UNCA CSCI 431
Exam 1 Fall 2019
17 October 2019 – 3:15 pm to **4:55** pm

You may use your notes, printouts, scratch paper, and your textbook. You may not use any calculators, electronic devices, or help from any other source or person.

Anyone needing a break during the exam must leave their exam with the instructor.

This exam must be turned in before **4:55** *PM.*

Name:________________________________

Note: textbook versus grep

- The textbook uses $E \cup F$ for union of E and F, grep uses `E|F` .
- The textbook uses $E \circ F$ for concatenation of E and F. **grep** uses EF.
- The textbook uses E^* for the Kleene star. **grep** uses E*.
- The textbook uses Σ to match any character. **grep** uses the period.

Use whichever you wish in your answer.

Also, notice the subtle difference between u, U, and ∪. The first two are letters. The last is the union operator (or \cup in LaTeX).

Each problem is worth 20 points. The first two are easy!

Problem 1: Regular expressions

Describe what is matched by the following regular expressions? For each of the following two expressions, ***give two examples of strings*** that belong to **each of** the corresponding regular languages.

borr(ow ∪ y) *or in **grep**,* `borr(ow|y)`

hissss^* *or in **grep***, `hissss*`

Problem 2: First NFA

Draw a state diagram for an NFA (nondeterminate finite automaton) that would accept strings from the alphabet Σ = {a, c, t} which contain the three-letter substring `cat` *at least two* times.

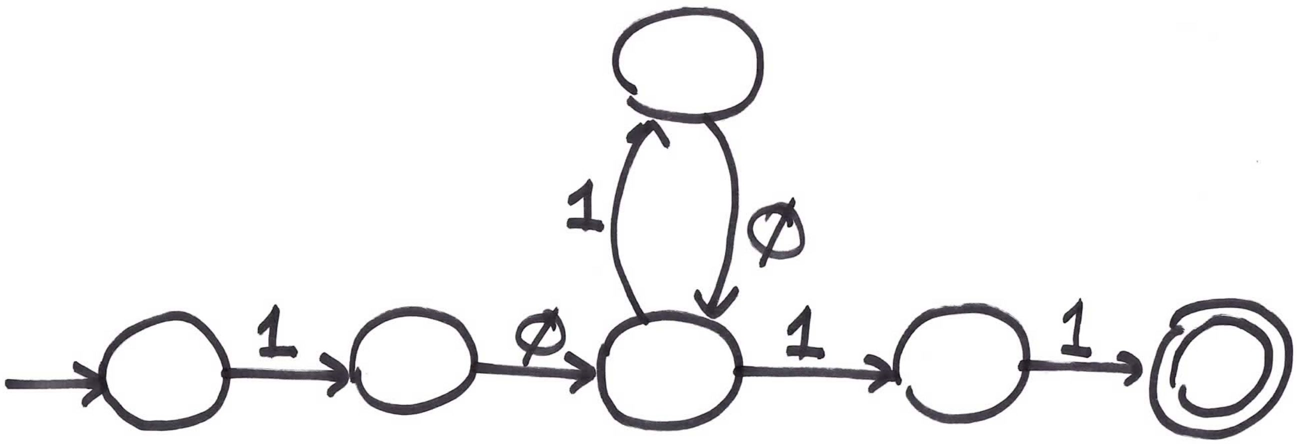
Problem 3: Second NFA

Use the mechanical RE-to-NFA conversion algorithm described in Chapter 2 of the textbook to construct an NFA for the following regular expression over the alphabet $\Sigma = \{a, \ldots, z\}$.

$(ab \cup yz^*)^* \cup dog$ or in **grep**: `(ab|yz*)*|dog`

Problem 4: NFA to DFA

Draw a DFA equivalent to the NFA (which has a relation to the preamble to Ethernet packets) shown below.



Problem 5: Pumping Lemma (Theorem 1.70)

If A is a regular language then there is a number p (the pumping length) where if s is any string in A of length at least p, then s may be divided into three pieces $s = xyz$, satisfying the following conditions:

1. for each $i \geq 0$, $xy^iz \in A$,
2. $|y| > 0$, and
3. $|xy| \leq p$.

Problem 5A: A tricky question for a simple RE

The language generated by the regular expression

- `borr(ow ∪ y)`

mentioned in Problem 1 **must** obey the Pumping Lemma even though there is nothing to pump! *How can this be the case!!??* What value of p could make be appropriate for this two-element regular language? (**Explain your answer.** You may have to use a bit of Chapter 0 reasoning!)

Problem 5B: A more interesting regular language

Now consider the other regular expression of Problem 1

- `hissss*`

In this case, there is something to pump. What would be an appropriate pumping length p for this regular language? **Justify your answer!**

Problem 5C:

Using your value of p from Problem 5B, use the pumping lemma to show that the string

- `hissssssssssssssssssssssssssssssssssssssssssssssssss`

(that's 50 s's) belongs to this language.

See the answers for a discussion of a problem with this question.