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# "K'Nex Derby" Demonstration Showing the Effect of Weight Placement on Speed

## 1. Abstract

The objective of the project is to design and build a race track to help elementary school children understand the physics of weight distribution and its effect on speed. By providing a K'nex car and a 12 ft track, the students will be able to add weight in washers around the back or front structure of the car. Weight distribution has been proven to have a significant effect on the speed of a car moving down a track. Weight focused in the back of the car will cause the speed to increase, whereas weight focused in the front of the car will not allow the car to move as fast. Increasing the weight in the back of the car will increase the potential energy of the car at the top of the track and increase the speed of the car as it moves down the track and its potential energy is converted to kinetic energy.

## 2. Background

Race tracks are often used in classrooms to demonstrate a myriad of physics topics, which include but are not limited to, friction, weight transfer, and resistance. These demonstrations are fairly entertaining and engaging, making them ideal for use in a K-5 setting. Furthermore, the tradition of pinewood derby racing has been observed and enjoyed by thousands of Boy Scouts annually, providing them with an opportunity to learn more about the construction of cars and the different components that filter into making the fastest car. This project hopes to take aspects of pinewood derby racing and common classroom physics

demonstrations to demonstrate the effect of certain variables on the speed of a car going down a track.

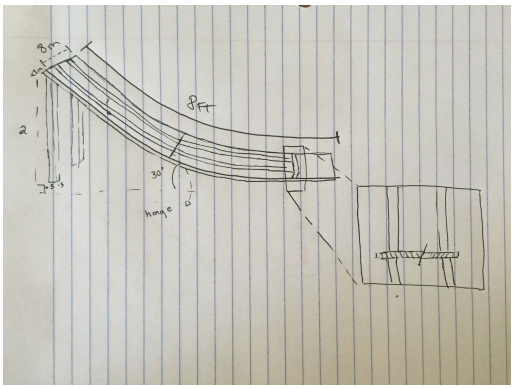

*Figure 1.* Initial sketch of track

The physics behind the project involves the concepts of potential and kinetic energy. The participants are given a chassis, building materials, and a fairly heavy weight with the ultimate goal of sending their car down the track the fastest. Based on prior experience and research, the ideal weight placement on the car is towards the back of the car. By placing the weight further back on the chassis, the potential energy of the car will be increased. The potential energy will then be converted to kinetic energy after being released from the starting gate. The increase in kinetic energy will send the car down faster than a car that did not initially have the increased potential energy caused by the shifted weight placement on the car (Meade). Typically, these rear weighted cars will exhibit an observable increase in acceleration where the track begins to straighten out towards the bottom of the K'Nex track.

3. <u>Materials and Methods</u>

*Figure 2.* Sample K'nex Chassis

Materials used in the building process include a 12 foot long piece of fiber cement siding to serve as the main portion of the track, four 1-inch by 4 foot wood laths used as the raised part of the track to keep the cars from going off the side, along with two 1"x1"x3' pieces of wood used as the stands, 2 hinges to allow the track to fold for moving and

storage, as well as concrete adhesive to attach various pieces of wood together. Additionally, the participants were provided with a pre-built K'nex chassis (shown in *Figure 2*) and various K'nex parts to build their cars.

To begin, all of the materials listed above were gathered. The constructing of the track took place in various stages over 5 weeks to allow for necessary drying time. First, the 4 foot wood laths were glued to the cement siding piece using the construction adhesive. That section was then let to dry for 1 week to ensure the construction adhesive had properly set. Next, the two sections of concrete were attached using a hinge and screws, ensuring that the apparatus would be able to fold for easier storage and transport. The two 2"x2"x30" poplar posts were cut 1 inch from the top at a 45º angle. The top portion was attached to the concrete using concrete adhesive. The notch of sorts is created to form a resting place for the remaining wooden posts to rest on, allowing the whole track to be elevated. Next, the track was painted using spray paint and allowed to dry.

Prior to this project, we did not have great experience or knowledge in the field of construction. To combat this issue, we could have asked our instructor and classmates, who have higher knowledge in construction, for tips and suggestions on how to build the K'Nex track. One important question we should have asked was what materials would work best for building the track. The primed siding was very difficult to work with, especially when we had to drill in hinges to allow the two parts of the ramp to fold up. Learning from our mistakes has prepared us well in case we would need to build another ramp, or an object that requires wood, adhesive, and hinges. A factor in choosing the materials was also pricing. Going to Home Depot and exploring all of the different options has allowed us to learn about the materials we needed. It was very

interesting to see all of the different kinds of adhesive, hinges, and washers available, and at what price they were at.

Cost of Project:

| Construction Item | Price |
|---|---|
| Primed Siding | $7.98 |
| Construction Adhesive | $4.00 |
| 1 inch by ¼ inch by 4 foot laths | $1.40 |
| Hinges | $5.94 |
| K'Nex Cars | $24.00 (estimated) |
| Washers | $7.08 |
| 2 inch by 2 inch by 30 inch Poplar Board | $11.30 |

4. Results and Discussion

Future additions to the track include a timing apparatus at the bottom of the track to allow for increased visibility of results. Additionally, a starting mechanism could be added at the top to ensure the cars were released at the same time, which would create accurate results.

The addition of a weight on the race car can affect its speed down the track. As proven by the equation $F=ma$, with a being the constant of 9.8 $m/s^2$, an increase in mass will increase the force of the car. Furthermore, the placement of the weight can also affect its speed down the track. Placing the weight further back on the chassis increases the potential energy of the car and will cause the car to accelerate once the track levels out (Meade). Though the placement of the weight is a seemingly insignificant change, the results were an observable difference.

5. Conclusions

Pinewood derby races have been present in the community of Boy Scouts since 1953 (Gargiulo). Since then, the applications of physics have been adapted and the cars have been modified for competitions. Small changes such as the placement of the weights on the cars and the alignment of the car have a large, noticeable effect on the overall speed of the cars. While many factors exist that contribute to the speed of the cars this project focused on the distribution of a weight. In conclusion, the addition of a weight in the back of the car caused the car to have the greatest speed.

Additionally, another possible project could be to test the different variables that affect the speed of a car down the ramp. One very testable variable is lubrication. Because of the great presence of friction, another interesting tests would be to make tracks out of different materials, such as graphite or molybdenum, and see how the speed of the cars down the track is affected (Kathol).

6. References


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