SCOTTISH
QUALIFICATIONS
AUTHORITY

STRUCTURES
Intermediate 2

Fourth edition – published February 2001

SCOTTISH QUALIFICATIONS AUTHORITY

NOTE OF CHANGES TO ARRANGEMENTS FOURTH EDITION PUBLISHED

COURSE TITLE: Structures (Intermediate 2)

COURSE NUMBER: C018 11

National Course Specification

Course Details:	Revisions are to the length and format of the external assessment and the grade descriptions. The changes will take effect as from Diet 2001 onwards.

National Unit Specification:

All Units:	No changes.

SCOTTISH QUALIFICATIONS AUTHORITY

National Course Specification

STRUCTURES (INTERMEDIATE 2)

COURSE NUMBER C018 11

COURSE STRUCTURE

This course comprises three mandatory units as follows:

D104 11	***Fundamentals of Technology – Structures (Int 2)***	***1 credit (40 hours)***
D105 11	***Fundamentals of Manufacture and Assembly Techniques (Int 2)***	***1 credit (40 hours)***
D106 11	***Statics – Equilibrium in Frameworks and Simple Stress (Int 2)***	***1 credit (40 hours)***

In common with all courses, this course includes 40 hours over and above the 120 hours for the component units. This is for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for external assessment. This time is an important element of the course and advice on its use is included in the course details.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Standard Grade Mathematics at grade 3 and either Standard Grade Technological Studies, Craft and Design or Graphic Communication at grade 3
- equivalent or appropriate National units or courses

Administrative Information

Publication date: February 2001

Source: Scottish Qualifications Authority

Version: 04

National Course Specification (cont)

COURSE Structures (Intermediate 2)

CORE SKILLS

This course gives automatic certification of the following:

Complete core skills for the course	None	
Additional core skills components for the course	Critical Thinking	Int 2
	Using Number	Int 2

For information about the automatic certification of core skills for any individual unit in this course, please refer to the general information section at the beginning of the unit.

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Course Specification: course details

COURSE Structures (Intermediate 2)

RATIONALE

This course aims to provide an insight into the reasons why structures and their components are designed to particular shapes and sizes and an understanding of the processes used to produce them. It is appropriate for those considering a career in some aspect of engineering or construction. While allowing progress to higher study in engineering and construction, it can also make a positive contribution to general education and personal development, particularly in progressing the candidate's overall technological capability.

The course would normally be delivered as an integral part of an Intermediate 2 programme in engineering although it can be taught as a course in its own right within further education or school. As a result of successfully completing this course, candidates will be able to apply fundamental principles, knowledge and understanding over a broad area as they will have a general knowledge of the manufacturing and assembly or structural fabrication techniques used across a wide range of industrial applications. The course contributes to the development of a technological perspective and technological confidence through improving candidate understanding of the analysis which takes place in applying the design process. It also contributes to technological creativity through developing candidates' skills in analysing forces and solving simple design problems.

The Intermediate 2 Structures course helps to develop understanding common to a wide range of applications including manufacture, fabrication and construction as well as mechanical engineering and introduces the characteristics and properties of materials, providing a sound preparation for a range of technical vocational areas. It promotes the enterprising application of knowledge as it covers economic and safety factors involving ergonomic, technical and scientific principles. In a more general way the course will also improve the candidate's ability to relate technological capability to everyday situations.

COURSE CONTENT

All of the course content will be subject to sampling in the external assessment.

Successful completion of this course will equip the candidate to apply basic force theory to simple systems, solve idealised frameworks to determine forces, stress and strain in directly loaded members, and select manufacturing and assembly or structural fabrication procedures commonly used to produce devices. The aim is to enable candidates to recognise that structures are important in every aspect of our lives. For example, we take for granted the fact that a bridge will be strong and fit for its purpose when we cross it, that the structural integrity of an aircraft fuselage or car body is sufficient for its purpose, or that the rungs of a ladder will support the necessary weight applied to them.

It is important that candidates should be aware of the holistic nature of the course. This requires the candidate to:

- integrate aspects of individual unit content
- apply knowledge and skill across a greater range than within individual units
- demonstrate extended application beyond that required within individual units
- analyse and synthesise more complex contexts than required within individual units

The syllabus might best be studied sequentially, attempting the unit Fundamentals of Technology – Structures (Int 2) before the unit Statics – Equilibrium in Frameworks and Simple Stress (Int 2). The unit Fundamentals of Manufacture and Assembly Techniques (Int 2) can be studied in parallel with either of the previous units or attempted after work on the other two units is complete.

