Car Clinic

For Cub Scout Pack 335

Tuesday, December 19, 2017

Dads not admitted without a Scout.

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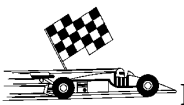

About this document

This document was prepared as a hand-out for participants in a Pinewood Derby Car Clinic conducted by Boy Scout Troop 206 for members of Cub Scout Pack 335, both of River Vale, NJ. It has been updated several times to reflect changes in local and district race rules, as well as adding lessons learned since the first clinic.

The purpose of the Clinic is to "level the field" and provide everyone – newcomers as well as veteran Pinewood Derby racers – with the information necessary for them to make the best car that they can make.

The information contained is based on years of participation in Pinewood Derby as both a Scout's parent and race official. During that period, we built 8 cars, five of which were raced, winning first, second and third place trophies at the Pack level, and an appearance award almost every year. As race official for more than 20 years with at least 90 cars run each year, we have seen just about everything that can be done (especially that can be done wrong), and have a pretty good idea of what works and what doesn't work. The Physics section and information related to placement of weights was helped by an excellent technical education including 8 semesters of high school and college physics as well as numerous related engineering courses. Much of what is on the internet regarding Pinewood Derby speed has been reviewed. Some of the concepts contained here were triggered by something on the internet.

If it didn't make sense, or hasn't proven out in our experience, you will not see it here. You will also not see it here even if it works, if it is not in conformance with our local rules.

The use of any tips or suggestions in this document is at the car builder's discretion. We strongly urge you to make sure that any tips you find here (or anywhere else) will not result in your car violating your local rules. The first suggestion at the "Basic Stuff" is that the car has to meet the rules that you will be running under.

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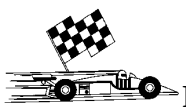


What is Pinewood Derby?

Pinewood Derby is a Cub Scout activity for father-son (or other adult-boy) teams to work together.

Each team builds a small car that is raced against cars built by other teams. Cars are also judged for appearance.

Each team starts with a Pinewood Derby car kit, which contains:

- Block of wood (the body of the car)
- 4 axles (large-headed nails)
- 4 molded plastic wheels
- Instruction/rules sheet.

Please note that both the instructions and rules contained in the kit are generic. Each local area (Pack, District) runs its races based on its own rules, which may be more or less restrictive than the generic rules that come in the box. **Make sure that you know, and conform to, your local rules**.

The general process is as follows:

1. Decide what you want your car to look like. Draw the design on paper first.
2. Transfer the design to the wood block.
3. Shape the wood block.
4. Finish the wood block (sand and paint).
5. Decorate the wood block (decals, stickers, add-ons)
6. Adjust the weight.
7. Prepare and install the wheels and axles.
8. Race Day.

The process of building the car is the most important part of Pinewood Derby. If the Scout is to get the most out of Pinewood Derby, it is important to remember that it is the SCOUT's project to be completed with dad's HELP.

The tips on these pages are intended to help your cub scout's car be the best that it can be – regardless of the tools he has available, and the amount of skill that either you or he possess.

It is possible to make a car that is both fast and looks good. It is possible to do this without having a machine shop, if you just take a little care in the process. Remember – the car is the CUB SCOUT's project.

Pinewood Derby History

2003 marked the fiftieth anniversary of the first Pinewood Derby race. Pinewood Derby started at Pack 280C in Manhattan Beach, CA in 1953. It was the idea of Cubmaster Don Murphy, who was looking for a smaller-scale version of the Soap Box Derby for his Cub Scout son.

From *Scouting* magazine:

So Murphy came up with the idea of a miniature car race, recalling the time when he was growing up in La Porte, Ind.

"I'd made models of airplanes, cars, boats, and any number of other structures and remembered the pleasure I got out of doing it," he said. "I also wanted to devise a wholesome, constructive activity that would foster a closer father-son relationship and promote craftsmanship and good sportsmanship through competition."

He asked the Management Club to sponsor a miniature racing event for his Cub Scout pack that he had named a "pinewood derby." The club agreed to pay for the wood and other materials.

Murphy designed a miniature car that could be carved out of soft pinewood and wrote the rules.

"Pack 280C had seven dens and den mothers," remembers Murphy, "and totaled 55 Cub Scouts at the time. Originally the block of wood we included in the kit was carved down in the forward third to a kind of cockpit. We put the wood, wheels, and nails into a brown paper sack with an assigned number. Some Cub Scout fathers built a 31-foot race ramp with two lanes and a battery-run finish line made from doorbells. Light bulbs would identify the winner."

Catching on like wildfire

The derby was an instant success and for a time was copied, with the Management Club's permission, by the Los Angeles County Department of Recreation. Then word reached the national director of Cub Scouting Service, O. W. (Bud) Bennett, who wrote Murphy:

"We believe you have an excellent idea, and we are most anxious to make your material available to the Cub Scouts of America."

Within the year the pinewood derby was adopted for use in all Cub Scout packs. In its October 1954 issue, *Boys' Life* publicized the event and offered plans for the track and a car, which featured "four wheels, four nails, and three blocks of wood."

Through 1991, BSA has sold over 81 million pinewood derby car kits. More than a million cars are made every year.

The role of Cubs and Dads

Note: for this discussion, "Dad" is dad or any substitute adult/older sibling partner in the role of "Dad" for Pinewood Derby.

Pinewood Derby is a project for Cub Scouts (Lions through Webelos) working with their Dads. This should be a two-way relationship, where the Scout and Dad both give to and receive from the other.

Primary Rule:

Don't do for a scout what a scout can do for himself. You will be surprised what a scout can do when you let him!

It is important that the Scout be permitted to do as much of the physical work as possible with his own hands. The Scout should make all or most of the important decisions. Ultimately the car should look the way the Scout wants it to look. If you are thinking that this might result in a car that is a bit slower, or that doesn't have a perfect paint job, or that it couldn't be as good as it might be if Dad did it all – you're right. But it will be a car that the Scout can honestly and proudly say is HIS car.

