.

## **Unit aim**

The aim of this unit is to provide knowledge and understanding of designing, implementing, and modifying software so that it is of higher quality, more affordable, maintainable, and faster to build.

## **Learning outcomes**

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

1. Understand the software development life cycle
2. Explain methods of managing software projects
3. Understand conventional methods of software design
4. Understand the concept of object oriented software engineering
5. Understand advanced topics in software engineering

## **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 laboratory practical work. 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.

Learners are expected to have knowledge of mathematics including statistics and probability and are expected to have computer programming ability as per the City & Guilds 7261/7267 awards or relevant HND or other equivalent.

# Unit 127      Software engineering

## Assessment Criteria

### **Outcome 1      Understand the software development life cycle**

The learner can:

1. Describe/explain the software development life cycle.
2. Analyse requirements of software design.
3. Develop knowledge on coding, testing, maintenance etc.

### **Outcome 2      Explain methods of managing software projects**

The learner can:

1. Describe project management concepts.
2. Describe the **software process and project metrics**.
3. Describe software project planning.
4. Explain risk analysis and management.
5. Perform project scheduling and tracking.
6. Develop software quality assurance.
7. Carry out **software configuration management**.

#### **Range**

##### **Software process and project metrics**

Eg project cost, time, communications with stakeholders

##### **Software configuration management**

Version control systems such as subversion and Git (software); Sharepoint (documents)

### **Outcome 3      Understand conventional methods of software design**

The learner can:

1. Identify concepts of project specification.
2. Describe concepts and principles of analysis and design.
3. Describe analysis modelling.
4. Describe architectural design, user interface design, component-level design.
5. Illustrate software testing techniques.
6. Use technical metrics for software.

### **Outcome 4      Understand the concept of object oriented software engineering**

The learner can:

1. Demonstrate knowledge of object-oriented concepts and principles.
2. Perform an object-oriented analysis, design and testing.
3. Illustrate technical metrics for object-oriented systems.

## **Outcome 5 Understand advanced topics in software engineering**

The learner can:

1. Describe formal methods.
2. Describe clean-room software engineering.
3. Describe component-based software engineering.
4. Describe advances in client/server software engineering.
5. Describe latest methods of web engineering.
6. Identify/State techniques of re-engineering.
7. Describe computer-aided software engineering.

# Unit 127                  Software engineering

## 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 knowledge specifications.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Software development life cycle	20
Managing software projects	20
Conventional methods of software design	20
Object oriented software engineering	20
Advanced topics in software engineering	20

### The requirement to achieve overall success for this unit is:

Written examination

Pass/Merit/Distinction

**Note:** Practical work is not required for this unit.

**Level:** 6

### Introduction

This unit is about thermodynamics when applied to power and refrigeration systems.

### Unit aim

The aim of this unit is to provide the learner with the knowledge and understanding of the performance and behaviour of thermodynamic power and refrigeration systems and the component parts of these systems.

### Learning outcomes

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

1. Apply the working relationships involved in the behaviour and performance of power and refrigeration cycles to solve practical problems
2. Solve realistic problems involving the steady flow of compressible fluids
3. Analyse and solve problems associated with compressors and turbines and gas turbine cycles
4. Analyse and solve problems associated with internal combustion engines
5. Apply the fundamental principles of mixtures of gases and vapours and of combustion processes to solve practical problems

### 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 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

Learners are expected to have knowledge of science and mathematics needed to solve basic engineering problems as per the City & Guilds Advanced Technician Diploma 2565 or relevant HND or other equivalent.

# Unit 128 Applied thermodynamics

## Assessment Criteria

### **Outcome 1 Apply the working relationships involved in the behaviour and performance of power and refrigeration cycles to solve practical problems**

The learner can:

1. Analyse steam turbine power cycles including:
  - a effects of superheating
  - b reheating and regenerative feed heating
  - c use of back pressure and pass-out turbines.
2. Analyse gas turbine power cycles including:
  - a effects of intercooling
  - b reheating and heat exchange
  - c influence of
    - i component efficiencies
    - ii pressure ratio
    - iii cycle temperatures.
3. Analyse vapour compression refrigeration cycles including:
  - a effect of expansion by throttling
  - b effects of working fluid state at
    - i compressor inlet
    - ii condenser outlet
    - iii choice of refrigerant.
4. Explain the elements of simple ammonia-water absorption cycle.
5. Apply the principles of the heat pump and evaluate its application possibilities.

### **Outcome 2 Solve realistic problems involving the steady flow of compressible fluids**

The learner can:

1. Determine one-dimensional steady flow of gases and vapours through nozzles and diffusers and evaluate the effects of:
  - a. critical pressure ratio
  - b. friction.
2. Analyse and solve problems involving adiabatic flow through long pipes.
3. Identify stagnation properties at a point in a fluid stream in terms of:
  - a. pressure
  - b. temperature
  - c. enthalpy.
4. Analyse and solve problems involving simple jet propulsion systems in terms of:
  - a momentum thrust
  - b pressure thrust
  - c specific impulse.

### **Outcome 3 Analyse and solve problems associated with compressors and turbines and gas turbine cycles**

The learner can:

- 1 Solve problems involving positive-displacement expanders and compressors:
  - a reversible reciprocating machines
  - b isothermal and isentropic efficiencies
  - c reciprocating air compressors
    - i volumetric efficiency
    - ii multi-stage working with intercooling
  - d the steam engine as an expander
  - e rotary positive displacement compressors.
- 2 Solve problems involving turbines and turbo-compressors:
  - a mean-diameter treatment of kinematics and momentum transfer
  - b radial and axial-flow machines
  - c impulse and 50% reaction blading in axial-flow turbines
  - d sources of internal losses
  - e overall, stage and polytropic efficiencies reheat factor.

### **Outcome 4 Analyse and solve problems associated with internal combustion engines**

The learner can:

1. Analyse reciprocating internal combustion engines:
  - a air-standard cycles underlying reciprocating engine processes:
    - i Otto
    - ii Diesel
    - iii Stirling
    - iv others.
2. Determine the cycle efficiency and mean effective pressure as criteria of performance of reciprocating internal combustion engines.
3. Explain the practical working of reciprocating internal-combustion engines.
4. Determine factors limiting the performance of:
  - a spark ignition engines
  - b compression-ignition engines.
5. Determine the effects of variable specific heat and dissociation on engine cycle efficiency.
6. Determine the relationship between air-standard cycles and reciprocating internal combustion engine processes.

### **Outcome 5 Apply the fundamental principles of mixtures of gases and vapours and of combustion processes to solve practical problems**

The learner can:

1. Analyse mixtures of gases and vapours and the relationship between specific and molar properties.
2. Determine the effects of mixtures of gases and vapours on the performance of:
  - a cooling towers
  - b condensers.
3. Analyse air-conditioning plant.
4. Use psychometric charts.
5. Analyse combustion processes in terms of:
  - a stoichiometry



- b internal energy of reaction
  - c enthalpy of reaction and formation.
6. Apply First Law of thermodynamics to chemical reactions.
  7. Explain chemical dissociation and determine its effect in reactions involving perfect gases.

# Unit 128 Applied thermodynamics

## 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:

<b>Topic</b>	<b>Approximate % examination weighting.</b>
Power and refrigeration cycles	20
Steady flow of compressible fluids	20
Compressors and turbines and gas turbine cycles	20
Internal combustion engines	20
Mixtures of gases and vapours and combustion processes	20

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

### Unit guidance

Deliver by first establishing thermodynamic principles and application to compressible fluids building up elemental understanding of cycles. Secondly, use heat engine laboratory for practical understanding and key parameters (m.e.p. etc.). Finally, cover combustion.

**Level:** 6

### **Introduction**

This unit is about the properties of fluids and the principles of fluid mechanics. Additionally, it covers fluid systems analysis, performance studies and the application of system design.

