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IAR Physics program Project Report: Golden lambert machine simulation and analyses

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ABSTRACT: *The golden lambert machine that are going to be constructed on software simulator-blender. The golden lambert machine will be fully constructed in software which all motion and physic simulation are under ideal conditions, the limitation for the task is that we will have to include physic concepts such as inelastic/elastic collisions and conservations of energy and momentum, 2D motion, rotational motion and torque. The timeframe for the simulation were suggested to be 20-45second to complete and no individual step is taken less then 3 seconds. Also required to be delightful and surprising. Also being presented clearly and confidently and full with mastery understanding with physic concepts.*

KEYWORDS*: Golden lambert machine, energy conservation, momentum, elastic/inelastic collision, 2D motion, circular motion, torque,*

Introduction

Golden lambert machine a machine that involves with multiple and complicated sets of interaction for reaching to the goal for a simple action, for example cracking an egg. Golden lambert machines are a perfect sample for us to understand how does the motion, energy, force, momentum, are interacting with each other. As we learn through physic concepts such as inelastic/elastic collisions and conservations of energy and momentum, 2D motion, rotational motion and torque. for the past few weeks. We have been instructed to construct a physical simulation on blender for

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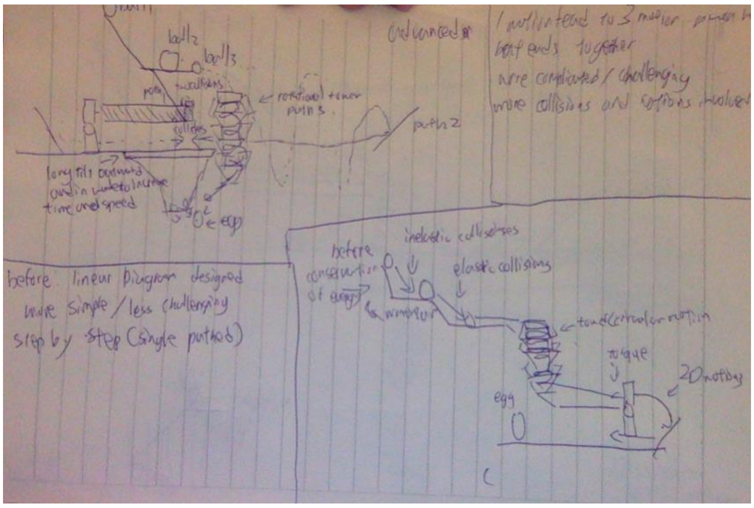
simulating a golden lambert machines that contains inelastic/elastic collisions, conservation of energy and momentum, circular motion, 2D motion. We have learned those knowledges for weeks and it will be great for us to better understand the topic above by having us analyzing the machine. We are going to apply those knowledges that we have been learning for weeks into the golden lambert machine. I will try as hard as I can to increase the complexity and time frame for the simulation for me to interact more with the physics concept that we have learned. The final goal of the experiment is to test out the reliability of the physics laws applied in golden lambery machine

Design



Before: the original design was simple and linear there are no steps that are going having motion parallelly, the benefit of the design before is that it is easy to track and collect information from during the process but the disadvantage of the thing is that the golden lambert machine will be looking to simple and not creative and also boring. Because of that I decide to make some changes on the parts of the diagram and make the diagram more complicated

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After: after redesigned the product the product have shared basically the same physical motion but I have separate them by three balls, initially there is going to be one ball, which the ball 1 will have a free fall motion and then contact with the slope. When it goes down the slope, it will collide other two balls experiencing inelastic and elastic collision