OK – that seems to say that Dad doesn't have much to do. So – just what is Dad's role? Dad is advisor. Dad helps to hold the car when Scout is shaping it. Dad makes suggestions. Dad provides ideas (but lets Scout decide whether to use them or not). Dad demonstrates how to use the tools – correctly and safely. Dad makes sure Scout works safely. Dad operates the power tools. Dad does the things that Scout cannot – assuming that Scout wants them done. Dad provides lots of praise when things go right. Dad provides lots of support and encouragement when they don't. Dad makes sure that the car complies with the rules. Dad provides transportation to the supply shop for car accessories. Dad cheers loudly when his Scout's car is run on race day. Dad cheers when his Scout's friends' cars are run on race day. Dad applauds when the winner is announced – whoever it is. Dad provides appropriate congratulations if his Scout's car wins. Dad demonstrates good sportsmanship and congratulates the winner's dad if it doesn't. After the race, Dad discusses with the Scout how they did – what was done right, what could have been better, what will be done next year. If you are thinking that this might result in a car that is a bit slower, or that doesn't have a perfect paint job, or that it couldn't be as good as it might be if Dad did it all – you're right. But it will be a car that Dad can honestly and proudly say is his SCOUT's car.

There will be a difference between the amount of "Hands-on" help Dad will do for a Lion or Tiger, and what he will do for a Webelos. Scouts are maturing rapidly in these years, and with that growth comes significantly increased ability to do the job himself. Because most tools are built to be used by adults, a Lion or Tiger may not even be able to properly hold some tools. The tool may be too heavy for a Tiger to lift or control. Use a little judgement and you will know what Dad has to do and what he should let the Scout do. Where possible, do it together. As a Lion or Tiger, it may be necessary for Dad to actually do the rough cutting – but let the Tiger have his hands on the saw handle. As a Wolf, he may still need Dad's hand on the saw for

guidance. As a Bear, maybe Scout can do it by himself with Dad observing. It is a process of growth.

Pinewood Derby should be a learning experience for both Scout and Dad. Scout will learn how to make decisions, how to use the tools and work the materials. Dad will learn that Scout really can do it with his own hands.

Scouts Practice NOW:

"Dad, it's MY car!"

Repeat as necessary.

There are three situations in which Dad should overrule the Scout:

The scout is doing or intending to do something unsafe.

The scout wants to do something that will violate the rules.

The scout wants to do something that will interfere with the car being able to roll on the track.

Even in these situations, the overrule should be accompanied by a discussion of WHY.

About the track

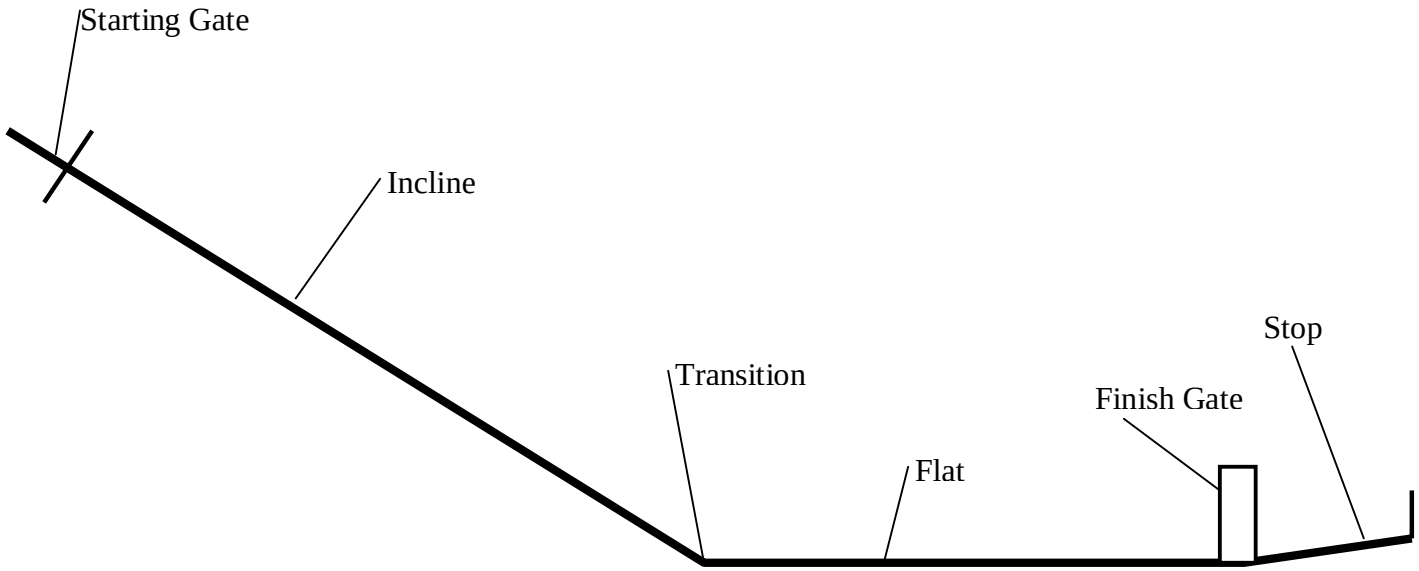
You have to know about the track. The track controls many of the aspects of car design, and without this knowledge, you will not understand why certain design elements are necessary.

Track cross-section: If you cut across the track, and look at the cut end-on, you will see a cross-section of the track. There is the track base. Older pack-made tracks usually have plywood or masonite base, possibly surfaced with Formica or similar material. The track will have two or more parallel lanes. Each lane consists of a raised guide strip, approximately ¼" high and 1 5/8" wide. During the race, the car will straddle the raised guide strip, which provides the "steering" as the car runs down the track. On most newer tracks (including Pack 335's and Tree Rivers District tracks), the running surface and raised strip are constructed of an aluminum extrusion, which tends to result in a faster track. The important thing about the track cross-section when building the car is that the space below the car body and between the wheels must fit on your track's guide strip. If it does not fit, the car will either get hung up, run sluggishly or jump the track.

