UNIVERSITY EXAMINATIONS

EXAMINATION FOR SEPTEMBER / DECEMBER 2019/2020 FOR BACHELOR OF SCIENCE IN COMPUTER SCIENCE

RCS 204: THEORY OF COMPUTATION

17TH DECEMBER 2019 **TIME: 2 HOURS**

GENERAL INSTRUCTIONS:

Students are NOT permitted to write on the examination paper during examination time.

This is a closed book examination. Text book/Reference books/notes are not permitted.

SPECIAL INSTRUCTIONS:

This examination paper consists Questions in Section A followed by section B.

Answer **Question 1 and any Other Two** questions.

QUESTIONS in ALL Sections should be answered in answer booklet(s).

1. **PLEASE start the answer to EACH question on a NEW PAGE.**
2. **Keep your phone(s) switched off at the front of the examination room.**
3. **Keep ALL bags and caps at the front of the examination room and DO NOT refer to ANY unauthorized material before or during the course of the examination.**
4. **ALWAYS show your working.**
5. **Marks indicated in parenthesis i.e. ( ) will be awarded for clear and logical answers.**
6. **Write your REGISTRATION No. clearly on the answer booklet(s).**
7. **For the Questions, write the number of the question on the answer booklet(s) in the order you answered them.**
8. **DO NOT use your PHONE as a CALCULATOR.**
9. **YOU are ONLY ALLOWED to leave the exam room 30minutes to the end of the Exam.**
10. **DO NOT write on the QUESTION PAPER. Use the back of your BOOKLET for any calculations or rough work.**

Instructions: Answer Question ONE and any other TWO questions.

Question One

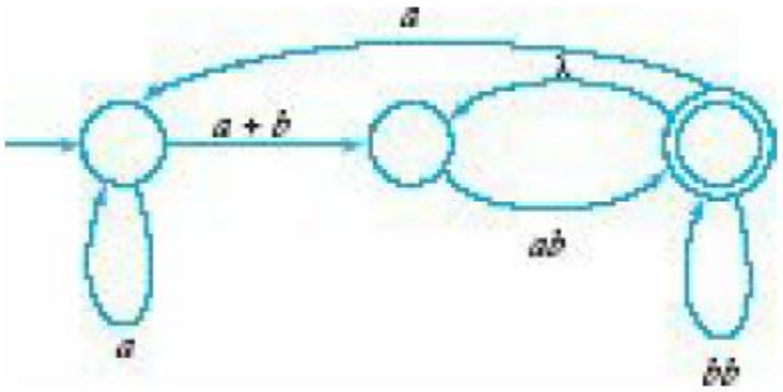
a. Determine the language generated by the following grammar:

G: N = {S, A, B} T = {a, b} P = {S → AB, A → aA|a, B → bB|b} **(4 marks)**

b. Construction of a minimal DFA accepting set of strings over {a, b} in which every 'a' is followed by a 'b' **(5 marks)**

c. Consider the DFA below and use it to answer the questions that follow.

d. Consider the following generalized transition graph.