### **Unit aim**

The aim of this unit is to provide the knowledge, understanding and skills required to analyse fluid properties, fluid mechanics and apply these to simple fluid systems.

### **Learning outcomes**

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

1. Demonstrate an understanding of basic fluid mechanics related to compressible and incompressible fluids
2. Perform fluid flow calculations
3. Analyse the mechanics of particles immersed in a fluid
4. Analyse the principles and applications of turbo-machinery

### **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 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

The learner is expected to have knowledge of science and mathematics needed to solve basic engineering problems as per the City & Guilds Advanced Technician Diploma 2565 or relevant HND or other equivalent.

# Unit 129 Fluid mechanics

## Assessment Criteria

### Outcome 1 Demonstrate an understanding of basic fluid mechanics related to compressible and incompressible fluids

The learner can:

1. Define compressible and incompressible **fluids**.
2. Derive and solve conservation equations for:
  - a continuity
  - b momentum
  - c energyand any combination of these.
3. Apply conservation equations to engineering systems.
4. Describe the kinematics of fluid motion in terms of:
  - a streamlines
  - b streamtubes
  - c particle paths
  - d streaklines.
5. Define:
  - a irrotational and rotational flows
  - b circulation
  - c vorticity.
6. Develop stress-strain relations for:
  - a Newtonian fluids
  - b non-Newtonian fluids
  - c Navier-Stokes equations of motion.
7. Determine and apply geometric, kinematic and dynamic similarity conditions in fluid systems.
8. Solve problems using:
  - a Buckingham theorem
  - b dimensional analysis.
9. Derive the principal dimensionless parameters of fluid flow:
  - a Reynolds number
  - b Froude number
  - c Mach number
  - d pressure, lift and drag coefficients
  - e roughness ratioand perform calculations involving the above.

#### Range

**Fluid:** a fluid is a material continuum that is unable to withstand a static shear stress. Unlike an elastic solid which responds to a shear stress with a recoverable deformation, a fluid responds with an irrecoverable flow.

## Outcome 2 Perform fluid flow calculations

The learner can:

1. Solve compressible fluid flow problems involving:
  - a speed of weak pressure waves
  - b stagnation pressure
  - c fluid temperature
  - d fluid density.
2. Solve problems involving isentropic flow of a perfect gas in ducts of varying cross-sectional area in terms of Mach number and including choked flow.
3. Describe the formation of a normal shock in convergent-divergent nozzles.
4. Determine and apply laminar flow in pipes and on and between flat plates.
5. Calculate the velocity distribution in laminar flow.
6. Calculate the volumetric flow rate in laminar flow.
7. Apply laminar flow to hydrodynamic lubrication.
8. Analyse laminar flow using:
  - a boundary layer theory
  - b displacement and momentum thicknesses
  - c skin friction coefficient.
9. Solve problems using the momentum integral equation.
10. Calculate the drag on a flat plate in laminar flow.
11. Describe the factors affecting boundary layer transition.
12. Analyse turbulent boundary layers in terms of:
  - a power law
  - b logarithmic velocity distribution
  - c laminar sub-layer
  - d skin friction on a flat plate.
13. Calculate the drag on a flat plate in turbulent flow.
14. Determine and apply the effects of surface roughness on fluid flow.
15. Describe boundary layer separation and the formation of wakes.
16. Solve problems involving steady flow in pipes of:
  - a Newtonian fluids
  - b non-Newtonian fluids.
17. Analyse the relationship in steady flow between friction factor, Reynolds number and relative roughness.
18. Analyse simple pipe networks using iterative calculations.
19. Apply Euler and Bernoulli equations to incompressible inviscid fluid flows.
20. Determine and apply the stream function and velocity potential function in steady two dimensional flows.
21. Determine and apply flows of incompressible fluids resulting from simple combinations of:
  - a uniform stream
  - b source
  - c sink
  - d doublet
  - e point vortex.
22. Determine and apply inviscid flow around a circular cylinder with circulation including the calculation of:
  - a pressure distribution
  - b lift force.

### **Outcome 3 Analyse the mechanics of particles immersed in a fluid**

The learner can:

1. Analyse the behaviour of single particles in a fluid in terms of:
  - a Stokes Law for spherical particles
  - b drag coefficient
  - c Reynolds number effects
  - d terminal velocity.
2. Investigate particles in fluid systems forming:
  - a sedimentation of uniform
  - b sedimentation of varying range.
3. Analyse flow in packed beds using:
  - a Darcy's law
  - b Carmen-Kozeny equation.

### **Outcome 4 Analyse the principles and applications of turbo-machinery**

The learner can:

1. Use one dimensional theory to analyse the performance of:
  - a turbines
  - b pumps
  - c fans.
- 2 Use flow measurement techniques
  - a. venturimeters
  - b. orifice plates
  - c. nozzles.
3. Assess axial and centrifugal flow machines.
4. Apply dynamic similarity to turbo-machines in terms of:
  - a flow, head and power coefficients
  - b specific speed
  - c characteristic performance curves
  - d net positive-suction head (NPSH).
5. Analyse turbo-machinery systems in terms of:
  - a system load line
  - b pump and turbine operating conditions.

# Unit 129      Fluid mechanics

## 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.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Basic fluid mechanics related to compressible and incompressible fluids	25
Compressible and incompressible fluid flow	25
Mechanics of particles immersed in a fluid	25
Principles and applications of turbo-machinery	25

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

### 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.

It is important to provide homework and frequent quizzes to make sure that the learners are studying the lectures continuously. 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 (eg, flow regimes, etc.)

## Unit 130

# Mechanics of machines and strength of materials

**Level:** 6

### Introduction

This unit covers two basic areas, mechanics of machines and strength of materials. Mechanics of machines deals with mechanisms and machines when they work as mechanical systems, and fundamentals of kinematics and kinetics of systems of particles and rigid bodies. Strength of material deals with analysing strength of machine elements and structural members under service conditions. The fundamental concepts of the two subject areas provide an opportunity for the learner to study mechanisms and machines, their behaviour and strength of materials of machine components and structural members.

### Unit aim

The aim of this unit is to provide the relevant theoretical concepts supported by practical exercises in order to provide the ability to analyse and understand various mechanisms and mechanical systems in engineering applications, and to analyse machine components and basic structural members for strengths before failure occurs.

### Learning outcomes

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

1. Explain static equilibrium, Newton's laws, and calculation of reaction and internal forces and the basic concepts of different stresses and strains and determine stresses and strains of components under loading conditions.
2. Solve problems involving simple and combined modes, including torsion and bending.
3. Analyse and design beams under bending loads and calculate deflection of beams using several methods, including energy method.
4. Explain buckling of columns under different loading conditions.
5. Explain kinematic concepts of link mechanisms and their velocities and accelerations.
6. Explain the concepts of friction and friction devices.
7. Explain fundamental of vibration of rotating masses and the need to balance rotating masses and determine unbalanced forces of systems with rotating masses and balance them.
8. Explain the principles, and explain use and application of different governors and cams.
9. Perceive vibration principles and develop skills in modelling simple vibratory systems with first degree of vibration to solvable models.
10. Explain the use of flywheel in machines, turning moment diagram and fluctuation of energy and law of conservation of energy.

### 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

Learners are expected to have the knowledge in the City & Guilds Advanced Diploma units 2565-03-026 and 2565-03-047 or relevant HND or other equivalent.

