Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

Faculty of Engineering, Mathematics and Science

School of Computer Science & Statistics

Integrated Computer Science Programme   **Trinity Term 2019**
Year 3 Annual Examinations

CS3071 – Compiler Design 1

Wednesday xxth May 2018   **SPORTS CENTRE**   **0x:30 – 1x:30**

Prof. John Waldron

Instructions to Candidates:

Each question is Section A and Section B is worth 4 marks. An incorrect amswer in Section A or B loses 20% of the correct mark. Marks for Section C are calculated based on the fraction of correct States identified in sequence. Enter your answers on the 3071 Optical Mark Recognition Answer Sheet provided. You may not start this examination until you are instructed to do so by the Invigilator. Exam Paper is not to be removed from venue.

Materials permitted for this examination:

Non-programmable calculators are permitted for this examination — please indicate the make and model of your calculator on each answer book used. To be accompanied by a 3071 Optical Mark Recognition Answer Sheet.

Section A

Q A.1 How many of the following 6 strings (whitespace and \n indicate a new string and are not part of the test data)

hhh h hh hhhh hhhhhh hhhhh

are matched at least once, in part or whole, by the Flex regular expression

hhh

(A) 4 (B) 2 (C) 3 (D) 5 (E) 6 (F) OTHER (4 marks)

Q A.2 How many of the following 15 strings (whitespace and \n indicate a new string and are not part of the test data)

YYYq qqqq YYYYY YYYY YY qYY YYYYYY qq qqqqq qqqYYY qqqqqq qqq YYY
YYq YYYqqq

are matched at least once, in part or whole, by the Flex regular expression

q[A-Z]Y

(A) 2 (B) 10 (C) 11 (D) 4 (E) 7 (F) OTHER (4 marks)

Q A.3 How many of the following 15 strings (whitespace and \n indicate a new string and are not part of the test data)

FFFFFFii bbbFFii FFFFFFiii bbbFiii FFFFFFFFF iFF FFFFFbbb bbbbi
bbbbbii FFFbbi iiFb ibb bbbib iiiFFb FFiiii

are matched at least once, in part or whole, by the Flex regular expression

b[a-zA-Z]F

(A) 6 (B) 5 (C) 7 (D) 2 (E) 3 (F) OTHER (4 marks)

Q A.4 How many of the following 15 strings (whitespace and \n indicate a new string and are not part of the test data)

Tddduuu dddTddd ddduuudd Tdddd uuuuuu uuuuddd TTTTTTuu TTdddTTT
uuTTTT uuddduu uuuddd TuuuT ddud uuduu uuuu

are matched at least once, in part or whole, by the Flex regular expression

dd[a-zA-Z][a-zA-Z]+u

(A) 3 (B) 7 (C) 15 (D) 9 (E) 14 (F) OTHER (4 marks)

Q A.5 How many of the following 15 strings (whitespace and \n indicate a new string and are not part of the test data)

jrrrr FjF rFFFF jjFFrrr rFFrr FFFrr jjrF jjjjjFFF rrjjjrr rjjjj
rrrjjF rFF rFjj FrrFFF FFFFFFr

are matched at least once, in part or whole, by the Flex regular expression

r[a-zA-Z][a-zA-Z]?jj

(A) 10 (B) 12 (C) 4 (D) 8 (E) 6 (F) OTHER (4 marks)

Q A.6 How many of the following 15 strings (whitespace and \n indicate a new string and are not part of the test data)

hhhhLLL LLoooh LLLLLL hhhLLL oooho LLohh ohhho ooohhhh LLLLLhhh
LLLLhh hhhhhhhh oooLLLhh oLLL hhhhooo LhhL

are matched at least once, in part or whole, by the Flex regular expression

o[a-zA-Z]{1,2}hh

(A) 11 (B) 2 (C) 12 (D) 10 (E) 5 (F) OTHER (4 marks)

Q A.7 How many of the following 15 strings (whitespace and \n indicate a new string and are not part of the test data)

AAfA ffhhA hAAhh hhAAhh fAh hhff AAfff hAf hhfA hhh Ahhhh AAhff
hffhh hffh AAh

are matched at least once, in part or whole, by the Flex regular expression

(f{2,3}|hhh?)

