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Please print clearly :

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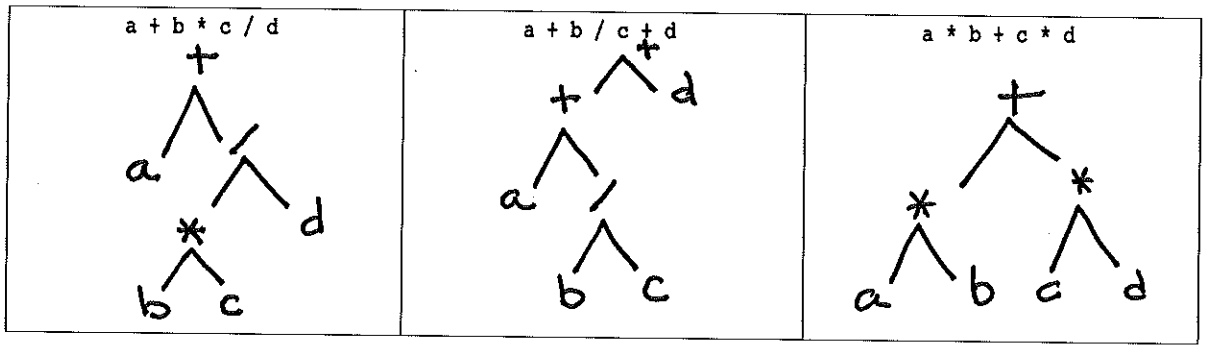
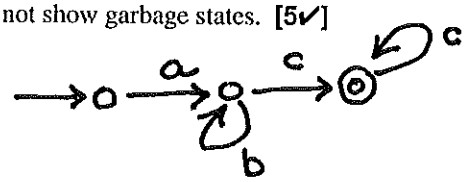
No books; No calculator; No computer; No email; No internet; No notes; No phone. Neatness counts! Do your scratch work elsewhere and enter only your final answer into the spaces provided.

1. Using the precedence and associativity of C, draw abstract syntax trees for each of the following. **[3✓]**

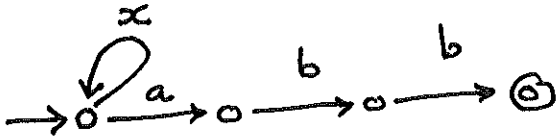


2. Using as *few* states as possible, draw deterministic finite αὐτόματα for each of the following `flex` regular expressions. Do not show garbage states. **[5✓]**

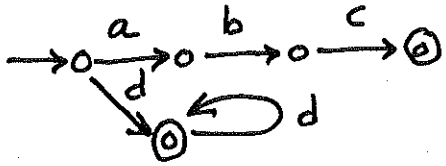
(i) `ab*c+`



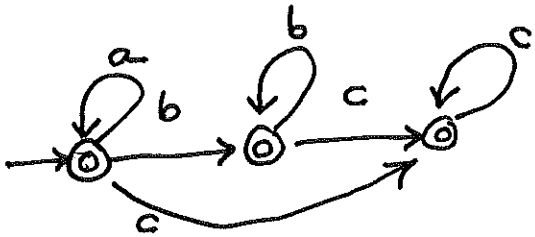
(ii) `x*abb`



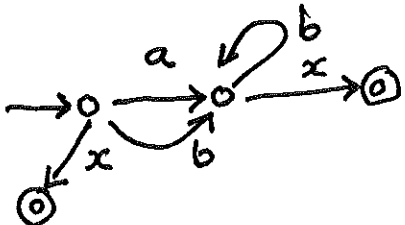
(iii) `abc|d+`



(iv) `a*b*c*`



(v) `(a?b*)x`



3. Write a function `openpipe` that will take a string `char* command`, as an argument and open a pipe to a subprocess for reading. If the open fails, call the function `void syserror()`. If it succeeds, pass the opened file to the function `void readpipe (FILE*)`. **[2✓]**

```
FILE* f = popen (command, "r");
if (f == NULL) syserror();
else readpipe (f);
```

4. Write `flex` patterns for each of the following descriptions. Whenever letters are mentioned or required, they may appear either as upper-case or lower-case. **[5✓]**

   (i) An identifier starts with a letter, followed by zero or more letters, digits, or underscores.

   `[A-Za-z][A-Za-zØ-9_]*`

   (ii) A hexadecimal constant which starts with the digit 0, a letter X, followed by one or more hexadecimal digits.

   `Ø[Xx][Ø-9A-Fa-f]+`

   (iii) A string constant which starts and ends with a single quote (') and has any number of characters (except single quotes) in between. If a single quote appears in the string it is doubled. Examples: `'abc'`, `'don''t'`.

   `'([^']|'')*'` — two single quotes not one double quote

   (iv) A floating point number consists of one or more decimal digits, possibly with a decimal point. If a decimal point appears, there must be at least one digit before and after the decimal point. It may have an optional exponent, which consists of the letter E, optionally followed by a + or - sign, then followed by one or more decimal digits.

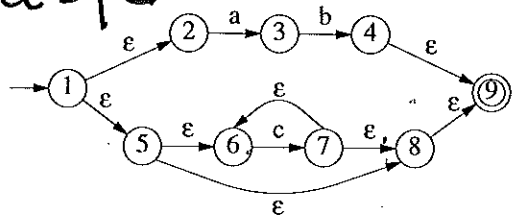
   `[0-9]+(\.[0-9]+)?([Ee][+-][0-9]+)?`

   (v) The name of a list-extracting function from Lisp or Scheme, which consists of the lower-case (only) letter C, followed by one or more occurrences of the lower-case letters A or D in any order, and terminated by the lower-case letter R. Examples: `car`, `cdr`, `caar`, `cadr`, `cdar`, `cddr`, ..., etc.