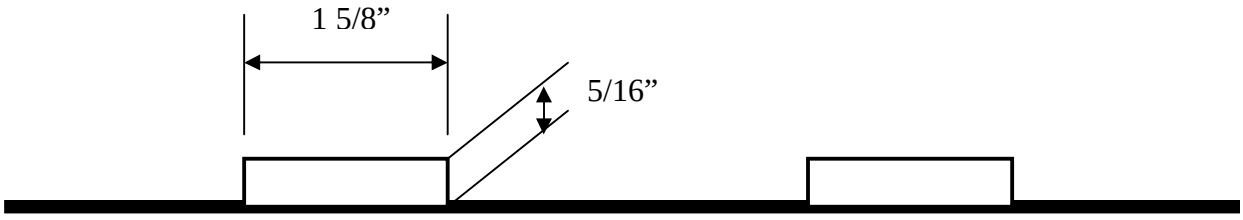
Track profile: If you look at the track from the side, you will see the track profile. Most tracks are about 32 feet long from start to finish, although some tracks (particularly those with aluminum track beds) are longer. On most tracks, the starting gate is located about 48" higher than the finish line. The typical track profile has 6 sections:

- The starting gate. This is where the cars are placed at the beginning of each heat. The lane guide strip extends to the back of the starting gate. The starting mechanism is located at the front of the starting gate. Typically, the starting mechanism consists of a peg or stop in each lane, that is rapidly lowered to start the race. If an electronic timing system is used (as in Pack 335 and Three Rivers District), the timing mechanism is connected to the start gate so that the time starts when the gate is lowered. The front of the car must be low enough so that the car can rest against the starting mechanism. If it does not, the car may have to be run backwards, or something may be placed between the car and the starting mechanism. This can only hurt the car getting out of the start gate.
- The incline. The upper portion of the track is on an incline, typically 30 to 45 degrees above horizontal. This is where your car accelerates. On a given track, the length and slope of the incline is the same for every lane. This is the main place where your car can speed up. If it doesn't get going here, it is not going to get going.
- The transition. This is exactly what is implied by the name – where the track changes from the incline to the flat. Depending on your track, the transition may be longer or shorter. In any case, the car should enter the transition gaining speed, and leave it maintaining the speed it already has.
- The flat. The final section before the finish, it is either level or nearly so. In either case, the important thing here is to maintain the speed that was generated on the incline and through the transition.
- The finish gate. If there is an electronic timer or finish line, this will be like a bridge across the track, containing a switch paddle or other sensor that determines when the car crosses the finish line. The important thing here is to make sure that your car fits under the finish gate. **The gate on Pack 335's track limits car height to a maximum of 3 ½".**

- The stop. This stops the car from running off the end of the track. Usually it includes a raised guide strip (this lifts the car off its wheels so that friction against the bottom of the car can slow it down) and some sort of trap that will catch the cars. Because each car will have more than one run, it is important that the car is not damaged at the stop. This means that everything on the car, and especially on the bottom of the car, be well secured.



Track Profile

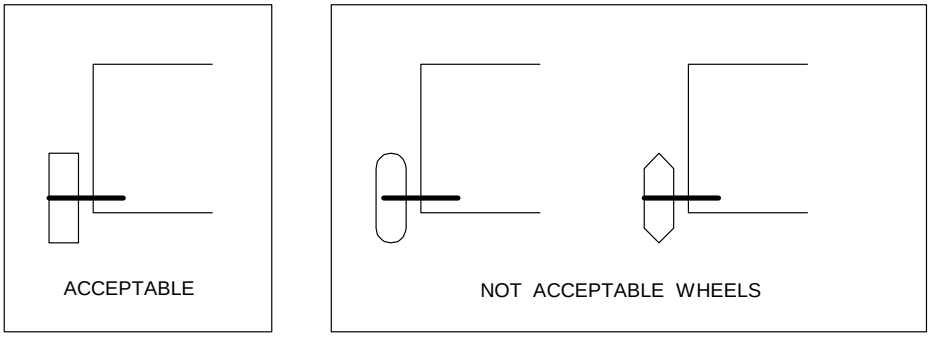


Track Cross-Section

The Rules

The rules vary based on local practice. The "basic" rules are shown on the instruction sheet that comes in the car kit box. **Make sure you are familiar with your local rules.** You do not want to be disqualified because of non-conformance to the rules. For the current (2017-2018 Scouting season) year, Pack 335 has decided to follow the same rules as posted for the Three Rivers District. The Three Rivers District rules are listed at the end of this document.

Note on wheels:



Pinewood Derby Physics

Pinewood Derby races are simple Physics demonstrations. When building a car, therefore, it helps to understand the physics involved.

Let's start with the concept of the center of gravity (abbreviated as C.G.). The C.G. is the place on the car where the car is perfectly balanced. Picture a playground see-saw with two boys who weigh the same – one on each end of the see-saw. The C.G. will be at the center of the see-saw. If a third boy gets on one end, the C.G. shifts closer to the end with two boys.

In a Pinewood Derby car, you can consider the location of the C.G. as if all of the car's weight was located at that point. This concept is important in understanding how location of the car's weight (i.e. the C.G.) affects the car's performance. The location of the C.G. of your Pinewood Derby car will affect the basic available speed of the car, and to an extent, the car's stability on the track.

During the race, at any given point your car will be doing one of two things: speeding up or slowing down. If it is not speeding up, it is slowing down. When you build the car therefore, you want to maximize the portion of the track on which the car is speeding up, and minimize the portion where it is slowing down. The distance between start line and finish line is fixed on any given track. The lengths of incline, transition and flat sections between start and finish are also fixed on any given track.

At the top of the track, your car will have Potential Energy. The amount of Potential Energy is dependent on how high the car is, and its weight. Once the car starts to move, some of this Potential Energy will be converted into Kinetic Energy (the energy of movement). Some of it will be converted to Heat (through friction, rubbing, air resistance). You want to convert as much Potential Energy as possible to Kinetic Energy, and as little as possible to Heat.