The unit Fundamentals of Technology – Structures (Int 2) introduces a wide range of structural entities and the classification of these on the basis of how they are loaded and supported. This builds up an interest and basic knowledge in the candidate which can then be developed in a design context within the unit Statics – Equilibrium in Frameworks and Simple Stress (Int 2) and in a manufacturing context within the unit Fundamentals of Manufacture and Assembly Techniques (Int 2). This should develop the candidate's ability to apply the wide range of justification and decision-making skills needed to conceive and fully develop the requirements of an integrated structure.

SUMMARY OF COURSE CONTENT

Fundamentals of Technology – Structures (Int 2)

Candidates will analyse a range of force systems in order to visualise all the forces acting on any component or on the system as a whole. Experience and understanding of how structural and engineering devices support and transfer load are developed during the course. Typical structures and components analysed could include pin-jointed frames, engine components, (for example a connecting rod) and machine tool applications (for example forces on a cutting tool). The force systems considered would all be coplanar and factors such as parallel/non-parallel and concurrent/non-concurrent loading would be used to classify systems. Problems would be solved for a wide range of force systems.

Reference should be made during the unit to the fact that the force analysis applied to any system is a starting point in calculating and collecting information which would eventually be used to produce structures and engineering components and assemblies

CONTENT STATEMENTS

Fundamentals of Technology – Structures (Int 2)

The content statements given in the left-hand column of the table below describe in detail what the candidate should be able to do in demonstrating knowledge and understanding.

The right-hand column gives suggested contexts, applications, illustrations and activities associated with the content statement.

National Course Specification: course details (cont)

COURSE Structures (Intermediate 2)

Knowledge and Understanding		*Contexts, Applications, Illustrations and Activities*
1	Simple application of force.	Use of a crowbar, chisel, bottle opener, force analysis, equilibrium, reactions, representation.
2	Force analysis.	Graphic representation, resolution, determination of resultants and equilibriants.
3	Force systems.	Classification into two-force, three-force, parallel and non-parallel, four or more force systems.
4	Conditions of equilibrium.	Individually leading to statement of general conditions. Solution of a range of graded problems involving force and moment analysis.

SUMMARY OF COURSE CONTENT

Fundamentals of Manufacture and Assembly Techniques (Int 2)

A range of manufacturing processes to produce simple devices and structural parts will be described in outline including classification, advantages and limitations of these techniques. This database of manufacturing processes and assembly or structural fabrication techniques will then be used to select the production requirements in order to produce a range of components and assemblies. Sequential operational planning will also be achieved.

Reference should be made during the presentation of this unit to the fact that without the force and stress analysis work undertaken in the previous units, the size and shape, material characteristics and function of the components to be manufactured would not be known. It should also be stated that these considerations are as important as the material availability, form of supply and shaping processes to be used and all the other manufacturing considerations which form the substance of this unit.

CONTENT STATEMENTS

Fundamentals of Manufacture and Assembly Techniques (Int 2)

The content statements given in the left-hand column of the table below describe what the candidate should be able to do in demonstrating knowledge and understanding.

The right-hand column gives suggested contexts, applications, illustrations and activities associated with the content statement.

National Course Specification: course details (cont)

COURSE Structures (Intermediate 2)

Fundamentals of Manufacture and Assembly Techniques (Int 2)

Knowledge and Understanding	*Contexts, Applications, Illustrations and Activities*
1 Fundamentals of manufacture and assembly techniques or structural fabrication techniques.	Describe measuring techniques, marking out, shape creation, joining and finishing. Classify into primary form, material preparation, assembly and finishing.
2 Select methods of manufacture or structural fabrication.	Use database. Select possible techniques. Decide optimum technique. Consider safety.
3 Plan.	Sequence of operations. Specify tools and equipment. Prepare documentation.

SUMMARY OF COURSE CONTENT

Statics – Equilibrium in Frameworks and Simple Stress (Int 2)

Candidates will analyse frame structures in order to determine reactions, force induced in the members, conditions of redundancy and collapse, using techniques developed from the general conditions of equilibrium. Additionally, simple stress and strain calculations will be undertaken using a wide range of materials including metals, concrete and plastics.

Reference should also be made to the fact that understanding of the overall forces applied to a loaded system studied in the previous unit Fundamentals of Manufacture and Assembly Techniques (Int 2) can be extended, using the general conditions of equilibrium, to determination of the forces acting on each component or member of the device. Again this process of analysis can be extended to determine the stress in individual components or members. The specific information collected and calculated during this unit can be used to help decide the shape and size of components or structural members to be manufactured.

