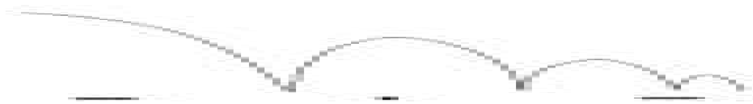


GROUP 1
Lennon Safe
Carol Obler

SMART PROJECT

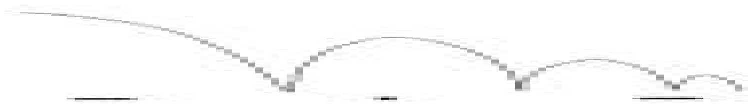
PROJECT PAPER:

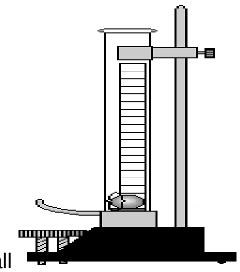
Introduction: According to Newton's experimental law, for a given pair of bodies in collision, the ratio of final relative speed to initial relative speed is always the same. This ratio is called the coefficient of restitution, and has the symbol ε. If the coefficient is high (very close to 1.00) it means that very little kinetic energy was lost during the collision. If the coefficient is low (close to zero) it suggests that a large fraction of the kinetic energy was converted into heat or was otherwise absorbed through deformation. When a moving object (say a rubber ball) collides with an immobile flat surface (say a steel floor), the object will rebound with some fraction of its original energy. If the collision is perfectly elastic, then the ball will rebound with all of the energy it arrived with and its rebound velocity will be the same as its approach velocity. In this case, the coefficient of restitution is said to be precisely 1.00. On the other hand, if there is considerable permanent deformation of either the object or the surface (or both) then the object will rebound with much less energy than it originally arrived with. In this case, the coefficient of restitution will be close to zero. In the latter case, the surface was probably soft or otherwise absorptive. In the first case, the surface might have been particularly hard or it may have been particularly springy.

CLASSIFIATION of ONE-DIMENSIONAL COLLISION

Type	Kinetic Energy	Restitution
Perfectly Elastic	Conserved	$\varepsilon = 1$
Partially Elastic	Not Conserved	$0 < \varepsilon < 1$
Perfectly Inelastic	Maximum Possible Loss	$\varepsilon = 0$
Hyperelastic	Energy Gained	$\varepsilon > 1$

In this particular experiment we will use a ball, a hollow tube on a platform, the graphical software (Stem Plot,) etc. to illustrate the maximum height the ball attains after every bounce, hence the name of the project " Follow the Bouncing Ball". Accompanying our demonstration is a computer code we created in PBasic for calculating the coefficient of restitution for any ball (one that fits in our tube) that is released in our apparatus.





OBJECTIVE: To determine the coefficient of restitution for different types of ball

APPARATUS: Tennis balls, golf balls, super balls, etc

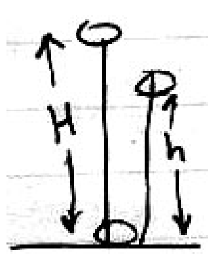
THEORY:

Most hard bodies are highly resilient while soft bodies are less resilient (do not bounce back after a collision). The coefficient of restitution is a measure of the bounciness of an object during a collision. The coefficient of restitution will be one for a perfectly elastic collision and zero for a completely inelastic collision. The coefficient of restitution can be expressed as:

Below is a formula used for calculating the coefficient of restitution which was used ib our program. The result of the value is displayed on an LCD

$$r = \frac{\text{velocity of separation}}{\text{velocity of approach}} = \frac{\sqrt{2gh}}{\sqrt{2gH}} = \frac{\sqrt{h}}{\sqrt{H}}$$

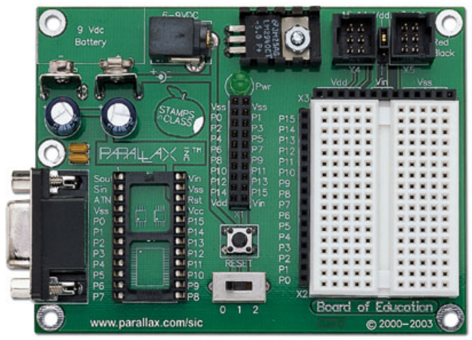
where H is the height from which a ball is dropped and h is the height to which the ball rebounces. In actual practice, collisions are neither perfectly elastic nor perfectly inelastic, but somewhere between. The coefficient of restitution for a body is usually specified for collision with another body made of the same material.



