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(RESEARCH ARTICLE)

Application of Newton's laws using CD hovercraft

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Abstract

Hovercrafts were constructed using a Compact Disk and Baloons to calculate linear and average displacement, speed and acceleration. The innovative concepts was used to promote learning of Astrophysics to 15 aspiring physics enthusiast to explain the Newton's laws of Physics as it applies to the working principle of an hovercraft and training of astronauts

1. Introduction

A Hovercraft is a vehicle that flies like a plane but can float like a boat, and can drive like a car but will traverse ditches and gullies as it is a flat terrain. A Hovercraft is also sometimes called an air cushion vehicle because it can hover over or move across land or water surfaces while being held off from the surfaces by a cushion of air [1]. A Hovercraft can travel over all types of surfaces including grass, mud, muskeg, sand, quicksand, water and ice. Hovercraft prefer gentle terrain although they are capable of climbing slopes up to 20%, depending upon surface characteristics. Modern Hovercrafts are used for many applications where people and equipment need to travel at speed over water but be able to load and unload on land. For example, they are used as passenger or freight carriers, as recreational machines and even use as warships. Hovercrafts are very exciting to fly and the feeling of effortlessly travelling from land to water and back again is unique

Over the centuries there have been many efforts to reduce the element of friction between moving parts. A hovercraft is a relatively new means of transportation. The concept of the hovercraft was born when engineers came up with an experimental design to reduce drag on ships [2]. The revolutionary idea was to use a cushion of air between boats and the water that they ploughed through to reduce friction. This idea eventually led to what is known today as the hovercraft, basically a vehicle that uses 1 or more fans to float on a cushion of air. These fans serve a dual purpose, to push air below the craft and force it off ground, and to create a forward thrust by pushing air out the back of the craft [3].

This research article therefore, presents an innovative way to use a compact disk and balloon to construct a hovercraft that explains the Newton's laws of motion in a way that motivates learning of the concepts. Group of students design hovercrafts and perform simple tasks to calculate displacement, speed, acceleration and their results were correlated using charts.

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2. Material and methods

2.1. Materials

Compact disks (CDs), Plastic Bottle, Round balloon (five-inch size), Meter rules, Nail, Super glue/hot glue gun, Air Pump, Scissors, Stopwatch

Students were divided to three groups to produce one CD hovercraft each. The three hovercrafts were used together to perform tasks which were recorded. This report therefore, present a group finding of the experiments carried out

2.2. Design Considerations and Precautions

Glue station with one or two glue guns was set up for the students. We use low-temperature glue guns. The heat from high temperature guns may warp the CD. There was a dish of cold water near the glue station for a good safety step. Peradventure if we get hot glue on their fingers, we will immerse the fingers in cold water will immediately "freeze" the glue and minimize any discomfort. It was preferred, by the supervisor to operate the glue gun. Eye protection was recommended and made available when we were working with glue guns. Pop-up spouts for water bottles was substituted for the PVC pipe and rubber stopper. We removed the cap from the bottle and attach it to the upper side of the CD with hot glue. We then fit the balloon over the pop-up spout. We inflated the balloon by blowing through the underside of the hovercraft and push the spout down to hold the air until ready. Caution was made that if there was any student with a latex allergy, so we wash the balloons before using them. Allergic students wore non-latex plastic gloves and inflate the balloons with a balloon pump

2.3. Construction Methodology

2.3.1. Assembling the Hovercraft_ The Process

- We squeeze a bead of hot glue on the edge of one end of the PVC pipe and immediately press the glued end to the center of the CD (label side up). The pipe surround the hole in the center of the CD.
- When the glue has cooled and hardened (in about 1-2 minutes), we checked for any gaps between the CD and pipe. When a gap was noticed, we squeeze some glue in to fill the gaps.
- We stretch the latex balloon a couple of times to relax it for inflating.
- We Stretch the balloon nozzle over the wide end of the rubber stopper.
- We used a hole punch and punch a hole through the center of the gummed paper dot. We applied the dot to the underside of the CD to cover the hole.

Thus, the hovercraft was assembled by each group

2.3.2. Running the Hovercraft

- We inflated the balloon by blowing through the hole of the stopper or by inserting the nozzle of a balloon hand pump into the stopper hole.
- We twist the balloon so that the nozzle is closed off and we pressed the small end of the stopper into the upper end of the PVC pipe in the hovercraft. The hovercraft was ready to launch.
- We placed the craft on a smooth, level surface such as a tabletop. We then released the balloon. It untwist and start blowing air downward through the small hole in the center. The thin cushion of air lifted the CD and eliminate friction with the tabletop.
- We tried pushing the hovercraft across a tabletop with the balloon inflated and again with it uninflated. We compared the craft's movement in the two runs.
- We experiment with the optimum size of the hole in the paper dot. The hole can be enlarged by pushing the point of a pencil into it. The hole size determined how fast the air runs out.
- We recorded the data on the Hovercraft Record and Result Page

