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Kinetic Energy – Young's Experiment

Prerequisite knowledge: 1. Know the general definition of energy. 2. Understand the differences between potential and kinetic energy. 3. Understand the concept of conservation of energy. 4. Know the definition of work. 5. Be familiar with the Work-Energy Theorem. 6. Know general kinematics equations.

Goal Q: What are the equations for kinetic and potential energies?

What difference do you feel when someone hits you with different amounts of kinetic energy? (eg. getting a pat on the back compared to being punched by a bully).

What factors influence the amount of kinetic energy with which you are hit?

This situation is comparable to a ball falling out of the sky onto a flat layer of clay.

Only by dropping a ball from rest, how can you increase the kinetic energy of the ball as it hits the clay?

Comparatively, how do you know if the clay has been hit by the ball with lots of kinetic energy, or with little kinetic energy?

Young assumed that the **volume** of the pit produced by the collision of the ball and the clay would be directly proportional to the kinetic **energy** of the ball at the moment of its impact. Young also assumed that the two influential factors in the final kinetic energy of the ball would be the final **velocity** and the **mass** of the ball.

You are given the following materials:
Meter stick
Metal balls of varying masses (5)
Scale
Clay
Rolling pin (or other device to flatten the clay)
Soap water
Dropper
Computer with graphing program

Part I
Conduct an experiment in which you relate the final velocity of the ball to the final kinetic energy of the ball (volume of the pit).

Dropping the ball from rest, how can you change the final velocities of the ball?

From the general kinematics equations we can calculated the final velocity as follows.

$$v_f = \sqrt{2ad}$$

Complete a total of at least ten trials with different velocities.

Graph your results with the clay's pit volumes in drops (Y-axis) versus the final velocities of the ball (X-axis).

By fitting the graph with the best-fit curve, what mathematical proportionality describes the relationship between kinetic energy and velocity?

Part II
Conduct an experiment in which you relate the mass of the ball to the final kinetic energy of the ball (volume of the pit).

Graph your results with the clay's pit volumes in drops (Y-axis) versus mass of the ball (X-axis).

By fitting the graph with the best-fit curve, what mathematical proportionality describes the relationship between kinetic energy and mass?

Part III
By combining the results from the above two parts of the experiment you should conclude that:

$$KE \sim kmv^2$$

With m = mass, v = final velocity, and k = constant

Because the energy is conserved by the falling ball from the moment of its release to the moment just before it collides with the clay, the initial and final energies must be equal.

Because of the Energy-Work Theorem,

$$\Delta E = W$$

the initial energy of the ball is equal to the work done on the ball to get it to its point of release.

What is the definition of work?

What is the force being placed on the ball as it is raised to its starting point?

From this, it can be concluded that the starting energy, also known as potential energy, in this case, can be calculated as:

$$PE = W = Fd = mgh$$

with m = mass, g = earth's acceleration due to gravity, and h = height above clay.

By using KE ~ mv^2, calculate the KE of each trial, and by using PE = mgh, calculate the PE of each trial of Part I of your experiment. Compare each PE and its respective KE and average them to find the value of k.

What is your final equation for the mathematical calculation of kinetic energy?