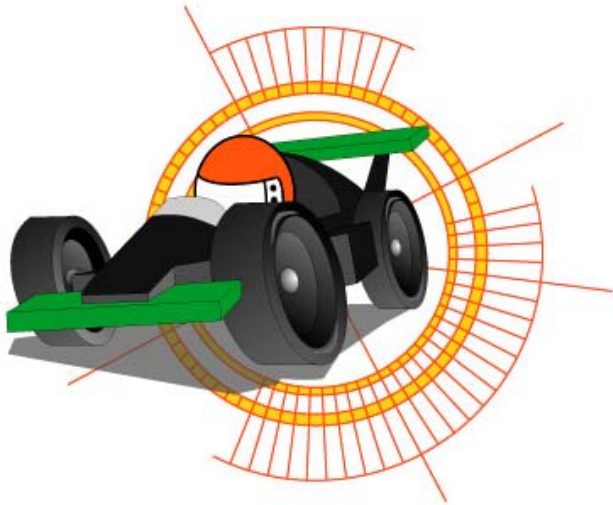




# ULTIMATE SPEED SECRETS



How to win  
the pinewood derby

**UPDATED FOR 2006**

## ***ULTIMATE SPEED SECRETS***

How to Win the Pinewood Derby

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# *Ultimate Speed Secrets*

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Tonight was one of the most memorable nights of our life! My son will never forget it. It was our first Pinewood Derby. We went to the race not really knowing what to expect. I wish I could have somehow captured the excitement on his face as his car began winning race after race after race. It was one of the proudest moments of his life when he stepped forward and was awarded the First Place trophy for the entire pack! Winning was exciting and fun. However, more importantly, the principles outlined in “Ultimate Speed Secrets” helped make this event into something that has strengthened our relationship and given us something in common that we both enjoy. We Laughed! We WON! It was truly a most memorable night!

Best Regards,

Dave



Figure 1: Another First Place Finish!  
(Spencer with his good friend, Austin)

## Introduction

Hello, and thank you for purchasing “Ultimate Speed Secrets, How to Win the Pinewood Derby.” Building Pinewood Derby cars that win and having a fun time doing it is a tradition that goes back generations in my family. Some of my most vivid and cherished memories are of the time I spent building derby cars with my father and brothers. Now I have sons of my own. We’ve been building cars together for many years. It’s been a wonderful adventure! It’s helped my sons build identity and confidence. It’s a tradition! Our family builds Pinewood Derby cars that Win... Every Time... Every Race!

You hold in your hands the most complete guide to building a winning car that is available on the market today. This is NOT just another speed tips book. There really is a difference between this book and the other books available on the market. I provide you with step by step instructions, photos, and diagrams for every step in the process. It is a complete construction guide to building what I call “The Ultimate Car.”

Remember that the Pinewood Derby is supposed to be fun! It’s supposed to be exciting! Its purpose is to help children develop skills, confidence, and self-esteem. So, even though we will spend a lot of time talking about principles that will help you win the Pinewood Derby, don’t forget that your derby experience is only a success if you enjoy the ride.

## The Ultimate Car

What is the Ultimate Car? Well, before I can answer that question I need to explain a few things about my sons, myself, and the competition. There are some that suggest they can help you win the Pinewood Derby because they have won a few trophies. Although winning two or three trophies is a remarkable accomplishment, it doesn’t necessarily make you an expert on the subject. Taking home the second or third place

trophy means someone else beat you! Trophies also say nothing about the level of competition in the respective Cub Scout pack or racing organization.

Listen very carefully to what I'm about to say! **MY SONS HAVE TAKEN FIRST PLACE** in every Pinewood Derby we have ever raced in! We don't have any second place trophies! We have raced in four packs in Texas and Wisconsin. Some of the derbies we have raced in have sported over 100 cars! Our cars have always won!

So, how do we do it? The answer is simple. We build The Ultimate Car! People show up at the Pinewood Derby every year with cars they built using advice they found on the internet, and every year we go home first place winners!

A few years ago, a friend jokingly told me that he thought that year was the year we were finally going to get beat, because there were several people who had vowed to end our winning streak. I chuckled, and then in a half joking/half serious manner asked him a simple question. "So, how are they going to accomplish this? What exactly are they going to do to build a faster car? We already build the Ultimate Car", I said.

