

Probabilities of initiation of response modes of rigid bodies subjected to base excitations

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Abstract. An unrestrained plane rigid body resting on a horizontal surface which shakes horizontally and vertically may assume one of the five modes of response: rest, slide, slide-rock, rock, and free flight. The first four are nontrivial modes of motion. It is important to study which one of these responses is started from rest as in most studies it is often assumed that the initial mode is the particular mode of response. Criteria governing the initiation of modes are first briefly discussed. It is shown that the commencement of response modes depends on the aspect ratio of the body, coefficients of static and kinetic friction at the body-base interface, and the magnitude of maximum base accelerations. Considering the last two factors as random variables, the initiation of response modes is next studied from a probabilistic point of view. Type I extreme value and lognormal distributions are employed for maximum base excitations and coefficient of friction respectively. Analytical expressions for computing the probability values of each mode of response are derived. The effects of slenderness ratio, vertical acceleration, and statistical distributions of maximum acceleration and coefficient of friction are shown through numerical results and plots.

Keywords: rigid body; coefficient of friction; base excitation; probability of response modes.

1. Introduction

A two-dimensional rigid body freely standing on a horizontal base undergoing horizontal as well as vertical motion, may be initiated into one of the following five modes of response: rest, slide, slide-rock, rock and free flight. The last of these responses is a trivial mode. Which of the rest of four modes of response is commenced from the rest position is studied. This study is important as the initial mode is essential to the analysis of the generalized behavior of a rigid body.

Shenton (1996) studied the criteria for initiation of slide, rock, and slide-rock rigid-body modes. Considering plane rigid bodies that rest freely on a rigid foundation, he was the first to point out that a slide-rock mode of response can be initiated from rest. Shenton presented the numerical results in the form of graphs which made it easy to see the conditions under which of each of the four modes of response can be initiated. The graphs were, however, prepared for rigid blocks subjected to horizontal accelerations only. Other studies that dealt, to an extent, with the commencement of response modes are those of Shao and Tung (1998), Yang *et al.* (2000), Taniguchi (2002), and Garcia and Soong (2003). A recent study by Tung (2005) investigated the

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