Level 7 Postgraduate Diploma in Engineering (9107-03)

Qualification handbook

100/6074/1

www.cityandguilds.com
May 2007
Version 3.0

About City & Guilds

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

City & Guilds Group

The City & Guilds Group includes ILM (the Institute of Leadership & Management) providing management qualifications, learning materials and membership services and NPTC which offers land-based qualifications and membership services. City & Guilds also manages the Engineering Council Examinations on behalf of the Engineering Council.

Equal opportunities

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

Publications

City & Guilds publications are available on the City & Guilds website or from our Publications Sales department at the address below or by telephoning +44 (0)20 7294 2850 or faxing +44 (0)20 7294 3387.

City & Guilds
1 Giltspur Street
London EC1A 9DD
T +44 (0)20 7294 2800
F +44 (0)20 7294 2400

www.cityandguilds.com
enquiry@cityandguilds.com

Level 7 Postgraduate Diploma in Engineering (9107-03)

Qualification handbook

www.cityandguilds.com
May 2007
Version 3.0

This page is intentionally blank

Contents

1 About this document

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

Level 7 Postgraduate Diploma in Engineering	
City & Guilds qualification number	**9107-03**
QCA accreditation number	**100/6074/1**

This document includes details and guidance on:

- centre resource requirements
- candidate entry requirements
- information about links with, and progression to, other qualifications
- qualification standards and specifications
- assessment requirements

2 About the qualification

2.1 Aim of the qualification

City and Guilds of London Institute conducts on behalf of the Engineering Council UK a world-wide Examination for those who wish to meet the academic standard required to apply for Chartered Engineer but whose circumstances prevent them from pursuing an accredited degree programme, those who have non-accredited degrees and who wish to undertake further qualification to meet the required standard, and for those overseas who wish to obtain a well respected British engineering qualification.

The Engineering Council Examinations have been designed to provide a flexible route to meeting the enhanced academic standard for Chartered Engineer registration as required under UK SPEC.

Although the Engineering Council Examinations does not set any restrictions on the combination of subjects selected or the length of time taken to complete a component, prospective candidates must be aware that, if they wish to join a professional institution in order to gain CEng registration or to further their career in general, the institution may set its own limits in order to meet particular membership standards. It is vital, therefore, that prospective candidates seek the advice of their professional UK engineering institution prior to beginning their study.

The aims of this qualification are to:

- meet the needs of candidates who are working toward Chartered Engineer Status in the UK.
- support Government initiatives towards the National Qualifications Framework (NQF). For further information on the NQF, visit the QCA websites www.qca.org.uk and www.openquals.org.uk
- allow candidates to learn, develop and practice the skills required for employment and/or career progression in the engineering sector

This qualification functions

- as a stand alone qualification, accredited as part of the NQF at Level 7

2 About the qualification

2.2 The structure of the qualification

The following certificates will be awarded to successful candidates on completion of the required combinations of units. Candidates completing one or more units, rather than the full qualification, will receive a Certificate of Unit Credit (CUC).

Candidates are required to complete successfully the following:

- One compulsory paper in Advanced Engineering Analysis
- One technical paper at an advanced level form the optional choice
- Two further papers chosen from amongst those available for the Level 6 Graduate Diploma candidates. These must not be papers which have been attempted previously
- Successful submission of a project report demonstrating group work and management principles.

QCA unit reference	City & Guilds unit number	Unit title	Excluded combination of units (if any)
H/500/1693	9107-201	Applied thermodynamics	
K/500/1694	9107-202	The analysis of heat and mass transfer	
T/500/1696	9107-203	The analysis of the mechanics of fluids	Cannot attempt if taking unit 204
A/500/1697	9107-204	Hydraulics and hydrology	Cannot attempt if taking unit 203
F/500/1698	9107-205	Separation processes in chemical engineering	
J/500/1699	9107-206	Chemical thermodynamics, kinetics and reactor design	
M/500/1700	9107-207	The internal environmental design of buildings	
R/500/1706	9107-208	Properties of materials for engineering applications	

Y/500/1707	9107-209	Mechanics of solids	
H/500/1726	9107-210	The analysis of engineering structures	
K/500/1727	9107-211	The design of engineering structures	
M/500/1728	9107-212	Design and operation of marine vehicles	
T/500/1729	9107-213	Geotechnical engineering	
K/500/1730	9107-214	Engineering surveying	
M/500/1731	9107-215	The analysis and design of electric circuits and fields	
T/500/1732	9107-216	Electrical machines and drives	
A/500/1733	9107-217	Electrical energy systems	
F/500/1734	9107-218	Electronic systems engineering	
J/500/1735	9107-219	Telecommunication systems engineering	
L/500/1736	9107-220	Quality and reliability engineering	
R/500/1737	9107-221	Analysis and design of manufacturing systems	Cannot attempt if taking unit 222
Y/500/1738	9107-222	The management of construction projects	Cannot attempt if taking unit 221

D/500/1739	9107-223	The management of engineering enterprises	
Y/500/1741	9107-224	Advanced mathematical techniques for engineering applications	
D/500/1742	9107-225	Dynamics of mechanical systems	
H/500/1743	9107-226	The technology of manufacturing processes	
K/500/1744	9107-227	Control systems engineering	
M/500/1745	9107-228	Information systems engineering	
T/500/1746	9107-229	Software engineering	
A/500/1747	9107-230	Software for embedded systems	
F/500/1748	9107-231	Computer systems engineering	
R/500/1771	9107-300	Advanced engineering analysis	
Y/500/1772	9107-301	The analysis of compressible fluid flow	
D/500/1773	9107-302	Computational mechanics using finite element method	
H/500/1774	9107-303	Telecommunications engineering	
K/500/1775	9107-304	The technology of advanced manufacturing processes	
M/500/1776	9107-305	High performance computer systems engineering	

T/500/1777	9107-306	Group engineering project	

2 About the qualification

2.3 Relevant sources of information

City & Guilds also provides the following documents specifically for this qualification:

Publication	Available from
Publications order form	Please see the website at www.cityandguilds.com/ecukexams for the order form

There are other City & Guilds documents which contain general information on City & Guilds qualifications:

- *Providing City & Guilds qualifications – a guide to centre and qualification (scheme) approval*: This document 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.
- *Ensuring quality* – This document contains updates on City & Guilds assessment and policy issues.
- *Centre toolkit* – This document contains additional information on *Providing City & Guilds qualifications*, in a CD-ROM, which links to the internet for access to the latest documents, reference materials and templates
- *Directory of qualifications* – This document contains details of general regulations, registration and certification procedures and fees. This information also appears on the Walled Garden, the online qualification administration service for City & Guilds approved centres. If there are any differences between the *Directory of qualifications* and this handbook, the *Directory of qualifications* contains the more up-to-date information.

For the latest updates on our publications and details of how to obtain them and other City & Guilds resources, please refer to the City & Guilds website.

City & Guilds websites

Website	Address	Purpose and content
City & Guilds main website	www.cityandguilds.com	This is the main website for finding out about City & Guilds qualifications. It contains qualification documentation and updates.
Walled Garden	www.walled-garden.com	The Walled Garden is a qualification administration portal for approved centres, enabling them to register candidates and claim certification online.

3 Candidate entry and progression

Candidate entry requirements

Candidates must hold the equivalent of a UK accredited BEng (hons) degree in a science or engineering discipline or have undergone an individual case procedure by their relevant UK engineering institution before undertaking this requirement.

Please note that for funding purposes, candidates should not be entered for a qualification of the same type, content and level as that of a qualification they already hold. (Information on Funding, is provided in Appendix 3.)

Age restrictions and legal considerations

This qualification is not approved for use by candidates under the age of 19, and City & Guilds cannot accept any registrations for candidates in this age group. Restrictions apply to candidates under the age of 18 working unsupervised with children. Centres and candidates should be fully aware of minimum age requirements in their home nation and any implications on completing assessments.

4 Centre requirements

4.1 Obtaining centre and qualification approval

Only approved organisations can offer City & Guilds qualifications. Organisations approved by City & Guilds are referred to as **centres**.

Centres must meet a set of quality criteria including:

- provision of adequate resources, both physical and human
- clear management information systems
- effective assessment and quality assurance procedures including candidate support and reliable recording systems.

An organisation that has not previously offered City & Guilds qualifications must apply for approval to become a centre. This is known as the **centre approval process** (**CAP**). Centres also need approval to offer a specific qualification. This is known as the **qualification approval process** (**QAP**), (previously known as **scheme approval**). In order to offer this qualification, organisations which are not already City & Guilds centres must apply for centre and qualification approval at the same time. Existing City & Guilds centres will only need to apply for qualification approval for this [these] particular qualification[s].

Full details of the procedures and forms for applying for centre and qualification approval are given in *Providing City & Guilds qualifications - a guide to centre and qualification (scheme) approval*, which is also available on the City & Guilds centre toolkit, or downloadable from the City & Guilds website.

Regional and national offices will support new centres and appoint a Quality Systems Consultant to guide the centre through the approval process. They will also provide details of the fees applicable for approvals.

Assessments must not be undertaken until qualification approval has been obtained.

City & Guilds reserves the right to withdraw qualification or centre approval for reasons of debt, malpractice or non-compliance with City & Guilds' policies, regulations, requirements, procedures and guidelines, or for any reason that may be detrimental to the maintenance of authentic, reliable and valid qualifications or that may prejudice the name of City & Guilds. Further details of the reasons for suspension and withdrawal of approval, procedures and timescales, are contained in *Providing City & Guilds qualifications.*

4.2 Resource requirements

Centre staff

Centre staff must satisfy the requirements for occupational expertise for this qualification. These requirements are as follows:

- Staff should be technically competent in the areas for which they are delivering training and should also have experience of providing training.

Assessor and verifier requirements

While the Assessor/Verifier (A/V) units are valued as qualifications for centre staff, they are not currently a requirement for the qualification.

Continuing professional development (CPD)

Centres are expected to support their staff in ensuring that their knowledge of the occupational area and of best practice in delivery, mentoring, assessment and verification remains current, and takes account of any national or legislative developments.

4 Centre requirements

4.3 Registration and certification

Full details of City & Guilds' administrative procedures for this qualification are provided in the *Directory of qualifications*, provided online to City & Guilds registered centres via the Walled Garden. This information includes details on:

- registration procedures
- enrolment numbers
- fees
- entry for examinations
- claiming certification.

These details are also available in the *Directory of qualifications*.

Centres should be aware of time constraints regarding the registration and certification periods for the qualification, as specified in the City & Guilds *Directory of qualifications*.

Centres should follow all guidance carefully, particularly noting that fees, registration and certification end dates for the qualification are subject to change.

4.4 Quality assurance

Internal quality assurance

Approved centres must have effective quality assurance systems to ensure optimum delivery and assessment of qualifications.

Quality assurance includes initial centre approval, qualification approval and the centre's own internal procedures for monitoring quality. Centres are responsible for internal quality assurance, and City & Guilds is responsible for external quality assurance.

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

- City & Guilds set and marked written examinations
- internal (centre) quality assurance
- City & Guilds external verification.

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

- moderator
- examinations secretary
- mentor
- invigilator.

Full details and guidance on the internal and external quality assurance requirements and procedures, are provided in *Providing City & Guilds qualifications* and in the *Centre toolkit* together with full details of the tasks, activities and responsibilities of quality assurance staff.

In order to fully support candidates, centres are required to retain copies of candidates' assessment records for three years after certification.

External quality assurance

External verifiers are appointed by City & Guilds to approve centres, and to monitor the assessment and internal quality assurance carried out by centres. External verification is carried out to ensure that assessment is valid and reliable, and that there is good assessment practice in centres.

To carry out their quality assurance role, external verifiers/moderators must have appropriate occupational and verifying knowledge and expertise. City & Guilds external verifiers attend training and development designed to keep them up-to-date, to facilitate standardisation between verifiers and to share good practice.

External verifiers:

The role of the external verifier is to:

- provide advice and support to centre staff
- ensure the quality and consistency of assessments within and between centres by the use of systematic sampling
- regularly visit centres to ensure they continue to meet the centre and qualification approval criteria
- provide feedback to centres and to City & Guilds

External quality assurance for the qualification[s] will be provided by the usual City & Guilds external verification process. This includes the use of an electronically scannable report form which is designed to provide an objective risk analysis of individual centre assessment and verification practice.

Further details of the role of external verifiers are given in *Providing City & Guilds qualifications*.

5 Course design and delivery

Recommended delivery strategies

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

In particular, staff should consider the skills and knowledge related to the national occupational standards.

Provided that the requirements for the qualification are met, centres may design course programmes of study in any way that they feel best meets the needs and capabilities of their candidates. Centres may wish to include topics as part of the course programme, which will not be assessed through the qualification.

Relationship to other qualifications and the wider curriculum

City & Guilds recommends centres address the wider curriculum, where appropriate, when designing and delivering the course. Centres should also consider links to the National Occupational Standards, Key/Core Skills and other related qualifications.

The following relationship tables are provided to assist centres with the design and delivery of the qualification:

- Relationship to the NOS can be found in Appendix 1.
- Signposting Key / core skills and Citizenship / PSHE for the qualification can be found in Appendix 2 of this handbook.

Health and safety

The requirement to follow safe working practices is an integral part of all City & Guilds qualifications and assessments, and it is the responsibility of centres to ensure that all relevant health and safety requirements are in place before candidates start practical assessments.

Should a candidate fail to follow health and safety practice and procedures during an assessment, the assessment must be stopped. The candidate should be informed that they have not reached the standard required to successfully pass the assessment and told the reason why. Candidates may retake the assessment at a later date, at the discretion of the centre. In case of any doubt, guidance should be sought from the external verifier.

Data protection and confidentiality

Centres offering this qualification may need to provide City & Guilds with personal data for staff and candidates. Guidance on data protection and the obligations of City & Guilds and centres are explained in *Providing City & Guilds qualifications*.

Images of minors being used as evidence

If videos or photographs of minors (those under 18) are used as the medium to present evidence as part of the qualification the approved centre and the candidates have responsibilities in terms of meeting child protection legislation.

It is the responsibility of the approved centre to inform the candidate of the

- need for the candidate to obtain permission from the minor’s parent/guardian prior to collecting the evidence
- purpose of the use of photographs or video recordings
- period of time for which the photographs or video recordings are to be kept
- obligation to keep photographs or video recordings secure from unauthorised access
- storage of the photographs or video recordings which are kept electronically, and the associated security of using electronic systems
- associated child protection legislation.

Initial assessment and induction

Centres will need to make an initial assessment of each candidate 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 candidate has, and the support and guidance they may require when working towards their qualification.

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

Further guidance about initial assessment and induction, as well as a learning contract that centres may use, are available in the Centre toolkit.

Equal opportunities

It is a requirement of centre approval that centres have an equal opportunities policy (see *Providing City & Guilds qualifications)*.

The regulatory authorities require City & Guilds to monitor centres to ensure that equal opportunity policies are being followed.

The City & Guilds equal opportunities policy is set out on the City & Guilds website, in *Providing City & Guilds qualifications*, in the *Directory of qualifications*, and is also available from the City & Guilds Customer Relations department.

Access to qualifications on the National Qualifications Framework is open to all, irrespective of gender, race, creed, age or special needs. The centre co-ordinator should ensure that no candidate is subject to unfair discrimination on any ground in relation to access to assessment and the fairness of the assessment.

Access to assessment

City & Guilds' guidance and regulations on access to assessment are designed to facilitate access for assessments and qualifications for candidates who are eligible for adjustments to assessment arrangements. Access arrangements are designed to allow attainment to be demonstrated. For further information, please see *Access to assessment and qualifications*, available on the City & Guilds website.

Appeals

Centres must have their own, auditable, appeals procedure that must be explained to candidates during their induction. Appeals must be fully documented by the quality assurance co-ordinator and made available to the external verifier or City & Guilds.

Further information on appeals is given in *Providing City & Guilds qualifications*. There is also information on appeals for centres and learners on the City & Guilds website or available from the Customer Relations department.

6 Assessment

6.1 Summary of assessment requirements

City & Guilds provides the following assessments:

- Written dated examinations for units 201 to 231 and 300 to 305. Not all subjects are examined each year, please check the website www.cityandguilds.com/ecukexams for updated information
- Unit 306 an examiner marked report is to be submitted

Grading and marking

Grading of written dated examinations for this qualification is:

Grade
A - Pass
B - Pass
C - Pass
D - Pass
E - Fail
F - Fail

Grading for Unit 306 is

Grade
C - Commended
P - Pass
X - Fail

The results are issued in the 2nd week of August.

Simulation

Simulation is not permitted for the assessment of this qualification

Regulations for the conduct of examinations

Regulations for the conduct of examinations for online and written examinations are given in *Providing City & Guilds qualifications - a guide to centre and qualification (scheme) approval* and in the *Directory of qualifications*. Centres should ensure they are familiar with all requirements prior to offering assessments.

7 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:

- title
- unit reference
- rationale
- statement of guided learning hours
- connections with other qualifications, eg NVQs, key skills
- learning outcomes in detail expressed as practical skills and/ or underpinning knowledge
- recommended reading list

The units in this qualification are:

201	Applied thermodynamics
202	The analysis of heat and mass transfer
203	The analysis of the mechanics of fluids
204	Hydraulics and hydrology
205	Separation processes in chemical engineering
206	Chemical thermodynamics, kinetics and reactor design
207	The internal environmental design of buildings
208	Properties of materials for engineering applications
209	Mechanics of solids
210	The analysis of engineering structures
211	The design of engineering structures
212	Design and operation of marine vehicles
213	Geotechnical engineering
214	Engineering surveying
215	The analysis and design of electric circuits and fields
216	Electrical machines and drives
217	Electrical energy systems
218	Electronic systems engineering
219	Telecommunication systems engineering
220	Quality and reliability engineering
221	Analysis and design of manufacturing systems
222	The management of construction projects
223	The management of engineering enterprises

224	Advanced mathematical techniques for engineering applications
225	Dynamics of mechanical systems
226	The technology of manufacturing processes
227	Control systems engineering
228	Information systems engineering
229	Software engineering
230	Software for embedded systems
231	Computer systems engineering
300	Advanced engineering analysis
301	The analysis of compressible fluid flow
302	Computational mechanics using finite element method
303	Telecommunications engineering
304	The technology of advanced manufacturing processes
305	High performance computer systems engineering
306	Group engineering project

Unit 201 Applied thermodynamics

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

Aims
The unit aims to provide the candidate with the knowledge required to understand the performance and behaviour of thermodynamic power and refrigeration systems and the component parts of these systems.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **five** outcomes to this unit. The candidate will be able to:
- Understand and apply the working relationships involved in the behaviour and performance of power and refrigeration cycles
- Solve realistic problems involving the steady flow of compressible fluids
- Analyse and solve problems associated with rotodynamic compressors and turbines and gas turbine cycles
- Analyse and solve problems associated with reciprocating compressors and expanders and internal combustion engines
- Understand the fundamental principles of mixtures of gases and vapours and of combustion processes

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:
- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt a strategy, as necessary, to achieve the quality of outcomes required when tackling **one** complex problem with at least three options.

PS4.3
Evaluate an overall strategy and present the outcomes from personal work using a variety of methods.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.2.2 Solve production problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.2.2 Solve operational problems with engineering solutions
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 201 Applied thermodynamics
Outcome 1 Understand and apply the working relationships involved in the behaviour and performance of power and refrigeration cycles

Knowledge requirements
The candidate will be able to:

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

Unit 201 Applied thermodynamics

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

Knowledge requirements
The candidate will be able to:

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

Unit 201 Applied thermodynamics

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

Knowledge requirements
The candidate will be able to:

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

Unit 201 Applied thermodynamics

Outcome 4 Analyse and solve problems associated with reciprocating compressors and expanders and internal combustion engines

Knowledge requirements
The candidate will be able to:

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

Unit 201 Applied thermodynamics

Outcome 5 Understand the fundamental principles of mixtures of gases and vapours and of combustion processes

Knowledge requirements
The candidate will be able to:

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 psychrometric 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 201 Applied thermodynamics

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Thermodynamic and Transport Properties of Fluids: S I Units	Rogers, Mayhew	Blackwell	0631197036
Engineering Thermodynamics, Work and Heat Transfer	Rogers, Mayhew	Longman	0582053765
Applied Thermodynamics for Engineering Technologists	Eastop, McConkey	Longman	0582091934

Unit 202 The analysis of heat and mass transfer

Unit summary
This unit is about heat and mass transfer in stationary and flowing systems.

Aims
The unit aims to provide the candidate with the knowledge required to understand and analyse heat transfer and mass transfer systems employed in industrial processes.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

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

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.2.2 Solve production problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.2.2 Solve operational problems with engineering solutions
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 202 The analysis of heat and mass transfer

Outcome 1 Predict rates of heat transfer and mass transfer by in simple geometries.

Knowledge requirements
The candidate knows how to:

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

8 analyse vaporization and evaporators involving

a natural circulation

b forced circulation

c surface effects

d evaporators with single and multiple effects

Unit 202 The analysis of heat and mass transfer

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

Knowledge requirements
The candidate knows how to:

1 define mass transfer as a transport process

2 apply Fick's law

3 determine molecular diffusivity

4 analyse steady-state molecular diffusion

5 determine film and penetration theory of mass transfer

6 understand diffusion
- a eddy diffusivity
- b boundary layer diffusivity

7 analyse mass transfer in two-phase fluid systems
- a counter-current flow
- b co-current flow

8 analyse coefficients of mass transfer
- a film
- b overall

9 determine mass transfer between fluids and solids

10 understand the fundamentals of continuous separation processes
- a operating and equilibrium lines
- b multistage and differential-contact separation
- c concepts of theoretical stage
- d stage efficiency and transfer units

11 analyse simultaneous heat and mass transfer
- a relationship between heat, mass and momentum transfer
- b jH and jD factors
- c psychometry

12 analyse humidification and dehumidification
- a direct contact water and gas cooling
- b air-conditioning
- c drying

Unit 202 The analysis of heat and mass transfer

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

Knowledge requirements
The candidate knows how to:

1 appraise heat exchangers
- a type of construction
- b mean temperature difference
- c effectiveness and number of transfer units

2 assess the economic factors of heat exchange systems
- a design of main types
- b costings

3 appraise the application of mass transfer processes
- a distillation
  - i design
  - ii transfer process
- b absorption
  - i design
  - ii transfer process
- c extraction
  - i design
  - ii transfer process

Unit 202 The analysis of heat and mass transfer

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Chemical Engineering: Fluid Flow, Heat Transfer and Mass Transfer v. 1	Coulson, Richardson	Butterworth-Heinemann	0750644443
Introduction to Heat Transfer	Incropera, De Witt	John Wiley	0471386499
Transport Phenomena	Beek, Mutzall, Van Heuven	John Wiley	0471999903
Engineering Calculations in Radiative Heat Transfer	Gray, Muller	Pergamon Press	0080177867 o/p
Fluid Mechanics and Transfer Processes Chapters 13-18	Kay, Nedderman	Cambridge Uni. Press	0521303036 o/p

Unit 203 The analysis of the mechanics of fluids

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

Aims
The unit aims to develop understanding and analytic skills in fluid properties, fluid mechanics and the application of these to simple fluid systems.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:

- Understand basic fluid mechanics related to compressible and incompressible fluids.
- Understand fluid flow and perform fluid flow calculations.
- Analyse the mechanics of particles immersed in a fluid.
- Analyse the principles and applications of turbo-machinery.

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.2.2 Solve production problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.2.2 Solve operational problems with engineering solutions
4.3.2 Evaluate operational processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 203 The analysis of the mechanics of fluids

Outcome 1 Understand basic fluid mechanics related to compressible and incompressible fluids.

Knowledge requirements
The candidate knows how to:

1 define compressible and incompressible fluids

2 derive and solve conservation equations for

- a continuity
- b momentum
- c energy

and 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

7 determine and apply geometric, kinematic and dynamic similarity conditions in fluid systems

8 solve problems using

- a Buckingham $\prod$ 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 ratio

and perform calculations involving these

Unit 203 The analysis of the mechanics of fluids

Outcome 2 Understand fluid flow and perform fluid flow calculations.

Knowledge requirements
The candidate knows how to:

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 analyze 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 analyze 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

- 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

Unit 203 The analysis of the mechanics of fluids

Outcome 3 Analyse the mechanics of particles immersed in a fluid.

Knowledge requirements
The candidate knows how to:

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 size
   - b sedimentation of varying size range
3. analyse flow in packed beds using
   - a Darcy's law
   - b Carmen-Kozeny equation

Unit 203 The analysis of the mechanics of fluids

Outcome 4 Analyse the principles and applications of turbo-machinery.

