National Unit Specification: general information

UNIT **Artificial Intelligence (Advanced Higher)**

NUMBER DF31 13

COURSE Computing (Advanced Higher)

SUMMARY

This Unit is designed to develop knowledge and understanding of the principles of artificial intelligence and practical skills related to artificial intelligence 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 artificial intelligence.

It is designed as an option for candidates undertaking the Advanced Higher Computing Course, but is also suitable for anyone wishing to extend and deepen their experience of artificial intelligence beyond Higher level.

OUTCOMES

1. Demonstrate knowledge and understanding of the principles, techniques and applications of artificial intelligence.
2. Demonstrate practical skills in the context of artificial intelligence 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, or equivalent:

- *Artificial Intelligence* (Higher) Unit
- Higher Computing

Administrative Information

Superclass: CB

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National Unit Specification: general information (cont)

UNIT Artificial Intelligence (Advanced Higher)

CREDIT VALUE
1 credit at Advanced Higher (8 SCQF credit points at SCQF level 7).*

**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
There is no automatic certification of Core Skills or Core Skills components in this Unit.

National Unit Specification: statement of standards

UNIT Artificial Intelligence (Advanced Higher)

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 artificial intelligence.

Performance criteria

(a) A wide range of advanced computing terminology is used appropriately.
(b) Technically accurate descriptions and explanations are related to familiar and unfamiliar contexts.
(c) Conclusions, predictions and generalisations are made from knowledge and understanding.

Evidence requirements

Written or oral evidence that the candidate can describe and explain the principles, techniques and applications of artificial intelligence accurately and concisely. Evidence should be obtained using questions in a closed-book test, under supervision, lasting no more than 45 minutes. The test must sample content (see Artificial Intelligence (Advanced Higher) Course content) in each of the following areas:

- search techniques
- knowledge representation
  - semantic networks/frames
  - declarative language programming
  - rule-based systems

- applications of artificial intelligence
  - computer vision
  - natural language processing
  - robotics
  - machine learning

(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: statement of standards (cont)

UNIT Artificial Intelligence (Advanced Higher)

OUTCOME 2

Demonstrate practical skills in the context of artificial intelligence using contemporary hardware and software.

Performance criteria

(a) Hardware and software is used independently, effectively and efficiently.
(b) Practical tasks are planned and organised independently.
(c) Practical tasks are undertaken in an appropriate range of familiar and unfamiliar contexts.

Evidence requirements

Observational checklist showing that the candidate has demonstrated the following skills in the context and at a level defined by the content statements (see Computing (Advanced Higher) Course content):

- construction of a knowledge base of facts and rules in a declarative language
- implementation of list processing, involving recursion
- creation of queries to elicit information from a knowledge base
- testing a knowledge base
- creation of a rule-based system.

Hard copy evidence should be provided of both the knowledge base and the rule-based system constructed.

These practical skills may be demonstrated in a number of individual, focused tasks, or in a single extended task.

The candidate will be allowed access to books, notes and on-line help while completing the task(s).

(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

UNIT Artificial Intelligence (Advanced Higher)

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 overleaf (and also in the National Course Specifications: Course details.)

Content statements in the left-hand column describe the relevant content covered in the corresponding Unit at Higher 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: Search techniques	
Higher	Advanced Higher
	Application of a problem solving approach to solve problems systematically: ♦ Problem abstraction: definition of the problem in terms of initial state, goal state, constraints. ♦ Symbolic representation: representation of transitional states in a state space graph, tree or production rules. ♦ Search strategy: selection of the best problem-solving technique and apply it to the problem.
	Representation of a problem as a start state (node), goal state (node), and transitions between states. Representation of transitions as production rules. Use of an AND-OR graph as a symbolic representation for appropriate problems.
Comparison of depth-first and breadth-first search (order of visiting nodes, memory implications, advantages and disadvantages, need for backtracking), and exemplification on a search tree. *Description and exemplification of combinatorial explosion.* *Description and exemplification of the use of heuristics to reduce search time/space.*	Definition of a heuristic (or cost/evaluation function). Explanation of advantages and disadvantages of heuristic search techniques. Description and use of the following search techniques: ♦ Hill-climbing ♦ Best first search ♦ A* Description of the relative advantages and disadvantages of each technique. Brief description of the minimax procedure in the context of game playing.

