APPARATUS

A rolling object, a timer, a meter stick, an incline, crash box, and chalk.

INTRODUCTION

Kinematics is the study of motion and the relationships that involve distance, speed, and acceleration. These experiments will allow you to discover some of these relationships and formulate some working equations for kinematics.

PART I. KINEMATICS OF A ROLLING OBJECT

Exploration:
1. Explore the motion of the rolling object on the table.
   (a) What variables influence its motion?
   (b) How can you characterize its motion?
2. Collect some quantitative data on the motion of the object.
   (a) What did you hold constant?
   (b) What did you vary?
   (c) What property of the system responded to the variations you made in the motion of the object?
   (d) Draw a graph that is appropriate.

Invention:
1. Describe the motion of a rolling object along a smooth flat table.
2. Describe the motion of a rolling object along an inclined plane.
3. Use these descriptions to describe the motion of a rolling object initially moving laterally along a tilted lab table. (See the diagram on next page.)
4. Now describe the motion of an object which rolls off a horizontal table with an initial velocity.
Set up the apparatus as suggested by the drawing above. Experimentally obtain data for the variables $H$ and $d$ of the system. Graph your data and determine the rule that relates $d$ to $H$. What is the effect of $h$ on the experiment? Experimentally test your rule after increasing the mass of the car. What alterations do you suggest for your rule? If your car is replaced by a point particle on a frictionless plane, find the algebraic relationship between $H$ and $d$. Compare it to your rule.

**Application:**

You can determine your take off velocity from the measurement of your maximum vertical jump height. This is a kinematic problem involving the constant acceleration due to gravity. The kinematic relation between the vertical jump height, $h$, the vertical take off velocity, $v$, and the acceleration due to gravity, $g$, is:

$$v^2 = 2gh$$

Experimental procedure should minimize variations in jump conditions. To this end, the jumper should jump with both arms fully extended above the head. The take off position is marked with chalk in hand next to the wall and peak height is marked with chalk at peak of the jump. Make ten trials, recording $h$ for each and determine the average take off velocity from the equation. The fractional experimental error in this case is given as:

$$\frac{\Delta v}{v} = \frac{1}{2} \frac{\Delta h}{h}$$
where $\Delta h$ is the mean deviation of your ten jump heights. Determine your experimental error.

2. Design an experiment to check the take off velocity by measuring it from the range of a horizontal jump. (Remember that the arms must be in exactly the same position as used in the vertical jump.) Derive the equation for the maximum horizontal jump distance in terms of take off velocity and the acceleration due to gravity. Carry out your experiment and compare this determination of take off velocity with that from your vertical jump. Are the results within experimental error of each other?