So, in a nutshell the Ultimate Car is exactly what its name implies. It is a collection of car design and speed tips which have enabled us to build a fleet of Pinewood Derby cars which have won race after race, year after year. I call it the Ultimate Car because I'm not aware of anything you can legally do to improve it. Some of the speed tips and design hints I will share with you can **ONLY BE FOUND IN THIS BOOK!** Many of the other books out there just skip over these important tips like they don't even matter, but they do matter and that's the difference between the Ultimate Car and the other cars out there.

So hang on tight and get ready to learn how we build cars that leave all

the others in the dust... No matter what they've done...No matter what book they have read... No matter how many other cars are in the race. This is the Ultimate Car!



Figure 2: Tanner Meade, First Place Winner!

Note: The author does not guarantee that you will be able to duplicate his success. He is not guaranteeing that you will win your Pinewood Derby. The tips and suggestions in this book are simply a collection of methods, which have enabled the author and his sons to consistently win over many years. The author does believe that success can be achieved by applying these tips correctly.

## Using This Book

I have designed this book to be useful to nearly everyone, regardless of experience. If this is your very first Pinewood Derby, that's OK! We'll take you by the hand and lead you down the path as far as you feel comfortable. If you're experienced and want to finally take home that trophy, this book will teach you the advanced techniques you need to win! The discussion is organized for beginners and experienced builders alike. However, it is important that you read through the book before you start building your car. Some of the design methods and speed tips are inter-related and cannot be properly applied unless you understand the whole picture.

The basic outline is as follows:

### Some Opening Advice

Be Safe: The Pinewood Derby is all about having fun. However, the fun quickly disappears when someone gets hurt. In this section we will briefly review some important steps you need to follow in providing a safe Pinewood Derby experience.

A Scout is Trustworthy: When you win, do so honestly! Obey all local rules.

Let Him Build the Car: It's impossible for your child to win the Pinewood Derby if you build the car! In this section, I will discuss ways that you can build a winning car while still allowing your child to do most of the work.

### Basics for Beginners

This section will teach you the basics of building a competitive car, including car design and detail. You will also learn four of the most important speed tips in Pinewood Derby racing. We also

provide a brief discussion of the scientific principles that make cars go FAST! This section is presented for those who want to stick to the basics and have limited access to tools.

### Building a Winner

This section is for those who want to take their car to a whole new level of performance! We focus on the additional speed tips found in winning cars. It's almost a guarantee that the top placed cars will incorporate many of these tips

### Building a Champion (The Ultimate Car)

Do You Want Ultimate Performance? This is the section of the book where I tell you why our cars take first place every single time. I'll show you how we separate ourselves from the second and third place finishers. This is where I give you the secret recipe for turning a fast car into the Ultimate Car!

## Some Opening Advice

### Be Safe

The Pinewood Derby is all about having fun. However, the fun quickly disappears when someone gets hurt. Make safety your #1 rule. The list below outlines some general safety rules which should be followed.

- 1: Wear eye protection at all times. You only have one set of eyes. Keep them safe.
- 2: Children should not use power tools without adult supervision. Some power tools should not be used by children at all.
- 3: Wear a breathing mask when appropriate. Activities which involve sanding, applying graphite, or spray painting are examples of activities which require the use of a breathing mask to protect against harmful fumes and airborne particles.
- 4: Wear gloves when using sharp tools.
- 5: Do not wear loose fitting clothing when operating power tools. Loose clothing can become caught or snagged by moving parts.
- 6: Do not use melted lead. Melted lead is extremely hot and very poisonous. Several Pinewood Derby tip books and videos actually recommend melting lead. Please ignore their bad advice! There is absolutely no reason whatsoever to melt lead. In this book, I will show you how to add weight to your car safely without melting lead.
- 7: There are appropriate ways to add weight to your car using lead. Whenever handling lead always wear gloves and/or wash your hands thoroughly after handling. Keep all lead products out of the reach of children. **ALL FORMS OF LEAD ARE VERY POISONOUS!**
- 8: Be sure to follow all safety rules and precautions listed on tools and products you use during the construction process.
- 9: Keep your work area clean and organized. A work space that is messy and cluttered is an accident waiting to happen. Remember, A Scout is Clean!

