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15) i) Length is at most 2

$L = \{\epsilon, a, b, ab, aa, ba, bb\}$

$(\epsilon + a + b)(\epsilon + a + b)$

ii) Language of even length

$L = \{aa, bb, aabb, aaabbb, \ldots\}$

$((a+b)(a+b))^*$

iii) Language starting and ending with the same letter

$a(a+b)^*a$

iv) Language starting and ending with different letters

$a(a+b)^*b + b(a+b)^*a$

16) Let L be a language over an alphabet, then L is a regular language if and only if there exists a regular expression R over an alphabet such that $L = L(r)$. A regular expression is a sequence of characters that define a search pattern.

Identities of R.E

i) $\emptyset + R = R$

ii) $\emptyset R + R\emptyset = \emptyset$

iii) $\epsilon R = R\epsilon = R$

iv) $\epsilon^* = \epsilon$ and $\emptyset^* = \epsilon$

v) $R + R = R$

vi) $R^* R^* = R^*$

vii) $RR^* = R^* R$

viii) $(R^*)^* = R^*$

ix) $\epsilon + RR^* = \epsilon + R^*R = R^*$

x) $(PQ)^* P = P(QP)^*$

xi) $(P+Q)^* = (P^* Q^*)^* = (P^* + Q^*)^*$

xii) $(P+Q)R = PR + QR$ and $R(P+Q) = RP + RQ$

17) Let A be a non empty alphabet the expression r and its corresponding language L(r) are defined inductively as follows. The symbol λ and pare () are regular expressions, each letter a in A is a regular expression. if r is a regular expression r^* is a regulare expression if r1 and r2 are R.E then r1 u r2 is a R.E. If r_1 and r2 are R.E then r_1, r_2 are R.E

ii) The symbols used in regular expression are {"()", "*", "U", "λ", ","}

18) i) $r = b^*$

The language L(r) consists of all b's including ε e.g {ε, b, bb, bbb, ...}

ii) Let $r = aa^*$

The language L(r) consists of all positive powers of a excluding the empty word.

iii) Let $r = a \cup b^*$

The language L(r) consists of a or any word in b.

iv) Let $r = (a \cup b)^*$

The language L(r) consists of all words over the given alphabet A

vi) Let $r = aa(a \cup b)^*$

The language $L(r)$ consists of all words ~~das~~ starting with aa

vii) Let ~~r~~ $= (a \cap b)^*$

The languge $L(r)$ consist of all combinatuns of a & b

19) $\Sigma = \{a, b\}$

$L_1 = \{b^m a^n \mid m > 0, n > 1\}$

$L_2 = \{a^n b^m a \mid m > 1, n > 0\}$

$L_3 = \{a b^n \mid n > 0\}$

find a R.E. r over $A = \{a, b\}$ $\forall L$

$L_i = L(r)$ $\forall i = 1, 2, 3$

$L_1 = bb^* a aa^*$

$L_2 = aa^* bbb^* a$

$L_3 = abb^*$

20) A regular set is any set represented by regular expression eg a, b, ϵ Σ then.

a denotes the set $\{a\}$

$a+b$ denotes the set $\{a, b\}$

ab denotes $\{ab\}$

a^* denotes the set $\{\epsilon, a, aa, aaa, \ldots\}$

$(a+b)^*$ denotes $\{\{a, b\}\}^*$

The set represented by R is denoted by $L(R)$. Eg let R_1 and R_2 denote any two regular expression Then

1 A string $L(R_1R_2)$ is a string from R_1 followed by a string from R_2

2 A string in $L(R_1+R_2)$ is a string from R_1 or a string from R_2

3 A string in $L(R^*)$ is a string obtained by concatenating n elements for some $n \geq 0$

Q1 {110}
{1}{0} are represented by 1 & 0 respectively therefore 110 is obtained by concatenating 1, 1 and 0

ii) {baab}
{b} {a} are represented by b and a respectively therefore baab is obtained by concatenating b, a, a and b

iii) {01, 10}
as {01, 10} is the union of {01} and {10} then we have it represented as 01 + 10

iv) {epsilon, 10}
The set {epsilon, 10} is also represented by epsilon + 10

v) {abb, a, b, bba}
The set {abb, a, b, bba} is also represented by abb + a + b + bba

vi) {epsilon, a, aa, aaa, ...}
R.E for this set is epsilon $(a)^*$

vii) $\{1, 11, 111, \dots\}$
The set represents $\{1\}^*$. RE for this set is
$1(1)^*$

22) i) L_1 is the set of all strings of a's and b's ending in aa
$(a+b)^* aa$

ii) L_2 is the set of all strings of 0's and 1's begining with 1 and ending with 0
$1(1+0)^* 0$

iii) L_3 is the set of $\{$epsilon, 11, 1111, 11111, ...$\}$
epsilon $1(1)^*$

23) Grammar are finite set of rules used to describe languages. "Grammar is a generator of language while Languag is a set of strings generated by grammar"

24) The sendencial derivation of a string is any string derivable from the start symbol ~~at~~ during language generation. e.g Consider the grammar $G = (\{S\}, \{a, b\}, S, P)$ with Production rules $S \to aSb$, $S \to \lambda$

$$\underbrace{S \to aSb \to a\lambda b \to ab}$$

This is a sentencial derivation.