

# Computer Science 181, Homework 6

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## Problem 1

a)

$$\begin{aligned}G &= (V, \Sigma, R, S) \\V &= \{A, B\} \\R &= \{A \rightarrow aAd \mid B, \\&\quad B \rightarrow bBc \mid \epsilon\} \\S &= A\end{aligned}$$

This context free grammar works in two stages. In the first, we start with the symbol  $A$ , which can produce matching pairs of  $a$  symbols and  $d$  symbols. It recurses into itself, so that an arbitrary number  $n \geq 0$  of matching  $a$ 's and  $d$ 's can be generated. There is no production rule for  $\epsilon$  in this first stage, as that would make the grammar ambiguous. In order to terminate, the grammar has to move into the second stage by producing a symbol  $B$ . The second stage works like the first in that it can generate an arbitrary number  $m \geq 0$  of matching  $b$ 's and  $c$ 's, but it has a rule for  $\epsilon$  so that it can terminate. Thus this grammar is unambiguous because there can be only one way to generate a string in the language defined by  $a^n b^m c^m d^n$ , which is by applying  $A \rightarrow aAd$  for  $n$  times, then  $A \rightarrow B$ , then  $B \rightarrow bBc$  for  $m$  times, then  $B \rightarrow \epsilon$ .

b) Define the stack symbols to be  $\Gamma = \{s, n, m\}$ . Then the PDA can be drawn as shown below.

