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1. Lakukan Penghilang Rekursif kiri. Pada tata bahasa bebas kontek berikut :

   a. $S \rightarrow ASd \mid Scb \mid BSd \mid Sae$
      $A \rightarrow Ade \mid bAe \mid Abb \mid a$
      $B \rightarrow bBb \mid Bac \mid BaA$

    1) Pisahkan aturan Produksi yang rekursif kiri
       $S \rightarrow Scb \mid Sae$
       $A \rightarrow Ade \mid Abb$
       $B \rightarrow Bac \mid BaA$

       Simbol S : $\alpha_1 = cb$, $\alpha_2 = ae$
       Simbol A : $\alpha_1 = de$, $\alpha_2 = bb$
       Simbol B : $\alpha_1 = ac$, $\alpha_2 = aA$

      # aturan yang tidak rekursif kiri
       $S \rightarrow ASd \mid BSd$
       $A \rightarrow bAe \mid a$
       $B \rightarrow bBb$

       Simbol S : $\beta_1 = ASd$, $\beta_2 = BSd$
       Simbol A : $\beta_1 = bAe$, $\beta_2 = a$
       Simbol B : $\beta_1 = bBb$

    2) Lakukan Pergantian aturan Produksi yang rekursif kiri
       $S \rightarrow Scb \mid Sae$
       1). $S \rightarrow ASdZ_1 \mid BSdZ_1$
          $Z_1 \rightarrow cb, \ ae$
          $Z_1 \rightarrow cbZ_1, \ aeZ_1$
       $A \rightarrow Ade \mid Abb$
       1). $A \rightarrow bAeZ_2 \mid aZ_2$
          $Z_2 \rightarrow de, \ bb$
          $Z_2 \rightarrow deZ_2, \ bbZ_2$
       $B \rightarrow Bac \mid BaA$
       1). $B \rightarrow bBbZ_3$

