UNIT   Expert Systems (Higher)

NUMBER   DM4H 12

COURSE   Information Systems (Higher)

SUMMARY

This Unit is designed to develop knowledge and understanding of the principles of expert systems and practical skills related to expert systems through the use of contemporary hardware and software. This knowledge and understanding, and these practical skills, may then be applied by the candidate to solve practical problems related to expert systems. It is designed as an option for candidates undertaking the Higher Information Systems Course, but is also suitable for anyone wishing to extend and deepen their experience of expert systems beyond Intermediate 2 level. It is also appropriate as an extension for those who have studied Artificial Intelligence at Higher level.

OUTCOMES

1.   Demonstrate knowledge and understanding of the principles, techniques and applications of expert systems.
2.   Demonstrate practical skills by applying knowledge and understanding of the principles, techniques and applications of expert systems using contemporary hardware and software.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following qualifications (or possess equivalent experience):

♦   Intermediate 2 Expert Systems Unit
♦   Intermediate 2 Information Systems
♦   Intermediate 2 Computing
♦   Standard Grade Computing Studies at Credit level

Administrative Information

Additional copies of this Unit Specification can be purchased from the Scottish Qualifications Authority. The cost for each Unit Specification is £2.50. (A handling charge of £1.95 will apply to all orders for priced items.)

National Unit Specification: general information (cont)

CREDIT VALUE
1 credit at Higher (6 SCQF points at SCQF level 6*).

SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.

CORE SKILLS
This Unit gives automatic certification of the following:

| **Core Skill components for the Unit** | Critical Thinking | H |
| | Planning and Organising | H |

National Unit Specification: statement of standards

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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
Demonstrate knowledge and understanding of the principles, techniques and applications of expert systems.

Performance Criteria
a)   Principles and techniques of expert systems are clearly explained using appropriate terminology.
b)   Descriptions of applications are technically accurate and concise.
c)   Conclusions, predictions and generalisations are made from knowledge and understanding.

Evidence Requirements
Written or oral evidence that the candidate can describe, explain and apply the principles, techniques and applications of expert systems accurately and concisely. Evidence could be obtained using questions in a closed book test under supervision, lasting no more than 45 minutes. The test must sample the content (see Information Systems (Higher) Course Content) in each of the following areas:

♦   expert systems in context
♦   characteristics of expert systems
♦   development, use and evaluation of expert system
♦   construction of a working expert system

(The content statements are also reproduced for convenience as a table in the support notes for this Unit).

The standard to be applied is illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit, they should be of a comparable standard.

OUTCOME 2
Demonstrate practical skills by applying knowledge and understanding of the principles, techniques and applications of expert systems to solve practical problems using contemporary hardware and software.

Performance Criteria
a)   A range of appropriate hardware is used effectively and efficiently.
b)   An appropriate range of features of software is used effectively and efficiently.
c)   Practical tasks are planned and organised with minimal guidance.
d)   Practical tasks are undertaken in an appropriate range of familiar contexts.

National Unit Specification: statement of standards (Cont)

UNIT Expert Systems (Higher)

Evidence Requirements
Observation checklist showing that the candidate has carried out practical activities in the following contexts:

♦ finding solutions to given problems by consultation of expert systems for advice, classification, diagnosis, and planning
♦ structured testing and critical evaluation of an expert system
♦ representation of a limited domain of knowledge in a structured form
♦ construction of a working expert system given a limited domain of knowledge

Hard copy evidence should be provided of the working expert system constructed.

These practical skills may be demonstrated in a single extended task, and in a number of smaller tasks.

The practical skills should be demonstrated in the context defined in the content statements (see Information Systems (Higher) Course Content).

The candidate will be allowed access to books, notes and on-line help while completing the tasks.

(The content statements are also reproduced for convenience as a table in the support notes for this Unit).

The standard to be applied is illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit, they should be of a comparable standard.

National Unit Specification: support notes

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This part of the Unit Specification is offered as guidance. The support notes are not mandatory.

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

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

The content for this Unit is detailed below (and also in the National Course Specifications: Course details.)

Content statements in the left-hand column describe the content covered in the corresponding Unit at Intermediate 2 level, and are included here to clarify the context for the new learning for this Unit. They indicate the prior learning required by the candidate before undertaking new learning within this Unit. Content in the right-hand column is the new content for this Unit.