Categories	Parts
Energy conservations	The energy conservation mainly is going to be the analyses of gravitational energy con verting into the kinetic energy during the effect of gravity pulling an object with mass down to the stable state due to gravity.
Momentum conservations	As there is inelastic and elastic collisions the momentum will be conserved or not conserved through out two kinds of collision, the collisions will be inelastic and elastic.
Elastic collisions	Elastic collisions happen when two object’s momentum are conserved within the system which there is no momentum are being passed on to the surroundings, the example will be ball 1 bouncing of the wall, after the ball 1 bouncing of the will elastically the amount of momentum/velocity should be the same in that case, the uncertainties of the two data will be calculated for deeper understanding of what happened
inelastic collisions	Elastic collisions happen when two

	object's momentum are not being conserved within the system which there is momentum are being passed on to the surrounding, the example will be ball 1 collision with all other balls and all other collision that involved which moving including friction or bounciness under 1 (1 is the value for perfectly bounciness that all the force are applied to the bounce)
2D motions (projectiles)	Different from 1D motion 2D motion involves with the movement in 2 direction simultaneously, in this case will the horizontal and vertical displacement for analyses 2D motion, in this case the ball 2 after the collision with ball 1 and ball3 will experience a collision and a horizontal velocity and it will drop of a cliff and experience vertical downward acceleration, which will cause ball3 to have both horizontal motion and vertical motion. After tracking we will be able to analyses the 2D motion of the ball.
Circular motions (rotation)	Inward acceleration of ball 3 inside the tower will be recorded for calculations, tangent acceleration and circular acceleration will be used for analyses the motion of the b all during the spiral rotation when ball 3 is going down the tower.
Torque	Torque will be calculated accord to

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	the rotational arm that ball 1 will go through after the collations with ball2 and after elastic collisions, it will apply a force onto one side of the arm and making it unbalanced and starting to rotate, using tracker for tracking the acceleration of the arm and using the mass of the ball for calculate the total amount of torque created and explain how does the arm effect the motion of the ball.
extra	Made for myself: I personally like to discover the energy efficiency of the machine by calculate the gravitational energy that those balls from initial and compare it with the kinetic energy of the ball by using the velocity and their mass for calculation and divide the value of potential energy and kinetic energy for result of the energy efficiency. Also in conclusion will be discussing the wys to improve the efficiency of the machine.

Equations:

Energy conservation

gravity potential energy and kinetic energy will be calculated by 1/2 $\text{mass* velocity}^2 = \text{mass} * \text{gvatational constant} * \text{height}$

Momentum

Momentum=mass*velocity

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2D motion

Analyses by two diagrams and calculate the velocity, energy by calculate it as a result force

Torque

Torque=force*radius

=mass*acceleration*radius

Extra equation required

$v=u+at$

$s=ut+1/2at^2$

$v^2=u^2+2as$

Note: the whole diagram is using unrealistic models, the model is been modeled into large scales for recording more data and make more accurate range for selecting data, and reliable average of data.

(There is problem with rendering the animations, so the videos are being record by computer's screenshot filming. So, there is going to be a wide range of uncertainties because the frame per second is not 24 as blender have been set.)

Rotation

circular acceleration

velocity final-velocity initial/t= circular acceleration

centripetal acceleration:

$(\text{linear velocity})^2/\text{radius}$

Results

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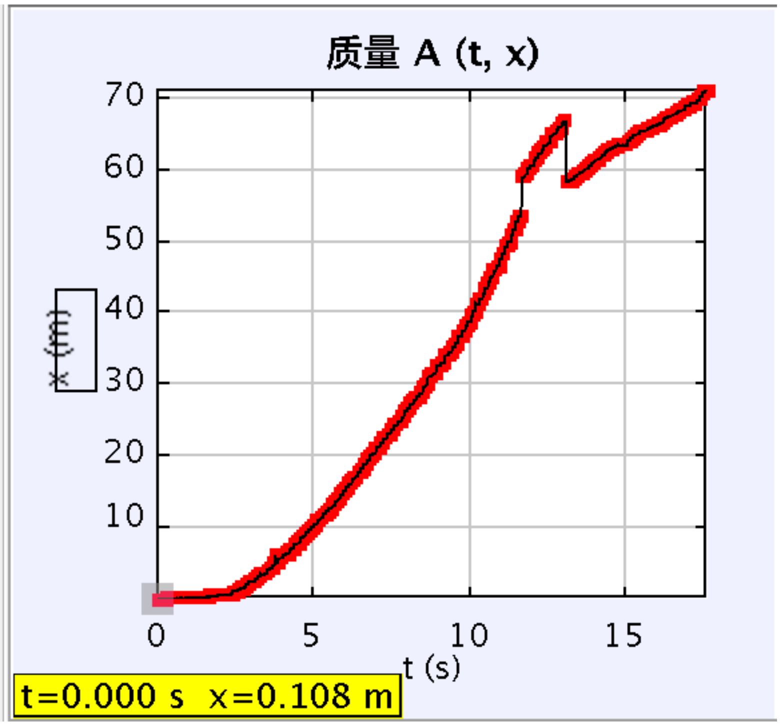
the energy conservation

