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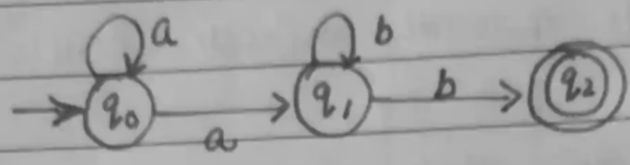
Rashika

Date.
Page No.

1) b) NFA to DFA



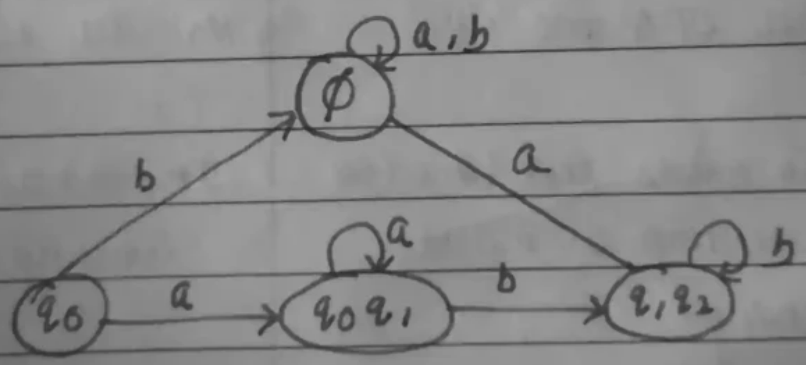
Transitn table:

| | a | b |
|---|---|---|
| $q_0$ | $q_0 q_1$ | – |
| $q_1$ | – | $q_1 q_2$ |
| $q_2$ | – | – |

$\xrightarrow{DFA}$

| | a | b |
|---|---|---|
| $\to q_0$ | $\{q_0 q_1\}$ | $\{\phi\}$ |
| $\{q_0 q_1\}$ | $\{q_0 q_1\}$ | $\{q_1 q_2\}$ |
| $\{q_1 q_2\}$ | $\{\phi\}$ | $\{q_1 q_2\}$ |
| $\{\phi\}$ | $\{\phi\}$ | $\{\phi\}$ |

→



b) MDFA for DFA

| | 0 | 1 |
|---|---|---|
| $\to q_0$ | $q_1$ | $q_2$ |
| $q_1$ | $q_3$ | $q_4$ |
| $q_2$ | $q_3$ | $q_2$ |
| $q_3$ | $q_3$ | $q_4$ |
| $q_4$ | $q_1$ | $q_4$ |

Divide Q into subset of final & non final state

$\{q_0, q_1, q_2, q_3\}$ $\{q_4\}$

| | 0 | 1 |
|---|---|---|
| $q_0$ | T1 | T1 |
| $q_1$ | T1 | T2 |
| $q_2$ | T1 | T2 |
| $q_3$ | T1 | T2 |

| T1 | T2 |
|---|---|
| $\Rightarrow \{q_0, q_2\}$ | $\{q_1, q_3\}$ |

$\{q_4\}$

T3

Breaking T1

| | 0 | 1 |
|---|---|---|
| $q_0$ | T2 | $T_1$ |
| $q_2$ | T2 | $T_1$ |

Can't be broken further

Breaking T2

| | 0 | 1 |
|---|---|---|
| $q_1$ | $T_1$ | T3 |
| $q_3$ | $T_1$ | T3 |

Cannot break further

So we have : $\{q_0, q_2\}$ $\{q_1, q_3\}$ $\{q_4\}$

Kashifa

Date.
Page No.

Transition Table:-

| | | 0 | 1 |
|---|---|---|---|
| start state | → $q_0q_2$ | $q_1q_3$ | $q_0q_2$ |
| | $q_1q_3$ | $q_0q_2$ | $q_4$ |
| final state | → $q_4$ | $q_1q_3$ | $q_4$ |

4) b) Relation b/w PDF and CFG

Pushdown Automata (PDA)
Context-Free Grammar (CFG)

i) CFG and PDA are equivalent in power
CFG generates a context-free language, and PDA recognizes a context free language.