## **A Scout is Trustworthy**

This principle from the Boy Scout Law applies to everyone! Honesty is the true measure of any human being. When you win the Pinewood Derby, do so honestly. Follow your local rules. If one of the speed tips discussed in this book is not allowed in your derby, then don't use it! If you want to use a particular speed tip but you aren't sure whether it's legal, clear it with your local race organizer before you start building your car. Be honest! It's the Scouting way! Below is a list of the official rules, which accompany each Official Grand Prix Pinewood Derby Kit.

### Rules:

- 1: Wheel bearings and bushings are prohibited.
- 2: The car shall not ride on springs.
- 3: Only official Cub Scout Grand Prix Pinewood Derby wheels and axles are permitted
- 4: Only dry lubricant is permitted
- 5: Details, such as steering wheel and driver are permissible as long as these details do not exceed the maximum length, width, and weight specifications.
- 6: The car must be free-wheeling, with no starting devices.
- 7: Each car must pass inspection by the official inspection committee before it may compete. If, at registration, a car does not pass inspection, the owner will be informed of the reason for failure, and will be given time within the official weigh-in time period to make the adjustment. After approval, cars will not be re-inspected unless the car is damaged in handling or in a race.

Your local rules may differ from the list above. Ask your local race committee for a copy of your rules and then abide by them.

Car Specifications: Below is a diagram illustrating the Official Grand Prix derby car specifications.

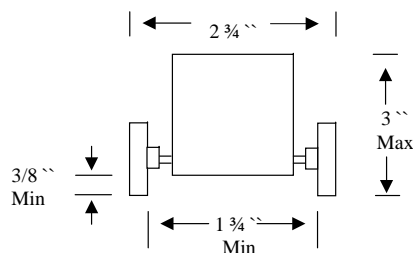


Figure 3: Car Specifications for Official Grand Prix Pinewood Derby Kits

## Let Him Build the Car !!!

As I said previously, **it is impossible for your son to win the Pinewood Derby if you build the car!** Even if your car comes in first place, your son will know that he is accepting a trophy that you earned. The Pinewood Derby is more than just winning! It's a time for children to learn skills and to develop a lasting relationship with an adult role model. Don't rob them of these opportunities. **It is 100% possible to build a winning car and still allow your child to do most of the work.** Here are a few suggestions that I use every year as I build cars with my sons.

Build two cars: That's right...build two cars. When we build derby cars, I build a car along side of my son. The technique I use is simple. My son watches me apply each step of the process to my car, then, he does the same thing to his car. For example, I will demonstrate how to trace the car design on to my raw block of wood. When I'm finished tracing, he will trace the design onto his block of wood, having seen me do the same thing moments before. There will, of course, be steps which for safety reasons need to be performed by an adult. In these situations try to find some way that your child can safely be involved in supporting the work you are doing.

Important Note: Building two cars is actually a **speed tip** which has helped us build faster cars and has saved us a lot of grief in the past. Building two cars will allow you to make mistakes and have learning opportunities on "your car." If you do it to your car first, you will be better prepared to do it right on "his car." This is especially true the first time you attempt to apply a particular speed tip or method. Building mistakes and errors into a derby car will not make it go faster! Make those mistakes on "your car." After all these years of racing, we still build two cars every time.

Let him help design the car: Your child will feel more connected with his car if he gets to help design it. Later in this book, I will discuss the issue of car design. Design does have a significant impact upon speed.

However, within the guidelines I lay out, there is room for individuality and creativity. Let your child be creative and influential in the design of the car.

Let him pick the color and detail options: Once again, let your child pick the color of their car. If they decide to use stickers or decals, let them do the choosing. Color and stickers will not affect the speed of the car, so let your child have as much say in this part of the car design as possible. One year I remember our car was really quite interesting to say the least. My son just had to put non-matching stickers all over his car. I let him do just exactly what he wanted to do. The car looked kind of messy, but he liked it... thought it was great...and we still took first place.

Teach principles while you work:As you work on this project together, take the opportunity to teach your child. Make sure they understand why each step of the process is important. Help them learn



Figure 4

woodworking and tool skills. If you ask my sons why we polish our car axles, they can tell you! The more they understand, the more they will feel a part of the process.



