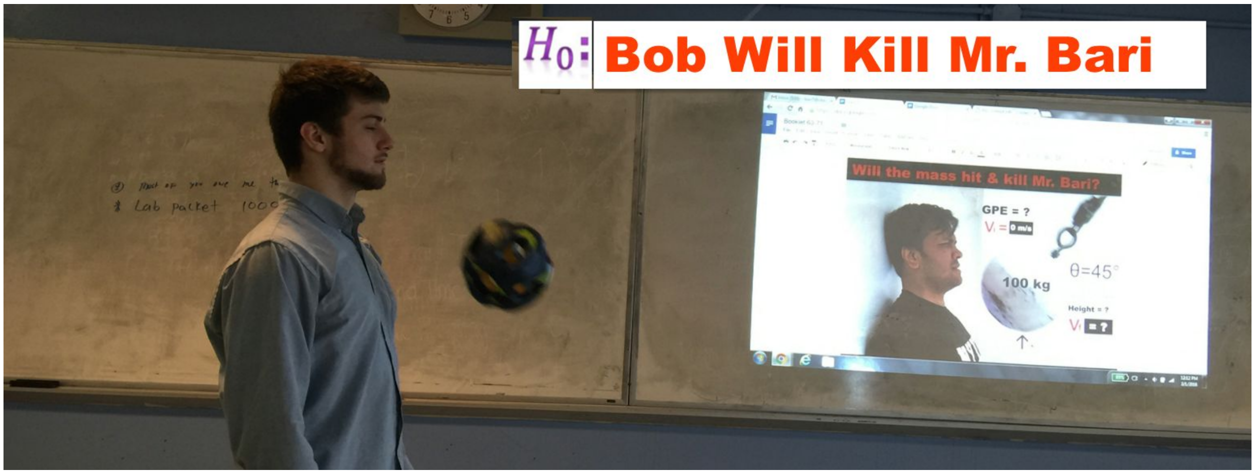
Bob Will Kill Mr. Bari

--By Rashidul Bari



Introduction:

Energy is the ability to do work. And work is energy transferred by force. The Law of Conservation of Energy tells us that Energy can neither be created or be destroyed, but can only transfer from one form (Potential Energy) to another (Kinetic Energy). However, I completely disagree with this so called (null) hypothesis that Energy is conserved. In fact, I strongly believe that I can create energy. I will put my own life on the line to disprove the law of conservation of energy:

H_0**: Energy is Conserved**

H_1**: I can create energy (Bob will Kill Mr. Bari)**

I will disprove the null hypothesis (H_0: Energy is Conserved) by accepting the alternative hypothesis: H_1: that I can create energy (Bob Will Kill Mr. Bari). I will do that in seven steps: (1) The Traditional pendulum lab; (2) Simulated pendulum; (3) Mathematical Rigor; (4) Algebraic & Calculus Derivation of work-energy theorem; (5) Calculating Total Energy on all positions; (6) Putting my life on the line for the love of physics and the (7) Conclusion.

Traditional Pendulum Lab:

I have borrowed a simple pendulum from Lehman College (thanks to Dr. Daniel Kabat) to test the alternative hypothesis -- that I can create energy. Our lab is designed in a way that we can suspend a 0.5 kg Bob from its pivot point in such a way that it can swing freely. When I displaced the Bob 20 degrees sideways, my claim was that it would not only swing back but also go higher than 20 degrees. But it did not. In fact, the Bob swung back to -20 degrees, and turned back to it's equilibrium position.