(A) 9 (B) 11 (C) 4 (D) 12 (E) 3 (F) OTHER (4 marks)

Q A.8 How many of the following 15 strings (whitespace and \n indicate a new string and are not part of the test data)

Zzzzz zZZZZ zzzmmmmmm mmmZZZZ zZZZz zmmz mmmZZZm mZZ mmmzmm zmmmm
zzzmmmm zzmmmmm ZZZmmmmmm Zmmm ZZZZZZZ

are matched at least once, in part or whole, by the Flex regular expression

..zZ.

(A) 8 (B) 0 (C) 4 (D) 5 (E) 9 (F) OTHER (4 marks)

Q A.9 How many of the following 15 strings (whitespace and \n indicate a new string and are not part of the test data)

qvq Qvq vQq vvQ vQv qQv Qqv qqq qqQ Qvv vqq vqQ qqv qvQ qQq

are matched at least once, in part or whole, by the Flex regular expression

^[a-z]

(A) 15 (B) 11 (C) 14 (D) 12 (E) 6 (F) OTHER (4 marks)

Q A.10 How many of the following 15 strings (whitespace and \n indicate a new string and are not part of the test data)

ookkoo Eok EEkkk kEEo kkok koooo ooooE kooEE EEkk kkEEo kooE ooEEEE koo kkkE EoEE

are matched at least once, in part or whole, by the Flex regular expression

^(k|E|[A-Z]+)

(A) 10 (B) 11 (C) 7 (D) 12 (E) 15 (F) OTHER (4 marks)

Section B

Q B.1 How many of the following 8 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

EEEEEE EE erQ8in1 EEEEE EEE sentence EEEEEEE EEEE

are in the language defined by the Bison Context Free Grammar

```
%token E
%%
sentence: E | E sentence
;
```

(A) 2 (B) 5 (C) 3 (D) 6 (E) 8 (F) OTHER (4 marks)

Q B.2 How many of the following 8 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

7IExavI M MMM MMMMM sentence MMMMMM MMMM MM

are in the language defined by the Bison Context Free Grammar

```
%token M
%%
sentence: M | sentence  M
;
```

(A) 3 (B) 4 (C) 6 (D) 1 (E) 8 (F) OTHER (4 marks)

Q B.3 How many of the following 7 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

sentence hhhhhhhZ hhhhhZZZZ e5iPght hhhhZ hhhhZZZZ hhhhhhhZZ

are in the language defined by the Bison Context Free Grammar

```
%token h Z
%%
sentence: sub | sub sentence
sub: h | Z
;
```

(A) 5 (B) 1 (C) 3 (D) 4 (E) 7 (F) OTHER (4 marks)

Q B.4 How many of the following 10 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

vvH HH vvvHH vvvvHH vvHHH vvvH vHHH vvHH vH v

are in the language defined by the Bison Context Free Grammar

```
%token v H
%%
sentence: v | H | v sentence
;
```

(A) 2 (B) 5 (C) 3 (D) 8 (E) 4 (F) OTHER (4 marks)

Q B.5 How many of the following 10 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

iiiAAA iiiiA iiiAA iiiA iAA ii iiA iA iiiAAAA AA

are in the language defined by the Bison Context Free Grammar

```
%token i A
%%
sentence: i | A | sentence i
;
```

(A) 4 (B) 1 (C) 10 (D) 5 (E) 2 (F) OTHER (4 marks)

Q B.6 How many of the following 10 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

uuDD uuuD uuDDDD uuD uuDDD D uDDD uuu uDDDD uuuuDD

are in the language defined by the Bison Context Free Grammar

```
%token u D
%%
sentence: u | D | D sentence
;
```

(A) 1 (B) 2 (C) 7 (D) 5 (E) 9 (F) OTHER (4 marks)

Q B.7 How many of the following 10 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

cccVVVV VV ccccVV cVVV cVVVV ccc cVV cccVV ccccVVVV cccVVV

are in the language defined by the Bison Context Free Grammar

```
%token c V
%%
sentence: c | V | sentence V
;
```

(A) 3 (B) 8 (C) 10 (D) 4 (E) 7 (F) OTHER (4 marks)

Q B.8 How many of the following 7 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

PP;PPP; PPPPP;P PPPPP P;PPPPPPPP PPP;P PP;PP;P;PP P;PP

are in the language defined by the Bison Context Free Grammar

```
%token P
%%
sentence: list | sentence list
list: listc ';'
listc: P | P listc
;
```

