Simple System Design Exercise

In these two exercises you are to design real causal LTI discrete-time systems. In both problems, the system you design should satisfy three requirements:

R1. The system preserves the value of constant (dc) signals.

R2. The system annihilates the signal $\cos\left(\frac{\pi}{2}n\right)$.

R3. The system produces an output signal of $\frac{1}{2}(-1)^n$ for input signal $(-1)^n$.

Exercise 1. Design a real causal FIR LTI discrete-time system satisfying the above three requirements.

Hint: The system can have an impulse response of length 4.

Exercise 2. Design a real causal second-order discrete-time LTI system satisfying the above three requirements.

Note: second-order means that 2 is the highest power of z in the transfer function.

Hint: The system will need to have a pole away from the origin.

For the systems you design:

1. Find the difference equation.
2. Sketch the pole-zero diagram.
3. Roughly sketch the frequency response magnitude $|H^f(\omega)|$ based on the pole-zero diagram.

Using MATLAB:

1. Plot the impulse response $h(n)$.
2. Plot the pole-zero diagram. Use `zplane`.
3. Plot the frequency response magnitude. Use the function `freqz`.
4. Demonstrate that your system satisfies the three requirements. To do that, create appropriate input signals and process them with your system. Plot the input signal and corresponding output signal on the same graph using MATLAB. Confirm the requirements are satisfied.

To turn in: Explanation of how you derive the systems. MATLAB plots of pole/zero diagram, frequency response, impulse response, and input-output plots.