MATERIALS/COMPONENTS USED:

Ultrasonic Sensor

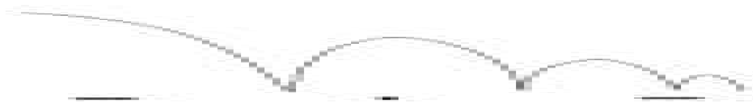
Basic 2 stamp



DC Motor

Board of education

Circuits

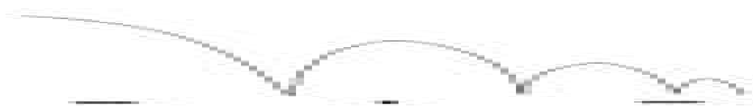


DESCRIPTION OF THE PROJECT:

Basically we installed a tube on a flat surface, and on this apparatus we incorporated the use of the following materials:

DC-motor
Pulley and a belt
Balls
Basic Stamp II microprocessor
An LCD display
Breadboard
An ultrasonic sensor
Several pieces if wire
A Switch

The motor which is connected to the pulley and belt will be turned on by the switch, which will cause the pulley and belt to rotate. Connected to the belt is a plate which will lift the ball and continuously dropped it from the top of the tube. When the ball is dropped the ultrasonic sensor which is located at the top of the tube will tracked the ball as it is dropped into the tube. The height of the ball will be tracked and by following the bounce of the ball were will be able to determine the maximum height of the first bounce the second bounce and so on. By simultaneously storing the maximum height of the bounces in our program we then calculated the coefficient of restitution: That is the bounce height divided by the drop height. On the LCD display the maximum height of the ball along the coefficient of restitution will be displayed.
There will be two locations on the tube with holes; these holes are placed at the first and second maximum height of the ball respectively. The idea is to slide a piece of flat object to hold the ball at that location and then re-release the ball so as to illustrate that the ratio will be the same as well as the behavior of the bounces from that location will overlap with the original bounce. This graph will be displayed on the software Stem Plot as the ball bounces in the tube

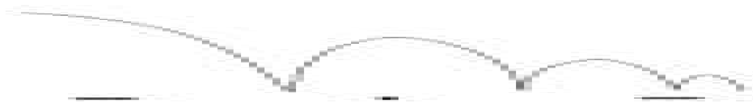


Rational for the project:

Both teachers involved in this project are Mathematics Teachers and so the idea of doing something that was not very abstract came up because one of the teachers work with students in a middle school. Working with something that moves is always a great motivator for students of any age as well as something that is easy to replicate in the classroom.

In a High School Mathematics class this Apparatus will be great for illustrating not on Coefficient of Restitution of a ball, but also as a physical model for showing an exponential decay. The current Mathematics curriculum in New York State requires the use of technology in the classroom as well as hands on approach to in Mathematics. The objective is to lead students away for thinking that Mathematics is a group of Axiomatic rules and patterns by showing them some type of applicability and relationship to other disciplines. This SMART project could show the interconnectedness of Mathematics, Physics, as well as Life Science.

The long term objective is to take all the ideas and skills acquired from the SMART project back to our respective school and try to integrate it into our curriculum. We also believe that it is extremely important to get students involved in engineering or exposure to engineering from an earlier age.

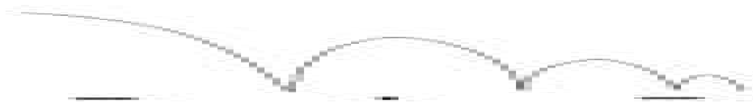


PBASIC CODE FOR CALCULATING THE COEFFICIENT OF RESTITUTION:

```
' {$STAMP BS2}

' {$PBASIC 2.5}

MAX_HEIGHT VAR WORD

RAWDIST    VAR WORD

COUNTER    VAR WORD

MAX1       VAR WORD

MAX2       VAR WORD

RAWTOIN    CON          889

RAWTOCM    CON          2257

SCALE      CON          $200

ISHIGH     CON          1

ISLOW      CON          0

TRIGGER    CON          5

PING       PIN          15


TEST  VAR WORD

TEST = 0


MAX_HEIGHT = 0

COUNTER    = 0


MAIN:

    GOSUB HEIGHT

    IF (TEST > 15) THEN GOTO LOOP2

GOTO MAIN


HEIGHT:
```

```
    GOSUB GET_SONAR
    TEST = RAWDIST** RAWTOIN
    TEST = 35 - TEST
    PAUSE 60
    'DEBUG DEC TEST,CR
RETURN

GET_SONAR:
    PING = ISLOW
    PULSOUT PING, TRIGGER
    PULSIN PING,ISHIGH, RAWDIST
    RAWDIST = RAWDIST*/ SCALE
    RAWDIST = RAWDIST/2
RETURN

LOOP2:
    IF (TEST < 6) THEN
    GOTO LOOP3
    ENDIF
    GOSUB HEIGHT
GOTO LOOP2

LOOP3:

    GOSUB HEIGHT
    IF TEST > MAX_HEIGHT THEN
     MAX_HEIGHT = TEST
     COUNTER = COUNTER + 1
    ENDIF
    IF COUNTER = 1 THEN
```

```
        MAX1 = MAX_HEIGHT
        DEBUG ?MAX1
      ELSEIF COUNTER = 2 THEN
        MAX2 = MAX_HEIGHT
        DEBUG ?MAX2
        GOTO FINAL_LOOP
       ENDIF
GOTO LOOP3

FINAL_LOOP:
GOTO FINAL_LOOP
```



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4. **TA at Polytechnic University Mechatronics Lab**
   (i) Nathan
   (ii) Anchieman
   (iii) Fahan
   (iv) Hong
   (v) Chris

SOURCES:

1. http://www.ac.wwu.edu/~vawter/PhysicsNet/Topics/Momentum/CoeffOfResititution.html
2.
3. http://www.oberlin.edu/physics/catalog/demonstrations/mech/restitution.html
4.