The Effect Of Pinewood Suspensions On Derby Cars

Erica Lastufka

Lifewalk Christian School
621 Brookside Dr.
Cedar Hill, TX 75104

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Introduction

Since Don Murphy created the original pinewood car derby fifty years ago, over 85 million car kits have been sold to Boy Scouts alone. Over one million children participate in this popular race annually in various clubs, organizations, and recently large corporations like Home Depot. The racetrack is typically a wooden ramp curving to a level run about thirty feet long, with a guide centered in each lane. Derby cars wander from a straight path from four main causes. Wheels can be rough and not perfectly round. They jiggle on the track from isolated bumps, joints between track sections, and debris. Larger track irregularities include patchy varnish and wood grain. Sometimes cars hit the lane guide.

High competition levels in Pinewood derbies demand faster car designs. Standard practices include polished axles and wheels with lubrication to reduce friction; making light bodies with isolated weight to reduce bulk; and carefully aligning wheels for straight travel. To take advantage of higher potential energy at the starting line, weight is placed farther back. Aerodynamic designs are used. A long wheelbase (Tamboli) and lifting a front wheel aid acceleration by reducing rotational inertia and vibration due to wheel and track defects. (DOE)

Recently, on his 'Go ask Grandpa' website (Borough), physicist Chuck Borough posted a simple pinewood car suspension pattern. When a wheel hits a bump, a good suspension absorbs or damps the force exerted on it by the bump. Only the suspension and wheel move, while the rest of the car does not. This prevents damage to the car and smoothes the ride for passengers. For rigid pinewood cars, each bump lifts the center of mass. Doing so converts a part of its limited kinetic energy to potential energy, which detracts from its speed. A working suspension should reduce energy loss, resulting in greater speed.

Some derbies prohibit cars from riding on springs, so suspensions can be illegal. In the original pinewood derby, there were nine rules (Wolcott). Rule number eight was worded: “The car shall not ride on any type of springs”. Don Murphy, wrote in e-mail that he does not remember how the rule originated. Well known is the fact that Murphy created the pinewood derby as a miniature soapbox derby because his son was too young to compete. A pinewood historian, Gary McAulay, agreed in e-mail that the “no springs” rule might have been derived from the soapbox derby rules. Nowadays, the local race administrator sets up the rules. However, the Boy Scouts are still likely to have the “no springs” rule. In these races, judges must decide if cantilevers are springs or not.

Purpose

The purpose of this project was to find out if and why suspensions make a car go faster.

Hypothesis

It was hypothesized that if a suspension damped the motion of the center of mass over isolated bumps, the car will speed up.

Research Plan

The pattern shown below in figure 1 consists of four cantilevers. It set the maximum width and length of four cantilevers, one supporting each wheel independently. Constructionwise, thickness was the only variable. Borough's suspension pattern could not be improved as other patterns chop the wood block into hard-to-align pieces.

The two straight front-wheel cantilevers and the longer forked back-wheel cantilevers are joined at the weight platform near the rear of the car. In Figure 1, the front is on the right and cut lines are highlighted in purple. The wheels anchor one end of the cantilevers and the weight platform at the other end pushes down on them. Therefore, as the weight rests on its suspension, the cantilevers sag slightly. The rear cantilevers extend forward from the weight and then fold back to the wheels. They are longer than the front and consequently bend more. Keeping the pattern simple, all four cantilevers were made to the same thickness.

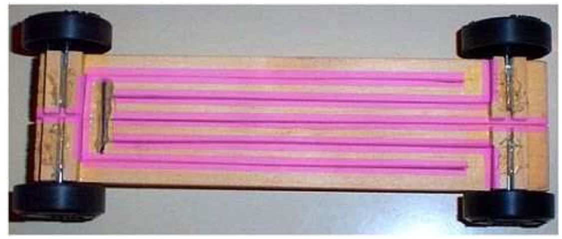
Figure 1 Suspension Pattern

In order to choose the optimum thickness of wood to build the trial car, it was necessary to find out how cantilevers bend with different applied forces. Two sets of five cantilevers with different thicknesses were made and their bending caused by different weights was measured. One set represented the straight front-wheel cantilevers and the other set represented the longer, forked rear ones. As there is great variation in the density and structure of pinewoods, the wood used for the cantilevers was also used for constructing the trial car. The amount of bending of the cantilever under certain forces was found.

The wood must bend to support the car's weight and to damp the bumps on the track. Knowledge of the amount of force exerted by a bump on a wheel at racing speed was needed. As shown in figure 2, an apparatus dubbed "bump force measurement apparatus" (BFMA) was constructed to determine how much force a bump exerts on a wheel at racing speed. Forces were measured for 1, 2, and 3-mm bumps. These heights were selected to amplify the suspension's reaction to the bump. These forces were compared with the bending data. An optimum thickness to damp 1-millimeter bumps was identified.