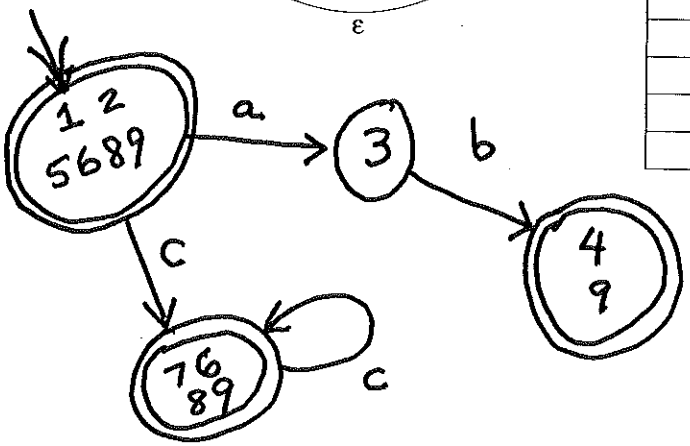
   `c[ad]+r`

5. Given the following nondeterministic finite αὐτόματον:
   (a) Write the regular expression from which Thompson's construction was used to construct it. **[1✓]**
   (b) Fill in the table with the ε-closure of each state. **[2✓]**
   (c) Use the subset algorithm to construct the equivalent deterministic finite αὐτόματον. Inside each state of the DFA write the numbers of the NFA states to which it corresponds. **[2✓]**

ab|c*



state s	ε-closure (s)
1	1 2 5 6 8 9
2	2
3	3
4	4 9
5	5 6 8 9
6	6
7	7 6 8 9
8	8 9
9	9



Multiple choice. To the *left* of each question, write the letter that indicates your answer. Write Z if you don't want to risk a wrong answer. Wrong answers are worth negative points. **[12✓]**

number of correct answers		× 1 =	$= a$
number of wrong answers		× ½ =	$= b$
number of missing answers		× 0 =	0
column total $c = \max(a - b, 0)$	12		$= c$

1. A scanner generated by `flex` makes use of what kind of language?
   (A) recursively enumerable
   (B) context-sensitive
   (C) context-free
   (D) regular

D

2. A parser generated by `bison` makes use of what kind of language?
   (A) recursively enumerable
   (B) context-sensitive
   (C) context-free
   (D) regular

C

3. The shortest string that the pattern `xx+` can match contains how many characters?
   (A) 1
   (B) 2
   (C) 3
   (D) unlimited

B

4. Which pattern will match one or more `a`'s followed by one or more `b`'s?
   (A) `(a|b)+`
   (B) `a+|b+`
   (C) `a+b+`
   (D) `a|b+`

C

5. The last byte of the string pointed at by `char* yytext` contains:
   (A) `'0'`
   (B) `'\0'`
   (C) `'\n'`
   (D) `EOF`

B

6. What is the expected speed of a lookup in an `unordered_set<string>`?
   (A) $O(1)$
   (B) $O(\log_2 n)$
   (C) $O(n)$
   (D) $O(n \log_2 n)$

A

7. Comments in `oc` are stripped of by the:
   (A) parser
   (B) preprocessor
   (C) scanner
   (D) stringset

B

8. For a grammar $G = \langle V_N, V_T, P, S \rangle$, the set P contains rules of the form $(A \rightarrow \beta)$, where
   (A) $A \in V_N$ and $\beta \in (V_N \cap V_T)^*$
   (B) $A \in V_N$ and $\beta \in (V_N \cup V_T)^*$
   (C) $A \in V_T$ and $\beta \in (V_N \cap V_T)^+$
   (D) $A \in V_T$ and $\beta \in (V_N \cup V_T)^+$

B

9. The expression `ab|c*` means
   (A) `((ab)|c)*`
   (B) `(a(b|c))*`
   (C) `(ab)|(c*)`
   (D) `a((b|c)*)`

C

10. A `stringset` with search time $O(1)$ can be implemented as a
    (A) `binarytree_map<string>`
    (B) `binarytree_set<string>`
    (C) `unordered_map<string>`
    (D) `unordered_set<string>`

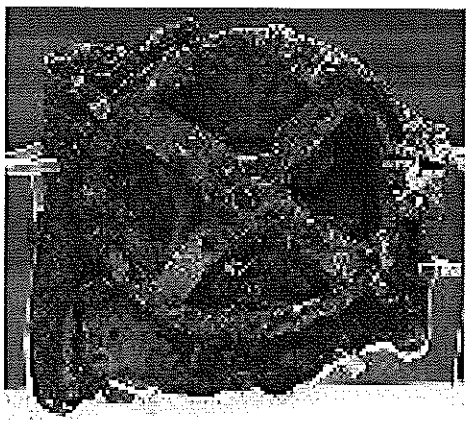
D

11. Which of the following rules from the ETF example shows that the operator + is left associative?
    (A) $E + T \rightarrow E$
    (B) $E + T \rightarrow T$
    (C) $E \rightarrow E + T$
    (D) $E \rightarrow T + E$

C

12. How many tokens in the following C statement?
    `printf ("%s\n", hello); // Say hello there.`
    (A) 5
    (B) 7
    (C) 9
    (D) 11

B



The Antikythera mechanism, built ca. 160–100 BCE, is the oldest known complex scientific calculator, and is sometimes called the first known analog computer, with operational instructions written in Greek.
http://en.wikipedia.org/wiki/Antikythera_mechanism