$z_3 \to ac, aA$

$z_3 \to acz_3, aAz_3$

3) Hasil akhir aturan Produksi Setelah Penghilangan rekursif kiri

$S \to Asd \mid Bsd$

$A \to bAe \mid a$

$B \to bBb$

$S \to Asdz_1 \mid bsdz_1$

$z_1 \to cb, ae$

$z_1 \to cbz_1, aez_1$

$A \to BAez_2 \mid az_2$

$z_2 \to de, bb$

$z_2 \to dez_2, bbz_2$

$B \to bBbz_3$

$z_3 \to ac, aA$

$z_3 \to acz_3, aAz_3$

b. $P \to Pab \mid rPq \mid aQP$

$Q \to Qbc \mid bQa \mid bRQ$

$R \to Rcd \mid dRb \mid abR$

1) Pisahkan aturan yang rekursif kiri

$P \to Pab$

$Q \to Qbc$

$R \to Rcd$

Smbol $P : \alpha_1 = ab$

Smbol $Q : \alpha_1 = bc$

Smbol $R : \alpha_1 = cd$

* aturan yang tidak rekursif kiri

$P \to rPq \mid aQP$

$Q \to bQa \mid bRQ$

$R \to dRb \mid abR$

Smbol $P : \beta_1 = rPq, \beta_2 = aQP$

Smbol $Q : \beta_1 = bQa, \beta_2 = bRQ$

Smbol $R : \beta_1 = dRb, \beta_2 = abR$

2) lakukan Pergantian aturan Produksi yang rekursif kiri

$P \rightarrow Pab$

1). $P \rightarrow rPqZ_1 \mid aQPZ_1$

$Z_1 \rightarrow ab$

$Z_1 \rightarrow abZ_1$

$Q \rightarrow Qbc$

1) $Q \rightarrow bQaZ_2 \mid bRQZ_2$

$Z_2 \rightarrow bc$

$Z_2 \rightarrow bcZ_2$

$R \rightarrow Rcd$

1) $R \rightarrow dRbZ_3 \mid abRZ_3$

$Z_3 \rightarrow cd$

$Z_3 \rightarrow cdZ_3$

3.) hasil akhir aturan Produksi setelah penghilangan rekursif kiri

$P \rightarrow rPq \mid aQP$

$Q \rightarrow bQa \mid bRQ$

$R \rightarrow dRb \mid abR$

$P \rightarrow rPqZ_1 \mid aQPZ_1$

$Z_1 \rightarrow ab$

$Z_1 \rightarrow abZ_1$

$Q \rightarrow bQaZ_1 \mid bRQZ_2$

$Z_2 \rightarrow bc$

$Z_2 \rightarrow bcZ_2$

$R \rightarrow dRbZ_3 \mid abRZ_3$

$Z_3 \rightarrow cd$

$Z_3 \rightarrow cdZ_3$

2. ubahlah tata bahasa kontek beriket kedalmbentuk BNC:

$S \rightarrow CBA \mid aE \mid sB$
$A \rightarrow AB \mid Eg \mid BAa$
$B \rightarrow aDB \mid bAA \mid bb$
$C \rightarrow cC \mid bC \mid DC$
$D \rightarrow e$

1) atur Produksi yang sudah dalam bentuk normal Chomsky
$A \mapsto AB$

$C \rightarrow DC$
$D \rightarrow e$

2) Lakukan Pergantian aturan Produksi yang belum bentuk normal Chomsky

$S \rightarrow cBA \Rightarrow S \rightarrow P1BA$
$\qquad\qquad\qquad S \rightarrow P_1 P_2$
$S \rightarrow aE \Rightarrow S \rightarrow P_3 E$
$S \rightarrow sB \Rightarrow S \rightarrow P_4 B$
$A \rightarrow Eg \Rightarrow A \rightarrow C P_5$
$A \rightarrow BAa \Rightarrow A \rightarrow BAP_3$
$\qquad\qquad\qquad A \rightarrow P_2 P_3$
$B \rightarrow aDB \Rightarrow B \rightarrow P_3 DB$
$\qquad\qquad\qquad B \rightarrow P_3 P_6$
$B \rightarrow bAA \Rightarrow B \rightarrow P_7 AA$
$\qquad\qquad\qquad B \rightarrow P_7 P_8$
$B \rightarrow bb \Rightarrow B \rightarrow P_7 P_7$
$C \rightarrow cC \Rightarrow C \rightarrow P_1 C$
$C \rightarrow bC \Rightarrow C \rightarrow P_7 C$

3) Terbentuk aturan Produksi dan Simbol Variabel baru :

$P_1 \rightarrow C$
$P_2 \rightarrow BA$
$P_3 \rightarrow a$
$P_4 \rightarrow S$
$P_5 \rightarrow g$
$P_6 \rightarrow DB$
$P_7 \rightarrow b$
$P_8 \rightarrow AA$
$P_g \rightarrow bb$

4) Hasil akhir aturan dalam bentuk normal Chomsky :

$A \to AB$ $B \to P_3 P_6$

$C \to DC$ $B \to P_7 P_8$

$D \to e$ $B \to P_7 P_7$

$S \to P_1 P_2$ $C \to P_1 C$

$S \to P_3 E$ $C \to P_7 C$

$S \to P_4 B$

$A \to C P_5$

$A \to P_2 P_3$

3. Buat BNG pada tata bahasa bebas konteks berikut ini :

   a. $S \to PQ$

       $P \to Qs \mid r \mid qa$

       $Q \to SP \mid q \mid p$

      * Lakukan Pergantian aturan Produksi yg belum bentuk normal Chomsky

         $P \to qa \Rightarrow P \to P_1 a$

                 $P \to P_1 P_2$

      * BNG

       $S \to PQ$

       $P \to Qs \mid r \mid P_1 P_2$

       $Q \to SP \mid q \mid p$

      * Tentukan urutan Simbol Variabel

         S, P, Q

        $(S < P < Q$

      * Priksa aturan Produksi apakah sudah memenuhi urutan Variabel

         $S \to \underline{P}Q$ $(S < P$ memenuhi)

         $P \to \underline{Q}s$ $(P < Q$ memenuhi)