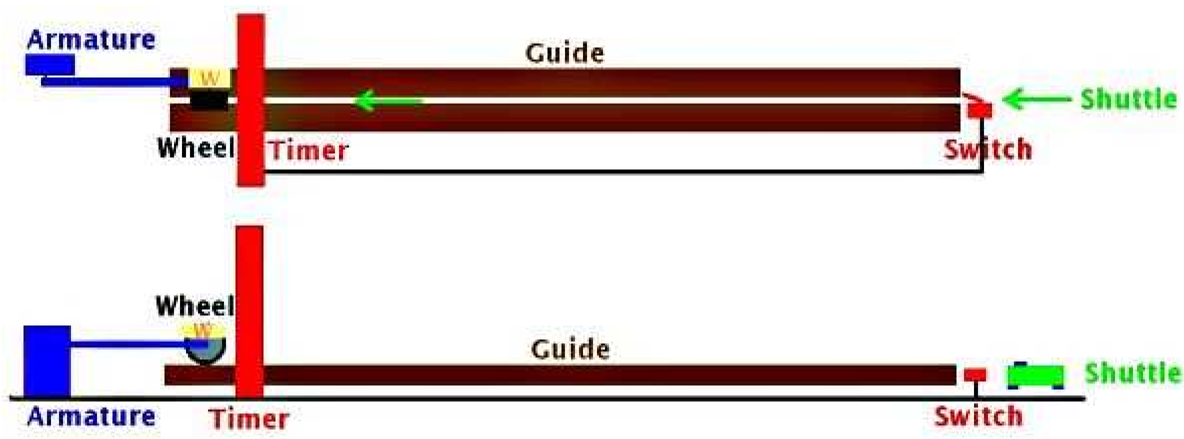

Figure 2 Bump Force Measurement Apparatus (BFMA)

The diagram in Figure 2 shows the main parts of the BFMA from a top and side view. A weighted armature allowed the wheel vertical movement, much as if it were mounted on a car. Rather than the wheel moving over a bump, the bump moved under the wheel on a shuttle mounted in a guide. The shuttle had little feet that traveled below a rail. Tugging the string upward a bit kept the bump at the correct height on impact.

Not shown is the ballistic pointer that initially rested on the end of the armature. The ballistic pointer was made from Lego tm with a long, balanced arm attached to a pivot and damped with folded paper that was slotted into the pivot interface. It offered little resistance to movement. When the wheel jumped, the pointer moved and held its position. Rectangular bumps are inserted into a notch on the shuttle.

Using this information, one time trial car was built with a 5mm thick suspension that could be locked to act like a normal rigid car. It weighed 5 ounces. The weight of the car was concentrated in a mass of tungsten placed at the only possible position near the rear axle, supported by the suspension and held in place by wire.

During the first day of time trials, the car was released down the track with and without isolated 1mm bumps, and in both locked/rigid and free suspension modes. On another day, a trial was run (and then rerun on another day) with professionally prepared lathe-rounded wheels. The BFMA was also employed to determine if both the tungsten and front wheel moved when passing over a bump at race speed.

Cantilever Forces And Deflections

A cantilever is a horizontal, massive, elastic beam anchored at one end and free to flex at the other as illustrated in figure 3. Cantilevers considered here are stiff enough that gravity has no measurable effect. When the bar was tweaked, it made a low musical tone, acting like a spring. When bent by a sudden force, the cantilever tries to return to its original shape. But it has gained momentum and overshoots until it has bent nearly an equal distance the other way. The amplitude becomes less until it finally stops. This vibration is its *natural frequency*.

L is the length of the cantilever.
h is the thickness of the cantilever.
w is the width of the cantilever, not shown in the diagram
F is a force perpendicular to the free end of the cantilever.
y is the deflection of the cantilever from a force downward at the free end.

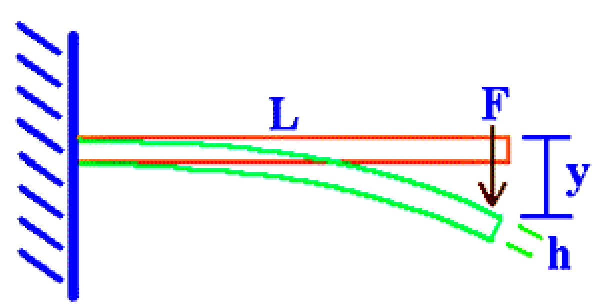

Figure 3 Bending a cantilever

Using Young's modulus for Southern Pine wood (Properties), the deflection expression of interest (Cantilever) is:
$y = FL^3/(3125000000wh^3)$

The simplified equation for the natural frequency (Whitney) of the cantilevers used is:
$f = 966.4165h/L^2$

For h = 5 mm and L = 13.3 cm, the dimensions of a front wheel cantilever

$f = 966.4165*0.005/0.017689 = 273.17$ Hz

Time To Roll Over A Bump

In order to damp a bump, the cantilever must bend up and down in the same time it takes to roll over it. Encounter time, T, is the distance the wheel is in contact with the bump, 2X, divided by car speed, V. V is assumed to change very little for bumps that are small, h, compared with the wheel radius, R, as shown in Figure 4.