National Course Specification: course details (cont)

COURSE Structures (Intermediate 2)

CONTENT STATEMENTS

Statics – Equilibrium in Frameworks and Simple Stress (Int 2)

The content statements given in the left-hand column of the table below describe what the candidate should be able to do in demonstrating knowledge and understanding.

The right-hand column gives suggested contexts, applications, illustrations and activities associated with the content statement.

Knowledge and Understanding	***Contexts, Applications, Illustrations and Activities***
1 General conditions of equilibrium.	Range of problems for simply supported and pin/roller supported structures.
2 Frameworks.	Graphical solution to forces induced in the members, three members, five members, more than five members. Conditions of redundancy and collapse.
3 Direct stress and strain.	Definitions, calculations of stress and strain within the elastic limit. Materials: metals, concrete, plastic. Simple problems involving more than one cross-section. Material properties to be introduced can be limited to ultimate strength, yield stress, modulus of elasticity.

During the additional 40 hours several investigations could be attempted which start with a full analysis of the forces and reactions applied to common engineering or structural assemblies, for example mounted engines, bridge or roof supporting structures. The investigation could then determine the loading and cross-sectional area requirements for one particular component and continue by establishing how the component would be manufactured and assembled or structurally fabricated.

The strength of the course award as opposed to the achievement of the individual units is demonstrated clearly through the ability to look at a load-bearing system in relation to a quantifiable function which must be manufactured using finite means to fulfil the requirements of this function. The candidate would begin to develop the complex processes of analysis and synthesis in order to consider, albeit in a simplified way, the many factors which relate efficient functional requirements with hardware development and the factors involved with the manufacturing and assembly domain.

National Course Specification: course details (cont)

COURSE Structures (Intermediate 2)

ASSESSMENT

To gain the award of the course, the candidate must pass all the unit assessments as well as the external assessment. External assessment will provide the basis for grading attainment in the course award.

When the units are taken as component parts of a course, candidates will have the opportunity to achieve a level beyond that required to attain each of the unit outcomes. This attainment may, where appropriate, be recorded and used to contribute towards course estimates, and to provide evidence for appeals. Additional details are provided, where appropriate, with the exemplar assessment materials. Further information on the key principles of assessment is provided in the paper *Assessment*, (HSDU, 1996) and in *Managing Assessment* (HSDU, 1998).

DETAILS OF THE INSTRUMENTS FOR EXTERNAL ASSESSMENT

The external assessment will comprise a written examination which will sample across the three units in the course. The time allocation will be 2 hours 30 minutes. The question paper will be worth 100 marks. It will consist of 3 sections as follows:

Section A – 12 marks
This will consist of 12 multiple choice questions, mainly of a qualitative nature, that will be worth 1 mark each. The questions will assess basic knowledge across all units. Candidates should attempt all questions in this section.

Section B – 48 marks
This will consist of 12 short answer questions, mainly of a quantitative nature, that will be worth 4 marks each. The questions will assess knowledge and understanding across all units in extended but familiar contexts. Candidates should attempt all questions in this section.

Section C – 40 marks
This will contain 5 extended response questions worth 10 marks each. There will be 1 question on each unit. There will be a further 2 questions that will integrate and sample across the context of each unit. All the questions will be more challenging. Candidates should attempt 4 questions in this section.

National Course Specification: course details (cont)

COURSE Structures (Intermediate 2)

GRADE DESCRIPTIONS

The descriptions below are of expected performances at grade C and at grade A. They are intended to assist candidates, teachers, lecturers and users of the certificate and to help establish standards when question papers are being set. The grade of the award will be based on the total score obtained in the examination.

Candidates who successfully complete the course assessment should be able to:

- demonstrate the ability to integrate knowledge, understanding, data selection and numerical skills across component units.
- retain the above abilities over the duration of the course.
- apply the above abilities in more complex and less familiar contexts.

APPROACHES TO LEARNING AND TEACHING

The units Fundamentals of Technology – Structures (Int 2) and Statics – Equilibrium in Frameworks and Simple Stress (Int 2), are designed to be undertaken in series while the unit Fundamentals of Manufacture and Assembly Techniques (Int 2) could be attempted in parallel with the previously mentioned units or taught as the third in the series.