Knowledge requirements
The candidate knows how to:

1 use one dimensional theory to analyse the performance of
   - a turbines
   - b pumps
   - c fans

2 assess axial and centrifugal flow machines

3 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)

4 analyse turbo-machinery systems in terms of
   - a system load line
   - b pump and turbine operating conditions

Unit 203 The analysis of the mechanics of fluids

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Chemical Engineering: Fluid Flow, Heat Transfer and Mass Transfer v. 1	Coulson, Richardson	Butterworth-Heinemann	0750644443
Engineering Fluid Mechanics	Robertson, Crowe	Wiley	0471173061
Fluid Mechanics	Streeter, Wylie, Bedford	McGraw Hill	0070665788
Fluid Mechanics	White	McGraw Hill	0071168486
Fluid Mechanics	Douglas, Gasiorek	Prentice Hall	0582414768
Introduction to Fluid Mechanics	Fox, McDonald	Wiley	0471124648
Mechanics of Fluids	Massey, Ward-Smith	Nelson Thornes	0748740430
Other useful texts			
Elementary Fluid Mechanics	Vennard, Street, Watters	John Wiley	0471013102
Fluid Flow for Chemical Engineers	Holland, Bragg	Butterworth-Heinemann	
Solving Problems in Fluid Mechanics Vol. 1	Douglas, Matthews	Longman Higher Education	0582239877
Solving Problems in Fluid Mechanics Vol. 2	Douglas, Matthews	Longman Higher Education	0582239885
Mechanics of Fluids	Duncan, Thom, Young	Arnold	0713132418 o/p

Unit 204 Hydraulics and hydrology

Unit summary

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

Aims

The unit aims to develop understanding in flow situations in fluid mechanics and hydraulics and explain aspects of engineering hydrology. It also aims to identify problems and devise solutions.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes

There are **two** outcomes to this unit. The candidate will be able to:

- Identify and process solutions for problems in fluid mechanics, pipe flow, rotodynamic machines and open channel flow.
- Explain aspects of engineering hydrology

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
3.1.1 Determine the installation requirements for engineering products or processes
3.3.2 Evaluate the installation process
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.2.2 Solve operational problems with engineering solutions
4.3.1 Monitor operational processes
4.3.2 Evaluate operational processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
7.1.1 Develop objectives for projects
7.2.2 Manage the implementation or projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 204 Hydraulics and hydrology

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

Knowledge requirements
The candidate knows how to:

1 determine fluid mechanics continuity and solve problems using Bernoulli's equation

2 assess fluid stream function and velocity potential function for a
  - a uniform stream
  - b source
  - c sink
  - d doublet and point vortex
  - e combinations of above

3 apply energy and momentum principles in an engineering context

4 assess free and forced vortex flow

5 determine laminar and turbulent flow
  - a boundary layers
  - b influence of surface roughness

6 analyse friction factors on flat plates

7 assess factors affecting
  - a boundary layer transition
  - b boundary layer separation and wake formation

8 investigate the drag force on single particles in fluids

9 calculate fluid
  - a drag coefficient
  - b Reynolds number
  - c terminal velocity

10 assess laminar flow between plates

11 assess steady flow in pipes
  - a pipe friction
  - b velocity distributions
  - c laminar and turbulent flows in
    - i smooth pipes
    - ii rough pipes
  - d Poiseuille's law
  - e Darcy's law

12 examine the relationship between friction factor, Reynolds number and relative roughness

13 examine local losses in pipe systems due to friction

14 analyse pipe networks using iterative methods

15 determine the reasons for unsteady pipe flow

- a frictionless incompressible behaviour
- b frictionless compressible behaviour
- c surge tanks

16 describe the one-dimensional theory of

- a pumps
- b turbines

17 classify pumps and turbines

18 assess pump and turbine

- a characteristics
- b dimensionless parameters
- c specific speed
- d cavitation

19 select a pump for a range of pipe systems

20 assess steady flow in an open channel

- a Chezy equations
- b Manning equations

21 design non-erodible channels

22 recognise the effect of sediment transportation in open channels

23 analyse gradual varied non-uniform flow in channels

24 apply energy and momentum principles to rapidly varied flow in open channels

- a hydraulic structures
- b short channel transitions
- c thin pipe weirs
- d critical depth flow gauging structures
- e hydraulic jump

25 investigate unsteady flow

- a surges
- b flood routing through channels

26 investigate the criteria, parameters and scales for physical models of

- a rivers
- b coasts
- c harbours
- d hydraulic structures

27 ascertain the relative merits of physical and computational models

Unit 204 Hydraulics and hydrology
Outcome 2 Explain aspects of engineering hydrology

Knowledge requirements
The candidate knows how to:

1 describe the hydrological cycle
   a rainfall
   b runoff
   c unit hydrographs
2 operate river gauging systems
3 analyse groundwater flow
4 assess flood and drought forecasting
5 assess storage and flood control reservoirs, mass curves and reservoir flood routing

Unit 204 Hydraulics and hydrology

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Civil Engineering Hydraulics	Nalluri, Featherstone	Blackwell	0632055146
Engineering Hydrology	Wilson EM	Macmillan	0333517172
Fluid Mechanics	Douglas, Gasiorek	Prentice Hall	0582414768
Fluid Mechanics with Engineering Applications	Franzini, Finnemore	McGraw-Hill	007112196X
Hydraulics in Civil and Environmental Engineering	Chadwick, Morfett	Spon Press	0419225803
Hydrology in Practice	Shaw	Nelson Thornes	
Open Channel Hydraulics	French	McGraw-Hill	0071133100
Solving Problems in Fluid Mechanics Volume 1	Douglas, Matthews	Longman	0582239877
Solving Problems in Fluid Mechanics Volume 2	Douglas, Matthews	Longman	
Understanding Hydraulics	Hamill	Palgrave	0333779061

Unit 205 Separation processes in chemical engineering

Unit summary
This unit is about the physical bases of separation processes involving gas absorption, distillation, liquid extraction, fluid-solid systems and other common methods.

Aims
The unit aims to equip the candidate with the expertise required in the selection, design and euclaction of industrial separation processes.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **five** outcomes to this unit. The candidate will be able to:
- Understand and analyse gas absorption/ desorption (stripping)
- Understand and analyse distillation
- Understand and analyse liquid-liquid extraction
- Understand and analyse various fluid-solid separation processes
- Understand other specified separation process

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:
- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required when tackling **one** complex problem with at least three options.

PS4.3
Evaluate your overall strategy and present the outcomes from your work using a variety of methods

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
4.1.1 Determine the operational requirements of engineering products or processes
4.3.1 Monitor operational processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 205 Separation processes in chemical engineering

Outcome 1 Understand and analyse gas absorption/desorption (stripping)

Knowledge requirements
The candidate knows how to:

1. interpret ideal and non-ideal gas-liquid equilibrium data
2. evaluate the mass transfer requirements of absorption and stripping columns using
   a. transfer unit method
   b. theoretical plate method
3. assess and correlate/predict efficiency of plate and packed columns
4. assess fluid mechanics related to the design of plate and packed columns
5. assess methods used for economic optimization of design

Unit 205 Separation processes in chemical engineering

Outcome 2 Understand and analyse distillation

Knowledge requirements
The candidate knows how to:

1 analyse, predict and correlate vapour-liquid equilibrium data
   - a binary
   - b ternary
   - c multi-component

2 describe and analyse steady-state distillation including the fundamentals of stagewise continuous distillation processes applied to
   - a binary mixtures
   - b multi-component mixtures

3 solve problems involving varying molal overflow

4 describe and analyse flash distillation

5 assess
   - a vacuum distillation
   - b steam distillation

6 describe and analyse batch distillation
   - a with and without hold-up
   - b time to reach equilibrium

7 assess and correlate/predict efficiency of plate and packed columns

8 assess and optimise the design of distillation equipment

9 assess methods used for economic optimization of design

Unit 205 Separation processes in chemical engineering

Outcome 3 Understand and analyse liquid-liquid extraction

Knowledge requirements
The candidate knows how to:

1. determine and represent phase equilibria in immiscible/partially miscible liquid-liquid systems
2. select solvents
3. calculate the equilibrium stage requirements in batch and in continuous co-current and counter-current extractions
4. apply the transfer unit method of column design
5. assess counter-current extraction with reflux
6. assess fluid mechanics in columns and mixer settlers
7. assess and correlate/predict efficiency of plate and packed column rate data
8. assess the design of liquid-liquid-extraction equipment
9. analyse economic optimization methods of design

Unit 205 Separation processes in chemical engineering

Outcome 4 Understand and analyse various fluid-solid separation processes

Knowledge requirements
The candidate knows how to:

1 analyse leaching
- a use of equilibrium data
- b equilibrium stage calculations in co-current and counter-current leaching
- c rate of leaching
- d leaching equipment design

2 analyse fluid solids separation processes
- a sedimentation and thickening
- b flotation
- c filtration equation
- d filtration equipment types

3 understand the general principles of precipitation and crystallisation
- a process fundamentals
- b equipment selection

Unit 205 Separation processes in chemical engineering
Outcome 5 Understand other specified separation process

Knowledge requirements
The candidate knows how to:

1. understand the general principles of
    a. membrane separation processes
    b. absorption
    c. ion exchange
2. make an informal choice of process for a specific separation requirement

Unit 205 Separation processes in chemical engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Chemical Engineering Particle Technology and Separation Processes, Vol 2	Coulson, Richardson	Butterworth-Heinemann	0750629428
Chemical Engineering, Vol 6	Coulson, Richardson, Sinnot	Pergamon Press	0080229700
Mass Transfer Operations	Treybal	McGraw Hill	0070666156
Principles of Unit Operations	Foust, Wenzel, Crump, Maus	John Wiley	0471047872
Unit Operations of Chemical Engineering	McCabe, Smith, Harriott	McGraw Hill	0070448442
Other useful texts			
Gas Purification Processes for Air Pollution Control	Kohl, Nielsen	Gulf Publishing Co	0884152200
Perry's Chemical Engineer's Handbook	Perry, Green	McGraw Hill	0071159827
Liquid Extraction	Treybal	McGraw Hill	
Mass Transfer	Sherwood, Pigford, Wilke	McGraw Hill	
Principles of Chemical Separations with Environmental Applications	Nobel, Terry	Cambridge University	
Separation Processes	Judson King	McGraw Hill	

Unit 206 Chemical thermodynamics, kinetics and reactor design

Unit summary
This unit is about the chemistry and chemical engineering concerned with the thermodynamics and kinetics of chemical reactions, the thermodynamics of phase behaviour, and the design of chemical reactors.

Aims
The unit aims to explore chemical thermodynamics, kinetics, phase behaviour, and chemical reactors

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:
- Appreciate and analyse chemical thermodynamics and phase equilibria.
- Appreciate and analyse the kinetics of chemical reactions.
- Understand heterogeneous catalysed reactions.
- Appreciate and design chemical reactors

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:
- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required when tackling **one** complex problem with at least three options.

PS4.3
Evaluate your overall strategy and present the outcomes from your work using a variety of methods

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.2.3 Propose and specify research into engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
3.1.4 Schedule installation activities to implement the installation methods and procedures
4.1.1 Determine the operational requirements of engineering products or processes
4.2.2 Solve operational problems with engineering solutions
6.1.1 Analyse the risks arising from engineering products and processes
6.1.2 Specify methods and procedures to reduce risks
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 206 Chemical thermodynamics, kinetics and reactor design

Outcome 1 Appreciate and analyse chemical thermodynamics and phase equilibria.

Knowledge requirements
The candidate knows how to:

1 appreciate the concept of reversible work and free energy
2 calculate the temperature and pressure dependence of free energies
3 determine free energy functions
4 describe and calculate fugacity and activity
5 appreciate the standard-state concept
6 assess quantitatively free energy and equilibrium
7 describe phase equilibria
8 determine T and P dependence of free energies
9 apply the Gibbs-Helmholtz equation
10 determine solubilities of solids, liquids and gases
11 apply Raoult's and Henry's laws
12 determine activity coefficients
13 use the Gibbs-Duhem Equation and perform thermodynamic consistency tests
14 ascertain chemical equilibrium and determine T and P dependence
15 recognize and be able to calculate, using tables of data
   a standard free energies
   b enthalpies
   c entropies
16 assess equilibrium constants
17 describe gas and liquid phase reactions with T and P dependence
18 investigate reversible electrochemical cells and standard electrode potentials
19 appraise concentration cells
20 analyse experimental determination of thermodynamic data

Unit 206 Chemical thermodynamics, kinetics and reactor design

Outcome 2 Appreciate and analyse the kinetics of chemical reactions.

Knowledge requirements
The candidate knows how to:

1 use simple homogeneous rate equations

2 assess overall rates

3 analyse temperature dependence of reaction rates

4 apply the Arrhenius equation and understand the role of an activated complex

5 determine

- a equilibrium constants
- b rate constants
- c free energy of reaction
- d free energy of activation
- e activation energy and frequency factor

6 analyse collision theory and frequency factors

7 interpret experimental results, determine reaction order and calculate activation energies

8 understand parallel and consecutive reactions

9 apply the concept of rate limiting steps

10 determine the effect of temperature on relative rates of competing processes

- a reaction
- b diffusion

11 assess reactions which are

- a chain
- b isothermal
- c adiabatic

12 appreciate free radicals

Unit 206 Chemical thermodynamics, kinetics and reactor design

Outcome 3 Understand heterogeneous catalysed reactions.

Knowledge requirements
The candidate knows how to:

1 analyse physical adsorption and chemisorption

2 determine the enthalpy of adsorption and dependence of surface coverage on temperature and pressure

3 determine surface areas by Langmuir and BET isotherms

4 determine adsorption coefficients

5 apply rate equations of simple reactions

- a first and second order
- b adsorption – desorption controlled
- c surface reaction controlled

6 assess the significance of the specific rate constants in reactions

Unit 206 Chemical thermodynamics, kinetics and reactor design

Outcome 4 Appreciate and design chemical reactors

Knowledge requirements
The candidate knows how to:

1. assess tubular reactors
2. investigate the solution of the elementary design equation based on plug flow for isothermal and adiabatic cases
3. assess continuous stirred-tank reactors (CSTR)
4. assess design equations based on the perfect mixing assumption in CSTRs
5. compare stirred tank and tubular reactors
6. apply residence time studies to reactors
7. compare batch and continuous processes with regard to
    a. reactor volume
    b. reaction yield
8. assess the logic of a choice of process
9. investigate optimisation problems and optimum temperature sequences

Unit 206 Chemical thermodynamics, kinetics and reactor design

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Physical Chemistry includes CD Rom	Atkins, PW	Oxford University Press	0198501013
Chemical Reaction Engineering	Levenspiel	John Wiley	047125424X
Introduction to Chemical Engineering Thermodynamics	Smith, Van Ness	McGraw Hill	0071147373
The Principles of Chemical Equilibrium	Denbigh, KG	Cambridge University Press	0521281504
Chemical Metallurgy	Moore	Butterworth-Heinemann	0408053690 o/p
Chemical Reactor Theory: an Introduction	Denbigh, Turner	Cambridge University Press	0521276306 o/p

Unit 207 The internal environmental design of buildings

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

Aims
The unit aims to develop understanding of the thermal, visual, aural and air quality needs of occupied spaces. It also aims to develop understanding of solar effects, weather and climate on the performance of environmental installations

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:
- Specify optimum conditions for occupied space.
- Assess the impact of external environmental conditions on occupied spaces.
- Assess the fire hazards exhibited in buildings and develop fire plans and fire detection systems.
- Relate functional requirements of buildings to the environment

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:
- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.2.1 Identify and define areas of research
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
8.1.1 Maintain and develop own engineering expertise

Unit 207 The internal environmental design of buildings

Outcome 1 Specify optimum conditions for occupied space.

Knowledge requirements
The candidate knows how to:

1 assess heat transmission through building shells
   a thermal capacity
   b decrement factor
   c time lag
   d periodic heat flow
   e heat gain through glass
   f internal heat gains
   g total heat gain
   h admittance factor
   i cooling loads/heat sinks
2 assess methods of reducing heat gains and cooling loads
3 assess the effect of ventilation in occupied spaces
   a air conditioning
   b buoyancy driven ventilation
   c natural ventilation
   d air quality and control
4 assess heating systems in occupied spaces
   a central heating
      i radiators
      ii convection heating
      iii climate control systems
5 assess the transmission of vapour through building shells
   a vapour barriers
   b effect of moisture on building materials
   c vapour pressure
   d dew point temperature gradients
   e interstitial and surface condensation
6 assess the flow of natural light through fenestration and its distribution by reflection
7 assess the properties of glazing materials
   a light transmission
   b light absorption
   c light reflection
   d heat absorption

8 assess the effects of blinds and curtains

9 assess the psychological and physiological impact of daylight in interiors

10 control glare from windows and roof lights

11 assess daylight performance

12 describe visual perception functions

- a colour
- b form
- c light

13 apply Gestalt laws of perception of patterns and shapes

14 assess the nature of light

- a transmission
- b reflection
- c absorption

15 determine the relationship between V_λ and P_λ and light output

16 assess the effect on visual performance of illuminance

- a contrast
- b size
- c task

17 determine the nature and components of glare

18 use statistical data on availability of daylight

19 apply lighting units and laws of illumination

20 assess the production of visible, thermal and discharge radiation associated with light sources

21 select artificial lighting sources which are appropriate to the conditions

- a discharge
- b fluorescent
- c incandescent

22 assess the energy consumption of lighting in buildings

23 determine the positioning of general and specific lighting in domestic and industrial buildings

24 measure artificial light values

25 assess the transmission of sound through building shells of various construction designs and materials

26 assess the attenuation of sound through

- a walls
- b floors
- c ceilings

27 assess the acoustic properties of enclosed space

28 use design criteria for the internal aural environment

29 determine the sound absorption properties of building materials

30 assess noise and vibration attenuation

   a generated externally

   b generated within

31 investigate methods of improving the acoustics in enclosed spaces

   a deadening

   b amplifying

32 assess the physical damage of noise on occupants of buildings

33 check noise levels

Unit 207 The internal environmental design of buildings

Outcome 2 Assess the impact of external environmental conditions on occupied spaces.

Knowledge requirements
The candidate knows how to:

1 determine the composition of solar radiation
2 determine the heat generated by
   a sunlight
   b daylight
3 use statistics to estimate the availability of daylight
4 use climatology statistics for estimating
   a annual temperature variations
   b diurnal temperature variations
   c mean temperatures
5 assess national and local climate conditions
6 interpret meteorological information in the derivation of external building design data
7 assess atmospheric pollution and pollution sources
   a general traffic noise
   b aircraft noise
   c air quality

Unit 207 The internal environmental design of buildings

Outcome 3 Assess the fire hazards exhibited in buildings and develop fire plans and fire detection systems.

Knowledge requirements
The candidate knows how to:

1 check the fire resistant properties of building materials using technical specifications or applying standard tests
   - a conbustibility
   - b ignitability
   - c flame propagation
   - d surface spread of flames
   - e production of
     - i toxic fumes
     - ii smoke

2 assess fire and smoke detection systems and alarm systems

3 assess the dangers of ignition and explosions of
   - a gases
   - b dusts

4 determine explosive limits

5 assess the fire ignition risks of
   - a open flame
   - b static electricity
   - c electric arcs
   - d spontaneous combustion

6 assess and select appropriate fire protection systems and the positioning of individual components

Unit 207 The internal environmental design of buildings

Outcome 4 Relate functional requirements of buildings to the environment

Knowledge requirements
The candidate knows how to:

1 develop building designs to clients briefs or user requirements

2 determine the functions of buildings and building performance

   a domestic

   b social

   c commercial

   d industrial

Unit 207 The internal environmental design of buildings
Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Building Services Engineering	Chadderton	Spon Press	0415315352
Heat and Mass Transfer in Building Services Design	Moss	Spon Press	0419226508
Air Conditioning Applications and Design	Jones	WP Butterworth-Heinemann	0340645547
Air Conditioning Engineering	Jones	WP Butterworth-Heinemann	0750650745
Engineering Principles of Industrial Ventilation		RJ John Wiley	0471637033
Essentials of Health and Safety at Work Health and Safety Exec,		HSE	071760716
Fire from First Principles Stollard	Abrahams	Spoon Press	0419152806
Lamps and Lighting Coaton	Marsden	Butterworth-Heinemann	0340646187
Solar Engineering of Thermal Processes	Duffie, Beckman	John Wiley	0471510564
Other useful texts			
Thermal Comfort Oseland	Humphreys	MA Building Research	

Unit 208 Properties of materials for engineering applications

Unit summary

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

Aims

The unit aims to develop the candidate's knowledge of metals, polymers and ceramics materials and their properties.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes

There are **five** outcomes to this unit. The candidate will be able to:

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

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

C4.1
Develop a strategy for using communication skills over an extended period of time.

C4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- **one** group discussion about a complex subject;
- **one** extended written communication about a complex subject.

C4.3
Evaluate your overall strategy and present the outcomes from your work, using at least **one** formal oral presentation, including the use of two images to illustrate complex points.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
7.1.1 Develop objectives for projects
7.1.2 Plan the delivery of projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 208 Properties of materials for engineering applications

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

Knowledge requirements
The candidate knows how to:

1 describe a 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 thermomechanical 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

Unit 208 Properties of materials for engineering applications

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

Knowledge requirements
The candidate knows how to:

Structural steels and cast iron

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

Non-ferrous alloys

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

Composite materials

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

Unit 208 Properties of materials for engineering applications

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

Knowledge requirements
The candidate knows how to:

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 degredation of polymeric materials in
- a processing
- b in service

Unit 208 Properties of materials for engineering applications

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

Knowledge requirements
The candidate knows how to:

1 describe the casting of metals and metal alloys
  a cast iron
  b concast steel
  c cast aluminium
2 analyse the structure of cast metals and the influence of casting conditions
3 describe casting mould design
4 recognise cast faults and soundness
  a burning
  b inclusions
  c porosity
5 develop models of cast metal nucleation
6 analyse the effects of super-cooling on cast metal microstructures
7 describe powder technology in the production of advanced ceramics
8 the role of diffusion in the manufacture of advanced ceramics

Unit 208 Properties of materials for engineering applications

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

Knowledge requirements
The candidate knows how to:

1 use model and use analytical techniques in support of Outcomes 1 to 4

Unit 208 Properties of materials for engineering applications

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Elements of Materials Science and Engineering	Van Vlack	Addison-Wesley	0201093146
Engineering Materials, Vol 1 An Introduction to their Properties and Applications	Ashby, Jones	Butterworth-Heinemann	0750630817
Engineering Materials, Vol 2 An Introduction to Microstructures, Processing and Design	Ashby, Jones	Butterworth-Heinemann	0750640197
Manufacturing with Materials	Edwards, Endean	Butterworth-Heinemann	0750627549
Materials Science and Engineering	Callister	John Wiley	0471320137
Materials, Principles and Practice	Newey,Weaver	Butterworth-Heinemann	0750603909
Structural Materials	Weidmann, Lewis, Reid	Butterworth-Heinemann	0408046589
Other useful texts			
Civil Engineering Materials	Jackson,Dhir	Palgrave	033363683
Concrete, Timber and Metals	Illston	Chapman & Hall	0412380803
Introduction to Composite Materials	Hull, Clyne	Cambridge University	0521388554
Materials in Construction	Taylor	Longman Higher Education	0582368898
Plastics	Mills	Butterworth-Heinemann	0340560436
Selection and Use of Engineering Materials	Crane, Charles	Butterworth-Heinemann	0750615494

Unit 209 Mechanics of solids

Unit summary

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

Aims

The unit aims to give students a thorough grounding in elastic behaviour and an introduction to non elastic behaviour of engineering components using classical theory, approximate numerical methods and experimental techniques.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and with other material as set out in the syllabus for subject 9107-105 Mechanical and structural engineering.

Learning outcomes

There are **three** outcomes to this unit. The candidate will be able to:

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

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

IT4.1
Develop a strategy for using IT skills over an extended period of time.

IT4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving the use of IT for **two** different, complex purposes.

IT4.3
Evaluate your overall strategy and present the outcomes from your work using at least **one** presentation, showing integration of text, images and number.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 209 Mechanics of solids

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

Knowledge requirements
The candidate knows how to:

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
   a deflection analysis to
   b beams of asymmetric cross section
   c composite beams
   d 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 Lame 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 understand 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

Unit 209 Mechanics of solids

Outcome 2 Select appropriate methods for the detail design of components.

Knowledge requirements
The candidate knows how to:

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

Unit 209 Mechanics of solids

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

Knowledge requirements
The candidate knows how to:

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

Unit 209 Mechanics of solids

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Mechanics of Engineering Materials	Benham, Crawford, Armstrong	Pearson Higher Education	0582251648
Mechanics of Materials	Gere, Adin, Nelson	Thornes	0748769897
Mechanics of Solids and Structures DWA	Rees	World Scientific Pub Co.	1860942172

Unit 210 The analysis of engineering structures

Unit summary
The unit is about the deformity of structures and the principles of elastic and plastic analysis of simple indeterminate forms.

Aim
The unit aims to equip the candidate with the techniques used to analyse the reactions of structures under various loading conditions. Internal stresses and forces are analysed to determine design specifications and avoid collapse or serious deformation.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:

- Undertake elastic analysis of structures.
- Undertake plastic analysis of structures.
- Understand the mechanics of deformable bodies.
- Understand stability and instability.

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

IT4.1
Develop a strategy for using IT skills over an extended period of time.