I realized that I should double the mass by doubling the magnitude of weight of the Bob. However, I observed the same phenomenon, recorded in the table below:

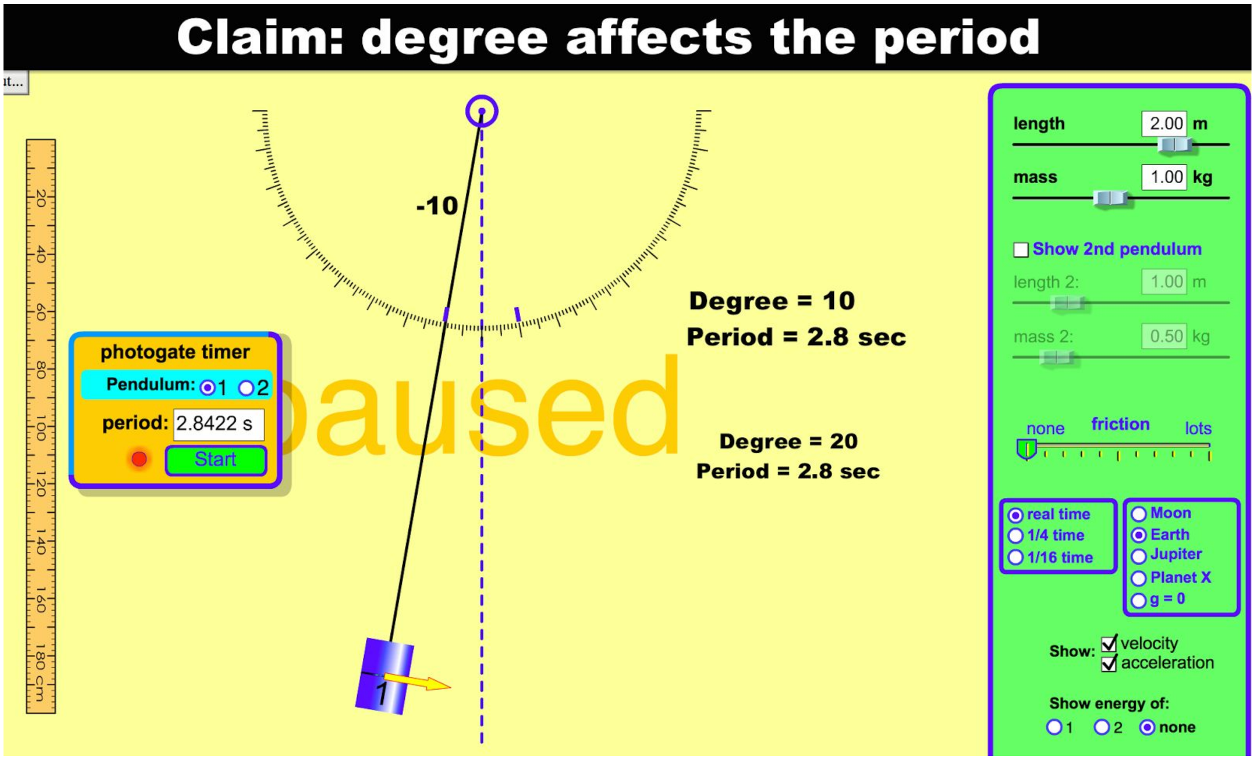
Claim: Mass affects the period		
Trial	Mass (kg)	Period
1	0.5 *kg*	2.9 sec
2	1 *kg*	2.9 sec
Decision: Mass does not affects the Period		

I have conducted my second experiment with the traditional pendulum. This time I had stronger claim: The degree affects the period. However, the experiment results disappointed me again. Here's the data I have collected from my experiment:

Claim: Degree affects the period		
Trial	Degree	Period
1	10	2.8 sec
2	20	2.8 sec
Decision: Degree of Bob does not affects the Period		

Simulated Pendulum:

I have decided to conduct my experiment using a simulation because I was not happy with the results of the traditional pendulum lab. My hope was that a simulation would give us a more accurate picture of the phenomenon because it would have less measurement errors.



As the image of the simulation above shows -- the degree doesn't affect the Period of the bob. In fact, when I changed the amount of degrees the bob was displaced by, from 10 degrees to 20 degrees, the period of the bob remained constant, meaning it didn't go higher because it's initial and final position were the same. However, I wanted to check the other claim as well, because I am a strong believer of investigation. Once again, I have conducted my first experiment with a simulated pendulum. Just like before, this time my hope was high because I really believe that I can create extra energy by doubling the mass of the Bob. However, the experiment results disappointed me again. Here's the data I have collected from my experiment:

Claim: Mass of Bob affects the period		
Trial	Mass (kg)	Period
1	0.5 kg	2.9 secs
2	1 kg	2.9 secs
Decision: Mass of Bob does not affects the Period		

This will take us to an even more detailed investigation of how the mass & degree affects the period through a mathematical rigor.