A range of learning strategies can be developed to help candidates meet the demands of the course. Some examples of how this can be developed are:

- determining the loading on a particular member of a structure, using skills and techniques developed across the course in order to select materials and forms of supply and plan the method of manufacture
- increasing the range of applications by considering where environmental or safety considerations are required as well as straightforward loading parameters
- considering offshore or aerospace case studies where essentially the same elements emerge

The breadth and interaction of the wider use of knowledge and understanding across the three units leads naturally to the consideration of more complex contexts.

Within the additional 40 hours the candidates could be introduced to a range of real industrial systems containing a range of elements which require analysis in a more complex and different context through stress considerations and the manufacturing or structural fabrication techniques required. The preferred learning and teaching approach would be based on a series of investigations completed as a range of systems under load and in equilibrium. The subject of each investigation would be to follow the process from load analysis through stress considerations to manufacturing or structural fabrication techniques required to produce the final resulting structure.

The additional 40 hours should also be used in part to prepare candidates for the external assessment by setting tasks drawn from across the course units which require to be completed within a time constraint and subject to controlled conditions. The integrated and complex nature of the external assessment will require candidates to be given extensive practice in applying this sort of approach.

SPECIAL NEEDS

This course specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SUBJECT GUIDES

A Subject Guide to accompany the Arrangements documents has been produced by the Higher Still Development Unit (HSDU) in partnership with the Scottish Consultative Council on the Curriculum (SCCC) and Scottish Further Education Unit (SFEU). The Guide provides further advice and information about:

- support materials for each course
- learning and teaching approaches in addition to the information provided in the Arrangements document
- assessment
- ensuring appropriate access for candidates with special educational needs

The Subject Guide is intended to support the information contained in the Arrangements document. The SQA Arrangements documents contain the standards against which candidates are assessed.

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Fundamentals of Technology – Structures (Intermediate 2)

NUMBER D104 11

COURSE Structures (Intermediate 2)

SUMMARY

This unit focuses on applying basic force theory to simple systems.

OUTCOMES

1 Analyse and resolve force systems.
2 Distinguish between concurrent and non-concurrent force systems.
3 Solve simple problems relating to parallel and non-parallel force systems.
4 Solve problems relating to forces acting in engineering applications.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Standard Grade Mathematics at grade 3 and either Standard Grade Technological Studies, Craft and Design or Graphic Communication at grade 3
- equivalent or appropriate National units or courses

CREDIT VALUE

1 credit at Intermediate 2.

Administrative Information

Superclass: RC

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Fundamentals of Technology – Structures (Intermediate 2)

CORE SKILLS

This unit gives automatic certification of the following:

Complete core skills for the unit	None	
Core skills components for the unit	Critical Thinking	Int 1
	Using Number	Int 2

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Fundamentals of Technology – Structures (Intermediate 2)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Analyse and resolve force systems.

Performance criteria

(a) The three parameters which define a force are represented correctly.
(b) A force is resolved into mutually perpendicular components correctly and accurately in line with current practice.
(c) The resultant of a two-force system is accurately determined graphically and analytically.

Note on range for the outcome

Parameters which define a force: magnitude, direction, sense.

Evidence requirements

Written and/or oral, and graphical evidence which satisfies all the PCs applied to a two-force system both graphically and analytically.

OUTCOME 2

Distinguish between concurrent and non-concurrent force systems.

Performance criteria

(a) Concurrency and non-concurrency applications are correctly recognised for three-force and multi-force systems.
(b) The principle of concurrency as it applies to three-force non-parallel systems is consistently interpreted for force systems of this type.

Evidence requirements

Written, oral and graphical evidence which shows the candidate can distinguish between concurrency and non-concurrency when applied to the force systems stated in PC (a) and apply the principle of concurrency as it applies to one example of a three-force non-parallel force system as indicated in PC (b).

National Unit Specification: statement of standards (cont)

UNIT Fundamentals of Technology – Structures (Intermediate 2)

OUTCOME 3

Solve simple problems relating to parallel and non-parallel force systems.

Performance criteria

(a) Parallel and non-parallel applications are correctly recognised for a range of force systems.
(b) Resolution of force techniques are used correctly to calculate the resultant force for appropriate force systems.
(c) Principle of moment techniques are used correctly to calculate the equilibriant for appropriate force systems.

Note on range for the outcome

Force systems: three-force, multi-force.

Evidence requirements

Written and/or oral evidence which shows the candidate can distinguish between parallel and non-parallel application of force for PC (a) as well as using force resolution techniques and applying principle of moment techniques for the selection of force systems stated in the range. Questions should be limited to one on three-force and one on multi-force systems.