# Unit 130                      Mechanics of machines and strength of materials

## Assessment Criteria

### **Outcome 1      Explain static equilibrium, Newton's laws, and calculation of reaction and internal forces and the basic concepts of different stresses and strains and determine stresses and strains of components under loading conditions.**

The learner can:

1. Explain the concept of stresses and strains: Compressive and shear stresses and linear, lateral, shear, thermal and volumetric strains.
2. Explain static equilibrium, Newton's Laws and Calculation of reaction and internal forces.
3. Explain **Hooke's law**, Poisson's ratio, Modulus of Elasticity and Modulus of Rigidity, Bulk Modulus.
4. Explain stress-strain diagrams for **ductile and brittle materials** and for various strengths of material- yield strength, ultimate tensile strength etc.
5. Explain the interrelation between elastic constants, proof stress and true stress and strain, axial force diagrams, stresses and strains in determinate, homogeneous and composite bars under concentrated loads and self weight.
6. Explain temperature stresses in simple and composite members.
7. Explain strain energy due to axial load (gradual, sudden and impact) and strain energy due to self weight.

#### **Range**

**Hooke's law** - the linear relationship between stress and strain.

**Ductile material** - the material that undergoes large permanent strains before failure.

**Brittle material** - the material that undergoes relatively low values of strain before failure. It is a material that fails in tension.

### **Outcome 2      Solve problems involving simple and combined modes, including torsion and bending.**

The learner can:

1. Explain and solve problems re centroids, moment, second moment of areas and products of moment of plane areas; parallel axis theorem.
2. Explain the basics of 2D and 3D stress states and stress elements.
3. Explain and solve problems in respect of torsional moments and stresses.
4. Solve problems in respect of stresses and strains due to shear forces, bending moments, torsional moments, combination of axial loads, and bending moments.
5. Explain Mohr's circle and use of Mohr's circle in solving problems; Maximum shear stress and **principal stresses** and **principal strains**.
6. Explain shear force and bending moment, sketch shear force and bending moment diagrams and application of shear force and bending moment diagrams to solve problems.

#### **Range**

**Principal stresses:** the maximum and minimum normal stresses that can be found from transformation equation for normal stress.

**Principal planes:** the planes on which the principal stresses act. The shear stresses are zero on the principal planes.

### **Outcome 3 Analyse and design beams under bending loads and calculate deflection of beams using several methods, including energy method.**

The learner can:

1. Explain and apply the flexure formula, slope and deflection of beams – relation between bending moment and slope; deflection determinate beams, double integration method (Macaulay's method), derivation of formula for slope and elastic deflection for standard cases.
2. Explain and apply Mohr's first and second theorems (Moment of Area method) to solve determinate problems.
3. Explain and apply Castigliano's theorem to solve problems.

### **Outcome 4 Explain buckling of columns under different loading conditions.**

The learner can:

1. Explain columns and failure of columns.
2. Explain **critical load** of a column and slenderness ratio.
3. Explain and apply Euler's formula for buckling load for column with different end conditions.
4. Explain the concept of equivalent length for various end conditions.
5. Explain Limitations of Euler's formula, and Rankine's formula.
6. Determine safe load on columns.

#### **Range**

**Critical load** - the maximum axial load that a column can support when it is on the verge of buckling.

**Ideal column** - the column that is perfectly straight before loading and made of homogeneous material, and the load is applied through the centroid of the cross section.

**Slenderness ratio** - is  $L/r$ , where  $r$  is the smallest radius of gyration of the cross section. Buckling will occur about the axis where this ratio gives the greatest value.

### **Outcome 5 Explain kinematic concepts of link mechanisms and their velocities and accelerations.**

The learner can:

1. Explain basic kinematic concepts:
  - Inversions
  - Single and double slider crank chains straight line motion **mechanisms**
  - **Four-bar mechanism kinematics (velocity, acceleration, coupler curve)**
  - **Kennedy theorem of three centers and applied for four-bar mechanism**
  - **Grashof's theorem to explain categories of four-bar mechanism.**
2. Determine velocity and acceleration analysis in mechanisms:
  - Relative velocity methods
  - Instantaneous center of rotation
  - Kennedy theorem of three centres
  - Centrifugal acceleration, Coriolis acceleration
  - Velocity and acceleration diagrams
  - Accelerations in different directions (centrifugal acceleration, tangential acceleration, and Coriolis acceleration).

**Range**

**Mechanism** - is mechanical portion of the machine for transferring motion and forces from a power source to an output.

**Outcome 6 Explain the concepts of friction and friction devices.**

The learner can:

1. Explain the friction phenomenon and laws of friction.
2. Analyse how belt and rope drives transmit power.
3. Analyse transmission of power through various types of friction clutches.
4. Explain power transmission through screw drives with square threads and V-threads.
5. Explain the theory of shoe, band and block brakes.

**Outcome 7 Explain fundamental of vibration of rotating masses and the need to balance rotating masses and determine unbalanced forces of systems with rotating masses and balance them.**

The learner can:

1. Explain the need to balance rotating parts; static and dynamic **unbalance** of rotating masses.
2. Solve balance problems of several masses in different planes through analytical and graphical methods.

**Range**

**Unbalance** - vibratory force or motion on bearings due to centrifugal forces

**Outcome 8 Explain the principles, and explain use and application of different governors and cams.**

The learner can:

1. Explain different types of governors and their distinct characteristics.
2. Explain the effect of friction, controlling force, governor effort and power, sensitivity and isochronism.
3. Explain different types of cams and the function performed by them.
4. Design a cam profile to produce the required follower motion.

**Outcome 9 Perceive vibration principles and develop skills in modelling simple vibratory systems with first degree of vibration to solvable models.**

The learner can:

1. Explain the types of vibrations, basic features of vibration systems and degrees of freedom.
2. Explain natural frequency, and calculation of natural frequency of vibration.
3. Explain resonance phenomenon and its importance in engineering
4. Model simple vibratory systems to form a mathematically solvable system.
5. Develop skills to solve mathematical equations and to obtain system response in terms of displacement, velocity and acceleration using both equilibrium and energy methods.
6. Explain damped and undamped vibrations and explain effect of damping.
7. Explain forced damped and undamped vibration and their impacts.
8. Explain vibration isolation and transmissibility.
9. Describe the importance of vibration, use of vibration in fault diagnosis control of vibration and vibration absorbers.

**Outcome 10 Explain the use of flywheel in machines, turning moment diagram and fluctuation of energy and law of conservation of energy.**

The learner can:

1. Explain the fluctuation of energy in machines and use of flywheels.
2. Explain the turning moment diagram under different load torque conditions.
3. Describe the law of conservation of energy.

# Unit 130                      Mechanics of machines and strength of materials

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.

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Stresses and strains	20
Bending of beams Buckling of columns	20
Velocities and accelerations of link mechanisms Friction and friction devices Balancing of rotating masses	20
Governors; flywheel in machines, turning moment diagrams and fluctuation of energy	20
Vibration of 1 d.o.f. systems	20

## The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

### **Introduction**

This unit is about the structure-mechanical property interrelationship of engineering materials and their predictive performance at the design, manufacture and in-service stages.

### **Unit aim**

The aim of this unit is to provide the knowledge required to understand the properties and behaviour of materials used in engineering applications particularly metals, polymers and ceramics.

### **Learning outcomes**

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

1. Demonstrate understanding of the relationship between atomic bonding mechanisms and the physical properties of materials
2. Distinguish between microstructure and properties in three classes of materials
3. Discuss the interaction between the physical properties of materials and their behaviour during manufacture and in-service
4. Describe how the microstructure of a material can be controlled and modified to optimise performance during manufacture
5. Demonstrate the use of simple analytical techniques and models to predict the characteristics of materials

### **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 laboratory practical work and independent study. The unit may be carried out on full time or part time basis.

### **Assessment**

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

Learners are expected to have knowledge of physical and chemical characteristics of common materials as per the City & Guilds Advanced Technician Diploma 2565-03-033 or relevant HND or other equivalent.