(A) 2 (B) 4 (C) 7 (D) 6 (E) 1 (F) OTHER (4 marks)

Q B.9 How many of the following 6 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

Q,QQQ,Q Q,Q,QQ,QQQQ QQQ, Q,QQQ,QQQ QQ,Q,QQQ, QQQQ,QQ,

are in the language defined by the Bison Context Free Grammar

```
%token Q
%%
sentence: listc | listc ',' sentence
listc: Q | Q listc
;
```

(A) 4 (B) 1 (C) 3 (D) 5 (E) 2 (F) OTHER (4 marks)

Q B.10 How many of the following 6 sentences (whitespace and \n indicate a new sentence and are not part of the test data)

K,KK,K K,KKK; KK,KK,K,K; KKKK,K, KKKKK,K; KKKK,K

are in the language defined by the Bison Context Free Grammar

```
%token K
%%
sentence: commal ';'
commal: listc | listc ',' commal
listc: K | K listc
;
```

(A) 5 (B) 3 (C) 4 (D) 2 (E) 1 (F) OTHER (4 marks)

Section C

Q C.1 Given the following tokens
```
"+"     { return PLUS; }
"-"     { return MINUS; }
":="    { return ASSIGN; }
[a-z]   { yylval = yytext[0]; return ID; }
\n      { return EOL; }
```
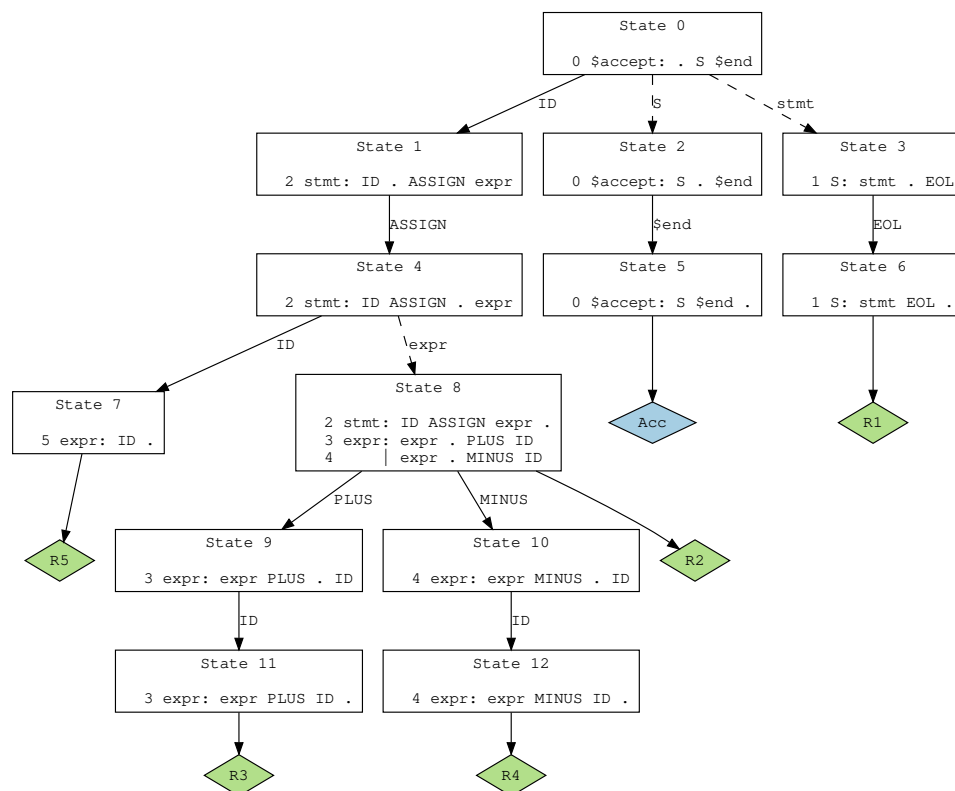and the following Bison Context Free Grammar
```
0 $accept: S $end
1 S: stmt EOL
2 stmt: ID ASSIGN expr
3 expr: expr PLUS ID
4     | expr MINUS ID
5     | ID
```
which generates the Bison Shift Reduce Parser

