Final Exam

Program:	**Computer Science**		
Course Name:	**Compilers**	**Date:**	**27/6/2021**
Course Code:	**CS419**	**Duration:**	**2 hours**
Instructor(s):	**Dr. Amin Allam**	**Total Marks:**	**60 marks**

تعليمات هامة:

- حيازة التليفون المحمول مفتوحا داخل لجنة الأمتحان يعتبر حالة غش تستوجب العقاب وإذا كان ضرورى الدخول بالمحمول فيوضع مغلقا فى الحقائب .
- لا يسمح بدخول سماعة الأذن أو البلوتوث .
- لايسمح بدخول اي كتب أو ملازم أو أوراق داخل اللجنة والمخالفة تعتبر حالة غش .

- **Exam consists of 40 multiple-choice questions in 6 pages. Each question weights 1.5 marks.**
- **Record in the bubble sheet exactly ONE answer for each question.**

Qa ⇒ For questions 1 to 6, consider the subset construction algorithm to convert the following NFA to DFA (without minimization). Let $T(s, a) = r$ means that there exists a direct transition (edge) in the NFA that starts from state s and ends at state r having the label a. The possible transition labels are $\{a, b, m\}$.

- The NFA consists of 8 nodes (labelled from 0 to 7) and the following 9 transitions:

$T(0,\varepsilon) = 1, T(0,\varepsilon) = 4, T(1,a) = 2, T(2,m) = 3, T(4,\varepsilon) = 5,$
$T(4,\varepsilon) = 6, T(5,a) = 7, T(6,b) = 7, T(7,\varepsilon) = 0.$

- The start state of the NFA is 0 and the accepting state is 3.

1 The start state of the resulting DFA is the ε-closure of state 0 in the original NFA, which is:
A {0} B {0,1} C {0,1,2} D {0,1,4} E {0,1,4,5,6}

2 The following state belongs to the resulting DFA:
A {1} B {2} C {3} D {5} E {6}

3 The following state belongs to the resulting DFA:
A {0,1,2,3,4,5,6} B {1,2,3,4,5,6,7} C {0,1,2,3,5,6,7} D {0,1,2,4,5,6,7} E {0,1,2,3,4,5,7}

4 The following state belongs to the resulting DFA:
A {0,1,4,5,6,7} B {1,2,4,5,6,7} C {0,1,2,3,5,6} D {1,2,3,5,6,7} E {0,1,3,4,5,7}

5 The number of transitions (edges) labelled a in the resulting DFA (without including transitions to or from the hidden error state) is:
A 1 B 2 C 3 D 4 E 5

6 The number of transitions (edges) labelled b in the resulting DFA (without including transitions to or from the hidden error state) is:
A 1 B 2 C 3 D 4 E 5

Qb ⇒ For questions 7 to 12, consider the DFA minimization algorithm to minimize the following D construct an equivalent DFA with the minimum number of states. Let $T(s, a) = r$ means that there a direct transition (edge) in the DFA that starts from state s and ends at state r having the label possible transition labels are $\{a, b\}$.

- The original DFA consists of 5 nodes (labelled from 0 to 4) and the following 8 transitions: $T(0, a) = 1$, $T(0, b) = 2$, $T(1, a) = 1$, $T(1, b) = 3$, $T(2, a) = 1$, $T(2, b) = 2$, $T(3, b) = 4$, $T(4, b$
- The start state of the original DFA is 0 and the accepting state is 4.