         $Q \to \underline{S}P$ $(Q > S$ tidak memenuhi)

      * Subtitusi pada Simbol Variabel yang belum memenuhi urutan :

         $Q \to SP \Rightarrow Q \to PQP \Rightarrow Q \to QSQP \mid r QP \mid P_1 P_2 QP \mid q \mid$

      * untuk $Q \to QSQP \mid P_1 P_2 QP$ Lakukan Penghilangan rekursif kiri

         $Q \to r QPz_1 \mid q z_1 \mid Pz_1$

         $z_1 \to SQP \cdot P_1 QP$

         $z_1 \to SQPz_1 \cdot P_1 QPz_1 \cdot$

         $Q \to r QPz_1 \mid q z_1 \mid Pz_1 \mid r QP \mid q \mid P$

* lakukan Subtitusi mundur pada produksi yang belum BNG

$P \to QS \Rightarrow P \to rQPz_1S \mid qz_1S \mid Pz_1S \mid rQPS \mid qS \mid rS \mid r \mid P_1P_2$

$S \to PQ \Rightarrow S \to rQPz_1SQ \mid qz_1SQ \mid Pz_1SQ \mid rQPSQ \mid qSQ \mid rSQ \mid rQ$

P_1P_2Q

* Subtitusi pada aturan baru

$z_1 \to SQP \Rightarrow z_1 \to rQPz_1SQQP \mid qz_1SQQP \mid Pz_1SQQP \mid rQPSQQP \mid qSQQP$
$\mid rSQQP \mid rQQP \mid P_1P_2QP \mid QP$

$z_1 \to SQPz_1 \Rightarrow z_1 \to rQPz_1SQQPz_1 \mid qz_1SQQPz_1 \mid Pz_1SQQPz_1 \mid rQPSQQPz_1$
$\mid qSQQPz_1 \mid rSQQPz_1 \mid rQQPz_1 \mid P_1P_2QPz_1 \mid QPz_1$

* hasil akhir aturan produksi yang sudah dalam bentuk BNG :

$S \to rQPz_1SQ \mid qz_1SQ \mid Pz_1SQ \mid rQPSQ \mid qSQ \mid rSQ \mid rQ \mid$

$P \to rQPz_1S \mid qz_1S \mid Pz_1S \mid rQPS \mid qS \mid rS$

$Q \to rQPz_1 \mid qz_1 \mid Pz_1 \mid rQP \mid q \mid r$

$z_1 \to rQPz_1SQQP \mid qz_1SQQP \mid Pz_1SQQP \mid rQPSQQP \mid qSQQP$
$\mid rSQQP \mid rQQP \mid P_1P_2QP \mid QP$

$z_1 \to rQPz_1SQQPz_1 \mid qz_1SQQPz_1 \mid Pz_1SQQPz_1 \mid rQPSQQPz_1$
$\mid qSQQPz_1 \mid rSQQPz_1 \mid rQQPz_1 \mid P_1P_2QPz_1 \mid QPz_1$

3. b. $S \to BC$
$A \to AD$
$B \to c|d$
$C \to AB$
$D \to a|b$

* Lakukan Penghilan rekursif kiri
$A \to AD \Rightarrow A \to ADD$

Simbol A : $\alpha_1 = DD$
$A \to ADD$
$A \to z_1$
$z_1 \to DD$
$z_1 \to DDz_1$

* tentukan urutan Simbol variabel
S, A, B, C, D
$(S < A < B, C, D)$

* Priksa aturan Produksi apakah Sudah memenuhi urutan Variabel :
$S \to BC$ ($S < B$ memenuhi)
$C \to AB$ ($C > A$ tdak memenuhi)

* lakukan Subtitusi Pada Simbol var yang blm memenuhi urutan :
$C \to AB \Rightarrow C \to z_1B \Rightarrow C \to DDz_1 \Rightarrow C \to aDz_1 | bDz_1$

* lakukan Subtitusi mundur
$A \to z_1D \Rightarrow A \to DDz_1 \Rightarrow aDz_1D | bDz_1D$
$S \to BC \Rightarrow B \to cC | dC$