OUTCOME 4

Solve problems relating to forces acting in engineering applications.

Performance criteria

(a) The forces acting are correctly identified and shown on a free body diagram for a given engineering application.
(b) The unknown forces are analytically determined correctly for a given engineering application.
(c) A pin-jointed frame is analysed to identify correctly the forces acting on one member or component.

Note on range for the outcome

Engineering applications: engine component (for example a connecting rod), machine tool application (for example forces on a cutting tool).

Evidence requirements

Written and/or oral, and graphical evidence which shows the candidate can determine resultant and equilibriant forces applied to the force systems stated in the range and also analyse one such force system to identify correctly all the forces acting on one member of a pin-jointed frame.

National Unit Specification: support notes

UNIT Fundamentals of Technology – Structures (Intermediate 2)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

It is recommended that you refer to the SQA Arrangements document for Intermediate 2 Structures before delivering this unit.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

On completion the candidate will be able to analyse a range of force systems in order to visualise all the forces acting on a part of the system or on the system as a whole, and will gain experience and understanding of the loading on structural and engineering devices. Additionally, the candidate will gain knowledge on how these devices support loading.

When selecting the engineering applications to use for illustrative purposes, the teacher/lecturer should use examples which are familiar to the candidate, for example related to the manufacturing or construction industry. Time is well spent at the early stages in graphical force representation and application of simple trigonometry to resolve forces. These techniques should also be applied to analyse a range of force systems since many applications of these same techniques will recur later in the course of study.

The Outcomes can be achieved in an integrative way, dealing with complexities such as non-parallel addition of forces and non-concurrency as they emerge during the analysis of a simple force system. Once the techniques of graphical addition and resolution are mastered, the skills of recognition of the type of system being analysed, and the specific difficulties involved with this type of force system and how to overcome them can be developed.

The high-level activity of deducing the forces acting on one member of a pin-jointed frame should be attempted towards the end of the unit. Starting with a simple device such as a crowbar, chisel or bottle opener, some idea of force and its parameters can be established. This can lead to individual or group work using a graded series of examples highlighting the peculiarities of concurrency, non-concurrency, parallel and non-parallel applications and how these are overcome. No attempt at complex loading should be tried at this stage. This can be introduced once the basic skills have been developed.

Once the techniques of resolving forces into perpendicular components and applying the principle of moments have been mastered and the conditions of equilibrium can be applied, the candidates can attempt more complex force analysis for complete systems. Finally, the force system applied to one part of a complex system can be extracted and analysed.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Information on learning and teaching is available in the Subject Guide, produced by the Higher Still Development Unit (HSDU) in partnership with the Scottish Further Education Unit (SFEU) and the Scottish Consultative Council on the Curriculum (SCCC). The Subject Guide is intended to support the information contained in the SQA Arrangements document for the Structures (Int 2) course. The SQA Arrangements document contains the standards against which candidates are assessed.

National Unit Specification: support notes (cont)

UNIT Fundamentals of Technology – Structures (Intermediate 2)

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcome 1

This outcome could be assessed using an illustration of a two-force system. This could be presented to the candidate with a written question asking that the resultant force be correctly identified using both graphical and analytical techniques.

Outcomes 2 and 3

These Outcomes could be assessed using illustrations of perhaps four different force systems. This could be presented to the candidate with a written question asking that each system be classified as concurrent/non-concurrent and parallel/non-parallel. A second question could be given on a three-force non-parallel system to ensure that this special case is recognised. A third question could be given on a multi-force system to cover the application of force and moment balance for a system in equilibrium.

Outcome 4

This Outcome could be assessed by presenting the candidate with a diagram of the forces acting on one of the engineering applications indicated in the range. It could ask for a free body diagram to be completed and for two forces or reactions to be calculated. A second question could be given on a pin-jointed frame. This could show all external loads and the value of the forces in the members. Candidates would be required to show all the forces acting on one member of the structure.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Fundamentals of Manufacture and Assembly Techniques (Int 2)

NUMBER D105 11

COURSE Structures (Intermediate 2)

SUMMARY

This unit focuses on selecting manufacturing and assembly or structural fabrication procedures commonly used in the making of simple products.

