**Question 1**

$$f_1(y_{-1}, x_1 \ldots x_N, j, y) = \begin{cases} 1 & \text{if } j = 1 \text{ and } y \in \{A, B\} \\ 0 & \text{otherwise} \end{cases}$$

$$f_2(y_{-1}, x_1 \ldots x_N, j, y) = \begin{cases} 1 & \text{if } j \geq 2 \text{ and} \\ \text{NOT}(y_{-1}, y \in \{A, B\} \text{ or } y_{-1}, y \in \{C, D\}) & \text{otherwise} \end{cases}$$

$$f_3(y_{-1}, x_1 \ldots x_N, j, y) = \begin{cases} 1 & \text{if odd}(x_j) \text{ and } y \in \{A, C\} \\ 0 & \text{otherwise} \end{cases}$$

$$f_4(y_{-1}, x_1 \ldots x_N, j, y) = \begin{cases} 1 & \text{if even}(x_j) \text{ and } y \in \{B, D\} \\ 0 & \text{otherwise} \end{cases}$$

Here `odd(x)` returns true if `x` has an odd number of letters. `even(x)` returns true if `x` has an even number of letters. `NOT(TRUE) = FALSE` and `NOT(FALSE) = TRUE`. 
Define a feature-vector representation

\[ f(t_1 \ldots t_m, j, y) \]

where:

- \( y \) is the label (STARTS(S), START(VP), START(NP), etc.)
- \( t_1 \ldots t_m \) are the sequence of subtrees in the current parser state
- \( j \) is the index of the left-most subtree that does not have START(\ldots) or JOIN(\ldots) as its root
Question 2 Continued

We can then define the following feature:

\[ f(t_1 \ldots t_m, j, y) = 1 \]

if and only if:

- \( y = \text{JOIN(VP)} \)
- root label of \( t_{j-1} = \text{START(VP)} \), and head-word of \( t_{j-1} \) is *questioned*
- root label of \( t_j = \text{NP} \), and head-word of \( t_j \) is *witness*
- root label of \( t_{j+1} = \text{IN} \), and head-word of \( t_{j+1} \) is *about*
- root label of \( t_{j+2} = \text{NP} \), and head-word of \( t_{j+2} \) is *revolver*

Note: the feature is 0 if the above conditions are not met. We can introduce a similar feature for each possible value of the label \( y \) (e.g., \( \text{START(NP)} \) etc.)
the lawyer questioned the witness about the revolver