Manhattan College/Physics/Dr. Lankar Name: _____

LAB ENERGY - EMILIE DU CHATELET(1706-1746)

KINETIC ENERGY VARIES AS THE SQUARE OF THE SPEED

MATERIAL

DVD Einstein's big idea from NOVA , Box of soft clay, a plumb line with bob, meter sticks, string, rulers, papers.

PART1:

Watch the segment: Emilie du Chatelet. Discuss the experiment.
Emilie found that the kinetic energy is proportional to the speed _____.
Who is the famous Physicist she demonstrated wrong ? _____
Newton thought energy of motion like the momentum has to be proportional to the _____ and the _____. Leibniz was right.

These 2 persons invented the branch of Mathematics called _____.
Note that Newton's derived the equations of kinematics that allowed the dutch scientist to derive the speed of the masses before they hit the clay.

$$speed = \sqrt{2gh}$$

In the equation, g is the acceleration due to gravity, h is the height from which the weighs are dropped. We neglect air resistance. This equations shows that the speed
does not depend on the masses. (as found by Galileo, masses fall at the same rate).

PART2: Fill the blanks and do the experiment

Like Emilie, You are going to drop a weigh in clay (lead bob). If we neglect air resistance, the mass will transfer their kinetic energy to the clay and will leave a mark in it. The kinetic energy is transformed into damage done to the clay.
Energy of clay = force x distance in clay.
We neglect the loss of energy due to friction between the clay and the ball (heat) and we suppose that the clay does not rebound.

Emilie du chatelet was able to show that, if you double the speed of the ball, the kinetic energy is not multiplied by _____ but by ____ ! and so is the damage done to the clay. The same way, if you

double your speed on the highway and, if you crash, the damage is not multiplied by ____ but by _____. The kinetic energy is transformed in broken glass, folded metal .. .

In this experiment, You are going to show that <u>if the speed of the falling masses is multiplied by a factor f, the mark of the sphere in the clay (volume) is multiplied by f^2</u>

You will be given 2 heights from which to drop the spheres. You will see what happen to the volume left in the clay.

PROCEDURE

2 heights are considered: H1, H2 You will drop the sphere from H1, then H2.

STEP1: Prepare a pad of flat, soft clay and place it on a paper on the ground. It has to be thick. Hold the plumb line such as the tip of the bob is at 1m (H1) above the clay. Let go with the string. The volume left in the clay is proportional to energy. The volume is proportional to the depth of the mark in the clay. (The area is the same regardless of H1 and H2). Cut the clay like Emilie did (through the impression) to measure the height of the impression and record in the table below as V1. Do the same experiment 3 times (or more). So the same thing for H2 (2m).

For each height compute the speed of the bob before they hit the clay. Note that the speed does not depend on the mass. (all free-falling bodies fall at the same rate, regardless of their mass)/

TABLE1:

drop height =h1= 1m (50cm) **speed before it hits the clay:** **(known by Newton)** $speed = \sqrt{2gh} =$ ____	**drop height =h2= 2m (200 cm)** **speed before it hits the clay:** **(known by Newton)** $speed = \sqrt{2gh} =$ ____
Volume**V1** =	Volume**V2**=
Volume**V1** =	Volume**V2** =
Volume**V1** =	Volume**V2** =
Average **V1** =	Average **V2**=

Is it true that the speed is multiplied by 2 ?
Compute the ratio between the average volumes **V2** and **V1** : _____ (1)
Compute the ratio between the 2 speeds. S2 and S1_____
square this ratio _____ (2)

Is (1) close to (2) ? Take (2) as the accepted value. Find the % error.

Discuss the sources of errors.

In this experiment, the manipulated variable (independent) was the _____. (what did you change)
The responding variable (dependent) was the _____ in the clay. The controlled variable was the _____. (stays the same)

The kinetic energy is therefore proportional to the speed _____. kinetic energy is however proportional to the mass. So, for the same height, if you double the mass you expect the volume in the clay to _____.

We studied potential energy in class and another way to look at this experiment is to say that since the heights are multiplied by 2 then the potential energy was also multiplied by _____.
So you expect the volume to be multiplied by _____ as well.
Was it the case ?

GOING FURTHER

1) A 875kg car speeds up from 22m/s to 44m/s while passing another car. What were its initial and final energies, and how much work was done on the car to increase its speed ?
(the work in done by the engine, you are using fuel)
hint: work done = increase energy. The work is the amount of energy transferred from the oil (chemical energy) to the motion of the car (kinetic energy).

2) A comet with a mass of 7.85 10^{11} kg strikes Earth at a speed of 25km/s
A) Find the kinetic energy of the comet in joules ?

hint: convert km to m

B) Compare the work is done by in stopping the comet (found in A) to the 4.2 10^{15}J of energy that were released by the largest nuclear weapon ever built. Such comet collision has been suggested as having caused the extinction of the dinosaurs.

3)
A) How much work is needed to accelerate a 5,700kg (almost 6 tons) trailer truck to 100km/h (from rest)? hint: convert to m/s (see above for the onversion)

B) What would be the truck's speed if half as much work were done on it?
hint: the work done is the change in kinetic energy. The new kinetic energy is what you found in A) divided by 2.
Then use work = 0.5 m V2 to solve for V.

C)What would be the truck 's speed if twice as much work were done on it ?
hint: multiply A) by 2 and solve for V

4)

A) Find the kinetic energy of a 5g snail moving at a speed 0.05km/h. Use scientific notation.

hint: convert g to kg and km/h to m/s

B) Find the kinetic energy of a 148g pitched baseball at 45m/s

hint: convert g to kg

C) Find the kinetic energy of 100kg orbiting satellite at 78km/s

hint: convert km/s to m/s

5) A riffle shoot a 4.20g bullet at a speed of 965m/s.

A) Find the kinetic energy of the bullet as it leaves the riffle

hint: convert g to kg, $KE = 0.5\ m\ V^2$

B) What work is done on the bullet as it leaves from rest?

hint: work = energy transfered to bullet = change in kinetic energy of bullet with Vinitial = 0 and Vfinal = 965m/s/ change in kinetic energy = $0.5mV_{final}^2 - 0.5mV_{initial}^2$

C) If the work is done over a distance of 0.75m (75cm), what is the average force on the bullet ?

hint: remember ? work (J)= force (N) x distance (m). The work has been computed in B)

D) If the bullet comes to rest by penetrating 1.5cm into metal, what is the magnitude and direction of the force the metal exerts ? Assume the force is constant.

hint: convert cm to m. The energy is conserved. Use work found in B). use work = force x distance.

6) A steel ball has a mass of 4.0kg and rolls along a smooth , level surface at 62m/s.

A) Find its kinetic energy

hint: again, use the formula for KW

B) At first, the ball was at rest on the surface. A constant force acted it through a distance of 22m to give it the speed of 62m/s.

What was the magnitude of the force?

hint: again, change in kinetic energy = work done = force applied x distance / with Change in kinetic energy = $0.5mV_{final}^2 - 0.5mV_{initial}^2$ / $V_{final} = 0$

1)A 1k hammer is dropped from a height = 1m over a pole If you neglect friction and air resistance, what is the force F exerted on the pole if moves in the ground by 10cm. (0.01m).

This is a machine because it magnifies the force. By how much?