The x-axis against time:



The y-axis against time

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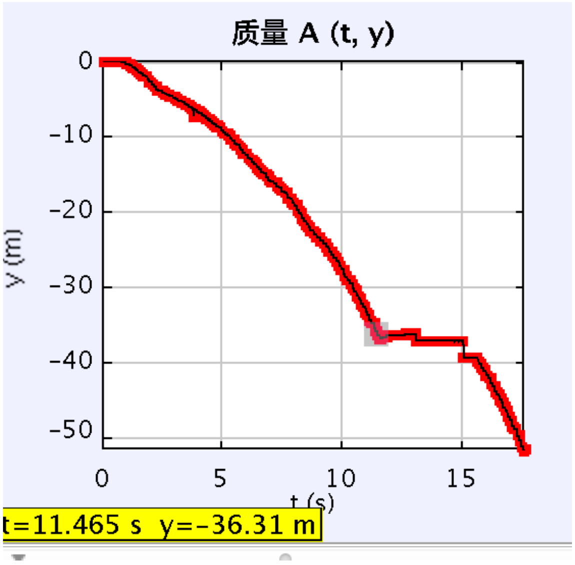

Explanation

As we can see in the diagram both x and y axis are sharing a quadratic functioned curved diagram, because as the ball are moving on the gradient due to gravity the acceleration of the ball will be applied by both increasing the speed of dropping and moving horizontally.

As we have set the origin and tilt the axis that the tracker is relying to determine the direction we are able to conclude the displacement of horizontal and vertical only with the change in value of y axis

I'm choosing the last part that the curve is still acting as a normal quadratic function liked diagram because his is the maximum velocity just before the collision with other balls. The time was about 11.451 the velocity can be calculated by time between two point and the displacement of the two point.

Height format start to the maximum velocity of ball 1 before collision

Gravitational potential 33.48*9.81*200=65,687.76 joules

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Velocity

Two point chosen:

Time: 11.451206250839716s-

Displacement: -62.79330235006887m

Time: 10.449058679295984s-

Displacement: -52.236355873828586m

(-62.79330235006887--52.236355873828586)/(11.451206250839716-10.449058679295984)= -10.5343232634m/s=velocity of the ball

The velocity are being chosen in this way is to minimize the uncertainties, by choosing the last second of the data can ignore the uncertainties create by the points between the two point chosen and lead to a more accurate result, but this will cause the actual velocity to decrease then the ideal value because the time intervals was larger, this will be included in reflection

Kinetic energy:

Two point chosen:

(-62.79330235006887--52.236355873828586)/(11.451206250839716-10.449058679295984)*(-62.79330235006887--52.236355873828586)/(11.451206250839716-10.449058679295984)*200*0.5=11,097.1966617124joules

Energy was not conserved accord to the calculations, but the energy did convert from gravitational potential energy into kinetic energy. The energy might not be conserved because of bounciness of the ball contacting to the surface of the plane while dropping might waste parts of energy. Also the filming angle of the motion might affect the data and decrease the numeral value of data.

The elastic collision

This part is the collision between the ball1 and 2 walls the bounciness of the wall are both set into 1 and wall is passive which the ball should share the same speed

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before and after the collision. In this case simply the speed of the ball are going to be determined before and after the collision and to insure that they are a elastic collision they should share the same magnitude.

