

Q1) i)

$$(0+1)^* \cdot 1 \cdot (0+1) + (0+1)^* \cdot 1 \cdot (0+1)$$

Let  $(0+1)$  be  $P$

$$\Rightarrow P^* \cdot 1 \cdot P + P^* \cdot 1 \cdot P$$

Let  $P^* \cdot 1 \cdot P$  be  $Q$

$$\Rightarrow Q + Q$$

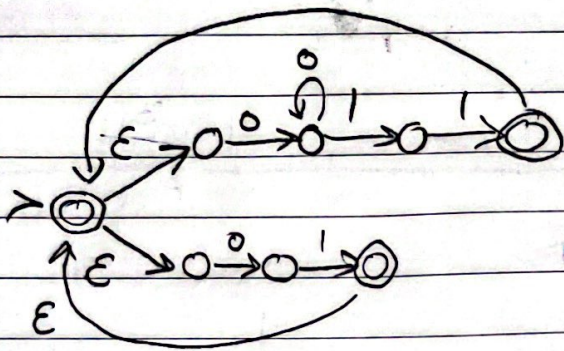
$$\Rightarrow Q$$

$$\Rightarrow P^* \cdot 1 \cdot P$$

$$\Rightarrow (0+1)^* \cdot 1 \cdot (0+1)$$

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Q2)  $((0.0^*. (1.1)) + 0.1)^*$



Q3)

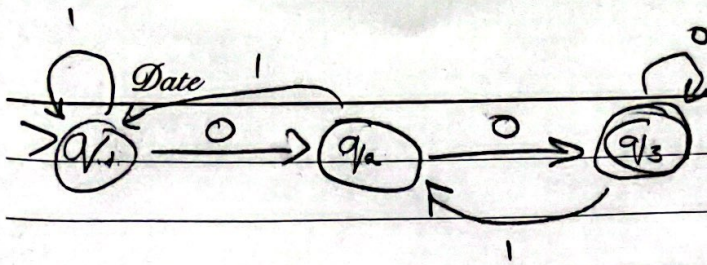
3.1.1 b)  $(0+1)^* (1) (0+1)^*$

c)  $(0+10)^* (11+e) (0+10)^*$

3.1.4 b) The set of strings of 0's and 1's with 3 consecutive 1's in them at least once

c) The set of strings of 0's and 1's with consecutive 1's only at the end (if any).





### Exercise 3.2.1

c)

$$R_{11}^2 = R_{11}^1 + R_{11}^1 \cdot (R_{22}^1)^* \cdot R_{21}^1$$

$$= 1^* + (1^* \cdot 0) \cdot (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot 1^* = (1 + 0 \cdot 1)^*$$

$$R_{12}^2 = R_{12}^1 + R_{12}^1 \cdot (R_{22}^1)^* \cdot R_{22}^1$$

$$= 1^* \cdot 0 + 1^* \cdot 0 \cdot (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot (\epsilon + 1^* \cdot 1 \cdot 0) = 1^* \cdot 0 \cdot (\epsilon + 1^* \cdot 1 \cdot 0)$$

$$R_{13}^2 = R_{13}^1 + R_{12}^1 \cdot (R_{22}^1)^* \cdot R_{23}^1$$

$$= \emptyset + 1^* \cdot 0 \cdot (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot 0 = (1 + 0 \cdot 1)^* \cdot 0 \cdot 0$$

$$R_{21}^2 = R_{21}^1 + R_{22}^1 \cdot (R_{22}^1)^* \cdot R_{21}^1$$

$$= 1 \cdot 1^* + \epsilon + 1^* \cdot 1 \cdot 0 \cdot (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot 1 \cdot 1^* = (\epsilon + 1^* \cdot 1 \cdot 0) \cdot 1^* \cdot 1$$

$$R_{22}^2 = R_{22}^1 + R_{22}^1 \cdot (R_{22}^1)^* \cdot R_{22}^1$$

$$= \epsilon + 1^* \cdot 1 \cdot 0 + \epsilon + 1^* \cdot 1 \cdot 0 \cdot (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot \epsilon + 1^* \cdot 1 \cdot 0 = (\epsilon + 1^* \cdot 1 \cdot 0)^*$$

$$R_{23}^2 = R_{23}^1 + R_{22}^1 \cdot (R_{22}^1)^* \cdot R_{23}^1$$

$$= 0 + \epsilon + 1^* \cdot 1 \cdot 0 \cdot (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot 0 = (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot 0$$

$$R_{31}^2 = R_{31}^1 + R_{32}^1 \cdot (R_{22}^1)^* \cdot R_{21}^1$$

$$= \emptyset + 1 \cdot (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot 1 \cdot 1^* = 1 \cdot (1 \cdot 1^* \cdot 0)^* \cdot 1 \cdot 1^*$$

$$R_{32}^2 = R_{32}^1 + R_{32}^1 \cdot (R_{22}^1)^* \cdot R_{22}^1$$

$$= 1 + 1 \cdot (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot (\epsilon + 1^* \cdot 1 \cdot 0) = 1 \cdot (1 \cdot 1^* \cdot 0)^*$$

$$R_{33}^2 = R_{33}^1 + R_{32}^1 \cdot (R_{22}^1)^* \cdot R_{23}^1$$

$$= (0 + \epsilon) + 1 \cdot (\epsilon + 1^* \cdot 1 \cdot 0)^* \cdot 0 = 0 + 1 \cdot (1 \cdot 1^* \cdot 0)^* \cdot 0 + \epsilon$$



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d) The language is:  $R_{13}^3$

$$R_{13}^3 = R_{13}^2 + R_{13}^2 \cdot (R_{33}^2)^* R_{33}^2$$

$$= R_{13}^2 \cdot (R_{33}^2)^*$$

$$= (1 + 0 \cdot 1)^* 0 \cdot 0 \cdot (0 + 1 \cdot (1 \cdot 1^* \cdot 0)^* 0)^*$$