OUTCOMES

1 Describe the characteristics of simple component manufacturing processes and assembly or structural fabrication methods.
2 Select component manufacturing and assembly or structural fabrication methods for given applications.
3 Plan the manufacture and assembly procedures for a product or structural fabrication.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Standard Grade Mathematics at grade 3 and either Standard Grade Technological Studies, Craft and Design or Graphic Communication at grade 3
- equivalent or appropriate National units or courses

Administrative Information

Superclass: WA

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Fundamentals of Manufacture and Assembly Techniques (Int 2)

CREDIT VALUE

1 credit at Intermediate 2.

CORE SKILLS

This unit gives automatic certification of the following:

Complete core skills for the unit	None
Core skills components for the unit	Critical Thinking Int 2

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Fundamentals of Manufacture and Assembly Techniques (Int 2)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Describe the characteristics of simple component manufacturing processes and assembly or structural fabrication methods.

Performance criteria

(a) The processes used to make a range of simple products or structural fabrications are correctly identified.
(b) Processes achieving the same requirements are critically compared for two situations.
(c) Processes are classified into general groupings in accordance with established practice.
(d) General and specific safe working practices are stated correctly in terms of current legislation.

Note on range for the outcome

Manufacturing and assembly or structural fabrication processes: measurement, marking out, shape creation, joining, finishing.
Classification into general groupings: primary forming, material preparation, assembly, finishing.

Evidence requirements

Written or oral evidence that a range of processes can be classified into the broad groupings listed in the range along with an exercise which critically compares two different processes which can be used to achieve the same effect during component manufacture and an assembly of products or structural fabrication. A short answer exercise would also be required to evidence the knowledge of safe working practice.

OUTCOME 2

Select component manufacturing and assembly or structural fabrication methods for given applications.

Performance criteria

(a) Given the form of material supply to be used, appropriate techniques are selected to manufacture a simple part.
(b) Given the components available, appropriate techniques are selected in order to assemble a device or structure.
(c) Specific safe working practices are correctly stated for each technique.

Note on range for the outcome

Manufacturing or structural fabrication techniques: measurement, marking out, hand shaping, machining methods, moulding, quality control.
Assembly techniques: measurement, marking out, fitting, joining, finishing, trial testing.

Evidence requirements

Written or oral evidence that appropriate techniques or processes can be selected and ordered in a logical sequence to manufacture components and assemble a product or a structural fabrication, indicating any special safety requirements against the list of operations chosen.

OUTCOME 3

Plan the manufacture and assembly procedures for a product or structural fabrication.

Performance criteria

(a) The order of operations selected is logical for the manufacture and assembly of a given product or structural fabrication.
(b) Appropriate consideration is given to methods of workholding, capacity of equipment and tools available.
(c) Special safety requirements are stated and consequent precautions are correctly identified.

Note on range for the outcome

Product: four components, eight operations.
Structural fabrication: four parts, four techniques.

Evidence requirements

Performance evidence showing that the candidate can produce planning documentation showing the sequential order of manufacturing operations or fabrication techniques, including the necessary safety requirements for the manufacture and assembly of a product or the building of a fabricated structure with four components or parts.

National Unit Specification: support notes

UNIT Fundamentals of Manufacture and Assembly Techniques (Int 2)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

It is recommended that you refer to the SQA Arrangements document for Intermediate 2 Structures before delivering this unit.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

On completion of this unit the candidate should be able to decide appropriate steps in component manufacturing and in the assembly of simple products or the building of a structural fabrication. The candidate should have gained an appreciation of what can be achieved using a wide range of common manufacturing or building techniques and should be aware of why particular products have been produced in their particular way. Additionally, the candidate should be competent in producing elementary planning documents and selecting tools and equipment.

The approach to presentation should reflect the needs of the candidate as far as possible and, by relating particular processes and techniques to the more general classification groupings, will help the candidate to transfer the underlying principles of manufacture or building to new situations. The Outcomes can be easily achieved in an integrated way if some recurring assemblies, groups of products or fabricated structures are used as a vehicle throughout.

Starting with a few simple products, a fairly extensive list of component manufacturing and assembly techniques can be built up and unfamiliar processes can be introduced by video or handout materials. As this process continues it should emerge that the same end result can be achieved using several techniques. Comparisons of advantages and disadvantages of the application of these should lead to critical comparison possibly on the basis of resources required, equipment availability, time constraints and other critical factors. In much the same way the techniques should usually fall into broad classifications and subsequently be listed into these classifications to provide a kind of menu for the candidate to use in later Outcomes. A general knowledge and awareness of safety and its implications should be fostered at this time.

