Chomsky Normal Form

Tag CFL

A context free grammar (CFG) is in Chomsky Normal Form (CNF) if all production rules satisfy one of the following conditions:

- A non-terminal generating a terminal (e.g.; X→x)
- A non-terminal generating two non-terminals (e.g.; X→YZ)
- Start symbol generating ε. (e.g.; S→ ε)

Steps:

Step 1. Eliminate start symbol from RHS.

If start symbol S is at the RHS of any production in the grammar, create a new production as:

S0→S where S0 is the new start symbol.

Step 2. Eliminate null, unit and useless productions.

Step 3. Eliminate terminals from RHS if they exist with other terminals or non-terminals. e.g,; production rule X→xY can be decomposed as:

X→ZY

Z→x

Step 4. Eliminate RHS with more than two non-terminals.

e.g,; production rule X→XYZ can be decomposed as:

X→PZ

P→XY

CFG to CNF

A website to convert Context Free Grammar(CFG) to equivalent Chomsky Normal Form(CNF)

https://devimam.github.io/cfgtocnf/

▼ Past Paper Qs

Convert to CNF and you must show all the intermediary four steps in the order studied to score full marks:

S → SS | AB | B

A → aAAa

B → bBb | bb | Δ

C → CC | a

D → aC | bb

Solution:

1. Augmented grammar

   So → S

   S → SS | AB | B

   A → aAAa

   B → bBb | bb | Δ

   C → CC | a

   D → aC | bb

2. Remove null productions

   So → S | ^

S → SS | AB | B | A | S

A → aAAa

B → bBb | bb

C → CC | a

D → aC | bb

Remove useless production

A,C,D are useless

So → S | ^

S → SS | B | S

B → bBb | bb

Remove unit productions

So → SS | bBb | bb | S | ^

S → SS | bBb | bb | S

B → bBb | bb

3. terminal-non-terminal

   So → SS | XBX | XX | S | ^

   S → SS | XBX | XX | S

   B → XBX | XX

   X → b

4. more than two non terminals

   So → SS | PX | XX | S | ^

   S → SS | PX | XX | S

   B → PX | XX

X → b

P → XB

Convert the following grammar to Chomsky Normal Form Grammar. Show all the
intermediary steps in the correct order clearly to score full marks.

S → aAbB | ABC | a
A → aA | a | CD
B → CbC | b
C → S | Δ
D → CC | Db
E → S | Δ

Solution:

1. no need of augmented grammar
2. remove useless productions (E)

   S → aAbB | ABC | a
   A → aA | a | CD
   B → CbC | b
   C → S | Δ
   D → CC | Db

   Remove unit prod

   S → aAbB | ABS | a | ^
   A → aA | a | SD
   B → SbS | b
   D → SS | Db

3. terminal-nonterminal

   S → XAYB | ABS | a | ^
   A → XA | a | SD

B → SYS | b
D → SS | DY

X → a

Y → b

4. remove more than two terminals

S → PYB | QS | a | ^
A → XA | a | SD
B → RS | b
D → SS | DY

X → a

Y → b

P → XA

Q → AB

R → SY

Final:

S → TB | QS | a | ^
A → XA | a | SD
B → RS | b
D → SS | DY

X → a

Y → b

P → XA

Q → AB

R → SY

T → PY

Convert the following grammar to Chomsky Normal Form Grammar. Show all the intermediary steps in the correct order clearly to score full marks.

S → aAbB | ABC | a

A → aA | a | CD

B → CbC | b

C → CC | Δ

D → CC | Db

E → EE | Δ

Solution:

1. no augmented grammar
2. remove null prod

   S → aAbB | ABC | a | AB | abB | BC | B

   A → aA | a | CD | D | C

   B → CbC | b | bC | Cb

   C → CC | C

   D → CC | Db | C | b

   E → EE | E

   remove useless prod (E,C)

   S → aAbB | AB | a | abB | B

   A → aA | a | D

   B → b

   D → Db | b

   remove unit prods

   S → aAbB | AB | a | abB | b

   A → aA | a | Db | b

   B → b

   D → Db | b

3. terminal, non-terminal

   S → XAYB | AB | a | XYB | b

   A → XA | a | DY | b

   B → b

   D → DY | b

   X → a

   Y → b

4. Two or more non terminals

   S → PYB | AB | a | QB | b

   A → XA | a | DY | b

   B → b

   D → DY | b

   X → a

   Y → b

   P → XA

   Q → XY

   Final:

   S → RB | AB | a | QB | b

   A → XA | a | DY | b

   B → b

   D → DY | b

   X → a

   Y → b

   P → XA

   Q → XY

   R → PY

CNF: Convert the following CFG to CNF

S→ASA|aB

A→B|S

B→b|bD | Δ

C → CC|aa|AB

D → DD

Solution:

1. augmented

   So → S

   S→ASA|aB

   A→B|S

   B→b|bD | Δ

   C → CC|aa|AB

   D → DD

2. remove null prods

   So → S

   S→ASA | aB | a | AS | SA | S

   A→B | S

   B→b | bD

   C → CC | aa | AB | A | B | C

   D → DD

   remove useless symbols (C,D)

So → S

S→ASA | aB | a | AS | SA | S

A→B | S

B→b

remove unit prods

So → ASA | aB | a | AS | SA

S → ASA | aB | a | AS | SA

A → b | ASA | aB | a | AS | SA

B → b

1. terminal, non-terminal

   So → ASA | XB | a | AS | SA

   S → ASA | XB | a | AS | SA

   A → b | ASA | XB | a | AS | SA

   B → b

   X → a

   Y → b
2. more than two non-terminals

   So → ZA | XB | a | AS | SA

   S → ZA | XB | a | AS | SA

   A → b | ZA | XB | a | AS | SA

   B → b

   X → a

   Y → b

   Z → AS