So rotate the y-axis to the ball's motion path is necessary, diagram below:

Normal diagram without rotating the axis:

Speed before the ball collides with the wall will be using the last part of the diagram:

Point chosen:

Time:19.283s:

21.65000666402513m

Time:18.283s:

14.92635306793375m

Speed:

(21.65000666402513-14.92635306793375)/19.283-18.283=6.7236535961m/s

Speed after the ball collides with the wall will be using the last part of the diagram:

Point chosen: there is no deacceleration on the diagram

Time:

19.333:

-17.19900434613028

20.3:

-10.456617312608344

(-10.456617312608344--17.19900434613028)/(20.3-19.333333333333=6.97488 31381m/s

Result:

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The result was

6.7236535961m/s before

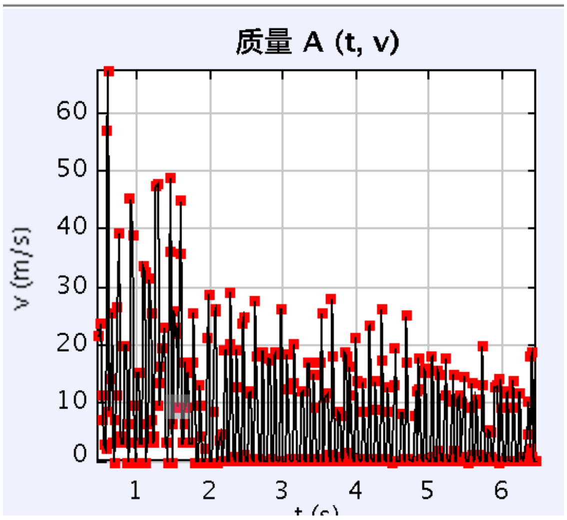
6.9748831381m/s after

Momentum:

As a result, the velocity of the ball were close but not exactly same in statistics, this might be caused by the uncertainties during the tracking process, and also the potential problem of filming angle, which personal I will consider this as a successful simulation of elastic collisions.

Inelastic collision

Ball 2's velocity:



Ball 3's velocity

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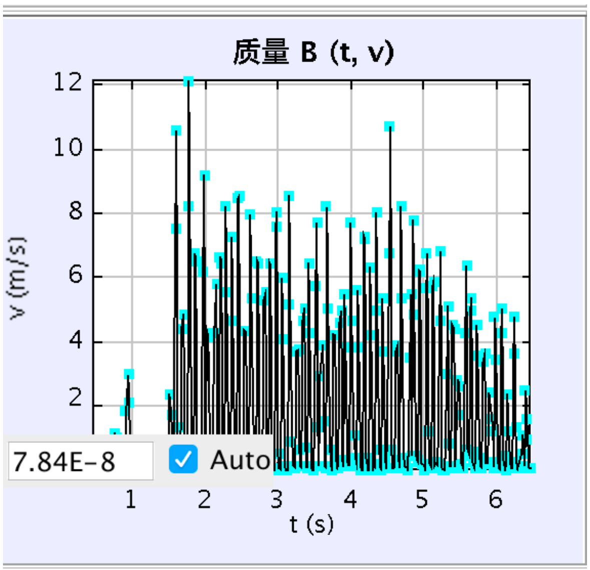

Inelastic collisions happen when the momentum is not being conserved throughout system. Which in my simulation most of the time friction exists and the bounciness of the ball are not set into 1 which the collision between ball2 and ball 3 will be a great example for inelastic collisions as the momentum are not conserved.

Collision time: 1.543

Speed of ball2

Before:16.30 m/s

After:6.877m/s

Speed of ball3

Before：0

After：0.418 m/s(taking the average of the velocity after the collision)

Mass of the ball

Ball2:200

Ball3:400

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16.3*200=3,260-momentum initially

6.877*200+0.418*400=1,542.6-momentum in final

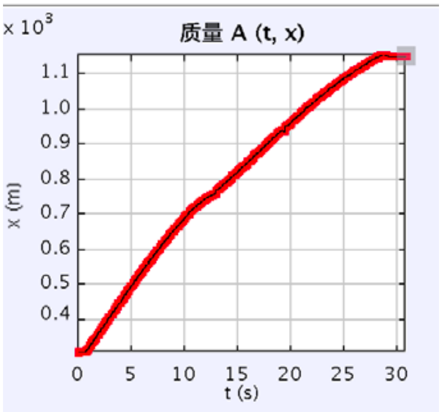
Result the result of the collision between ball 2 and ball 3 was inelastic because the result of the momentum are different from the initial momentum. This happens because the bounciness of the ball didn't set to 1 which not all the momentum have been involved during the conversion, it can be lost by inefficiency

