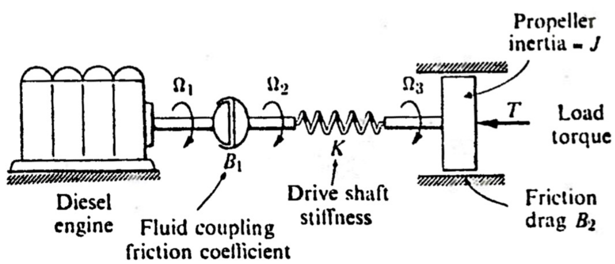
Problem 1 (linearization) Study in detail the linearization process presented in the class notes for the torque driven wheel. Reproduce the comparison of the analytical and numerical results using either Matlab or Python.

Problem 2: The simplified model of a power transmission system of a ship (discussed in class) is shown below. (a) The equations needed to show how the propeller speed, Ω_3, is related to the



input speed, Ω_1, and to the load torque, T, were presented in class. It is assumed that the engine is an ideal source of speed, Ω_1. Briefly confirm the system equations.
(b) Draw a block diagram of the system
(c) It is found that when the system is running at steady state (a stationary equilibrium), the following conditions hold: $\Omega_{30} = 0.95\Omega_{10}$, the load torque is $T_0 = k_1\Omega_{30}$, and $B_2 = B_1/20$. Find B_1 and B_2 in terms of k_1.
(d) (ME 397 only) After the engine has been running steadily under the conditions in (c), the speed is suddenly dropped at $t = 0$ to one half its initial value. Find the response of Ω_3 to this change in the input $\Omega_1(t)$, assuming the shaft stiffness K is such that the system damping is 0.5. Let $T = k_1\Omega_3$ during this transient.

Problem 3 (Ogata B-4-3) An open-loop transfer function is $G(s) = 4/s(s+5)$ is put into **unity-feedback system** ($H = 1$). (a) Find the closed-loop transfer function for output to reference, c/r, (b) Use a partial fraction expansion approach to find the analytical solution for the output, $c(t)$, for unit-step response in the reference input, $r(t)$. (c) Use Matlab (or Python) to confirm your results and plot the response for a unit step input (r = 1).

Problem 4 (Ogata B-4-7) The block diagram shown is for a space-vehicle attitude control system. Assuming the time constant, T, of the controller is 3 seconds and the ratio of torque to inertia, K/J, is 2/9 rad^2/sec^2, find the damping ratio of the closed loop system. In addition, find the unit step response and check with Matlab tools.