The information organised and classified previously may now be used and added to when using individual and group exercises to select, from the materials and equipment available, those techniques which would be required to manufacture a series of components and assemblies or a series of fabricated structures. Safety requirements can now be incorporated in a more direct way.

An introduction to logical planning can now be attempted for a simple manufactured product or a structural fabrication of three or four components and decisions taken on the likely tools and equipment required. Planning documentation, such as bills of material, operation sheets and manufacturing instructions, can be introduced and produced by the candidate at this time.

Safety requirements could be looked at for particular operations in the manufacture and assembly sequence of the product or the making of a structural fabrication where this would be a significant and appropriate consideration, for example the use of a toxic substance in a finishing operation or the moving of a bulky or heavy structural fabrication with restricted access.

National Unit Specification: support notes (cont)

UNIT Fundamentals of Manufacture and Assembly Techniques (Int 2)

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Information on learning and teaching is available in the Subject Guide, produced by the Higher Still Development Unit (HSDU) in partnership with the Scottish Further Education Unit (SFEU) and the Scottish Consultative Council on the Curriculum (SCCC). The Subject Guide is intended to support the information contained in the SQA Arrangements document for the Structures (Int 2) course. The SQA Arrangements document contains the standards against which candidates are assessed.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcome 1

A classification of perhaps 20 techniques into the four general groupings, coupled with an exercise comparing different techniques to achieve the same end product for two situations, would cover all PCs in Outcome 1 except safety, which could use a case study approach followed by a set of questions.

Outcomes 2 and 3

An exercise for a manufactured assembly or fabricated structure, involving choosing appropriate techniques and then ordering them into a logical sequence indicating appropriate tool and equipment requirements, coupled with noting specific safety requirements for specific operations, would cover all the PCs in Outcomes 2 and 3.

Alternatively an integrative approach to assessment could be developed, using a common product or structural fabrication as a vehicle for applying an in depth analysis. A portfolio could be produced containing:

- a range of component manufacturing and assembly techniques
- the reasons why particular techniques had been chosen from a range of alternatives
- the safety implications associated with each technique

A second product could be considered by candidates. Details could be provided of the processes and equipment available for manufacture, the materials available and their preferred form of supply. Candidates could then be given a carefully structured series of questions that would cover all the necessary evidence for the whole unit.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Statics – Equilibrium in Frameworks and Simple Stress (Int 2)

NUMBER D106 11

COURSE Structures (Intermediate 2)

SUMMARY

This unit focuses on determining force induced in the members of ideal frames and calculating direct stress and strain in simply loaded members.

OUTCOMES

1 Determine the support reactions for frame structures in equilibrium.
2 Draw vector diagrams and evaluate force induced in the members of idealised frame structures.
3 Calculate direct stress and strain and select materials for components.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Standard Grade Mathematics at grade 3 and either Standard Grade Technological Studies, Craft and Design or Graphic Communication at grade 3
- equivalent or appropriate National units or courses

CREDIT VALUE

1 credit at Intermediate 2.

Administrative Information

Superclass: RC

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Statics – Equilibrium in Frameworks and Simple Stress (Int 2)

CORE SKILLS

This unit gives automatic certification of the following:

Complete core skills for the unit	None
Core skills components for the unit	Critical Thinking Int 1 Using Number Int 2

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Statics – Equilibrium in Frameworks and Simple Stress (Int 2)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Determine the support reactions for frame structures in equilibrium.

Performance criteria

(a) Equilibrium in frame structures is analysed in relation to forces induced in the members.
(b) The general conditions of equilibrium are correctly stated.
(c) Free body diagrams are accurately produced for frame structures in terms of force equilibrium.
(d) The reaction forces are calculated correctly for frame structures in equilibrium.

Note on range for the outcome

Conditions of equilibrium: force balance, turning effects balance.
Frame structures: simply supported.

Evidence requirements

Written or oral evidence that the candidate can state the general conditions of equilibrium as they apply to three examples of loaded structures and use these conditions to calculate reactionary forces.

OUTCOME 2

Draw vector diagrams and evaluate force induced in the members of idealised frame structures.

Performance criteria

(a) All the assumptions made when considering plane frames are in accordance with established practice.
(b) Frames are analysed correctly to determine all external forces.
(c) Combined vector diagrams for frames are drawn to a scale which allows accurate determination of forces in members.
(d) The magnitude and nature of force caused to act on specified members are determined correctly using combined vector diagrams.
(e) The conditions of redundancy and collapse are indicated correctly during the production of appropriate combined vector diagrams.