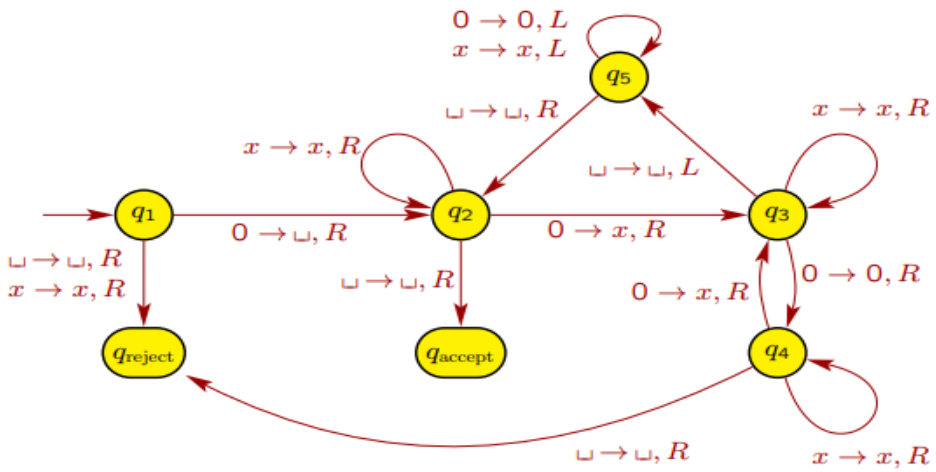


i. Find an equivalent generalized transition graph with only two states.

ii. What is the language accepted by this graph? **(4 marks)**

e. Give a pushdown automata that recognize the following language:
A = {w ∈ {0, 1} ∗ | w contains at least three 1s} (**5 marks)**

f. The Turing machine M below recognizes the language A = $\{0^{2^n} \mid n \geq 0\}$



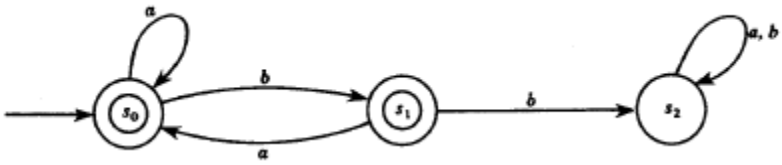
In each of the parts below, give the sequence of configurations that M enters when started on the indicated input string

a. 00 **(3 marks)**
b. 000000 **(4 marks)**

g. Outline two characteristics of a regular language **(2 marks)**

h. Describe the language L(M) of the automaton M below **(3 marks)**

i.



Question Two

a. Give a regular expression that generates the language over the alphabet *{a, b}* where each b in the string is followed by exactly one or three a's (so ε, aaa, and babaaa are in the language but baabaaa is not). **(5 marks)**

b. Determine whether the grammar implicitly defined by the following rules is ambiguous **(3 marks)**

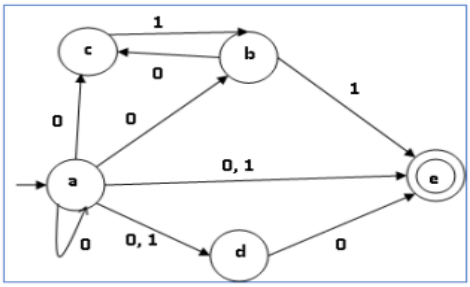
$$S \longrightarrow AB$$
$$A \longrightarrow aA$$
$$A \longrightarrow abA$$
$$A \longrightarrow \varepsilon$$
$$B \longrightarrow bB$$
$$B \longrightarrow abB$$
$$B \longrightarrow \varepsilon$$

The following defines a grammar *G* with *S* as the start symbol:

$$V = \{A, B, S, a, b\}, \quad T = \{a, b\}, \quad P = \{S \xrightarrow{1} AB,\ A \xrightarrow{2} Aa,\ B \xrightarrow{3} Bb,\ A \xrightarrow{4} a,\ B \xrightarrow{5} b\}$$

i. Deduce the production rules **(3 marks)**

c. Consider the NFA shown in the figure below:



Draw the equivalent DFA **(4 marks)**

d. Let M be the finite state machine with state table appearing below **(5 marks)**

F	a	b
s_0	s_2, y	s_1, z
s_1	s_2, x	s_3, y
s_2	s_2, y	s_1, z
s_3	s_3, z	s_0, x

i. Find the input set A, the state set S, the output set Z, and the initial state of M.

ii. Draw the state diagram D = D(M) of M.