On the incline section of the track, the car is basically in a controlled fall. The maximum possible speed of the car at the bottom of the incline (Kinetic Energy) is a factor of the distance that the car falls. The further the car falls, the faster it will be going when it stops falling. This distance appears to be controlled by the layout of the track – the effective fall will be about 48". However, how you build your car can increase or decrease the effective fall as a result of where you put the center of gravity. The target is to maximize the height of fall of the C.G., which effectively maximizes the available Potential Energy at the start line. This can be accomplished by making the C.G. as high as possible at the start gate, and as low as possible at the end of the transition.

Remember – at the start gate, the front of the car is against the starting mechanism, and the car is on an incline. Therefore, a car with its C.G. at the front of the car will be starting with its C.G. lower than a car with its C.G. at the rear of the car. As a result, you want to put the C.G. as far back as possible, effectively giving the car a greater starting height (more Potential Energy). **See warning regarding car stability and location of center of gravity.**

The car will then accelerate down the incline and through the transition until the car is on the flat section, and the car will stop accelerating. At this point, the location of the C.G. is also important, because this controls the location of the "bottom" of the fall (and thus the location of the end of acceleration (and start of slowing down)). If the C.G. is located over the front wheels, the acceleration stops when the front wheels reach the flat (there is no Potential Energy left). If the C.G. is at the rear axle, the car continues to fall until the rear wheels reach the flat. This means that the car will be accelerating (or decelerating) an additional distance of about 4 ½" if the C.G. is at the rear axle. Add this toi the 4 ½" further that the C.G. moved at the starting gate, and you have gained a 9" advantage. This is about 2.4% of the track length, and about 5% of the acceleration portion of most tracks. This may not seem like much, but it is the main reason that some cars seem to jump ahead of others coming into the flat. Think about it – would you prefer that your car was accelerating or slowing down for these 9"?

The height of the C.G. is also important. If the C.G. is near the top of the car, the bottom of the fall will be higher than if the C.G. were low in the car. Because of the incline, the effect of height of C.G. is less at the start gate. Since the goal is to maximize the fall distance, a low C.G. is better than a high C.G. Note that this also helps car stability – a car with a low C.G. is more difficult to run up on the guide strip and lose control (think of sports car vs. SUV roll-over stability).

While the car is accelerating, there are other forces working to slow it down. These will continue to work when the car reaches the flat, and is no longer accelerating. With the exception of angular momentum of the wheels, these can all be controlled and minimized. Here are some of those forces (most of these result in conversion of energy to Heat – useless for making the car go faster):

- Friction between the wheels and axles. This is proportional to the weight of the car, area of contact between wheel and axle, and the coefficient of friction between wheels and axles. This can be controlled by preparation of wheels and axles, and lubrication. Even if you don't prepare and lubricate well, this force is much less than the acceleration and momentum gained by having a heavier car.
- Wheel binding. The axles must be installed so that there is a small amount of "play" between the wheel hub and the car body/axle head. If you put the axle too far in, the wheel hub will be bound up between the car body and axle head. With a little care, this should not be a problem.
- Friction between wheels and car body. Paint the car early (so the paint is fully dry) and lubricate.
- Rolling resistance of wheels. If the wheels are not smooth and round on the running surface, they will not roll as easily. Prepare the wheels (remove mold flash and sprue from tread of wheels).
- Rubbing between wheels and guide strip. Prepare the wheels (remove mold flash on edge of wheel) to minimize effect, and align axles so that car runs straight and does not rub as much.
- Air drag. Use an aerodynamic shape, minimize front area, and make the car body smooth (do a good job finishing).
- Angular momentum of spinning wheels. This is what keeps a bicycle tire (or pinewood car wheel) spinning. It works against you at the start (you have to get the wheel spinning) and

for you on the flat (wants to keep spinning). There isn't much that the rules allow you to do to correct this, so don't worry about it.

The car now reaches the flats – and this is where your car has to maintain as much of the speed it gained on the incline as possible. All of the forces above will be working to slow the car down. The ONLY thing that keeps it going is its momentum (Kinetic Energy), which is directly proportional to the weight of the car – the more weight, the more momentum. The more momentum and the less the car will slow down. So you want more weight – as much as the rules allow – when the car hits the flat.

This brings us back to acceleration. A heavier car will have more Potential Energy at the start gate. This will all convert to Kinetic Energy as the car accelerates (except for energy lost to Heat). Because the race environment is not a perfectly controlled laboratory – in a vacuum, no friction or air resistance – the weight of the car DOES matter. A heavier car will accelerate better than a light car. This will be to a much greater extent than the friction factor that is also dependent on the weight. Therefore, during the acceleration phase, you also want the car as heavy as possible.

Warning – car stability and location of center of gravity

The stability of your car will also be affected by the location of the C.G. As discussed above, from the perspective of acceleration, you want the C.G. as far back as possible. There is a practical limit however. If the C.G. is behind the rear axle, the front wheels will not stay on the track, as the car will pivot on the rear axle (picture the see-saw with only one Cub Scout on one end). This will cause loss of front end steering, and may cause the car to jump off the track (a similar effect happens if the C.G. is in front of the front axle). You do NOT want this to happen. Therefore, the C.G. should be a small distance in front of the rear axle.

Axle Placement

The current Pack and District rules allow axles to be placed anywhere (it is not necessary to place the axles in the slots of the block). Moving the axles closer to the end of the block will result in the car running straighter, and therefore not rubbing on the guide strip as often. As note above, running against the guide strip is one of the factors that cause the cars to slow down. In addition, moving the real axles back also permits the C.G. to be further back without creating stability issues. The axles should therefore be placed as close to the front and back of the car as possible without exceeding the maximum car length.

BASIC STUFF

Or – what to do so you won't be totally embarrassed on race day

Build your car so it meets the rules.

