This question paper consists of 4 printed pages, each of which is identified by the Code Number COMP232101.

School of Computing

May/June 2018

COMP2321

Formal Languages and Finite Automata

Answer all THREE questions

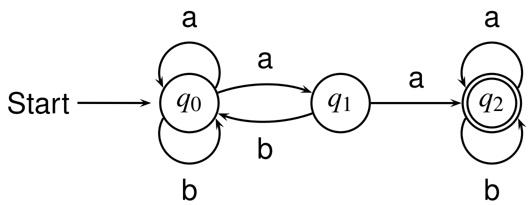
Time allowed: 2 hours

TURN OVER FOR QUESTIONS

Question 1

(a) What is the state transition function of a deterministic finite automaton? State its functionality. **[2 marks]**

(b) What feature of the finite automaton drawn below makes it non-deterministic? Construct a deterministic finite automaton which is equivalent to the non-deterministic finite automaton below.



[7 marks]

(c) Write down a regular expression which denotes the language accepted by the finite automaton above. **[4 marks]**

(d) (i) Is $(0+1)^* = (1+0)^*$? Explain your answer.

(ii) Is $(01)^* = (10)^*$? Explain your answer.

[4 marks]

(e) Compare and contrast the Turing Machine and the Finite Automaton, with particular reference to their power as modules of computation. **[3 marks]**

[question 1 total: 20 marks]

Question 2

(a) Define the word *ambiguous* as used of grammars. **[2 marks]**

(b) Show, using a diagram or diagrams, that the following grammar is ambiguous. The grammar is presented in BNF notation. The semicolon symbol is one of the terminals in the grammar.

$< Program >$ ::= $< ListofStatements >$
$< ListofStatements >$ ::= $< Statement >$ | $< Statement >$; $< ListofStatements >$
$< Statement >$ ::= S | T | U | $< WhileStatement >$
$< WhileStatement >$ ::= While $< Boolean >$ do $< ListofStatements >$
$< Boolean >$ ::= **true** | **false**

[5 marks]

(c) Explain how a parse tree can be used to give meaning to a word in a context-free grammar. Show on a diagram how this method gives meaning to the word $+\times 324$ in the grammar

$< expr >$ ::= + $< expr > < expr >$ | $\times < expr > < expr >$ | $< digit >$
$< digit >$ ::= 1 | 2 | 3 | 4

[7 marks]

(d) The statement of the Pumping Lemma for Regular Languages is given below.

For any regular language L on an alphabet Σ there exists a constant $n \in N$ such that for all $z \in L$ with $|z| > n$ there exist $u, v, w \in \Sigma^*$ satisfying: $z = uvw$; $|uv| \leq n$; $|v| \geq 1$; $(\forall i \in N) uv^i w \in L$.

Use this lemma to prove that the language

$$L = \{a^j b^{3j} c^j \mid j \in N\}$$

is not regular on the alphabet $\{a, b, c\}$.

[6 marks]

[question 2 total: 20 marks]

Question 3

(a) What is a *parser* for a grammar? **[2 marks]**

(b) Explain the statement *the parsing problem for grammars is undecidable*. **[3 marks]**

(c) What does the program *Yacc* do?
As part of your answer explain why *Yacc* does not constitute a contradiction to to the statement that the parsing problem for grammars is undecidable. **[4 marks]**

(d) What are the *computable functions*, also known as the partial recursive functions? **[3 marks]**

(e) It is possible to define an *uncomputable function* by *diagonalising out of* the computable functions. Explain how this is done. **[5 marks]**

(f) Explain the statement *the Halting Problem is undecidable*. Use only words; do not use any mathematical symbols. **[3 marks]**

[question 3 total: 20 marks]