AME 302 Project

Project Title: **Modeling and Simulation of a Rotor with Gear Train Driving a Propeller**

Project Outline

This project consists of three tasks:

1. Modeling of a linear system – rotor with gear train driving a propeller
    a. Deriving equations of motion
    b. Deriving transfer function
    c. Deriving state-space representation
2. Implementation of the derived model in software; simulation and analysis of this system (software: either MATLAB or Wolfram Mathematic is required for simulation)
3. Modeling of the augmented system – nonlinear effects are added. Implementation of the derived model in software; simulation, analysis, and comparison of performance of linear and nonlinear systems (software: either MATLAB or Wolfram Mathematic is required for simulation).

Project score **90 points**

Task 2.

Simulation of a Rotor with Gear Train Driving a Propeller **30 points**

Assigned: October14, 2020
Due: November 4, 2020

Implement the derived in Task 1 model of the given dynamic system: rotor with gear train driving a propeller, in software – either MATLAB/Simulink or Wolfram Mathematica.
Let the parameters of the dynamic system in Task 1 be as follows (assume that all the parameters are of non-dimensional values):

$$J_1 = 15,\ \ J_2 = 80,\ \ b_1 = 0.2,\ \ b_2 = 0.15,\ \ c_T = 0.08,\ \ {}^{n_2}/_{n_1} = 2.5,\ \ {}^{n_3}/_{n_2} = 4.2$$

a) For the stiffness values $k_T = \{5,\ 15,\ 50,\ 100,\ 500,\ 1000\}$ plot the propeller rotation speed $\dot{\theta}_p = \omega(t)$ subject to an impulse input $T(t) = 400 * \delta(t)$, where $\delta(t)$ is a Dirac Delta function; simulation time is 2000 time units. Observe character of vibrations (amplitude and frequency) in addition to overall system behavior by separately plotting the first and last 20 time units of simulation.

b) For the stiffness values $k_T = \{5,\ 15,\ 50,\ 100,\ 500,\ 1000\}$ plot the propeller rotation speed $\dot{\theta}_p = \omega(t)$ subject to a step input $T(t) = 400 * UnitStep(t)$; simulation time is 1500 time units. Observe character of vibrations (amplitude and frequency) in addition to overall system behavior by separately plotting the simulation for $t \in [460, 480]$ and also the last 20 time units of simulation.

c) For both types of input discuss the effect of stiffness on the system response. ***Make theoretical predictions of system behavior such as: (a) existence and magnitude of steady-state response, (b) system stability, (c) ability to approximate this system with the lower order one. If such approximation is possible, how would you explain the dependence of oscillations frequency on the stiffness coefficient? Compare your predictions with simulation results – were your predictions confirmed in simulation?*** How torsional damping of the flexible shaft influences system response?