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Mathematical Modelling of a dynamic vibration absorber

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This work presents a vibration model of a system with bounce and pitch motions subjected to a base oscillation, this system has 2 degrees of freedom. In order to reduce the amplitude of the system, a vibration absorber, which consist of a simple pendulum, was attached in the mass of the system. The methodology followed was to vary the main parameters that affect the amplitude of the system to minimize it.

The model is presented in Figure 1:

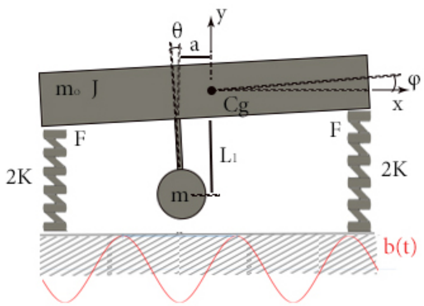

Figure 1: Bench Model

The model consist of a simple concrete block with mass m_0 and moment of inertia J, with a simple pendulum attached at a distânce a from the center of mass. The length of the pendulum and its mass are L_1 and m, respectively. The concrete block is supported by springs with stiffness k. All the system is subjected to a sinusoidal base excitation $b(t)$. The equation of movement of the system is given by equation 1, where $m_T = m_0 + m$ and $J_T = J + ma^2$, y is the vertical displacement; φ is the angle of the mass with relation to the horizontal plane and θ is the angle of the pendulum with relation to the vertical plane. The rotation along the x and y axis, and the translation along the x and z axis were not considered in the model.

$$\begin{aligned} m_t\ddot{y} + mL_1(\ddot{\theta}sin(\theta) + \theta^2) + 2ky + m_t g = -m_t\ddot{b}(t) \\ J_t\ddot{\varphi} + maL_1(\ddot{\theta}sin(\varphi-\theta) - \dot{\theta}^2cos(\varphi-\theta)) + 2a^2ksin\varphi cos\varphi = 0 \\ mL_1\ddot{\theta} + \ddot{y}mL_1sin\theta + maL_1(\ddot{\varphi}sin(\varphi-\theta) - \dot{\varphi}^2cos(\varphi-\theta)) + mgL_1sin\theta = 0. \end{aligned} \tag{1}$$

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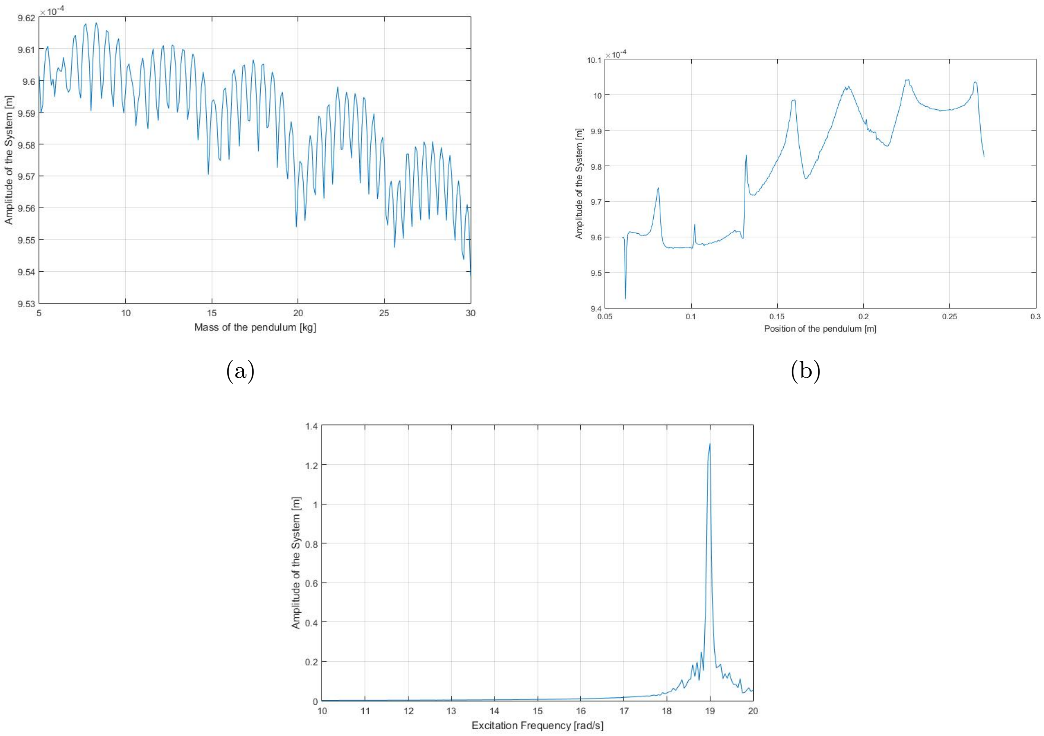
The fixed parameters used in the simulations are listed: Mass of the concrete $(m_o)[kg] = 400,00$; Spring Stiffness $(k)[N/m] = 3,00 \times 10^6$; Moment of inertia of the block $(J)[kg * m2] = 19,14$; Length of the pendulum $(L_1)[m] = 0,10$;



(a) (b)

(c)

Figure 2: System responses:(a)mass of the pendulum, (b)the distance of pendulum attachment point,(c) frequency of excitation

With the purpose of reducing the amplitude of oscillation of the system, the mass of the pendulum (m), its distance of attachment (a) and the excitation frequency (ω) were varied to study the system behavior. Figure 2 shows the results obtained. It was seen that the frequency of excitation has greater impact in the reduction of the amplitude comparing with the mass of the pendulum and its distance of attachment.

References

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