Mathematical Rigor:

I'm not ready to give up the alternative hypothesis. Therefore, I decided to investigate the phenomena using pure mathematics. If I can proof that the $\theta f > \theta i$ (theta final > theta initial) , I would be very happy because that would be enough to accept the alternative hypothesis that I can create energy. In order to do so, I have to set the following equation: $\theta f = \theta i$. If I can prove this wrong, then $\theta f > \theta i$ must be true. So let's do it:

Step # 1:

$\theta i = \theta f$

$PEi = PEf$

$mghi = mghf$

$hi = hf$

Step # 2:

$hi = hf$

$L - Lcos\theta i = L - Lcos\theta f$

$L(1 - cos\theta i) = L(1 - cos\theta f)$

$(1 - cos\theta i) = (1 - cos\theta f)$

$(- cos\theta i) = (- cos\theta f)$

$(cos\theta i) = (cos\theta f)$

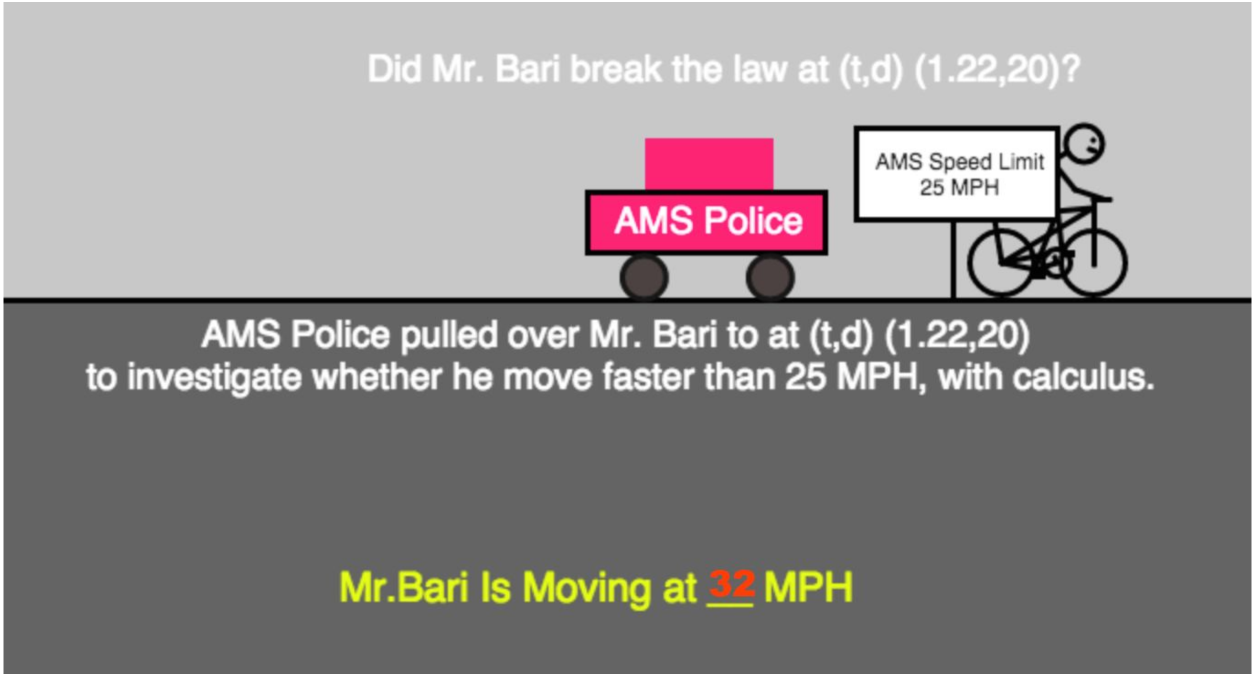
$(\theta i) = (\theta f)$

$\theta i = \theta f$

The mathematics also did not support my hypothesis. However, the good news is that I still have two options left: use the work-energy theorem to disprove the Law of Conservation of Energy and put my life on the life to actually test out the hypothesis in real life. I will first derive work-energy theorem (1) algebraically and (2) Using calculus.

