1. Consider the $AC-3(csp)$ algorithm (reproduced below), can the last line “add $(X_k, X_i)$ to queue” be replaced with “if $X_k \neq X_j$ then add $(X_k, X_i)$ to queue”? Justify your answer.

```plaintext
function AC-3(csp) returns the CSP, possibly with reduced domains
inputs: csp, a binary CSP with variables \{X_1, X_2, \ldots, X_n\}
local variables: queue, a queue of arcs, initially all the arcs in csp

while queue is not empty do
    \( (X_i, X_j) \leftarrow \text{Remove-First}(queue) \)
    if \text{Remove-Inconsistent-Values}(X_i, X_j) then
        for each \( X_k \) in \text{Neighbors}[X_i] do
            add \( (X_k, X_i) \) to queue

function Remove-Inconsistent-Values(X_i, X_j) returns true iff succeeds
removed \leftarrow false
for each \( x \) in \text{Domain}[X_i] do
    if no value \( y \) in \text{Domain}[X_j] allows \( (x, y) \) to satisfy the constraint \( X_i \leftrightarrow X_j \) then delete \( x \) from \text{Domain}[X_i]; removed \leftarrow true
return removed
```

2. Consider the following constraint satisfaction problem:

Variables:

\[ A, B, C \]

Domains:

\[ D_A = D_B = D_C = \{0, 1, 2, 3, 4\} \]

Constraints:

\[
\begin{align*}
A &= B + 1 \\
B &= 2C
\end{align*}
\]

Construct a constraint graph for this problem. Show a trace of the $AC-3$ algorithm on this problem. Assume that initially, the arcs in queue are in the order \{\((A, B), (B, A), (B, C), (C, B)\)\}.

3. Consider the 4-queens problem on a 4×4 chess board. Suppose the leftmost column is column 1, and the topmost row is row 1. Let \( Q_i \) denote the row number of the queen in column \( i \), \( i = 1, 2, 3, 4 \). Assume that variables are assigned in the order \( Q_1, Q_2, Q_3, Q_4 \), and the domain values of \( Q_i \) are tried in the order 1, 2, 3, 4. Show a trace of the backtracking algorithm with forward checking to solve the 4-queens problem.
4. Show a trace of the backtracking algorithm with forward checking to solve the cryptarithmetic problem shown in Figure 1. Use the most constrained variable heuristic, and assume that the domain values (digits) are tried in ascending order (i.e., 0, 1, 2, \cdots).