

Solution 4. To replace rules forms $AB \rightarrow c$, we need to know how AB can be derived. Below are all the cases in which AB can be derived.

1. For each rule of the form $U \rightarrow AB$, replace AB on the right-hand side with c , and introduce a new rule $U \rightarrow c$.
2. If a rule $Z \rightarrow XC$ exists, where $X \rightarrow YA$ (with the string ending in A) and $C \rightarrow BD$ (with the string starting with B), introduce a new rule $Z \rightarrow YcD$.

For every rule in the form $X \rightarrow YA$, if there is a rule $E \rightarrow XB$, add a new rule $E \rightarrow Yc$.

3. For every rule in the form of $P \rightarrow AQ$, if we want to derive AB , then Q needs to derive something that starts with B during the derivation process. For each derivation that starts with B (i.e., B followed by remaining variables or terminal symbols R), we add a new rule $G \rightarrow cR$.

By adding these new rules to replace $AB \rightarrow c$, we can remove the rule $AB \rightarrow c$. The new context-free grammar will be equivalent to the original one.