(You don't even get on the track if you are disqualified.)

Make sure the car fits the track.

If the wheels are too close together or the bottom of the car is too close to the track, it will hang up on the guide strip. If you add weight on the bottom, make sure you remove some wood first so that the weight does not stick out below the bottom of the block. If you make the car narrower than the block, be sure to leave the original block width at the axle locations.
This is THE NUMBER ONE reason that cars do not race well.

Make sure that your car fits under the finish line gate.

(If it can't get under the gate, it won't get to the finish line.)
Maximum height for Pack 335 is 3 ½". District gate is taller, so Pack gate controls.

Make sure the axles are securely attached to the car.

(If a wheel falls off, the chances are that the car won't make it to the finish line.)

Car design and construction for speed

From the Pinewood Derby Physics essay we learned:

- Make the car as heavy as possible.
- Put the C.G. as far back as possible, but in front of the rear wheels.
- Put the C.G. as low as possible.
- Use an aerodynamic/low profile shape.
- Put the axles as close to the ends of the car as possible.

If you look at the basic kit, you will note the following:

- The block of wood is not very aerodynamically shaped.
- There are 2 axle slots, one is closer to the end of the block than the other.

The components of the kit total about 3.5 ounces, about 1.5 ounces less than the maximum 5-ounce allowance.

Putting this together with what we already learned:

- We are going to have to cut and shape the block.
- We do not want to reduce the width of the block at the axle locations. This could cause problems with the car binding on the track.
- Do NOT make the block shorter. This would result in moving the C.G. toward the front of the car.
- Use the axle slot that is closer to the end of the block for the REAR axle. This will allow the C.G. to be further back while still being in front of the rear axle. This makes about 5/8" difference in location of C.G. Better yet, create NEW locations for the axles closer to the ends of the block.
- Removing wood from the top of the block will produce a lower C.G. (good) and a more aerodynamic shape (good).
- Weight will have to be added to reach the maximum allowed.
- Added weight should be low (best at the bottom of the car) to keep the C.G. low, but NOT BELOW the bottom of the block, which would cause the car to bind on the track. Putting the weight at the bottom means that it does not have to be pretty, and can be adjusted on race day.
- The bottom of the block will have to be drilled or gouged to provide space for the weight (so it doesn't bind on the track).

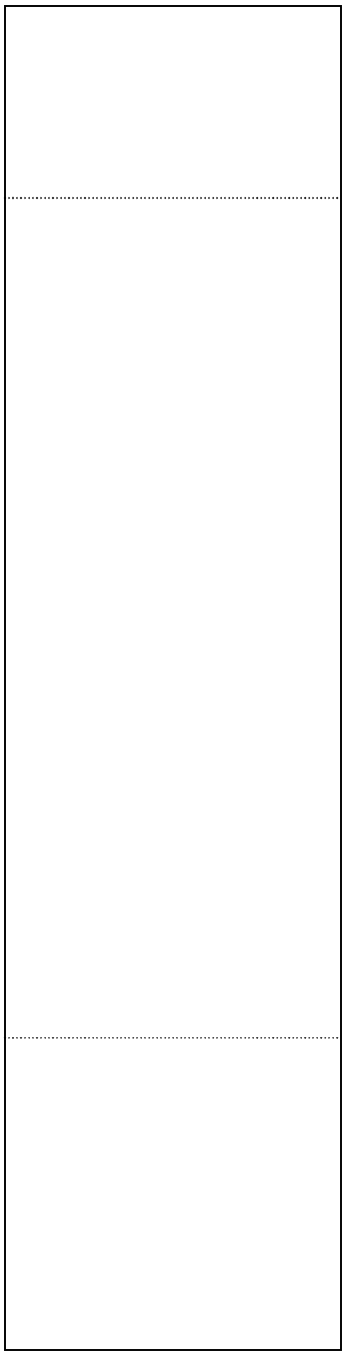
Use the design sheet, mark the front and rear of the side and top views (remember which slot is the rear axle). Now let's look for some design considerations for APPEARANCE.

Everything else being equal:

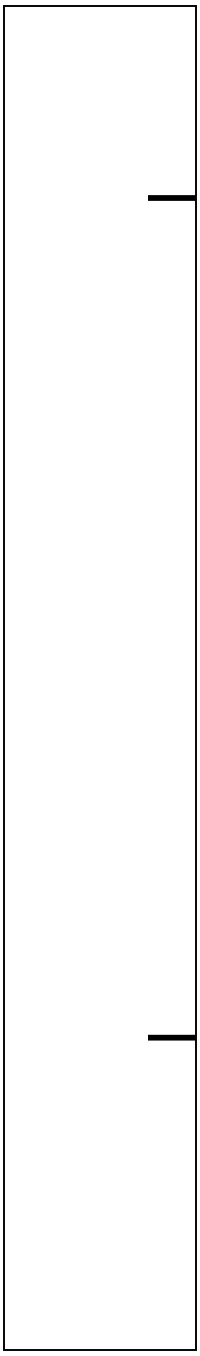
- Heavier car is faster
    - Car with weight further to rear is faster
        - Car with weight lower is faster
- Car with polished axles is faster
    - Car with mold flash and sprue removed from wheels is faster
        - Car with lubricated wheels and axles is faster
            - Car with properly aligned wheels/axles is faster
- Aerodynamically shaped car is faster
    - Car without lots of stuff “stuck on” is faster (because it is more aerodynamically shaped)
        - Car with completely dry paint (i.e. at least a week since last coat) is faster
            - Car that is well-sanded and polished is faster
- Car with axles close to ends of car is faster

Car Layout Sheet

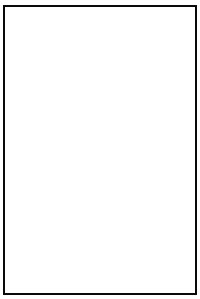
Use this page to draw your car design. (Make copies first.)