IT4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving the use of IT for two different, complex purposes.

IT4.3
Evaluate your overall strategy and present the outcomes from your work using at least one presentation, showing integration of text, images and number.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1	Identify the requirements of clients for engineering products or processes
1.1.2	Produce specifications for engineering products or processes
4.1.1	Determine the operational requirements of engineering products or processes
6.1.1	Analyse the risks arising from engineering products and processes
7.1.1	Develop objectives for projects
7.1.2	Plan the delivery of projects
7.2.3	Evaluate projects
8.1.1	Maintain and develop own engineering expertise

Unit 210 The analysis of engineering structures
Outcome 1 Undertake elastic analysis of structures.

Knowledge requirements
The candidate knows how to:

1. define and determine strain energy
2. apply the principle of virtual work
3. use virtual forces in obtaining displacements
4. use virtual displacements in obtaining equilibrium equations
5. apply the principle of minimum potential energy
6. analyse statically determinate and statically indeterminate structures
    a. calculation of forces for
    b. calculate displacements for
    c. generate influence lines for
        i. pinjointed frames
        ii. beams
        iii. rigid jointed frames
        iv. arches
7. apply to structures the force method
    a. displacement method including slope deflection and moment distribution
    b. statical and Kinematic indeterminacy
    c. effect of temperature and lack of fit
    d. matrix formulations
    e. computer methods based on the stiffness matrix

Unit 210 The analysis of engineering structures

Outcome 2 Undertake plastic analysis of structures.

Knowledge requirements
The candidate knows how to:

1 analyse frames and beams using graphical procedures applied to
  - a plastic collapse of simple steel frames
  - b plastic collapse for continuous beams

2 analyse frames and beams using the method of exploring mechanisms applied to
  - a plastic collapse of simple steel frames
  - b plastic collapse of continuous beams

3 apply plastic analysis to reinforced concrete slabs

4 use plastic analysis techniques for reinforced concrete slabs
  - a upper bound method (yield-line theory)
  - b lower bound method (strip theory)

Unit 210 The analysis of engineering structures

Outcome 3 Understand the mechanics of deformable bodies.

Knowledge requirements
The candidate knows how to:

1 understand and apply plane elasticity
- a equilibrium and compatibility conditions
- b stress functions
- c applications

2 use finite element method for deformable bodies

Unit 210 The analysis of engineering structures

Outcome 4 Understand stability and instability.

Knowledge requirements
The candidate knows how to:

1 investigate the general principles and criteria of elastic instability

2 assess struts and frames for instability

3 use Euler load for pin-ended struts and effect of other end conditions

4 investigate the effects on structures/beams/columns of

- a initial curve
- b lateral load
- c eccentric load

5 investigate lateral torsional buckling of beams

Unit 210 The analysis of engineering structures
Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Structural Analysis	Ghali, Neville	Spon Press	0419212000
The Finite Element Method Volume 1: The Basics	Zienkiewicz, Taylor	Butterworth-Heinemann	0750650494
Theory of Elasticity	Timoshenko	McGraw Hill	0070858055
Theory of Plates and Shells	Timoshenko	McGraw Hill	0070858209
Understanding Structural Analysis	Brohn	Arnold	034074068X

Unit 211 The design of engineering structures

Unit summary

This unit is about the structural action of common building materials and techniques and the development of an engineer's ability to use computational and calculation methods to determine loads and forces from first principles. It also includes British Codes of Practice for Steelwork, Concrete, Timber and Masonry.

Aims

The unit aims to develop the candidate's ability to investigate the behaviour of steelwork, reinforced concrete, timber and masonry in buildings and bridges.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and with other material as set out in the syllabus for subject 9107-105 Mechanical and structural engineering.

Learning outcomes

There are **four** outcomes to this unit. The candidate will be able to:

- Demonstrate understanding of the behaviour of steelwork elements, their support and connections in buildings and bridges
- Understand the design and detailing of reinforced concrete elements in buildings, walls and bridges
- Design and detail structural masonry and timber elements in buildings
- Use the British Loading Codes of Practice.

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required when tackling **one** complex problem with at least three options.

PS4.3
Evaluate your overall strategy and present the outcomes from your work using a variety of methods.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 211 The design of engineering structures

Outcome 1 Demonstrate understanding of the behaviour of steelwork elements, their support and connections in buildings and bridges

Knowledge requirements
The candidate knows how to:

1 use design techniques for structural steel elements in simple
- a frames and trusses
- b plain columns
- c beams
- d crane girders
- e lattice gantry columns
- f plate girders
- g hollow section truss members

2 use elastic and plastic design techniques for rigid portal frames

3 design connections in steel frames
- a brackets
- b haunches
- c column splices
- d base-plates

4 produce designs of composite floor beams including checks on pull-out shear studs

Unit 211 The design of engineering structures

Outcome 2 Understand the design and detailing of reinforced concrete elements in buildings, walls and bridges

Knowledge requirements
The candidate knows how to:

1. design in-situ and pre-cast concrete elements
   - a simply supported and continuous beams of
     - i rectangular section
     - ii T section
     - iii L section
   - b singly and doubly reinforced slabs
     - i two-way spanning
     - ii one-way spanning
   - c plain and ribbed slabs
   - d “short” columns subject to axial and moment loading
2. assess the use of sub-frames in analysis
3. design crank members in staircases
4. design combined and balanced foundations
5. assess the principles and design of pre-stressed concrete
   - a pre-tensioned
   - b post-tensioned

Unit 211 The design of engineering structures

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

Knowledge requirements
The candidate knows how to:

1 produce designs for load-bearing brickwork and block-work for vertical loading

2 assess the design of masonry panels for lateral loading

3 assess the design of Industrial sheds
  - a reinforced brickwork
  - b reinforced cavity retaining walls
  - c pierced walls

4 design solid timber sections as
  - a beams
  - b columns

5 assess the design of
  - a built-up members
  - b glued-laminated members
  - c timber truss design

6 assess structural timber applied to
  - a formwork
  - b falsework

Unit 211 The design of engineering structures

Outcome 4 Use the British Loading Codes of Practice.

Knowledge requirements
The candidate knows how to:

1. use codes of practice to aid design
2. extract information from codes of practice
3. check designs and design calculations against codes of practice

Unit 211 The design of engineering structures

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Reinforced Concrete Design	Mosley, Bungey, Hulse	Palgrave	0333739566
Steel Designers Manual	Steel Construction Inst.	Blackwell Science	0632049251
Timber Designers' Manual	Ozelton, Baird, Steer	Blackwell Science	0632039787
Introduction to Load Bearing Brickwork Design	Hendry, Sinha, Davies	Prentice Hall	0135391725 o/p
Structural Steel design	Dowling, Knowles, Owen	Butterworth-Heinemann	0408037172 o/p
Structural Steelwork	MacGinley, Ang	Butterworth-Heinemann	0750660440 9 o/p
Other useful texts			
Constructional Steel Design	Dowling, Harding, Bjorhovde	Chapman & Hall	1851668950
Load Bearing Brickwork		British Ceramic Society	0901092398

Unit 212 Design and operation of marine vehicles

Unit summary

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

Aims

The unit aims to equip the candidate with the knowledge and analytical skills required for involvement in marine engineering.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and with other material as set out in the syllabus for subject 9107-105 Mechanical and structural engineering.

Learning outcomes

There are **four** outcomes to this unit. The candidate will be able to:

- Determine appropriate dimensions, masses, propulsive power and auxiliary systems for a marine vehicle to satisfy a set of owners' requirements
- Analyse the operational dynamics of marine vehicles and justify their acceptability against appropriate criteria
- Select, and justify the selection of, appropriate materials for manufacturing marine vehicles and techniques or joining these materials
- Describe the effects of economic, regulatory and safety considerations on the characteristics of marine vehicles.

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required when tackling **one** complex problem with at least three options.

PS4.3
Evaluate your overall strategy and present the outcomes from your work using a variety of methods.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.2.1 Identify and define areas of research
1.2.2 Develop a research methodology
1.2.3 Propose and specify research into engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
3.2.2 Solve installation problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.3.2 Evaluate operational processes
6.1.1 Analyse the risks arising from engineering products and processes
6.1.2 Specify methods and procedures to reduce risks
6.2.1 Assure the quality of engineering products or processes
6.2.2 Identify the reasons for quality assurance problems
7.1.1 Develop objectives for projects
7.1.2 Plan the delivery of projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 212 Design and operation of marine vehicles

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

Knowledge requirements
The candidate knows how to:

1 recognise and apply components of the design process
- a iteration
- b synthesis
- c optimisation

2 assess owner's requirements and prepare specifications

3 review preliminary ship design methods and determine dimensions for mass limited and space governed designs
- a mass groups
- b capacity
- c stability
- d powering estimations

4 assess the limitations of basis ship and regression based methods

5 select form coefficients and position of Longitudinal Centre of Buoyancy (LCB)

6 use computer aided ship design software for
- a hull generation
- b curve fitting
- c fairing

7 incorporate structural requirements in the design of marine vehicles
- a understand longitudinal strength calculations
- b appreciate the influence of longitudinal strength considerations on various ship types
- c recognize limitations on length/depth ratio

8 appreciate torsional strength problems in
- a bulk carriers
- b container ships

9 assess offshore vehicle design including the naval architecture of principal types of offshore vehicle with particular reference to stability

10 select main and auxiliary power systems taking account of thermodynamic cycles and other characteristics of the prime movers, singly and in combination

   a diesel
   b steam
   c gas turbines
   d electric motors

11 match machinery to

   a vessel operational profile
   b hull resistance
   c propeller

12 assess methods of waste energy recovery

13 assess electrical plant

   a load distribution
   b management
   c control of electric propulsion

14 assess the design and operation of control systems 3-term controllers

15 appraise fuel and lubricating oil management

   a specification
   b quality
   c purchase and storage
   d testing and treatment

16 describe the combustion process for oil

Unit 212 Design and operation of marine vehicles

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

Knowledge requirements
The candidate knows how to:

1 analyse wave and sea states
   a properties of regular waves
   b characteristics of irregular waves
   c long and short crested seas
   d properties of sea spectra
   e definition of sea state
   f encounter spectra

2 analyse rigid body motions leading to natural frequencies
   a simple uncoupled solutions for
      i roll
      ii pitch
      iii heave
   b added mass and damping terms
   c magnification factor
   d phase relationships
   e curves of extinction

3 analyse response amplitude operators
   a definition
   b determination by experiment
   c application of strip theory

4 analyse ship motion spectra

5 investigate operational conditions of marine vehicles in relation to
   a human tolerance limits
   b speed loss in waves
   c slamming
   d wetness
   e drilling and helicopter restrictions

6 analyse motion reduction systems
   a passive
   b active

7 understand marine vehicle manoeuvring

- a steering and turning
- b angle of heel while turning
- c rudder types and steering gear
- d stopping
- e dynamic positioning systems

8 analyse marine vehicle vibrations

- a types of vibration experienced by
  - i hull girder
  - ii local structure
  - iii systems
    - A rudders
    - B shafts
    - C brackets
    - D machinery
- b sources of excitation
  - i waves
  - ii propellers
  - ii machinery
- c prevention and cure
  - i resonance avoidance
  - ii damping
  - iii effect of local stiffening

9 estimate the natural frequencies of free-free beams

- a virtual mass
- b shear and rotational effects
- c energy
- d deflection
- e approximate methods for fundamental vertical mode
- f higher modes

Unit 212 Design and operation of marine vehicles

Outcome 3 Select, and justify the selection of, appropriate materials for manufacturing marine vehicles and techniques or joining these materials

Knowledge requirements
The candidate knows how to:

1 determine the requirements of marine materials
  a mechanical properties
  b constructional aspects
  c economic aspects
2 review currently available materials for marine vehicles
  a steels
  b light alloys
  c fibre reinforced composites
3 review currently available materials for the offshore industry
4 appraise fabrication and joining techniques
  a weldability
  b types of weld
  c weld testing
  d detrimental effects of welding on fatigue life
5 understand general principles of structural detailing
  a continuity
  b stress concentration avoidance
  c classification society requirements
  d corrosion margins

Unit 212 Design and operation of marine vehicles

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

Knowledge requirements
The candidate knows how to:

1 evaluate the criteria governing the economic operation of marine vehicles
- a required freight rate
- b net present value
- c yield
- d permissible price

2 evaluate the economic factors influencing selection of
- a ship size
- b ship speed
- c machinery
- d type

3 appreciate the role of IMO, government agencies and classification societies in the regulatory and statutory aspects of, for example, crew accommodation, fire protection & life saving appliances

4 appreciate the role of safety management systems and outline reliability concepts

5 describe environmental management related to marine vehicles
- a statutory regulations
- b strategies to manage
  - i solid discharges
  - ii liquid discharges
  - iii gaseous discharges

Unit 212 Design and operation of marine vehicles
Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Basic Ship Theory, Vol. 1	Rawson &Tupper	Butterworth-Heinemann	0750653965
Basic Ship Theory, Vol. 2	Rawson & Tupper	Butterworth-Heinemann	0750653973
Elements of Shipping Branch	Nelson	Thornes	0412604604
Introduction to Naval Architecture	Tupper	Butterworth-Heinemann	0750625295
Principles of Naval Architecture, Vol. 1	Lewis (Ed.)	SNAME	0939773007
Principles of Naval Architecture, Vol. 2	Lewis (Ed.)	SNAME	0939773015
Principles of Naval Architecture, Vol. 3	Lewis (Ed.)	SNAME	0939773023
Ship Design and Construction, Vol. 1	Lamb (Ed.)	The Society of Naval Architects	0939773406
Ship Design and Construction, Vol. 2	Lamb (Ed.)	The Society of Naval Architects	0939773414
Ship Design for Efficiency and Economy	Schneekluth, Bertram	Butterworth-Heinemann	0750641339
Marine Engineering	Harrington (Ed.)	Society of Naval Architects & Marine Engineer	0939773104
Other useful texts			
Marine Technology Reference Book	Morgan (Ed.)	Butterworth-Heinemann	0408027843 o/p
Ship Structural Design	Hughes	The Society of Naval Architects and Marine Engineers	0939773104
Mechanics of Engineering Materials	Benham, Crawford, Armstrong	Pearson Educational	0582251648
Introduction to Marine Engineering	Taylor	Butterworth-Heinemann	0750625309
Marine Auxiliary Machinery	McGeorge	Butterworth-Heinemann	0750643986
Ship Construction	Eyres	Butterworth-Heinemann	0750648872
Offshore Engineering - An Introduction	Mather	Witherby & Co	1856091864

Unit 213 Geotechnical engineering

Unit summary
This unit is about the geotechnical conditions which effect the design of load bearing foundations and earth retaining structures. It also includes geotechnical engineering involved in the conservation, preservation and protection of existing structures.

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

Prerequisites
None.

Learning outcomes
There are **five** outcomes to this unit. The candidate will be able to:

- Create and interpret simple engineering geological models in plan and cross section
- Analyse soils and rock and undertake ground investigations
- Undertake soil analysis techniques
- Investigate stress states in natural and man made situations
- Determine appropriate foundations and earth retaining structures

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
2.1.3 Obtain the resources to implement the production methods and procedures
2.1.4 Schedule production activities to implement the production methods and procedures
2.2.2 Solve production problems with engineering solutions
2.3.1 Monitor the production process
2.3.2 Evaluate the production process
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.3.2 Evaluate operational processes
6.1.1 Analyse the risks arising from engineering products and processes
6.1.2 Specify methods and procedures to reduce risks
7.1.1 Develop objectives for projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 213 Geotechnical engineering

Outcome 1 Create and interpret simple engineering geological models in plan and cross section

Knowledge requirements
The candidate knows how to:

1 read and interpret a geological map including

- a constructing structure contours (strike lines)
- b drawing the position of outcrops and intersections of strata with proposed engineering works
- c drawing cross sections depicting geological sequence and structure
- d identify geotechnical settings and the modes of failure to which they might give rise

2 classify acquifers and predict the behaviour of ground water in excavations

- a confined aquifier (water table or phreatic surface)
- b unconfined aquifier (piezometric surface, artesian conditions)

Unit 213 Geotechnical engineering
Outcome 2 Analyse soils and rock and undertake ground investigations

Knowledge requirements
The candidate knows how to:

1 assess the features of rocks as an engineering material
  a types of rock
  b constituents of various rocks
  c classification
  d folds and faults
2 review the engineering behaviour of principle rock types
3 undertake testing methods appropriate to rock types
4 analyse rock masses
  a description
  b classification
  c behaviour
5 undertake rock masses mapping
6 implement discontinuity analysis
  a translational failures
  b toppling failures
  c rotational failures
7 analyse rock anchoring designs
8 describe the principle methods of excavations in rock
9 analyse rock support systems during excavations
10 undertake site and ground investigations
  a planning procedures
  b methods
  c producing reports

Unit 213 Geotechnical engineering
Outcome 3 Undertake soil analysis techniques

Knowledge requirements
The candidate knows how to:

1 describe and classify soils
   - a physical properties
   - b phase relations
   - c index properties
   - d particle size distributions
   - e mineralogy

2 analyse total and effective stress concepts

3 investigate the strength and deformation characteristics of soils
   - a triaxial tests
   - b Mohr-Coulomb analysis
   - c stress path analysis
   - d stiffness at small strain

4 conduct stress analysis within a soil mass and determine pressure distribution due to foundation loads

5 assess the effect of settlement on stress distribution

6 analyse the settlement of granular soils

7 investigate the settlement of clays
   - a immediate
   - b consolidation
   - c secondary settlement

8 investigate the rates of settlement of clays

9 investigate the effects of vertical drains on settlement

Unit 213 Geotechnical engineering

Outcome 4 Investigate stress states in natural and man made situations

Knowledge requirements
The candidate knows how to:

1 analyse lateral earth pressures and stress states in natural and man made situations
   - a banks
   - b retaining walls
   - c piling

2 analyse the effects of pore water pressures and uniform surcharges

3 design soil retaining walls

4 assess the effectiveness cantilever and anchored sheet pile walls

5 assess the effectiveness of ground anchors

6 use graphical and mathematical techniques to solve problems involving water flow in soils

7 investigate soil compressibility
   - a fundamentals consolidation
   - b normal and over-consolidated soils
   - c pre-consolidation pressure
   - d primary and secondary consolidation

8 solve consolidation settlement problems using calculations

9 conduct soil tests
   - a laboratory
   - b insitu

10 investigate soil slopes
   - a principle concept
   - b methods of analysis
   - c effects of water

Unit 213 Geotechnical engineering

Outcome 5 Determine appropriate foundations and earth retaining structures

Knowledge requirements
The candidate knows how to:

1 determine the bearing capacity of foundations
- a shallow
- b deep

2 determine foundation types
- a pads
- b rafts
- c buoyant
- d basements
- e piled
- f strip

3 determine ultimate and allowable bearing capacities of types of foundations

4 analyse the problems associated with foundation deformation and its effect on building

5 undertake foundation geotechnical analysis

6 determine necessary ground treatments
- a drainage and dewatering
- b exclusion techniques
- c soil stabilisation/modification
- d cement and lime stabilisation
- e reinforcement
- f geotextiles

7 determine field application and equipment for ground treatments

8 assess the need for grout and grouting of rocks and soils

9 understand the environmental aspects of geotechnical processes

Unit 213 Geotechnical engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Foundation Analysis and Design	Bowles	McGraw Hill	0079122477
Principles of Foundation Engineering	Das	PWS	0534954030
Soil Mechanics Principles and Practice	Barnes	Palgrave	033377776X
A Geology for Engineers	Blyth, De Freitas	Butterworth-Heinemann	0713128828
Engineering Properties of Soils and Rocks	Bell	Blackwell Science	0632052058
Engineering Rock Mass Classifications	Bieniawski	John Wiley	0471601721
Geology for Civil Engineers	McLean, Gribble	Spon Press	0419160000
Introduction to Rock Mechanics	Goodman	John Wiley	0471812005
Foundations of Engineering Geology	Waltham	Blackie	0751400718 o/p
Hemispherical Projection Methods in Rock Mechanics	Priest	Allen and Unwin	0046220070 o/p
An Introduction to the Mechanics of Soils and Foundations	Atkinson	McGraw Hill	007707713X
Other useful texts			
Elements of Soil Mechanics	Smith, Smith	Blackwell Science	0632041269
Foundation Design and Construction	Tomlinson	Longman HE	058222697X
Foundations on Rock	Wyllie	Routledge	0419232109
Principles of Geotechnical Engineering	Das	PWS	0534981569
Rock Slope Engineering	Hoek, Barry	Spon Press	0419160108
A Short Course in Foundation Engineering	Menzies, Simons	Thomas Telford Ltd	0727727516
Design Methodology in Rock Engineering	Bieniawski	AA Balkema, Netherlands	9054101210

Unit 214 Engineering surveying

Unit summary
This unit is about the fundamental survey techniques required for civil engineering applications including roads, railways and tunnels.

Aims
The unit aims to develop understanding and techniques of modern surveying procedures and to appreciate the importance of “setting out” in construction.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:

- Apply uncertainty and quality assessment
- Carry out survey methods
- Manage data
- Apply survey methods to industrial applications

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

WO4.1
Develop a strategy for using skills in working with others over an extended period of time.

WO4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in taking a leading role in managing at least **one** complex group activity.

WO4.3
Evaluate your overall strategy and present the outcomes from your work in at least **one** group situation.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1	Identify the requirements of clients for engineering products or processes
1.1.2	Produce specifications for engineering products or processes
1.3.1	Undertake research into engineering products or processes
1.3.2	Evaluate the results of research
4.1.1	Determine the operational requirements of engineering products or processes
4.2.2	Solve operational problems with engineering solutions
4.3.2	Evaluate operational processes
6.1.1	Analyse the risks arising from engineering products and processes
6.2.1	Assure the quality of engineering products or processes
6.2.2	Identify the reasons for quality assurance problems
6.2.3	Implement improvements to the quality of engineering products or processes
7.1.1	Develop objectives for projects
7.2.3	Evaluate projects
8.1.1	Maintain and develop own engineering expertise

Unit 214 Engineering surveying
Outcome 1 Apply uncertainty and quality assessment

Knowledge requirements
The candidate knows how to:

1. explain the meaning and purpose of engineering surveying
2. take measurements and understand the principles of measurement
3. recognise errors in measurement
4. undertake surveys
5. establish precision and accuracy limits
6. eliminate mistakes and systematic errors in measurement
7. recognise random errors and understand the general laws of probability
8. weight and adjust measurements

Unit 214 Engineering surveying
Outcome 2 Carry out survey methods

Knowledge requirements
The candidate knows how to:

1 measure angles using a theodolite
  a set-up and adjustment
  b measure, book, abstract and set-out
    i horizontal angles
    ii vertical angles
2 recognise errors in angular measurements
3 recognise the effects of miscentering on horizontal angles
4 choose the most suitable instrument
5 use electronic total station instruments
6 explain the fundamental principles of levelling
  a test and adjust levelling instruments
  b sources of error
  c levelling techniques
  d calculation of reduced levels
    i rise and fall
    ii height of collimation
  e inverted staff readings
  f sectional and contour levelling
  g reciprocal levelling
  h trigonometrical levelling
  i earth curvature and refraction
  j acceptable limits of errors in levelling
  k digital levels
  l 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 understand the principles of photogrammetry in surveying
10 interpolate measurements from aerial photographs
11 assess stereoscopic viewing and parallax

12 use Global Positioning Systems (GPS) in surveying

- 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

13 appraise recent developments in GNSS engineering surveying instrumentation and techniques, including laser scanning

Unit 214 Engineering surveying
Outcome 3 Manage data

Knowledge requirements
The candidate knows how to:

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

Unit 214 Engineering surveying
Outcome 4 Apply survey methods to industrial applications

Knowledge requirements
The candidate knows how to:

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 set out
   a roads
   b buildings
   c pipelines
5 identify sources of error in surveys
6 monitor deformation and subsidence
7 survey tunnels
   a direction control
   b gyro-theodolite observations and computations
   c laser instruments for alignment and setting out
8 determine areas from plan measurements by
   a co-ordinates
   b cross-sections
9 use general volume and earthwork formulae
10 construct and use mass-haul diagrams

Unit 214 Engineering surveying

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Engineering Surveying	Schofield, Breach	Butterworth-Heinemann	0750669497
Surveying for Engineers	Uren, Price	Palgrave	0333577051
Surveying	Bannister, Raymond, Baker	Longman Higher Education	0582302498
Other useful texts			
Maths for Map Makers	Allan	Whittles Publishing Services	1870325915
Surveying for Construction	Irvine	McGraw Hill	0077079981
Setting -Out Procedures	Sadgrove		0408028378 o/p

Unit 215 The analysis and design of electric circuits and fields

Unit summary
This unit is about two fundamental topics in electrical engineering, fields and circuits.

Aims
The unit aims to develop understanding of fields and circuits and to use this understanding to solve problems in electrical engineering.

Prerequisites
None.