Evidence requirements

Oral and/or written and graphical evidence that the candidate can satisfy the PCs which apply to a frame with seven members.

National Unit Specification: statement of standards (cont)

UNIT Statics – Equilibrium in Frameworks and Simple Stress (Int 2)

OUTCOME 3

Calculate direct stress and strain and select materials for components.

Performance criteria

(a) Direct stress and strain are defined accurately in terms of established practice.
(b) The relationship between stress and strain within the elastic limit is stated in terms of established theory.
(c) Calculations of stress and strain are accurately performed for loaded components.
(d) Component materials are correctly selected to meet simple loading requirements.

Note on range for the outcome

Components: uniform cross-sectional area, two different cross-sectional areas.
Materials: 3 linear elastic.
Materials selection: ultimate strength, yield stress, modulus of elasticity

Evidence requirements

Oral and/or written evidence which satisfies the PCs and items in the range which apply to at least one component of two different cross-sections.

National Unit Specification: support notes

UNIT Statics – Equilibrium in Frameworks and Simple Stress (Int 2)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

It is recommended that you refer to the SQA Arrangements document for Intermediate 2 Structures before delivering this unit.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

On completion of this unit the candidate should be able to analyse frame structures to determine reactions, and establish the value and nature of forces induced in the members of the frame. The candidate should also be able to calculate the stress and strain caused in components by external loading and select suitable materials on the basis of their properties related to their requirements.

Candidates should have ready access to a range of devices such as mechanical linkages, supporting frameworks and structural frames which should be used to develop and reinforce the theoretical approach. Computer software can also be used to confirm candidates' analysis of frame structures. A pre-prepared series of at least six worksheets could be used by candidates on an individual basis to determine the forces in frameworks, and a blank sheet of paper approach should be attempted at least twice. Appropriate simple practical assignments could be attempted by small groups of candidates. Material behaviour beyond the elastic limit could be briefly examined, if desired, to help with the understanding of elementary material properties.

The conditions required to produce equilibrium could be determined from a series of structural analyses, ending in the general conclusion that no tendency to move or turn should be present. The formal statement of the general conditions of equilibrium could then be composed and used to calculate reactions for a series of graded examples. The normal graphical method of determining the forces in the members of frames could be built up using a simple three-member frame with a single applied load and two reactions. Combining the vector diagrams for each of the three joints would lead to the requirement for Bow's notation to be used, the selection of vector scales and the layout of solutions.

A checklist of the necessary procedures could be developed, but a detailed set of step-by-step instructions should be avoided as it does not encourage understanding. The effects of roller and pin reactions could be reinforced as examples with a greater number of members being attempted. Redundancy and inadequate presence of members could be introduced after three or four examples have been successfully completed but this should be treated in as simple a way as possible.

Discussion and demonstrations should highlight the concepts of stress and strain under direct tensile and compressive loading. The relationship between stress and strain within the elastic limit and the examination of modulus of elasticity values for a range of materials should be introduced once a few elementary stress and strain calculations have been mastered. A series of straightforward examples could then be attempted by individual candidates to develop the mathematical and numerical skills necessary. Materials and components relevant to analyse at least one practical situation should be used to calculate stress and change in length of a component under load.

National Unit Specification: support notes (cont)

UNIT Statics – Equilibrium in Frameworks and Simple Stress (Int 2)

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Information on learning and teaching is available in the Subject Guide, produced by the Higher Still Development Unit (HSDU) in partnership with the Scottish Further Education Unit (SFEU) and the Scottish Consultative Council on the Curriculum (SCCC). The Subject Guide is intended to support the information contained in the SQA Arrangements document for the Structures (Int 2) course. The SQA Arrangements document contains the standards against which candidates are assessed.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcome 1

The candidate could be supplied with:

- data concerning a loaded structure, where it is simply supported by one pin and one roller. The candidate would be required to state the relevant conditions of equilibrium, sketch the free body diagram and calculate the reactions for the loaded structure

Outcome 2

The candidate could be supplied with:

- a prepared worksheet containing the free body diagram for a frame with seven or more members, simply supported, having at least one member with zero force. The candidate could be asked to draw the vector diagram for the complete frame to a given scale and deduce the value and nature of the forces in three specified members, one of which is in tension, one in compression and one without force

Outcome 3

The candidate could be supplied with:

- data concerning a component or structural member in tension made from one material but with two different cross-sections over its length. The candidate could be asked to calculate the maximum stress produced and the overall extension under the load. A suitable material could then be chosen to suit the loading requirements

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).