# Unit 131                      Materials

## Assessment Criteria

### **Outcome 1      Demonstrate understanding of the relationship between atomic bonding mechanisms and the physical properties of materials**

The learner can:

1. Describe materials solidification under equilibrium conditions.
2. Describe the concepts of metallographic structures.
3. Interpret phases, phase diagrams and phase changes.
4. Recognise cast structures.
5. Explain departures from equilibrium conditions.
6. Describe the effects of thermo mechanical treatments on microstructure.
7. Explain the formation of polymer molecules by:
  - a addition reactions
  - b condensation reactions.
8. Demonstrate the **structure** of:
  - a thermoplastics
  - b thermosetting resins
  - c elastomers.
9. Explain the compounding of plastics and rubbers for manufacture and service.
10. Conceptualise timber as a natural polymer.
11. Categorise ceramics and cements:
  - a naturally occurring
  - b manufactured.
12. Relate **atomic bonding** mechanisms to physical and mechanical properties.

#### **Range**

#### **Atomic bonding**

The nature of the interatomic forces which hold atoms together and eg define the physical properties, including chemical, mechanical, electrical and magnetic behaviour of materials.

#### **Structure**

'Subatomic' describes the behaviour of electrons within a given atom, 'atomic', which encompasses the relationship between atoms and 'micro-', which examines the effect of large groups of atoms (a phase) in relation to other compositional different groups within a given material.

### **Outcome 2      Distinguish between microstructure and properties in three classes of materials**

The learner can:

1. Use the iron-carbon diagram to explain the effect on plain carbon steel of:
  - a hardening
  - b tempering
  - c normalising
  - d stress relieving
  - e surface treatments.
2. Explain the relationship between microstructure and mechanical properties.



3. Describe the effects of **alloying** of steels on:
  - a **heat treatment** response
  - b final properties.
4. Extend the iron-carbon diagram to cast irons.
5. Explain the effects of non-equilibrium cooling on morphology and properties.
6. Determine the effect of alloying to produce stainless steel on:
  - a structure
  - b corrosion resistance.
7. Explain carbide formation in stainless steel when joining by welding.
8. Explain stainless steel stabilisation to avoid carbide formation when welding.
9. Ascertain the properties of cast and wrought aluminium alloys.
10. Select aluminium alloys to suit particular applications:
  - a aeronautical
  - b ship and boat building
  - c lightweight structures
  - d automobile.
11. Describe heat treatment processes and their effect on properties:
  - a age hardening
  - b precipitation treatment.
12. Assess fibre reinforced plastics for properties and applications.
13. Explain **reinforcing** techniques and fibre-matrix reaction.
14. Assess cement, concrete and aggregates for properties and applications:
  - a types and treatment
  - b chemical composition.
15. Determine the influence on hardening of cement and concrete of chemical **admixtures**.
16. Describe the properties of fresh concrete:
  - a setting process
  - b hardening process.
17. Describe the properties of hardened concrete:
  - a chemistry
  - b microstructure
  - c effect of curing
  - d strength
  - e creep
  - f shrinkage
  - g durability.
18. Conduct standard tests on concrete specimens.
19. Determine the mechanical properties of bitumen – aggregate mixes.

### Range

**Alloying** – the addition of impurity atoms to a metal, resulting in a solid solution or new second phase.

**Heat Treatment** – controlled application of thermal processes used to modify the phases in a material with the end of improving some of the properties.

**Admixture** – a mixture of different materials, generally for the purpose of encouraging a subsequent aggregation process.

Composite **reinforcing** – the dispersion of one phase or material within another with the purpose of creating a material with (some) physical properties superior to either.

### Outcome 3 Discuss the interaction between the physical properties of materials and their behaviour during manufacture and in-service

The learner can:

- 1 Analyse the effect **deformation** processes on metals:
  - a line and point defects
  - b effect of grain boundaries
  - c multiphase structures.
2. Assess the results of work hardening.
- 3 Describe the deformation characteristics of:
  - a rolling
  - b extrusion
  - c forging
  - d deep drawing.
4. Describe the effects of deformation processes on mechanical properties.
5. Describe the effect of in-service activity on materials:
  - a fatigue
  - b creep
  - c tensile strength.
6. Explain the influence of bad design or accidental defects on the setting up of stress concentrations when in service.
7. Analyse **fracture** mechanics concepts.
- 8 Determine the origins of **brittle** behaviour in advanced ceramics.
9. Determine remedies for brittle behaviour in ceramics.
10. Perform electrochemical **corrosion** tests on materials.
11. Assess corrosion prevention treatment techniques and treatments.
12. Explain how corrosion prevention treatments affect the microscopic structure of materials.
13. Explain the **degradation** of polymeric materials in:
  - a processing
  - b in service.

#### Range

**Deformation** – the application of stress to a material resulting in material movement, elastically (stress linearly proportional to recoverable strain) or plastically (stress not linearly proportional to strain and not recoverable).

**Fracture** – the separation of a body into two pieces as the result of an imposed stress, at temperatures below the melting point of the material.

**Brittle fracture** - takes place by fast crack propagation without appreciable plastic deformation. Opposite of ductile fracture, where fracture is preceded by measurable permanent plastic deformation.

**Corrosion** -the destructive and unintentional attack of (usually) a metal, or other material by a second material in surface contact by an electrochemical process.

**Degradation** – deterioration of properties of a (usually) polymeric material by a physiochemical process.

## **Outcome 4 Describe how the microstructure of a material can be controlled and modified to optimise performance during manufacture**

The learner can:

1. Describe the microstructure and properties of nanomaterials
2. Describe the casting of metals and metal alloys:
  - a cast iron
  - b concast steel
  - c cast aluminium.
3. Analyse the structure of cast metals and the influence of casting conditions.
4. Describe casting mould design.
5. Recognise cast faults and soundness:
  - a burning
  - b inclusions
  - c porosity.
6. Develop models of cast metal nucleation.
7. Analyse the effects of super-cooling on cast metal microstructures.
8. Describe powder technology in the production of advanced ceramics.
9. Explain the role of diffusion in the manufacture of advanced ceramics.

## **Outcome 5 Demonstrate the use of simple analytical techniques and models to predict the characteristics of materials**

The learner can:

- 1 Use model and use **analytical techniques** in support of Outcomes 1 to 4.

### **Range**

**Analytical technique** – the testing or otherwise evaluation of a material to determine a physical property.

# Unit 131                      Materials

## 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:

<b>Topic</b>	<b>Approximate % examination weighting.</b>
Atomic bonding mechanisms and the physical properties of materials	20
Microstructure and properties of materials	20
Physical properties of materials and their behaviour during manufacture and in-service	20
Control and modification of microstructure of a material to optimise performance during manufacture.	20
Use of simple analytical techniques and models to predict the characteristics of materials	20

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

### Unit guidance

Wherever possible, learners should have access to materials as studied and practical opportunity to process, analyse, test and examine materials practically, assessment being made of laboratory reports.

**Level:** 6

### **Introduction**

This unit is about the tools used in production of manufactured goods and the related technologies that deal with turning of raw materials into the affordable, quality goods essential to today's society. Production tools include machine tools and other related equipment and their accessories and tooling. Machine tools are non-portable, power-driven manufacturing machinery and systems used to perform specific operations on materials to produce products or components. Therefore, this unit covers processes, machine tools and tooling in manufacturing.

### **Unit aim**

The aim of this unit is to provide the knowledge required to understand the manufacturing processes, production tools, machine tools and related technologies and build capacity of using the three parameters to convert raw materials into products.

### **Learning outcomes**

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

1. Differentiate various manufacturing processes and their limitations, technological parameters of such processes, and decide best and economical processes in product manufacturing
2. Understand fundamentals of machine tools and production tools, and select correct machine and production tools related to the processes
3. Explain the principles of production planning applied to a given manufacturing system
4. Explain the principles of conventional and numerical control machine tools, the limitation of conventional machine tools and benefits from numerical control machine tools
5. Develop simple programmes for Computer Aided Machining of components and use computers in manufacturing

### **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 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

Learners are expected to have basic working skills and knowledge of workshop operations and common machining processes as per the City & Guilds Advanced Technician Diploma 2565 03 034 unit or relevant HND or other equivalent.

