CS3133
HW #6 Solutions

1.

```
                        <expression>
                              |
                           <term>
                 /            |            \
          <term>       <mult op>      <factor>
             |              |          /   |      \
         <factor>         div         (  <expre>   )
             |                             |
         <variable>                      <term>
             |                    /        |          \
        <identifier>        <term>  <mult op>    <factor>
             |                 |          |            |
          <letter>         <factor>       *       <uns const>
             |                 |                       |
             x            <variable>             <uns number>
                               |                       |
                          <identifier>           <uns integer>
                               |                       |
                           <letter>                <digit>
                               |                       |
                               y                       3
```

2. An equivalent grammar without useless symbols is

$$S \to CA$$

$$A \to a$$

$$C \to b$$

which is equivalent to the trivial grammar $S \to ab$.

3. An equivalent essentially noncontracting grammar without chain rules is

$$S \to bA \,|\, b$$

$$A \to AbA|bA|Ab|b|\,aS\,|\,a\,|\,aB$$

$$B \to aB|a$$

An equivalent grammar in Chomskey Normal Form is

$$S \to Y_1 A \mid b$$
$$Y_1 \to b$$
$$A \to AZ_2 \mid Y_3 A \mid AY_4 \mid b \mid Y_5 S \mid a \mid Y_6 B$$
$$Z_2 \to Y_2 A$$
$$Y_2 \to b$$
$$Y_3 \to b$$
$$Y_4 \to b$$
$$Y_5 \to a$$
$$Y_6 \to a$$
$$B \to Y_7 B \mid a$$
$$Y_7 \to a$$

4. The grammar is already in Chomskey Normal Form. After the first phase of the algorithm, the grammar is

$$S \to AB$$
$$A \to BS \mid b$$
$$B \to bBAZ_3 \mid aZ_3 \mid bBA \mid a$$
$$Z_3 \to SBA \mid SBAZ_3$$

Replacing the *A* and the *B* on the righthand sides of the first two rules yields

$$S \to bBAZ_3SB \mid aZ_3SB \mid bBASB \mid aSB \mid bB$$
$$A \to bBAZ_3S \mid aZ_3S \mid bBAS \mid aS \mid b$$
$$B \to bBAZ_3 \mid aZ_3 \mid bBA \mid a$$
$$Z_3 \to SBA \mid SBAZ_3$$

“Fixing” the two Z_3 productions (replacing them with ten! new rules) yields:

$$S \to bBAZ_3SB \mid aZ_3SB \mid bBASB \mid aSB \mid bB$$
$$A \to bBAZ_3S \mid aZ_3S \mid bBAS \mid aS \mid b$$
$$B \to bBAZ_3 \mid aZ_3 \mid bBA \mid a$$
$$Z_3 \to bBAZ_3SBBA \mid aZ_3SBBA \mid bBASBBA \mid aSBBA \mid bBBA$$
$$Z_3 \to bBAZ_3SBBAZ_3 \mid aZ_3SBBAZ_3 \mid bBASBBAZ_3 \mid aSBBAZ_3 \mid bBBAZ_3$$