Equation 1: $T = 2X/V$

X is found from the Pythagoras theorem, applied to a wheel the instant it touches a bump rolling through the distance it takes to top the bump as shown in Figure 4. The encounter distance involves ascending the bump then descending, which is 2X.

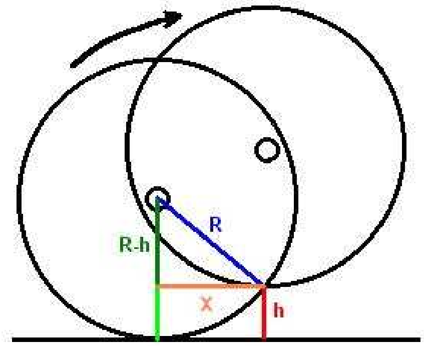

Figure 4 Wheel topping a bump

Equation 2: $X^2 = R^2 - (R-h)^2$

This reduces to:

Equation 3: $X = \sqrt{(2Rh-h^2)}$

Using h = 1 mm and R = 15 mm (the radius of a typical pinewood wheel), $X = \sqrt{(29)}$ mm.

Finally, using V = 4 m/s (the speed of a fast pinewood car), T = 0.0027 seconds.

Materials, Methods, And Procedures

Overview:

Part A: Preliminaries to Car Construction

Order of procedures:

1 Cantilever and Forked Cantilever Elasticity experiment
2 Vertical Bump Force experiment

Part B: Testing Hypothesis

Order of procedures:

3 Suspension Elasticity Check
4 Suspension Locking
5 Suspension Time Trial experiment
6 Vertical Bump Force Effect with Suspension experiment
7 Lathed Wheels Time Trial experiment

Details:

Part A: Preliminaries to Car Construction

Procedure #1 Cantilever and Forked Cantilever Elasticity experiment

Purpose: To determine how much cantilevers of different thicknesses bent under certain forces. This helped to determine the thickness of the car's cantilevers.

Materials:
31 cubes of tungsten (3.658-gram, ¼ inch cubes)
1 C-clamp
1 scrap of wood
1 depth gauge
2mm, 4mm, 6mm, 8mm, 10mm thick 13.3 cm long bars or cantilevers
2mm, 4mm, 6mm, 8mm, 10mm thick 25.0 cm long forks with one leg 13.3 cm and the other 11.7 cm
1 13 cm. stationary, long wood bar

Steps:

1. Clamp a cantilever and the stationary bar in parallel to a table using the C-clamp and wood scrap.
2. Put 1 cube of tungsten on the cantilever. Measure the difference between the weighted cantilever and the stationary bar with the depth gauge. Adjust the flange of the depth gauge until no light is visible between it and the cantilever and so the flange doesn't push down on the cantilever. Record the measurement.
3. Put 2 more cubes on the bar. Measure. Record. Put 3 more cubes on the bar, measure, record, and repeat until 24 cubes are the bar.
4. Repeat steps 1-3 for the rest of the bars.
5. Clamp a fork to a table (by the base of the long leg) with the clamp and wood scrap.
6. Repeat steps 1-3 for the bars but measure the displacement from the free end of the fork to the base.

Procedure #2 Vertical Bump Force experiment

Purpose: To discover how much force was applied to a wheel when bumps of different heights were encountered.

The ballistic pointer indicated how much the armature jumped. If it just cleared the bump, then the weight on the wheel equaled the vertical force exerted by the bump. To compute the weight on the wheel, the wheel weight, half the armature weight and the tungsten weights were added. 3.658-gram tungsten cubes (1/4 inch cubes) were placed into a 0.75 x 1.25 x 0.5 inch cardboard box on top of the armature centered over the wheel. A timer produced the shuttle's speed; the bump's travel distance is from the trigger to the timer's eye.

