

## Pack 3273 Pinewood Derby Tips and Tools

Compiled by Brad Spencer in 2011 from the works of many and following several years of building cars with marginal successes. This is not meant to be an exhausting study on the subject, opinions vary and many more resources are available. Questions and suggestions are welcomed. Have Fun & Good Luck!

### How Pinewood Derby Cars Work

Pinewood derby cars are gravity-powered vehicles. They start the race on a sloped track held back by starting pins. When the pins drop, the cars roll down the sloped track towards the finish line, guided by rails. Most tracks are built with a transition from the sloped starting section to a long flat section. On these tracks, cars must complete the flat section while maintaining as much speed as possible.

The only force that can be used to make the car move is **gravity**. But since gravity is a constant there is nothing you can do to get more! Fortunately, there are things you can do to get the most from this constant force.

While our ally, gravity, pulls the car down the sloped track, our enemy, **friction**, is hard at work slowing down the car. In every place where moving parts are in contact (wheels rubbing on the track, the axles, the car body, and the guide rails) friction is at work. Even the air flow over the car body is a form of friction that slows down the car.

A final factor that must be considered is **momentum**. In an automobile, momentum helps the car keep rolling when you take your foot off the gas. In a similar way, momentum helps a pinewood derby car to continue rolling as fast as possible on the flat section of the track. So, to build a fast pinewood derby car you must **maximize momentum** and **minimize friction**.

**1. Make sure your car weighs the full 5 ounces.** In our race, the maximum allowable weight for the car is 5 ounces. Momentum is maximized when your car has the maximum allowable weight for the race. For a five ounce maximum weight, you will likely need to add 2 or 3 ounces of weight to the car. ***I have seen many cars that didn't have the full 5 ounces total weight and they were not able to be competitive!*** Exposed lead or drilling of lead at the race site is prohibited by our District and our Pack.

**2. Add weight towards the rear of the car.** Most commonly you want as much weight as far back as you can without the front end coming off the ground and as low as you can on the car without obstructing the track. Putting the weight too far back might make your car pop up and maybe even jump off the track when it comes to the bottom, but putting it too far up front will make it slow down on the straight-away. The car should balance somewhere between 3/4 and 1-1/4 inches in front of the rear axle. Use a ruler and put it on edge and then try to balance your car on the ruler to see where your center of gravity is (some call this center of mass also).

You may be overweight when you completely finish the car, if that happens you can drill out some from the bottom of the car to bring it back down to 5 ounces. Just make sure you hold the car and the drill so metal pieces don't get into the wheels. The best thing to do is to actually have it slightly overweight when you take it to the races and make minor adjustments there to bring it down to the maximum using the official race scale as weight scales may vary a little. Our Pack race committee will have a drill or Dremel tool on hand for the boys to use for last minute adjustments.

**3. Aerodynamic design.** There are many elaborate ways to improve aerodynamics, but to simplify matters, let's use the following principles:

1. Low-profile cars (smaller surface area as viewed from the front of the car) will tend to outperform higher-profile cars.
2. Cars should taper from a smaller surface area in the front to a (possibly) larger surface area in the rear.
3. Edges running across the car should be rounded or tapered.
4. Wings, sails, flags, pennants, etc. add to the surface area, thus they tend to decrease performance.
5. Unfilled (major) holes or pockets can catch air and slow down a car.

To add some balance to this topic, aerodynamics is not as important as the other tips shown here, so I don't suggest that you sacrifice looks to achieve an aerodynamic shape. If you want to build a car that is not particularly aerodynamic, don't worry about it. Just make sure that the other design elements are carefully followed. Style and Fun are part of the enjoyment too!

**4. Polish the axles.** This is where most of your friction is built up. The axles are the 4 nails that come with the kit. They will have molding marks or burrs on the shaft that must be removed. You can do this by putting the nail in a drill chuck and using a steel file or even a fingernail file to remove the burrs from the head and shaft of the nail. Be sure to only take off enough to knock the burrs off. You want the nail to stay as large and as round as possible for your car. You can also use the file to give the head of the nail a slight taper so the wheel hub will have less friction when riding against the nail, just angle the file against the head while it's spinning in the drill.