Figure 1 Construction and demonstration of CD Hovercraft

3. Results and discussion

The table below show how far hovercraft travels before it stop on its own

Table 1 The distribution of distance covered by different balloons

Balloon	First Run Distance (cm)	Second Run Distance (cm)	Third Run Distance (cm)	Average Distance (cm)
Balloon 1	298	274	245	272.33
Balloon 2	286	226	99	203.67
Balloon 3	300	257	225	260.67

The table below shows the time the hovercraft covers the distance

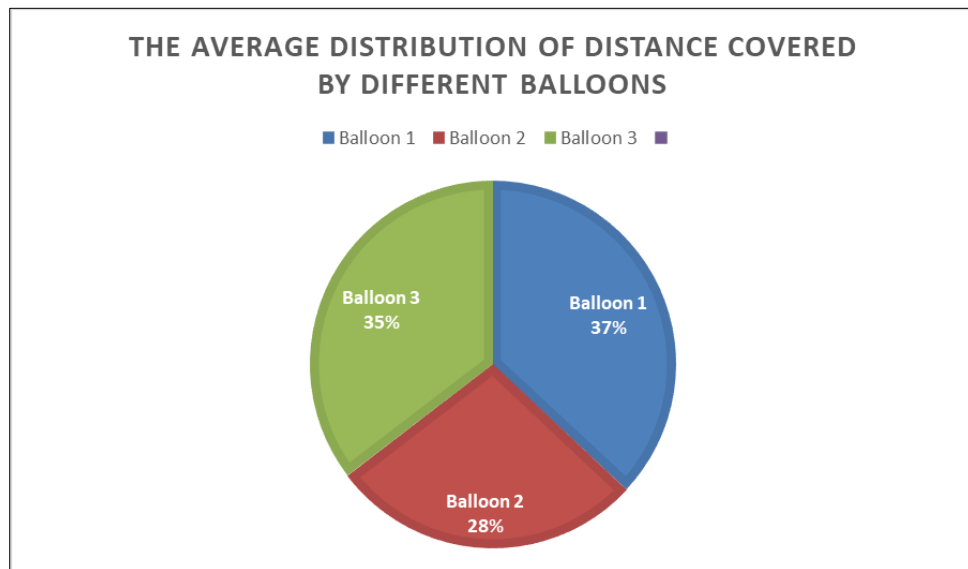**Table 2** The distribution of time for hovercraft to cover distance

Balloon	First Run in seconds	Second Run in seconds	Third Run in seconds	Average Time in seconds
Balloon 1	90	79	49	72.67
Balloon 2	111	54	46	70.33
Balloon 3	75	69	59	67.67

The table below shows the measurement of how fast the hovercraft covers

The table below shows the speed of the hovercraft

Table 3 The distribution shows the speed of the hovercraft covered by different balloons

| Balloon	First Run speed in cm/sec	Second Run speed in cm/sec	Third Run speed in cm/sec	Average Speed in cm/sec
Balloon 1	3.31	3.47	5.00	3.75
Balloon 2	2.57	4.18	2.15	2.97
Balloon 3	4.00	3.72	3.81	3.84

Figure 1 The average distribution of Distance covered by different balloons
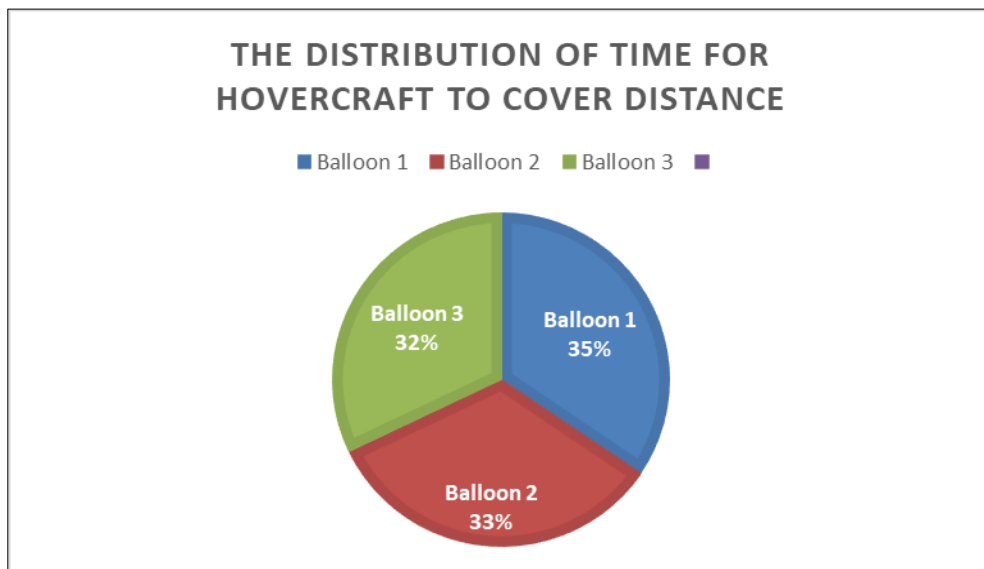
Figure 2 The distribution of Time for hovercraft to cover distance

