Rube Goldberg Machine

Final Product Testing Proof

Team 02

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Hair dryer step summary:

In the project of the Rube Goldberg machine our objective was to move the solid object with the use of energy of air which will engage force in to a metal ball down a path to activate the sensors so that metal ball and after that it will activate the magnetic elevator so that magnetic ball will come back to its original position.

For this project we have used main components are

1. A car with balloon
2. A wooden base with guideway for car
3. An elevator with magnet
4. Metal Ball and
5. Arduino
6. Relay
7. Motor drive
8. Sensor

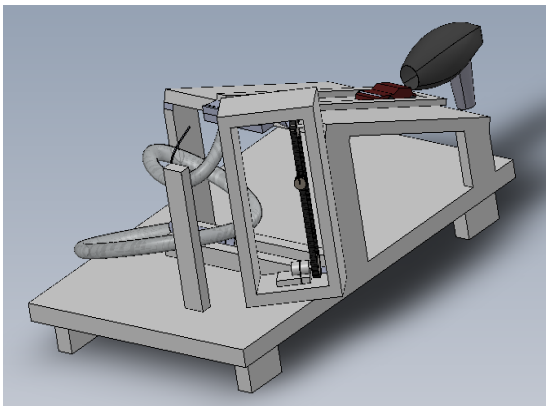

Figure 1: Assembly 3D model

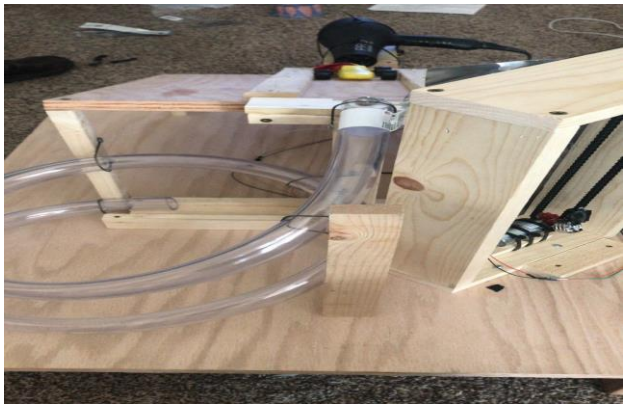

Figure 2: Assembly picture of the machine

For the operational overview firstly Hair dryer will have switched on with a switch provided on the downside of the wooden base. It will blow the air and car with the balloon will move in the upward direction. Car will push the metallic ball and ball will start rolling toward magnetic elevator and after 5 seconds motor will start automatically and magnetic elevator will deliver the ball from downward to upward. And due to slope of the guide way ball will reach to its original position. Arduino sensors will be triggered once metal ball will pass the through the sensor. One can change the time of the starting of the motor to slow the metal ball. The Hairdryer shall be switched off after 5 seconds so that car with balloon can come back to its original position.

Testing:

For this project we have performed 25 times all the analysis for the time required for the metal ball to reach the end of the tube. Time for the metallic ball to reach back to end of tube are as shown below:

Sr No.	Time
1	00:05.49
2	00:05.95
3	00:05.58
4	00:05.36
5	00:05.64
6	00:05.59
7	00:05.62
8	00:05.35
9	00:06.02
10	00:05.38
11	00:05.86
12	00:05.73
13	00:05.25
14	00:05.42
15	00:06.36
16	00:05.53
17	00:05.35
18	00:05.86
19	00:05.54
20	00:06.38
21	00:06.25
22	00:05.82
23	00:06.00
24	00:05.85
25	00:05.66
Average	**00:05.71**
Standard Deviation	**00:00.32**

Figure 3

Before we get to the testing proof the ball velocity was tested to take 2.5 seconds to reach the end of the tube from its original position. After the last testing done and according to the time, I have change the length of the tube so that to increase the time by slowing the ball. As show in the table, the average time taken by the ball to travel to the end of the tube is 5.71 seconds. And from the standard deviation value we can say that all the values of the analysis are differing from the mean value by 0.32 second.

Gear Escalator step summary:

In this step the objective is to carry the ball with the hangers attached from left to right. this system components are gears,chain,touch sensors, DC motor see thru plastic board, wooden base and arduino kit.The process is once the ball hits the touch sensor it will trigger the elevator and the ball will be carried to the other side.The escalator will keep rotating until another hanger gets in position to carry the ball again. This step will be combined with the bicycle wheel to be fully self resetting.

