Problem-01:

Consider the following grammar and eliminate left recursion-

$$A \rightarrow ABd / Aa / a$$

$$B \rightarrow Be / b$$

Solution-

The grammar after eliminating left recursion is-

A → aA'

A' → BdA' / aA' / ∈

B → bB'

B' → eB' / ∈

Problem-02:

Consider the following grammar and eliminate left recursion-

$$E \rightarrow E + E / E \times E / a$$

Solution-

The grammar after eliminating left recursion is-

E → aA

A → +EA / xEA / ∈

Problem-03:

Consider the following grammar and eliminate left recursion-

$$E \rightarrow E + T / T$$

$$T \rightarrow T \times F / F$$

$$F \rightarrow id$$

Solution-

The grammar after eliminating left recursion is-

E → TE'

E' → +TE' / ∈

T → FT'

T' → xFT' / ∈

F → id

Problem-04:

Consider the following grammar and eliminate left recursion-

S → (L) / a

L → L , S / S

Solution-

The grammar after eliminating left recursion is-

S → (L) / a

L → SL'

L' → ,SL' / ∈

Problem-05:

Consider the following grammar and eliminate left recursion-

S → S0S1S / 01

Solution-

The grammar after eliminating left recursion is-

S → 01A

A → 0S1SA / ∈

Problem-06:

Consider the following grammar and eliminate left recursion-

S → A

A → Ad / Ae / aB / ac

B → bBc / f

Solution-

The grammar after eliminating left recursion is-

S → A

A → aBA' / acA'

A' → dA' / eA' / ∈

B → bBc / f

Problem-07:

Consider the following grammar and eliminate left recursion-

A → AAα / β

Solution-

The grammar after eliminating left recursion is-

A → βA'

A' → AαA' / ∈

Problem-08:

Consider the following grammar and eliminate left recursion-

$$A → Ba / Aa / c$$

$$B → Bb / Ab / d$$

Solution-

This is a case of indirect left recursion.

Step-01:

First let us eliminate left recursion from A → Ba / Aa / c

Eliminating left recursion from here, we get-

A → BaA' / cA'

A' → aA' / ∈

Now, given grammar becomes-

A → BaA' / cA'

A' → aA' / ∈

B → Bb / Ab / d

Step-02:

Substituting the productions of A in B → Ab, we get the following grammar-

A → BaA' / cA'

A' → aA' / ∈

B → Bb / BaA'b / cA'b / d

Step-03:

Now, eliminating left recursion from the productions of B, we get the following grammar-

A → BaA' / cA'

A' → aA' / ∈

B → cA'bB' / dB'

B' → bB' / aA'bB' / ∈

This is the final grammar after eliminating left recursion.

Problem-09:

Consider the following grammar and eliminate left recursion-

$$X → XSb / Sa / b$$

$$S → Sb / Xa / a$$

Solution-

This is a case of indirect left recursion.

Step-01:

First let us eliminate left recursion from X → XSb / Sa / b

Eliminating left recursion from here, we get-

X → SaX' / bX'

X' → SbX' / ∈

Now, given grammar becomes-

X → SaX' / bX'

X' → SbX' / ∈

S → Sb / Xa / a

Step-02:

Substituting the productions of X in S → Xa, we get the following grammar-

X → SaX' / bX'

X' → SbX' / ∈

S → Sb / SaX'a / bX'a / a

Step-03:

Now, eliminating left recursion from the productions of S, we get the following grammar-

X → SaX' / bX'

X' → SbX' / ∈

S → bX'aS' / aS'

S' → bS' / aX'aS' / ∈

This is the final grammar after eliminating left recursion.

Problem-10:

Consider the following grammar and eliminate left recursion-

S → Aa / b

A → Ac / Sd / ∈

Solution-

This is a case of indirect left recursion.

Step-01:

First let us eliminate left recursion from S → Aa / b

This is already free from left recursion.

Step-02:

Substituting the productions of S in A → Sd, we get the following grammar-

S → Aa / b

A → Ac / Aad / bd / ∈

Step-03:

Now, eliminating left recursion from the productions of A, we get the following grammar-

S → Aa / b

A → bdA' / A'

A' → cA' / adA' / ∈

This is the final grammar after eliminating left recursion.