Question 3

In an M-PSK system, the use of Gray coding plays a crucial role in minimizing the BER. Gray coding is a binary coding system where two consecutive symbols differ by only one bit. The fundamental idea behind M-PSK modulation is the mapping of multiple bits to distinct symbols, where each symbol corresponds to a specific phase angle. In such systems, noise or signal distortions during transmission can cause a received symbol to deviate from its original phase, leading to detection errors. When this happens, the system might detect a neighboring symbol instead of the transmitted one.

Without Gray coding, neighboring symbols in the constellation diagram could have a misinterpretation of more than one bit. For example, in an 8-PSK system without Gray coding, neighboring symbols could differ by two or more bits. If a symbol is detected as its neighbor due to noise, the result could be a multi-bit error, significantly increasing the BER. However, when Gray coding is applied, each neighboring symbol in the phase constellation differs by only one bit. This means that if noise or interference causes the receiver to detect a neighboring symbol instead of the correct one, the resulting error will affect only one bit.

By reducing multi-bit errors to single-bit errors, Gray coding minimizes the impact of noise, thus improving system performance. Additionally, Gray coding is particularly beneficial in higher-order M-PSK systems (e.g., 16-PSK or 64-PSK) because the constellation points are closer together as the modulation order increases. In such systems, even a small amount of noise can cause the incorrect interpretation of a symbol as one of its neighbors.