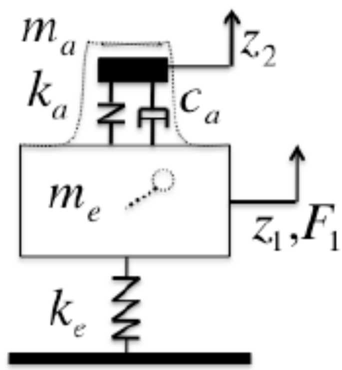
Matlab Sheet 4

Two Degree of Freedom Systems

1. We are asked to isolate the floor completely from the engine vibration, as shown in the figure. An absorber system housing a mass, a spring, and a damper is placed on the top of the engine to absorb the energy from the engine vibration. You are given the following

$$k_e = 4.934802 \times 10^5 \text{ N/m}, m_e = 500 \text{ Kg}, \omega = 1500 \text{ RPM}.$$
$$F_1 = 98\ \sin(\omega t) = F_0 \sin(\omega t)$$



(a) Develop the equations of the motion for the two DOF system. Note no external force is applied to the absorber mass, F_2= 0.
(b) We are asked to isolate the floor completely from the engine vibration. In the absence of damping, determine the spring constant k_a such that the absorber can undergo the displacement of 1 inch in the housing when 2% of engine weight is applied statically.
(c) By using the spring constant k_a calculated in part b, The natural frequency of the absorber system is set equal to the engine natural frequency, hoping to improve the isolation. Calculate $|F_{TR}|/|F_1|$ at 1500 RPM. Does the absorber improve the isolation?

Use the k_a **stiffness and** m_a **values of part b in the following problems:**

(d) To improve isolating the base from the engine vibration, a damper ca is added to the system corresponding to 1%, 2%, 5%, 10%, 20% and 30%. Calculate $|F_{TR}|/|F_1|$ of the damped engine mount at 1500 RPM. Does the damper improve or hinder isolation?
(e) In the absence of damping, calculate and plot $|F_{TR}|/|F_1|$ from 0 to 2000 RPM.
You may observe two spikes (resonances) at two distinct frequencies or system natural frequencies. Determine the eigenvalues and eigenvectors from the equations of motion. Explain the meaning of the eigenvalues and eigenvectors. Show the orthogonality of the eigenvectors.
(f) Design an absorber such that its natural frequency is tuned with the operating frequency. To achieve this, we are asked to replace the mass of the absorber. In the absence of damping, plot $|F_{TR}|/|F_1|$ vs. m_a/m_e for m_a/m_e = 0 ~ 0.1 at 1500 RPM.
Note that the force ratio is very sensitive to the mass ratio. (USE $\Delta\ m_a/m_e$ =1×10^{-8} in the calculation).

2. The engine equipped with the newly designed absorber is mounted on a vehicle. The RPM in the engine follows the curve shown below and the force due to the imbalance is $F_1(t) = 100 \mathrm{Sin}(\Omega t)$. The vehicle starts going up and down due to the rough pavement, represented by

$$z_b = 0, \; t < 1 \text{ sec},$$
$$z_b = 10^{-3} \sin(2\pi t) \text{ for } t \geq 1 \text{ sec}$$

.

Determine and plot the response of the engine and the absorber over 20 seconds.