­­­­­­­­­­­**Q1:** **Construct a regular expression defining each of the following languages over the**

**alphabet ∑= {a, b}.**

1. All words in which a appears tripled, if at all. This means that every clump of a's contains 3 or 6 or 9 or 12... a's.

**Solution:** (aaa + b) \* or (b + aaa) \* or ((aaa)\* + (b\*)) \* or ((b)\* + (aaa)\*).

**2. All words that contain exactly three b's in total.**

**Solution:** a\*(b + ^) a\*ba\*ba\*

**3. All words that contain exactly two b's or exactly three b's, not more.**

**Solution:** a\*ba\*ba\*+ a\*ba\*ba\*ba\* or a\*(b + ^) a\*ba\*ba\*

**4. (i) All strings that end in a double letter.**

**Solution:** (a + b) (aa + bb)

(ii) All strings that have exactly one double letter in them.

**Solution:** (a + b) (ab + ba) \* + a + b + ^

**5. All strings in which the letter b is never tripled. This means that no word contains the**

**substring bbb.**

**Solution:** (^ + b + bb) (a + ab + abb) \*

Words can be empty or start and end with a or b.

A compulsory a’s is inserted between all repetition of b’s.

**7. (i) All strings that do not have the substring ab.**

**Solution:** b\*a\*

This only contains b’s or a’s. Or b’s followed by a’s or ^.

**(ii)** All strings that do not have both the substrings bba and abb.

**Solution:** a\*(baa\*) \*b\* or b\*(a\*ab\*) \*a\*

**9. (i) All strings in which any b's that occur are found in clumps of an odd number at a time,**

**such as abaabbbab.**

**Solution:** a (b(bb)\* aa\*) \*(^+b(bb)\*)

The compulsory a after some number of odd b's is there because odd + odd = even, so it is

needed to separate these odd clumps.

**(ii) All strings that have an even number of a's and an odd number of b's**.

**Solution:**

EVEN-EVEN = [aa + bb + (ab + ba) (aa + bb) \*(ab + ba)] \* Divide the language into 2 groups:

1. Words that start with b (followed by even a's and even b's) b)
2. Words that start with a (followed by odd a's and odd b's)

**b)** (EVEN-EVEN) + a [EVEN-EVEN (ab + ba) EVEN-EVEN]

**(iii) All strings that have an odd number of a's and an odd number of b's**

**Solution:**

EVEN-EVEN (ab + ba) EVEN-EVEN

The smallest string is ab or ba.

Even letters can be added to the left, right, or both.

1. **All strings that do not end with aa.**

a + b + (a + b) ∗ (ab + ba + bb)

1. **All strings that contain an even number of b’s**

a ∗ (ba∗ ba∗ ) ∗

1. **All strings which do not contain the substring**

ba. a ∗ b ∗