Testing:

We are required to test the step for 25 trails just look for errors and estimate the average time for the system to work and self reset. As mentioned before, the hanger will carry the ball to the other side, then gets in position to carry the ball again. The DC motor is timed to work once the ball hits the touch sensor and stops after 53 seconds. This time was calculated for the whole process. The duration is way off the engineering requirements, and to fix this issue, we have to increase the battery voltage so the DC motor have more power. below is the table of trails:

No. Trails	Duration
1	53.3
2	53.6
3	52.9
4	55.2
5	53
6	55.6
7	54.4
8	53.5
9	53.5
10	53.5
11	55
12	54.5
13	53.9
14	55
15	53.2
16	53.5
17	55
18	53.5
19	53.7
20	53.5
21	53.9
22	53.3
23	53.35
24	53.72
25	54.21
Avg time	53.9112

Figure 4

Wood Spiral Staircase Step Summary:

The system will work by turning the DC motor on which will make the Archimedean screw spin that will help on moving the ball way up till it falls to the staircase. There’s a sensor in the last staircase that the ball will hit and once it does that the system will turn

off and make a servo move right & left to trigger another step.

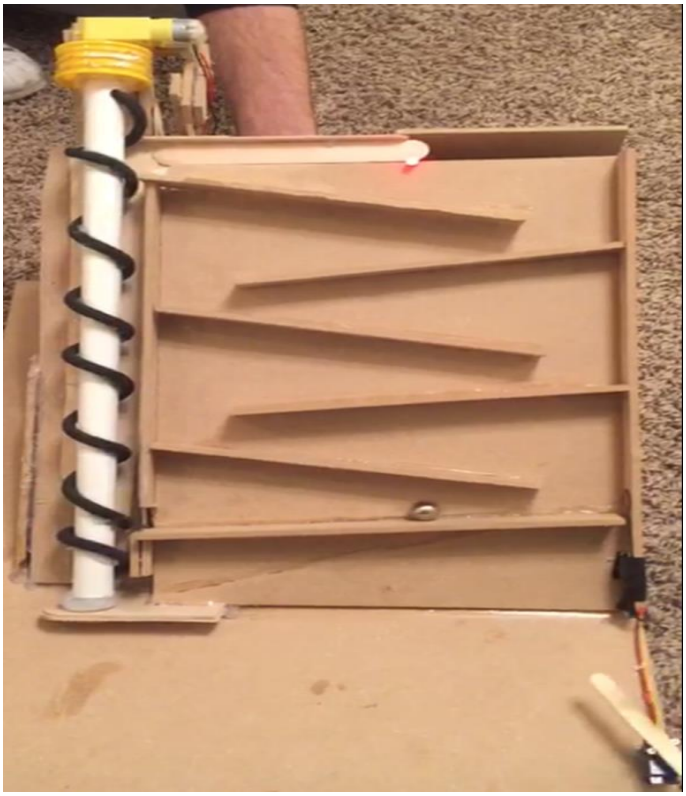

Figure 5 - Picture of the system

Testing

The system is required to be tested, so 25 tries has been done for this step and the average time for this step from the beginning till the end was 7.0948s. The difference in time is because of some human errors. The time recording was done by an Iphone. All tries were successful and nothing stopped the system to fail.

Number of tries	Time (s)	Durability
1	7.07	successful
2	8.67	successful
3	7.48	successful
4	7.24	successful
5	7.09	successful
6	7.08	successful
7	8.01	successful
8	7.65	successful
9	6.91	successful
10	6.65	successful
11	6.62	successful
12	6.98	successful
13	7.05	successful
14	6.94	successful
15	6.95	successful
16	6.84	successful
17	6.85	successful
18	7.04	successful
19	6.72	successful
20	6.88	successful
21	7.01	successful
22	6.81	successful
23	7.21	successful
24	6.88	successful
25	6.74	successful

Figure 6 - system testing

Catapult Step Summary:

The catapult is loaded with the help of spinner attached to it and it launches the object as the thin metal pin is removed after the loading. The spinner and metal pin is clearly shown in the below figure**.** The catapult will be connected to a programmable multifunction time delay relay that will trigger a 2 different linear actuator on different time sets in order to make the step resettable.

