Science Toy for Open House 2022

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Abstract

"Play is the highest form of research." ~Albert Einstein

Science Toys are able to engage students through play, instead of just cold hard knowledge on the textbooks. This gives the students hands-on experience and the opportunity to experiment. Science Toys also make for a fun and enjoyable learning experience and research has proven that that leads to a higher absorption rate of knowledge. This thus has a high value in teaching science concepts, being almost the most effective method to do so. We thus decided to make a science toy. We initially worked on the Euler's Disc, but we realised that with the Phase 2 restrictions we could no longer use the school's 3D printing labs which means that we were unable to carry forth with our initial design. Due to further restrictions, we also could not meet which meant that it would be impractical to work on one toy. Eventually, we decided to make three separate toys and then critique each other's designs and ideas and help to spot each other's blind spots. Our three toys are a balloon hovercraft, a magnetic toy and a simple electric train.

1. Introduction

"Play is the highest form of research." ~Albert Einstein

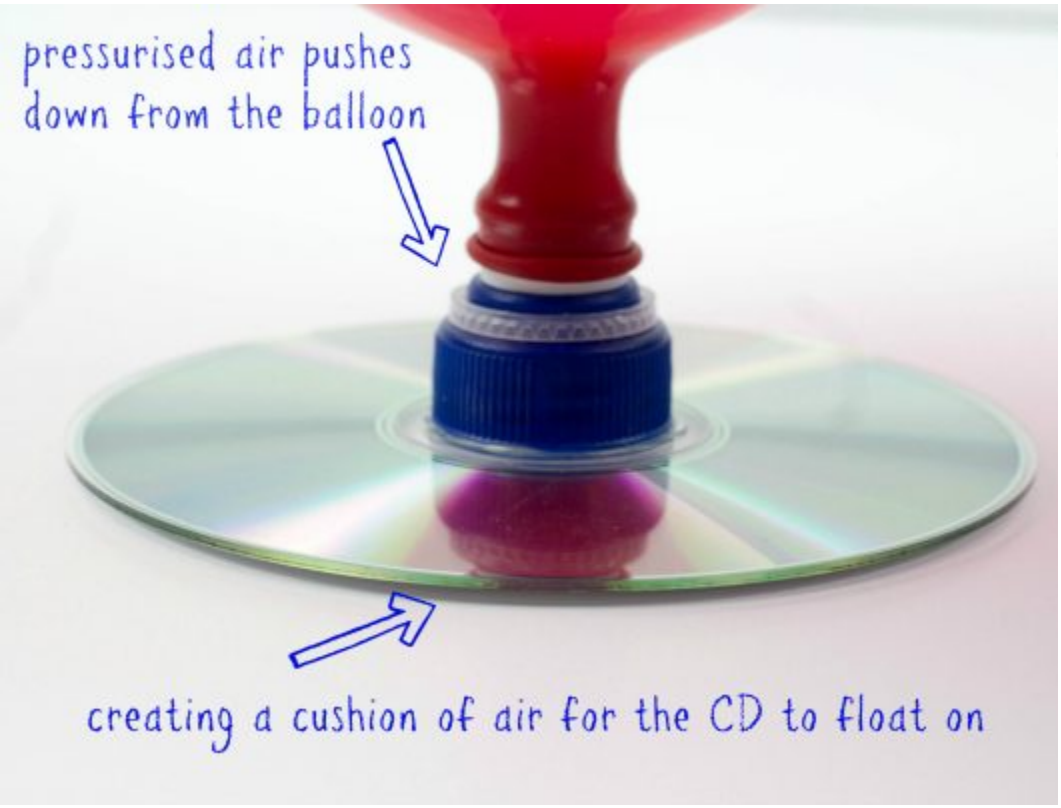
Science Toys can engage students through play, instead of just cold hard knowledge on the textbooks. This gives the students hands-on experience and the opportunity to experiment. Science Toys also make for a fun and enjoyable learning experience and research has proven that that leads to a higher absorption rate of knowledge. This thus has a high value in teaching science concepts, being almost the most effective method to do so. Some students may not learn as effectively when they are only reading through the textbook or listening to the teacher, and they may require some hands-on experience and play to learn. Thus we decided to help those students by designing a Science Toy that would help them learn and also reinforce the concepts learnt in class. We initially built a toy that would require 3D printing. However as phase 2 came along, we realised we could no longer use the 3D printing machines in school, and that we had to work on our homemade toys ourselves. We were also unable to meet, so we decided to work separately. We came up with three designs, a balloon hovercraft, a magnetic toy and a simple electric train.

2. Proposed Solution and Solution Design

We initially decided on a different idea, but due to phase 2 restrictions, we could not use the school 3D printing machines located in the Science Research Centre (SRC). Thus, we chose to work on homemade science toys instead. Since we also could not meet, we made three separate designs and helped each other to improve our toys.