Materials:
1 bump force measurement apparatus (BFMA)
1 electric timer accurate to 1/1000th of a second

1 ballistic depth gauge
1 bump shuttle with pull string
1 tube very fine graphite lube
3 bumps 1mm, 2mm, 3mm for shuttle use
31 cubes of tungsten (3.658-gram, ¼ inch cubes)
1 Prepared AWANA kit wheel
1 Prepared AWANA kit axle

Steps:

1. Mount wheel and axle on BFMA armature.
2. Test timer.
3. Graphite the guide rails and shuttle for easy sliding.
4. Mount a bump in shuttle notch.
5. Empty the wheel load box.
6. Repeat the following:
    a. Add a cube of tungsten to the wheel load box.
    b. Pull the shuttle under the wheel in 0.2 seconds (about 4 m/s).
    c. Measure the height of the bar on the ballistic depth gauge.
7. When it matches the bump height, record the wheel load.
8. Repeat steps 4-10 with the rest of the bumps.

Part B: Testing Hypothesis

Procedure #3 Suspension Elasticity Check

Purpose: To ensure that the suspension elasticity was the same after each time trial or break.

Materials:
1 Suspension Time Trial Car
24 cubes of tungsten (3.658-gram, ¼ inch cubes)
1 depth gauge

Steps:

1. Remove wheels and axles.
2. Clamp the weight platform to the table.
3. Put 24 cubes of tungsten on an axle plate. Measure deflection against twin plate with depth gauge.
4. Remove cubes, record.
5. Repeat with remaining axle plates.

Procedure #4 Suspension Locking

Purpose: To lock the car's suspension and make it act like a normal, rigid car.

Materials:
1 Suspension Time Trial Car
1 Suspension Locking kit; 2 clamps consisting of 2 wooden bars and 2 wire pins each
1 needle nose pliers

Steps:

1. Slide a wood clamp with one locked pin in front of the tungsten, sandwiching the suspension as in Figure 5.
2. An unlocked wire pin forms an "L" shape. Stick the long end of the pin up into the predrilled holes of the wood bars and bend it parallel to the top bar, using the pliers.
3. Repeat behind the front wheels.
4. To remove, rotate a wire so it faces opposite its original direction. Using pliers, unbend top of pin. Take it out and slide clamp off. Tape the tungsten cube to the front of the tungsten mass to offset the weight of the removed locks.

Figure 5 Trial car with suspension locks

Procedure #5 Suspension Time Trial experiment

Purpose: To find out if the suspensions helped a car while going over bumps and also while on a smooth track by comparing it against the locked configuration.

Materials:

1 Standard AWANA Grand Prix track with custom ballistic stoppers (Stoppers)
1 Electric timer accurate to 1/1000th of a second
1 Suspension Time Trial Car
1 Racer-Spacer (Spacer), ensures good starting alignment
20 1mm Bumps (L-shaped 20 gauge wire)
1 Scotch tape dispenser
1 Silicone spray lubricant can (GUNK)
1 Tungsten cube (3.658-gram, ¼ inch cube)

Steps:

1. Lube car with silicone spray before mounting wheels.
2. Check car wheel alignment by rolling on tilted, smooth table in locked and free configurations. If it deviates 2 cm from straight over 1 m, adjust axles by melting hot glue. (No adjustment was needed.)
3. Test the timer.
4. For each run:
   a. Set the configured car on track, aligning it with a Racer-Spacer.
   b. Pull the cord to start run.
   c. Record the race time from the digital timer display.
5. Make 6 runs alternating car configuration from locked to free suspension.
6. Tape bumps across the track 7.5 inches apart beginning 7.5 inches from the transition on the flat. Alternate bumps on both sides of the lane median. Clean track.
7. Make 6 runs alternating car configuration from locked to free suspension.
8. Remove bumps from track. Clean track.

9. Make 6 runs alternating car configuration from locked to free suspension.
10. Tape bumps across the track 7.5 inches apart beginning 7.5 inches from the transition on the flat. Alternate bumps on both sides of the lane median. Clean track.
11. Make 6 runs alternating car configuration from locked to free suspension.
12. Remove bumps from track. Clean track.
13. Make 6 runs alternating car configuration from locked to free suspension.
14. Repeat car wheel alignment check. (It was still perfect.)

Procedure #6 Vertical Bump Force Effect with Suspension experiment

Purpose: To see if the weight and wheels moved when going over a bump at racing speed.

Materials:
1 bump force measurement apparatus (BFMA) (see figure 2)
1 electric timer accurate to 1/1000th of a second
1 ballistic depth gauge
1 bump shuttle with pull string
1 tube graphite
1 bump 1mm
1 Prepared suspension car

Steps:
1. Mount car on BFMA so that the bump rolls under both the front and rear wheel.
2. Test timer.
3. Graphite the guide rails and shuttle for easy sliding.
4. Mount the bump on shuttle.
5. Repeat the following:
    a. Pull the shuttle under the wheels in 0.2 seconds, about 4 meters per second.
    b. Measure the height of the bar on the ballistic depth gauge over the car's weight.
    c. Record the deflection.