Algebraic Derivation of the Work-Energy Theorem (optional):

Now we will investigate alternative hypothesis that I can create energy by combining work and energy using physics. This makes sense as both have the same units, and the application of a force over a distance can be seen as the use of energy to produce work. To complete the theorem we define kinetic energy as the energy of motion of Mr. Bari's Bike. So let's revisit Trimester #1 essay topic: Mr. Bari went out to a bike trip for 1 hour and half long & his position function is : $P(t) = \frac{40}{3} t^2$. In 20 mile of the trip, he saw a speed limit sign that said 25 MPH. Did Mr. Bari Break The Law? Let's take a look at a simulated view of our problem.



It turned out that he actually broke the law because he was moving faster and faster. During Trimester I, our investigation revealed that his velocity was 32 m/s when he was passing the speed limit sign. Let's investigate this problem using the work-energy theorem. Mr. Bari's Bicycle was acted upon by a force as it moved from x_0 (initial position) to x_f (Final position). Its velocity also increases from v_0 to v_f (he broke the Law). The net work on his bike is given by:

Newton's Second Law	Equation of Work
F = ma	W = fd
Kinematics equation	
$V^2_f = V^2_i + 2ad$	
Derivation of work-energy theorem	
$V^2_f = V^2_i + 2ad$ $a = \frac{V^2_f - V^2_i}{2d}$	

$$W = Fd$$
$$W = m\,a\,d$$
$$W = m\,\frac{V^2_f - V^2_i}{2d}\,d$$
$$W = m\,\frac{V^2_f - V^2_i}{2} \text{ (d and d canceled)}$$
$$W = \frac{1}{2}\,m\,(V^2_f - V^2_i) \text{ (Distribute } \frac{1}{2} \text{ m on both side)}$$
$$W = \frac{1}{2}\,m\,V^2_f - \frac{1}{2}\,m\,V^2_i$$

This equation is one form of the work-energy equation, and gives us a direct relation between the net work done on Mr. Bari's Bike and it's velocity.

Calculus Derivation of the Work-Energy Theorem (Optional):

Let's differentiate Newton Second Law:

$$F = ma = m\frac{dv}{dt}$$

If we multiply both sides by v, here's what we get:

$$F \cdot v = mv\frac{dv}{dt}$$

What actually is v? It's the change of distance over change of time, or simply $v = dx/dt$. So let's plug that in:

$$F\frac{dx}{dt} = mv\frac{dv}{dt}$$

We rearrange and do the cross multiplication:

$$F(dx)(dt) = (dt)(dv)(mv)$$

Notice that (dt) and (dt) canceled each other:

F (dx) = (dv) (mv)

Let's integrate it:

$$F\,dx = mv\,dv$$

$$F\int_0^x dx = m\int_0^v v\,dv$$

$Fx = m(½v^2) = ½mv^2 = E_k$

But Fx = Work; therefore Work = $m(½v^2) = ½mv^2$

Taking into consideration the equation derived previously, we define the kinetic energy numerically as:

$$K = \frac{1}{2} mv^2$$

Thus we can substitute for K in our work energy theorem:

$$W_{net} = \frac{1}{2} mv_f^2 - \frac{1}{2} mv_I^2 = K_f - K_o$$

Implying that

$$W_{net} = \Delta K$$

This is our complete Work-Energy theorem. The equations says that net work done by the forces on Mr. Bari's Bike causes a change in the kinetic energy of the Bike. We will use this theorem to find the

Derivation of Work Energy Theoram

Newton's Second Law	Equation of Work
F = ma	W = fd
Kinematics equation	
$V^2_f = V^2_i + 2ad$	
Derivation of work-energy theorem	