# Unit 132      Manufacturing technology

## Assessment Criteria

### **Outcome 1      Differentiate various manufacturing processes and their limitations, technological parameters of such processes, and decide best and economical processes in product manufacturing**

The learner can:

1. Explain the characteristics of the following manufacturing processes and their basic technological parameters, limitations and applications:
  - a Casting of metals
  - b Metal cutting
  - c Hot and Cold working of Metals
  - d Using Plastics and Polymers, and Forming of polymers
  - e Welding, soldering and brazing
  - f Unconventional methods of machining
  - g Gear manufacturing
  - h Heat treatment
  - i Powder coating
  - j Finishing methods,
  - k Electroforming, coating, metal spraying and packaging
  - i Any other manufacturing processes.
2. Select and decide most appropriate operations as required by product designs.

### **Outcome 2      Understand fundamentals of machine tools and production tools, and select correct machine and production tools related to the processes**

The learner can:

1. Explain cutting motion, process capability, structure, kinematics of machine tool drives, elements of machine tools, driving mechanisms, characteristics of machine tools, methods of lubrication, etc.
2. Explain and apply control of machine tools.
3. Explain the operation of lathes, slotting machines, drilling machines, milling machines, broaching and sawing machines, drilling and boring machines, grinding machines, injection moulding machines, hot and cold forming and forging machines, blanking machines, power presses, etc. and levels of automation of these machine tools.
4. Select and use the appropriate tools in the above processes and understand the technological parameters of the tools.
5. Explain the theory of metal cutting, cutting tools and cutting tool materials and their suitability, machineability, dynamometry, effect of cutting fluids and dies and punches.
6. Differentiate the equipment related to various heat treatment methods.

### **Outcome 3 Explain the principles of production planning applied to a given manufacturing system**

The learner can:

1. Plan for manufacturing a product from the design and customer perspective.
2. Plan the manufacturing process.
3. Judge relevant economical operations depending on the product requirements, product planning and scheduling operations.
4. Evaluate the operational planning with a view to reduction of cost and so achieve economy in manufacturing ensuring:
  - a cost reduction
  - b maintain the product functional and aesthetic values
  - c flexibility in tooling and operations
  - d maintaining the required tolerances
5. Costing of manufacturing process and product costing.

### **Outcome 4 Explain the principles of conventional and numerical control machine tools, the limitation of conventional machine tools and benefits from numerical control machine tools**

The learner can:

1. Explain the constraints of conventional machines and advantages and disadvantages of numerical control machine tools.
2. Explain Numerical and Computer Numerical Control Machine Tools and their operation.
3. Explain Computer Numerical Control and Direct Numerical Control.
4. Identify hardware used in NC machines and CNC machines.
5. Explain various manufacturing processes and machine tools with CNC.
6. Explain NC and CNC machine accuracy and safety.

### **Outcome 5 Develop simple programmes for Computer Aided Machining of components and use computers in manufacturing**

The learner can:

1. Design and produce a part program.
2. Use computers in product manufacturing.

# Unit 132            Manufacturing technology

## Notes for guidance

### Test specification for written paper

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

The examination will cover knowledge specifications:

<b>Topic</b>	<b>Approximate % examination weighting.</b>
Manufacturing processes in product manufacturing	20
Machine tools and production tools	10
Process planning and evaluation	15
Conventional and numerical control machine tools	10
Programmes for Computer Aided Machining of components and use of computers in manufacturing	15
CAD and CAM systems in manufacturing	15
Automation of production facilities and use of robotics	15

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass



## Unit 133

# Analysis and design of manufacturing technology

**Level:** 6

### Introduction

This unit is about the procedures and methodologies for designing manufacturing systems.

### Unit aim

The aim of this unit is to provide the knowledge, understanding and techniques to analyse and design manufacturing systems, and apply analytical techniques to solve problems associated with manufacturing activities.

### Learning outcomes

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

1. Describe business strategy in the analysis and design of manufacturing systems
2. Apply modelling and representation to manufacturing systems
3. Analyse the design of manufacturing systems
4. Apply performance criteria to manufacturing systems
5. Understand workstation design and ergonomics

### 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 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 have knowledge as per the City & Guilds Advanced Technician Diploma units 2565-03-034, 2565-03-035 and 2565-03035 or relevant HND or other equivalent.

# Unit 133      Analysis and design of manufacturing technology

## Assessment Criteria

### **Outcome 1      Describe business strategy in the analysis and design of manufacturing systems**

The learner can:

1. Compare manufacturing systems in a minimum of **three** industrial sectors:
  - a. economic characteristics
  - b. value added activities
  - c. productivity indices
  - d. innovation
  - e. engineering for manufacture (EFM)
  - f. managing the design process.
2. Assess corporate, business unit and process strategies:
  - a. speed of response
  - b. product and process flexibility
  - c. cost minimisation
  - d. capabilities and synergy
    - R and D
    - Design
    - Manufacturing
    - management and sales.
3. Undertake an audit of manufacturing activities and process capabilities for assessing make-or-buy decisions.

### **Outcome 2      Apply modelling and representation to manufacturing systems**

The learner can:

1. Identify systems and sub-systems.
2. Explain concepts of structured design methods:
  - a. input-output models
  - b. flow diagrams
  - c. material mapping
  - d. information flows.
3. Explain soft system methodologies and their applications.
4. Assess steady state and dynamic models:
  - a. system delays
  - b. queuing and distribution
  - c. continuous and discrete mathematical modelling methods.
5. Implement simulation, discrete event and Monte Carlo methods of modelling /representation.
6. Use empirical data.
7. Test production schedules.
8. Apply and appraise computer simulation and virtual reality modelling.

### **Outcome 3 Analyse the design of manufacturing systems**

The learner can:

1. Analyse design and production classification:
  - a. jobbing
  - b. batch line
  - c. Detroit automation
  - d. cellular manufacture
  - e. flexible manufacture systems (FMS)
  - f. group technology (GT)
  - g. single minute exchange of dies (SMED)
  - h. just-in-time (JIT).
2. Assess the criteria for the selection of the above.
3. Undertake sensitivity analysis.
4. Compare and contrast manual and automated design systems.
5. Synchronise information and material flow systems:
  - a. forecasting methods
  - b. vector networks
  - c. information needs of different functional units.
6. Analyse the concepts and elements of computer integrated manufacturing and business management systems.
7. Analyse waste reduction systems:
  - a. effective design of work
  - b. facilities planning
  - c. plant layout and materials handling systems
  - d. elimination of no-value-added operations.

### **Outcome 4 Apply performance criteria to manufacturing systems**

The learner can:

1. Identify performance indices and the business strategy:
  - a. resource utilisation
  - b. customer satisfaction
  - c. benchmarking.
2. Assess production and inventory control systems:
  - a. KANBAN
  - b. OPT
  - c. MRPII.
3. Assess system capacity and reliability:
  - a. run-time
  - b. delivery performance
  - c. work in progress (WIP)
  - d. throughout time.
4. Assess maintenance strategies and techniques:
  - a. Total Productive Maintenance (TPM)
  - b. planned maintenance systems.