What sequence of states will the Bison Shift Reduce Parser go through parsing the sentence
a:=b+c\n
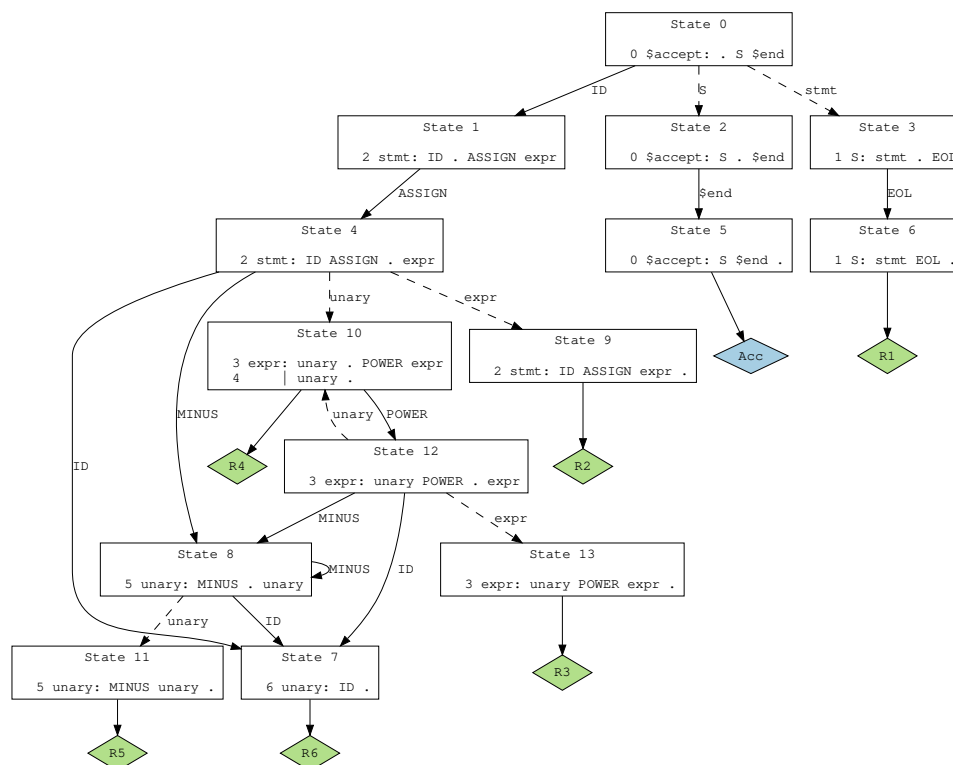 (10 marks)

Q C.2 Given the following tokens
```
"^"      { return POWER; }
"-"      { return MINUS; }
":="     { return ASSIGN; }
[a-z]    { yylval = yytext[0]; return ID; }
\n       { return EOL; }
```
and the following Bison Context Free Grammar
```
    0 $accept: S $end
    1 S: stmt EOL
    2 stmt: ID ASSIGN expr
    3 expr: unary POWER expr
    4     | unary
    5 unary: MINUS unary
    6       | ID
```
which generates the Bison Shift Reduce Parser

State 0
0 $accept: . S $end

— ID → State 1 — S → State 2 — stmt → State 3

State 1
2 stmt: ID . ASSIGN expr

State 2
0 $accept: S . $end

State 3
1 S: stmt . EOL

State 1 — ASSIGN → State 4

State 2 — $end → State 5

State 3 — EOL → State 6

State 4
2 stmt: ID ASSIGN . expr

State 5
0 $accept: S $end .

State 6
1 S: stmt EOL .

State 4 — unary → State 10 — expr → State 9

State 5 — Acc

State 6 — R1

State 10
3 expr: unary . POWER expr
4 | unary .

State 9
2 stmt: ID ASSIGN expr .

State 10 — R4, unary, POWER → State 12

State 9 — R2

State 12
3 expr: unary POWER . expr

State 8
5 unary: MINUS . unary

State 13
3 expr: unary POWER expr .

State 12 — MINUS → State 8, ID → State 7, expr → State 13

State 8 — MINUS (self), ID, unary → State 11, ID → State 7

State 11
5 unary: MINUS unary .

State 7
6 unary: ID .

State 13 — R3

State 11 — R5

State 7 — R6

What sequence of states will the Bison Shift Reduce Parser go through parsing the sentence
a:=----c\n
 (10 marks)