One of our designs is the Balloon Hovercraft. It is made of a CD with a bottle cap with a hole on it and there is an inflated balloon attached to the bottle cap. When the air inside the

balloon is let out, the whole system can seemingly reduce friction and move about more freely. It looks like this:



It works due to Newton's third law of motion, which states, originally, that all forces occur in pairs, and these two forces are equal in magnitude and opposite in direction (also more commonly known as "every force has an equal and opposite reaction"). When the balloon neck is released, all the air rushes out because the air inside has a greater pressure. This air pushes against the table. Likewise, the table exerts an equal and opposite force on the system. This means that the whole system will experience reduced gravity, as the table's force on the system helps counteract the force of gravity. Even though the table's force on the system is little, it still helps to reduce the friction between the system and the table. This means that if we push it along the table, we will see that it can glide further compared to when we do not inflate the balloon.

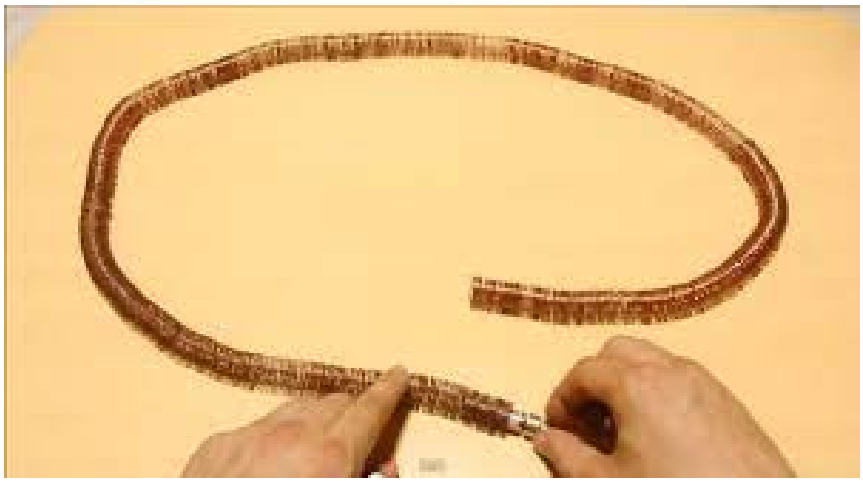
Newton's third law in classical mechanics is always used in our daily lives and this toy would be a great way to help students understand Newton's third law.

Our second design is the Moondrop, which is created to imitate the gravity on the Moon and Mars. It is precisely calculated so the falling ring moves at a similar speed as if you were dropping it on the Moon or Mars.

The anti-gravity movements of Moondrop are caused by the electrical current induced in a circuit due to a change in a magnetic field which is directed to exert a direct force that opposes the motion of the falling magnet. Moondrop is made from a pure copper or aluminium slider, aluminium body and strong natural earth magnets inside the thin aluminium tube. Copper and aluminium are non-magnetic materials but are great conductors of electricity while each magnet is surrounded by its own magnetic field. When the magnet moves through a conductor such as a

sliding copper ring its magnetic field creates an electric current in the copper. According to Lenz's law, the electric current creates an opposite magnetic field that adds a certain amount of resistance to moving magnet. This makes the falling slider move like it would if it was dropped on the moon.

Our third design is the simple electric train.



It is a long copper coil with a battery that has 2 magnets attached to each end of it. When placed inside the copper coil, the battery will rush around the coil at high speeds. This is an example of a basic homopolar motor, which is driven by the Lorentz force, where a conductor with a current flowing through it when placed in a magnetic field that is perpendicular to the current feels a force in the direction perpendicular to both the magnetic field and the current.

3. Results and Discussion

We eventually decided that we are going to work on all three toys since we were unable to meet due to restrictions. We critiqued each other’s designs and improved our own designs based on certain blind spots that other members have noticed.

4. Conclusion and Further Improvements

For the balloon hovercraft, more ideas to improve include changing the CD to other materials, for example, cardboard or other types of plastics. More variation can also be made on the type of balloon. Other variables like the size of which the balloon is blown to, or the number of holes made on the cap or a study of how certain add-ons, such as cloth around the perimeter, may affect the system.

For the magnetic toy, improvements like changing the strength of the magnets, varying the materials used could change the outcome of the experiment. The smoothness between the sliding materials could be tweaked.

For the simple electric train, certain things can also be changed. For example, the strength of the battery, the number of coils of the copper wire, the strength of the magnets and how all these variables change the speed of movement of the battery through the copper coil.

5. Acknowledgements

We would like to acknowledge and express our gratitude towards our mentor Dr Tan Yong Leng Kelvin for providing us with his guidance and help throughout the year, without which this project would not have developed.

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