

Kinetic Energy: How Do the Mass and Velocity of an Object Affect Its Kinetic Energy?

Introduction

When law enforcement officials investigate car crashes (see figure to the right), it can sometimes be difficult to determine who is at fault and what laws were broken, especially when there is no footage of the crash. To recreate the crash scene, investigators use physics concepts to determine the specifics of a crash, including the speed and direction (together, the velocity) in which a car was traveling and when the driver attempted to stop. These figures can then be used to help determine who is at fault in a crash and the laws that person broke.

You already know that energy is conserved and transferred within and between systems, not created or

destroyed. This is also true in car crashes. A traveling car has a certain amount of kinetic energy, and when that car hits another car or a different object, some of that energy is transformed into heat or sound, but most is used to do the work that deforms the car or object it crashes into. So, when cars collide, the transfer of their kinetic energy is responsible for the resulting damage. The damage done to the cars can be used, along with other pieces of evidence, to determine the velocity of the car.

In this investigation, you will be applying the same physics concepts to determine the mass or velocity of an object that has been dropped onto an inelastic surface (one that does not return to the same shape after impact). You will be creating a collision between a ball of variable mass and a large container of flour to investigate this relationship.

Your Task

Use what you know about force and motion, patterns, and causal relationships to design and carry out an investigation that will allow you to create a mathematical model explaining the relationship between mass, velocity, and force of impact.

The guiding question of this investigation is: ***How do the mass and velocity of an object affect its kinetic energy?***

Materials

You may use any of the following materials during your investigation:

- Large plastic container filled with flour
- String
- Stopwatch
- Balance
- Racquetball with slit
- Funnel
- Rice or beans
- Meter stick
- Ruler

A police officer investigates a crash scene.



Getting Started

The first step in developing your mathematical model is to design and carry out an investigation to determine how mass and velocity affect the kinetic energy of the variable-mass ball. Because the kinetic energy of the ball will deform the flour surface during an impact, the extent of this deformation can be used to determine the kinetic energy of the ball at impact.

To determine *what type of data you need to collect*, think about the following questions:

- What information do you need to create your mathematical model?
- What measurements will you take during your investigation?
- How will you determine the velocity of the ball?
- In what way will you vary the mass of the ball, if at all?
- How will you know how much kinetic energy has been absorbed by the flour surface?

To determine *how you will collect your data*, think about the following questions:

- What equipment will you need to collect the data you need?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect?
- How will you organize your data?

To determine *how you will analyze your data*, think about the following questions:

- What type of calculations will you need to make?
- What type of table or graph could you create to help make sense of your data?

Once you have carried out your investigations, your group will need to use the data you collected to develop a mathematical model that can be used to help explain the relationship between the mass of an object, the velocity of the object, and the kinetic energy of the object. You should be able to use your mathematical model to predict any one of the three values when given the other two. For example, if given the kinetic energy measurement and the object's mass, you should be able to use your mathematical model to determine the velocity of the object at impact.

The last step in this investigation is to test your mathematical model. To accomplish this goal, you can predict the kinetic energy measurement of a ball with a given mass and velocity. If you are able to use your mathematical model to make accurate predictions about the object's mass, velocity, and kinetic energy, you will be able to generate the evidence you need to convince others that the mathematical model you developed is valid.

Report

Once you have completed your research, you will need to prepare an investigation report that consists of four sections (be sure to have section headings):

1. Introduction: Give some background information on the topic. Explain what question were you trying to answer and include a hypothesis. (Background info, research question and hypothesis)
2. Procedure: What did you do during your investigation and why did you conduct your investigation in this way? (How you collected and analyzed data)
3. Data: Include a data table and/or graph to show your results. Be sure to include a title for your table or graph with labels for the variables.
4. Conclusion: What is your argument? (Claim - Evidence - Reasoning)

Your report should answer these questions in two pages or less. The report must be typed, and any diagrams, figures, or tables should be embedded into the document. Type your report on Google Docs (12 point font, double-spaced) and share it with your teacher. Your report will be graded based on the rubric in the class syllabus.