* Subtitusi Pada aturan baru
$z_1 \to DD \Rightarrow z_1 \to aD | bD$
$z_1 \to DDz_1 \Rightarrow z_1 \to aDz_1 | bDz_1$

* hasil akhir
$S \to cC | dC$ $D \to a|b$
$A \to aDz_1D | bDz_1D$ $z_1 \to aD | bD$
$B \to c|d$ $z_1 \to aDz_1 | bDz_1$
$C \to aDz_1 | bDz_1$

4. $Q = \{q_0, q_1, q_2\}$ funasi transisi
   $S = q_0$ $\Delta(q_0, a, Z) = (q_0, XZ)$
   $\Sigma = \{a, b, c\}$ $\Delta(q_0, b, Z) = (q_0, XZ)$
   $T = \{X, Z\}$ $\Delta(q_0, a, X) = (q_0, XX)$
   $F = \{q_2\}$ $\Delta(q_0, b, X) = (q_0, XX)$
   $Z = Z$ $\Delta(q_0, c, X) = (q_1, X)$
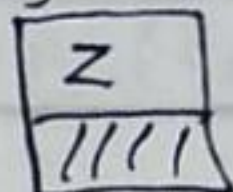 $\Delta(q_0, c, Z) = (q_1, Z)$
                      $\Delta(q_1, a, X) = (q_1, \varepsilon)$
                      $\Delta(q_1, b, X) = \{q_1, \varepsilon\}$
                      $\Delta(q_1, \varepsilon, Z) = (q_2, Z)$

a. * String "abca" dan "abcab"

1). Konfigurasi awal. State : q_0 ; Top Stack : 7 ; membaca Input a

$$\Delta(q_0, a, Z) = (q_0, XZ)$$

   Konfigurasi mesin menjadi   State q_0. Push X
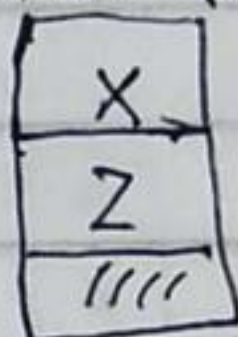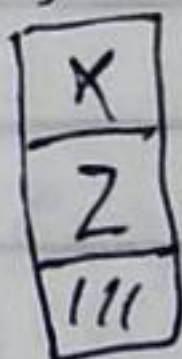

2). $\Delta(q_0, b, X) = (q_0, XX)$
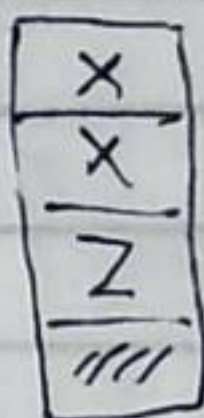
                   Push X

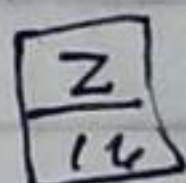3). $\Delta(q_0, c, X) = (1, \alpha)$
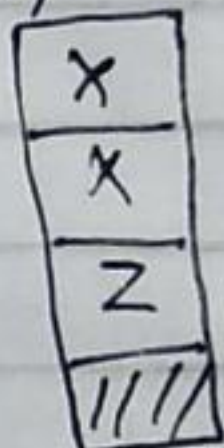
4). $\Delta(q_1, a, x) = (q_1, \varepsilon)$

                   State q_1, Pop top Stack

5) $\Delta(q_1, \varepsilon, x) = $ "abcu" → ditolak
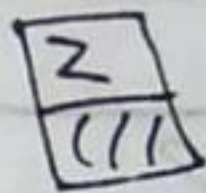
6). $\Delta(q_1, b, x) = (q_1, \varepsilon)$

                   Pop top state

(KAY)