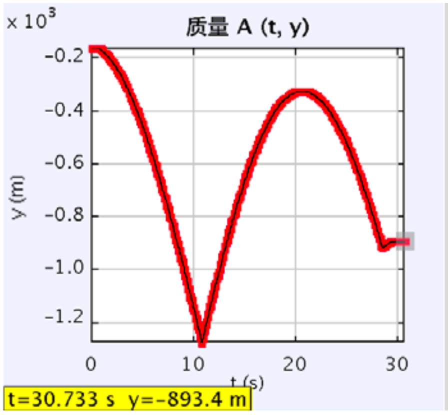
2D motion

This will be recorded accord to the projectile motion when ball 2 are launched horizontally after collision with ball 1 and ball 3 and the motion was 2 dimensional by having it travels horizontally because of its initial velocity, and vertical because of the gravity.

Two graphs

Horizontal: Vertical:





Horizontal motion has a constant speed because there is no friction that is going to cause effect on the velocity, but the bounciness of the ball are not set into 1.0 and that will cause that the force created during the collision will not be applied efficiently back into eh ball so there will be a decrease for the velocity immediately and continue travels with new constant velocity. The point of the change is 10.85 second

Accord to tracker the horizontal velocity in average was, about 11m/s a average value taken by the change of displacement over time it was about the value of 3m/s

Vertical component has a constant acceleration of 9.81m/s because this is a free fall diagram, the displacement after the bounce is lesser then the displacement before the bounce because the bounciness of the ball aren't set to 1 which there is going to be waste of energy out of the system.

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Calculations:

(120.2-32.88)/(28.407)= 3.0738902383m/s

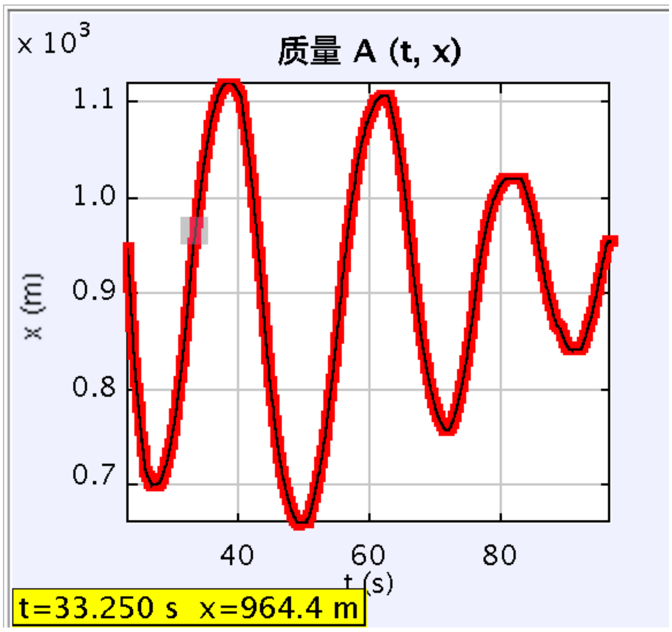
Torque

=200*(-)5.1509*33.8/2=17,410.042 kg.m

The acceleration of the product are being calculated accord to the data given from blender, which is basically using the displacement to divide time for velocity and then divide by time for getting average acceleration of the product, which in this scenario the direction of the acceleration doesn't matter for the numeral value for torque but it only matters for the direction of the torque. The acceleration was lesser then 9.81 might be caused by the pushing back of the arm and problem with tracking, those two problems might cause uncertainties within data collections.

Rotation

The displacement of the ball in terms of x axis it is definitely a circular motion.



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The motion of ball three spinning down the tower will be used for calculations. The height change during the ball's motion are going to be ignored because the tilting angle of the tower is going to make the ball to travel downward in a constant velocity.

The calculation of circular motion will be required for calculate the circular acceleration

(17.889281484444425-2.184433471477313)/(96.750-23.017)= 0.2129961891m/s^2

centripetal acceleration:

$(17.889281484444425-2.184433471477313)^2$/18.1=$15.704848013^2$/18.1=13.6266437078m/$s^2$

The radius was about 18.1 because there is no actual value as the radius is changing, so the medium value is being taken for calculation

The radius was decreasing because there is friction of the plane that will prevent the ball from slipping but also will waste certain amount of energy and decreasing the velocity of the ball in time.

