Exam #2

This examination is based on an interactive computer simulation. Various details of the assignment are described in the accompanying videos and web page. Here, I focus specifically on the tasks I want you to perform.

For problems 1 through 5, you should watch the videos and review written materials in sections *Challenge Overview*, *Reference Information*, and *Energy* on the exam web page.

1. Derive a mathematical expression for the kinetic energy of Poli using quantities that you have available to you in the simulation.

2. Derive a mathematical expression for the gravitational potential energy of Poli using quantities that you have available to you in the simulation.

3. There are at least three testable cases in the simulation where the total energy (kinetic plus gravitational potential) of Poli should be constant: (a) when Poli is swinging from the pendulum at a fixed large radius; (b) when Poli is swinging from the pendulum at fixed smaller radius; (c) when Poli has been released from the pendulum and is flying through the air. Why?

4. Generate graphs of the kinetic and potential energy of Poli in the simulation. Verify that total energy is conserved in all three cases described in the question above. Respond to this question by simply confirming that you performed the test.

5. Does the system conserve energy when the actuator (variable length rod) moves poli to a larger or smaller circle? Explain why or why not using free body diagrams and physical principles.

To answer the next question, you are going to have to develop a modest amount of skill "playing" the game. In particular, you are going to have to figure out how to coordinate the swinging of Poli to button presses which lengthen/shorten the pendulum rod in order to generate large amplitude swinging motions. This is discussed in the *Challenge Overview* video.

6. Use free body diagrams and physical principles to explain how your strategy for increasing the energy of the system works. In particular, explain how you obtain a net increase in pendulum energy.

It is possible to get Poli to drop between the goalposts with a "lucky shot." It is very rare to get two such lucky shots in a row. Trying to get three consecutive lucky shots is a total wast of time. Your goal is to develop a strategy, based on the physics of the system, that will allow you to successfully complete the task every time, without fail. The most critical part of the strategy is to calculate the precise conditions in which to release Poli from the pendulum, and then the specify the condition mathematically in an automatic trigger. (Video will be posted soon.) Since the parameters of the problem (e.g. masses, stiffness, lengths, et cetera) change every time you run the simulation, it is important that your solution automatically account for the changes. Therefore, your strategy should be based on engineering analysis rather than trial and error.

7. Present the engineering analysis behind your strategy for solving the challenge. Use the problem-solving checklist as a guide when presenting your solution. The presentation should describe the dynamics of Poli from the instant it is released from the pendulum to when it passes through the goalposts.

8. Submit the five digit code that appears in the bottom right corner of the screen when you achieve the goal for the third consecutive time.

9. Submit a copy of the automatic trigger condition you used.