## **Outcome 5 Understand workstation design and ergonomics**

The learner can:

1. Apply work study and method study fundamentals:
  - a. History of Work Study
  - b. Analysis of Work Content
  - c. Method Study
  - d. Process Analysis, Process and Activity Charts
  - e. Operation Analysis
  - f. Basic procedure in Micro Motion Study, Principles of Motion Economy
  - g. Work Measurement: Purposes and uses
  - h. Basic procedure, Techniques – Work Sampling, Stop-Watch Time Study, rating and allowances, Setting Standard Times for Jobs, Standard Data, Predetermined Time Standards.
2. Apply fundamental concepts of ergonomics to man-machine systems in manufacturing:
  - a. describe the basic ergonomics factors and related problems in the interfaces of a man machine system
  - b. diagnose the problems of given man machine interfaces
  - c. apply relevant ergonomics principles and factors in system design
  - d. Fatigue Measurement and Evaluation
  - e. Environmental Factors and Work Systems.
3. Explain basic concepts of job evaluation:
  - a. Objective and Subjective methods
  - b. Compensation Schemes
  - c. Relationship of Work Study to Incentive Schemes, Wage Incentive Plans.

# Unit 133      Analysis and design of manufacturing technology

Notes for guidance

## Test specification for written paper

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

The examination will cover knowledge specifications:

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Business strategy in the analysis and design of manufacturing systems	20
Modelling and representation of manufacturing systems	20
Design of manufacturing systems	20
Performance criteria of manufacturing systems	20
Workstation design and ergonomics	20

## 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

Delivery should be action-centred learning with learners undertaking group exercises in combination with theoretical delivery. The action-centred components could consist of case study development or worked group exercises around preferably real scenarios.

**Level:** 6

### **Introduction**

This unit deals with hydraulics ie the movement of fluids, particularly water, and the transfer of energy through liquids. The unit also deals with hydraulic machines ie equipment which is powered by fluids to perform work.

### **Unit aim**

The aim of this unit is to provide knowledge and the skills required to understand principals of fluid mechanics and hydraulics and to apply these principles in hydraulic machines.

### **Learning outcomes**

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

1. Demonstrate an understanding of fluid mechanics related to fluid power and perform fluid power calculations
2. Explain the principles and application of fluid power machinery
3. Identify unique features of components that are used in hydraulic circuits and to design hydraulic circuits to drive and control machinery

### **Guided learning hours**

It is recommended that **150** hours should be allocated for this unit of which **90** would 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

Learners are expected to have knowledge of science and mathematics needed to solve basic engineering problems as per the City & Guilds Advanced Technician Diploma 2565-03-047 and also the award 3565-03-040 or relevant HND or other equivalent.

# Unit 134      Hydraulics and hydraulic machines

## Assessment Criteria

### **Outcome 1      Demonstrate an understanding of fluid mechanics related to fluid power and perform fluid power calculations**

The learner can:

1. Explain the following:
  - a Properties of fluids
  - b Hydraulic pressure
  - c Hydrostatic force, centre of pressure.
2. Calculate hydraulic pressure, hydrostatic force and centre of pressure in various application.
3. Explain kinematics of fluid flow:
  - a Types of motion
  - b Stream line, path line and streak line
  - c Practical acceleration
  - d Control volume approach.
4. Explain principles of fluid flow dynamic and apply to solve problems:
  - a Linear momentum equation
  - b Reaction of a jet
  - c Impact of jets
  - d Moment of momentum
  - e Euler Equation along a stream line
  - f Bernoulli Principle
  - g Jet pump
  - h Applications of above principles to problems.
5. Explain and analyse pipe flow problems:
  - a Laminar flow
  - b Turbulent flow
  - c Losses in pipes, pipe fittings and valves
  - d Pipes in parallel and series
  - e Water hammer and its applications
  - f Quasi-steady flow in pipes.
6. Analyse Open Channel flow:
  - a Classification of flows through open channels
  - b Specific energy, critical depth
  - c Flow through sluice gate
  - d Flow in circular pipes with a free surface
  - e Optimum shape of cross sections
  - f Hydraulic jump
  - g Characteristics of channel flow.
7. Explain incompressible viscous flow:
  - a Navier Stokes equation and its applications
  - b Between parallel plates and concentric cylinders
  - c Navier Stokes equation in lubrication applications.
8. Explain formation of boundary layer and turbulent flows:
  - a Laminar boundary layer
  - b Boundary layer thickness

- c Two dimensional boundary layer
  - d Coefficient of drag on a flat plate
  - e Velocity profiles for turbulent flow through pipes and channels
  - f Turbulent flow over flat plate.
9. Explain the behaviour of compressible fluid flow:
    - a Law of conservation energy to open and closed systems
    - b Stagnation effects
    - c Normal shock
    - d Nozzles.
  10. Explain flow over immersed bodies:
    - a Lift and drag forces
    - b Flow past circular cylinders and spheres
    - c Aerofoil theory.

## **Outcome 2 Explain the principles and application of fluid power machinery**

The learner can:

1. Explain the impact of free jets and hydraulic turbines:
  - a Force exerted on stationary and moving flat plates
  - b Force exerted on curved vanes stationary and moving
  - c Jet propulsion of ships.
2. Explain Hydraulic Turbines and compute power output and efficiency:
  - a Differentiate between impulse and reaction turbines
  - b Power calculation
  - c Application of aerofoil theory to Kaplan turbines
  - d Governing mechanism.
3. Explain positive displacement pumps and rotodynamic pumps:
  - a Classification of pumps
  - b Working principles of reciprocating and centrifugal pumps
  - c Working principles of other popular pumps in use
  - d Function of various hydraulic devices such as ram, press, accumulator, intensifier, crane, etc.
4. Explain fluid coupling and torque converter:
  - a Fluid couplings
  - b Torque converters
  - c Efficiency calculations.
5. Explain water power development:
  - a Meaning of hydrology
  - b Run-off curves and tables
  - c Hydrograph
  - d Hydropower.



### **Outcome 3 Identify unique features of components that are used in hydraulic circuits and to design hydraulic circuits to drive and control machinery**

The learner can:

1. Explain principles of operation and carry out relevant calculations on:
  - a Forces and torque multiplication
  - b Hydraulic circuits incorporating CETP/ISO symbols
  - c Constant pressure and load sensing systems
  - d Open and Closed circuits
  - e Hydraulic pumps
  - f Controlling valves and their operations (manual and solenoid)
  - g Actuators and hydraulic motors
  - h Accumulator
  - i Hydraulic fluids
  - j Filters Seals, fittings and connections
  - k Basic fluid power calculations
  - l Circuit designs.

# Unit 134            Hydraulics and hydraulic machines

## 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:

<b>Topics</b>	<b>Approximate % examination weighting</b>
Fluid mechanics related to fluid power	
Incompressible fluid flow	
Compressible fluid flow	40
Flow over immersed bodies	
Fluid power machinery	
- Hydraulic Turbines	
- Pumps	40
- Fluid coupling and torque converter	
Components in hydraulic circuits	
Design of hydraulic circuits to drive and control machinery	20

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

### Unit guidance

Delivery should be mainly practical/laboratory based.

**Level:** 6

**Introduction**

This unit is about the elastic behaviour of engineering components and the use of theoretical, numerical and experimental techniques to determine stresses, strain and deflections under various load conditions.

**Unit aim**

The aim of this unit is to provide knowledge and understanding of elastic behaviour and an introduction to non elastic behaviour of engineering components using classical theory, approximate numerical methods and experimental techniques.

**Learning outcomes**

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

1. Calculate stresses, strain and deflections in a range of components under various load conditions
2. Select appropriate methods for the detail design of components
3. Demonstrate an understanding of the basis of computer software used in stress analysis

**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 and 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

Learners are expected to have knowledge of mathematics and scientific principles needed to solve problems applicable to mechanical engineering as per the City & Guilds Advanced Technician Diploma 2565-03-047 or relevant HND or other equivalent.