Learning outcomes
There are **two** outcomes to this unit. The candidate will be able to:

- Solve problems involving field theory
- Solve problems involving circuit theory

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
3.2.2 Solve installation problems with engineering solutions
3.3.1 Monitor the installation process
3.3.2 Evaluate the installation process
3.4.1 Commission engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.1.3 Schedule operational activities to implement the operational methods and procedures
4.3.1 Monitor operational processes
4.3.2 Evaluate operational processes
5.1.1 Determine the maintenance requirements of engineering products or procedures
5.1.2 Specify maintenance methods and procedures to achieve maintenance requirements
6.1.1 Analyse the risks arising from engineering products and processes
6.1.2 Specify methods and procedures to reduce risks
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 215 The analysis and design of electric circuits and fields

Outcome 1 Solve problems involving field theory

Knowledge requirements
The candidate knows how to:

1 use Laplace's equation to determine potential distribution in two dimensions for simple geometric shapes of conducting boundaries

2 apply image methods to the above

3 use Gauss's theorem for electrical flux density calculations for

- a isotropic dielectric media
- b composite dielectric media

4 calculate D and E

5 calculate capacitance of configurations with two or more conductors

- a parallel plate capacitor
- b concentric cylinders
- c parallel wires
- d wire and parallel plate

6 determine dielectric polarisation and energy density

7 produce and measure magnetic fields

8 assess the properties and characteristics of magnetic materials

9 assess magnetic losses with alternating excitation

10 determine magnetic potential and magnetomotive force

- a Biot-Savart and Ampere laws for calculating B and H in fields produced by conductor and coil configurations
- b calculations for coil arrangements to produce magnetic fields between poles faces
- c flux leakage
- d fringing

11 determine electromagnetic induction by calculation of self-inductance and mutual induction for simple configurations

- a co-axial cable
- b transmission line

12 determine mechanical force and torque relations for conductor shapes in magnetic and electrical fields

13 assess electromagnetic skin effect

Unit 215 The analysis and design of electric circuits and fields

Outcome 2 Solve problems involving circuit theory

Knowledge requirements
The candidate knows how to:

1 assess time-domain response

2 analyse lumped-parameter networks excitations
   - a impulse
   - b step
   - c ramp
   - d sine wave
   - e others

3 determine steady-state and transient responses

4 evaluate the response from poles and zeroes

5 apply superposition theorem and convolution

6 use locus diagrams

7 use Fourier series and Fourier transforms power spectra and spectral analysis of simple waveforms

8 systematic formulate network equations in linear dc and ac circuits
   - a nodal
   - b mesh

9 manipulate two port parameters in two-port networks

10 apply the above to filter circuits and networks
   - a transformers
   - b T-networks
   - c Π - networks
   - d ladder networks

11 analyse the relationships of the above

Unit 215 The analysis and design of electric circuits and fields

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
An Introduction to Circuit Analysis: A Systems Approach	Scott	McGraw Hill	0070561273
Analysis of Linear Circuits	Paul	McGraw Hill	007909340X
Fundamentals of Engineering Electromagnetics	Cheng	Addison Wesley	0201566117
Fundamentals of Electromagnetics with Engineering Applications	Wentworth	John Wiley	0471661325

Unit 216 Electrical machines and drives

Unit summary
This unit is about the principles involved in electrical machines and machine drives including power electronics.

Aims
The unit aims to develop understanding of dc machines, induction machines and various drives and includes the development of knowledge of energy conversion, operational parameters and characteristics.

Prerequisites
It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Appreciate electrical machine fundamentals
- Appreciate dc, induction, stepper and reluctance machines
- Appreciate general issues common to all drive systems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
8.1.1 Maintain and develop own engineering expertise

Unit 216 Electrical machines and drives
Outcome 1 Appreciate electrical machine fundamentals

Knowledge requirements
The candidate knows how to:

1 determine force on current – carrying conductors
   a Faraday's law
   b motional electro-motive force (emf)
2 investigate electrical machines
   a concentrated windings
   b magneto-motive force (mmf)
   c working and leakage flux
   d flux density and mmf distributions
      i smooth air gap case
      ii harmonic mmf
   e magnetic and electric loading and relation to machine volume
3 investigate machine rating
   a losses
   b cooling
   c temperature rise
   d case style

Unit 216 Electrical machines and drives

Outcome 2 Appreciate dc, induction, stepper and reluctance machines

Knowledge requirements
The candidate knows how to:

1 analyse steady state performance of dc machines and use relevant equations
  a equivalent circuits
  b characteristics of machines
    i separately-excited
    ii shunt
    iii series
2 determine the transient performance of dc machines
  a with armature inductance
  b without armature inductance
3 investigate universal dc machines (ac series commutator)
4 assess the operation of dc machines with a chopper and with field weakening
5 investigate dc wound field and permanent magnet excitation
6 analyse the construction, operation and control of brushless dc machines
7 assess steady state performance of induction machines and use relevant
  a equations
  b equivalent circuits
  c phasor diagrams
8 understand the characteristics and constructional features of cage-rotor induction machines in
  a three-phase form
  b single-phase form
  (including capacitor-fed auxiliary winding configuration)
9 determine torque/speed relationship of induction machines
  a fixed supply
  b variable voltage supply
  c variable frequency supply
10 analyse open-loop variable speed operation and closed-loop controlled slip operation in induction machines to include
  a control block diagrams
  b V/f relationship

11 assess basic torque production mechanisms for stepper machines

   a reluctance effect machines

   b permanent magnet machines

12 determine the relationship between machine features and step angle

13 investigate the circuits required for current pulse control

14 analyse commutation sequences and control for stepper and reluctance machines

Unit 216 Electrical machines and drives

Outcome 3 Appreciate general issues common to all drive systems

Knowledge requirements
The candidate knows how to:

1 use equations of motion for rotary dynamic drive systems

2 determine speed/time relationships for drives

3 determine the relevance to acceleration of length to radius ratio of machines

4 produce speed and torque curves including
   - a regeneration
   - b reverse rotation regions

5 assess torque, speed and position controlled drives

6 develop an awareness of drive requirements for the common application of electrical drives such as
   - a machine tools
   - b transport
   - c lifts

7 develop an awareness of speed, current and torque transducers

8 investiage high-current and high-voltage device
   - a characteristics (ratings, gate drives and switching characteristics) of
     - i diodes
     - ii thyristors including the GTO thyristor
     - iii semiconductor field effect thyristor (MOSFET)
     - iv insulated gate bipolar transistors (IGBT)
   - b conduction and switching power losses

9 investigate circuits relevant to supplying electrical machines
   - a dc to dc
   - b dc to ac power conversions
   - c ac to dc power conversions

10 assess limits placed on machine operation by converters including regeneration constraints

11 understand the pulse-width-modulation (PWM) of switching waveforms

Unit 216 Electrical machines and drives

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Basic Electrical Power & Machines	Bradley, Kluwer	Academic Pubs.	0412455404
Electric Motors and Drives	Hughes	Newnes	0750617411
Power Electronics	Mohan, Undeland, Robbins	John Wiley	0471584088
Electrical Machines and Drives	Slemon	Pergamon Press	201578859 o/p
Power Electronic Control of AC Motors	Murphy, Turnbull	Pergamon Press	0080226833 o/p

Unit 217 Electrical energy systems

Unit summary
This unit is about the analysis and design of the generation, transmission, distribution and supply of electrical energy in a contemporary industrial society.

Aims
The unit aims to develop the candidate's knowledge of electrical generation, 3 phase systems of transmission and distribution and the environmental impact of electrical energy systems.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and with other material as set out in the intended learning outcomes for subject 9107-107 Electrical and electronic engineering.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:
- Assess energy conversion, economics and environment
- Understand power generation
- Describe transmission and distribution systems
- Analyse systems and understand system operation

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:
- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
5.1.1 Determine the maintenance requirements of engineering products or procedures
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 217 Electrical energy systems

Outcome 1 Assess energy conversion, economics and environment

Knowledge requirements
The candidate knows how to:

1 describe methods of producing electrical energy using fossil fuel
   a coal
   b diesel
   c gas
2 assess the cost of fossil fuel usage for generating electricity
3 describe energy conversion in electrical energy generation
   a wind
   b solar
   c wave
   d hydro
4 describe oil, gas and steam turbines
5 describe and assess
   a system loads
   b loss factors
   c tariffs (capacity and energy charges)
   d load management
   e forecasting
6 describe system layout including interconnection for
   a security
   b transfer across territorial boundaries
   c retail distribution
   d dominant costs and restraints

Unit 217 Electrical energy systems
Outcome 2 Understand power generation

Knowledge requirements
The candidate knows how to:

1 identify types of synchronous generators
  a cylindrical rotor
  b salient pole
2 describe the parameters and operating characteristics of synchronous generators
3 calculate and assess short circuit performance
4 describe parallel operation with single control by
  a governors
  b automatic voltage regulators (AVR's)
5 explain an operating chart and its derivation including
  a stability limits
  b rating limits
6 ensure electrical earthing arrangements are adequate

Unit 217 Electrical energy systems
Outcome 3 Describe transmission and distribution systems

Knowledge requirements
The candidate knows how to:

1 describe power transformers
- a types of construction
- b parameters
- c testing connections (delta/star)
- d use of tap-changers
- e sequence impedances

2 describe overhead lines
- a construction
- b parameters
  - i short equivalent circuits
  - ii medium equivalent circuits
  - iii long equivalent circuits
- c voltage stress calculations
- d conductors
- e natural load
- f need for compensation

3 describe types of cables for transmission circuits
- a operational parameters
- b insulation
- c need for compensation

4 describe substation components
- a switchgear operating principles of main types
  - i gas
  - ii airblast
  - iii oil
  - iv vacuum
- b breaking and making capacity
  - i asymmetrical
  - ii symmetrical

5 describe substation layouts and types

6 describe instrumentation transformers and transducers

7 recognise the need for surge diverters

8 appreciate high voltage direct current transmission

   a characteristics

   b economics

   c converter operation

9 assess the design of distribution systems for reliability and economic operation in

   a urban areas

   b rural areas

10 understand voltage control under maximum and minimum load conditions

11 describe the metering and protection of the consumer and system

Unit 217 Electrical energy systems
Outcome 4 Analyse systems and understand system operation

Knowledge requirements
The candidate knows how to:

1 analyse network representation
- a network equations method solution (iterative) (Gauss Seidel method) including
  - i per unit concepts
  - ii fault and unbalanced calculations
  - iii symmetrical components

2 understand the concepts and calculations involved in steady state and transient stability

3 understand step-by-step and equal area criterion

4 understands methods used for increasing system stability limits

5 understands over voltage and surges on systems
- a causes
- b generation
- c protection

6 understand modern system control concepts
- a digital systems
- b data transmission links
- c energy systems and management
- d role of control engineers

7 understand system frequency and voltage control from a control centre

8 understand scheduling and dispatch generation for minimum operating
- a cost
- b reliability
- c spinning reserve

9 understand forms of system protection

10 understand system safety requirements

Unit 217 Electrical energy systems

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Electric Power Systems	Weedy, Cory	John Wiley	0471976776
Power System Analysis	Grainger, Stevenson	McGraw Hill	0071133380
Electrical Energy Systems Theory, an Introduction	Elgerd	McGraw Hill	007099286X o/p

Unit 218 Electronic systems engineering

Unit summary
This unit is about the fundamentals underlying the physical operation, analysis and design of electronic circuits and systems.

Aims
The unit aims to develop the candidate's knowledge of semiconductor devices, signal amplifiers, oscillators and digital logic families.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and with other material as set out in the intended learning outcomes for subject 9107-107 Electrical and electronic engineering.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Understand the operation and application of semiconductor devices
- Understand, analyse, design and apply analogue circuits and systems
- Understand, analyse, design and apply digital circuits and systems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
No Key Skills were identified for this unit.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.4.1 Establish a design brief for engineering products or processes
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
4.1.1 Determine the operational requirements of engineering products or processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 218 Electronic systems engineering

Outcome 1 Understand the operation and application of semiconductor devices

Knowledge requirements
The candidate knows how to:

1 understand the physical principles underlying a pn (positive/negative) junction diode and describe its V – I characteristics

2 apply large and small-signal diode models

3 understand the physical breakdown mechanisms of diodes

- a Zener diodes
- b Schottky Barrier diodes

4 understand, describe and analyse the physical operation of a bipolar junction transistor (BJT)

- a BJT operating conditions, cut-off and saturation
- b BJT small signal behaviour and the hybrid - π model
- c BJT switching properties
- d BJT as a diode
- e emitter coupled pair
- f BJT power ratings

5 understand the physical features of a FET junction field effect transistor (JFET)

- a metal-oxide semiconductor field effect transistor (MOSFET)
- b structure and physical properties
- c V-I characteristics

6 describe enhancement and depletion models

7 understand how to apply a (FET)

- a as a resistance
- b as a switch
- c as an amplifier

8 describe small signal FET models

9 develop awareness of the Ebers-Moll model and semiconductor fabrication techniques

Unit 218 Electronic systems engineering

Outcome 2 Understand, analyse, design and apply analogue circuits and systems

Knowledge requirements
The candidate knows how to:

1 develop small signal amplifiers circuits involving
   a bipolar transistors
   b field effect transistors
2 understand biasing and current mirror circuits
3 develop transistor small signal equivalent circuits
4 develop amplifiers circuits involving
   a cascade connections
   b Darlington connections
5 develop circuits involving differential amplifiers
6 understand dynamic response of amplifiers
   a Bode diagrams
   b step response
7 understand the High Frequency hybrid - π model
8 understand the effect of coupling and bypass capacitors
9 describe the structure and operation of operational amplifiers
   a frequency response
   b slew rate
10 understand, analyse and develop operational amplifier applications
   a operational amplifiers as
      i adder
      ii integrator
      iii differentiator
   b first and second order active filters
   c logarithmic and exponential amplifiers
   d analogue multipliers
11 understand feedback amplifiers
   a feedback topologies
   b effects of negative feedback on
      i gains
      ii impedance levels
   c frequency response and distortion noise
   d stability and compensation in feedback amplifiers

12 design feedback amplifiers to meet gain, stability and bandwidth criteria

13 recognise the apply design principles for types of sinusoidal waveform oscillators

- a RC
- b LC
- c crystal

14 describe the amplitude and frequency stabilisation of waveform generators

15 describe, analyse and design circuits using

- a mono and astable multivibrators
- b Schmitt trigger circuits
- c square and triangular wave generators
- d sweep and staircase generators
- e voltage control oscillators

16 understand and analyse the operation of Class A, AB, B and C power amplifier circuits in terms of

- a power output
- b efficiency
- c distortion effects

17 understand the application and operation of rectifier circuits, regulated power supplies and switching regulators

Unit 218 Electronic systems engineering

Outcome 3 Understand, analyse, design and apply digital circuits and systems

Knowledge requirements
The candidate knows how to:

1 understand the implementation of logic gates in integrated circuit form

2 develop awareness of fabrication technologies

3 recognise the characteristic features of the principle bipolar and metal-oxide semiconductor (MOS) logic families

- a TTL
- b ECL
- c NMOS
- d CMOS

4 understand and apply

- a Boolean theorems
- b reduction techniques
- c Karnaugh maps

to the analysis and design of combinational logic circuits having up to five variables

5 apply the above techniques to the design of

- a half and full adders
- b code converters
- c comparators
- d decoders
- e encoders
- f multiplexers

6 implement combinational logic functions using

- a programmable read only memory (PROM)
- b programmable logic array (PLA)
- c programmable array logic (PAL) structures

7 understand and apply

   a state diagrams and tables

   b simple state reduction methods

   c excitation tables

   to the analysis and design of sequential logic circuits using

   a RS

   b JK

   c D

   type flip flops

8 understand the analyse, synthesis and design of shift registers and counters

9 understand simple concepts of sampling and multiplexing for data acquisition

10 describe the structure, operation and make speed/cost comparisons for common forms of analogue-to-digital and digital-to-analogue converters

Unit 218 Electronic systems engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Digital Design Omitting Sections 3.10,3.11,5.2,5.3,7.6-7.9, chapter 8 & 9.1-9.6,9.8	Morris, Mano	Prentice Hall	013212937
Microelectronics Omitting chapter 9, sections 10.4,10.5,11.7-11.12,12.8-12.15,13.5-13.10,15.12 &15.15	Millman, Grabel	McGraw Hill	007100596

Unit 219 Telecommunication systems engineering

Unit summary

This unit addresses the underlying principles of telecommunication systems.

Aims

The unit aims to develop an understanding of modern digital communications principles by breaking down the complex signal processing that takes place in a transceiver into its component parts. The emphasis is on transmission.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and with mathematical methods, statistics and queuing

Learning outcomes

There are **five** outcomes to this unit. The candidate will be able to:

- Demonstrate an overview of modern digital communication systems
- Describe signals in the time, frequency and statistical domains, translate freely between these domains and evaluate the effect of transmission through a linear system
- Demonstrate an understanding the principles of digital transmission, line coding and modulation
- Demonstrate knowledge of elementary information theory and describe the purpose and principles of source coding and error control coding
- Demonstrate an understanding of noise and link budgets

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

No Key Skills were identified for this unit.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
3.1.1 Determine the installation requirements for engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
6.1.1 Analyse the risks arising from engineering products and processes
8.1.1 Maintain and develop own engineering expertise

Unit 219 Telecommunication systems engineering

Outcome 1 Demonstrate an overview of modern digital communication systems

Knowledge requirements
The candidate knows how to:

1 describe the historical development of telecommunications services

2 describe the purpose of the following digital communications processes
- a sampling and anti-aliasing filtering
- b quantization/reconstruction filtering
- c pulse code modulation/demodulation
- d source coding/decoding
- e encryption/deciphering
- f error control coding/decoding
- g multiplexing/demultiplexing
- h line coding/decoding
- i pulse shaping/matched filtering
- j bandpass modulation/demodulation
- k multiple accessing
- l equalization

3 compare and contrast the advantages and disadvantages of line and radio transmission

4 describe the 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

6 suggest, and comment on, the advantages of digital communications compared with analogue communications

7 describe a range of telecommunication network applications

8 explain the fundamental network problem

9 distinguish between broadcast and switched networks

10 distinguish between LANs, MANs and WANs

11 describe a range of network structures (including star, tree, mesh, bus, ring) and represent them, where appropriate, using a connection matrix

12 explain the following network switching philosophies
- a circuit switching
- b message switching
- c packet switching

13 explain the principles and advantages of a 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

17 explain what is meant by the transmission system, the switching system and the signalling system of a network

18 explain what is meant by the terms core network, access network, bearer network and service (or functional) networks

Unit 219 Telecommunication systems engineering

Outcome 2 Describe signals in the time, frequency and statistical domains, translate freely between these domains and evaluate the effect of transmission through a linear system

Knowledge requirements
The candidate knows how to:

1. recognise and distinguish between periodic and non-periodic signals
2. recognise and distinguish between deterministic and random signals
3. recognise and distinguish between transient and non-transient signals
4. use analytical formulas to represent common periodic and transient signals in time and frequency domains
5. use probability distributions and statistics to describe random signals
6. translate simple signals between time and frequency domains using the fourier series and fourier transform
7. translate signals between time and frequency domains using tables of Fourier series, Fourier transforms and Fourier transform theorems
8. calculate the power spectra and autocorrelation functions of signals
9. relate power spectra and autocorrelation functions using the Wiener-Kintchine theorem
10. explain what is meant by cross-correlation function and correlation coefficient and calculate these for simple signals and random variables
11. describe the effect of a linear system using frequency response and/or impulse response, especially in the context of pulse transmission
12. relate the frequency response and impulse response of a linear system
13. describe the origin, effects and mitigating techniques for the following types of distortion
    a. loss
    b. amplitude distortion
    c. phase and group delay

Unit 219 Telecommunication systems engineering

Outcome 3 Demonstrate an understanding the principles of digital transmission, line coding and modulation

Knowledge requirements
The candidate knows how to:

1 state, and apply, Nyquist's sampling theorem

2 break the process of analog-to-digital conversion into sampling, quantization and pulse code modulation

3 explain the process and significance of quantization

4 explain what is meant by quantization noise

5 calculate signal to quantization-noise ratios (SN_qR) for signals with uniform pdf

6 describe pulse code modulation (PCM)

7 explain the advantages of PCM

8 calculate the signal-to-noise ratio (SNR) of a demodulated PCM signal

9 explain the process and advantages of non-linear quantization and companding

10 quantify the benefits of A-law companding

11 describe centre point detection (CPD) as applied in simple baseband receivers

12 derive and calculate the bit error ratio (BER) for a baseband CPD system in the presence of Gaussian noise

13 explain what is meant digital signal regeneration and describe how it is achieved

14 calculate the effect of error accumulation over multi-hop links using linear amplifiers or regenerative repeaters between hops

15 describe the purpose and requirements of a line code

16 describe the general properties of unipolar, polar, dipolar and bipolar (AMI) line codes

17 distinguish between return-to-zero and non-return-to-zero line codes

18 describe HDB3, CMI and *n*B*m*T line codes

19 explain the purpose of band-pass modulation

20 describe the basic binary forms of digital modulation

a amplitude shift keying (ASK)

b frequency shift keying (FSK)

c phase shift keying (PSK)

21 sketch example waveforms, spectra and constellation diagrams for each of the binary modulation schemes

22 show how each ASK, FSK and PSK signals could be generated in principle

Unit 219 Telecommunication systems engineering

Outcome 4 Demonstrate knowledge of elementary information theory and describe the purpose and principles of source coding and error control coding

Knowledge requirements
The candidate knows how to:

1 summarize elementary information theory

- a explain and define the basic measures of information (bits, nats and hartleys)
- b explain and define entropy, redundancy and transmission (or code) efficiency
- c apply measures of information, entropy, redundancy and transmission efficiency to simple numerical problems

2 explain the purpose and principles of source coding

- a implement a Huffman code
- b describe source coding for speech, music (Hi-Fi), facsimile, pictures (JPEG) and video (MPEG)
- c define channel capacity (Shannon-Hartley law)
- d comment on the limiting factors of channel capacity (error rate due to noise and bit rate due to bandwidth) and the possible trade-off between these factors

3 explain the purpose and principles of error control coding

- a define Hamming distance and codeword weight
- b explain the principles of (n, k) block codes and the use of parity check digits
- c define the error detection and correction capability of a code
- d implement nearest neighbour and syndrome decoding of a block code
- e explain what is meant by a cyclic code and, in particular, the special case of a Hamming code
- f explain the meaning and significance of interleaving

Unit 219 Telecommunication systems engineering

Outcome 5 Demonstrate an understanding of noise and link budgets

Knowledge requirements
The candidate knows how to:

1 explain what is meant by additive noise, white noise and Gaussian noise

2 explain why thermal noise can normally be assumed to be additive, white and Gaussian

3 explain origin and characteristics of shot noise

4 distinguish between internal and external receiver noise

5 define noise temperature and noise figure and convert freely between the two

6 calculate the overall noise temperature and noise figure of a system comprising multiple subsystems connected in cascade

7 explain what is meant by antenna noise temperature

8 sketch the typical noise temperature of a narrow beam antenna as a function of frequency for low and high elevation angles

9 explain the origin of the dominant antenna noise at different frequencies

10 explain and define antenna directivity, gain and effective area

11 explain and define spreading loss, free-space path loss, plane Earth path loss and interference patterns due to ground reflection

12 construct simple microwave or millimeter-wave link budgets for point-to-point terrestrial links

13 describe what is meant by multipath fading and diversity reception in the context of a radio link

14 explain the principles of optical fibre transmission including fibre contruction, propagation modes and their characteristics

15 give an elementary account of optical sources, detectors and amplifiers

16 construct simple optical fibre link budgets

Unit 219 Telecommunication systems engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Digital Communications	Glover, Grant	Prentice-Hall	0130893994
Telecommunication switching, Traffic and Networks	Flood	Pearson Education	0130893994
Transmissions Systems	Flood, Cochrane	Peregrinus	0863413102
Other useful texts			
Communication Systems	Carlson	McGrawHill	007009960
Telecommunication Engineering	Dunlop, Smith	Chapman Hall	0-412562707
Digital Communications	Proakis	McGraw Hill	007-2321113
Digital Communications	Sklar	Prentice Hall	0130847887
Introduction to Communication Systems	Stremler	Addison Wesley	0201516519
Optical Communication	Sibley	McMillan	0-333-61792-4
Modern Digital and Analogue Communication Systems	Lathi	Oxford University Press	0195110099

Unit 220 Quality and reliability engineering

Unit summary

This unit is about the design process that leads to reliable systems with built-in quality. It enables measurement of effectiveness and repeatability.

Aims

The unit aims to develop in the candidate an awareness of artifact quality, reliability, safety, and maintainability by measurement and planning.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examinations. In particular knowledge of statistics and probability mathematics is needed.