Procedure #7 Lathed Wheels Time Trial experiment

Purpose: To determine if the suspension damped out wheel or track irregularities.

Materials:
1 Standard AWANA Grand Prix track with custom ballistic stoppers (Stoppers)
1 Electric timer accurate to 1/1000th of a second
1 Suspension Time Trial Car
1 Racer-Spacer (Spacer), ensures good starting alignment
1 set of lathed wheels
1 Silicone spray lubricant can (GUNK)
1 tungsten cube (3.658-gram, ¼ inch cube)

Steps:
1. Lube car with silicone spray before mounting wheels.
2. Check car wheel alignment by rolling on tilted, smooth table in locked and free

configurations. If it deviates 2 cm from straight over 1 m, adjust axles by melting hot glue. (No adjustment was needed, but not perfect)

3. Test the timer.
4. For each run:
    a. Set the configured car on track, aligning it with a Racer-Spacer.
    b. Pull the cord to start run.
    c. Record the race time from the digital timer display.
5. Make 12 runs alternating car configuration from locked to free suspension. Add cube to compensate for removed locks.
6. Repeat car wheel alignment check. (Same result as in step 2)

RESULTS

Part A

In the Figure 6, the deflection of the cantilevers was measured in 64ths of an inch. Thickness was measured in millimeters and each force line represents the number of cubes. There are three lines to show the bending to 1mm, 2mm, and 3mm. Figure 6 represents the straight cantilevers and Figure 7 the forked cantilevers. These charts show that the deflection is nearly proportional to the force applied to the cantilever. The force curves do not fit the theory and instead are closer to an inverse square model for thickness rather than the inverse cubed model the theory suggests. The estimated natural frequency also proved too high (see discussion).

Figure 8 shows that the force of the bump on the wheel increases linearly with bump height. With the newly acquired

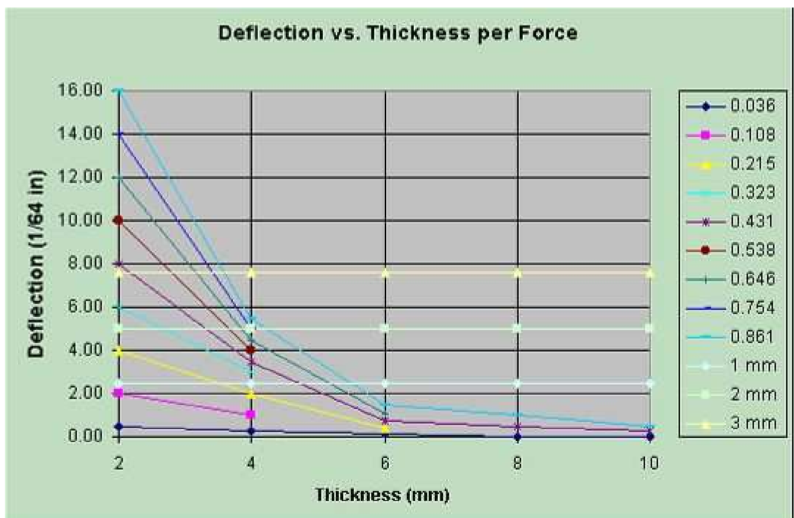

Figure 6 Straight Cantilevers

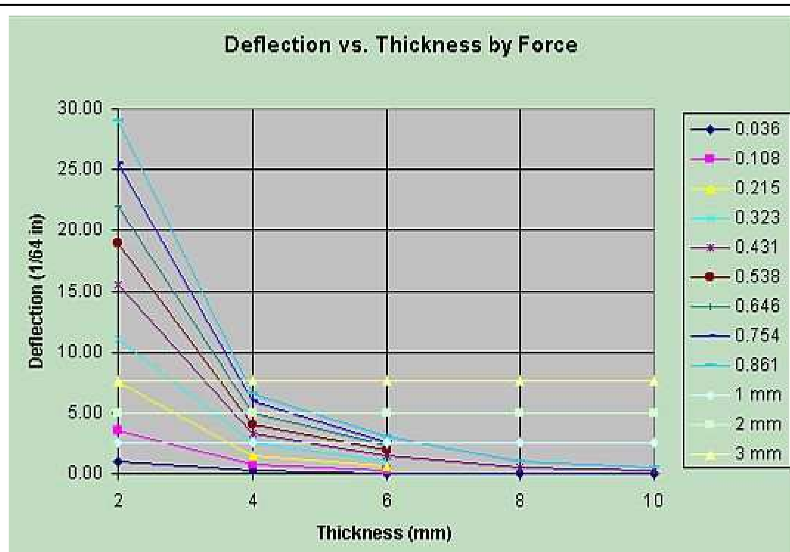

Figure 7 Forked Cantilevers

data from the BFMA, a thickness for the cantilevers of the car could be decided on. The amount of weight supported by a wheel of the average car is 0.35 N (this is one quarter of the weight of the car). A 1mm bump exerts 0.25 N on the wheel, the only height not to exceed the average force on the wheel. This enables the wheels to stay on the track while going over the bumps. 1mm is a large bump compared to the isolated bumps found on a typical track, which should increase the effect of the suspension during time trials. The largest bump a car is likely to face comes at the joint between track sections, where a gap spans a few millimeters. Using geometry, it was determined that the effective depth of such gaps was less than 1/10th of a millimeter.

