

CMSC330 Spring 2011 Midterm #1

Name _____

Discussion Time (circle one): 9am 10am 11am 12pm 1pm 2pm

Do not start this exam until you are told to do so!

Instructions

- You have 75 minutes to take this midterm.
- This is a closed-book exam. No notes or other aids are allowed.
- If you have a question, please raise your hand and wait for the instructor.
- Answer essay questions concisely using 2-3 sentences. Longer answers are not necessary and a penalty may be applied.
- To be eligible for partial credit, show your work and clearly indicate your answers.
- Write neatly. Credit cannot be given for illegible answers.

	Problem	Score
1	True or False	/10
2	Regular expressions & finite automata	/20
3	RE to NFA to DFA	/20
4	CFGs	/20
5	Ruby Programming	/30
	Total	/100

1. (10 pts) Indicate whether each of the following statements is true (“T”) or false (“F”)

- a. ____ Ruby is a scripting language.
- b. ____ In Ruby classes are also objects.
- c. ____ Ruby uses static type checking.
- d. ____ The backend of a compiler handles program parsing.
- e. ____ There is no such thing as an interpreted object-oriented language.
- f. ____ A language is regular if and only if there is a DFA that accepts it.
- g. ____ Every DFA is also an NFA.
- h. ____ Every NFA is also a DFA.
- i. ____ If a string is accepted by a CFG then there is a unique parse tree for that string.
- j. ____ Every string accepted by a CFG is also a sentential form of the CFG.

2. (20 pts) **Regular expressions and finite automata**

- a. (5 pts) Give a regular expression over the alphabet $\{0,1\}$ for binary numbers with no leading 0s. For example, the language contains 0, 10, 11, etc., but not ϵ , 00, 01, etc.

- b. (5 pts) Give a DFA for the language in part a.

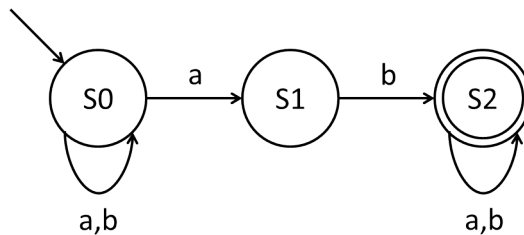
- c. (5 points) Suppose that s is a string in Ruby, that R is a regular expression, and that the Ruby expression $s =~ /R/$ evaluates to 0. Does this mean that s is in the language of R ? Explain.

- d. (5 pts) A class of languages is *closed with respect to union* if whenever two languages L_1 , L_2 are in the class, then so is $L_1 \cup L_2$. Is the class of regular languages closed with respect to union? (That is, if two languages are regular, is their union also regular?) Briefly explain your answer.

3. (20 pts) **RE to NFA to DFA**

- a. (10 pts) Create a NFA for the regular expression $0(0|1)^*0$ using the method described in lecture. In particular, be sure to show the regular expressions associated with each state, and that the transitions and final-state labelings match what the method would produce.

- b. (10 pts) Apply the subset construction algorithm discussed in class to convert the following NFA to a DFA. Show the NFA states associated with each state in your DFA.



4. (20 pts) **CFGs**

- a. (8 points) Give a context-free grammar for the language $L = \{w \in \{a,b\}^* \mid w \text{ is a palindrome}\}$. A palindrome is a string that reads the same from left to right and right to left. So ϵ , aba, and abba are palindromes, while ab and baba are not.

- b. (8 points) Consider the grammar G given as follows.

$$E \rightarrow E \circ E \mid E \sqcap E \mid (E) \mid 0 \mid 1$$

Give two different parse trees for the string $0 \circ 1 \sqcap 0$.

- c. (4 points) Consider the following grammar, which is unambiguous and accepts the same language as the grammar in part b.

$$E \rightarrow E \circ C \mid C$$

$$C \rightarrow C \sqcap T \mid T$$

$$T \rightarrow (E) \mid 0 \mid 1$$

Which operator has higher precedence, according to this grammar: $\circ$ or $\sqcap$? (Hint: construct the parse tree for $1 \sqcap 0 \circ 1 \sqcap 0$. What does this tell you?)

5. (30 pts) Ruby programming

In this problem, you will write a series of Ruby methods that, combined, work with airport weather data. The initial input you are given is a file containing lines of the form

```
dd-mm-yyyy, hh:mm, apt, temp
```

where

dd is a two-digit day, ranging from 01 to 31
mm is a two-digit month, ranging from 01 to 12
yyyy is a four-digit year (any four digits are allowed)
apt is a three-letter airport code that must be one of: DCA, BOS, ORD, ATL, SFO
temp is a temperature value, which may be any (positive, zero or negative) integer

The following methods on arrays / strings may be helpful.

```
a = s.split("x")      // returns array of substrings of s delimited by x
s.to_i                // returns integer value for string s
a = h.keys             // returns keys in hash h as an array a
a.sort!               // sorts elements of array a in place
a.size                // number of elements in the array
a.each { ... }         // apply code block to each element in array
a.push / a.pop         // treat array as stack
```

- a. (10 pts) Write a Ruby regular expression that exactly matches the line format for the input file. That is, if R is your regular expression and l is an input line from the file, then $l =~ R$ should return true if and only if the line is in the correct format. (You do not need to check whether the day is valid for the given month, e.g., for purposes of this problem, 31-02-2011 is a valid date.)

- b. (10 pts) Write a Ruby method `parse(l)` that, given a line `l` in the format above, returns an array of the form `[dd, mm, yyyy, hh, mm, apt, temp]`, where `dd`, `mm`, `yyyy`, `hh`, and `temp` are integers and `apt` is a string. You can assume the line is valid according to the regexp in part (a). We'll call the kind of array returned by `parse()` an *entry*.
- c. (10 pts) Write a Ruby method `avg(data, apt, dd, mm, yyyy)` that takes an array of entries (i.e., an array of the arrays returned by `parse`), a three-letter airport code as a string, and integers corresponding to a day, month and year, and returns the average temperature recorded across all entries for that airport on that date. For this problem, it doesn't matter what time of day those temperatures were recorded—just average them all.