Learning outcomes

There are **three** outcomes to this unit. The candidate will be able to:

- Describe the importance of quality and reliability
- Use methods for measuring and improving quality and reliability
- Develop quality and reliability programme plans

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

No Key Skills were identified for this unit.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
2.3.1 Monitor the production process
2.3.2 Evaluate the production process
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
6.1.1 Analyse the risks arising from engineering products and processes
6.1.2 Specify methods and procedures to reduce risks
6.2.1 Assure the quality of engineering products or processes
6.2.2 Identify the reasons for quality assurance problems
6.2.3 Implement improvements to the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 220 Quality and reliability engineering
Outcome 1 Describe the importance of quality and reliability

Knowledge requirements
The candidate knows how to:

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)

Unit 220 Quality and reliability engineering

Outcome 2 Use methods for measuring and improving quality and reliability

Knowledge requirements
The candidate knows how to:

1 state the general principles of metrology

2 measure and test
   - a length
   - b angle
   - c form
   - d surface finish
   - e roundness
   - f gauging

3 use co-ordinate measuring machines

4 undertake on-line inspection and testing using
   - a non-destructive techniques
   - b vision systems
   - c electrical, mechanical and radiological methods

5 inspect and evaluate the quality of raw materials
   - a for purchasing purposes
   - b use supplier evaluation and rating methods

6 use statistical methods for quality and reliability
   - a acceptance sampling
   - b control charts
   - c tests of significance and confidence limits
   - d sampling schemes
   - e Seven Quality Tools
   - f and determine control system choice

Unit 220 Quality and reliability engineering
Outcome 3 Develop quality and reliability programme plans

Knowledge requirements
The candidate knows how to:

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 understand Failure Mode, Effect and Criticality Analysis (FMECA) for
   a design
   b process
   c system
6 understand 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

Unit 220 Quality and reliability engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Managing Quality	Dale	Blackwell	0631236147
Practical Approach to Quality Control	Caplen	Random House	0091735815
Practical Reliability Engineering	O'Connor	John Wiley	0470844639
Statistical Methods for Quality Improvement	Ryan	John Wiley	0471197750
Taguchi Techniques for Quality Engineering	Ross	McGraw Hill	0070539588
The Capability Maturity Model for Software	Paulk, Weber, Curtis ,Chrissis	Addison-Wesley	0201546647
Total Quality Management	Oakland	Butterworth-Heinemann	0750609931
ZQC: Source Inspection and the Poka-Yoke System	Shingo	Productivity Press Inc.	0915299070
Metrology for Engineers	Gayler, Shotbolt		0304306126 o/p
Quality Management for Software	Daily	Blackwell NCC	1855540827 o/p
Other useful texts			
Statistical Tables	Murdoch, Barnes	Palgrave	0333558596

Unit 221 Analysis and design of manufacturing systems

Unit summary
This unit is about the methods used for the analysis and design of manufacturing systems.

Aims
The unit aims to furnish the candidate with the knowledge and techniques used to analyse manufacturing systems and apply analytical techniques to solve problems associated with manufacturing activities.

Prerequisites
It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examinations.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:

- Describe business strategy in the analysis and design of manufacturing systems
- Apply modelling and representation to manufacturing systems
- Analyse the design of manufacturing systems
- Apply performance criteria to manufacturing systems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

C4.1
Develop a strategy for using communication skills over an extended period of time.

C4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- **one** group discussion about a complex subject;
- **one** extended written communication about a complex subject.

C4.3
Evaluate your overall strategy and present the outcomes from your work, using at least one formal oral presentation, including the use of two images to illustrate complex points.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.2.1 Identify and define areas of research
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
2.2.2 Solve production problems with engineering solutions
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.1.3 Schedule operational activities to implement the operational methods and procedures
4.3.1 Determine the operational requirements of engineering products or processes
4.3.2 Specify operational methods and procedures to achieve operational requirements
5.1.1 Determine the maintenance requirements of engineering products or procedures
5.1.2 Specify maintenance methods and procedures to achieve maintenance requirements
6.1.1 Analyse the risks arising from engineering products and processes
6.1.2 Specify methods and procedures to reduce risks
6.2.1 Assure the quality of engineering products or processes
6.2.3 Implement improvements to the quality of engineering products or processes
7.1.1 Develop objectives for projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 221 Analysis and design of manufacturing systems

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

Knowledge requirements
The candidate knows how to:

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
  - i R and D
  - ii design
  - iii manufacturing
  - iv management and sales

3 undertake an audit of manufacturing activities and process capabilities

4 assess make-or-buy decisions

Unit 221 Analysis and design of manufacturing systems

Outcome 2 Apply modelling and representation to manufacturing systems

Knowledge requirements
The candidate knows how to:

1 identify systems and sub-systems

2 understand concepts of structured design methods

- a input-output models
- b flow diagrams
- c material mapping
- d information flows

3 understand 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

Unit 221 Analysis and design of manufacturing systems
Outcome 3 Analyse the design of manufacturing systems

Knowledge requirements
The candidate knows how to:

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 ventor 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

Unit 221 Analysis and design of manufacturing systems

Outcome 4 Apply performance criteria to manufacturing systems

Knowledge requirements
The candidate knows how to:

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

Unit 221 Analysis and design of manufacturing systems
Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Automation, Production Systems and Computer Integrated	Groover	Longman HE	0130889784
Manufacturing Strategy	Terry Hill	Palgrave	0333762223
Production and Operations Management	Wild	Continuum Publishing	0826451926
Production and Operations Management	Muhlemann, Oakland, Locklear	Prentice Hall	0273032356
World Class Manufacturing The Lessons of Simplicity	Schonberger	Free Press	0029292700
Other useful texts			
Strategic Management	Bowman, Asch	Palgrave	0333387651
The Essence of Business Economics	Nellis, Parker	Pearson Education	0135731305
The Essence of Competitive Strategy	Faulkner, Bowman	Pearson Education	0132914778
The Essence of the Economy	Nellis, Parker	Pearson Education	0133565025
The Essentials of Production and Operations Management Text and Cases	Wild	Continuum Publishing	0304331309
Tutor's Guide for "Production and Operations Management"	Wild	Continuum Publishing	0304335703

Unit 222 The management of construction projects

Unit summary
This unit is about the management principles, organisational structures, performance measurement and control of issues of particular relevance to the management of construction companies and projects.

Aims
The unit aims to develop a candidate's awareness of the functions of management in the execution of construction projects including planning, cost and time management.

Prerequisites
It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examinations.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Demonstrate the process involved in construction project management
- Demonstrate the techniques required to procure projects
- Apply control techniques during the project execution

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
3.1.1 Determine the installation requirements for engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
7.1.1 Develop objectives for projects
7.1.2 Plan the delivery of projects
7.2.1 Establish project management systems
7.2.2 Manage the implementation or projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 222 The management of construction projects

Outcome 1 Demonstrate the process involved in construction project management

Knowledge requirements
The candidate knows how to:

1 describe the nature and structure of the construction industry

2 describe the construction project cycle

3 identify the roles and functions of relevant parties

4 describe various construction companies organisational formats and departmental roles within it

5 describe contractual relationships and the project procurement process

6 assess types of contract

Unit 222 The management of construction projects

Outcome 2 Demonstrate the techniques required to procure projects

Knowledge requirements
The candidate knows how to:

1 identify and prepare the documentation required at the tendering stage

2 describe the tendering and estimating process

3 use estimating methods

   a unit rate and operational estimating

   b direct and indirect costs

   c preliminaries

   d overheads

   e tender adjustment

4 prepare pre-tender planning and method statements

Unit 222 The management of construction projects

Outcome 3 Apply control techniques during the project execution

Knowledge requirements
The candidate knows how to:

1 develop cost control measures
  - a total budget and sub-budgets
  - b S curves and cash flow forecasting
  - c cost control coding
  - d reporting systems
  - e standard costs and variances
  - f indices and price adjustments
  - g interim evaluations
  - h claims

2 apply arbitration, adjudication and alternative dispute resolution

3 implement various types of construction planning and know their relationship to stages of the construction process

4 use planning methods
  - a bar charts
  - b critical path networks
  - c line of balance

5 use methods of resource estimation
  - a scheduling
  - b allocation

6 monitor and record progress

7 take corrective action

8 define performance

9 implement key performance indicators

10 explain the cost/time/quality triangle

11 define productivity

12 measure and improve productivity through work study
  - a method study
  - b work measurement

13 organise sitework

a selection of construction plant

b plant maintenance policies

c site layout

d materials management

e Health and Safety issues and regulations

f Construction (Design and Management) regulations

g quality management

i principles

ii application

Unit 222 The management of construction projects
Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Construction Management in Practice	Fellows, Langford et al	Blackwell	0632064021
Construction Methods and Planning	Illingworth	Spon Press	041924980X
Modern Construction Management	Harris, McCaffer	Blackwell	0632055138
Principles of Construction Management	Pilcher	McGraw-Hill	0077072367 o/p
Other useful texts			
Building Economics	Seeley	Palgrave Macmillan	0333638352
Project Cost Estimating	Smith (Editor)	Thomas Telford	0727720325
Cost Planning of Building		Ferry Blackwell	0632042516 o/p

Unit 223 The management of engineering enterprises

Unit summary

This unit is about management principles, organisational structures, performance measurement and control issues of particular relevance to engineering, technology and operations management.

Aims

The unit aims to develop a candidate's awareness of the functions of management in the control of engineering, technology and operations.

Prerequisites

It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examinations.

Learning outcomes

There are **two** outcomes to this unit. The candidate will be able to:

- Understand managerial functions, roles and responsibilities
- Recognise the issues, difficulties and problems facing management and how to address them

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

KS5.1
Explore the demands of the work and formulate viable proposals for meeting these demands.

KS5.2
Plan to manage the work, and meet your own skill-development needs, and gain the necessary commitment from others.

KS5.3
Manage the work, adapting your strategy as necessary to resolve at least **two** complex problems and achieve the quality of outcomes required. Formally review, with an appropriate person, your use of skills in:

- communication;
- problem solving;
- working with others.

KS5.4
Evaluate your overall performance and present the outcomes, including at least:

- one formal, oral presentation of the outcomes from the work;
- one written evaluation of your overall approach and
- application of skills.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.2.1 Identify and define areas of research
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
2.1.3 Obtain the resources to implement the production methods and procedures
2.1.4 Schedule production activities to implement the production methods and procedures
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
5.1.1 Determine the maintenance requirements of engineering products or procedures
5.1.2 Specify maintenance methods and procedures to achieve maintenance requirements
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
6.2.2 Identify the reasons for quality assurance problems
7.2.2 Manage the implementation or projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 223 The management of engineering enterprises

Outcome 1 Understand managerial functions, roles and responsibilities

Knowledge requirements
The candidate knows how to:

1 recognise the nature of organisations
   a types of business
   b business objectives, strategy and policy
   c legal requirements of business
2 recognise the impact of technology on society
3 understand technology transfer and technology strategy
4 understand the structures, functions and roles within contemporary business organisations
5 prepare financial reports, budgets, costings, accounts and project appraisals
6 understand roles of and skills required for management
   a leadership
   b motivation
   c team working and team building
   d personal management
7 chart professional development and career advancement
8 understand the professional issues in management
9 understand the generic issues in project management environments
10 recognise classical techniques for project management
11 control resource scheduling, budgeting and cost control
12 assess the risks 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
   a decision trees
   b EMV
   c EVPI
16 assess the value of information
17 understand optimisation principles
   a LP formulation
   b graphic solutions
18 use simulation principles for analysing business problems
19 use forecasting techniques

Unit 223 The management of engineering enterprises

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

Knowledge requirements
The candidate knows how to:

1 recognise management issues within and across business functions

- a marketing and sales
  - i market research
  - ii the marketing process
  - iii customer focus
  - iv quality
- b managing the design and product development process
- c procurement, purchasing and supply chain management
- d human resource management
- e job design and work organisation
- f productivity and work measurement
- g performance measurement
- h continuous improvement
- i Japanese management principles
- j knowledge and information management

2 recognise issues facing contemporary organisations

- a ethics and corporate responsibility
- b engineering Health and Safety at Work
- c legal requirements
- d environmental issues
- e International business and the impact of globalisation

Unit 223 The management of engineering enterprises

Recommended reading list

Core texts	**Author(s)**	**Publisher**	**ISBN**
Exploring Corporate Strategy: Text and Cases	Johnson,Scholes	Pearson Education	0273687344
Financial Accounting for Non-Specialists	Atrill, Peter	Prentice Hall	0273655876
Management and Organisational Behaviour	Mullins	FT Pitman	0273688766
The Essence of Business Economics	Parker	Pearson Education	0135731305
The Essentials of Project Management	Lock	Gower	0566082241
Operations Management	Wild	Continuum	0826449271
Principles of Marketing	Kotler, Saunders, Armstrong	Pearson	0273684566

Unit 224 Advanced mathematical techniques for engineering applications

Unit summary
This unit is about the advanced mathematical techniques and their applications as required by professional engineers.

Aims
The unit aims to equip the candidate with the mathematical expertise required to function as a professional engineer.

Prerequisites
It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examinations.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Solve engineering problems using mathematical methods
- Solve engineering problems using numerical methods
- Solve engineering problems using statistical methods

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.2 Evaluate the results of research
4.1.1 Determine the operational requirements of engineering products or processes
4.2.2 Solve operational problems with engineering solutions
6.2.1 Assure the quality of engineering products or processes
6.2.3 Implement improvements to the quality of engineering products or processes
7.1.1 Develop objectives for projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 224 Advanced mathematical techniques for engineering applications

Outcome 1 Solve engineering problems using mathematical methods

Knowledge requirements
The candidate knows how to:

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

- a Green's theorem
- b Stokes' theorem
- c Gauss' theorem
- d employ vector calculus to simple applications

5 apply simple applications from field theory

6 solve problems involving complex variable theory

- a analytic functions
- b Cauchy-Riemann equations
- c poles, zeros and residues
- d conformal transformations

7 apply Laplace transform methods to the solution of differential equations

- a transfer functions
- b convolution theorem

8 apply Z-transform methods to the solution of difference equations and discrete systems

9 solve second order partial differential equations by separation of variables including the use of Fourier series

Unit 224 Advanced mathematical techniques for engineering applications

Outcome 2 Solve engineering problems using numerical methods

Knowledge requirements
The candidate knows how to:

1 solve sets of linear equations
- a Gauss – Seidel and Jacobi methods
- b matrix factorization methods

2 solve numerical optimization problems
- a direct search method
- b simple gradient methods

3 determine matrix eigenvalues and eigenvectors
- a direct and inverse iteration
- b shift of origin

4 solve simple systems of ordinary differential equations using eigenvalue analysis

5 apply the above to vibration problems

6 solve initial value problems for ordinary differential equations numerically
- a Taylor series
- b Runge-Kutta method
- c Simple linear multi-step methods
- d convergence and stability
- e coupled ordinary differential equations

7 solve boundary value problems for ordinary differential equations numerically
- a shooting and finite difference methods
- b simple eigenvalue problems

8 use simple finite difference methods to solve partial differential equations

9 solve initial value problems for partial differential equations numerically
- a explicit and implicit procedures
- b simple ideas on errors and stability

10 solve boundary value problems for partial differential equations numerically
- a direct solution of finite difference equations
- b iterative solution of finite difference equations

Unit 224 Advanced mathematical techniques for engineering applications

Outcome 3 Solve engineering problems using statistical methods

Knowledge requirements
The candidate knows how to:

1. solve problems using Binomial, Poisson and Normal distributions to include
   a. probability of defects in production
   b. errors in observation
2. test samples to make statistical decisions
   a. χ^2
   b. t-tests
   c. regression
3. use Markov chains
4. apply the above to queuing theory

Unit 224 Advanced mathematical techniques for engineering applications

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Advanced Engineering Mathematics	Stroud	Palgrave	1403903123
Advanced Modern Engineering Mathematics	Glyn James	Addison-Wesley	0130454257
Applied Numerical Analysis Specialist book; this subject now features more strongly in the syllabus	Gerald, Wheatley	Addison Wesley	0201592908
Applied Statistics and Probability for Engineers Specialist book; this subject now features more strongly in the syllabus	Montgomery, Runger	John Wiley	0471426822
Modern Engineering and Mathematics	Glyn James	Addison-Wesley	0130183199
Other useful texts			
Advanced Engineering Mathematics Broad coverage, but quite advanced and may be too difficult for some students	Kreyszig	John Wiley	0471488852
Numerical Methods for Engineers Specialist book; this subject now features more strongly in the syllabus	Chapra, Canale	McGraw Hill	0071231404

Unit 225 Dynamics of mechanical systems

Unit summary
This unit is about analysing engineering problems where dynamic behaviour is a major consideration.

Aims
The unit aims to develop the candidate's knowledge of the dynamics of rigid bodies, dynamics of machines and vibration of mechanical systems.

Prerequisites
It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examinations.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Solve problems involving three dimensional motion of solids bodies
- Analyse common engineering machines and mechanisms
- Analyse vibration involved in mechanical systems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.3.2 Evaluate the results of research
8.1.1 Maintain and develop own engineering expertise

Unit 225 Dynamics of mechanical systems

Outcome 1 Solve problems involving three dimensional motion of solids bodies

Knowledge requirements
The candidate knows how to:

1. solve problems involving the motion of rigid bodies in three dimensions
   a. linear momentum
   b. moment of momentum (angular momentum)
   c. kinetic energy
2. use the momentum equation of motion
   a. rotating frames of reference
   b. Euler's equations
   c. work/energy equations
3. solve problems involving gyroscopic motion with steady precession
4. analyse the effects of impulsive forces and moment of force

Unit 225 Dynamics of mechanical systems
Outcome 2 Analyse common engineering machines and mechanisms

Knowledge requirements
The candidate knows how to:

1 solve problems involving Kinetics of planar mechanisms with
   a revolute (pin) joints
   b prismatic (sliding) joints
2 solve problems involving forces and torques in planar mechanisms including those due to the inertia and moments of force associated with acceleration of the links
3 analyse the balancing of rigid rotors
   a the out-of-balance forces in single and multi-cylinder reciprocating engines, pumps and compressors
   b the moments of force of the above

Unit 225 Dynamics of mechanical systems
Outcome 3 Analyse vibration involved in mechanical systems

Knowledge requirements
The candidate knows how to:

1. analyse free vibration of systems with two degrees of freedom
   a. undamped natural frequencies
   b. normal modes of vibration of undamped systems (eigenvalues and eigenvectors)
   c. the orthogonality principle
   d. coupling and beat phenomena
2. analyse undamped and damped force vibration of systems with one degree and two degrees of freedom
   a. with forcing by harmonic displacement
   b. rotating out-of-balance
   c. force or moment of force applied to a body in the system
3. investigate frequency response characteristics
   a. resonant frequencies
   b. magnification factor and peak magnification
   c. modulus and phase diagrams
4. determine the forces transmitted to supports
5. examine the dynamic vibration absorber and the untuned viscous damper
6. extend vibration analysis to undamped multi-degrees of freedom systems
   a. influence coefficients
   b. Holzer's method
7. analyse free vibration of undamped continuous systems
   a. longitudinal vibration of bars
   b. torsional vibration of circular shafts
   c. flexural vibration of beams
   d. analytical solutions for simple systems
   e. Rayleigh's method for multi-body and continuous linear systems

Unit 225 Dynamics of mechanical systems

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Engineering Mechanics Vol 2: Dynamics	Meriam, Kraige	John Wiley	0471241679
Mechanics and Dynamics of Machinery	Mabie, Reinholtz	John Wiley	0471802379
Theory of Vibration with Applications	Thomson	Unwin Hyman	0044450699
Other useful texts			
The Theory of Vibration with Applications	Thomson	Nelson Thornes	0748743804

Unit 226 The technology of manufacturing processes

Unit summary
This unit is about the range of commonly used manufacturing processes and associated materials of manufacture.

Aims
The unit aims to develop the student's awareness of manufacturing processes and the limitations and opportunities placed on manufacturing by workplace behaviour, design constraints, economic aspects, automation and modelling.

Prerequisites
It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examinations.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Material behaviour and treatment that is relevant to manufacturing of parts and components
- Casting, moulding, cutting, machining, forming, joining and powder based processes
- Automation of manufacturing processes and control systems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

C4.1
Develop a strategy for using communication skills over an extended period of time.

C4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- **one** group discussion about a complex subject;
- **one** extended written communication about a complex subject.

C4.3
Evaluate your overall strategy and present the outcomes from your work, using at least **one** formal oral presentation, including the use of two images to illustrate complex points.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
2.2.1 Implement production methods and procedures
2.2.2 Solve production problems with engineering solutions
2.3.2 Evaluate the production process
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
3.1.4 Schedule installation activities to implement the installation methods and procedures
3.2.2 Solve installation problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.3.2 Evaluate operational processes
5.1.1 Determine the maintenance requirements of engineering products or procedures
5.1.2 Specify maintenance methods and procedures to achieve maintenance requirements
5.2.1 Implement maintenance methods and procedures
5.3.2 Evaluate maintenance processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 226 The technology of manufacturing processes

Outcome 1 Material behaviour and treatment that is relevant to manufacturing of parts and components

Knowledge requirements
The candidate knows how to:

1 apply heat treatment to materials to produce the desired properties

2 conduct surface treatment and coating processes
   - a surface hardening
   - b PVD
   - c CVD

3 assess a materials plasticity
   - a Von Mises and Tresca yield criterion
   - b Coulomb friction and friction factor models
   - c Levy-Mises flow rule
   - d empirical equations to describe stress-strain relations
   - e plastic anisotropy parameters for sheet metal

Unit 226 The technology of manufacturing processes

Outcome 2 Casting, moulding, cutting, machining, forming, joining and powder based processes

Knowledge requirements
The candidate knows how to:

1 describe metal casting processes
- a sand
- b die
- c investment

2 describe polymer forming processes
- a injection moulding
- b rotational
- c resin transfer
- d thermoforming
- e compression moulding
- f extrusion moulding

3 describe metal forming processes
- a open and closed die forging
- b cold forging
- c tube making processes
- d sheet drawing and pressing
- e extrusion of solid and thin walled sections
- f apply energy, slab and upper bound methods to calculate forming forces
- g identify the characteristics of forming machinery and tools
- h appreciate the capabilities of finite element modelling

4 evaluate alternative design configurations for moulds and dies in casting and forming processes

5 describe mechanical cutting processes
- a chip formation
- b cutting forces and power estimation
- c Taylor's tool life equation
- d drilling, turning and milling operations
- e grinding configurations
- f surface texture and measurement
- g cutting tool materials as associated ISO/EN standards

6 describe laser cutting technology

7 describe electro-chemical processes

   a ECM

   b EDM rapid prototyping

   c PVD

   d CVD

8 describe liquid phase joining processes

   a gas welding

   b arc welding

      i SMAW

      ii SAW

      iii MIG

      iv TIG

      v plasma

   c laser welding

   d resistance welding

   e electron beam welding

   f friction welding

   g diffusion bonding

   h adhesive bonding

9 select and carry out weld inspection methods

   a destructive

   b non-destructive

10 select materials appropriate to the product manufacture or manufacturing process

Unit 226 The technology of manufacturing processes

Outcome 3 Automation of manufacturing processes and control systems

Knowledge requirements
The candidate knows how to:

1 utilise automation systems in manufacturing
  - a NC
  - b CNC
  - c DNC

2 part programme using G codes

3 utilise programmable logic control (PLC) methods for
  - a adaptive control
  - b robotics
  - c sensors

4 develop and adapt CAD systems and concepts of solid modelling virtual reality

5 utilise data transfer in CAD/CAM

6 estimate production costs

7 plan mechanical and production processes

Unit 226 The technology of manufacturing processes

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Computer Integrated Manufacturing and Engineering	Rembold, Nnaji & Storr	Addison-Wesley	0201565412
Introduction to Manufacturing Processes	John Schey	McGraw Hill	0071169113
Manufacturing Engineering and Technology	Kalpakjian, Schmid	Longman HE	0130174408
Robotics	Fu, Gonzales & Lee	McGraw Hill	0071004211
Total Design	Stuart Pugh	Addison-Wesley	0201416395

Unit 227 Control systems engineering

Unit summary
This unit is about the methods used for the design and evaluation of control systems.

Aims
The unit aims to equip the candidate with the knowledge and skills required to design and evaluate control systems relating to mechanical, manufacturing, chemical and electrical engineering applications.

