Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_Time:\_\_\_\_\_\_\_\_\_\_

Partner(s):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ballistic Pendulum Pre-Lab
1. Define [momentum](https://en.wikipedia.org/wiki/Momentum), identify it as a vector or scalar, and state its SI unit.

<http://www.youtube.com/watch?v=4IYDb6K5UF8&feature=relmfu>
2. Watch the above video and state the principle of conservation of momentum.

3. A ball of mass 2-kg travelling to the right at 1.5 m/s collides head-on with another ball (mass = 3-kg) travelling to the left at 2.0 m/s. If the two balls stick together during the collision, what is the velocity (speed and direction) of the two balls after the collision?

<http://www.youtube.com/watch?v=mFNe_pFZrsA&feature=related>

4. Explain how the above demo illustrates the conservation of momentum.

5. Watch the following video: <https://www.youtube.com/watch?v=GIuvYgdOFqI>

Which conservation laws are used to find the initial velocity of the bullet?

**PHYS LAB Remote Lab on Ballistic Pendulum Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Purpose:** To study a ballistic pendulum using a simulation and understand how it is used to determine the initial velocity (u) of a bullet.

Simulation: <https://ophysics.com/e3.html>

**Theory:**

The collision is completely inelastic. The momentum is conserved but the kinetic energy is not conserved. During the collision, most of the energy is lost as heat. After the collision the energy is conserved. Just after the collision the block & bullet has kinetic energy and it is converted into gravitational potential energy when the block & bullet are raised to a height, *h*.

Assume that the bullet has a mass of *m* and is fired with a velocity of *u*. Mass of the block is *M* and it is stationary before the firing. Also, assume that the bullet is impeded in the block quickly during the collision and both moves with a velocity *v* after the collision.

Applying the conservation of momentum for the collision gives,

$mu=\left(m+M\right)v$ or $u=\frac{(m+M)}{m}v$ …….(1)

Applying the conservation of energy, after the collision gives,

$\frac{1}{2}\left(m+M\right)v^{2}=\left(m+M\right)gh$ or $v^{2}=2gh$ or $v=\sqrt{2gh}$ ……(2)

Eliminating *v* between (1) and (2) gives:

 $u=\frac{(m+M)}{m}\sqrt{2gh}$

Procedure:

A) Open the simulation: <https://ophysics.com/e3.html>

1) Write down the values for the following in this simulation:

a. Range for the initial velocity of the bullet\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. Range for the mass of the bullet\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

c. Range for the mass of the wood block\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

d. What is the height for the bottom of the wood block\_\_\_\_\_\_\_\_\_\_\_\_

2) Fire the bullet and measure the maximum height, *h* reached by the bottom of the block. This can be done by matching the slider line for *h* to the bottom of the block, momentarily when it reaches the maximum height. Also, record other variables below, and calculate the initial velocity of the bullet.

Maximum height reached by the wood block, *h* = \_\_\_\_\_\_\_\_\_\_\_\_\_

Mass of the bullet, m = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Mass of the wood block, M = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Acceleration due to gravity = g = 9.8 m/s2

Velocity of the block and bullet after the collision, calculated using the measured h,

 *v* = \_\_\_\_\_\_\_\_\_\_\_\_

Initial velocity of the bullet, calculated using the above *v* and masses, m & M,

 u =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Initial velocity of the bullet, simulation value, u =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 %Error =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

B) Perform the following calculations in SI unit.
1) Calculate the kinetic energy of the bullet before the collision.

2) Calculate the kinetic energy of the bullet and block just after the collision.

 3) Calculate the energy loss due to the collision.

4) What fraction of the initial kinetic energy is lost?

5) Fraction of the initial kinetic energy lost is also given by, $\frac{M}{m+M}$.
Calculate the ratio, and compare it to 4) above.

6) What happened to the lost energy?

C. Keep the mass of the bullet (0.075 kg) and mass of the wooden block (4 kg) constant.

Measure the height raised, *h* for initial velocities 100, 125, 150, 175, 200, 225 m/s.

Tabulate your results in excel and plot a graph, initial velocity *versus* *h*, add a power trendline, and determine the value of the coefficient of the power fit. Also, calculate a value for the coefficient of the power fit using the simulation values of the constants and find the % error.

$$u=\frac{(m+M)}{m}\sqrt{2gh}$$

 Coefficient of the power fit from trendline =\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Coefficient of the power fit, calculated using constants = \_\_\_\_\_\_\_\_\_\_\_\_\_

 %Error = \_\_\_\_\_\_\_\_\_\_\_\_

**D) Write a conclusion**