

2022 EXAMINATIONS



Part II

COMPUTING AND COMMUNICATIONS – On-line Assessment [150 Minutes]

SCC.312 Languages and Compilation

*Candidates are asked to answer **THREE** questions from **FOUR**; each question is worth a total of 25 marks.*

[Please turn over]

Question 1:

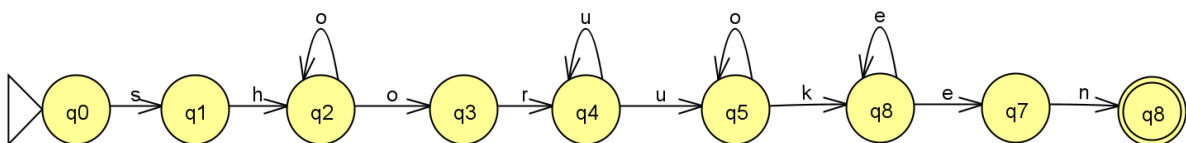
1.a Write a set of grammar rules in Backus-Naur Form (BNF) to describe the name and seat number of the attendees of the UN Climate Change Conference (COP26), where Greta Thunberg is giving a talk on Climate Change. Each of the attendees will have a lanyard badge showing their names and specific seat. You should include BNF rules describing the structure of the attendee's details and each element such as name and seat number. The badge could show first and last names followed by the seat number. Some attendees may decide they want the initial of their middle name to be included. Others may just want only their last name to appear. In all cases the seat number should always follow the name.

Notes:

- You do not need to specify the full set of terminal symbols corresponding to each non-terminal.
- Up to three example terminal symbols are sufficient for each non-terminal.
- You do not need to include punctuation characters in your grammar.
- Terminal symbols for attendee names in this grammar are words in the English alphabet separated by spaces.
- Seat numbers are made of three digits.
- Attendees with single- or two-digits seat numbers should be preceded with zero(s).
- Examples: "David Attenborough 001", "Anne Hidalgo 035", "Carlos M Rodriguez 003", "Nguy T Khanh 211" and "Parikh 202" are accepted but it should reject sentences as "Naomi Klein", "M Allen", "25 Sefiani", "M A Sowah", "99", and "J 15".

[5 marks]

1.b Generate the grammar associated with this finite state recogniser (FSR):



[3 marks]

1.c Using set definition notation, describe the set of valid sentences accepted by the FSR in part **1.b** above.

[3 marks]

Question 1 continues next page

[Please turn over]

1.d Mention which states are non-deterministic then generate a deterministic FSR from the non-deterministic FSR in question **1.b**.

[7 marks]

1.e Given the following production rules for a context free language, draw (by hand or using JFlap) a non-deterministic push-down recognizer (PDR) directly from this grammar. Four marks will be given for the correct nodes and three marks for the correct arcs in the graph.

$S \rightarrow cA \mid sA \mid hA \mid rA$

$A \rightarrow a \mid aA \mid vB \mid aAA$

$B \rightarrow e \mid eS$

[7 marks]

[Total 25 marks]

[Please turn over]

Question 2:

2.a Consider the following grammar:

$S \rightarrow wA \mid lA \mid sA$

$A \rightarrow e \mid eA \mid kB \mid eAA$

$B \rightarrow s \mid sS$

Classify this grammar by explaining what type of grammar it is and why.

[2 marks]

2.b Show that the grammar in part **2.a** is ambiguous. Illustrate your answer by providing two possible parse trees for the sentence: 'weeks'

[3 marks]

2.c Modify the grammar in **2.a** to do the following:

- i. In addition to the strings it already accepts, the grammar should also accept the new strings: "sad", "wad" and "lad", and their plural forms.
- ii. Demonstrate that the grammar is still ambiguous when considering a word such as "laads" by creating two possible parse trees.

Note: The grammar should continue to have the 3 non-terminals S, A, and B.

[4 marks]

Question 2 continues next page

[Please turn over]

2.d The base-1 format is used to represent unary numbers, as follows: 1 is 1, 2 is 11, 3 is 111, 4 is 1111 and so on. This format can be used to keep a tally or count of something. Design a Turing Machine to carry out unary addition of two numbers. The initial TM tape will be set up with a unary number on the left followed by a plus sign and finally a smaller or higher number on the right. For example, to represent five plus two the input tape would look like (B refers to blank):

... BBB11111+11BBB
 or ... BBB11+11111BBB

The resulting tape should show the answer (i.e., seven):

... BBB1111111BBB

You can assume that neither number will be zero and the input tape will only consist of 1s and a single plus sign, so no error checking is required. The read/write head will start directly over the leftmost non-blank symbol. First describe your algorithm in words and then draw a TM to carry out the addition operation.

Your answer should include:

- 1- a description of the algorithm that you have used (6 marks)
- 2- a diagram of the Turing Machine itself (a screenshot from JFlap is recommended but a hand-drawn one is also accepted), you can also provide a screenshot of a number of examples showing accept/reject and output in JFlap or a normal table (10 marks)

Note: Your TM should not accept strings other than 1s and one plus sign (+).

[16 marks]

[Total 25 marks]

[Please turn over]

Question 3:

Here is a grammar G, with terminals {h, a, l, o}, non-terminals {H, A, L} where H is the distinguished symbol.

$H \rightarrow h A$

$A \rightarrow a L$

$L \rightarrow l L$

$L \rightarrow o$

Build the Action and Goto tables for this grammar. In your answer, you **must** use the technique shown in the course.

Marks will be awarded as follows.

Step 1 : augment the grammar [1 mark]

Step 2 : build the item sets. [15 marks]

Step 3 : generate the state transition table [3 marks]

Step 4 : produce the Action and Goto Tables. [6 marks]

[Total 25 marks]

[Please turn over]

Question 4:

4.a Here is an augmented grammar G, with terminals {a, b, c}, non-terminals {T, A, B} and T is the distinguished symbol, along with the Action and Goto tables.

- (0) $S \rightarrow T$
- (1) $T \rightarrow A b B$
- (2) $T \rightarrow B$
- (3) $A \rightarrow a B$
- (4) $B \rightarrow c$

action	a	b	c	\$
0	4	5		
1				acc
2		6		
3	r2	r2	r2	r2
4			5	
5	r4	r4	r4	r4
6			5	
7	r3	r3	r3	r3
8	r1	r1	r1	r1

goto	T	A	B
0	1	2	3
1			
2			
3			
4			7
5			
6			8
7			
8			

Parse the sentence "a c b c". Show all working and the changing state of the parser.

[17 marks]

4.b What kind of information is stored in the symbol table? Your answer should consider simple variables, arrays, functions and record types.

[6 marks]

4.c Show how the symbol table might be used to reveal the error in the following program fragment:

```
public void one()  
{  
  int x ;  
  x = "42" ;  
} // end of method one
```

[2 marks]

[Total 25 marks]

--- End of paper ---