# Unit 135                      Mechanics of solids

## Assessment Criteria

### **Outcome 1      Calculate stresses, strain and deflections in a range of components under various load conditions**

The learner can:

1. Use Mohr's Circle to determine:
  - a. stresses on inclined planes
  - b. combined bending torsion and axial loading.
2. Use and position on components strain gauge rosettes.
3. Use calculations and or graphic means to determine:
  - a. shear force and bending moments in laterally loaded beams
  - b. bending stress and shear stress distribution in beams
  - c. deflection of beams
  - d. solution of statically indeterminate beams
  - e. centre of shear in beams.
4. Extend shear force, bending moment, bending stress, shear stress and deflection analysis to:
  - a. beams of asymmetric cross section
  - b. composite beams
  - c. beams of 'elastic-perfectly plastic' material.
5. Determine shear stress and twist of:
  - a. circular solid sections
  - b. thin walled cylinders
  - c. simple open sections.
6. Apply Euler critical loads to determine buckling for a combination of:
  - a. free conditions
  - b. pinned conditions
  - c. built in end conditions.
7. Determine limiting stress condition.
8. Use analytical methods to determine stresses and displacements in rings, cylinders and discs under axi-symmetric loading:
  - a. internal/external pressure
  - b. shrink fits
  - c. rotation.
9. Apply Lamé equations to problem solving.
10. Employ **Finite Element Analysis**:
  - a. discretisation
  - b. types of elements
  - c. relationship between
    - i nodal forces
    - ii nodal displacements
    - iii stiffness matrix.
11. Represent examples of linear elements using springs.
12. Obtain stiffness matrix using:
  - a. one-dimensional quadratic elements
  - b. displacement functions
  - c. shape functions

- d. principle of virtual work.
- 13. Determine stresses from primary unknown nodal displacements.
- 14. Explain the underlying assumptions and approximate nature of the results of Finite Element Method.
- 15. Analyse engineering materials behaviour when loadings and service conditions:
  - a. involve
  - b. **fatigue**
  - c. yield criteria
  - d. fracture mechanics
  - e. creep
  - f. **viscoelasticity.**
- 16. Assess and select materials for applications:
  - a. plastics
  - b. composites
  - c. ceramics
  - d. modern materials.

### **Range**

**Finite Element Analysis (FEA):** for many types of practical engineering problems analytical solutions do not exist. To obtain a solution, the region of interest is divided up into numerous connected sub-regions or elements within approximate functions (usually polynomials) are used to represent the unknown quantity. The numerical method that obtains a solution using these elements is called Finite Element Analysis Software.

**Fatigue life:** the number of cycles of a specified loading that a given specimen can be subjected to before failure occurs.

**Viscoelasticity:** is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation.

## **Outcome 2    Select appropriate methods for the detail design of components**

The learner can:

1. Implement the analytic techniques in Outcome 1 to engineering designs involving:
  - a. beams
  - b. columns
  - c. thin cylinder applications
  - d. pressure vessels
  - e. structural steelwork
  - f. shafts
  - g. buildings.

## **Outcome 3    Demonstrate an understanding of the basis of computer software used in stress analysis**

The learner can:

1. Undertake and solve engineering design calculations and mechanics of materials problems using various computer software packages.

# Unit 135                      Mechanics of solids

## 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:

<b>Topics</b>	<b>Approximate % examination weighting.</b>
Stress, strain and deflections	40
Design of components	30
Computer software used in stress analysis	30

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

### 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.

It is important to provide homework and frequent quizzes to make sure that the learners are studying the lectures continuously. Solving problems is the most efficient way to understand this module.

**Level:** 6

### Introduction

This unit is about the methodology used for the design and evaluation of control systems.

### Unit aim

The aim of this unit is to provide the knowledge and skills required to design and evaluate control systems relating to mechanical, manufacturing, chemical and electrical engineering applications.

### Learning outcomes

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

1. Apply mathematical modelling to dynamic systems and analyse their responses
2. Analyse and solve problems associated with feedback control systems
3. Choose instrumentation for measurement of variables commonly used in control systems

### Guided learning hours

It is recommended that **150** hours should be allocated for this unit of which **90** would 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

The learner is expected to have knowledge of mathematics needed to solve basic engineering problems and be familiar with complex variable theory, solution of 1st and 2nd order differential equations using time domain and Laplace techniques and also have knowledge of the basics of applied mechanics as per the City & Guilds Advanced Technician Diploma 2565-03-038 and 039 and 047 or relevant HND or other equivalent (ie 8030-2000).

## Unit 136      Control systems

### Assessment Criteria

#### **Outcome 1      Apply mathematical modelling to dynamic systems and analyse their responses**

The learner can:

1. Apply mathematical modelling to lumped-parameter components, devices and systems with examples from some of the following areas:
  - a. electrical
  - b. hydraulic
  - c. mechanical
  - d. pneumatic
  - e. thermal.
2. Apply linearisation of dynamic equations about an equilibrium operating state.
3. Use following methods of system representation:
  - a. block diagrams and block diagram reduction
  - b. transfer functions
  - c. signal flow graphs.
4. Perform transient and steady-state response analysis of first-order and second-order systems to the function inputs:
  - a. impulse
  - b. step
  - c. ramp
  - d. sinusoidal.
5. Analyse transfer function and state variable formulations of dynamic system equations including the effects of initial conditions.
6. Demonstrate the understanding of response characterisation:
  - a. time constant
  - b. un-damped and damped natural frequencies
  - c. damping ratio
  - d. settling time
  - e. rise time
  - f. resonant frequency
  - g. maximum of the modulus of the frequency response
  - h. bandwidth.
7. Extend the above to higher order systems such as systems with a dominant time constant.

#### **Outcome 2      Analyse and solve problems associated with feedback control systems**

The learner can:

1. Compare control systems without and with feedback.
2. Assess common types of close-loop control systems and relationship with steady state errors.
3. Obtain characteristic equation of closed-loop control systems and analyse using Routh-Hurwitz stability criterion.
4. Apply design criteria to closed loop control systems:
  - a. stability margins
  - b. steady-state errors



- c. performance indices in the time domain
  - d. disturbance rejection
  - e. concept of design sensitivity.
5. Implement control algorithms by finite difference techniques (discrete mathematics).
  6. Perform frequency domain analysis of closed loop control systems:
    - a. Root locus diagram
    - b. Nyquist
    - c. Bode
    - d. Nichols
    - e. stability criteria
    - f. relative stability
    - g. peak magnitude of frequency response
    - h. gain and phase margins.
  7. Apply closed-loop system response to disturbances with differing entry points.
  8. Assess state variable formulation of the system equation; canonical transformation and canonical state variables.
  9. Assess the implication of controllability and observability.
  10. Apply compensation techniques using frequency response and root loci design methods:
    - a. lead/lag networks
    - b. proportional – integral - derivative (PID) control .

### **Outcome 3    Apply performance criteria to manufacturing systems**

The learner can:

1. Assess the performance characteristics of instruments:
  - a. static
    - i. sensitivity
    - ii repeatability
    - iii resolution
  - b. dynamic
    - i bandwidth
    - ii settling time
    - iii dead time.
2. Assess transducers commonly used for the measurement of controlled variables, with examples from some of the following areas:
  - a. displacement
  - b. velocity
  - c. acceleration
  - d. force
  - e. torque
  - f. power
  - g. pressure
  - h. temperature flow rate
  - i. light
  - j. sound
  - k. time.
3. Recognise and select types of instruments:
  - a. passive
  - b. active analogue
  - c. digital.
4. Analyse signal conditioning and conversion:
  - a. bridge circuits

- b. operational amplifiers
- c. impedance converters
- d. digital filters
- e. microprocessors in relation to instrumentation.