We can convert a CFG into a PDA that recognises the language specified by the CFG and vice-versa.

If a language L is context-free then there is a PDA, M, that recognizes it.

or

Rashi

Date.

Page No.

If a language ~~is~~ L is recognized by a PDA, $M_L$ then there is a CFG $G_L$ that generates L.

ii> Rules to convert CFG into PDA.

Step 1: Push the start symbol 'A' on to the stack

Step 2: Push RHS of 'A' as follows:

$\delta(q_1, a, A) = (q_1, \alpha)$

if $A \to a\alpha$ is in Grammar

and $\delta(q_1, b, A) = (q_1, \beta)$

if $A \to b\beta$ is in Grammar.

Step 3: Add final state with

$\delta(q_p, \epsilon, Z_0) = (q_f, \epsilon)$

iii> Find PFA

$X \to 0X3$

$X \to 0A3$

$A \to 1A2$

$A \to 12$

=> $X \to 0X3 / 0A3$

$A \to 1A2 / 12$

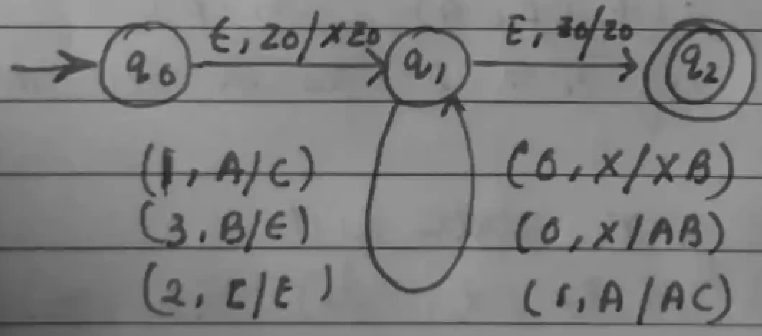
Rashika

Date.
Page No.

Convert Grammar to GNF (Greibach Normal form)

X → 0XB / 0AB
A → 1AC / 1C
B → 3
C → 2

Now, GNF to PDA



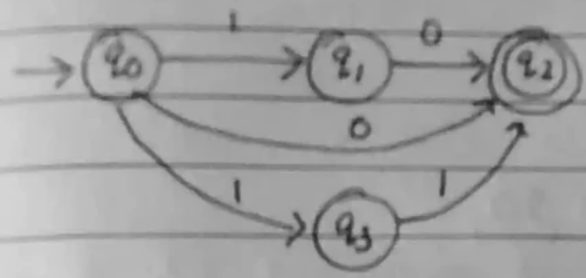

= Required PDA

Ramika

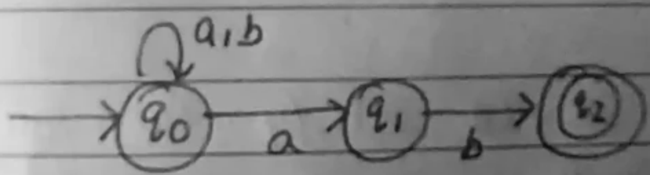
Date.
Page No.

2) a)

i) 10 + (0 + 11)




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




b) $L = \{0^n / n \text{ is prime}\}$ is not regular

$L = \{0, 000, 00000, \ldots\}$

Let there be a string $\omega = 00000$ which belong to lang $L$ and let this be a regular language.

Kashika

Date
Page No.

* Then $w$ can be divided into $x, y, z$ such that

1) $|w| \geq n$
2) $|xy| \leq n$
3) $|y| \geq 1$

$$w = \underbrace{0}_{x}\ \underbrace{00}_{y}\ \underbrace{00}_{z}$$

$|y| = 1 > 0$

$|xy| = 3 \leq n$

Then $w$ should satisfy the following:
If we write $w = xy^iz$, it should belong to lang $L$ $\quad (w = \underbrace{0}_{x}\underbrace{00}_{y}\underbrace{00}_{z})$

For $i=1$ $\quad w = 00000 \Rightarrow 0^5 \in L$

$i=2$ $\quad w = 0000000 \Rightarrow 0^7 \in L$

$i=3$ $\quad w = 000000000 \Rightarrow 0^9 \notin L$

So, this contradicts our point that lang $L$ is regular.
Hence lang $L$ is not a regular language

Rashika

Date

Page No.

