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The Effect of Pinewood Suspensions on Derby Cars

Since Don Murphy created the original pinewood car derby 50 years ago, over 85 million car kits have been sold in Boy Scouts alone. Over one million children participate in this popular race annually. Because of high competition levels, faster car designs are in demand. In some derbies, rules prohibit cars from riding on springs, so suspensions can be illegal. Even so, some judges do not consider wooden cantilevers as springs. The purpose of this project was to find out if suspensions make a car go faster and why.

The racetrack is typically a wooden ramp curving to a level run about 30 feet long, with four lane guides. 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 features include patchy varnish and wood grain. Sometimes cars hit the lane guide. When the car's center of mass is disturbed, as in going over a bump, it increases its potential energy, taking it from the kinetic energy of the car and consequently slowing it down. It is hypothesized that if a suspension damps the motion of the center of mass over isolated bumps, the car will speed up.

Recently, on his 'Go ask Grandpa' website, physicist Chuck Borough posted a pinewood car suspension pattern. Borough's suspension pattern could not be improved as other patterns chop the wood block into hard-to-align pieces. The pattern set the maximum width and length of four cantilevers, one supporting each wheel independently. Thickness was the only variable construction-wise.

Two sets of five cantilevers with different thicknesses were made and their bending caused by different weights was measured. One set was for the front wheel cantilevers and the other set for the longer, zigzag rear ones. As there is great variation in the density and structure of pinewoods, wood from the same block was used to construct the trial car. An apparatus, dubbed bump force measurement apparatus (BFMA), was constructed to determine how much force a bump has on a wheel at racing speed. To test the suspension's effectiveness, these forces were compared with the bending data. An optimum thickness to handle 1-millimeter bumps was identified. 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, with most of the weight concentrated in a mass of tungsten near the rear axle, supported by the suspension.

During the time trials, the two variables tested were the car in locked mode as opposed to unlocked mode; and smooth track as opposed to a bumpy track. As expected, the bumps slowed down the car, but the suspension configuration went 0.015 seconds faster, gaining a virtual 2-inch margin over the locked configuration. Unexpectedly, the suspension proved just as fast on a smooth track. To investigate this, the BFMA was employed to determine if both the tungsten weight and front wheel moved when passing over a bump at race speed. Surprisingly, both the free and locked configurations did this with the same height. In contrast, at slow speed the suspension damped the motion as expected. This indicated that, at race speed, the suspension did not react in time (the wheel rides over a 1mm bump in only 0.003 seconds) to damp out the bump. Isolated bump damping was not the reason the suspension works so the hypothesis was proved incorrect.

The natural frequency of the cantilevers was estimated at a couple hundred hertz, because when they were tweaked they produced a low musical note. The wheels spin approximately 35 revolutions per second, so it was concluded that the suspension damped the wheel imperfections or wave-like wood grain textures in the track. A trial was also run with professionally prepared lathe-rounded wheels versus the original wheels to test this factor. However, the trial was inconclusive. In summary, it was concluded that suspensions do speed up pinewood cars by damping wheel or track imperfections but not isolated bumps. If permitted, cars with this simple pinewood suspension will be very competitive in derby racing.