Figure 5: Tracing car design on to pine block. In this photo Tanner is using a pattern cut from blue paper. He then traces the pattern onto his pine block using a pencil.

I always help my boys draw a pattern on a sheet of paper. They cut that pattern out and then transfer the design to the pine block, see Figure 5. We then use either a coping saw or a ban saw to cut the design into the block. By doing this, my son is learning how to create and transfer a pattern. He also learns how to properly and safely use a saw to cut wood. I oversee this entire process and ensure that proper safety skills are adhered to. It's so important that your child be involved in the work and that they learn skills as they build their car.

## ***Basics for Beginners***

This section is designed especially for people who are new to Pinewood Derby racing. Some people in this situation will open the box, pour out the contents, stare at the pile, and then kind of look at each other and wonder what to do next. Well, if that's how you feel, don't worry! I'm going to lead you through the process, step by step. This beginning section will explain the basics of building a competitive car.

After you finish reading this section, you might decide that sticking to the basics is all you're ready to handle. If so, that's OK. That is exactly why I wrote this section of the book. If you stick to the basics, your car will hold its own, win some races, and be a car your child can be proud of.

However, after reading this section, you might also decide that you want to go all the way and build the Ultimate Car! If so, simply continue reading through the remaining sections where advanced techniques are discussed. The advanced sections will turn your car into a rocket!

OK, are you ready? Let's build a Pinewood Derby Car!

## **Three Basic Principles of Speed**

There are three basic principles which govern how fast a car will go. Every speed tip in this book is designed to give your car the maximum benefit from each of these three principles.

### **Principle #1 (Maximize Potential Energy)**

Gravity provides the energy which makes your car roll down the track. Gravity is a strong force which pulls on your car. You can think of gravity as being the engine in your car. Before the race begins, your car

is sitting stationary at the top of the track. It isn't moving yet. At this time your car has what we call "potential energy." Potential energy is the amount of energy available to make your car roll down the track. The important point to understand here is that cars with more potential energy will roll faster as they move down the track! For example, in the real world an automobile with a 300-horse power engine will go faster than an automobile with a 100-horse power engine. The first principle of maximizing speed is to maximize the amount of potential energy your car has.

Believe it or not, 99% of the cars out there end up having far less potential energy than is actually possible. In this book I will show you how to maximize the potential energy of your car when the race begins. You will be the guy who shows up with the 300 horse power engine.

### **Principle #2 (Reduce Friction)**

Friction is the enemy of speed! So, you've built a car with tons of potential energy... unfortunately not all of that energy actually gets converted into speed. Some of that energy gets converted into heat as surfaces rub against one another causing friction.

More Friction = Less Speed

Most of the speed tips in this book are aimed at reducing friction. We want to save as much of your energy as possible so that it can be used to make your car rocket down the track.

### **Principle #3 (Reduce Inertia)**

Reduce the inertia coefficient as much as possible. What is inertia anyway? According to Newton's first law of motion, any stationary object will tend to remain stationary until it is acted upon by an outside

force. What does that mean? Well in layman's terms it means that your car will stay motionless at the top of the track until a force pushes on it and makes it start moving. Objects at rest tend to resist a change in movement. We call this resistance to change inertia.

Heavy objects have more inertia than light objects. This means that lighter objects take a smaller force to make them start moving. For example, if you put light-weight wheels on your car, then it will take a smaller force to make them start rolling down the track, than it would if you put heavy wheels on your car. Cars with light-weight wheels will begin rolling sooner than cars with heavy wheels. Taking advantage of principle #3 is discussed in the section titled, "Building a Winner."

## Car Design

The possible number of shapes and designs which can be applied to Pinewood Derby cars is endless. I'm sure you have some ideas floating around in your mind right now. However, before you begin it is important to consider the following car design guidelines.

- 1: The dimensions of your car must remain within the width, height, length, and weight specifications listed in your derby rules. The official BSA specifications are outlined on page 13 of this book.
- 2: Designs with a pointed nose are generally not a good idea. A pointed nose will make it difficult for your car to rest on the pin at the starting gate. It may cause your car to get bumped around when the pin drops. It may cause problems for electronic timing systems. Do not select a design with a pointed nose (examples are shown in Figure 6).