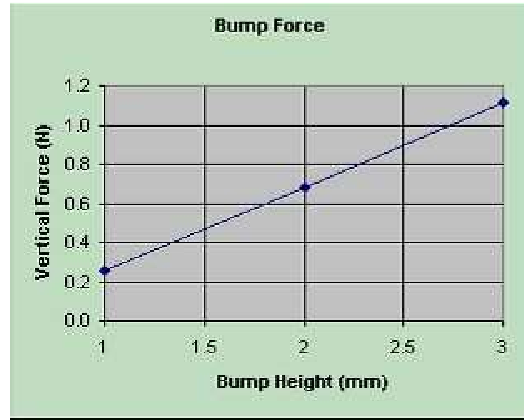

Figure 8 Bump Force vs. Height

Matching the 1mm bump force to the cantilever data, a thickness of five millimeters was identified. Since at 5mm, the front cantilevers bent slightly less than desired and the rear cantilevers bent slightly more than desired, 5mm was a good overall thickness for the car. The rear cantilevers can be thicker than the front ones because the longer they are the thicker they can be.

The chassis was then cut out. The bending of the suspension with the right amount of weight was checked. All cantilevers bent a little more than 1mm. The bending was also checked with more weight to make sure the cantilever pairs bent the same amount. Adding axle guides, wheels, axles and weight finished car construction.

Part B

The data gathered from Procedure #5, the first time trial is shown in Figure 9a, with the averages and standard deviations shown in Figure 9b. The lines representing the times of the various runs are fairly straight. The time difference in the trial with bumps (two lines at the top of the graph) is noticeable. R, B (rigid, bumps) and S, B (suspension, bumps) represents the runs with bumps. NB means no bumps. As expected, the bumps slowed the car, but the suspension configuration went 0.015 seconds faster, gaining a virtual 2-inch margin over the locked

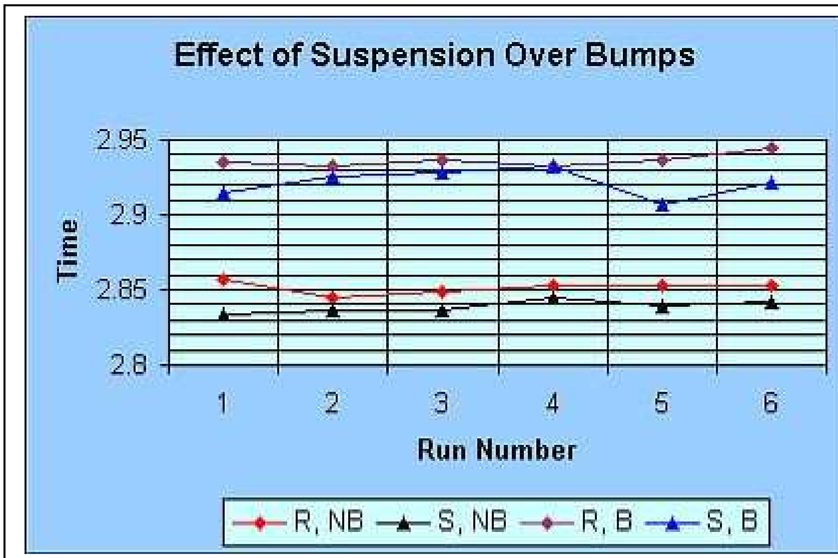

Figure 9a Suspension vs. Rigid with and without bumps data

configuration, proving the superiority of the suspension. While running over the bumps, the car broke at the "knee" of the left rear fork. It was repaired with wood glue and checked for bending using Procedure 3. No deviation was found. Smooth track runs before and after the breakage remained similar.

Unexpectedly, the suspension proved just as beneficial on the smooth track (lower two lines in the graph). The time difference between the rigid and suspension configurations, represented by R, NB (rigid, no bumps) and S, NB (suspension, no bumps) is statistically significant with 95% confidence using a one-tailed Student's t-Test.

