

Pack 1776
Pinewood Derby Tip #3
Physics: Where To Place Weights

Assuming all other factors are equal, a heavier car will be faster than a lighter car. The Pinewood Derby rules limit the weight of each car to 5 ounces. So where should you place weights to make the car heavier (faster)?

Most PWD experts believe a car is faster when the weight is predominately placed towards the rear of the car. Why? Because most tracks are designed so a car rolls down the track on an incline from a height of 3.5 feet - 4.5 feet before traveling down a long flat stretch. When the car is resting on the starting gate, it has potential energy. When the car starts to roll, it is releasing kinetic energy. The farther the car drops (gravity), the more energy it releases and the faster it will go by the time it reaches the flat portion of the track. If the weight is placed towards the back of the car, it has longer to "drop" (by several inches) than if the weight is placed towards the front of the car. This difference is highly significant in terms of race times. Therefore, weight should be concentrated towards the rear of the car.

How far back should you place the weight? That depends on many factors, including wheel set-up, how light or heavy the car is before placing weights on it, and the balance between the front wheel(s) and the rear wheels. Many racers try to place the center of gravity (COG) of their car at a certain distance in front of their rear axle. You find the COG by simply balancing the car on a fulcrum (a ruler or paint scraper will do), and measuring how far in front of the rear axle the balance point is. For example, you want a COG of 1", you simply place your weights in the appropriate place on your car to achieve this. You can always ask other people where they place the COG on their PWD cars, but don't expect honest or direct answers since many competitors consider this a closely guarded secret. Please note that placing the weight too far back can make the front wheels too "light", causing the car to wobble or even jump the track.

What kind of weights should you use? Some builders use lead weights while others use denser materials like tungsten. Some people use whatever is available in their homes, like washers and coins. There are many ways to add weight to the car. One method is to drill holes and drop in lead rods or tungsten weights. Another method is to make the weights part of the car design. Others use milling machines to make a cavity in the bottom of the car, and carefully pour in

molten lead (Note: There are several safety issues with melting and pouring lead!). The important thing (aside from shop safety) is to get the car weighing close to, but not over, 5 ounces.

Some scouts add weight to their car *before* it is painted or decorated, and then hide the holes or cavities that contain the weight with wood putty. If you do this it is important to remember that paint and other decorations, along with the nails, wheels and glue all add additional weight to each car. You must make allowances for these items or risk having a car that weighs too much. Adding weight is easier than taking weight off of the car! Therefore, many builders target a car weight that is slightly less than 5 ounces. These builders have a margin for error and add a little bit of weight if necessary at the weigh-in using a "weight port" (hole drilled) on the bottom of the car.

How can you tell how much your car weighs? You can always take it down to the post office and borrow their scale. Another option is to purchase a postal scale for the home, which doubles as a scale for baking (weighting flour and sugar is usually more accurate than measuring). The last option is to borrow a scale. The PWD chairperson usually has a scale available before the weigh-in.

Weights can be purchased in many places including the Scout Store in Pleasant Hill. The Scout Store has a variety of options to choose from, including lead rods (inexpensive), flat lead weights that screw onto the bottom of the car, and the more dense tungsten weights that allow for less moment of inertia (approximately \$18 per car).

Is all of this too complicated for the scouts or their Akela's? Not is building the car is a learning experience. I imagine in most elementary schools there is a teacher impressed with the kids who know about gravity, potential and kinetic energy, friction, aerodynamic drag, measuring, weighing, MOI (twisting), COG, fulcrums, and workshop safety because they built a PWD car (see diagram below). For some kids scouting is more than making friends and having fun. It is also a lesson in the principles of physics!

Here is a link to one of many fun articles that show how some in academia take the PWD seriously: <http://www.dispatch.com/content/stories/science/2012/04/08/engineers-tackle-pinewood-derby.html> .

Pinewood Derby physics

A pinewood derby car is a simple machine that demonstrates several fundamental principles of physics, including potential and kinetic energy, the force of gravity, friction and aerodynamic drag.