Content Statements: Expert systems in context	
Intermediate 2	Higher
Description of the purpose of an expert system: to represent the knowledge of one or more domain experts; to provide advice to a user via a consultation; to provide explanations of why certain questions are being asked and how conclusions have been reached. *Definition of an 'expert system shell'.* *Identification of applications for expert systems, including medical, legal and financial advice.*	Description of the advantages/benefits of expert systems, including preservation of expertise, dissemination of expert knowledge, training, combining expertise of multiple experts. Description of the limitations/drawbacks of expert systems, including restricted domain, high development and maintenance costs. Description of the social, ethical and legal implications of expert systems, including responsibility for 'bad' advice.
Distinction between knowledge (created by the application of inference rules to known facts), data and information.	Distinction between expert systems and other information systems (including Management/Executive Information Systems, Decision Support Systems). Comparison of databases and expert systems, in terms of representation of data/knowledge; method of extraction of information/knowledge. Description of the characteristics of a deductive database which combines the inferencing of an expert system with the power of a database for large scale storage of 'facts'.
Identification of the components of an expert system: knowledge base, inference engine, user interface.	Description of the components of an expert system: knowledge base, inference engine, user interface.
Identification of the categories of expert system: planning, advice, classification, diagnosis. *Classification of example expert systems into these categories.*	Correct classification and description of the domains and main characteristics of the following 'classical' expert systems: MYCIN, ONCOCIN, R1/XCON, INTERNIST, DENDRAL, PROSPECTOR, OPS5, STRIPS.

National Unit Specification: support notes (cont)

UNIT   Expert Systems (Higher)

Content Statements: Characteristics of expert systems	
Intermediate 2	Higher
Description of the main features of the knowledge base: contains facts and rules.	Description of the knowledge base as representing knowledge in a knowledge representation language (KRL).
Representation of knowledge as rules and factor tables.	Representation of knowledge in a range of knowledge representation forms, including forward and backward chaining rules, factor tables, decision trees. Transformation of knowledge between representations. Description of the advantages and limitations of each representation.
	Representation of simple statements using propositional (zero order) or predicate (1st order) logic.
Description of the main features of the inference engine: to determine the order in which rules are applied, and hence questions are asked. *Identification of inferencing methods: forward and backward chaining.* *Description of advantages and disadvantages of forward and backward chaining.*	Comparison of forward chaining and backward chaining inference engines. Description of the main characteristics of a forward chaining system: working memory; conflict set; conflict resolution. Explanation of why conflict resolution strategies are required. Explanation of how different conflict resolution strategies achieve the required effect, including rule ordering (first-come-first-served), recency, specificity/size ordering, refractoriness, data ordering, context limiting/setting a rule agenda. Description of the RETE algorithm for achieving conflict resolution.
	Representation of the degree of certainty of the data provided by the user, the degree of certainty inherent in the rules within the rule base, or the degree of certainty in the conclusion reached using certainty factors (as percentages or probabilities). Calculation of the certainty of a conclusion using the formula $CF_{conc} = CF_{rule} \times \min(CF_{cond1}, CF_{cond2}, \ldots)$.
Description of the main functions of the user interface: to ask questions and obtain answers from the user; to display advice; to justify questions and answers.	Explanation of how explanations are generated, using a rule tree.

National Unit Specification: support notes (cont)

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Content Statements: Development, use and evaluation of expert systems	
Intermediate 2	Higher
Identification of the principal personnel in the development of an expert system. ♦ *domain expert* ♦ *knowledge engineer* ♦ *programmer* ♦ *user* *Identification of the stages of development of an expert system* ♦ *knowledge acquisition/elicitation* ♦ *knowledge representation* ♦ *system validation*	Description of the stages of development of an expert system, and the roles performed by personnel at each stage: ♦ knowledge acquisition/elicitation ♦ knowledge representation ♦ system validation Description of the sources of error which can occur at each stage of development, including expert's knowledge; mis-interpretation of expert knowledge; programming; inferencing; expert system advice beyond the 'limits of ignorance'.
Querying of the expert system to answer simple structured questions.	Querying of the expert system to answer more complex unstructured questions.
Testing of an expert system using a set of structured test cases.	Design of a set of structured test cases to thoroughly test an expert system.
Use of How and Why justification facilities.	
Evaluation of an expert system, in terms of: purpose (type of expert system, domain of expertise); range and coverage of rules; quality of user interface (structure/syntax/order of questions asked, presentation of conclusion; quality of explanation facilities).	Critical evaluation of an expert system, in terms of: purpose (type of expert system, domain of expertise); range and coverage of rules; quality of reasoning; quality of user interface (structure/syntax/order of questions asked, presentation of conclusion; quality of explanation facilities); correctness of conclusions; fitness for purpose.

Content Statements: Construction of a working expert system	
Intermediate 2	Higher
Description and demonstration of techniques of analysis, design, implementation, testing and evaluation of an expert system.	Description and demonstration of techniques of analysis, design, implementation, testing and evaluation of an expert system.
Derivation of suitable attribute-value pairs, from a short piece of structured text, not involving multi-valued attributes. *Representation of attribute-value pairs as a factor table and as a decision tree.*	Derivation of suitable attribute-value pairs, from an extended piece of unstructured text, involving some multi-valued attributes. Representation of attribute-value pairs as a factor table and as a decision tree.