Figure 1 and 2 show a variation in the distance covered and time taken for each of the hovercraft contracted with different balloons. Balloons 1 which is the smallest of the three balloons covered the highest distance, while the biggest balloon (balloon 3) covered the least distance.
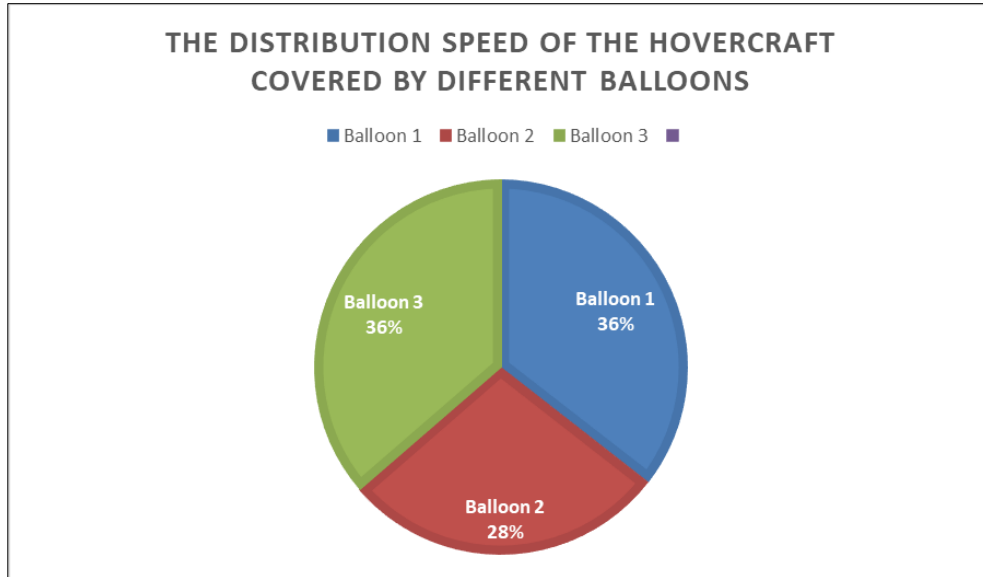
Figure 3 The distribution of speed of the hovercraft covered by different balloons

From figure 3 it can be declared from the average speed tabulated that the average speed of each of the hovercraft (3.75cm/s, 2.97cm/s and 3.84cm/s respectively) was close to each other; almost the same which implies that the size of the balloon do not play a significant role in the speed of the hovercraft.

The students use the result to answer the following questions in group. The response is tabulated blow:

Table 4 Discussion Feedback on Nexus of Hovercraft on Newton's laws of motion

Discussion Question	Response from Group
What causes the hovercraft to become frictionless?	Air from the balloon escapes beneath the hovercraft. It forms a thin cushion that lifts the craft a few millimetres above the table. Without direct contact with the table top, friction is greatly reduced
What happens to the hovercraft's movement when the balloon runs out of air? Why?	When the balloon runs out of air, the lifting cushion stops. The full surface of the CD bottom contacts the table top, friction is greatly increased, and the hovercraft stops
How do different surfaces affect the hovercraft?	Smooth surfaces permit a uniform cushion of air to lift the craft. Rough surfaces allow air to escape more in some directions than others and the craft is no longer level. Parts of the CD touch the surface and cause drag.
How does the size of the paper dot hole affect the hovercraft?	The hole controls the flow of air from the balloon. If the paper is removed, the hole is very large and the air escapes quickly. A tiny hole greatly slows the flow of air and may not provide enough lifting force.
How does Newton's Laws of Motion control the movement of the hovercraft?	1. An unbalanced force is needed to lift the craft. Another force is needed to propel the craft along the table.

	2. The lifting force is determined by how much air is released (its mass) and how fast it accelerates out of the hole.
	3. The action force of the air released from the balloon creates a reaction force lifting the hovercraft. Pushing on the hovercraft to cause it to move along the tabletop is also an example of action and reaction.
How can hovercraft technology be used to simulate microgravity when training astronauts?	During Astronauts training, three air bearing pads, similar in size and identical in function to the CD hovercraft, produce great lifting force and nearly eliminate friction. The bearing pads are able to provide much greater lifting force than the CD hovercraft because high pressure air from compressors is used. When the two astronauts push on each other, they fly apart in a great demonstration of Newton's Laws of Motion.

4. Conclusion

Hovercraft is a vehicle which can float in any lands also it is known by Air Cushion Vehicle due to its ability to move by cushion or skirt filled with air. The concept of the hovercraft is simplified using Compact Disks and balloons to explain the Newton's laws to motivate young learners to Astrophysics

Compliance with ethical standards

Acknowledgments

References

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Author's Biography

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