**Signal Processing Concepts – Fourier Series**

**Objective:**

To use Fourier Series to determine the response of a Single Degree of Freedom (SDOF) system subjected to periodic forcing.

**Task 1: Plotting the Forcing Signal**

* **Objective:** Load forcing1.npz containing arrays for the applied force and its time span.
* **Actions:**
  + Load data and plot force vs time.
  + Analyze whether the array represents a signal.
  + Determine the amplitude and period of the signal.
* **Expected Outcome:** Identification of the signal’s periodicity and amplitude from the plot.

**Task 2: Extracting One Period of the Signal**

* **Objective:** Isolate the signal corresponding to one fundamental period T0*T*0.
* **Actions:**
  + Find indices in the time vector spanning 00 to T0*T*0.
  + Extract the corresponding segment of the force array.
* **Expected Outcome:** A single period of the force signal is ready for further analysis.

**Task 3: Fourier Series Decomposition**

* **Objective:** Express the extracted force signal as a Fourier Series.
* **Actions:**
  + Use the coefficients formula:
    - a0+a1cos⁡(ω0t)+b1sin⁡(ω0t)*a*0+*a*1cos(*ω*0*t*)+*b*1sin(*ω*0*t*)
    - Compute Fourier coefficients (an,bn*an*,*bn*) numerically, using area under the curve (numerical integration).
    - Discretize force and sinusoidal functions as per the sampled time data.
    - Evaluate coefficients for the first 15 harmonics.
  + Plot the principal Fourier coefficients.
* **Expected Outcome:** Quantification and visualization of the signal’s harmonic content up to the 15th term.

**Task 4: System Response Calculation**

* **Objective:** Find the response of the SDOF system to the constructed Fourier series representation of the force.
* **Actions:**
  + Use the SDOF equation (without damping, c=0*c*=0):
    - Plug in the Fourier coefficients into the system’s response solution (as covered in class).
  + Plot the calculated response over time.
* **Expected Outcome:** Visualization of how the system responds dynamically to the periodic force.

**Task 5: Analysis with Second Forcing Input**

* **Objective:** Repeat preceding analysis with data from forcing2.npz.
* **Actions:**
  + Load forcing2.npz; plot the new force signal.
  + Comment on differences in magnitude and period compared to the first signal.
  + Repeat Tasks 2–4 with the new forcing data, using period T0≈10.99*T*0≈10.99 seconds.
  + Plot and compare system responses between the two cases.
* **Expected Outcome:** Comparative insight into dynamic response for two different force signals (in amplitude, harmonic content, and period).

**Skills and Concepts Developed**

* **Signal plotting and basic data handling**
* **Period and amplitude estimation from plots**
* **Practical computation of Fourier coefficients**
* **Interpretation of mechanical system response**
* **Comparison of different input excitations**