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Derivation of structured rules involving multiple (up to three) conditions to represent knowledge. *Construction of forward or backward chaining rules (in pseudocode or appropriate KRL).* *Construction of a rule base of 5—-10 rules, leading to direct conclusions without rule chaining.*	Derivation of structured rules involving multiple (three or more) conditions to represent knowledge. Construction of forward and backward chaining rules (in pseudocode or appropriate KRL). Exemplification of parameterised rules which can provide multiple conclusions. Construction of a rule base of at least 15 rules, demonstrating chaining to a minimum of three levels.
Production of structured questions, including some multi-response.	Derivation of structured questions to extract necessary information from a user consultation in an efficient manner, without duplication.
Entry of rules into an expert system shell. *Debugging of rules to produce a working system.* *Testing of expert system using a given set of structured test cases.*	Entry of rules into an expert system shell. Debugging of rules to produce a working system. Design and use of a set of structured test cases to thoroughly test that the expert system produces correct results against the knowledge provided.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Candidates will require individual access to appropriate computer hardware and software throughout this Unit. In particular, candidates will require access to an expert system shell which will enable them to construct and test a working expert system. In addition to commercial software, there are a wide variety of free expert system shells available. However, centres should note that these are very often research vehicles and are provided 'as is', without support, and may be aimed at a university level audience. Nevertheless, some shells have active user groups which can provide useful backup.

Candidates will also benefit from the opportunity to consult and evaluate as wide a range as possible of expert systems, including both those which they have constructed themselves, and others made available to them.

Possible sources of software are easily available by searching on the world wide web.

The two Outcomes should be delivered in an integrated way. Appropriate practical activities, both computer and non-computer based, should be taught and used to illustrate and exemplify the knowledge and understanding required for Outcome 1.

Candidates who have completed the *Expert Systems* Unit at Intermediate 2 level should already have covered the content listed in the left-hand column of the content grids, but may well need to revise this material before progressing to the right-hand column.

The amount of time spent on each area of content will vary depending on the teaching methodology used and the ability and prior experience of the students. However, the following times may be suggested as a rough guide:

National Unit Specification: support notes (cont)

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Expert systems in context	4 hours
Characteristics of expert systems	9 hours
Development, use and evaluation of expert systems	8 hours
Construction of a working expert system	15 hours

1½ hours should be set aside to:
    a) administer the Outcome 1 test
    b) gather evidence for Outcome 2

A further 2½ hours is allowed for remediation and re-assessment if required.

If the Unit is delivered as part of a Course, the Course documentation will provide further information on teaching and learning in a Course context, including the identification of a number of 'themes' to facilitate holistic learning across the Course.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

National Assessment Bank tests have been created specifically to assess Outcome 1 of the Unit. This assessment consists of a closed book test, and must be conducted under examination conditions. In order to gain success in this Outcome, the candidate must achieve at least the cut-off score for the test. If a centre wishes to design its own assessments for this Unit, they should be of a comparable standard.

Outcome 2 requires the candidate to demonstrate practical skills while using contemporary hardware and software. These practical skills will normally be demonstrated in the context of a number of relatively small tasks. The task(s) will normally be undertaken by the candidate as part of the teaching and learning activities of the Unit, rather than as separate formal assessment activities. The candidate will be allowed access to books, notes and online help while completing the task(s).

To gain success in this Outcome, the candidate must demonstrate practical skills in the following contexts and at an appropriate level as context defined by the content statements (see Information Systems (Higher) Course Content):

♦   find solutions to given problems by consultation of expert systems for advice, classification, diagnosis, or planning
♦   structured testing and critical evaluation of an expert system
♦   representation of a limited domain of knowledge in a structured form
♦   construction of a working expert system given a limited domain of knowledge (involving at least 15 rules, some involving multiple conditions, and requiring chaining to at least three levels)

Hard copy evidence should be provided of the expert system constructed; note that this need not be formal documentation — hard copy of the rule base is sufficient.

An observation checklist for Outcome 2 is provided in the National Assessment Bank materials.

All evidence must be retained by the centre. The assessment of this Unit is subject to moderation by SQA.

National Unit Specification: support notes (cont)

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The assessment of this Unit will require candidates to be familiar with, and able to correctly use in context, the following technical terms:

♦ *advice*	♦ first order (predicate) logic	♦ production rule
♦ certainty factor	♦ *forward/backward chaining*	♦ *query*
♦ *classification*	♦ *inference engine, inferencing*	♦ *question*
♦ *conclusion*	♦ *justification*	♦ recency
♦ conflict resolution	♦ *knowledge*	♦ refractoriness
♦ conflict set	♦ *knowledge acquisition/elicitation*	♦ RETE algorithm
♦ *consultation*	♦ *knowledge base/rule base*	♦ *rule*
♦ decision tree	♦ *knowledge engineer*	♦ specificity
♦ deductive database	♦ *knowledge representation*	♦ *type of expert system: advice; classification; diagnosis; planning*
♦ *domain*	♦ *knowledge representation language (KRL)*	♦ uncertainty
♦ *domain expert*		♦ *user*
♦ *expert system*		♦ *user interface*
♦ *expert system shell*		♦ *validation*
♦ expertise		♦ working memory
♦ *explanation: how, why*		♦ zero order (propositional) logic
♦ *factor table*		
♦ fire		

The terms which are shown in italics are those which are listed in the corresponding table for the Unit Specification for *Expert Systems* (Intermediate 2).

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 special alternative Outcomes for Units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, September, 2003).