Question Three

a. Construction of a minimal DFA accepting set of strings over {a, b} in which every 'a' is never be followed by 'b' **(5 marks)**

b. (a+b)* is an example of a regular expression. It is a set of strings of a's and b's of any length including the null string. So L = { ε, a, b, aa , ab , bb , ba, aaa…….}.

i. What are the strings accepted by the regular expression (11)* **(2 marks)**

ii. Draw a Finite automata to the above regular language **(5 marks**

c. For each of the following languages, construct an NFA that accepts the language. In Both cases, the alphabet is {0, 1}.

i. {w : w contains the substring 11001} **(4 marks)**

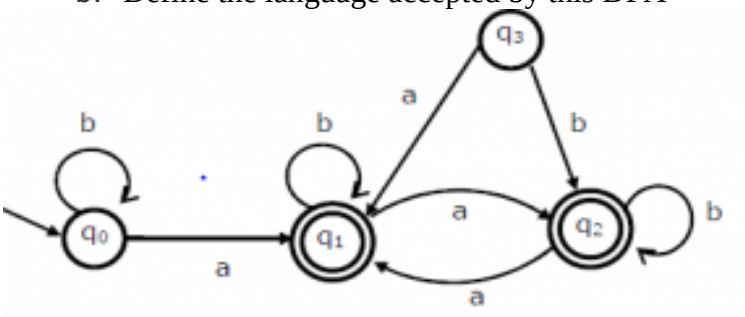
ii. {w : w has length at least 2 and does not end with 10} **(4 marks)**

Question Four

a. Consider the language L = $\{a^n b^n \mid n > 0\}$. **(4 marks)**

i. Find a context-free grammar *G* which generates *L*.
ii. Find a regular grammar *G* which generates *L*.

b. Define the language accepted by this DFA **(4 marks)**



c. Consider the following grammar G= ({a,b},{S,A,B}, S, P) with P:
S ::= Aba
A ::= a
Ab ::= AAbA | ABb | AbB
B ::= A | AB

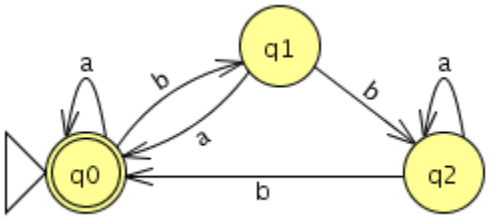
i. What type of grammar is it? Explain in detail. **(4 marks)**

ii. Define the language generated by means of a regular expression **(4 marks)**

d. Draw and automata the generate a valid variable names in C++ **(4 marks)**

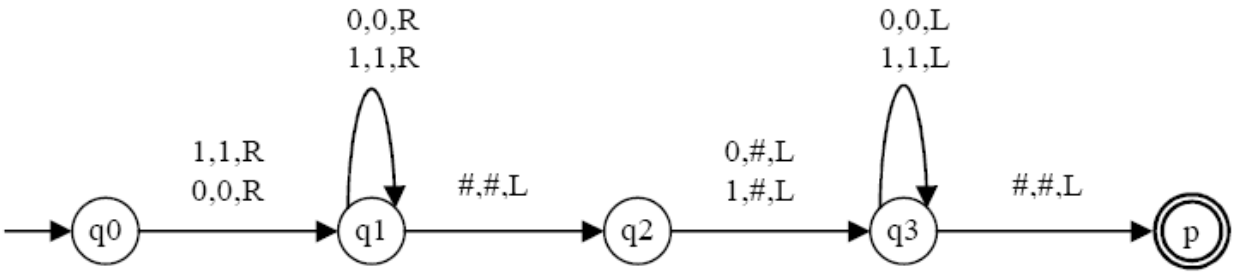
Question Five

a. Find a regular expression that generates the language accepted by the following DFA.



(5 marks)

b. Given the following Turing Machine



TM = ({q0,q1,q2,q3},{0,1},{0,1,#},δ,q0,{p})

i. Write the transition table. **(7 marks)**

ii. Which is the function that the TM carries out? Explain in detail. **(4 marks)**

iii. Show the sequence of movements to process the input string "1110" **(4 marks)**