Mechanics Corner
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Mouse Trap / Pendulum Dynamics Challenge - Part I

1 Introduction

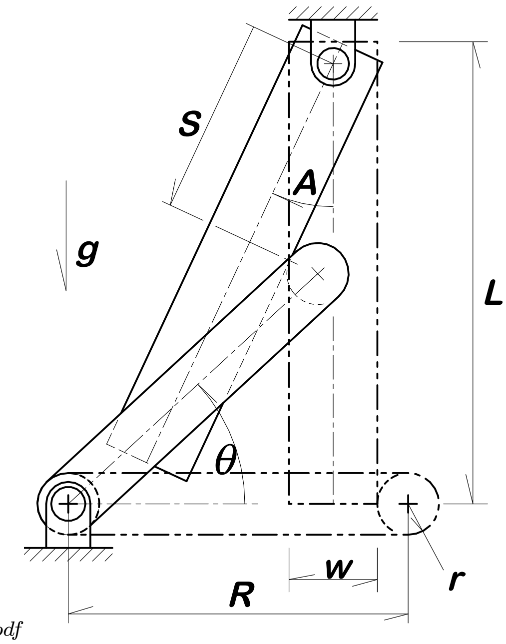
Mice are a problem all over the world, and as a result, I'm sure that there are mouse traps of various sorts found everywhere. It would be utterly amazing if this were not true! In the USA, there is a very common type of mouse trap that I have seen used all my life, the sort of system shown below in Figure 1. I want to spend a few minutes discussing this mouse trap, to be certain that all readers understand how it works, before moving on to the main part of the post.

Figure 1: Victor Spring-Powered Mouse Trap

1.1 The Mouse Trap

The Victor Mouse Trap is a simple spring-powered mechanical device designed for killing mice. In Figure 1, it is shown in the cocked (or "set") position, ready to trap an unwary mouse. Some sort of bait is placed on the bait platform (marked Bait), something like cheese, bacon, bread, or some other foodstuff that will attract the mouse. When the mouse's mouth is on the bait, his head is in a position to be trapped by the bale. When the mouse moves the bait platform ever so slightly, the release bar (marked Release) is set free at the left end, allowing the bale to flip from the position shown to the left end, pinning the mouse in the process.

MouseTrapPendulumGeom



$_2$.pdf

The quick flip of the bale is powered by a rather strong torsion spring seen wrapped around the bale pivot shaft. It is quite a strong spring; it will deliver a real snap to the unwary finger that gets in the way! Of course, it does the same to the mouse, and that's the point. The mouse dies with its head clamped in the mouse trap.

Now, why is all of this of engineering interest? That's a fair question, and there is an answer!

1.2 The Challenge Problem

Recently (well, just 32 years ago!), Prof. R.A. Willem of New Mexico State University posed a challenge problem involving a mouse trap[1]. Willem proposed that we should investigate the dynamics of a mouse trap powered pendulum, the sort of system shown in Figure 2.

Let me point out two things about Figure 2: (1) the figure does not show the torsion spring (but it is very much a part of the problem), and (2) the figure is highly distorted in that the wire bale is shown much thicker than actual, to show the effect of wire diameter. We will assume that all the geometric parameters are available, including numerical values for: r, R, w, L as well as mass properties M_b = mass of the bale, M_p = mass of the pendulum, R_{cmb} = radius to the bale center of mass, S_{cmp} = radius to the pendulum center of mass, I_b = mass moment of inertia of the bale with respect to the rotation axis, and I_p = mass moment of inertia of the pendulum with respect to the pendulum axis of rotation. Finally, the parameters of the torsion spring are known, $T(\theta) = T_o + K(\pi - \theta)$ where T_o and K are given.

[1] Willen, R.A., "A Challenge in Rigid-Body Dynamics," *Mechanics Monograph M-5*, Mechanics Division of ASEE, 1985, pp. 21–28.

ASEE is the American Society for Engineering Eduation.

Recently I came across some work I had done on Willem's problem back in 1985. It was incomplete, but I have now almost finished it. Thus I propose to you, the readers of ME Forum, that you work through this problem as well. Please send me your answers by PM, and I'll let you know if we agree. (I no longer have the original Willem article, but I have requested it from the library. If I get it, I'll tell you if you agree with Willem as well.)

For Part I, let's only deal with the kinematics (data below). In particular, send me your system of equations solvable for A and S, and also the equations for K_A, K_S, L_A, and L_S (please use the notation I have given here). If we can agree on this much, we will be off to a good start to go on to the dynamics. Without the kinematics, the dynamics is simply a lost cause!!

Data:

$r = 0.75$ mm

$R = 42.164$ mm

$w = 25.4$ mm

$L = 217.17$ mm

2 Closure

This is a very good problem in elementary dynamics. While it hardly qualifies as industrial machinery, the principles involved apply directly to the dynamics of industrial machines, and yet is simple enough to be formulated with minimum effort. In later parts, I will give more details on the question, particularly the dynamics aspect. One of the key components of the question is the inclusion of Coulomb friction between the bale and the pendulum. Have fun with the problem, and get back to me soon on your formulations.