$V^2_f = V^2_i + 2ad$

$a = \frac{V^2_f - V^2_i}{2d}$

W = **Fd**

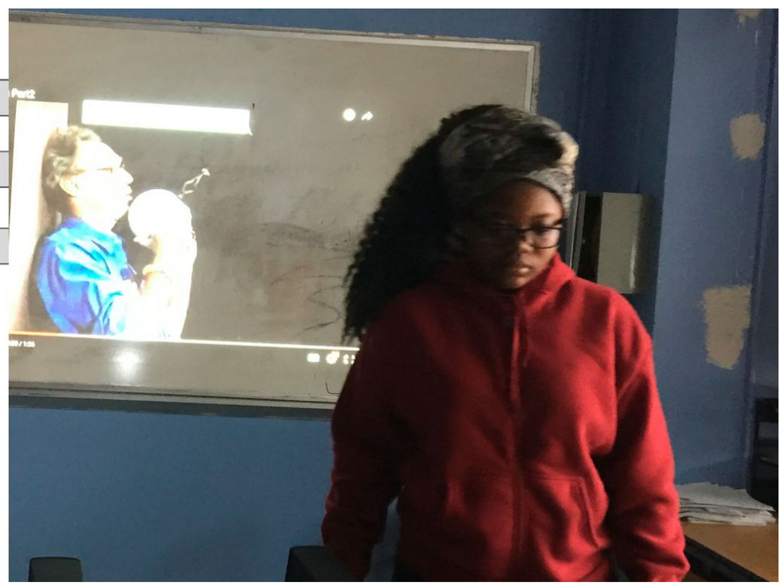
W = m **a** **d**

W = m $\frac{V^2_f - V^2_i}{2d}$ **d**

W = m $\frac{V^2_f - V^2_i}{2}$ (**d** and d canceled)

W = $\frac{1}{2}$ m (V^2_f - V^2_i) (Distribute $\frac{1}{2}$ m on both side)

W = $\frac{1}{2}$ m V^2_f - $\frac{1}{2}$ m V^2_i



velocity of the pendulum at its equilibrium position to see whether it equal to potential energy.

Investigating it by Work-Energy Theorem:

Let's divide the position of Pendulum in 3 different sections: (1) Position 1 is + 45 degree, Position 2 is at the Equilibrium and Position # 3 is at - 45 degree. We will calculate the following items from all three positions: (1) Gravitational Potential Energy (GPE), (2) Kinetic Energy (KE); (3) Total Energy (TE) and Velocity (V). Our goal is to prove $TE_{-45\ degree} > TE_{+45\ degree}$

<table>
<tr><td colspan="3">$Goal: \ TE_{-45\ degree} > TE_{+45\ degree}$</td></tr>
<tr><th>GPE at Position # 1 (+ 45^0)</th><th>GPE at Position # 2 (Equilibrium)</th><th>GPE at Position # 1 (- 45^0)</th></tr>
<tr><td>Find GPE at $+45^0$
GPE = mgh_1

Step # 1 : Collecting data
m = 100 kg
g= 10 m/s^2
h_1 = ?

Step # 2 (finding h_1)

h_1 = L-Lcosθ
h_1 = 3 m- 3 m cos45^0
h_1 = 3 m- 3 m cos45^0
h_1 = 3 m- (3 m) X 0.71
h_1 = 3 - 2.12
h_1 = 3 - 2.12
h_1 = 0.88 m

Step # 2 (Let’s find GPE)

$GPE_1 = mgh_1$
GPE_1 = (100 kg) X (10 m/s^2) X (0.88 m)
GPE_1 = 880 J</td>
<td>$GPE_2 = mgh_{equilibrium}$

Step # 1 : Collecting data
m= 100 kg
g= 10 m/s^2
$h_{equilibrium}$ = ?

Step # 2 (Finding GPE)

$GPE_2 = 0$
(because $h_{equilibrium} = 0$)</td>
<td>Find GPE at - 45^0
GPE = mgh_1

Step # 1 : Collecting data
m= 100 kg
g= 10 m/s^2
h_3 = ?