National Unit Specification: support notes (cont)

UNIT Artificial Intelligence (Advanced Higher)

Content Statements: Knowledge Representation	
Higher	Advanced Higher
Description of the software development process as it applies to declarative language programming.	Description of the software development process as it applies to declarative language programming
Creation of a semantic net from given problem statement.	Description of the purpose of frames to represent inheritable knowledge: ♦ comparison of frames and semantic networks ♦ distinction between *classes* and *instances* ♦ description and use of slots, current values, default values, inheritance ♦ use of a frame notation to represent a simple hierarchy of domain knowledge
Description and exemplification of the following features in Prolog (or similar declarative language): ♦ *multi-argument clauses* ♦ *recursive and non recursive rules* ♦ *complex queries: (multiple variable, conjunction of queries)* ♦ *negation* ♦ *inheritance*	Description and exemplification of the following features in Prolog (or similar declarative language): ♦ recursion ♦ list processing
Explanation of the concepts of goal, sub-goal, instantiation, matching.	Explanation of the concepts of goal, sub-goal, instantiation, unification.
Explanation of complex manual trace: multiple level including backtracking.	
	Description and exemplification of multiple inheritance.
Explanation of the importance of the order of rules.	Explanation of the benefit of rules involving inheritance.

National Unit Specification: support notes (cont)

UNIT Artificial Intelligence (Advanced Higher)

Content Statements: Rule-based systems

Higher	Advanced Higher
Expert Systems *Description of the components of an expert system (knowledge base, inference engine, user interface with justification/explanation, working memory).* *Distinction between an expert system and an expert system shell.* *Description of contemporary applications of expert systems.* *Description of advantages of expert systems (including permanence, cost effectiveness, consistency, portability).* *Description of disadvantages of expert systems (including narrow domain, lack of 'common sense', need for expertise to set up and maintain, inability to acquire new knowledge, inflexibility).* *Description of moral issues (including medical implications).* *Description of legal issues (including responsibility when advice is wrong).*	**Rule-based systems** Representation of knowledge in terms of IF..THEN rules. Explanation and exemplification of the use of certainty factors. Identification and explanation of how forward and backward chaining inference may be used or combined to help solve a given problem. Description of the main characteristics of a forward chaining system: working memory; conflict set; conflict resolution. Explanation of why conflict resolution strategies are required. Calculation of the certainty of a conclusion using the formula $CF_{conc} = CF_{rule}$ x min(CF_{cond1}, CF_{cond2}, …)

Content Statements: Applications and uses of artificial intelligence	
Higher	Advanced Higher
Computer vision *Description of the problems of interpreting 2D images of 3D objects.* *Description of the stages of computer vision (image acquisition, signal processing, edge detection, object recognition, image understanding).*	**Computer vision** Application of the Waltz algorithm to a tri-hedral figure to produce a valid labelling. Explanation of the role of search in the application of the Waltz algorithm. Description of the causes and effects of ambiguities.
Natural language processing (NLP): *Identification of the main stages of NLP (speech recognition, natural language understanding (NLU), natural language generation, speech synthesis).* *Explanation of some difficulties in NLP (including ambiguity of meaning; similar sounding words; inconsistencies in grammar of human language; changing nature of language)* *Identification of applications of NLP (including automatic translation, speech driven software, NL search engines, NL database interfaces).*	**Natural language processing** Simple description of main stages of natural language understanding (speech recognition, syntactic analysis, semantic analysis, pragmatic analysis). Description of ambiguities which can occur at each stage. Definition of grammar rules for a simple subset of English involving noun phrase, verb phrase, determiner, noun, proper noun, pronoun, verb, preposition, adjectives, with a simple vocabulary to reflect the grammar. Implementation of a simple parse tree Explanation of the role of search in the parsing process.