Prerequisites
It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examinations and be familiar with complex variable theory, solution of 1st and 2nd other differential equations using time domain and Laplace techniques and the basics of applied mechanics.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:
- Apply mathematical modelling to dynamic systems and analyse responses
- Choose instrumentation for measurement
- Understand feedback control systems
- Understand digital control systems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:
- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.2 Evaluate the results of research
1.4.1 Establish a design brief for engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
6.2.3 Implement improvements to the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 227 Control systems engineering

Outcome 1 Apply mathematical modelling to dynamic systems and analyse responses

Knowledge requirements
The candidate knows how to:

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 understand linearisation of dynamic equations about an equilibrium operating state

3 use methods of system representation
  - a block diagrams and block diagram reduction
  - b transfer functions
  - c signal flow graphs

4 understand systems with dead time
  - a distance/velocity lag

5 understand the transient and steady-state response of first-order and second-order systems to the function inputs
  - a impulse
  - b step
  - c ramp
  - d sinusoidal

6 analyse transfer function and state variable formulations of dynamic system equations including the effects of initial conditions

7 understand response characterisation
  - a time constant
  - b undamped 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

8 extend the above to higher order systems such as systems with a dominant time constant

Unit 227 Control systems engineering
Outcome 2 Choose instrumentation for measurement

Knowledge requirements
The candidate knows how to:

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 227 Control systems engineering

Outcome 3 Understand feedback control systems

Knowledge requirements
The candidate knows how to:

1 compare control systems without and with feedback

2 understand and manipulate open and closed-loop transfer functions

3 assess types of close-loop control systems and relationship with steady state errors

4 understand characteristic equation of closed-loop control system and the Routh-Hurwitz stability criterion

5 use design criteria

- a stability margins
- b steady-state errors
- c performance indices in the time domain
- d disturbance rejection
- e concept of design sensitivity

6 implement control algorithms by finite difference techniques (discrete mathematics)

7 understand frequency diagrams

- a Nyquist
- b Bode
- c Nichols
- d stability criteria
- e relative stability
- f peak magnitude of frequency response
- g gain and phase margins

8 understand the root locus diagram

- a stability criterion
- b constraints on pole locations to satisfy damping ratio and speed response requirements

9 apply closed-loop system response to disturbances with differing entry points

10 assess state variable formulation of the system equation; canonical transformation and canonical state variables

11 assess the implication of controllability and observability

12 understand the application of compensation techniques using frequency response and root loci design methods

- a lead/lag networks
- b proportional - integral-derivative (PID) control

13 understand pole placement by state vector feedback

14 understand digital compensation

Unit 227 Control systems engineering
Outcome 4 Understand digital control systems

Knowledge requirements
The candidate knows how to:

1 describe the main features of computer based control systems

2 describe sampler/zero-order-hold systems

3 understand the Z-transform with sampling interval T

4 assess the relationship between Laplace variables S and Z and Z-transform inversion and final value theorem

5 understand the Nyquist/Shannon Sampling-rate theorem and aliasing

6 understand poles and zeros in the Z-plane

7 establish criterion for system stability

Unit 227 Control systems engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
The Art of Control Engineering	Dutton, Thompson, Barraclough	Addison Wesley	0201175452
Control Engineering	Bissell	Nelson Thornes	0412577100
Digital Signal Processing Primer	Steiglitz	Benjamin Cummings	0805316841
Measurement Systems: Application and Design	O'Doeblin	McGraw Hill	0071194657
Modern Control Systems	Dorf, Bishop	Addison-Wesley	0201326779
Principles of Measurement Systems	Bentley	Longman Higher Edu	0582237793
Real-Time Computer Control	Bennett	Prentice Hall	0137641761
System Modelling and Control	Schwarzenbach,Gill	Butterworth-Heinemann	0340543795
Instrumentation: Measurement and Feedback	Jones	McGraw Hill	0070993831
Sensors and Transducers	Usher, Keating	Palgrave	0333604873 o/p
Other useful texts			
Control Systems Engineering	Nise	John Wiley	0471366013
Digital Control of Dynamic Systems	Franklin, Powell, Workman	Addison-Wesley	0201331535
Further Engineering Mathematics	Stroud	Palgrave	0333657411
Schaum's Outline of Digital Signal Processing	Hayes	Schaum	0070273898
Schaum's Outline of Electronic Devices and Circuits	Cathey	Schaum	0070102740
Schaum's Outline of Feedback and Control Systems	Distefano, Stubberud, Williams	McGraw Hill	0070170525
Schaum's Outline of Theory and Problems	Buchanan	Schaum	0070087148

Unit 228 Information systems engineering

Unit summary
This unit is about the provision of a theoretical foundation, focus and theme to a subject by using a database approach.

Aims
The unit aims to develop the candidate's ability to develop, analyse, design and effectively use information systems.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and with subject 9107-108 Software and information systems engineering and practical experience of information systems.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Describe, analyse, evaluate and use information systems
- Design and implement database systems
- Investigate, analyse and evaluate world wide web based information systems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

IT4.1
Develop a strategy for using IT skills over an extended period of time.

IT4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving the use of IT for **two** different, complex purposes.

IT4.3
Evaluate your overall strategy and present the outcomes from your work using at least **one** presentation, showing integration of text, images and number.

C4.1
Develop a strategy for using communication skills over an extended period of time.

C4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- **one** group discussion about a complex subject;
- **one** extended written communication about a complex subject.

C4.3
Evaluate your overall strategy and present the outcomes from your work, using at least **one** formal oral presentation, including the use of two images to illustrate complex points.

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required when tackling **one** complex problem with at least three options.

PS4.3
Evaluate your overall strategy and present the outcomes from your work using a variety of methods.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 228 Information systems engineering

Outcome 1 Describe, analyse, evaluate and use information systems

Knowledge requirements
The candidate knows how to:

1 describe the range of scope of data used in information systems
   a bibliographic/free text
   b formatted text
   c record oriented
   d file based
   e legacy data
2 analyse and evaluate existing information systems
3 investigate emerging developments in information systems
4 extend existing information systems
5 apply multimedia formats and their storage, and use transmission and compression techniques
6 understand the ideas of data management and data mining and the concept of a data warehouse
7 describe the role of a database administrator
8 apply a multiuser relational database product including its
   a data management
   b application development techniques
9 apply the use of Forms as a metaphor to the interface to an information system
10 design a database user interface including
   a menu design
   b use of colour
   c use of graphics
11 assess programming Form activations using
   a 4GL code
   b embedded SQL
   c event procedures
12 use other programming techniques such as embedded SQL in C
   a static
   b dynamic

Unit 228 Information systems engineering
Outcome 2 Design and implement database systems

Knowledge requirements
The candidate knows how to:

1. understand the principles of database design and implementation
2. apply methods for modelling information systems including diagramming conventions supported by
   a. Yourdon/SSADM utilising data flow diagrams (DFD) to show
      i. process modelling
      ii. entity relationship (ER) diagrams
   b. alternative process design techniques
      i. Unified Modelling Language (UML)
3. compare and evaluate different approaches
4. utilise relational modelling and data analysis
5. understand functional dependency theory and normalisation
6. apply Boyce Codd Normal Form rule to a relational data set
7. undertake data modelling
   a. mapping an ER model to form a relational data set (Schema)
   b. coding a schema in SQL
8. create indexes, keys and clusters
9. apply entity and referential integrity
10. compare the data centred approach with the file based approach
11. assess data integrity and quality control
12. understand transaction processing
13. use a data dictionary
14. discuss data independence and physical views of data
15. compare and assess distributed information systems and database architectures
16. understand relational calculus and algebra
17. understand theoretical foundations of SQL
18. assess SQL standards and be able to apply these standards for
    a. data definition
    b. views
    c. updates insertion of referential integrity constraints
19. understand open SQL standard
20. recognise the operators available in single and multiple (Join) table queries
21. use embedded SQL

Unit 228 Information systems engineering

Outcome 3 Investigate, analyse and evaluate world wide web based information systems

Knowledge requirements
The candidate knows how to:

1 assess www based information systems

2 undertake comparison of different client server architectures

3 apply www access to databases through techniques such as cgi scripts and HTML

4 develop interactive graphical tools (applets) and the choice of tools for web enabled information processing

5 undertake effective implementation, evaluation and testing of systems

Unit 228 Information systems engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
A Guide to SQL	Pratt	Boyd & Fraser	0877095205
Designing the User Interface	Scheiderman	Addison-Wesley	0201694972
Fundamentals of Database Systems	Elmasri, Navathe	Addison Wesley	032118095X
Introduction to Database Systems	Date	Addison-Wesley	0321189566
Data Analysis for Database Design	Howe	Oxford University Press	0340691506 o/p
Database, Design & Management	Stamper, Price	McGraw Hill	0075577860 o/p
Engineering the Human Computer Interface	Downton	McGraw Hill	007707727X o/p

Unit 229 Software engineering

Unit summary
This unit is about the fundamentals of software engineering and providing a framework which allows a disciplined approach to the development and maintenance of a range of high quality software.

Aims
The unit aims to equip the candidate with the knowledge and skills to monitor and measure aspects of the software process, and to implement mechanisms leading to the development of high quality software.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and subject 9107-108 Software and information systems engineering.

Learning outcomes
There are **two** outcomes to this unit. The candidate will be able to:

- Monitor and measure aspects of the software process
- Validate, verify and manage software

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

IT4.1
Develop a strategy for using IT skills over an extended period of time.

IT4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving the use of IT for **two** different, complex purposes.

IT4.3
Evaluate your overall strategy and present the outcomes from your work using at least **one** presentation, showing integration of text, images and number.

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required when tackling **one** complex problem with at least three options.

PS4.3
Evaluate your overall strategy and present the outcomes from your work using a variety of methods.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.1 Establish a design brief for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
3.4.2 Configure engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
4.3.1 Monitor operational processes
5.1.1 Determine the maintenance requirements of engineering products or procedures
5.1.2 Specify maintenance methods and procedures to achieve maintenance requirements
5.2.1 Implement maintenance methods and procedures
6.2.1 Assure the quality of engineering products or processes
7.1.1 Develop objectives for projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 229 Software engineering

Outcome 1 Monitor and measure aspects of the software process

Knowledge requirements
The candidate knows how to:

1 appraise the standard software life cycle model
- a requirements
- b specification
- c architectural design
- d detail design
- e implementation and testing
- f coding
- g maintenance

2 appraise alternative models
- a spiral model
- b prototyping model
- c transformational model

3 evaluate the strengths and weaknesses

4 understand the concept of the software process

5 appraise the SEI five level maturity model

6 understand Software Specification
- a functional
- b non-functional

7 understand requirements analysis and relationship with systems engineering and systems analysis and design

8 appraise systems modelling

9 discriminate between formal and informal approaches to describing specifications and their relative merits

10 assess different approaches to formal specifications
- a benefits
- b drawbacks

11 understand a common formal specification language
- a Z
- b VDM

12 produce a specification of a simple system using a formal specification language

13 analyse Software Design

- a characteristics of good design
- b different approaches to architectural design

14 undertake a detailed study of two commonly used approaches to software design

- a object oriented
- b data flow methods
- c real-time methods
  - i MASCOT
  - ii HOOD
- d utilisation software
  - i CASE tools to support this activity

15 understand the principles of interface design including the relative merits of

- a graphical user interface systems
- b command interfaces

16 undertake user interface evaluation

17 understand tool support

18 assess programming issues

- a choice of programming language
- b choice of programming
- c project support environment
- d selection of appropriate tools and factors influencing their choice

19 understand

- a strong typing
- b safe programming constructs
- c exceptions
- d fault tolerance
- e information hiding to combat complexity
- f separate compilation
- g concurrency

Unit 229 Software engineering
Outcome 2 Validate, verify and manage software

Knowledge requirements
The candidate knows how to:

1. validate and verify software
   - a terminology
   - b use of reviews and walkthroughs
   - c steps to be taken to ensure the effectiveness of approaches
2. use the above throughout the life cycle
3. approach testing to including
   - a black box or functional testing
   - b white box or structural testing
   - c path coverage
   - d dynamic analysers
4. test programs
5. undertake program verification using verification conditions and loop invariants in providing proofs of the correctness of simple programs that involve
   - a assignments
   - b conditionals
   - c simple while loops
6. manage software
   - a aims and purpose
   - b planning and scheduling
   - c risk identification and analysis
7. understand software re-engineering and re-use
8. cope with change in all its forms
   - a personnel
   - b improvements and defect removal
   - c requirements
   - d specifications
   - e hardware
   - f tools
   - g environment
9. assess team selection methods and team building techniques

10 relate software engineering standards

a coding

b company specific

c national and international

11 understand the role and purpose of standards

12 understand software metrics and related tools to assist management

13 assess software cost estimation models including COCOMO

14 understand software quality assurance

15 assess the role of management in the review process

16 explain configuration management and version control

17 define terms

18 state the main activities involved in configuration management and version control

19 use tools to support software engineering activities including

a make

b RCS

c SCCS

20 have a disciplined approach to the above activities based on the use of appropriate tools

a change control boards

b impact analysis

c appropriate statistics gathering

d release of changes

Unit 229 Software engineering
Recommended reading list

Core texts	Author(s)	Publisher	ISBN
An Introduction to Discrete Mathematics, Formal System Specification and Z	Ince	Clarendon Press	0198538367
Managing the Software Process	Watts Humphrey	Addison-Wesley	0201180952
Software Engineering	Sommerville	Addison-Wesley	0321210263
Software Engineering with Java	Schach	Irwin	0256241678
Other useful texts			
Program Derivation	Geoff Dromey	Addison-Wesley	0201416247
Software Development with Z	Wordsworth	Addison-Wesley	0201627574
Software Engineering- A European Perspective	Richard, Thayer, McGetterick	IEEE Computer Press	0818691174
Software Engineering-Principles and Practice	Van Vilet	John Wiley	0471975087
Systematic Software Development using VDM	Jones	Prentice Hall	0138804362
Z - An Introduction to Formal Methods	Diller	John Wiley	0471939730
Program Construction and Verification	Backhouse	Prentice Hall	0137291469 o/p
Software Configuration Management	Babich	Addison-Wesley	0201101610 o/p

Unit 230 Software for embedded systems

Unit summary

This unit is about Software Rich Systems where both hardware and software form a significant proportion of the total development but where the software dominates.

Aims

The unit aims to develop a basic theoretical foundation and focus for understanding systems software and systems theory. It includes the development of skills required to understand the principles and practices for the development and management of software for Software Rich Systems.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and subject 9107-108 Software and information systems engineering.

Learning outcomes

There are **four** outcomes to this unit. The candidate will be able to:

- Illustrate the differences between various types of system software (real-time, information systems, fault tolerant)
- Understand the division of hardware/software in embedded systems
- Explain the fundamental needs of the Human Computer Interface and needs of data capture
- Demonstrate quality and management processes

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

IT4.1
Develop a strategy for using IT skills over an extended period of time.

IT4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving the use of IT for **two** different, complex purposes.

IT4.3
Evaluate your overall strategy and present the outcomes from your work using at least **one** presentation, showing integration of text, images and number.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.3.2 Evaluate operational processes
5.1.1 Determine the maintenance requirements of engineering products or procedures
5.1.2 Specify maintenance methods and procedures to achieve maintenance requirements
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 230 Software for embedded systems

Outcome 1 Illustrate the differences between various types of system software (real-time, information systems, fault tolerant)

Knowledge requirements
The candidate knows how to:

1 explain the following system software
   - a operating systems including real time control and IS
   - b compilers
   - c interpreters
   - d linkers
   - e loaders
   - f diagnostic tools
   - g debugging tools

2 explain system development techniques for embedded systems
   - a co-specification and co-design
   - b testing and varification

3 use programming languages for control system software development

4 explain the notation and classification of systems

5 understand System Models, Black Box models and the modelling process

6 understand the interaction of systems and the environment

Note: a detailed knowledge of specific system software is **not** required although candidates should be able to provide illustrative examples in answer to questions.

Unit 230 Software for embedded systems

Outcome 2 Understand the division of hardware/software in embedded systems

Knowledge requirements
The candidate knows how to:

1 determine the division of functionality between hardware/firmware/software components and assess the trade-offs

2 explain the principles of fault tolerance in embedded systems

3 explain real-time software systems in terms of

- a definition s
- b system model
- c types of hard and soft systems

4 understand the problems of concurrency including

- a mutual exclusion and deadlock
- b conditions for avoidance of the above
- c process management
- d different approaches to concurrency
  - i shared memory
  - ii semaphores
  - iii monitors
  - iv task mechanisms

5 understand interprocess communication

- a close coupled systems
- b distributed systems

6 understand scheduling and allocation of priorities to task/processes

7 apply various scheduling algorithms and dynamic allocation of task/processes and appreciate fault tolerance in real time systems

8 describe functions and features of the hardware/software interface including

- a support to facilitate operating system activity
- b multiprogramming
- c multitasking
- d storage management
- e graphics
- f window systems
- g animation
- h networking
- i multimedia facsimile

9 state the relative advantages and particular configurations of the above including support for compiler building and language translation, execution and debugging

Unit 230 Software for embedded systems

Outcome 3 Explain the fundamental needs of the Human Computer Interface and needs of data capture

Knowledge requirements
The candidate knows how to:

1 describe types of Human Computer Interaction (HCI)
- a menus, icons, forms and graphical user interface (GUI)
- b user characteristics
- c screen design
- d colour
- e accessibility

2 use methods for evaluation of types of HCI, especially for different users
- a novice
- b expert

3 apply different metaphors for user interface design

4 explain data capture
- a input/output
- b analogue data acquisition
- c sampling
- d reconstruction

Unit 230 Software for embedded systems
Outcome 4 Demonstrate quality and management processes

Knowledge requirements
The candidate knows how to:

1 understand the role of software integrated support environments

2 apply computing services management techniques to
- a performance considerations
- b installation
- c security
- d virus protection
- e hacking
- f backup
- g disaster recovery
- h contingency planning
- i management of change
- j system configuration control

3 understand the process of Quality Management including
- a quality systems
- b quality manuals
- c quality plans
- d standards such as
  - i ISO 9000
  - ii TickiT
- e inspection methods
- f auditing
- g measurement and control
- h process assessment including
  - i software process improvement
  - ii capability determination such as
    - A European software development model
    - B SPICE
    - C CMM

Unit 230 Software for embedded systems

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Embedded Microprocessor Systems	Ball	Newnes	075067234X
Embedded Systems Design	Berger	Osborne McGraw-Hill	1578200733
Languages for Digital Embedded Systems	Edwards	Kluwer Academic Pub	079237925X
Lectures on Embedded Systems	Rozenberg, Vaandrager	Springer-Verlag Berlin	3540651934
Real-Time Systems and Programming Languages	Burns	Addison Wesley	0201729881
Real-Time Systems Design and Analysis	Laplante	John Wiley	0780334000
Software Process Improvement	Haug, Olsen, Bergman	Springer-Verlag Berlin	3540417877
Software Process Improvement: Concepts and Practices	McGuire	Idea Group Publishing	1878289543

Unit 231 Computer systems engineering

Due to errors in the Learning outcome format of this syllabus, it has been removed and replaced with this old style syllabus. The examination for 2007 will be set to a new unit which will fully reflect this syllabus below. We apologise for any inconvenience caused but since the previous unit was only posted on the website in July 2007 we do not anticipate this change effecting candidates adversely.

AIMS

To provide the student with the necessary knowledge and skills to design processor based computer systems.

To appreciate the effect of a processor's architecture on the performance of a system.

PREREQUISITES

Candidates will be expected to be familiar with the relevant Certificate examination topics.

OUTCOMES

A student should be able to:

1. undertake digital processor based design with the appropriate interfaces.
2. select suitable logic chips, architectures, languages and tools.
3. understand the effect the components of a system have on its overall performance

SYLLABUS

The Processor

Load and store architecture, the use of a stack for arithmetic expressions, subroutine and interrupt handling

Zero, single and multiple address architectures, addressing modes including, but not limited to, immediate, relative, direct and indirect , pointer based addressing

Instruction formats: zero, single and multiple address instructions

Reduced Instruction Set Computer (RISC) versus Complex Instruction Set Computer (CISC)

Computer Arithmetic

Floating point numbers and arithmetic: IEEE floating-point format, underflow, overflow, rounding, and truncation errors

Twos complement numbers, arithmetic and circuits: Adders (ripple, carry look ahead, carry save), subtractors, multipliers, dividers

Combinational and Sequential Circuits

Analysis and design of, for example, counters, multiplexers, comparators, decoders, priority encoders, shift registers

Analysis and design of sequential logic using finite state machines.

Timing and Control

Hardwired and microprogrammed control, status bits and their use in program control

Instruction cycle phases and timing diagrams

Dealing with interrupts and exceptions

High Performance Techniques

Pipeline principles, problems and solutions, including data hazards and stalling, branch hazards and exceptions.

Pipelining for RISC and CISC architectures

Superscalar systems and dynamic pipelining

Parallel functional units, memory interleaving

Cache memories

Instruction level parallelism

Multiprocessor systems and associated problems: including consideration of speed versus number of processors issues, inter-processor communication issues

Memory Organisation

Characteristics and use of different memory types

Single and multi-level cache memory – including reference to direct-mapped, set associative and fully associative placement

Static RAM, DRAM, ROM, optical memory, disc, tape

Timing cycle for RAM and ROM

Memory hierarchy and memory management

Virtual memory and addressing

Input-Output Interfacing

Interface considerations: synchronous and asynchronous communication, handshaking, serial and parallel interfaces

Program controlled input/output, interrupt controlled input/output, including hardware for handling interrupts

Hardware and timing for Direct Memory Access (DMA)

Input-Output Processors

Designing an I/O system

Design Options

Fixed function off-the shelf devices, logic families for example CMOS.

Clock speed issues

Programmable devices: characteristics and use of PLAs, PALs, PROMs, Field Programmable Gate-Arrays (FPGAs), standard cells.

Complex devices: microprocessors, memories, peripheral interfaces. Application Specific Integrated Circuits (ASICs).

Design Methodology

Need for hierarchical design methodology: behavioural, structural and physical levels.

Design synthesis

Design capture tools: hardware description languages (for example Verilog, VHDL), schematic capture.

Testing strategies

ASSESSMENT

Assessment will comprise of the following elements:

- a three-hour written examination designed to test the theoretical content specified in each unit outcome

Unit 231 Computer systems engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Computer Organization and Design:The Hardware/Software Interface	Patterson, Hennessy	Morgan Kaufmann	1558606041
Computer System Architecture	Morris Mano	Prentice Hall	0131757385
Logic and Computer Design Fundamentals Xilinx Student Edition 4.2 Package	Morris Mano, Kime	Prentice Hall	0131247891
Principles of Digital Design	Gajski	Pearson Education	0132423979

Unit 300 Advanced engineering analysis

Unit summary

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

Aims

The unit aims to enable the candidate to apply analytical techniques to engineering systems design and problem solving.

Prerequisites

It is expected that candidates will have competence in mathematics at a level exemplified by the Graduate Diploma syllabus 9107-224 Advanced mathematical techniques for engineering applications or equivalent.