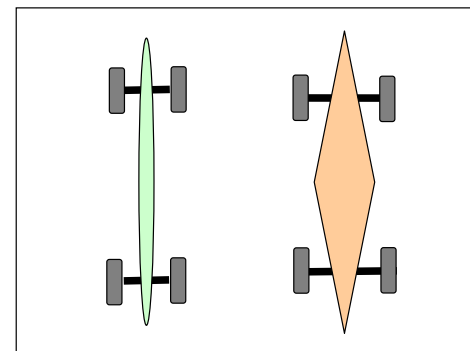


Figure 6: Examples of designs with a pointed nose. Try to stay away from similar designs.

- 2: Leave enough wood in the rear of the car so that you can place additional weight there. We will discuss weight placement in a moment. However, it is important to know at the design stage, that you will be putting most of your weight in the rear of the car.
- 3: Be sure that it is very clear which end of your car is the front and which end is the back. In many races, the race officials actually place each car on the track. I've seen many situations where the officials put the car on the track backwards because they can't tell which end is which.
- 4: Choose an aerodynamic design. By aerodynamic I mean choose a design which allows the air to move over and around the car body in a smooth manner (see Figure 7). Cars with an aerodynamic profile go faster!

- 5: Remember to let your child help design the car! This isn't "Your" car. It's theirs.

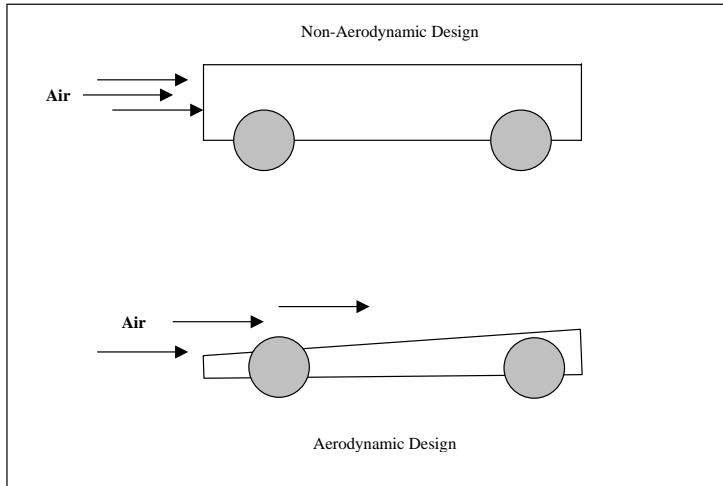


Figure 7: Illustration of Aerodynamics

Note: The most basic aerodynamic design is the simple wedge. Figure 8 illustrates a basic wedge shaped car. If you don't have a lot of time available, this is a time proven design used by many Pinewood Derby winners.



Figure 8

## Cutting the Design

Once you have selected your design, you will need to make a template, which can be used when cutting the block. Most designs will require that you make a template for the top view of the car and another template for the side view, as shown in Figure 9.

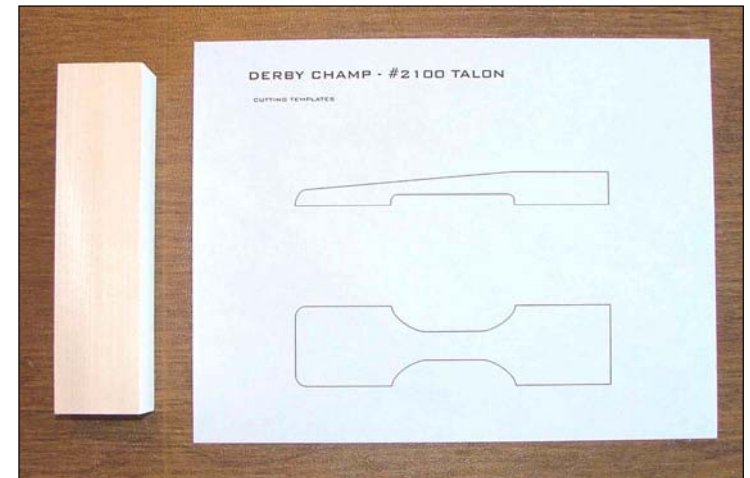


Figure 9: Car design template

Cut your design template out and attach it to the block of wood with clear tape. To not glue it on. Glue will just create a mess that needs to be sanded off later. I normally begin by attaching the side view first. However, whether you attach the side view or the top view first will depend upon which makes the most sense when cutting out the car, see Figure 10. In the example below, I have colored the template to make it easier to see. This is probably a good idea for you as well. When cutting the block you need to be able to clearly see where you are cutting.



