# Homework 1

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## Exercise 1

1. Describes the languages denoted by the following regular expressions:

   (a) $a(a|b)^*a$
   : All strings of 'a' and 'b' that starts and ends with 'a'.

   (b) $((\varepsilon|a)b^*)^*$
   : All strings of 'a' and 'b'.

   (c) $(a|b)^*a(a|b)(a|b)$
   : All strings of 'a' and 'b' where the $3^{\text{rd}}$ element from the right is 'a'.

   (d) $a^*ba^*ba^*ba^*$
   : All strings of 'a' and 'b' that only contains three 'b'.

   (e) $(aa|bb)^*((ab|ba)(aa|bb)^*(ab|ba)(aa|bb)^*)^*$
   : All strings of 'a' and 'b' that has a even number of 'a' and 'b'.

2. Write regular definitions for the following languages:

   (a) All strings of lowercase letters that contain the five vowels in order.
   : other $\rightarrow$ [bcdfghjklmnpqrstvwxyz]
   want $\rightarrow$ other*a(other|a)*e(other|e)*i(other|i)*o(other|o)*u(other|u)*

   (b) All strings of lowercase letters in which the letters are in ascending lexicographic order.
   : a* b* ... z*

   (c) Comments, consisting of a string surrounded by `/*` and `*/`, without an intervening `*/`, unless it is inside double-quotes (`"`).
   :

   (d) All strings of digits with no repeated digits. Hint: Try this problem first with a few digits, such as $\{0, 1, 2\}$.
   : A $\rightarrow$ 0?2(02)*
   want $\rightarrow$ 0|A?0?1(A0?1|01)*A?0?|A0?

   (e) All strings of $a$'s and $b$'s that do not contain the substring $abb$.
   : b*(a+b?)*

   (f) All strings of $a$'s and $b$'s that do not contain the subsequence $abb$.
   : b* | b*a+ | b*a+ba*

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3. Write character classes for the following sets of characters:

   (a) The first ten letters (up to "j") in either upper or lower case.
       : [A-Ja-j]

   (b) The lowercase consonants.
       : [bcdfghjklmnpqrstvwxzy]

   (c) The "digits" in a hexadecimal number (choose either upper or lower case for the "digits" above 9).
       : [0-9a-f]

   (d) The characters that can appear at the end of a legitimate English sentence (e.g., comma, exclamation point).
       : [.?!]

4. Design finite automata (deterministic or nondeterministic) for this language

   (a) All strings of digits with no repeated digits. Hint: Try this problem first with a few digits, such as $\{0, 1, 2\}$.

5. Convert the following regular expressions to deterministic finite automata:

   (a) $(a|b)^*$

   (b) $(a^*|b^*)^*$

   (c) $((\varepsilon|a)|b^*)^*$

   (d) $(a|b)^*abb(a|b)^*$