Next you will want to start with some course grit wet sandpaper and begin smoothing the axle down. Cut the paper so you can hold it against 1/4" of the shaft from the nail head. Be careful not to remove too much of the nail's diameter. Use finer grit sandpaper each time you perform this procedure down to the finest paper you can find (1200 or 1500 grit works well). You can finish off the axle with some Metal Polishing compound if you wish. This will make the axle shine and bring it to a very smooth finish.

**5. Polish the Wheels.** The shape of the wheel needs to be as round as possible. The tread surface (area that touches the track) should be as smooth as possible. Rounding, narrowing, or grooving the wheel tread surface is prohibited. Use of the BSA official wheels is required. Lighter wheels are faster so avoid painting the wheels if possible.

In 2009 BSA came out with a new wheel. They no longer have the little dimple molding mark on the tread surface, it appears the wheels are now being somewhat machined (if your wheels have a dimple in the tread then you will need to sand the wheel until the dimple has been removed). With the new wheels, roundness is not so much of a factor anymore and plus you do not have to remove the molding mark, the tread surface is much smoother and doesn't require a lot of sanding. You will, however, still want to polish the inside hub of the wheel where it rides on the axle. This can be done with either a non-metal pipe cleaner or the shaft of a Q-Tip installed into a drill. Use a good plastic polish, apply to the pipe cleaner or Q-Tip and turn the drill on slow while sliding the wheel hub onto the rotating pipe cleaner. Make sure you clean out all the polish from the wheel hub after this process.

**6. Lift one wheel?** Some argue that having only three wheels touching the track will reduce friction / increase speed. Seems logical! Lifting one front wheel off of the track by angling/bending an axle upwards will provide a speed advantage. But make sure that the center of gravity of the car is behind the center point of the car. Test spin the wheels, and use the poorest spinning wheel as the lifted wheel. Be mindful of the resulting alignment!

**7. Lubricate the Axle and Wheel when you install.** Using dry graphite, (I suggest Hob-E-Lube graphite w/molybdenum) pour into the wheel hub and then install the axle into the hub and spin the wheel to a stop for 10 times. Do this same process two more times, adding graphite each time. Once you have finished, keep that particular axle with that wheel, you have now matched them together. Perform this procedure for all four wheels. Install the axle / wheel combination after all finish work is completed using just enough adhesive to hold the axle in place. Do not over glue as the excess can impair wheel performance and you may need to remove the axles and reinstall at some later time (like to prep for district races with your championship car!). When lubricating with graphite, take the time to work it in thoroughly; a casual puff before the race is not sufficient. Since graphite works best after a break-in period, don't re-lubricate between race heats.

**8. Alignment, Alignment, Alignment!** Next to polishing the wheels & axles this is the 2nd most important area to reduce friction. In order for the car to get to finish line as quickly as possible, it needs to go straight! If it zigzags down the track, it will travel a longer distance, but worse it will continually lose speed as it bumps and rubs against the guide rail. This should be your last and final adjustment for your pinewood derby car. Many people shove the wheels and axles into the slots and think they are done with the car. Without good alignment it doesn't matter what else you have done to the car, it will not be fast with poor alignment.

The simplest way to align a car is to put a long strip of masking tape onto a smooth table and roll the car down the tape to see how straight it goes. You want your car to go as straight as possible. Once you see if the car veers to the left or right you can start making adjustments to the axles.

It is preferable to see if you can adjust the axles without having to bend them. Once you bend an axle you can't go back without replacing it. Start by adjusting the front axles first. Take a small magic marker and mark all the axles with a small line pointing to the 12:00 o'clock position just like a clock hand coming from the middle of the head of the nail. This will help you know where you are at when you turn the head of the axle to adjust.

Turn either the right front or left front axle 1/4 of a turn and then roll the car again and see what results you get. If it still veers the same direction then try turning the other axle 1/4 of a turn. Keep turning until you get a different or better result and try to get it to roll as straight as possible. Work on the front axles until you can not make the car go any straighter.

You now need to start adjusting the rear axles. If your car veers right then check to see if the left rear is turning out or right rear turning in. Adjust the one that looks most obvious and then test drive again. Experiment until you can get the car to go as straight as possible. Try not to turn the axles too much as you may loosen them in the slots.