7 The number of states in the resulting DFA is:
A 1 B 2 C 3 D 4 E 5

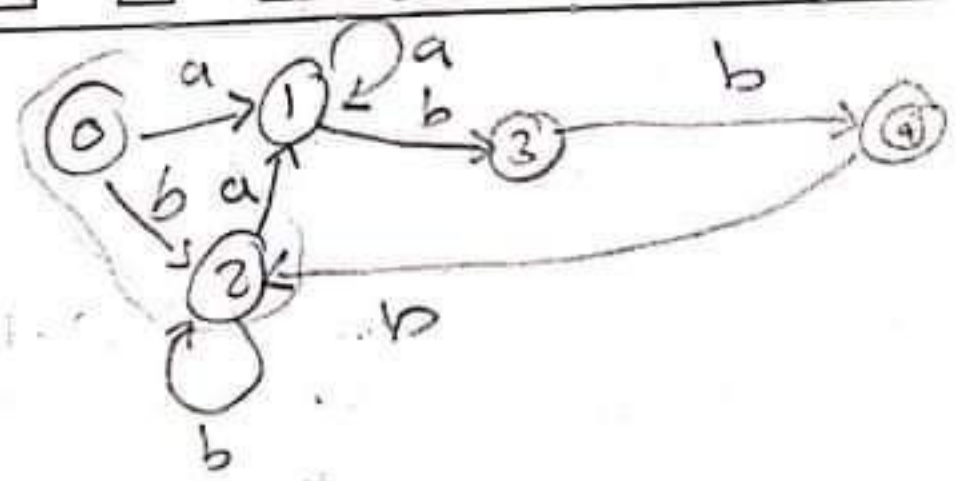
8 The following original DFA states are combined to form one state in the resulting DFA:
A {0} B {0,1} C {0,2} D {0,1,2} E {0,1,2,3}

9 The following original DFA states are combined to form one state in the resulting DFA:
A {1} B {1,2} C {1,2,3} D {1,3} E {1,2,3,4}

10 The following original DFA states are combined to form one state in the resulting DFA:
A {2,3} B {2,4} C {2,3,4} D {3,4} E {3}

11 The number of transitions (edges) labelled a in the resulting DFA (without including trans or from the hidden error state) is:
A 1 B 2 C 3 D 4 E 5

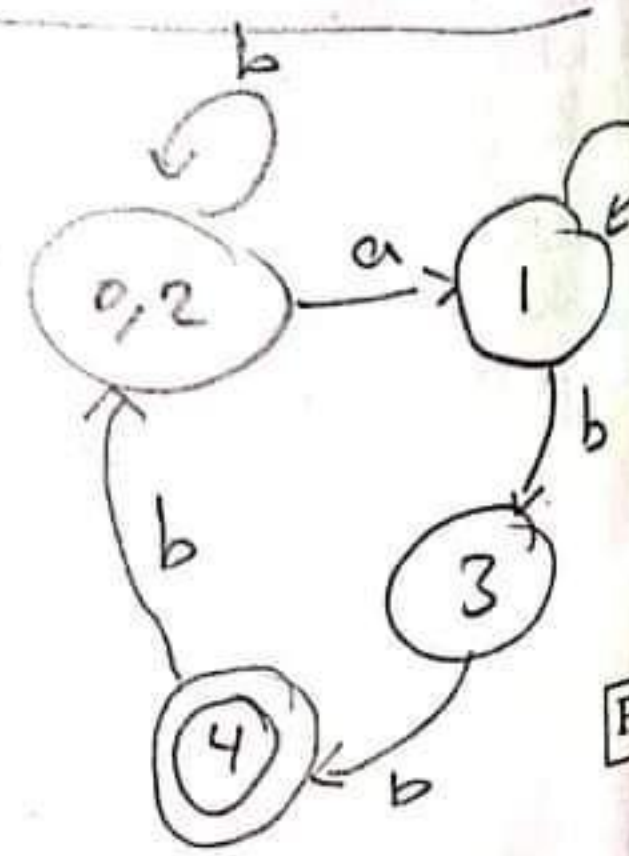
12 The number of transitions (edges) labelled b in the resulting DFA (without including trans or from the hidden error state) is:
A 1 B 2 C 3 D 4 E 5



accept 4

non a 0, 1, 2, 3

G1	4
G2	0, 1, 2
G3	3
G4	1



Qc ⇒ For questions 13 to 18, consider the following BNF grammar which consists of 5 tokens {int, (,), +, ×} and 4 non-terminals $\{E, T, H, Y\}$. Assume that a \$ exists after the last input token. The start symbol is E:

$E \to TH$
$H \to +E \mid \varepsilon$
$T \to (E) \mid \text{int } Y$
$Y \to \times T \mid \varepsilon$

13 The set First(E) consists exactly of:
A {ε} B {(} C {int} D {(, int} E {(, int, ε}

14 The set First(H) consists exactly of:
A {ε} B {+} C {×} D {+, ε} E {+, ×, ε}

15 The set Follow(E) consists exactly of:
A {(} B {)} C {\$} D {), \$} E {+,), \$}

16 The set Follow(H) consists exactly of:
A {(} B {)} C {\$} D {), \$} E {+,), \$}

17 The set Follow(T) consists exactly of:
A {(} B {)} C {\$} D {), \$} E {+,), \$}

18 The set Follow(Y) consists exactly of:
A {(} B {)} C {\$} D {), \$} E {+,), \$}

E = { (int }
H = { +, ε }
T = { (, int }
Y = { ×, ε }

E = { ϕ,) }
H = { ϕ,) }
T = { +, ε, ϕ,) }
Y = { +, ϕ,) }

First(T) = { (, int }
First(E) = { (, int }
First(H) = { +, ε }
Follow(E) = { ϕ }
Follow(H) = { ϕ }
Follow(T) = { +, ε, ϕ }