Learning outcomes

There are **four** outcomes to this unit. The candidate will be able to:

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

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

No Key Skills were identified for this unit.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.2.1 Identify and define areas of research
1.3.2 Evaluate the results of research
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.2.2 Solve production problems with engineering solutions
2.3.2 Evaluate the production process
3.2.2 Solve installation problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.2.2 Solve operational problems with engineering solutions
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 300 Advanced engineering analysis

Outcome 1 Solve engineering problems by applying partial differential equations

Knowledge requirements
The candidate knows how to:

1 apply partial differential equations in civil, electrical and mechanical engineering systems

2 classify partial differential equations as parabolic, hyperbolic or elliptical

3 identify Cartesian, cylindrical and spherical co-ordinate forms

4 apply analytic solution methods using trial functions, separation of variables (including Bessel and Legendre functions as appropriate), Laplace and Fourier transforms

5 use finite-difference methods to solve partial differential equations

- a approximation of derivatives
- b explicit and Crank-Nicholson implicit methods
- c numerical stability

6 apply methods for solving linear equations resulting from finite-difference methods

- a direct solution, including Cramer's rule and Gaussian elimination
- b iterative methods, including relaxation and Gauss-Seidel methods

7 solve problems using the method of lines

8 use the method of characteristics for hyperbolic equations

9 use the finite-element method at an introductory level

Unit 300 Advanced engineering analysis

Outcome 2 Apply optimisation techniques to engineering-problem solving

Knowledge requirements
The candidate knows how to:

1 describe the characteristics of functions used in optimisation including combinatorial, unimodal and multi-modal functions, single-variable and multi-variable functions, functions with constraints, local and global extremes of functions

2 formulate and solve constrained optimisation problems by the simplex method of linear programming

3 use Fibonacci, golden section and Brent's single-variable search methods to solve optimisation problems

4 apply multi-variable methods to optimisation problems using gradient methods

- a steepest descent
- b conjugate gradient
- c Newton's variable metric techniques

5 apply the penalty-function method, complex method of Box and the Kuhn-Tucker conditions to functions with inequality constraints

6 solve optimisation problems by heuristic search methods, random-number generation and objective functions

7 apply the simulated-annealing method to combinatorial and continuous variable problems

8 apply genetic algorithms, coding, reproduction and cross-over mutation to solve optimisation problems

Unit 300 Advanced engineering analysis

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

Knowledge requirements
The candidate knows how to:

1 describe the role of random processes in the testing and analysis of engineering systems

2 recognize the engineering applications of random processes in random vibrations, electrical circuits and communications

3 derive the principal functions used to characterise random processes and the dynamic response of engineering systems

4 recognise the characteristics of random processes including stationary and non-stationary processes, ergodic processes, probability distributions for single and multiple random variables, auto- and cross-correlation functions, spectral and cross-spectral density

5 determine the response of engineering systems to stochastic inputs

6 recognise white noise, wide-band, narrow-band, Gaussian and pseudo-random binary signal (PRBS) noise sources

7 describe the dynamic characteristics of linear systems using impulse-response functions, convolution integral and frequency response-functions

8 explain the operation of fast Fourier transform algorithms

9 describe random input-output relationships for linear systems, power spectra and cross-spectra for single-input and two-input systems, coherence functions

10 describe and compare analogue and digital methods of spectral-density measurement

11 undertake digital spectral analysis in signal sampling, aliasing, data windows, spectral leakage, frequency smoothing and fast Fourier transform

12 use fast Fourier transform for power spectra estimates

13 apply the techniques to data filtering and system identification problems

Unit 300 Advanced engineering analysis

Outcome 4 Use statistical analysis to solve engineering problems

Knowledge requirements
The candidate knows how to:

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

Unit 300 Advanced engineering analysis

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Advanced Engineering Mathematics - Section A	Kreyszig	John Wiley and Sons	047133328X
Advanced Engineering Mathematics	James	Addison-Wesley	201565196
Advanced Engineering Mathematics	Kreyszig	John Wiley and Sons	947133328X
Advanced Modern Engineering Mathematics	James	Addison Wesley	0201565196
Fourier Series and Boundary Value Problems	Brown	McGraw-Hill Education	0072325704
Numerical Methods for Mathematics, Science and Engineering	Mathews	Prentice Hall	0136249906
Numerical Methods for Partial Differential Equations	Ames	Nelson	0120567601
Schaum's Outline of Partial Differential Equations	Duchateau	McGraw-Hill Education	0070178976
Advanced Engineering Mathematics - Section B	Kreyszig	John Wiley and Sons	047133328X
Advanced Modern Engineering Mathematics	James	Addison Wesley	0201565196
An Introduction to Genetic Algorithms for Scientists and Engineers	Coley	World Scientific	9810236026
Applied Statistics for Engineers and Scientists	Devore, Farnum	Brooks/Cole. Pacific Grove USA	053435601X
Statistical Methods for SPC and TQM	Bissell	Chapman and Hall	0412394405
MINITAB statistical software	MINITAB	The Pennsylvania State University, U.S.A.	
Reliability and Risk Assessment	Andrews, Moss	Longman Scientific and Technical, Harlow. U.K	0582096154
Engineering, Quality, and Experimental Design	Grove, Davis	Longman Scientific and Technical, Harlow. U.K	0582066875
Other useful texts			
Basic Optimisation Methods	Bunday	Hodder Arnold	0713135069

Numerical Methods for Mathematics, Science and Engineering	Mathews	Prentice Hall	0136249906
Operations Research: An Introduction	Taha	Prentice Hall	0131876597
Analogue and Digital Signal Processing - Section C	Baher	John Wiley and Sons	0471923427
Detection of Signals in Noise	McDonough, Whalen	Academic Press	0127448527
Digital Signal Processing: Concepts and Applications	Mulgrew	Palgrave Macmillan	0333963563
Introductory Digital Signal Processing with Computer Applications	Lynn, Fuerst	John Wiley and Sons	0471976318
Probabilistic Methods of Signal and System Analysis	Cooper, McGillen	Oxford University Press	0195123549
Applied Statistics for Engineers and Physical Scientists. (2nd Ed.)	Hogg, Ledolter	Macmillan, New York	0029461324, 0023557907
Applied Life Data Analysis	Nelson	John Wiley & Sons. New York	0471094587
Accelerated Testing Statistical Models, Test Plans and Data Analyses	Nelson	John Wiley & Sons. New York	0471522775
Systems Reliability - Evaluation and Prediction in Engineering	Pages, Gondran	North Oxford, London	094653621X

Unit 301 The analysis of compressible fluid flow

Unit summary
This unit is about the analysis of compressible fluid flow. It includes one, two and three-dimensional flow for subsonic and supersonic situations.

Aim
To provide the candidate with advanced knowledge and understanding of the behaviour of compressible fluid motion.

Prerequisites
It is anticipated that candidates will have successfully completed units in Applied thermodynamics and The analysis of the mechanics of fluids at the Certificate and Graduate Diploma level or equivalent.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:
- Understand and apply the working relationships involved in one-dimensional flow
- Understand and apply the working relationships involved in two and three-dimensional flow
- Understand and apply the working relationships involved in unsteady one-dimensional flow
- Understand and apply the working relationships involved in real gas flow in the presence of heat transfer and viscosity

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
No Key Skills were identified for this unit.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.2.1 Identify and define areas of research
1.3.2 Evaluate the results of research
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.2.2 Solve production problems with engineering solutions
2.3.2 Evaluate the production process
3.2.2 Solve installation problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.2.2 Solve operational problems with engineering solutions
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 301 The analysis of compressible fluid flow

Outcome 1 Understand and apply the working relationships involved in one-dimensional flow

Knowledge requirements
The candidate knows how to:

1 recognise the general features and applications of isentropic flow for a perfect gas

2 analyse nozzle flows with and without choking for varying pressure ratios and low Mach number flows

3 recognise the general features of adiabatic flow of a perfect gas

4 identify deviations from the perfect gas laws and flows in real nozzles

5 recognise the features and governing relations of a normal shock, shock wave formation, thickness and movement

6 determine the features and governing relationships of a normal shock in ducts, converging-diverging nozzle characteristics, supersonic diffusers and supersonicpitot tubes

7 recognise adiabatic flow of a perfect gas in a constant area duct

8 analyse isothermal flow in long ducts and flow at various pressure ratios

9 apply friction coefficients to gas flow situations

10 recognise stagnation pressure and temperature and the change of stagnation temperature with heat transfer

11 solve problems involving recovery factor, coefficient of heat transfer and shock waves with changes of stagnation temperature

12 solve problems involving flow with

- a combined friction and area change
- b combined friction and heat transfer

Unit 301 The analysis of compressible fluid flow

Outcome 2 Understand and apply the working relationships involved in two and three-dimensional flow

Knowledge requirements
The candidate knows how to:

1 use the equations of motion for irrotational flow

2 recognise the links between continuity, rotation, thermodynamic properties of a fluid and the laws of thermodynamics

3 recognise the interrelationship between velocity potential and stream function

4 solve problems involving two-dimensional subsonic flow with small perturbations including
   - a linearisation of the pressure coefficient and the potential equation
   - b flow inside two-dimensional passages and wind tunnel corrections
   - c the effects of compressibility

5 solve problems involving three-dimensional subsonic flow with small perturbations including
   - a flow past bodies of revolution, spheres and ellipsoids
   - b flow past
     - i wings of finite span
     - ii swept-back wings
     - iii swept-back wings of finite span

6 solve problems involving two-dimensional supersonic flow with small perturbations including
   - a linearisation of the equations of motion
   - b flow past
     - i wave-shaped walls
     - ii supersonic aerofoils

7 solve problems involving the reflection and intersection of waves

8 apply the method of characteristics to
   - a two-dimensional supersonic flow
   - b the design of supersonic wind tunnel nozzles

9 analyse adiabatic, non-viscous flow with rotation

10 derive the oblique shock equations

11 analyse the geometry and special features of oblique shocks applied to
   - a reflection and interaction of shocks
   - b curved shocks
   - c two-dimensional flow profiles
   - d interaction of shocks with boundary layers

12 describe axially-symmetric supersonic flow and flow over wings of finite span

13 describe and develop the features of hypersonic flow using
   a the similarity laws
   b oblique-shock and simple-wave relations
14 determine the performance of two-dimensional profiles and bodies of revolution
15 describe and develop the features of transonic flow using the similarity laws
16 analyse transonic flow
   a in the throat of converging-diverging nozzles
   b over walls and wedges
17 describe the characteristics of transonic flow
   a over wings
   b in terms of drag on bodies of revolution
18 describe detached shocks and their interaction with boundary layers

Unit 301 The analysis of compressible fluid flow

Outcome 3 Understand and apply the working relationships involved in unsteady one-dimensional flow

Knowledge requirements
The candidate knows how to:

1 extend linearised theory and the method of characteristics to simple waves of small amplitude in the presence of a pressure pulse

2 determine the effects of gradual changes in duct area and boundary conditions

3 analyse moving shocks, weak shocks and the shock tube

4 analyse the interaction between shocks and end conditions

Unit 301 The analysis of compressible fluid flow

Outcome 4 Understand and apply the working relationships involved in real gas flow in the presence of heat transfer and viscosity

Knowledge requirements
The candidate knows how to:

1 analyse the laminar boundary layer using differential and integral equations

2 determine laminar flow conditions when using
   a gases with a Prandtl number of unity
   b gases with arbitrary Prandtl number values

3 explain comparisons between theoretical and experimental results for laminar boundary layer flows

4 determine the stability of a laminar boundary layer

5 analyse the turbulent boundary layer using differential and integral equations

6 determine the effects of turbulent boundary-layer flow over a flat plate in terms of
   a skin friction
   b recovery factor
   c heat transfer

   for gases with a Prandtl number of unity

7 determine turbulent boundary layers on bodies of revolution

8 explain comparisons between theoretical and experimental results for turbulent boundary-layer flows

9 analyse real gas flow in ducts involving
   a shock-boundary layer interactions in supersonic and transonic flows
   b normal shocks
   c boundary layer separation produced by shocks

Unit 301 The analysis of compressible fluid flow

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Fundamentals of Gas Dynamics	Zucker	John Wiley & Sons Inc.	0471059676
Gas Dynamics	Aksel	Prentice Hall	0134977289
Gas Dynamics, theory and applications	George	American Institute of Aeronautics & Astronautics	0930403126
Rarefied Gas Dynamics from basic concepts to actual calculations	Cercignani	Cambridge Uni Press	0521659922
Other useful texts			
The Dynamics and Thermodynamics of Compressable Fluid Flow Vol 1&2	A H Shapiro	Renold Press Company	

Unit 302 Computational mechanics using finite element method

Unit summary

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

Aims

To provide the candidate with a sound foundation in Finite Element Analysis.

Prerequisites

Candidates should have studied Mathematics for engineering to first degree level, or equivalent, incorporating an introduction to numerical methods for the solution of systems of equations. They will normally have previous study experience in courses in Mechanics of solids and/or The analysis of engineering structures.

Learning outcomes

There are **five** outcomes to this unit. The candidate will be able to:

- Apply and solve constitutive equations used in Finite Element Analysis (FEA)
- Apply strain-displacement formulations used in Finite Element Analysis
- Define material behaviour within Finite Element Analysis
- Apply solution algorithms and interpret results
- Analyse special case applications

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

No Key Skills were identified for this unit.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.4 Evaluate designs for engineering products or processes
2.2.2 Solve production problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.2.2 Solve operational problems with engineering solutions
6.2.1 Assure the quality of engineering products or processes
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 302 Computational mechanics using finite element method

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

Knowledge requirements
The candidate knows how to:

1 formulate strain displacement relationships, shape functions and element stiffness matrices

2 apply local-global co-ordinate transformations

3 apply boundary conditions, constraints and loads

4 define equivalent nodal forces for

- a body forces
- b concentrated loads
- c distributed loads
- d thermal loads

5 form global stiffness matrix and load vectors

Unit 302 Computational mechanics using finite element method

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

Knowledge requirements
The candidate knows how to:

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

Unit 302 Computational mechanics using finite element method

Outcome 3 Define material behaviour within Finite Element Analysis

Knowledge requirements
The candidate knows how to:

1 recognise degrees of material behaviour
   - a isotropic
   - b transversely isotropic
   - c orthotropic
   - d fully anisotropic

2 define material behaviour using
   - a Young's moduli
   - b shear moduli
   - c Poisson's ratios
   - d thermal expansion coefficients

3 define various types of non-linear materials
   - a elasto-plastic
   - b Drucker-Prager
   - c foam
   - d rubber
   - e soil

Unit 302 Computational mechanics using finite element method

Outcome 4 Apply solution algorithms and interpret results

Knowledge requirements
The candidate knows how to:

1 solve linear and non-linear systems using
  - a Gaussian Elimination Gauss-Seidel iteration relaxation techniques
  - b Gauss-Seidel iteration
  - c Relaxation techniques

2 recognise
  - a banded storage
  - b sykline storage
  - c frontal solvers
  - d effects of nodal and element numbering

3 determine convergence and completeness requirements

4 determine inter-element compatibility using the patch test

5 interpret the quality of results using
  - a element quality test
  - b discretisation error
  - c global measures of error
  - d h-refinement
  - e p-refinement

Unit 302 Computational mechanics using finite element method

Outcome 5 Analyse special case applications

Knowledge requirements
The candidate knows how to:

1 analyse special case applications

- a axisymmetric
- b plane stress
- c plane strain
- d dynamic
- e thermal

Unit 302 Computational mechanics using finite element method

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Finite Element Modelling for Stress Analysis	Cook RD	John Wiley & Sons Inc	0471107743
Finite Elements in Solids and Structure	Astley RJ	Kluwer Academic	0412441608
An Introductory Guide to Finite Element Analysis	Becker AA	Professional Engineering	1860584101
Introduction to Finite Elements in Engineering	Chandrupatla TR, Belegundu AD	Prentice Hall	0131784536
The Finite Element Method, A Practical Course	Liu GR, Quek SS	Butterworth Heinemann	0750658665
Other useful texts			
Solutions Manual for the Analytical Problems	Cook RD	John Wiley & Sons Inc	0471111473
Applied Numerical Analysis	Gerald CF, Wheatley PO	Addison-Wesley	0201474352

Unit 303 Telecommunications engineering

Unit summary
This unit is about engineering communication systems problems and their engineering solutions. It is also about the promise and probable limitations of evolving communication technologies.

Aim
The unit aims to enable the candidate to analyse, compare and utilise communication systems in order to meet specifications.

Prerequisites
It is expected that candidates will have a working knowledge of the principles of telecommunications systems engineering as exemplified by the Graduate Diploma subject 9107-219 Telecommunication systems engineering.

Learning outcomes
There are **five** outcomes to this unit. The candidate will be able to:

- Analyse switching and transmission systems
- Compare quantitatively methods of coding
- Utilise optical communication design principles
- Understand key constraints in mobile communications
- Utilise satellite communication design principles

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
No Key Skills were identified for this unit.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.2.2 Solve production problems with engineering solutions
2.3.1 Monitor the production process
2.3.2 Evaluate the production process
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.2.2 Solve operational problems with engineering solutions
4.3.2 Evaluate operational processes
5.1.1 Determine the maintenance requirements of engineering products or procedures
5.3.2 Evaluate maintenance processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

Unit 303 Telecommunications engineering

Outcome 1 Analyse switching and transmission systems

Knowledge requirements
The candidate knows how to:

1 analyse and investigate time and space switch problems

2 understand the principles of operation of digital telephone exchanges

3 analyse routing systems

   a permanent circuits

   b virtual circuits

4 design alternative routing systems

5 utilise traffic theory including Erlang's model

6 understand the causes of system congestion

7 analyse and rectify distortion and interference

   a SQNR

   b delay distortion

   c aliasing

   d inter-symbol interference

8 compute bandwith and implement filtering techniques

Unit 303 Telecommunications engineering
Outcome 2 Compare quantitatively methods of coding

Knowledge requirements
The candidate knows how to:

1. process sound, picture and multi-media data
2. instigate bandwidth reduction techniques
3. determine spectral and power efficiency
   a. PSK
   b. FSK
   c. QPSK
   d. spectra
4. determine binary error rates
5. operate demodulation techniques

Unit 303 Telecommunications engineering
Outcome 3 Utilise optical communication design principles

Knowledge requirements
The candidate knows how to:

1. evaluate propagation in optical fibres
   a. dispersion
   b. attenuation
2. determine optimum wavelengths in optical fibres
3. analyse the benefits and limitations of transmitters, LED's and lasers
4. check the function of
   a. detectors
   b. PINS
   c. avalanche diodes
5. determine noise, impulse and frequency responses
6. determine bandwidth in optical communication systems
7. implement WDM-modulation for multi-channel use.

Unit 303 Telecommunications engineering

Outcome 4 Understand key constraints in mobile communications

Knowledge requirements
The candidate knows how to:

1 recognise the implications of service requirements on system design

2 determine present and future targets

3 determine cell and cluster sizes

4 express the multipath problem

5 analyse modulation, speech and channel coding for

   a GSM systems

   b 3G systems

   c UMTS systems

6 manipulate data and appreciate network layer principles of

   a GSM systems

   b UMTS systems

Unit 303 Telecommunications engineering

Outcome 5 Utilise satellite communication design principles

Knowledge requirements
The candidate knows how to:

1 analyse satellite orbits, look angles and coverage

2 analyse transponder and earth station design

3 analyse propagation and link budgets

4 assess digital transmission, modulation and multiple access

5 recognise mobile radio applications of satellite systems

6 recognise broadband applications of satellite systems

Unit 303 Telecommunications engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Digital Communication	Glover, Grant	Prentice Hall	0130893994
Other useful texts			
Introduction to the Wireless Loop	Webb W	Artech House	1580530710
Networks and Telecommunications	Clark MP	John Wiley	0471973467
Telecommunication Engineering	Dunlop J, Smith DG	Chapman Hall	0412562707
Digital Communications	Proakis	McGraw-Hill Education	0072321113
Digital Communication	Sklar	Prentice Hall	0130847887
Introduction to Communication Systems	Stremler	Addison Wesley	0201516519
Mobile Wireless Communications	Schwartz	Cambridge University Press	0521843472

Unit 304 The technology of advanced manufacturing processes

Unit summary

This unit is about recently developed modern manufacturing technologies and processes.

Aims

To provide the candidate with the knowledge and understanding required in the integration of the design of a product, its manufacture and associated commercial considerations. The candidate will be able to choose the most appropriate technology for a manufacturing system.

Prerequisites

It is expected that candidates will have a suitable knowledge of engineering materials, manufacturing processes and CNC techniques consistent with successful completion of the Graduate Diploma examination subject 9107-226 The technology of manufacturing processes.

Learning outcomes

There are **four** outcomes to this unit. The candidate will be able to:

- Assess product design for most suitable manufacturing processes
- Apply modern technologies to the manufacture of products
- Determine process parameters for given conditions
- Apply modern manufacturing strategies in various industries

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

KS5.1
Explore the demands of the work and formulate viable proposals for meeting these demands.

KS5.2
Plan to manage the work, and meet your own skill-development needs, and gain the necessary commitment from others.

KS5.3
Manage the work, adapting your strategy as necessary to resolve at least **two** complex problems and achieve the quality of outcomes required. Formally review, with an appropriate person, your use of skills in:

- communication;
- problem solving;
- working with others.

KS5.4
Evaluate your overall performance and present the outcomes, including at least:

- **one** formal, oral presentation of the outcomes from the work;
- **one** written evaluation of your overall approach and
- application of skills.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
2.1.4 Schedule production activities to implement the production methods and procedures
2.2.1 Implement production methods and procedures
2.2.2 Solve production problems with engineering solutions
2.3.1 Monitor the production process
2.3.2 Evaluate the production process
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
3.1.4 Schedule installation activities to implement the installation methods and procedures
3.2.1 Implement installation methods and procedures
3.2.2 Solve installation problems with engineering solutions
3.3.1 Monitor the installation process
3.4.2 Configure engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.1.3 Schedule operational activities to implement the operational methods and procedures
4.2.2 Solve operational problems with engineering solutions
4.3.2 Evaluate operational processes
5.1.1 Determine the maintenance requirements of engineering products or procedures
5.1.2 Specify maintenance methods and procedures to achieve maintenance requirements
5.1.3 Schedule maintenance activities to implement the maintenance methods and procedures
5.2.2 Solve maintenance problems with engineering solutions
5.3.2 Evaluate maintenance processes
6.1.1 Analyse the risks arising from engineering products and processes
6.1.2 Specify methods and procedures to reduce risks
6.2.1 Assure the quality of engineering products or processes
6.2.2 Identify the reasons for quality assurance problems
6.2.3 Implement improvements to the quality of engineering products or processes
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 304 The technology of advanced manufacturing processes

Outcome 1 Assess product design for most suitable manufacturing processes

Knowledge requirements
The candidate knows how to:

1 assess the implication of design on

 a traditional manufacturing methods

 b modern advanced manufacturing methods

2 correlate the interrelationship between design, component manufacture and product assembly

3 analyse production machining systems

4 analyse constraints affecting system performance

5 determine and analyse manufacturing systems operating parameters

6 assess performance, accuracy and quality requirements

Unit 304 The technology of advanced manufacturing processes

Outcome 2 Apply modern technologies to the manufacture of products

Knowledge requirements
The candidate knows how to:

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

Unit 304 The technology of advanced manufacturing processes

Outcome 3 Determine process parameters for given conditions

Knowledge requirements
The candidate knows how to:

1. assess the performance of high-speed machining techniques with regard to
   - a material removal rate
   - b surface finish requirements
   - c accuracy
   - d economic considerations
2. assess the effect of tool manufacture, materials and coatings on
   - a performance
   - b tool life
   - c component quality
3. determine optimum cutting tool performance in high precision machining techniques
   - a micro-machining
   - b three and five axis machining
   - c "single-hit" machining
4. integrate machining techniques for increased production flexibility
5. assess and apply industrial lasers technology
   - a cutting
   - b welding
   - c surface treatments
   - d in-process sensing systems
   - e automation
6. assess the influence of machining systems on the accuracy and surface generation of components (metrology) using
   - a in-line and off-line measurements
   - b contact and non-contact technologies
   - c co-ordinate measuring systems

Unit 304 The technology of advanced manufacturing processes

Outcome 4 Apply modern manufacturing strategies in various industries

Knowledge requirements
The candidate knows how to:

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

Unit 304 The technology of advanced manufacturing processes

Recommended reading list

Core text	Author(s)	Publisher	ISBN
Implementing Six Sigma: Smarter Solutions Using Statistical Methods	Breyfogle	John Wiley & Sons Inc	0471265721
Automation, Production Systems and Computer Integrated Manufacturing	Groover	US Imports & PHIPEs	0130546100
Design for Manufacturing and Assembly: Concepts, Architectures and Kluwer Academic Publishers		Chapman, Hall	0412781905
Laser Metrology and Machine Performance: VI	Ford, DG	WIT Press	1853129909
Materials and Processes in Manufacturing	DeGarmo	John Wiley	0471429449
Metal Cutting and High Speed Machining	Dudzinski, Molinari	Schulz Kluwer Academic/Plenum	0306467259
Product Design for Manufacture and Assembly	Boothroyd, Dewhurst, Knight	Marcel Dekker	082470584X
Rapid Manufacturing: The Technologies and Applications of Rapid	Pham, Dimov	Springer-Verlag UK	185233360X
Rapid Prototyping and Manufacturing: Fundamentals of Stereo Lithography Jacobs, P Society of	Jacobs	Society of Manufacturing Engineers	0872634256
Laser Material Processing	Steen	Springer-Verlag Berlin	o/p
Statistical Process Control: A Practical Guide	Oakland	Butterworth-Heinemann	0434914762 o/p

Unit 305 High performance computer systems engineering

Unit summary
This unit is about current technologies and possible future trends in computer systems engineering.

Aims
To provide the candidate with the knowledge and understanding to appreciate the benefits of high performance parallel computing and its applications in science and engineering. It also aims to equip the candidate with an understanding of special purpose hardware and of the requirements for the reliability, safety and integrity of embedded systems particularly in safety critical applications.

Prerequisites
It is expected that candidates will have a working knowledge of computer systems engineering as exemplified by the Graduate Diploma examination Syllabus 9107-231 Computer systems engineering or a similar syllabus.