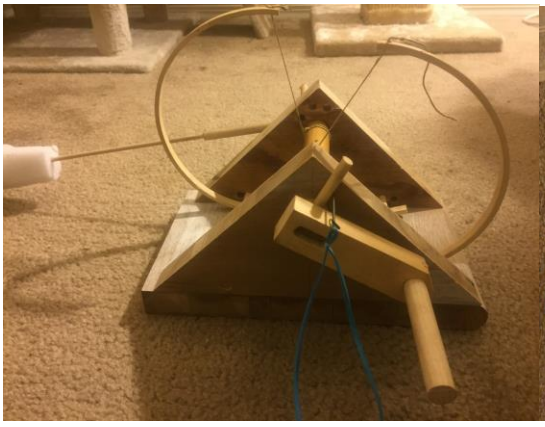

Figure 7 - Catapult System

Figure 8 - Time Delay System

Testing:

The launching for the catapult is accurate and can be adjusted for different trajectory. Once the time delay system is attached to the catapult, the system will be resettable. Two actuators is attached to the time delay system that will work on different time sets. The black actuator will work on pushing the metal pin back, and that will make the catapult launch, then the silver actuator will push back the firearm to its original position.

Water Duck Step Summary:

The system will by pushing the button which will run the pump to pump the water and make it spin the wheel inside the water duck that is attached to wooden stick that will turn with wheel direction. A string can be attached to it to pull any light weight object.

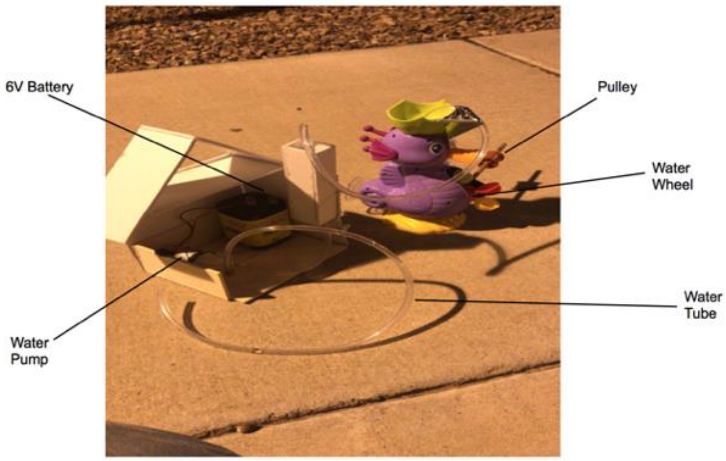

Figure 9 - Water Duck Step

Testing:

The system is attached to an arduino system that will make the system run on for 6 seconds and then turns off. The use of water and making the water wheel spin makes the step resettable. The system is durable and works every time the switch is turned on.

Bicycle Step Summary

The step will be triggered by a linear actuator that holds the wheel from spinning. The ball in the cup will make the wheel go down and makes the ball fall and hits a sensor. The sensor will trigger a DC motor that will pull back the wheel back to its original point, and make the linear actuator go back to its original position. The actuator and DC motor will be programmed by time delay system that will make each run on different time sets.

Figure 10 - Bicycle wheel

Testing:

There is still some error for the cup where it doesn't make the ball fall in the right position.

Car Step Summary:

In this project, the major aim is to create a Rube Goldberg machine step which will engage a variety of steps that will be used to move a metal ball along a defined path. In order to accomplish this objective, the team held detailed discussions with the client so as to get the required customer requirements which included: a device that is entertaining, resettable, durable, reliable, safe and cost effective. In the first step, this part of the Rube Goldberg machine is comprised of components which are performing a variety of functions such as a toy car which is powered by a battery, a curved track on which the toy car will move along, a wooden barrier which has a rotating base and it is used to hit the metallic ball so that it hits a coiled spring. The car is placed at a starting point and on putting it on it moves along the curved track. The car gains momentum and hits the wooden barrier which in turn hits the metallic ball towards the coiled spring. When the metallic ball is hit, its impact makes the coil spring to compress hence gaining a significant of mechanical energy which then pushes the ball along a tunneled wooden path. This process is repeated 25 times after which average time and standard deviation are calculated. The diagram for the first step and the schedule used are presented in figure 1 and table 1 below. The analysis reveals that the average time

taken by the ball travel is 4.424 while the standard deviation is 0.105119.