Qd ⇒ For questions 19 to 26, consider $LL(1)$ top-down parsing of the following BNF gramma grammar of the previous question) which consists of 5 tokens $\{\text{int}, (,), +, \times\}$ and 4 no $\{E, T, H, Y\}$. Assume a \$ exists after the last input token. The start symbol is E. As and pop() operations are applied to the parsing stack:

$E \rightarrow TH$ $\quad H \rightarrow +E \mid \epsilon$ $\quad T \rightarrow (E) \mid \text{int } Y$ $\quad Y \rightarrow \times T \mid \epsilon$

19 The first step in the $LL(1)$ top-down parsing of the above grammar is:
A push(H) B push(T) C push(Y) D push(ϵ) E push(E)

20 During $LL(1)$ parsing, if the stack top is int and the current input token is int, the acti
A pop(int) B pop(int) and remove the current input token
C push(int) D push(int) and remove the current input token E flag an error

21 During $LL(1)$ parsing, if the stack top is E and the current input token is int, the acti
A push(T), push(H) B pop(E), push(T), push(H)
C push(H), push(T) D pop(E), push(H), push(T) E flag an error

22 During $LL(1)$ parsing, if the stack top is Y and the current input token is $\times$, the actio
A push(T), push($\times$) B pop(Y), push(T), push($\times$)
C push($\times$), push(T) D pop(Y), push($\times$), push(T) E pop(Y)

23 During $LL(1)$ parsing, if the stack top is Y and the current input token is $+$, the actio
A pop(Y), push(T), push($\times$) B push($\times$), push(T)
C pop(Y), push($\times$), push(T) D pop(Y) E flag an error

24 During $LL(1)$ parsing, if the stack top is H and the current input token is \$ (no m
action must be:
A pop(H), push(E), push($+$) B push($+$), push(E)
C pop(H), push($+$), push(E) D pop(H) E flag an error

25 During $LL(1)$ parsing, if the stack top is T and the current input token is (, the actio
A pop(T), push(( ), push(E), push( )) B pop(T), push( )), push(E), push(( )
C push(int), push(Y) D pop(T) E flag an error

26 During $LL(1)$ parsing, if the stack top is T and the current input token is), the actio
A pop(T), push(( ), push(E), push( )) B pop(T), push( )), push(E), push(( )
C push(int), push(Y) D pop(T) E flag an error

Qd ⇒ For questions 27 to 33, consider $SLR(1)$ bottom-up parsing of the following BNF grammar which consists of 3 tokens $\{a, b, c\}$ and 3 non-terminals $\{S, X, Y\}$. The start symbol is S.

$S \to X \mid c\,b \qquad X \to a\,X\,b \mid Y \qquad Y \to c$

In order to perform $SLR(1)$ bottom-up parsing, the DFA of $LR(0)$ items must be constructed. $T(s, a) = r$ means there is a transition that starts from state s and ends at state r having the label a. Let $T(0, X) = 1, T(0, c) = 2, T(0, a) = 3, T(0, Y) = 4, T(2, b) = 5, T(3, X) = 6, T(3, c) = 7, T(6, b) = 8$.
From the above BNF grammar, the start state (State 0) of the DFA is:

$S \to \bullet X \;,\; S \to \bullet c\,b \;,\; X \to \bullet a\,X\,b \;,\; X \to \bullet Y \;,\; Y \to \bullet c$

27 State 1 of the above DFA is the following $LR(0)$ item:

A $S \to X\bullet$ B $S \to \bullet X$ C $S \to X\bullet \;,\; S \to \bullet c\,b \;,\; X \to \bullet a\,X\,b \;,\; X \to \bullet Y \;,\; Y \to \bullet c$
D $X \to \bullet a\,X\,b \;,\; X \to \bullet Y$ E $S \to \varepsilon$