Configuration	Average Time(s)	Standard Deviation(s)
R, NB	2.852	0.0041
S, NB	2.839	0.0037
R, B	2.937	0.0041
S, B	2.922	0.0092

Figure 9b Suspension vs. Rigid with and without bumps statistics

To investigate this, the BFMA was employed in Procedure #6 to determine if both the tungsten and front wheel moved when passing over a bump at race speed. When the front wheel goes over a bump, both front wheels lift to the height of the bump. The amount that the center of mass is lifted when the front wheels go over a bump is directly proportional to the distance it is from the rear axle. When the back wheel goes over, both it and the same-side front wheel are lifted. For a rear-weighted car, the center of mass is lifted half the height of the bump.

Surprisingly, both the free and locked configurations lifted to the same heights at race speed. In contrast, at slow speed the suspension damped the vertical motion as expected. This indicated that, at race speed, the suspension did not react in time to damp out the bump. The wheel rides over a 1mm bump in 0.003 seconds.

Figure 10a shows the run times of the lathed wheel time trial, with the averages and standard deviations shown in Figure 10b. Represented by the red line R, L is the rigid configuration. Represented by the black line S, L is the suspension configuration. Wheel irregularities were absent, so no significant time difference was expected if they were being damped

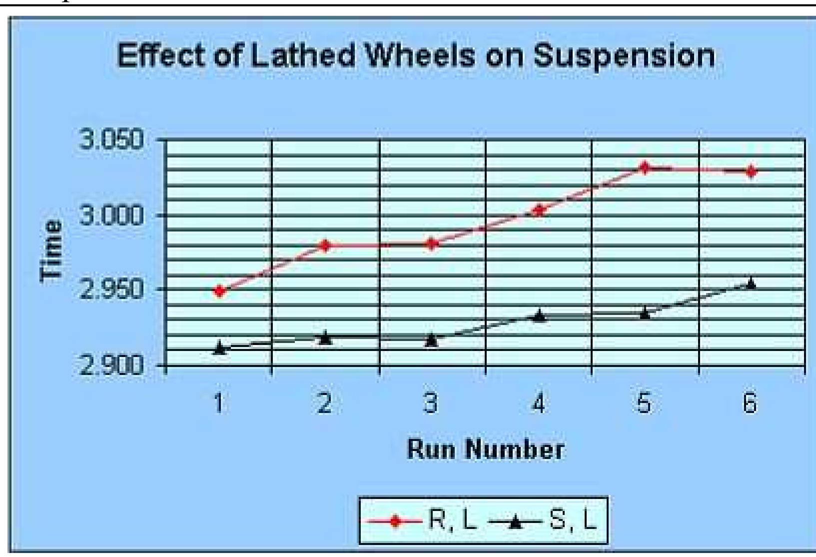

Figure 10a Suspension vs. Rigid with lathed wheels data

Configuration	Average Time(s)	Standard Deviation(s)
R, L	2.996	0.0319
S, L	2.928	0.0160

Figure 10b Suspension vs. Rigid with lathed wheels statistics

in the previous trial. The suspension configuration was again significantly faster.

There were two problems in the lathed wheel trial. Though wheel alignment was acceptable via Procedure #7, it was not as good as in the first time trial. Many runs were made deciding the best way to test using the lathed wheels. All these times were slower.

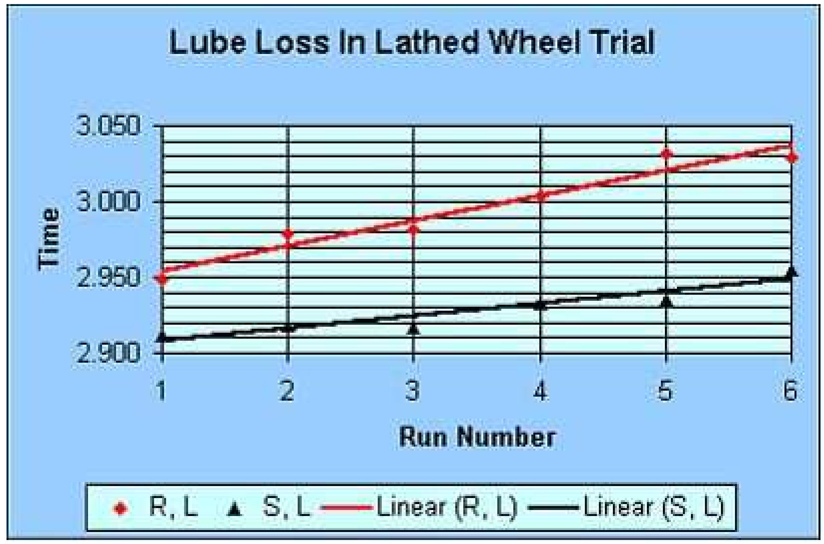

Figure 11a Lubricant degradation data

The first lathed wheels trial was inconclusive due to large variation in the data, so a re-run was executed. Trying to increase the observable effect of the suspensions, Procedure #7 was modified during the course of the day.

