2021 EXAMINATIONS

Part II

COMPUTING AND COMMUNICATIONS – On-line Assessment

Available Time **[23 Hours]**

Recommended Completion Time **[3 Hours]**

SCC.312 Languages and Compilation

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

Question 1

1.a Copy this table and complete the classification of phrase structure grammars and machines by filling in the blank cells.

Type	Grammars	Machines
0		
1		
2		
3		

[4 marks]

1.b Give the name for the classification scheme invented by an American linguist.

[1 mark]

1.c Consider the following set of Backus–Naur Form (BNF) production rules. Generate a parse tree for the sentence "The footballer scores a goal":

<simple_sentence> ::= <noun_phrase> <verb> <noun_phrase>
<noun_phrase> ::= <article> <noun>
<noun> ::= footballer | ball | goal
<article> ::= the | a
<verb> ::= tackles | kicks | scores

[5 marks]

1.d Derive a syntactically valid sentence from the grammar in part **1.c** whose meaning is nonsensical in English.

[1 mark]

1.e What type is the grammar in **1.c** according to the classification in the table that you completed in part **1.a**? Explain your answer in no more than 40 words.

[3 marks]

Question 1 continues on next page…

Question 1 continued.

1.f In the process of coding a Universal Turing Machine (UTM), describe what is contained in each quintuple.

[2 marks]

1.g What two restrictions are placed upon type 1 grammar rules that are not placed on type 0 grammar rules?

[3 marks]

1.h Assume you have just been awarded a PhD degree and want to change your title in all of your documents into Dr (no dot to follow). Design a Turing machine that transforms titles such as Mrs, Miss, Ms, Mx and Mr into Dr. A possible input tape for a TM is (the Bs are blank symbols):

...BBBMissBB

Your Turing machine should be able to process this and subsequently end up with a tape containing a Dr title as in:

...BBBDrBBB

Your answer should include:

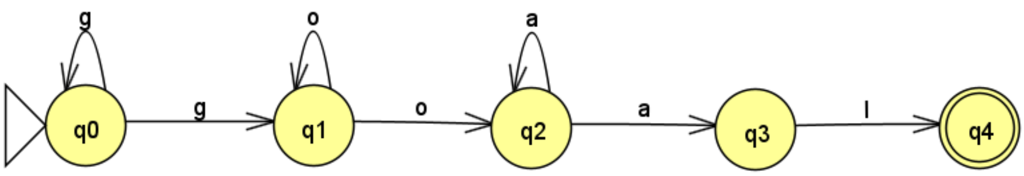
- a diagram of the Turing Machine itself (a screenshot from JFlap is recommended)
- Your TM should not accept strings other than Mrs, Miss, Ms, Mx and Mr. **Do not include a dot.** Strings such as 'Mrrrr', 'Missss', or 'Mi' should be rejected.

[6 marks]

[Total 25 marks]

Question 2

2.a Generate the grammar associated with this finite state recogniser (FSR):



[2 marks]

2.b Using the grammar in part **2.a,** give two examples of valid sentences and two examples of sentences that are not valid.

[2 marks]

2.c The FSR in part **2.a** is non-deterministic. Mention which states are non-deterministic

[1 mark]

2.d Using set definition notation, describe the set of valid sentences accepted by the FSR in part **2.a** above.

[2 marks]

2.e Using the subset construction algorithm, generate a deterministic FSR from the above non-deterministic one.

[3 marks]

2.f Consider the following grammar:

S $\rightarrow$ cA | bA

A $\rightarrow$ a | aA | tB | aAA

B $\rightarrow$ s | sS

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

[2 marks]

Question 2 continues on next page…

Question 2 continued.

2.g Show that the grammar in part **2.f** is ambiguous. Illustrate your answer by providing two possible parse trees for the sentence: ‘caats’

[4 marks]

2.h Give two examples of sentences (words) that are accepted by this grammar and three sentences that are rejected.

[2 marks]

2.i Generate a non-deterministic push-down automata (PDA) directly from the grammar in part **2.f** above.

[5 marks]

2.j Define the halting problem and briefly explain (maximum one paragraph) the implications of the halting problem for a Universal Turing Machine simulating a Turing Machine.

[2 marks]

[Total 25 marks]

Question 3

3.a When designing a split compiler with an Intermediate Language (IL) you may encounter problems when using multiple front-end languages (say, C vs Java front-ends). State one of the problems you might encounter, explain why this is a problem, and propose a solution.

[5 marks]

3.b.

i. Using the following grammar and input string, show each step of a bottom-up (LR) parse to attain a single <value>. Starting with an empty stack, at each step of the parse show the state of the stack, and the cursor location in the input stream.

Grammar:

```
<value> ::= <number> | <expression>
<number> ::= { any integer number }
<expression> ::= <value> * <value> | <value> / <value>
<expression> ::= <value> + <value> | <value> - <value>
```

Input:

```
2 + 3 * 4
```

[16 marks]

ii. What answer does this expression interpreter produce from the input string above, and what might be incorrect about this result? Demonstrate your answer with examples.

[4 marks]

[Total 25 marks]

Question 4

4.a Draw the parse tree for the following expression; remember the order of operations:

a + b * c

[2 Marks]

4.b Using the parse tree for **4.a**, produce for each node of the tree a code and result (CR) block. Start at the leaves of the tree and write out each in order to reach a complete block for the root of your parse tree.

[10 Marks]

4.c.

i. Rewrite the following code/result block to optimize it for memory efficiency, while still adhering to the Three-address code (TAC) methods.

C	`t1 = st[a] + st[b]`
	`t2 = st[c] + st[d]`
	`t3 = st[e] + st[f]`
	`t4 = t1 + t2`
	`t5 = t3 / 4`

R	`t4`

[3 Marks]

ii. Explain why the a compiler might want to do this? In your answer state a type of machine that might benefit from this output style.

[2 Marks]

iii. In a language using structure equivalence to determine type equality, explain how the following pseudocode definition might cause problems.

```
type node is record
    value : integer
    next : pointer to node
end record
```

[4 Marks]

4.d State and provide an example for each form of type coercion

[4 marks]

[Total 25 marks]

--- End of Paper ---