DSP2025 Homework 7 Due date: 12:00 noon, May. 26, 2025

1. Implement the Overlapping-Add and Overlapping-Save algorithms in Python.

   Create Python functions (50%)
   `overlap_add(x, h, L)`, `overlap_save(x, h, L)`
   via circular convolution (using the FFT/IFFT for speedup)

   Parameters:
   `x`: A 1D NumPy array representing the input signal.
   `h`: A 1D NumPy array representing the impulse response of the filter.
   `L`: An integer representing the length of the input blocks (chunks) to segment x into

   Return Value:
   `y`: A 1D NumPy array representing the full convolution result

2. Apply these methods to a real-world audio signal. (10%)

   You will use an audio file as your long input signal $x[n]$. The file is seashell-01-90046.mp3 available from Pixabay: https://pixabay.com/sound-effects/seashell-01-90046/

   Convert MP3 to WAV:

```
from pydub import AudioSegment
sound = AudioSegment.from_mp3("seashell_01-90046.mp3")
sound.export("seashell.wav", format="wav")
```

   Load the audio data from your seashell.wav file using `scipy.io.wavfile.read`.

   Define at least two simple FIR filters $h[n]$ for testing:
   - A simple high-pass filter: `h_hp = np.array([1, -1])`
   - A simple low-pass filter: `h_lp = np.array([1, 1, 1, 1, 1])`
   - Compute the convolution using `numpy.convolve(x, h, mode='full')` as the reference.

3. Verify the correctness of your implementations against a standard convolution function. (20%)
   - Verify that the lengths of the output signals from all three methods are identical.
   - Use `np.allclose(your_output, reference_output)` to check if the numerical values are very close. Due to floating-point arithmetic, minor differences are acceptable.
   - Report the maximum absolute difference between your implementations and the reference.

4. Bonus
   1. Compare the execution time of your `overlap_add`, `overlap_save`, and `np.convolve(x, h, mode='full')` with various Signal Length, Filter Length, and Block Size. (You can define a random signal for this task.) (15%)
   2. You can play with other filters and describe what you found. (5%)

5. Submission Guidelines

   Submit a single ZIP file containing:
   - Your Python script(s) (.py files).
   - Your report in PDF format.