Step # 1 (finding h_3)

h_3 = L-Lcosθ
h_3 = 3 m- 3 m cos45^0
h_3 = 3 m- 3 m cos45^0
h_3 = 3 m- (3 m) X 0.71
h_3 = 3 - 2.12
h_3 = 3 - 2.12
h_3 = 0.88 m

Step # 2 (Let’s find GPE)
$GPE_3 = mgh_1$
GPE_3 = (100 kg) X (10 m/s^2) X (0.88 m)
GPE_3 = 880 J</td></tr>
<tr><td colspan="3">Finding KE at three positions</td></tr>
<tr><th>KE at Position # 1 (+ 45^0)</th><th>KE at Position # 2 (Equilibrium)</th><th>KE at Position # 1 (- 45^0)</th></tr>
<tr><td>$KE_{+45^0} = \frac{1}{2} m v^2$

Step # 1 : Collecting data
PE = KE = 880 J
M = 100 kg

Step 2: Finding velocity</td>
<td>$KE_{equilibrium} = \frac{1}{2} m v^2$

Step # 1 : Collecting data
PE = KE = 880 J
M = 100 kg
V = ?

Step 2: Finding Velocity</td>
<td>$KE_{-45^0} = \frac{1}{2} m v^2$

Step # 1 : Collecting data
PE = KE = 880 J
M = 100 kg

Step 2: Finding velocity</td></tr>
</table>

<table>
<tr>
<td>V = 0 m/s

Reason: the Bob had to stop in order to swing back to $+45^0$</td>
<td>$V = \sqrt{\frac{(2)\,X\,(KE)}{m}}$

$V = \sqrt{\frac{(2)\,X\,(880)}{100}}$

$V = 4.20\ \frac{m}{s}$</td>
<td>V = 0 m/s
Reason: the Bob had to stop in order to swing back to -45^0</td>
</tr>
<tr>
<td colspan="3">Finding Total Energy (TE) at three positions</td>
</tr>
<tr>
<td>KE at Position # 1 ($+45^0$)</td>
<td>KE at Position # 2 (Equilibrium)</td>
<td>KE at Position # 1 (-45^0)</td>
</tr>
<tr>
<td>$TE_{+45^0} = GPE_{+45^0} + KE_{+45}$

Step # 1 : Collecting data:

M= 100 kg
$V = 4.20\ \frac{m}{s}$
$KE_{equi} = 0$

Step # 2 : finding TE

$TE_{+45^0} = GPE_{+45^0} + KE_{+45}$
$TE_{+45^0} =$ 880 J + 0 J

$TE_{+45^0} =$ 880 J</td>
<td>$TE_{Equi} = GPE_e + KE_e$

Step # 1 : Collecting data

M= 100 kg
$V = 4.20\ \frac{m}{s}$
$KE_{equi} = ?$

Step # 1 : finding KE_{equi}
$KE_{equilibrium} = \frac{1}{2} m v^2$
$KE_{equilibrium} =$
$0.5\ X 100\ X\ 4.20^2$
$KE_{equilibrium} =$ 880 J