Top View



Side View



End View

Car design and construction for appearance

If you look at all the things that you should do for a FAST car, you don't find anything that says a fast car can't look good, too. Positioning of the wheels and keeping the car low / aerodynamic are the only things that really affect appearance at all. And if you consider that most real race cars are low and aerodynamic, there is almost no conflict between the requirements for speed and the ability to make your car look good.

Most years, Pack 335 has about 25 – 40 appearance awards, compared to 3 speed trophies at each program level (Lions, Tigers, Wolves, Bears, Webelos). If you consider that there are always more awards for appearance than for speed, you have a better chance taking home an appearance prize than a speed prize.

What are the keys to building a good-looking car? Try these:

- Imagination.
- Attention to detail.
- Take your time to do it right.
- What would YOU look for if YOU were judging the cars?
- Think about what you are capable of doing well – and do it.

Maybe it helps to have an idea of what the categories for appearance prizes are. These change every year, and are usually not determined until race night. Here is a sample of some that we have used in the past:

- Most realistic
- Most colorful
- Best (obviously) boy-built car
- Most original
- Most unusual
- Most expensive (only when there are a number of cars that use coins for weight – winner determined by counting value of coins on each car)
- Most radical
- Best paint job
- Best decorations
- Best in show

What are the judging criteria? Whatever strikes the fancy of the judges on race night. Be assured that the judges take their job seriously, and try to make sure that whatever the categories, the judging is fair.

Well. Let's get started.

Take out that car design sheet that you labeled "front" and "rear" on when we were doing the speed design. Make some copies, and then start to put your ideas down on paper.

Keep in mind everything that we discussed under speed. Remember that it is usually easier to cut the basic shape from the block, then add something on, than to cut everything out of the solid block.

Remember that on race night, race officials will place a ¾" sticker on your car to identify it. You might want to leave a place on the top of the car for the sticker so that it doesn't affect your decoration and appearance.

Consider the materials that you will have to work with:

- The kit components (including "waste" wood that you cut off when shaping the car block)
- Paint
- Decals
- Stickers
- The weights - these can serve as decorative elements, or you might want them hidden
- "Stuff" – Legos®, Construx®, dowels, toothpicks, plastic soda bottle parts, bolts, nuts, nails, screws – anything you can imagine.

Try several different ideas on paper, then select one.

It is possible that you will decide to give up something from the "speed" stuff to achieve your desired appearance. This is YOUR decision, and it is typical of decisions that are made all the time by real car designers.

Transfer your selected design to the wood block, and you are ready to start building your car.

ALMOST BASIC STUFF

Down the track isn't good enough – you want a bit faster?

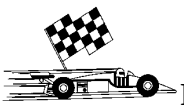
Lubricate your car's wheels and axles.
(Reduces friction – graphite is best.)

Make your car as heavy as the rules allow.
(For acceleration & momentum.)

Pay attention when you install the wheels and axles.
(They should be reasonably straight and secure. There should be a little bit of play so that the wheel is not bound up. The only stuff on the wheels and axles should be lubricant (no sticky stuff. DO NOT use solvent-based lubricant.).

Paint the car early.
(Paint takes time to dry and cure (at least a couple of days). Paint that isn't completely dry may cause the wheels to stick.)

Don't play with the car until AFTER the race.
(Play with it and you might do something that will hurt performance.)



Building the car

Warning: All tools should be used with proper adult supervision only. This is especially true with cutting tools and any power tools (including battery powered tools).

The car body.
After you have transferred your design to the wood block, the first thing that you should do is to make sure that the axle slots are square to the sides of the car body. If they are not, you will have to correct them. If you are going to move the axles closer to the ends of the car, now is the time, before making any cuts on the block. The best way to do this is with a drill bit slightly smaller than the size of the axle, in a drill press. If you ask around, you probably know someone who has a drill press and will help you with this step. This will only work if you do it before you do any cutting on the block, because you need the square side of the block as a guide against the drill press table. Some hobby suppliers and Scout Shops also sell a jig made specifically for this purpose. Jig or drill press could be a den activity where all scouts true the slots or drill new axle holes together.

Using the drill press or jig set to drill a hole perpendicular to the drill press table, run the bit into the block at the top of each axle slot or at the new location which should be the same distance from the bottom of the block as the top of the kit axle slots to maintain proper underclearance.. This will make a straight pilot hole for when you install the axles later. This is the ONLY step that requires the use of any but basic hand and hand-held electric tools.

Now you can start to shape the car body. Straight cuts can be made with a handsaw. Curved cuts will require a coping saw. It helps if you use a vise or clamps to hold the block while you are cutting. If you have one, a band saw can be used, but this takes away from the scout being able to do the work. It helps to cut a bit OUTSIDE the lines – you can always take off a bit more with a file, rasp, plane or by sanding, but it's hard to put back on once you take it off!

After the big cuts are done, it's time for shaping. A rasp is good for rough shaping. Files and progressively finer sandpaper do the fine shaping. A good pocketknife can also be used to carve away unwanted material. Keep working until you get the shape that you want. Use special care to avoid cutting away any of the wood around the axle slots – either on the sides (this might reduce the effective wheeltrack and cause the car to bind on the guide strip) or on the bottom (you might accidentally split off the wood necessary to hold the axles). Don't forget to make a place for your add-on weights.

If you are adding decorative elements that will be a part of the car, this may be the time to install them. Others might be added after sanding, or after painting – it depends on your design and what you are adding.

Once the car is rough shaped, it's time to finish sand. Use courser grades of sandpaper first, then progressively finer grits. It may be necessary to use a wood filler to correct gouges or other defects in the shaping – this is the time to do that. Make sure the filler is completely cured

before continuing the sanding. Go at least to extra fine grit to best prepare the block for finishing.

Clean the work area as you go. When you are done sanding, you have to either clean up all your dust, or find a clean place to paint. Mom's kitchen probably is clean but does not qualify as a good place to paint! Use a tack cloth (rag with mineral spirits) to remove all dust from the block.

Spread some newspaper (to protect your work surface) and apply a wood sealer to the whole car body.

