UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE

ARTIFICIAL INTELLIGENCE 2

Monday, 11th June, 1984 2 - 5pm

Examiners: Chairman J A M Howe
External R M Young

INSTRUCTIONS TO CANDIDATES

1. Candidates in the third or later years for the degree of B.A. (Arts), B.Com., B.Sc. (Social Science), B.Sc. (Science) and LL.B. should put (3) after their names on the script book.

2. Answer any FOUR questions. All questions carry equal weight.

3. Each question is marked out of 100%. The marks at the side of the questions show how these are apportioned.

1. a) Explain the difference between forward and backward chaining. 20%

b) Given a set of facts {p, q, r, s, t} and the following ordered set of rules

```
m & n -> g
j & k -> m
    p -> n
v & w -> j
    t -> j
q & r -> k
    l -> z
    x -> y
    h -> x
p & r -> l
s & t -> h
```

show how the goal g can be derived by forward and backward reasoning. 50%

c) Which method is most efficient? Without necessarily repeating the above exercise, which method would be most efficient if you reversed the order of the rules in the rule set, and why should this be the case? 30%

2. Universal Widgets Ltd. produces 27 different kinds of widgets - three colours, three sizes, and three shapes. They use a 3 digit code to identify particular kinds of widgets, as defined below:

x0x - unspecified for colour, x1x - red, x2x - green, x3x - blue
0xx - unspecified for size, 1xx - big, 2xx - medium, 3xx - small
xx0 - unspecified for shape, xx1 - round, xx2 - square, xx3 - oblong

Thus a big, red, square widget has the code 112.

You have been asked to build a part of a new computerised inventory and order control systems for Universal Widgets. Your part of the system is a natural language interface, which translates typed descriptions of widgets, consisting of conjunctions and disjunctions of properties, into one or more (in the case of ambiguity) sets of identification codes. A set of example inputs and outputs is given below:

i) big and red and square => {112}
ii) blue and round => {031}
iii) medium => {200}
iv) oblong or square =>{003, 002}
v) red or small => {010, 300}
vi) medium and round or square and green =>
{201, 022}, {221, 222}, {201, 222}

Note in particular the last example, which receives three different interpretations depending on whether it is analysed as '(m and r) or (s and g)' or '(m and (r or s) and g' or 'm and (r or (s and g)).'

a) Give a grammar of context-free phrase structure rules for use in the interface. It should recognise all strings of the form (q c)*q, where q is one of the nine widget qualifiers listed above, and c is 'and' or 'or'. Your grammar should produce triple-branching recursive structures, and produce two analyses for i) and three for vi). 10%

b) Provide semantic interpretation information for your grammar, specifying for each rule in your answer to part a) what the meaning of its part of an analysis tree is, either as a constant or as some function of the meanings of its descendants. You may assume the user is cooperative - that is, you do not have to worry about what to do with e.g. "round and square". 20%

c)/... continued on next page

Continued from previous page

2. c) For each of the six example descriptions given above, provide tree-structured analyses, showing how the interpretations given are built up according to your answer to b). 10%

d) Discuss the consequences of the ambiguity of your grammar for the parsing and interpretation process. Include a description of the two different approaches to producing multiple analyses we have considered in the course. 30%

e) What is meant by the phrase "compositional semantics?". Is your solution to b) compositional? What are the benefits of such an approach to the problem of computing internal representations? 30%

3. a) Turner applied the line labelling approach to regular curved objects.

i) Explain the problems that arise when handling surfaces that are non-planar. 20%

ii) Explain the rationale for Turner's labelling scheme. 30%

b) Mackworth constructed a program that interprets line drawings of objects.

i) Explain the limitations of line labelling of polyhedral objects. 20%

ii) Outline Mackworth's gradient space technique. 30%

4. You have been given the task of developing a domestic robot by a major manufacturer of domestic appliances. The robot is to exist in prototype form by 1990. It should be capable of performing at least one task of real utility to a householder. Discuss the design of the robot, its software and hardware. 100%

5. Consider what would be involved in constructing a question answering system, using first-order logic and a database of assertions, which could perform as follows:

i) User: Robin bought a car.

ii) User: The car is red.

iii) User: Does Robin own a red car?

iv) System: Yes.

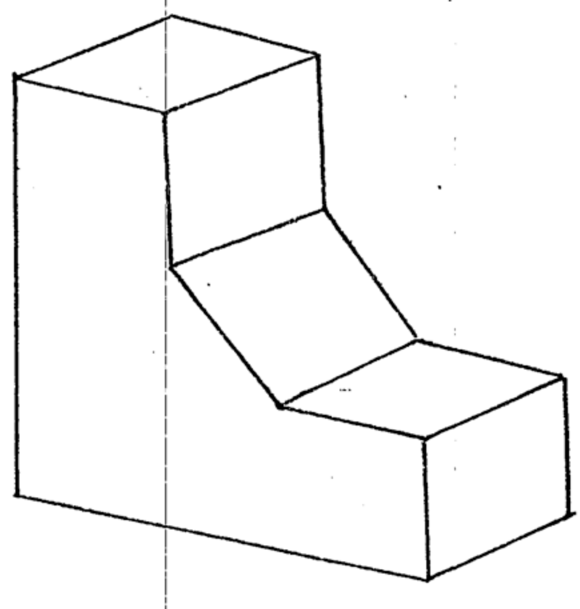
a) Given the one-place predicates car(X) and red(X) and the two-place predicates own(X,Y) and buy(X,Y) associated with the appropriate words in the lexicon, and the constant robin associated with the word "Robin", give translations for i) and ii) into assertions of first-order logic for addition to the database and for iii) into a query to be checked against the database. 25%

b) Give a goal-directed proof of your translation of iii), assuming your translations for i) and ii) have been asserted. You will need an axiom/meaning postulate relating buy and own. 25%

c) Discuss how proper nouns, definite noun phrases, and indefinite noun phrases are treated differently in this sort of approach to meaning. Use examples from a). Include the difference between indefinite noun phrases in statements and questions, e.g. in i) and iii). 50%