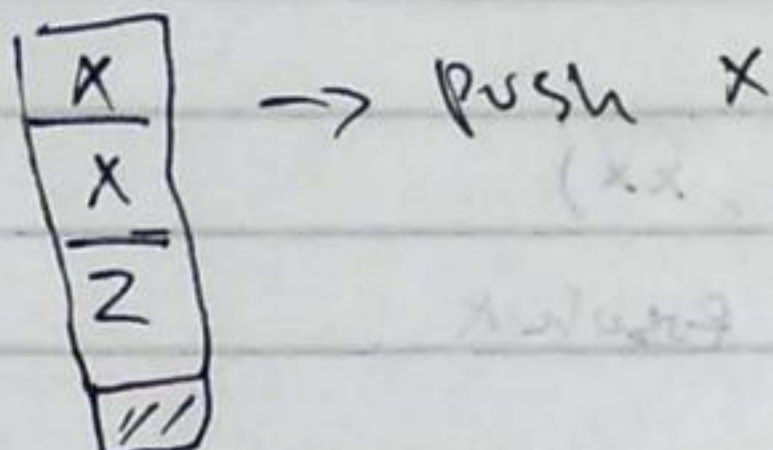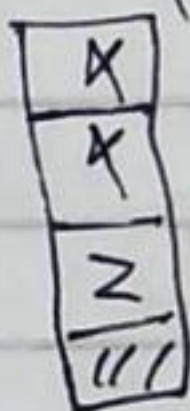7.) $\Delta q_1, \varepsilon, z) = (q_2, z)$

Maka string "abcdb" → diterima

$\boxed{\begin{array}{c} Z \\ \hline ||| \end{array}}$

* String "bbcaa"

1) $\Delta(q_0, b, z) = (q_0, xz)$

$\boxed{\begin{array}{c} X \\ \hline Z \\ \hline ||| \end{array}}$ → Push x

2) $\Delta(q_0, b, x) = (q_0, xx)$

$\boxed{\begin{array}{c} X \\ \hline X \\ \hline Z \\ \hline || \end{array}}$ → Push x

3) $\Delta(q_0, c, x) = (q_1, x)$

$\boxed{\begin{array}{c} X \\ \hline X \\ \hline Z \\ \hline ||| \end{array}}$

4) $\Delta(q_2, a, x) = (q_1, \varepsilon)$

$\boxed{\begin{array}{c} X \\ \hline Z \\ \hline ||| \end{array}}$ → Pop top stack

5) $\Delta(q_1, a, x) = (q_1, \varepsilon)$

$\boxed{\begin{array}{c} Z \\ \hline ||| \end{array}}$ Pop top stack
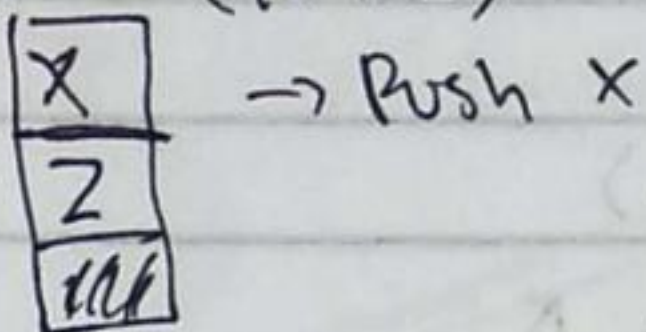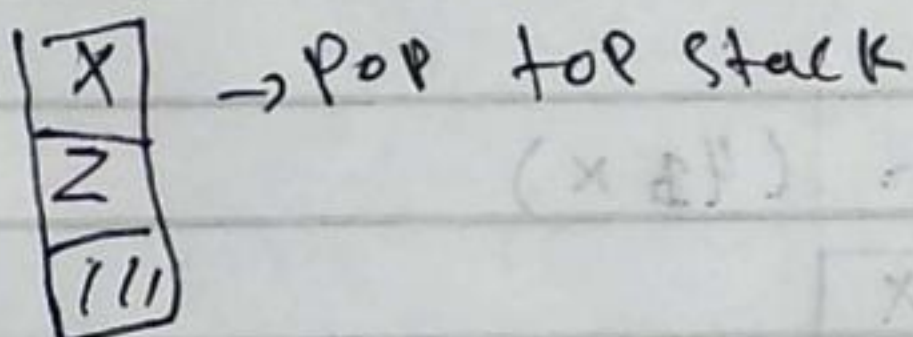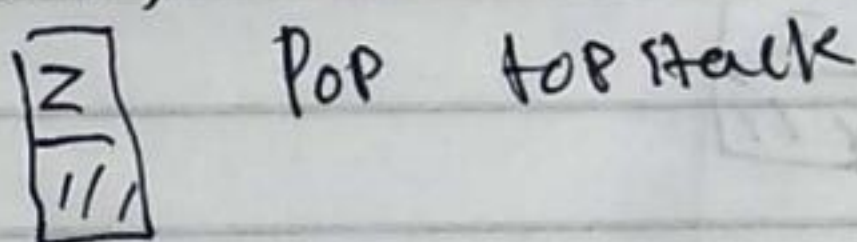
6) $\Delta(q_1, \varepsilon, z) = \{(q_2, z)\}$