After the sealer is dry, sand lightly with extra fine sandpaper, remove dust with the tack cloth, and apply the first coat of paint. Allow to dry. After each coat of paint, check for blemishes, sand and tack if necessary, then apply the next coat. Several thin coats are preferable to one thick coat. Thin coats are easier to control (less drips and runs), and dry faster.

After the last coat is DRY, you can put on any remaining decorative elements. You may also want to use a little bit of polish (car polish works well on enamels and car paints) to complete the finish. Note that polish will probably interfere with adhesives, stickers and decals, so you do NOT want to polish if you are going to add these.

The wheels and axles.
While you were working on the car body, you should also have started preparing the wheels and axles.

Start by finding a nail that is slightly smaller in diameter than the axle hole on the wheels. Place all 4 wheels on the nail, and chuck the nail in a drill press or hand drill so that the wheels spin when the drill is turned on. Staple or tape a piece of fine sandpaper to a flat board. Operate the drill at slow speed. Very carefully press the sandpaper board against the tire tread until all unevenness on the wheel treads is removed. **Be very careful to not overheat the plastic or cause the wheels to turn against the nail. Doing either may ruin your wheels.**

Remove the wheels from the nail. Place ONE wheel on the nail, with the inside edge of the wheel facing the nail head. Chuck the nail in the drill. Operate the drill at slow speed, pressing the sandpaper board against the inside edge of the wheel rim, removing any irregularities. Be careful not to change the shape of the wheel. Use the same caution as before. Repeat for the other 3 wheels.

Note: some Scout Shops and hobby stores also sell jigs to "shave" the wheels, which perform similar tasks for dressing the wheels.

Using a small magnifying glass (10X is ideal), look at each axle nail – under the head and along the shaft below the head. You will probably see burrs from the manufacturing process on both the head and shaft. You will also probably see several raised ribs on the shaft parallel with the head. The burrs will contribute to friction between the wheel hub and axle, so you want to

remove all of the burrs. The ribs will help reduce the contact area between the wheel hub and axle, so you want to leave them.

Start with a very fine file (like a fingernail file). Chuck one nail in the drill so that about ½" and the head sticks out of the chuck. With the drill running, press the file against the underside of the nail head. Use narrow strips of progressively finer sandpaper or emery cloth to finish the job of removing burrs from the nail with the drill running. Check your progress with the magnifying glass. Finish with jeweler's rouge or automotive rubbing compound on a strip of rag. When you are done, make sure you get all of the compound off the nail – it is a very fine abrasive and will add friction if not removed.

Leave the wheels and nails in a small zip-lock bag containing graphite powder. Rub the graphite onto the nails. Do this 2 – 3 times.

Get a small box that will fit the 4 wheels. Insert a nail in each wheel. Place some graphite powder at the wheel hub (both sides). Use your finger to spin the wheel on the axle. It should spin very freely for a long time. If not, go back and check how you prepared the wheels and axles (especially the axles), correct if necessary. Repeat for all 4 wheels and axles. Once you have put a wheel together with an axle, NEVER TAKE THEM APART. You are trying to make 4 matched sets. Every day, apply graphite and spin the wheels several times. Continue as long as possible.

Check the weight

Once the block is painted and decorated, and the wheels are prepared, check your weight. You should have your add-on weights ready also, and a way to adjust them. Use an accurate scale – a good postal scale works well. Usually the post office will cooperate if you don't go when it is real busy. Place the car, wheels and axles on the scale. Add weight until you are just over the maximum allowed weight. Keep everything that makes your weight together, and take it home.

Install the weight

Install the weight so that it is secure. If you are adding weight at the bottom (recommended – remember to keep the weight low), make sure that the weight does not stick into the required underclearance space.

Install the wheels and axles

If you did the wheel preparation correctly, you can spin the wheels and they will all spin for a long time. Some experts suggest placing the "fastest" wheel in one corner, the next fastest in the opposite corner, and so on, to "balance" the relative friction pull. In theory this should make the car run straighter. In practice however, it is impossible to apply the same starting speed to each wheel, thereby making any measurement of relative wheel speed all but impossible.

Therefore, we are just going to install the wheels.

First, rub some graphite into the paint finish on the side of the car at the axle slot/hole. It only needs a ¼" or so around where the axle will go.

It is imperative that the wheels be installed straight, otherwise the car will tend to run to one side or the other. Assuming that the axle slots were trued before you cut the block, this should not be a problem. You can test this by drawing a straight line on a board, placing the car on the line, and lifting one end o the board a couple of inches. The car should roll along the line. With this test, you are NOT looking for FAST. You are looking for STRAIGHT travel. Adjust the wheels and axles until the car rolls straight. Now hot-glue the axles in the axle slots, making sure to keep the hot glue away from the wheels (including 1/8" of the slot closest to the wheel).

Put the car someplace where it will be safe from mom, dad, brother and sister, the dog, cat and anyone/anything else around the house. Every day, lubricate each wheel with graphite and spin it a few times.

Do a final check. Do you have the required underclearance? Do you meet all of the rules requirements? Do the wheels turn freely? Are the axles securely attached? Does the car run straight? Did you have fun? Are you ready to RACE?

Put together your pit tool kit:
Screwdriver
Extra Weights
Graphite
Means to adjust (add/remove) weight
Glue (quick setting)
Something to carry it all in.

The Weight

We have established that the weight of the whole car should be as close to 5 ounces as possible. In fact, on race day, you want to go in just a bit over 5 ounces, because you will be allowed to remove weight, but not add it, at car check-in.

Where does the weight come from?

- The kit components – block, wheels and axles (about 3.5 ounces)
- Less what you remove when cutting the block (may be more than half of what you started with)
- Paint (a fraction of an ounce)
- Decoration (depending what you add, this may be nothing, or anything up to several ounces)
- Added weight

What do you use for added weight?