Extra：energy effientcy for breaking the egg

The energy of three balls before starting:
74.901*9.81*200+74.901*9.81*400+112.68*9.81*200= 661,945.446J

The kinetic energy were calculated by first track the last frame before the ball reaches to the egg and use tracking to calculate the velocity in that exact moment and then use equations for calculate the kinetic energy

Kinetic energy of the ball when breaking the egg

15.36*200*0.5*15.36+28.55*200*0.5*28.55+20.74*400*20.74*0.5= 191,132.73J

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Energy efficiency

191,132.73/661,945.446=0.28=28%

result

Energy required to break an egg-estimate to

The energy efficiency was 28% percent each there is only 28% of the gravitational potential energy have been transferred into kinetic energy when they finally breaks the egg.

Personally, I consider this that the egg should be able to be break by the collision by three balls, because in total they transfer huge amount of kinetic energy to egg, I personally have estimated the egg can maximum withstand 20kg of weight in ideal situation and using the entire egg for with stand the weight. In my case the weight of the ball were 200 kg at least and the size of the ball are smaller then the egg which will decrease the amount of force that the egg are able to withstand.

The way to improve the machine buy increase the efficiency is to increase the bounciness and decrease the friction as much as possible, increase in conservation of energy and momentum, will lead to the increase of momentum.

Discussion

（no, discussion because there is explanation in every part of calculations）

Conclusion

Overall the machine’s motion was reliable and the physic content that we have been contacting with have been working during the process of the transferring of the motion, momentum and energy. The machine in the end will crack an egg by launching 3 balls on the egg. First analyze the benefit of the model, first it is online simulated, which the physics that we are applying is mostly able to be applied on the model (not including bug, and errors). Secondly when there is error in the system it

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can be easily adjusted, for example the angle for the tilting plane can be adjected for bring different acceleration on object.

Disadvantage of the model was that the during tracking tracker can bring huge range of uncertainties during tracking object's center mass when there is increase in the data the uncertainties will be largely increased, it will require a lot of time for adjusting for getting a reliable data. Secondly is that technical issue is really playing a important character during whole project, as an example I am faced with problem of blender's rendering system, it took me 2 days for nothing, and I give up and used the self-filming mode of computer and it caused the frame per second on blender was not 24, each I will have to adjust the frame per second on tracker by myself and that doesn't give the solution, the increased time brought more frame that the ball was still. Which in thoracically if I change the frame per second it will decrease the error. However, it still contains wide range of uncertainties.

Now evaluate process by process, from start during the ball 1's free fall motion there wasn't any problems, but the part when the ball is falling down on the slope, we have a problem is that we can't observe the rotation of the ball 1's motion, we can only observe the displacement, wo we can't be sure that the where was the loss of energy. During the collisions of all three balls the displacement was too small for evaluating the velocity of 3 balls, because amount instantaneously started to fall of the cliff due to gravity which will cause the cameras harder to catch the motions. But surprisingly the data was relatively accurate because it required lesser adjustment for collecting the proper result. Then there is the separate path of ball 1,2, and 3, first with ball 1. Ball 1 will continue moving and then fall of the edge and gain acceleration due to gravity and after a short 2d motion it will land on a slope and continue the acceleration, until it bounces on two walls. The process was reliable but tracker and camera have caused the filing to be inaccurate by have the 6.7236535961m/s before

6.9748831381m/s after which is not correct value which can be indicate that there is a huge uncertainties/error, after calculation percentage yield of error have reach to 3.7365%during the process, however the method was clear and correct. Ball 2's motion doesn't have a lot of problem expect camera, there is some angle tilted during filming which the result will not be clear and accurate. For ball 3 the

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modeling of the tower can be imported from other website, because the tower designed for rotational motion required huge amount of time and having low accuracy. And when they all collide with each other the camera is really struggle for a correct film angle. In conclusion, theory was right, clear, but there is problem is modeling and rendering and camera filming angle.

The ways to improve is to overcome the technical issues, like camera angles and importing data's in software to make the calculation more reliable.

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