National Unit Specification: support notes (cont)

UNIT Artificial Intelligence (Advanced Higher)

Intelligent robots: *Explanation of the difference between dumb and intelligent robots.* *Description of contemporary research and developments.* *Description of social and legal implications of the increasing use of intelligent robots.* *Descriptions of practical problems (including processor power, power supply, mobility, vision recognition, navigation, path planning, pick and place) and strategies for overcoming these problems.*	**Robotics** Description of the classical "blocks world" environment. Definition of the actions (stack, unstack, pickup, putdown) and states (on, ontable, clear, holding, empty) in the blocks world. Application of rules for solving simple problems in the blocks world. Description of the role of planning Explanation of the role of search in the problem solving process.
	Machine learning Description of and distinction between: rote learning, learning from advice, learning from experience, learning from examples (inductive learning); explanation-based learning; learning by discovery; learning by analogy. Exemplification of each type of learning. Recommendation of a learning method for given scenario.

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 implementation of Prolog (or a similar declarative language. Many versions are available either commercially or as freeware. A search on the World Wide Web will lead to sources for these.

The two Outcomes should be delivered in an integrated way rather than sequentially. For Outcome 2, the practical activities, both computer based and non-computer based, should be taught and used to illustrate and exemplify the knowledge and understanding required for Outcome 1, whenever this is possible. At the very least, candidates should carry out practical tasks using Prolog, and have experience of creating a rule-based system using an expert system shell. Practical illustrations of other applications and uses of artificial intelligence should be provided where suitable hardware and software is available.

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 candidates. However, the following times are suggested as a rough guide:

Problems and search	12 hours
Knowledge representation	10 hours
Applications and uses of Artificial Intelligence	14 hours

1½ hours would be set aside to:

- administer the Outcome 1 test
- gather evidence for Outcome 2

National Unit Specification: support notes (cont)

UNIT Artificial Intelligence (Advanced Higher)

A further 2 ½ 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 1of the Unit. This assessment consists of a closed book test, and must be conducted under supervision. 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 a single extended task or a number of relatively small tasks. The task(s) may 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 on-line help while completing the task(s). The practical skills should be demonstrated in the context defined in the content statements (see Artificial Intelligence (Advanced Higher) Course content).

To gain success in this Outcome, the candidate must demonstrate practical skills in the following contexts:

- construction of a knowledge base of facts and rules in a declarative language
- implementation of list processing, involving recursion
- creation of queries to elicit information from a knowledge base
- testing a knowledge base
- creation of a rule-based system

Hard copy evidence should be provided of both the knowledge base and the rule-based system constructed.

A pro-forma observation checklist for Outcome 2 is provided in the National Assessment Bank materials.

All evidence for Outcome 2 should be gathered under 'open-book' conditions and must be retained by the centre. The assessment of this Unit is subject to moderation by SQA.

National Unit Specification: support notes (cont)

UNIT Artificial Intelligence (Advanced Higher)

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

Problem spaces and search ♦ constraint ♦ goal state ♦ heuristic ♦ initial state ♦ production rule ♦ state space ♦ state space search ♦ transition	*Prolog* ♦ backtracking ♦ compound term ♦ instantiation ♦ list ♦ recursive	*General terms* ♦ ambiguity ♦ combinatorial explosion
Frames ♦ class ♦ default ♦ inheritance ♦ instance ♦ multiple inheritance ♦ slot	*Computer vision* ♦ edge ♦ trihedral ♦ vertex ♦ Waltz algorithm	*Natural language understanding* ♦ discourse ♦ grammar ♦ parse ♦ pragmatic ♦ semantic ♦ syntactic
Robotics ♦ pre-condition ♦ post-condition	*Machine learning* ♦ decision tree ♦ inductive ♦ rote learning	

Note that this list is not exhaustive: in particular, there are some terms in everyday use which also are applied to aspects of artificial intelligence, and which are not reproduced here, eg 'analogy' (as a learning method in machine learning).

CANDIDATES WITH ADDITIONAL SUPPORT NEEDS

This Unit Specification is intended to ensure that there are no artificial barriers to learning or assessment. The additional support 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 document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* (SQA, 2004).