CS3311 Homework 9 Due date: Wednesday, April 2, 2014, in class

---

The answers must be the original work of the author. While discussion with others is permitted and encouraged, the final work should be done individually. You are not allowed to work in groups. You are allowed to build on the material supplied in the class. Any other source must be specified clearly.

---

1. *(10+ 10+ 10 points)* Consider the following grammar G over $\Sigma = \{a, b\}$.

$$S \to AB \mid aB$$
$$A \to aB \mid BS$$
$$B \to bB \mid b \mid \lambda$$

(a) Transform the grammar into $G1$ so that the recursion to the start symbol is removed.

(b) Show the set of nullable variables in the **new grammar** $G1$.

(c) Construct an essentially noncontracting grammar G_L (with a non-recursive start symbol) equivalent to $G1$.

2. *(10+10 points)* Consider the following grammar G. Note that the grammar does not contain λ-rules except at S.

$$S \to aSb \mid DEF \mid D \mid \lambda$$
$$D \to E \mid EF \mid abEF$$
$$E \to eEff \mid a \mid F$$
$$F \to ffFe \mid a$$

(a) Use algorithm 4.3.1 to construct the `CHAIN` sets for the variables in V.

(b) Construct an equivalent grammar G_c that does not contain chain rules.

3. *(10+10 points)* Consider the following grammar G:

$$S \to a \mid aA \mid BC$$
$$A \to aB \mid b$$
$$B \to Aa$$
$$C \to cCD$$
$$D \to ddd$$

(a) Construct the TERM set for G.

(b) Use the TERM set to construct an equivalent grammar G_T that does not contain variables that do not generate strings of terminals.

Please turn the page over for additional questions.

4. *(10+10 points)* Consider the following grammar G with $\Sigma = \{$ `Robots, Humans, have, batteries, computers, artificial intelligence, food, brains, natural intelligence, Working, with, computers, is, fun, awesome, cool` $\}$.

$S \to$ `Robots have` $N \mid$ `Humans have` R
$T \to$ `Working with computers is` D
$N \to$ `batteries` $\mid$ `computers` $\mid$ `artificial intelligence`
$R \to$ `food` $\mid$ `brains` $\mid$ `natural intelligence`
$D \to$ `fun` $\mid$ `awesome` $\mid$ `cool`

(a) Construct the REACH set for G.

(b) Use the REACH set to construct an equivalent grammar G_U that does not contain unreachable variables.

5. *(10 points)* Convert the following grammar G into Chomsky normal form. Show your steps clearly. Note that G already satisfies the conditions on the start symbol S, λ-rules, useless symbols, and chain rules.

$S \to bT$
$T \to aAA \mid AbAT$
$A \to aT \mid bT \mid a$