1. (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.

2. (10+10 points) Consider the following grammar $G$ where $\Sigma$ contains every word listed in the rules: $\Sigma = \{\text{Michigan, Tech, ..., cool}\}$.

   $S \to \text{Michigan Tech CS gives} N \mid \text{Having a graduate degree is} R$
   $T \to \text{Being in a computing field is} D$
   $N \to \text{BSc degrees} \mid \text{MSc degrees} \mid \text{PhD degrees}$
   $R \to \text{fun} \mid \text{intellectually challenging} \mid \text{financially rewarding} \mid \text{not as hard as one would think} \mid \text{a worthwhile option to explore}$
   $D \to \text{fun} \mid \text{awesome} \mid \text{cool}$

(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.

3. (20 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 $S$, $\lambda$-rules, useless symbols, and chain rules.

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

4. (40 points) Remove left recursion from the following grammar using the method described in class.

   $S \to A \mid B$
   $A \to AAA \mid a \mid B$
   $B \to BBB \mid b$