Learning outcomes
There are **four** outcomes to this unit. The candidate will be able to:

- Apply parallel computing techniques/systems
- Assess the performance of microprocessors in varying situations
- Chart the development of computer virtual environments
- Understand and operate real-time and embedded systems

Unit 305

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
No Key Skills were identified for this unit.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
3.1.1 Determine the installation requirements for engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
5.1.1 Determine the maintenance requirements of engineering products or procedures
6.2.1 Assure the quality of engineering products or processes
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 305 High performance computer systems engineering

Outcome 1 Apply parallel computing techniques/systems

Knowledge requirements
The candidate knows how to:

1 relate the motivation for high performance and parallelism to
- a application areas
- b relevant technologies

2 function at abstraction levels
- a models of computation
- b overheads
- c multiple program counters
- d multi-threaded execution models

3 use
- a parallel languages and compilers
- b task-parallel programming models
- c data-parallel programming models

4 present experimentation results

5 evaluate memory architecture, memory access times and associated overheads

6 instigate performance turning

7 restructure for parallel performance
- a parallelising compilers
- b loop and data transformations

8 apply parallel algorithms
- a cyclic reduction
- b iterative and divide-and-conquer algorithms
- c adaptive quadrature
- d correct termination

9 investigate state of the art research and anticipate future directions

Unit 305 High performance computer systems engineering

Outcome 2 Assess the performance of microprocessors in varying situations

Knowledge requirements
The candidate knows how to:

1 investigate computer trends in technology with regard to
 a usage and costs
 b performance
 c benchmarks and benchmarking in respect to
  i advances pipelining
  ii dynamic scheduling
  iii data hazards
  iv static and dynamic branch prediction
  v zero-cycle branches
  vi multiple issue implementations

2 apply scaling and be conversant with scalability

3 implement superscalar compilation

4 recognise future technological implications, the market place and requirements for
 a mobile coding
 b JAVA implications
 c JIT compilation
 d dynamic optimisation

5 recognise and investigate the applications of digital signal processors in
 a communications
 b mobile phone developments
 c mobile computing
 d GPS

6 assess the role of microcontrollers in dedicated applications in
 a industry
 b commerce
 c the home

7 investigate processors for

   a image processing
   b graphics and animation
   c vision systems
   d neural networks
   e robotics
   f simulations

8 assess hardware in order to support fault tolerant computing

9 analyse concurrency and its implications for computer systems architecture

10 apply synchronisation methods

11 recognise the role of asynchronous processors for

   a high performance applications
   b low power applications

12 apply the ARM processor three and five stage pipelines and integer processor cores to specific and general cases

13 utilise architectural extensions for

   a floating point
   b DSP

14 manage memory hierarchy

15 analyse system-on-a-chip development

Unit 305 High performance computer systems engineering

Outcome 3 Chart the development of computer virtual environments

Knowledge requirements
The candidate knows how to:

1 trace the history and produce an overview of virtual environments
2 analyse 2D and volume virtual environments using reference models
3 analyse flow virtual environments
4 employ graphics hardware and software
5 interpolate and approximate
6 use systems utilising visual perception and colour
7 utilise basic and modal interaction
8 use and manage multidimensional data
9 assess virtual environments systems
10 assess animation systems
11 assess remove virtual environments
12 use advances user interfaces

Unit 305 High performance computer systems engineering

Outcome 4 Understand and operate real-time and embedded systems

Knowledge requirements
The candidate knows how to:

1 implement real-time and embedded systems

2 operate interface systems for complex industrial applications

  a timers and counters

  b signal multiplexing

3 operate mixed analog and digital systems

4 determine advanced sampling and data reconstructions

5 analyse real-time operating system kernels

6 manage

  a interupt task

  b clock task

  c base level task

7 determine exceptions and exception handling and develop techniques for managing overload under fault conditions

8 use

  a fail-soft techniques

  b high integrity systems

9 assess standards for safety critical systems

Unit 305 High performance computer systems engineering

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
3D Computer Graphics	Watt	Addison Wesley	0201398559
ARM System-on-Chip Architecture	Furber	Addison Wesley	0201675196
Asynchronous Circuit Design	Myers	John Wiley & Sons Inc	047141543X
Asynchronous Digital Circuit Design	Birtwhistle, Davis	Springer-Verlag Berlin	3540199012
Computer Architecture: A Quantitative Approach	Hennessy, Patterson	Morgan Kaufmann	1558603298
Image Processing, Analysis and Machine Vision	Sonka et al	PWS Publishing	053495393x
Mobile Robotics: A Practical Introduction	Springer-Verlag UK	Springer-Verlag UK	1852331739
Multiprocessor Methods for Computer Graphics Rendering	Whitman	Jones and Bartlett	0867202297
Parallel Computer Architecture: A Hardware/Software Approach	Culler, Singh, Gupta	Morgan Kaufmann	1558603433
Scientific Visualisation, Advances and Challenges	Rosenbaum et al	IEEE Society Press & Academic Press This title is only available through IEEE directly	

Unit 305 High performance computer systems engineering

1 Rules for the Postgraduate Diploma group project unit

The project on which a report is to be submitted should satisfy aspects a) to g) in the Guidelines.

1.1 Approval for entry

A candidate must be registered as a Postgraduate Diploma candidate following submission of the registration form.

Entry must be made on the project proposal form, which may be obtained from the Engineering Council examinations department. The applicant must complete this form with an outline description of the objective of the project, the sequence of work to be undertaken and how aspects a) to g) in the guidelines are to be satisfied and the work of the candidate in the project team. This outline must not exceed 500 words.

The completed project proposal form must reach the above department at least 8 months before the intended date of submission of the full report. Engineering Council examinations department will notify candidates of the acceptance or otherwise of the proposal within three months of receipt of the outline description. If the proposal is rejected, a short summary of the reasons will be given and a candidate will have the opportunity to submit a revised proposal.

The submission of a completed project proposal form is the candidate's acknowledgement that the examination rules have been read and understood.

1.2 The report

The report on the project must be submitted in the English language. It must be typewritten on A4 size white paper and securely bound in a folder. The report must not exceed 40 pages excluding drawings, tables, computer output and appendices. Every page of the submission must be numbered and signed by the candidate as certification that it is his/her own work. No computer discs etc should be submitted with the Report.

Engineering Council examinations department will refuse to consider reports, which exceed the specified length, or reports which are considered to be illegible or ineligible for any other reason.

The candidate must ensure that he/she has the permission of his/her employer to submit the report where this is appropriate. Engineering Council examinations department will not consider reports, which are marked confidential and cannot undertake to maintain confidentiality of the report.

All material on submission becomes and will remain the property of the Engineering Council examinations department. No arrangements can be made for the return of any material submitted.

1.3 Submission of the report

The final report on the project must be submitted to this department within two years of the candidate's proposal being approved.

The report must be accompanied by the completed official certifying form which confirms which work has been undertaken by the candidate and that he/she alone is responsible

for the report. The supervisor of the project must countersign this form. This can be the Head of department of the educational establishment which the candidate has attended or, if the candidate is working in industry and the report is on an industry-based project, by a Chartered Engineer of a UK institution, or a corporate member of the professional engineering institution of the country of residence.

The candidate must accept responsibility for the submission of the report to the Engineering Council examinations department. Candidates must therefore use appropriate security of transport at their own expense.

1.4 Assessment of the report

Engineering Council examinations department reserves the right to require a candidate to attend an oral examination.

Engineering Councils examinations department will notify candidates of the acceptance or otherwise of the project report within four months of receipt of the document.

Unsuccessful candidates will be given brief reasons for the failure.

The decisions of the Engineering Council examinations Committee are final. No correspondence will be entered into regarding the results of the assessment.

1.5 Resubmission

Candidates will be permitted to make a resubmission of their project proposal within twelve months of their previous project proposal not being accepted.

Candidates will be permitted to make a resubmission of their project report within twelve months of their previous project report not being accepted.

Candidates will not be permitted any extension of this time.

Candidates who wish to submit a new report on a different topic must complete and submit a fresh project proposal.

Details of the entry fee will be sent with the appropriate entry form.

If a candidate's initial project proposal is rejected, part of the fee less an administrative charge will be refunded if the candidate decides not to continue with the project report unit.

1.6 Guidance

This document assumes that the rules have been read and understood.

The following paragraphs give useful guidance to candidates in their application, preparation and submission for Postgraduate Diploma project unit. In all instances the published rules take precedence over any statement in this section.

All the information required by the project proposal form must be given but within the limitations imposed by the rules.

The scope of the engineering disciplines is extremely wide. For the purpose of assessing projects, the scope has been divided into six broad groups:

A. Civil and Structural Engineering
B. Electrical and Electronic Engineering
C. Mechanical and Production Engineering
D. Process Engineering
E. Transport Engineering
F. Information Systems Engineering

An applicant must indicate clearly on the proposal form the particular and most appropriate group in which the proposed project should be assessed.

In formulating a project proposal, an applicant may wish to select some of the following headings. The list is not exhaustive nor necessarily in any meaningful order.

- Objectives
- Method or Approach
- Outcome
- Validation
- Problems
- Safety
- Environmental Aspects
- Economic Aspects
- Quality centred techniques and procedures.

When the examiner approval of the outline description of the objective of the project and the work to be undertaken, it is done only in the sense that it is agreeing that the work proposed, when undertaken under competent supervision, may provide suitable material for the submission of a project report.

No responsibility can be accepted for supervision of the work to be undertaken.

The rules state:

> The project on which a report is to be submitted should satisfy aspects a) to g) in the guidelines.

The report should be written in English and its standard is expected to be similar to that of a project undertaken during the final year of a course leading to a UK accredited MEng degree in an engineering discipline. Close attention will be paid to presentation and to clarity and style of the written work.

The examiner will expect the project report to take account of any comments made at the time of approving the project proposal.

If the project is not the work of a single applicant, the candidate must indicate clearly in the report those parts of the project for which he/she is solely responsible.

It is expected that the majority of projects will be undertaken whilst in employment. In such cases, the candidate must ensure that he has the permission of his employer to submit the report where this is appropriate. Reports marked confidential will not be

accepted. Engineering Council examinations department cannot undertake to maintain confidentiality of the project report.

It is essential in all cases for candidates to obtain the guidance and supervision of a competent person.

It is essential that any experimental work is undertaken in a safe manner, and at all times must follow the precepts of any Health and Safety policy statement of the establishment or organisation in which the candidate is working.

The Report should not exceed a total of 40 pages excluding drawings, tables, computer output and appendices. This restriction on length should not be thought to minimise the importance of this project unit of the Postgraduate Diploma examination; rather it is to encourage conciseness of expression and selective presentation of results.

The arrangement and style of papers published in the technical and scientific literature should be studied. Comparing them with one another will help in deciding both what to avoid and what constitutes a suitable type of presentation, viz. one which adequately and concisely describes the work done and at the same time maintains the interest of the report.

In addition to the requirements for the presentation of the project report, it is suggested that the following recommendations are taken into account:

- a The full name of the candidate, the candidate's enrolment number, the place where the project was undertaken, the date of submission and the title of the project should appear on the outside of the folder as well as on the title page.
- b Identification of the contribution of all people (including their designation) who are involved in the development of the report.
- c A short abstract including a summary of the purpose and results of the work should be submitted on a separate sheet (included in the report but not bound to it).
- d A page listing the contents, with page numbers, should be included and the text should be sectionalised and sub divided wherever this is helpful.
- e A list of the symbols used should be included on page at the end. It is convenient if this is made to fold outwards.
- f All quotations, facts and opinions from published work should be identified by the name of the author and the date of publication. The collected references should be given in alphabetical order of the first named author.
- g In the case of a report including computing material, flow charts and programme listings are expected and it should be shown clearly how the programmes were tested to ensure that they worked correctly.
- h All diagrams must either be A4 size or less or else folded and bound to fit within the limits of the A4 size
- i The report should conclude with a short summary including conclusions.

Candidates will be informed as soon as is practicable, after submission whether their report is satisfactory. Normally the Engineering Council examinations department will expect to the assessment of the report to be completed within four months of its receipt.

1.7 Postgraduate Diploma projects

1.7.1 The guidance on group projects endorsed by the Registration Standards Committee states in paragraph 6 that

Specific aspects that should normally be covered within the group project include the application and integration of:

a Team working skills (but with the individual being responsible for at least one major part of the project
b Multi-disciplinary activities (i.e. across the engineering disciplines)
c Multi-function activities, where possible (i.e. across the business functions, such as finance, legal, etc)
d Project management skills and quality control techniques and procedures
e Written and verbal communication skills (i.e. both to communicate effectively with other project team members and to communicate the results of the project)
f Industrial relevance (i.e. the 'real world' of the discipline)
g Industrial involvement (i.e. a 'real' industrial problem)

In all cases the performance of the individual must be assessed.

And in paragraph 7 that:

Where a matching section is undertaken in industry concurrently with Initial Professional Development, or simply during employment in an engineering environment, it is likely that the Group Project can be undertaken as part of the normal employment tasks. Candidates for the Postgraduate Diploma would fall into these categories.

1.7.2 The Guidance goes on to state that:
Where a project has to be carried out to satisfy the requirements of the Engineering Council Part 3 (Postgraduate Diploma) examination, it is essential that the above seven aspects are still satisfied. However, in this event, the aspects which need to be 'simulated' and those which are 'real' will be different from those described in the previous section (for university based routes). The requirements could be met in the following ways:

1.7.3 It is unlikely that anyone working in industry or commerce will not be working in some form of team. This may be a small or large internal team or may be a self-employed individual working in a 'team' with his/her client. In either case, the team will be 'real' with a real objective and a real customer. The members will have varying experience and the team or project leader will have to develop and use team management and communication skills. The project must have an acceptable amount of engineering content. This situation would satisfy aspects a) to d).

Aspect e) will almost certainly need to be simulated, at least in part. The individual concerned may be the only member of the team who needs to use the project for formal assessment. It will thus be necessary to produce an individual, written project report which will be available for assessment during the Professional Review process, if not before (to complete the requirements for the Postgraduate Diploma).

The report would need to replicate the normal requirements of a university-based project. Firstly, this would be describe and analyse the project aims, design, implementation and results. Secondly, it would analyse the project in terms of its management, quality control and progression; set out the successes and failures and propose alternative improved procedures, etc. Obviously, the report will need to be cleared with the team leader or supervisor of the author.

By definition, a project undertaken in industry should satisfy aspects f) and g).

1.7.4 Since the project reports will be the work of an individual, their assessment will relatively straightforward, following similar procedures to those currently followed for the Part 2 (Graduate Diploma) projects. Supporting documentation and authentication would be available from the Supervisor/employer. Involvement of the nominated body at this stage should be possible.

1.7.5 The RSC has made an explicit statement in the Guidance as to the acceptability of assessed group project work carried out in employment as a replacement for the simulated project in an academic environment. In many cases, the work-based project could be seen to be advantageous.

1.8 Guidance on group projects

(Endorsed by Registration Standards Committee on 4 May 1999)

Introduction

1.8.1 SARTOR 3rd Edition specifies a number of important differences which will exist between an accredited BEng (Hons) course and an accredited MEng course or between an accredited IEng course and an HND course.

1.8.2 These are:

- a Both broader and deeper technical knowledge
- b Broader coverage of non-technical aspects, such as commercial, management, communication, legal, etc.
- c A group project, preferably multi-disciplinary

Each of the above requirements must be presented with industrial relevance.

1.8.3 For an HND or BEng (Hons) graduate, the above aspects have to be completed by the addition of a Matching Section to the prior educational experience. The Matching Section may be achieved totally or partially by means of a formal course in a university or college; by distance learning, such as through the Open University; by Work Based Learning (WBL), assessed during employment; or by a combination of these.

1.8.4 While RSC wishes, as always, to retain variety and flexibility in the routes to Registration, it is necessary to aim for comparable standards. Thus, it is preferable that, whichever of the above routes is to be used, any definition of a Group Project should meet the general requirements and assumptions set out below, both for the Project itself and for demonstrating its industrial relevance.

SARTOR project requirements

1.8.5 The required course content for CEng and IEng degrees is specified in SARTOR 1997 Part 2, CEng Section 4.1.1., paragraph 14 and IEng Section 4.1.2., paragraph 12. Much of the required practical awareness of management issues, leadership, risk analysis, environmental factors, etc., can be gained through a Group Project. Similarly, potential professional engineers are able to demonstrate, while working in a team, the ability to be creative, innovative and adaptable in their problem solving.

1.8.6 Specific aspects that should normally be covered within the Group Project include the application and integration of:

- a Team working skills (but with the individual being responsible for at least one major part of the project)
- b Multi-disciplinary activities (i.e. across the engineering disciplines)
- c Multi-function activities, where possible (i.e. across the business functions, such as finance, legal, etc.)
- d Project management skills and quality control techniques and procedures
- e Written and verbal communication skills (i.e. both to communicate effectively with other project team members and to communicate the results of the project)
- f Industrial relevance (i.e. the ‘real world’ of the discipline)
- g Industrial involvement (i.e. a ‘real’ industrial problem)

In all cases the performance of the individual must be assessed.

1.8.7 Thus, any MEng degree or degree for IEng should satisfy the above requirements. The same will be true in a Matching Section package which must always include a Group Project if the individual's first qualification did not contain one (and see paragraph 8, below). Where a Matching Section is undertaken in industry concurrently with Initial Professional Development, or simply during employment in an engineering environment, it is likely that the Group Project can be undertaken as part of the normal employment tasks.

University-based or College-based projects

1.8.8 The Group Project should always occur after the end of the second year of any full-time CEng course and after the end of the first year for a full-time IEng course (or equivalent position in a part-time course). This requirement is to ensure that the project will be at the correct academic level, building on knowledge and skills already acquired. As, realistically, there is usually not time to carry out a Group Project as well as an individual project in the final year of a BEng (Hons) or HND, the Group Project will normally need to be part of a Matching Section, in these cases. If, however, the Group Project is designed as part of any formal course, the requirements could be met in the following ways:

1.8.9 **Problem** To satisfy items (a) to (d)

Solution Student teams could be established possibly including members from different engineering courses within the Faculty or School and possibly also from business-related courses. The team members will all have approximately the same level of experience, will manage the project themselves and will usually be supervised by an academic staff member. This is thus simulating a real-world project.

1.8.10 **Problem** To satisfy item (e)

Solution Formal project reports and presentations will be required as in any academically based project. Some of the assessment will be of the whole group and some will be of each individual.

1.8.11 **Problem** To satisfy items (f) and (g)

Solution An appropriate project will be defined and/or approved by academic staff and the industrial aspects may need to be simulated by involving selected industrial or commercial organisations and relevant individuals in the specification of the project. A better solution would be to tackle a real industrial problem, with some supervision by and involvement of the company concerned.

1.8.12 **Problem** To provide a robust system of individual assessment.

Solution This would form part of the normal process of 'in course' assessment with the same requirements as for any project in an accredited course.

Work-based projects

1.8.13 Where a project has to be carried out to satisfy the requirements of a formal Distance Learning route, such as the OU or Engineering Council Part 3 examination, or as part of WBL, it is essential that the above seven aspects are still satisfied. However, in this event, the aspects which need to be 'simulated' and those which are 'real' will be different from those described in the previous section.

1.8.14 Depending on the company size and geographical situation of the individual's employment, the requirements could be met in the following ways:

1.8.15 **Problem** To satisfy items (a) to (d)

Solution It is unlikely that anyone working in industry or commerce will not be working in some form of team. This may be a small or large internal team or may be a self-employed individual working in a 'team' with his/her client. In either case, the team will be 'real' with a real objective and a real customer. The members will have varying experience and the team or project leader will have to develop and use team management and communication skills. The project must have an acceptable amount of engineering content.

1.8.16 **Problem** To satisfy item (e)

Solution This aspect of the requirements will almost certainly need to be simulated, at least in part. The individual concerned may be the only member of the team who needs to use the project for formal assessment. It will thus be necessary to produce an individual, written project report which will be available for assessment during the Professional Review process, if not before.

The report would need to replicate the normal requirements of a university-based project. Firstly, this would be to describe and analyse the project aims, design, implementation and results. Secondly, it would analyse the project in terms of its management, quality control and progression; set out the successes and failures and propose alternative improved procedures, etc. Obviously, the report will need to be cleared with the team leader or supervisor of the author.

This recommended procedure follows very closely that which runs successfully in high quality sandwich degree programmes where student assessment is a joint procedure between the University and the employer and, often, presentations are given by the student.

1.8.17 **Problem** To satisfy items (f) and (g)

Solution By definition, the project undertaken in industry should be able to satisfy these requirements.

1.8.18 **Problem** To provide a robust system of individual assessment.

Solution This would need to be provided through a range of means and would certainly require assessment expertise from an academic source, possibly in conjunction with the nominated body. Preferably, supporting documentation and authentication would be available from the employer. In cases where the employer is formally supporting the applicant this will be simpler than where the applicant is acting independently.

Conclusion

1.8.19 RSC wishes to make an explicit statement as to the acceptability of assessed group project work carried out in employment as a replacement for the simulated project in an academic environment. In many cases, the work-based project could be seen to be advantageous.

1.8.20 Nominated bodies should develop appropriate advice and guidance for academia, employers and potential members, either based on that proposed above or a demonstrably equivalent alternative. This guidance should include any specific requirements regarding the selection of project topics.

Appendix 1 Connections to NVQs and other qualifications

City & Guilds has identified the connections to linked NVQs and other qualifications. This mapping is provided as guidance and suggests areas of overlap and commonality between the qualifications. It does not imply that candidates completing units in one qualification are automatically covering all of the content of the qualifications listed in the mapping.

Centres are responsible for checking the different requirements of all qualifications they are delivering and ensuring that candidates meet requirements of all units/qualifications. For example, a qualification may provide knowledge towards a N/SVQ, but centres are responsible for ensuring that the candidate has met all of the knowledge requirements specified in the N/SVQ standards.

This qualification has connections with and provides knowledge and understanding, in whole or in part, for the following Engineering Occupational Standards for Higher Levels:
1: Develop engineering products and processes
2: Produce engineering products and processes
3: Install engineering products and processes
4: Operate engineering products and processes
5: Maintain engineering products and processes
6: Improve the quality and safety of engineering products and processes
7: Plan, implement and manage engineering projects
8: Develop own engineering competence.

Appendix 2 Key/Core Skills signposting

The qualification provides opportunities to gather evidence for the accreditation of Key skills as shown in the table below. However, to gain Key Skills certification the Key Skills would need to be taken as additional qualifications.

Unit number	Communication	Application of Number	Information Technology
201		N4.1, N4.2, N4.3	
202		N4.1, N4.2, N4.3	
203		N4.1, N4.2, N4.3	
204		N4.1, N4.2, N4.3	
205		N4.1, N4.2, N4.3	
206		N4.1, N4.2, N4.3	
207		N4.1, N4.2, N4.3	
208	C4.1, C4.2 C4.3		
209		N4.1, N4.2, N4.3	IT4.1, IT4.2, IT4.3
210		N4.1, N4.2, N4.3	IT4.1, IT4.2, IT4.3
211			
212		N4.1, N4.2, N4.3	
213		N4.1, N4.2, N4.3	
214		N4.1, N4.2, N4.3	
215		N4.1, N4.2, N4.3	
216		N4.1, N4.2, N4.3	
217		N4.1, N4.2, N4.3	
218			

Unit number	Communication	Application of Number	Information Technology
219			
220			
221	C4.1, C4.2 C4.3	N4.1, N4.2, N4.3	
222		N4.1, N4.2, N4.3	
223			
224		N4.1, N4.2, N4.3	
225		N4.1, N4.2, N4.3	
226	C4.1, C4.2 C4.3		
227		N4.1, N4.2, N4.3	
228	C4.1, C4.2 C4.3		IT4.1, IT4.2, IT4.3
229			IT4.1, IT4.2, IT4.3
230			IT4.1, IT4.2, IT4.3
231			IT4.1, IT4.2, IT4.3
300			
301			
302			
303			
304			
305			

Unit number	Problem Solving	Improving own learning and performance	Working With Others
201	PS4.1, PS4.2, PS4.3		
202			
203			
204			
205	PS4.1, PS4.2, PS4.3		
206	PS4.1, PS4.2, PS4.3		
207			
208			
209			
210			
211	PS4.1, PS4.2, PS4.3		
212	PS4.1, PS4.2, PS4.3		
213			
214			WO4.1, WO4.2, WO4.3
215			
216			
217			
218			
219			
220			
221			
222			
223	*****KS5.1, KS5.2, KS5.3, KS5.4		
224			
225			

Unit number	Problem Solving	Improving own learning and performance	Working With Others
226			
227			
228	PS4.1, PS4.2, PS4.3		
229	PS4.1, PS4.2, PS4.3		
230			
231			
300			
301			
302			
303			
304	*****KS5.1, KS5.2, KS5.3, KS5.4		
305			

***** These are level five key skills

Appendix 3 Funding

This qualification is accredited and included on the National Qualifications Framework, and is therefore eligible for funding.

City & Guilds does not provide details on funding as this may vary between regions. Centres should contact the appropriate funding body to check eligibility for funding and any regional/national arrangements which may apply to the centre or candidates.

For funding regulatory purposes, candidates should not be entered for a qualification of the same type, level and content as that of a qualification they already hold.

Please see the table below for where to find out more about the funding arrangements for this qualification.

Nation	Who to contact	For higher level qualifications
England	The Learning and Skills Council (LSC) is responsible for funding and planning education and training for over 16-year-olds. Each year the LSC publishes guidance on funding methodology and rates. There is separate guidance for further education and work-based learning. Further information on funding is available on the Learning and Skills Council website at **www.lsc.gov.uk** and, for funding for a specific qualification, on the Learning Aim Database **http://providers.lsc.gov.uk/lad**.	Contact the Higher Education Funding Council for England at **www.hefce.ac.uk**.
Scotland	Colleges should contact the Scottish Further Education Funding Council, at **www.sfc.co.uk**. Training providers should contact Scottish Enterprise at **www.scottish-enterprise.com** or one of the Local Enterprise Companies.	Contact the Scottish Higher Education Funding Council at **www.shefc.ac.uk**.
Wales	Centres should contact Education and Learning Wales (ELWa) at **www.elwa.ac.uk** or contact one of the four regional branches of ELWa.	For higher level qualifications, centres should contact the Higher Education Funding Council for Wales at **www.hefcw.ac.uk**.
Northern Ireland	Please contact the Department for Employment and Learning at **www.delni.gov.uk**.	

This page is intentionally blank

Published by City & Guilds
1 Giltspur Street
London
EC1A 9DD
T +44 (0)20 7294 2800
F +44 (0)20 7294 2400
www.cityandguilds.com

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

HL-03-9107