Design PDA for the followings:

a) $\Sigma = \{x, y\}$, $L = \{ x^n y^n \mid n \geq 1 \}$ Hints: Push x's, Then pop x's for y's in input string

b) $\Sigma = \{x, y\}$, $L = \{ x^n y^{2n} \mid n \geq 1 \}$ Hints: for each x in input, push two 2 x's for having the same no of x's & y's. Then pop x's for y's in input string

c) $\Sigma = \{x, y\}$, $L = \{ x^{2n} y^n \mid n \geq 1 \}$ Hints: for every 2 x's, push only 1 x

d) $\Sigma = \{x, y\}$, $L = \{ x^n y^{n+1} \mid n \geq 1 \}$ Hints: $x^n y^n y$

e) $\Sigma = \{x, y\}$, $L = \{ x^m y^n \mid n > m \geq 0\}$ Hints: m>=0, n>m, n>=m+1. So, $x^m y^n = x^m y^{m+1}$ y….. (at least one extra y at end of input string)

f) $\Sigma = \{a, b, c, d\}$, $L=\{a^m\, b^n\, c^n\, d^m \mid m, n >=1 \}$ Hints: a,d pair, b,c pair Push a's. Push b's. Pop b's for c's in input string. Pop a's for d'd in input string

g) $\Sigma = \{a, b\}$, $L=\{a^n\, b\, a^m\, b\, a^{m+n} \mid m, n >=1 \}$ Hints: a^n b a^m b a^n. Push all a's, ignore b. Push all a's, ignore b. pop a's for a's in input

h) $\Sigma = \{x, y\}$, $L = \{ x^n y^m x^n \mid m,n \geq 1 \}$ Hints: push all x's. Then transition for y. Ignore y's. pop x's for x's in input string

i) $\Sigma = \{x, y, z\}$, $L= \{ x^n y^m z^{(n+m)} \mid n,m \geq 1\}$ Hints: push all x's & y's. Then pop x's & y's for z's OR

   it can be solved with this logic $x^n\ x^m Z^m\ z^n$

j) $\Sigma = \{x, y, z\}$, $L= \{ x^{(n+m)} y^m z^n \mid n,m \geq 1\}$ Hints: push all x's. Pop x's for y's & pop x's for z's **sequentially.**

   OR it can be solved with this logic $x^n x^m y^m z^n$

k) $\Sigma = \{x, y, z\}$, $L= \{ x^n y^{(n+m)} z^m \mid n,m \geq 1\}$ Hints: $x^n y^n\quad y^m z^m$ push all x's, then pop x's for y's. when stack empty, push all y's, then pop y's for z's.

l) $\Sigma = \{x, y\}$, $L = \{$no of x's are greater than the no of y's$\}$ Hints: push all x's and y's. Pop x's for y's (at least one x extra at end)

m) $\Sigma = \{x, y\}$, $L = \{ x^n y^m \mid m,n \geq 1$ & $m > n+2\}$

   Hints: minimum value of n is 1. So, m >n+2, m>1+2, m>3. minimum no of x is 1 & minimum no of y is 4.

   Again, m>n+2 , m>=n+3

   Push all x's in stack, then pop x's for y's. Then you should have at least 3 extra y's in the input String.

n) Design a PDA to match parenthesis. Hints: Push all ('s. Pop '(' for ')' in the string.

Conceptual Questions:

1. How can you relate a NFA and PDA?
2. How do we choose the next move in PDA?
3. What are the ways to accept strings in PDA?
4. How many arguments does a PDA take in its transition function?
5. How to convert an empty stack PDA into a final state PDA?
6. How to convert a final state PDA into an empty stack PDA?