Maka String "bbcaa" → diterima

* String "abcba"   String "abc" (q_1, x)

$\boxed{\begin{array}{c} X \\ \hline X \\ \hline Z \\ \hline || \end{array}}$

4) $\Delta(q_1, b, x) = (q_1, \varepsilon)$

$\boxed{\begin{array}{c} X \\ \hline Z \\ \hline ||| \end{array}}$ Pop top stack

KKY

5) $\Delta(q_1, a, x) = (q_1, \varepsilon)$

$\boxed{\begin{array}{c} Z \\ /// \end{array}}$ Pop top state

6. $\Delta(q, \varepsilon, Z) = \{(q_2, Z)\}$

Maka String "abcba" $\rightarrow$ diterima

* String "abacba"

1). $\Delta(q_0, a, Z) = (q_0, x Z)$

$\boxed{\begin{array}{c} K \\ Z \\ /// \end{array}}$ Push K

2) $\Delta(q_0, b, x) = (q_0, xx)$

$\boxed{\begin{array}{c} K \\ x \\ Z \\ /// \end{array}}$ Push K

3) $\Delta(q_0, a, x) = (q_0, xx)$

$\boxed{\begin{array}{c} x \\ x \\ Z \\ /// \end{array}}$

4) $\Delta(q_0, c, x) = (q_1, x)$

$\boxed{\begin{array}{c} x \\ x \\ Z \\ /// \end{array}}$

5) $\Delta(q_1, b, x) = (q_1, \varepsilon)$

$\boxed{\begin{array}{c} x \\ Z \\ /// \end{array}}$ Pop top stack

6) $\Delta(q_1, a, x) = (q_1, \varepsilon)$

$\boxed{\begin{array}{c} Z \\ /// \end{array}}$ Pop top stack

7. $(q, \varepsilon) =$

Maka String "abacba" $\rightarrow$ ditolak

* String "ababaabbacbb acabbahhaba" $\rightarrow$ diterima
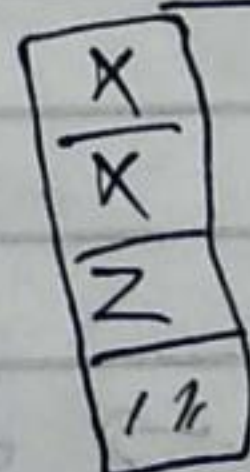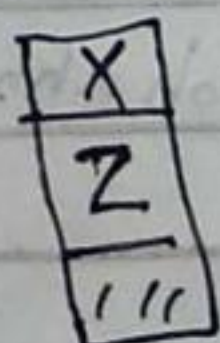
b. + 2 String lainya yang diterma
  - String "bbcaaa" → diterma karena berakhir di State q_2
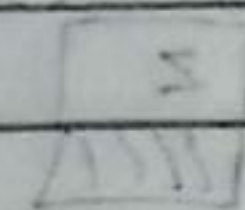 - String "abcabb" → diterma " " q_2

+ 2 String lainya yangditolak
  - String "abacbab" → ditolak karena tidak berakhir di State q_2
  - String "abcab" → ditolak " " " " " q_2