If you must bend an axle to align the wheels:

1. Determine which of the front axles appears to be the most out of alignment (or with a raised wheel, adjust the wheel/axle that is on the ground).
2. Make a mark on that axle where it comes out of the car body.
3. Remove the axle from the car and remove the wheel.
4. Using a vise, pliers, etc. very slightly bend the front axle at the point marked in step 2.
5. Replace the wheel and re-insert the axle.
6. Roll the car on a smooth and level surface.
7. If it does not roll straight, slightly rotate the bent axle by grasping the axle head with a pair of pliers.
8. Repeat steps 6 and 7 until the car rolls straight.

Once you are done with all alignment adjustments you may want to white glue the axles into the slots taking care not to let the glue get into the wheel. You don't want an axle to come out during the race!

## **9. Top Ten Common Mistakes:**

**Pointed, raised, or concave front end design** - Some online speed tips recommend creating a front end that will leave the starting pin faster. On our track the cars start against a raised center pin, if the front of the car is too pointed or concave it may be disqualified. The rules require that the front bottom of the car which rests on the pin is no higher than 1" above the track. The front end must be at least ½ inches wide in the middle. No part of the car can extend beyond the starting pin.

**Clearance** - If the car lacks sufficient bottom clearance it will “bottom out” on the center strip of the track, usually where the track slope flattens out. Make sure you have at least 3/8” of bottom clearance.

**Under-weighting** - Make sure your car will weigh the maximum allowed 5 ounces.  
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**Poor quality lubricant** - cheap dry lubes like automotive grade graphite will prove disappointing. Look for dry hobby lubricants like graphite with molybdenum (I like Hob-e-lube) available online and at most hobby stores.

**Wheel rubs on car body** - make sure the axles aren't so tight as to allow enough play so the wheel will roll freely. Some will lubricate the inside hub where the wheel contacts the body at the axle entry point. The use of washers or bushings is prohibited.

**“Illegal” components** - many online websites offer “speed kits”, specially lathed axles, machined/lightened wheels, etc. In most cases these items are prohibited by rules and easily identified. Your car may be disqualified if you use them.

**Car exceeds size specifications** - Some of the most interesting cars are much larger than the original wood block provided. Have fun with your design but be mindful of the overall size.

- **Width** - Not to exceed 2 3/4 inches

- **Length** - Not to exceed 7 inches

- **Height** - Not to exceed 3 inches

- **Nose** - No part of the car body, wheels or attachments may protrude in front of the starting peg.

**Mismanagement of expectations** - it's inevitable, with 80+ scouts and 16 or so awards, someone will be disappointed with their results. Winning is not the primary objective! Spending parent / son quality time, having fun planning, designing, building, and competing is what we're shooting for. This is a great opportunity to teach good sportsmanship, fair play, learning from experience. If your scout doesn't do as well as he would have liked then encourage him to work on ways to improve his design. Talk to his fellow scouts whose cars may have performed better to compare notes, gain knowledge and strive do better next year!

**Building the "perfect" car** - some pinewood derby cars clearly have never been touched by the scout! What's the fun in that? Typically, a well meaning adult has done all of the building and design removing the scout from the equation almost entirely. We encourage the scout to design, build and finish as much of his own car as possible perhaps leaving some of the power tools and or technically challenging steps to his adult partner. Please keep your scout involved, perhaps having him be responsible for building even more of the car each year as he grows older. If an adult wishes to show off some building skills (like me LOL!) we offer an opportunity for them to buy & build their own car and race it in the parent/leader class of races. ***FYI - the trophies for best design in all ranks is never awarded to a car that doesn't look like the scout had a hand in its creation!***

**Not knowing about a rule** - Read the rules and follow them, nothing ruins a scout's day like building a great car only to have it be disqualified or forced to make unattractive alterations on race day! Rules are posted to the web at [www.pack273.net](http://www.pack273.net) and at: <http://www.northernstarbsa.org/Forms/Activities/PinewoodDerbyRules.pdf>.

***Remember that learning while having fun is the goal.  
Let's have some fun! See you on race day!***

***B^)***