Figure 11 - Car Step System

Testing:

Table 1: Schedule

Serial No	**Time**
1	4.67
2	4.42
3	4.4

4	4.38
5	4.33
6	4.35
7	4.45
8	4.36
9	4.39
10	4.43
11	4.35
12	4.6
13	4.55
14	4.5
15	4.62
16	4.52
17	4.38
18	4.26
19	4.3
20	4.33
21	4.51

22	4.37
23	4.34
24	4.44
25	4.35
Average	**4.424**
Standard Deviation	**0.105119**

The part is meeting the customer requirements as follows. It is entertaining since the color of the car and the track are aesthetically appealing. Also, the way the first action is triggering the action of the other is amazing. The part is also resettable since as the car goes round the track it comes back to the starting point. Also the wooden barrier returns to its position after hitting the metallic ball. The spring also, returns to its position after pushing the ball. The device is durable since it is made up of high quality materials. It is reliable since it is operating without fail. It is safe to the user since the device does not have protruding edges and there is minimal human intervention. However, the device is cost effective since the materials and components used are cheap and others have been sourced locally such as wood and the springs.

In the second part, the major components are two wooden cars, a wooden platform, a motor, a battery, Arduino circuit and a spring. The first cars have a long string which is attached to a motor. The motor is power by a battery. The start of the part is when a human hand pushes the first car so that it moves down the wooden platform and hits the second car with an impact. The second car then hits a spring which trigger a switch and puts it on. This then makes the motor to rotate and in turn facilitates coiling of the string on a part attached to the shaft of the rotating motor. The coiling of the string round the part attached to the shaft makes the first wooden car to move up the wooden platform up to the starting point. The diagram showing the arrangement of this process is represented in the figure below.

Car Magnet Step Summary:

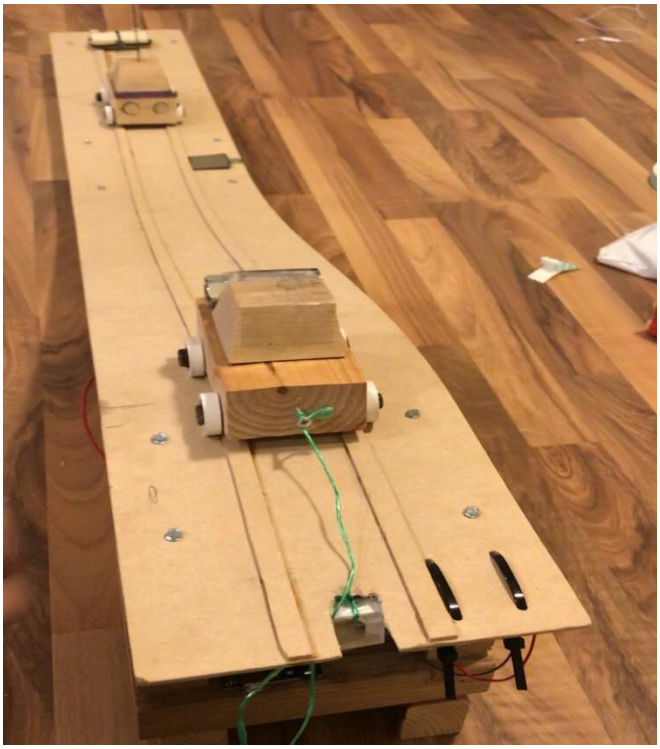

Figure 12 - Car Magnet Step

In this second part analysis was conducted for 25 times to determine the time taken for the first wooded car to reach the top and the schedule is presented in the table below. In the tale average and standard deviation have been indicated. It is evident that the average time taken by the car to move up the platform is 2.2684 and the standard deviation is 0.215.

Testing:

Table 2: Schedule

Serial No.	**Time**
1	2.53
2	2.03
3	2.13
4	2.52
5	2.5

6	2.16
7	2.18
8	2.16
9	2.35
10	2.3
11	1.9
12	2.55
13	2.4
14	2.48
15	2.2
16	2.44
17	2.09
18	2.06
19	2.15
20	2.6
21	1.97
22	2.07
23	2.06

24	2.68
25	2.2
Average	2.2684
Standard Deviation	0.215103324

The second part is meeting the customer requirements as follows. It is entertaining since the audience is watching the entire process and is impressed by the creativity displayed. The device is resettable since as the car moves up the wooden platform its goes back to the starting position. The device is durable since it is made up of high quality materials like wooden blocks. It is reliable since it is able to operate as scheduled and reset itself. It is safe as device is not inflicting any harm to the audience or animals. The device is cost effective since locally available materials such as wood have been used.