



Gradiane Online Accelerated Learning

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Based on Section 7.1 of HMU.

Help

1. Here is a context-free grammar:

```
S → AB | CD
A → BG | 0
B → AD | ε
C → CD | 1
D → BB | E
E → AF | B1
F → EG | 0C
G → AG | BD
```

Find all the nullable symbols (those that derive ϵ in one or more steps). Then, identify the true statement from the list below.

- D is not nullable.
- F is nullable.
- C is nullable.
- S is nullable.

Answer submitted: **d)**

You have answered the question correctly.

Question Explanation:

B derives ϵ directly. Then, D derives ϵ using the production $D \rightarrow BB$. Thus, B and D are nullable. We can then discover G is nullable because of the production $G \rightarrow BD$; A is nullable by the production $A \rightarrow BG$, and S is nullable by the production $S \rightarrow AB$. But then we can discover no more nullable symbols. That is, C, E, and F are not nullable.

2. Convert the grammar:

$$\begin{aligned}
 S &\rightarrow A \mid B \mid 2 \\
 A &\rightarrow C0 \mid D \\
 B &\rightarrow C1 \mid E \\
 C &\rightarrow D \mid E \mid 3 \\
 D &\rightarrow E0 \mid S \\
 E &\rightarrow D1 \mid S
 \end{aligned}$$

to an equivalent grammar with no unit productions, using the construction of Section 7.1.4 (p. 268). Then, choose one of the productions of the new grammar from the list below.

- a) $E \rightarrow E0$
- b) $S \rightarrow E$
- c) $A \rightarrow 3$
- d) $S \rightarrow 3$

Answer submitted: **a)**

You have answered the question correctly.

Question Explanation:

Each of S, A, B, D, and E derives each of the others on this list, using only unit productions. Thus, they each get all the nonunit right sides of any of these. For example,

$$S \rightarrow C0 \mid C1 \mid E0 \mid D1 \mid 2$$

The variables A, B, D, and E have exactly the same five production bodies.

Variable C is a little different, since it derives each of the five other variables by unit productions. It therefore gets its own nonunit production body, 3, as well as the nonunit bodies of the others. That is:

$$C \rightarrow C0 \mid C1 \mid E0 \mid D1 \mid 2 \mid 3$$

3. Here is a context-free grammar:

$$\begin{aligned}
 S &\rightarrow AB \mid CD \\
 A &\rightarrow BG \mid 0 \\
 B &\rightarrow AD \mid \varepsilon \\
 C &\rightarrow CD \mid 1 \\
 D &\rightarrow BB \mid E \\
 E &\rightarrow AF \mid B1 \\
 F &\rightarrow EG \mid 0C \\
 G &\rightarrow AG \mid BD
 \end{aligned}$$

Find all the nullable symbols, and then use the construction from Section 7.1.3 (p. 265) to modify the grammar's productions so there are no ε -productions. The language of the grammar should change only in that ε will no longer be in the language.

- a) $F \rightarrow EG \mid 0C \mid E \mid G$
- b) $B \rightarrow AD \mid A \mid D$
- c) $D \rightarrow BB \mid E \mid B \mid B$

d) $C \rightarrow CD \mid C$

Answer submitted: **b)**

You have answered the question correctly.

Question Explanation:

S, A, B, D, and G are nullable. Thus, whenever one or more of these appear in a production body, we must add new bodies that have all subsets of the nullable symbols deleted. However, when the entire body consists of nullable symbols, we do not introduce the body ϵ . Finally, we eliminate all existing ϵ -productions; in this example, the only one is $B \rightarrow \epsilon$. The result:

```

S → AB | CD | A | B | C
A → BG | 0 | G
B → AD | A | D
C → CD | 1 | C
D → BB | E | B
E → AF | B1 | F | 1
F → EG | 0C | E
G → AG | CD | A | G | C | D

```

4. For the grammar:

```

S → AB | CD
A → BC | a
B → AC | C
C → AB | CD
D → AC | d

```

1. Find the generating symbols. Recall, a grammar symbol is *generating* if there is a derivation of at least one terminal string, starting with that symbol.
2. Eliminate all *useless productions* --- those that contain at least one symbol that is not a generating symbol.
3. In the resulting grammar, eliminate all symbols that are not *reachable* --- they appear in no string derived from S.

In the list below, you will find several statements about which symbols are generating, which are reachable, and which productions are useless. Select the one that is FALSE.

- a) S is not generating.
- b) $C \rightarrow CD$ is useless.
- c) $C \rightarrow AB$ is useless.
- d) B is generating.