6. Any expert system must be able to apply a large body of knowledge efficiently and effectively to particular problems. Take TWO expert systems as your exemplars and compare and contrast the ways in which they focus and control deductive inference during the search for a solution. 100%

7. Robert's program recognises the bodies in the following scene:



(a) Step by step, explain how Roberts' program decomposes this scene into its primitive objects. 30%

(b) Using drawings of the scene, identify the picture fragments which act as cues to models. 20%

(c) Using drawings of the scene, show how the models account for the scene. 20%

(d) Discuss the program's limitations as a recognition system. 30%

8. The gripper shown in Figure 2 has two "fingers" which are moved in and out by equal and opposite amounts by a motor. The fingers are symmetrically disposed in the gripper. If g is the gap between the fingers, write down a ROBMOD expression for the shape of the gripper with its fingers. Take account of the position of the co-ordinate axes. 40%

The gripper is to be used to insert a variety of components into printed circuit boards. Discuss how you would use ROBMOD to verify that a particular component insertion plan was valid. Discuss ROBMOD's adequacy for this purpose. Would you wish to use other software in conjunction with ROBMOD, and if so what function would it perform? 60%

Figure for Question 8

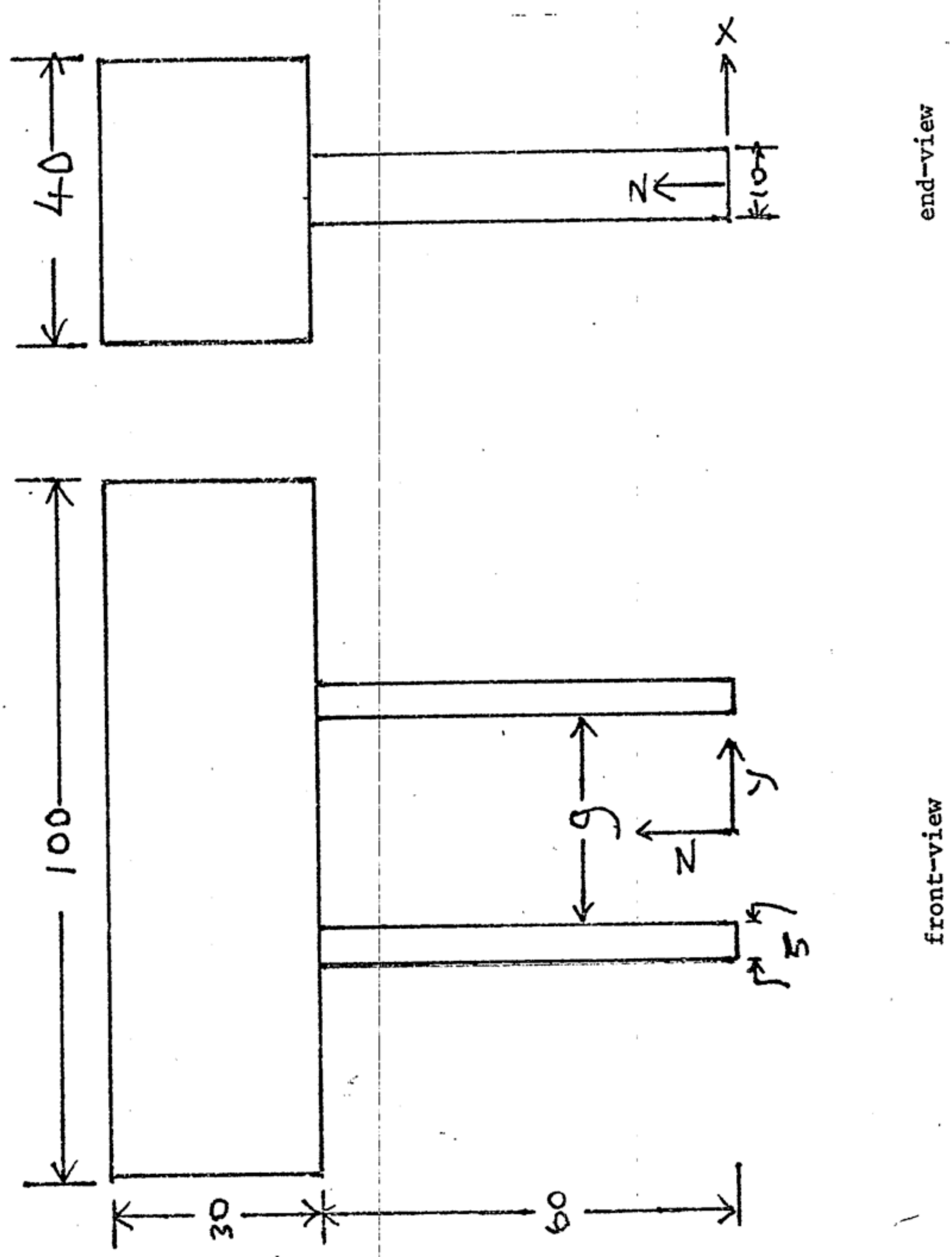


Figure 2