28 State 2 of the above DFA is the following $LR(0)$ item:

A $S \to \bullet c$ B $S \to c\bullet b \;,\; Y \to c\bullet$ C $S \to c\bullet b \;,\; X \to \bullet a\,X\,b \;,\; X \to \bullet Y \;,\; Y \to c\bullet$
D $S \to c\bullet b$ E $S \to \bullet X \;,\; S \to c\bullet b \;,\; X \to \bullet a\,X\,b \;,\; X \to \bullet Y \;,\; Y \to c\bullet$

29 State 3 of the above DFA is the following $LR(0)$ item:

A $X \to a\bullet X\,b \;,\; X \to \bullet a\,X\,b \;,\; X \to \bullet Y$ B $X \to a\bullet X\,b \;,\; X \to \bullet Y \;,\; Y \to \bullet c$
C $X \to a\bullet X\,b$ D $X \to a\bullet X\,b \;,\; X \to \bullet a\,X\,b \;,\; X \to \bullet Y \;,\; Y \to \bullet c$
E $S \to \bullet X \;,\; S \to \bullet c\,b \;,\; X \to a\bullet X\,b \;,\; X \to \bullet Y \;,\; Y \to \bullet c$

30 State 4 of the above DFA is the following $LR(0)$ item:

A $X \to \bullet Y$ B $X \to Y\bullet$ C $S \to \bullet X \;,\; S \to \bullet c\,b \;,\; X \to \bullet a\,X\,b \;,\; X \to Y\bullet \;,\; Y \to \bullet c$
D $X \to \bullet a\,X\,b \;,\; X \to Y\bullet$ E $X \to \bullet Y \;,\; Y \to \bullet c$

31 State 5 of the above DFA is the following $LR(0)$ item:

A $S \to c\bullet b$ B $S \to c\,b\bullet \;,\; Y \to c\bullet$ C $S \to c\,b\bullet \;,\; X \to \bullet a\,X\,b \;,\; X \to \bullet Y \;,\; Y \to c\bullet$
D $S \to c\,b\bullet$ E $S \to \bullet X \;,\; S \to c\,b\bullet \;,\; X \to \bullet a\,X\,b \;,\; X \to \bullet Y \;,\; Y \to c\bullet$