Step # 3: finding TE

$TE_{equi} = GPE_e + KE_{equi}$
$TE_{equi} =$ 0 j + 880 j

$TE_{equi} =$ 880 j</td>
<td>$TE_{-45^0} = GPE_{-45^0} + KE_{-45^0}$

Step # 1 : Collecting data

M= 100 kg
$V = 4.20\ \frac{m}{s}$
$KE_{equi} = 0$

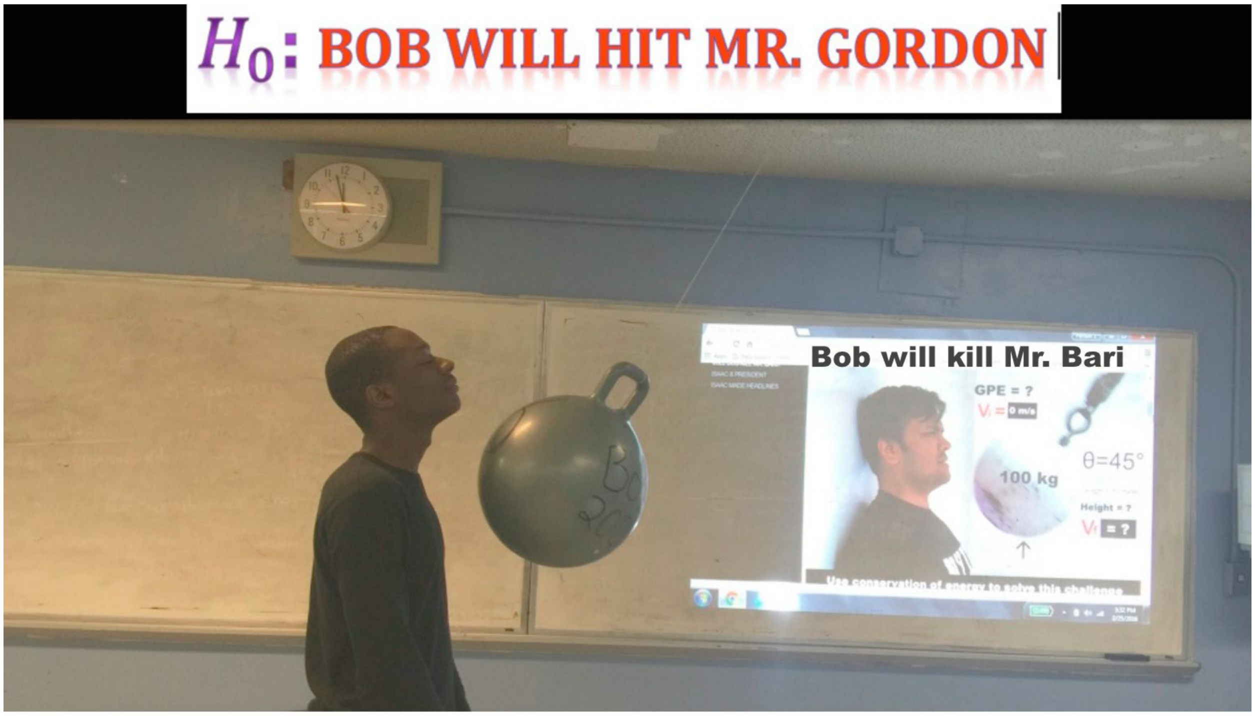
Step # 2 : finding TE

$TE_{-45^0} = GPE_{-45^0} + KE_{-45^0}$
$TE_{-45^0} =$ 880 J + 0 J

$TE_{-45^0} =$ 880 J</td>
</tr>
<tr>
<td colspan="3">$TE_{+45^0} = TE_{equi} = TE_{-45^0}$</td>
</tr>
</table>

Putting my life on line for the love of physics:

I have tried many different ways to accept H_1 -- *that I can create energy (Bob Will Kill Mr. Bari). However, data from the traditional pendulum lab and data from the Phet Simulation does not support it. I tried to use math, and failed as well. I derived the work-energy theorem to calculate the total energy (TE) and found that the total energy is conserved in all three positions. That is* $TE_{+45^0} = TE_{equi} = TE_{-45^0} =$ 880 joule. This is why, I decided to put my life on line. I asked my students to bring a massive Bob for the experiment. Sam brought a huge Bob for me.



I was super excited. So I had all my students around me to witness the investigation. I stood +45 degree sideways from the equilibrium position of the pendulum and let the heavy Bob (100 kg) go and closed my eyes. I was hoping for Bob to come back and hit me on my face. **I was ready to die for the love of physics**. I shut my eyes. I let the Bob go. The entire room was silent. I heard a massive object was approaching me. I was getting very excited. I was eagerly waiting for the massive Bob to hit me on the chin. I opened my eyes when I heard clapping. I realized that I did not get hit by the Bob. Tears dropped from my ears: no, I was not crying because I failed to demonstrate creating energy. I shed tears because I fell in love with math and physics instantly. Math and physics predicted that the Bob will not hit my chin, and it did not. I'm amazed.

Conclusion:

I'm rejecting my hypothesis H_1: I can create energy (Bob Will Hit Mr. Bari) because $\theta i = \theta f$.
I am accepting H_0: Energy is Conserved because $TE_{+45^0} = TE_{equi} = TE_{-45^0} =$ 880 j.