Configuration	Rate (s/run)	Linear Fit (R^2)
R, L	0.0165	0.94
S, L	0.0081	0.89

Figure 11b Lubricant degradation statistics

Usually, the silicone lube begins to wear off after a couple dozen runs. It takes a couple hours for the silicone spray to dry completely so, relubing during a trial is not an option. Silicone lube lasts longer and is more consistent than other lubricants. Figure 11a shows the trend lines of the lube degradation that resulted. Figure 11b shows the rate of degradation and the linear fit. This accounted for the slower times of the later runs.

The time difference between the suspension and rigid configurations was still statistically significant at the 5% level. In fact, the time difference between means was 0.07 seconds, more than 4 times greater than the smooth track runs of the previous time trial. Furthermore, the slope of the suspension configuration indicated that it lost lubricant at half the rate of the rigid configuration. Perhaps the suspension prevented some wheel motion that loosened lubricant from the rigid car.

Discussion And Conclusions

This project investigated the possibility that if a suspension damped the motion of car's the center of mass over isolated bumps, the car will speed up. Because the suspension gained a virtual 2-inch margin over the locked configuration both over bumps and a smooth track, the hypothesis was proved partially incorrect. If the suspension had been damping isolated bumps on the track, the times of suspension vs. rigid on the smooth track would have been similar. However, the suspension did speed it up, proving that the suspension was damping something else. If the cantilevers had been thinner, they would eventually have damped isolated bumps. This would increase the car's frailty and breaks would be inevitable. A very thick suspension would act like a rigid car because it would be too thick to damp anything.

The results of the BFMA experiment showed that the cantilevers did not respond to the bump in time when the car was going fast. No isolated bumps were damped, not even small ones. If it takes 0.003 seconds to roll over a 1mm bump, it takes less time to run over a smaller one. Consequently, the suspension had less time to respond to smaller bumps than it did to larger bumps. Given the alternatives, either large wheel imperfections or large track imperfections were being damped.

If the suspension did not respond to a bump in three thousandths of a second, its natural frequency must be less than 167 Hz. The period of the natural frequency was twice the bump encounter time since the bump was at a maximum in the period. The radius of the average derby wheel is 1.5 cm, spinning 42 times per second at a race speed of 4 meters per second. Since its spinning frequency is likely less than the natural frequency, the suspension could be damping distortions on the tread or bore. Track irregularities would have to be rounded and longer than one centimeter to be effectively damped out by the suspension.

The lathed wheel experiment showed that the suspension was not damping wheel imperfections. As a result, track imperfections must be responsible for the time difference between suspension and rigid configurations on a smooth track. The lathed wheel experiment depended on the fact that the wheels were perfectly round both on the tread and bores. Lacking precise equipment to measure roundness, the researcher trusted the supplier. A positive test to show that the suspension damps track defects would require creating removable track defects.

Compared to the first time trial (Figure 9b) the times and their standard deviations of the lathed wheel time trial (Figure 10b) were both larger. Logically, “perfect” wheels should produce less opportunity for vibration and decrease race time and race time variation. This was not the case. However, inferior wheel alignment might explain both.

This study indicates that the wooden suspension must damp track irregularities to speed up the car. But these irregularities must interact with the wheels over a longer time than it does with a bump.

A study (DOE) including lifting a wheel also supports this result. When a wheel is lifted, the rotational inertia of the car is reduced by a quarter with one less wheel to spin up. But since the wheel no longer contacts the track, irregularities in the track cannot affect it, so track noise is also reduced by a quarter. Lifting a wheel produces a competition advantage of a few inches, much more than can be accounted for by modeling the reduction in wheel inertia (Lift). If a suspension design with a lifted wheel could be developed, the resulting times may be faster than just having a suspension or a lifted wheel.

The purpose of this project was to find out if suspensions sped up the car and why. Based on the idea that tracks have isolated bumps, it was hypothesized that if suspensions damped out the isolated bumps, the car would speed up. A pinewood car with a suspension was constructed and a trial was run. The conclusion was that the suspension was not damping isolated bumps but something else. Data from the BMFA showed that the suspension does not react in time to damp out the bumps at race speeds. After the lathed wheels time trial, it was clear that wheel imperfections were not damped by the faster suspension configuration. This researcher concluded that the pinewood suspension was damping out track imperfections and therefore part of the hypothesis was correct – suspensions can speed up derby cars. If suspensions were ineffective, pinewood derby judges wouldn’t have to worry about cantilevers being an unfair advantage.

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