5) The undecidability of the string is determined with the help of post's correspondence problem (PCP) over an alphabet $\Sigma$:-

Given the following two lists, M and N of non-empty string over $\Sigma$

$M = (x_1, x_2, x_3 \dots x_n)$

$N = (y_1, y_2, y_3 \dots y_n)$

We can say that there is a Post Correspondence solutn, if for some. $i_1, i_2, \dots i_k$, where $1 \leq i \leq n$, the condition $x_{i_1} \dots x_{i_k} = y_{i_1} \dots y_{i_k}$ satisfies

Proof :

If we are able to reduce turing machine to PCP that we will prove the PCP is undecidable as well.

Consider turing machine M to simulate PCP's input string $\omega$ can be represented as

$M = (Q, \Sigma, \Gamma, \delta, q_0, q_{accept}, q_{reject})$

Rashika

Date

Page No.

Solution for system of PCP

$A = \{100, 0, 1\}$ and $B = \{1, 100, 00\}$

| | $x_1$ | $x_2$ | $x_3$ |
|---|---|---|---|
| A | 100 | 0 | 1 |
| B | 1 | 100 | 00 |

Now we have to find out a sequence that string formed by x & y are identical

For A :-

1 3 1 1 3 2 2

100 + 1 + 100 + 100 + 1 + 0 + 0

$x_1 x_3 x_1 x_1 x_3 x_2 x_2 = 100\ 1100100100$

For B :-

1 3 1 1 3 2 2

1 + 00 + 1 + 1 + 00 + 100 + 100

$y_1 y_3 y_1 y_1 y_3 y_2 y_2 = 100\ 1100100100$

Solution is 1, 3, 1, 1, 3, 2 2

As both (A & B) string are identical

Date
Page No.

If there is match in input string w, then turing machine M halts in accepting state. This halting state of Turing machine is acceptance problem $A_{TM}$ since.

$A_{TM}$ is undecidable ∴ PCP is also undecidable. We make 2 modifications to Turing machine M and one change to ours PCP problem.

1) M on input we can never attempt to move tape head beyond left end of input tape.
2) If input is empty string ε, we use 2.
3) PCP problem start match with first $[u_1/v_1]$. This is called modified PCP problem.

MPCP = { [D] | D is instance of PCP starts with first domino }

Kaswika.

Date
Page No.

3)a) $L = \{0^i 1^i 2^i \mid |2| \}$

Let L is context-free
Now, we can take string such that
$w = 0^i 1^i 2^i$
we decide w in 5 parts uvxyz
let $i = 4$
so, $w = 0^4 1^4 2^4$

→ vxy contain only 1 type of symbol.

→ Every $w \in L$ with $|w| \geq i$ can be written as uvxyz for same string u, v, x, y, z.

→ $|vy| \geq 1$
→ $|vxy| <=$ pumping length (i)
→ $uv^kxy^kz \in L$ for all $k >= 0$

$w = \underbrace{000}_{u}\underbrace{0}_{v}\ \underbrace{11}_{x}\underbrace{11}_{y}\ \underbrace{2222}_{z}$

$u = 000$
$v = 0$
$x = 11$
$y = 11$
$z = 2222$

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Date.
Page No.

for $k=1$ $uv^1xy^1z$

$0000\,1111\,2222 \in L$

for $k=2$ $uv^2xy^2z$

$000(0)^2 11(11)^2 2222$

$00000\,11\,1111\,2222$

$0^5 1^6 2^4 \notin L$

Hence. for $k=2$ $uv^kxy^kz$ does not belong to $L$.

$\therefore$ It is contridiction to our assumption.

$\therefore$ $L = \{0^i 1^i 2^i \mid i >= 1\}$ is not a CFG