Answer submitted: **d)**

You have answered the question correctly.

Question Explanation:

All terminals are generating. The nonterminals A and D evidently derive terminal strings a and d , respectively. However, B and C are not generating. To see why, notice that each production for B and C has either B or C in the body. Then, since B and C are not generating, and each production for S has a B or C in the body, S is not generating.

Consequently, the only productions that are useful (not useless) are $A \rightarrow a$ and $D \rightarrow$

d. Therefore, the only symbol reachable from S is S itself.

5. Suppose we execute the Chomsky-normal-form conversion algorithm of Section 7.1.5 (p. 272). Let $A \rightarrow BC0DE$ be one of the productions of the given grammar, which has already been freed of ϵ -productions and unit productions. Suppose that in our construction, we introduce new variable X_a to derive a terminal a , and when we need to split the right side of a production, we use new variables Y_1, Y_2, \dots

What productions would replace $A \rightarrow BC0DE$? Identify one of these replacing productions from the list below.

- a) $A \rightarrow BY_2$
- b) $Y_2 \rightarrow X_0Y_3$
- c) $Y_1 \rightarrow Y_2C$
- d) $Y_3 \rightarrow X_0Y_4$

Answer submitted: **b)**

You have answered the question correctly.

Question Explanation:

First, we introduce the production $X_0 \rightarrow 0$ for the terminal 0, and replace the given production by $A \rightarrow BCX_0DE$. Then, since the body has length 5, we introduce $5-2 = 3$ new variables, Y_1, Y_2 , and Y_3 , with the productions:

$A \rightarrow BY_1$
 $Y_1 \rightarrow CY_2$
 $Y_2 \rightarrow X_0Y_3$
 $Y_3 \rightarrow DE$

6. Here is a grammar, whose variables and terminals are NOT named using the usual convention. Any of R through Z could be either a variable or terminal; it is your job to figure out which is which, and which could be the start symbol.

$R \rightarrow ST \mid UV$
 $T \rightarrow UV \mid W$
 $V \rightarrow XY \mid Z$
 $X \rightarrow YZ \mid T$

We do have an important clue: There are no useless productions in this grammar; that is, each production is used in some derivation of some terminal string from the start symbol. Your job is to figure out which letters definitely represent variables, which definitely represent terminals, which could represent either a terminal or a nonterminal, and which could be the start symbol. Remember that the usual convention, which might imply that all these letters stand for either terminals or variables, does not apply here.

- a) T could be a variable or a terminal.
- b) U must be a variable.
- c) Z could be a variable or a terminal.
- d) Y must be a terminal.

Answer submitted: **d)**

You have answered the question correctly.

Question Explanation:

All the symbols appearing on the left side of some production must be variables. Thus, R , T , V , and X are definitely variables. But if any other symbol was a variable, then it could not derive any terminal string, since it has no productions. Since all the other symbols appear in the body of some production, we can be sure they are terminals, because if they were variables they would render that production useless. Since we are told there are no useless productions, we can be sure S , U , W , Y , and Z are terminals.

We can also deduce that R is the start symbol. Notice that R appears in no production body. If R were not the start symbol, then its productions would be useless. Again, we are told there are no useless productions, so we must conclude R , and only R , could be the start symbol.

7. A *unit pair* (X,Y) for a context-free grammar is a pair where:

- 1. X and Y are variables (nonterminals) of the grammar.
- 2. There is a derivation $X \Rightarrow^* Y$ that uses only unit productions (productions with a body that consists of exactly one occurrence of some variable, and nothing else).

For the following grammar:

```
S → A | B | 2
A → C0 | D
B → C1 | E
C → D | E | 3
D → E0 | S
E → D1 | S
```

Identify all the unit pairs. Then, select from the list below the pair that is NOT a unit pair.

- a) (S,C)
- b) (C,E)

c) (E,A)

c) (E,A)

d) (E,E)

Answer submitted: **a)**

You have answered the question correctly.

Question Explanation:

The cycle of unit-productions $S \rightarrow A \rightarrow D \rightarrow S$ says that any pair involving only S, A, and D is a unit pair. Similarly, the cycle $S \rightarrow B \rightarrow E \rightarrow S$ tells us that any pair involving S, B, and E is a unit pair. But since S is on both cycles, there are derivations involving only unit productions from any of S, A, B, D, and E to any of these five variables. Thus, any combination of these five variables is a unit pair.

Further, the productions $C \rightarrow D \mid E$ tells us that any pair (C,X) is a unit pair if X is any of the six variables. The only pairs that are not unit pairs are (X,C) for $X = S, A, B, D, \text{ or } E$.