- Coins
- Fishing weights
- BBs
- Nuts, bolts, nails
- Specialty Pinewood Derby weights

The specialty Pinewood Derby weights come in two basic types – round cylinders and flats. Both types are designed so that pieces can be broken off to adjust the weight. This can be useful for quick adjustments on race night.

It is up to you what you use – just make sure that whatever you use is securely attached to the car!

Also, if you use the flat weights (or anything else) attached to the bottom of the car, make sure that they do not extend below the bottom of the wood block. Weights extending below the bottom of the wood block is the number one reason that cars do not get off the starting line, or hang up somewhere along the track.

NOT SO BASIC STUFF
(But still easy)

Oh – you mean REALLY Fast??

Make the car an aerodynamic shape.

Put the rear wheels near the back of the car.

(This increases stability while letting the weight be further back. Using the factory slots, this means having the rear axle in the slot closest to the end of the block. Better yet move BOTH axle locations close to the ends of the car)

Make the car as long as the rules allow

(also necessary to get the weight as far back as possible)

Put the weight to the back of the car and low.

Prepare the wheels

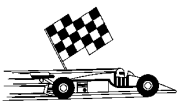
(Remove the mold flash and sprue on the wheel tread and hub. Make sure they are round. Do NOT alter the shape of the wheel.)

Prepare the axles

(Remove the burrs and polish the nails.)

Carefully align the axles.

(Adjust them until the car runs straight on a slight incline.)



Race Day

This is the general race day procedure.

All cars must be registered and checked by the race officials during the established check-in period. (Note that check-in may take place a day or so earlier than the actual race, and may be at a different location.)

1. Make sure that your car is ready to run. Do your last-minute check and final lubrication.

2. Get in the check-in line. You will need to know:
    a. Your name
    b. Your program level (Lion, Tiger, Wolf, Bear, Webelos)
    c. Your pack and town (if you are representing the Pack at the District race)

3. When you get to the race official, present your car. Give them your information. They will place an identification sticker on your car – remember your number.

4. The race officials will check your car for compliance with the rules. The official scale controls – regardless of what "your" scale said. The official rules for the race you are entering govern – not something you found somewhere on the internet or that your cousin Billy's Pack used three years ago.

5. If necessary, correct any problems. Lube again!!

6. Get re-checked.

7. When your car is OK, it will be impounded in the "pit" area until the races are completed. Therefore, it is important that you re-lube before you turn in your car.

8. Join your den in the spectators' area. Enjoy the races.

9. Appearance awards will be judged at the pits during the races.

10. Cars will not be released from the pit area until after race officials complete a category – please do not ask!

11. If you are a winner, please stay for photos!

12. If you are a speed winner, please take care of your car. You will be advised by the Pack race committee if you will represent the Pack at the District race.

Good Luck!!

Resources

More information:

An internet search on “Pinewood Derby” will produce a HUGE amount of information. Like most internet information, some is better than others, and some is just plain wrong – buyer beware.

Materials:

Official Pinewood Derby Car Kits and Wheels. Also official BSA accessories including weights and decals. At Northern NJ Scout Shop, 25 Ramapo Valley Rd. (Rte. 202), Oakland, NJ

Check out your local hobby shops for pinewood derby accessories and for generic accessories and materials (decals, paint, etc.) to complete your car.

Lowes, Home Depot and local hardware stores also carry supplies you may need – sandpaper, paint, graphite lubricant (usually where keys and locks are located)

3 RIVERS DISTRICT

THE DON WARE CLASSIC

RULES

Driver's License Fee $5.00 per Entry

The information listed below is the official guide established by the racing committee in judging all entries at the 3 Rivers District Pinewood Derby.

Information from other sources that does not conform will not be allowed.

1. The car must have been made for this year's race. Previous year cars cannot be entered.
2. The wood provided in the Official BSA Pinewood Derby Car kit must be used. The block may be shaped any way that is desired.
3. The wheels supplied with the kit (or other BSA-approved wheels) must be used. Open-spoke wheels are prohibited. The wheels may not be cut, drilled, beveled or rounded. You may remove the seam from the wheels, but the surface of the wheel that touches the track must be left flat.
4. The axles supplied with the kit must be used. They may be polished or lubricated. One-piece wheel-to-wheel axles are prohibited.
5. Wheel bearings, washers or bushings are prohibited.

6. The car must not ride on any type of springs.
7. The car must be freewheeling, with no starting devices.
8. No loose material of any kind, such as lead shot, may be used.
9. The maximum car length shall not exceed 7 inches.
10. The maximum overall width (including wheels and axles) shall not exceed 2-3/4 inches.
11. The car must have 1 ¾" clearance between the wheels, side to side. This is to ensure the car will clear the center guide strip on the track. There is no min/max distance between front and rear axles, as long as the cars overall length doesn't exceed 7 inches.
12. The car must have 3/8 of an inch underneath the body. This is to ensure the car will clear the center guide strip on the track.
13. The maximum weight of the car shall not exceed 5 ounces. Though the car's check-in weight may differ from that of your own scale, the official 3 Rivers District scale is considered final,.
    a. Weights can be used. Moving weights are prohibited.
    b. Weights that become dislodged during racing will not be reattached.
14. Only dry lubricant may used. Liquid lubricants are prohibited. All wheel lubrication must be done prior to check in.
15. Each car must pass inspection by the official inspection committee before it will be allowed to compete. The Inspection Committee has the responsibility to disqualify those cars that do not meet these specifications.
    a. A staffed "pit" will be set up to make minor revisions to race cars as necessary -- attaching loose pieces, reducing/adding weight, reducing length, etc.
16. Once qualified, the car stays in control of the racing committee until the end of the race. No adjustments may be made after a car qualifies for the race.

The 3 Rivers District Pinewood Derby is run using three-lane tracks. The tracks are fitted with electronic timers with infrared starting gate and finish line. Computer software captures the results of each race lane. Each car races at least once per lane (in heats) – in most cases, each car will race three times per lane. After all races have been completed, the total elapsed time for each car is calculated. The car with the lowest total time wins.