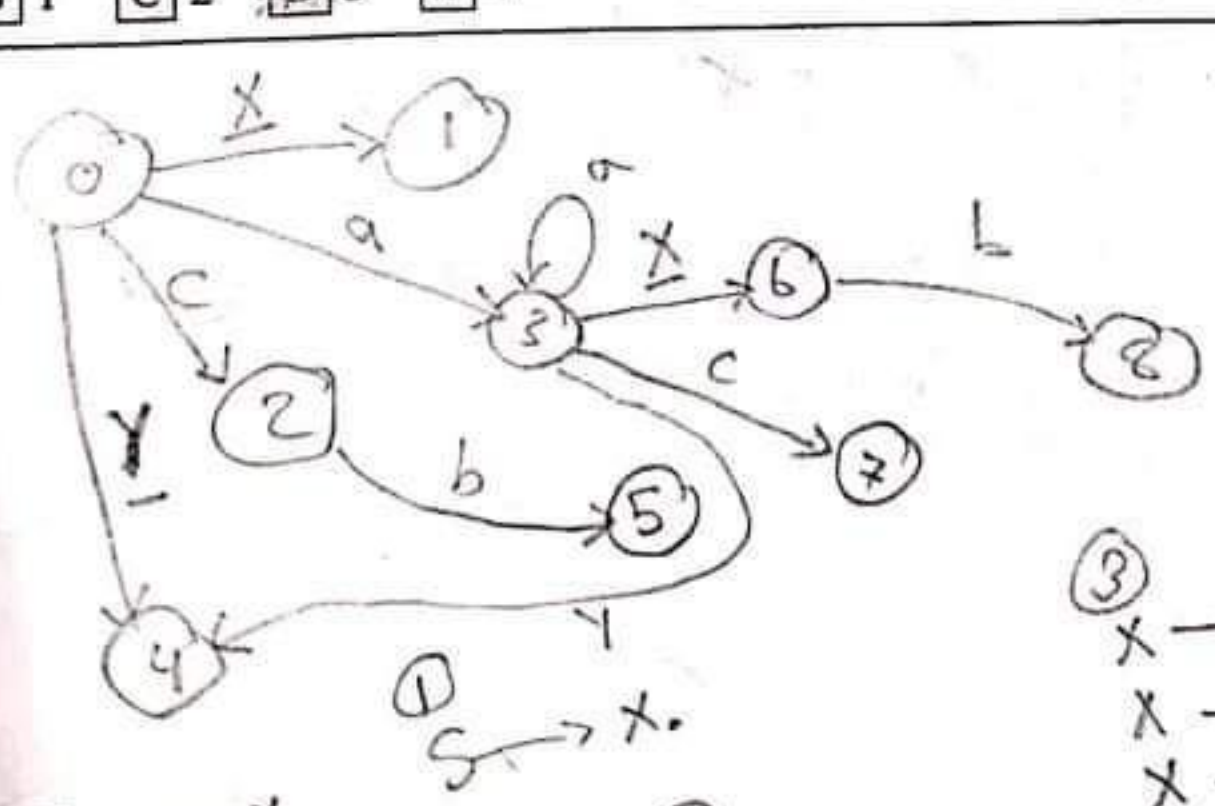
32 $T(3, Y) =$

A 0 B 1 C 2 D 3 E 4

33 $T(3, a) =$

A 0 B 1 C 2 D 3 E 4

Follow(X) = {b, $}
Follow(Y) = {$, b}



Qd ⇒ For questions 34 to 40, consider $SLR(1)$ bottom-up parsing of the following BNF grammar (the same grammar of the previous question) which consists of 3 tokens $\{a, b, c\}$ and 3 non-terminals $\{S, X, Y\}$. The start symbol is S.

$S \rightarrow X \mid c\,b \qquad X \rightarrow a\,X\,b \mid Y \qquad Y \rightarrow c$

Assume a \$ exists after the last input token. Assume push() and pop() operations are applied to the parsing stack. The first step in the $SLR(1)$ bottom-up parsing is to construct the DFA of $LR(0)$ items. $T(s, a) = r$ means there is a transition that starts from state s and ends at state r having the label a. Let $T(0, X) = 1, T(0, c) = 2, T(0, a) = 3, T(0, Y) = 4, T(2, b) = 5, T(3, X) = 6, T(3, c) = 7, T(6, b) = 8$.

State 0 of the DFA is: $S \rightarrow \bullet X$, $S \rightarrow \bullet c\,b$, $X \rightarrow \bullet a\,X\,b$, $X \rightarrow \bullet Y$, $Y \rightarrow \bullet c$

34 The first step in the $SLR(1)$ bottom-up parsing of the above grammar is:
A push(S) B push(X) C push(Y) D push(0) E push(ϵ)

35 During $SLR(1)$ parsing, if the stack top is 0 and the current input token is a, the following is done:
A push(a) and remove the current input token B pop(0) and remove the current input token
C pop(0), push(a) and remove the current input token D flag an error
E push(a), push(3) and remove the current input token

36 During $SLR(1)$ parsing, if the stack top is 2 and the current input token is \$ (no more input), the following is done:
A pop(2), pop(c), push(X), push(1) B pop(2), pop(c), push(X), push(2)
C pop(2), pop(\$), and remove the current input token D flag an error
E pop(2), pop(c), push(Y), push(4)

37 During $SLR(1)$ parsing, if the stack top is 6 and the current input token is b, the following is done:
A push(b), push(8) and remove the current input token B pop(6) and remove the current input token
C push(b) and remove the current input token D flag an error
E pop(6), pop(X), pop(3), pop(a), push(X), push(4)

38 During $SLR(1)$ parsing, if the stack top is 6 and the current input token is a, the following is done:
A push(a), push(8) and remove the current input token B pop(6) and remove the current input token
C push(a) and remove the current input token D flag an error
E pop(6), pop(X), pop(3), pop(a), push(X), push(4)

39 During $SLR(1)$ parsing, if the stack top is 7 and the current input token is b, the following is done:
A pop(7), pop(c), push(Y), push(3) B pop(7), pop(c), push(Y), push(4)
C pop(7), pop(b), and remove the current input token D flag an error
E pop(7), pop(c), push(X), push(6)

40 During $SLR(1)$ parsing, if the stack top is 8 and the current input token is a, the following is done:
A pop(8), pop(X), pop(a), push(X) B pop(8), pop(X), pop(6), pop(a), push(X), push(4)
C pop(8), pop(b), and remove the current input token D flag an error
E pop(8), pop(X), pop(6), pop(a), push(X), push(7)