# Unit 136            Control systems

## 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:

<b>Topic</b>	<b>Approximate % examination weighting.</b>
Mathematical modelling of dynamic systems and applications	25
Feedback control systems	25
Stability of digital control systems	25
Instrumentation	25

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**Level:** 6

### **Introduction**

This unit is about the fundamentals underlying the physical operation, analysis and design of electronic circuits and systems, principles of electrical machines and machine drives including power electronics. It also includes electrical/electronic measuring systems and analogue/digital communication systems.

### **Unit aim**

The aim of this unit is to provide knowledge of semiconductor devices, signal amplifiers, oscillators and digital logic families and to develop an understanding of DC machines, induction machines and various other drives.

### **Learning outcomes**

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

1. Demonstrate an understanding of DC and AC theory and describe how electric machines in industrial drive systems work and are controlled and analyse AC and DC circuits using network theorems
2. Demonstrate knowledge in applied electronics, both analogue and digital, and apply knowledge to solve problems and design analogue and digital circuits
3. Demonstrate knowledge in electric measurement, measuring instruments, sensors and how signals are amplified and filtered, use measuring instruments in various applications
4. Demonstrate knowledge in Programming Logic Devices (ROM, PLA, PAL, FPGA and CPLDs) and programming of a PLC-system and be able to perform basic automation control using a PLC-systems

### **Guided learning hours**

It is recommended that **150** hours should be allocated for this unit of which **90** would 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 plus satisfactory completion of prescribed assignments and laboratory work. The assessments will be carried out separately.

Learners are expected to have knowledge of the mathematics and scientific principles needed to solve problems in electrical and electronic engineering and the fundamentals of electrical and electronic engineering including logic circuits, measuring instruments and instrumentation systems as per the City & Guilds Advanced Technician Diploma 2565-03-047 or relevant HND or other equivalent.

# Unit 137      Electro techniques

## Assessment Criteria

### **Outcome 1      Demonstrate an understanding of DC and AC theory and describe how electric machines in industrial drive systems work and are controlled and analyse AC and DC circuits using network theorems**

The learner can:

1. Analyse ac and dc circuits.
2. Apply network theorems to ac and dc circuits.
3. Undertake mesh and nodal analysis.
4. Determine active, reactive, apparent power and power factor.
5. Analyse balanced three-phase systems.
6. Appraise the characteristics of transformers, losses and efficiency.
7. Investigate electrical machines:
  - a. concentrated windings
  - b. magneto-motive force (mmf)
  - c. working and leakage flux
  - d. flux density and mmf distributions
  - e. magnetic and electric loading and relation to machine volume.
8. Assess steady state performance of induction machines.
9. Understand the characteristics and constructional features of cage-rotor induction machines.
10. Analyse and determine torque/speed relationship of induction machines, and frequency, vector and phase controls of induction machines.
11. Investigate machine rating:
  - a. losses
  - b. cooling
  - c. temperature rise.
12. Analyse variable speed drives, permanent magnet synchronous and brushless motor drives.
13. Experience dynamic modelling of induction machines.

### **Outcome 2      Demonstrate knowledge in applied electronics, both analogue and digital, and apply knowledge to solve problems and design analogue and digital circuits**

The learner can:

1. Develop small signal amplifiers circuits involving bipolar and field effect transistors.
2. Develop circuits involving differential amplifiers, and understand dynamic response of amplifiers.
3. Describe the structure and operation of operational amplifiers, and understand the application and operation of rectifier circuits, regulated power supplies and switching regulators.
4. Use gates for combinational designs, design using MSI devices, learn sequential circuits and their applications, digital logic families, A/D converters and D/A converters with their applications.

### **Outcome 3 Demonstrate knowledge in electric measurement, measuring instruments, sensors and how signals are amplified and filtered, use measuring instruments in various applications**

The learner can:

1. Select and use a variety of measuring instruments appropriate to:
  - a. single-phase ac circuits
  - b. three-phase ac circuits
  - c. dc circuits.
2. Use various measuring instruments to measure various parameters and select a variety of measuring instruments appropriate to analysing electrical and electronic circuits.
3. Explain the function of various sensors and transducers and how signals are amplified and filtered, A/D conversion; select sensors and transducers relevant to applications.
4. Apply low and high resistance measurements, limitations of instruments and AC bridges.

### **Outcome 4 Demonstrate knowledge in Programming Logic Devices (ROM, PLA, PAL, FPGA and CPLDs) and programming of a PLC-system and be able to perform basic automation control using a PLC-systems**

The learner can:

1. Demonstrate an understanding of Binary code, Boolean algebra, programmable circuits.
2. Explain Programmable Logic Devices (PLDs) programmable logic array (PLA), Programmable Array Logic (PAL) introduction to Field Programmable Gate Arrays (FPGAs), introduction to complex programmable logic device (CPLD), design flow and hardware description languages.
3. Explain microcontrollers and microprocessor and their applications. Control using PLC (Programmable Logic Controllers).

# Unit 137          Electro techniques

## 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:

<b>Topic</b>	<b>Approximate % examination weighting.</b>
DC and AC theory	30
Electric machines in industrial drive systems	30
Analogue and digital electronics	20
Electric measurement, sensors	20
Amplification and filtering of signals	20
Programmable Logic Devices (PLDs)	20
Field Programmable Gate Arrays (FPGAs), design flow and hardware description languages	20

### The requirements to achieve overall success for this unit are:

Written examination	Pass/Merit/Distinction
Practical work	Pass

**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 **four** 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.



# Unit 138      Quality and reliability engineering

## Assessment Criteria

### **Outcome 1      Understand the importance of quality and reliability**

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**

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
- 7. Determine control system choice.

### **Outcome 3    Develop quality and reliability programme plans**

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.



## 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](http://www.cityandguilds.com).

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

- The centre and qualification approval process and forms
- Assessment, verification and examination roles at the centre
- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Frequently asked questions.

**Our Quality Assurance Requirements** encompasses all of the relevant requirements of key regulatory documents such as:

- Regulatory Arrangements for the Qualifications and Credit Framework (2008)
- SQA Awarding Body Criteria (2007)
- NVQ Code of Practice (2006)

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

**Access to Assessment & Qualifications** provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates 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:** how to register and certificate candidates on line
- **Qualifications and Credit Framework (QCF):** general guidance about the QCF and how qualifications will change, as well as information on the IT systems needed and FAQs
- **Events:** dates and information on the latest Centre events
- **Online assessment:** how to register for e-assessments.

## Useful contacts

### UK learners

#### General qualification information

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**T: +44 (0)844 543 0033**

**E: [learnersupport@cityandguilds.com](mailto:learnersupport@cityandguilds.com)**

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### International learners

General qualification information

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T: +44 (0)844 543 0033

F: +44 (0)20 7294 2413

**E: [intcg@cityandguilds.com](mailto:intcg@cityandguilds.com)**

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### Centres

Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results

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T: +44 (0)844 543 0000

F: +44 (0)20 7294 2413

**E: [centresupport@cityandguilds.com](mailto:centresupport@cityandguilds.com)**

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### 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

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T: +44 (0)844 543 0000

F: +44 (0)20 7294 2413

F: +44 (0)20 7294 2404 (BB forms)

**E: [singlesubjects@cityandguilds.com](mailto:singlesubjects@cityandguilds.com)**

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### International awards

Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports

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T: +44 (0)844 543 0000

F: +44 (0)20 7294 2413

**E: [intops@cityandguilds.com](mailto:intops@cityandguilds.com)**

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### Walled Garden

Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems

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T: +44 (0)844 543 0000

F: +44 (0)20 7294 2413

**E: [walledgarden@cityandguilds.com](mailto:walledgarden@cityandguilds.com)**

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### Employer

Employer solutions, Mapping, Accreditation, Development Skills, Consultancy

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T: +44 (0)121 503 8993

**E: [business@cityandguilds.com](mailto:business@cityandguilds.com)**

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### 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](mailto:feedbackandcomplaints@cityandguilds.com)**

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