Figure 10: Side view template attached to block

With the template attached, you are ready to cut the block. I recommend using either a power ban saw or a hand held coping saw. Be sure to obey all safety rules and exercise caution when cutting the block. Find a way your child can safely help in this process. Figure 11 illustrates the block being cut using a ban saw. Figures 12 and 13 illustrate the same process using a coping saw.



Figure 11: Cutting the block using a ban saw



Figure 12: Coping Saw, templates, and block



Figure 13: Securely clamp block in vise. Then carefully cut the block. After you cut half way through, turn the block over and finish cutting from the other side.

After cutting out the side (or top) view, attach the remaining template view as shown in Figure 14.



Figure 14: Top template attached to block

Use the ban saw or coping saw to finish cutting out the car. In this example, our cut out car is shown in Figure 15.



Figure 15: Car design with both top and side view templates having been cut out.

Complete the process by sanding your car with several grades of sandpaper. Finished the process by using sandpaper with at least 220 grit, to give it a smooth finish.

## Paint and Detail

You have designed, cut, and sanded your car. It's starting to look cool! Now it's time to apply paint and perhaps stickers or decals. Before you begin, consider these suggestions for making your car look the best.

- 1: Before you apply the first coat of paint, go over the car one more time with some 400-grit sandpaper. Make it as smooth as possible.
- 2: Wipe the car body down with a cotton rag. This will remove any remaining dust or particles which could become visible when you apply paint.
- 3: Find a cardboard box and two pencils. Place the car body on top of the pencils, see Figure 16.
- 4: Next, apply a coat of primer to the car, see Figure 10. The wood is full of small cracks and pores, which need to be filled before applying paint. Spray one good coat of primer on your car and let it dry.



Figure 16



Figure 17

- 5: Lightly sand the primer coat with 0000 grade steel wool. This will remove any bumps or particles in the primer coat. Wipe the car down with a cotton cloth.
- 6: OK, now we are ready to apply paint. Apply one coat of paint. Be careful not to apply it too thick, or it will run. Let the paint dry. In Figures 16 and 17 I show a can of orange spray paint. I prefer to use spray paint because it goes on smoother than brush on paint. The layer of paint applied is also thinner than brush on paint, and thus weighs less. Less paint means you have more control over where you put the weight of the car. I discuss the topic of weight placement in “Building a Champion.”
- 7: Lightly sand with 0000 steel wool and wipe down with cotton cloth.
- 8: Apply a second coat of paint and let it dry.
- 9: Apply one good coat of clear coat to make it shine!

#### Decals or Stickers?

- 10: Many children want to add decals or stickers to their car. It really doesn't make any difference in the long run which decals or stickers you apply (if any). However, let me give you a small bit of advice that will help make your car look the best it can.

Dry transfer decals look much more professional than any kind of sticker I've ever seen. We have used dry transfer decals for several years. Every year people come up and ask where we got “those awesome looking decals.” Dry transfer decals actually end up looking like you painted the design on the car. Stickers look like... well stickers. You can find dry transfer decals at any major hobby store.

Note: PineCar® also has a new product out on the market called Body Skin. It's a large decal that you transfer by applying water. It's really quite cool. Your car looks like it's had a professional paint job. The wedge car shown in Figure 8 was detailed using a PineCar® Body Skin. Check your local hobby shop for PineCar® products.

### Attaching the Wheels

Ok, it's time to attach the wheels. Wheel attachment and spacing is extremely important. If you leave too much space between the wheel and car body, your wheels will shake and wobble as they turn. If you put them too close to the body then the wheel hub will rub against the car almost the entire way down the track... ouch! So, we need to get the spacing right! The correct amount of space to leave between the wheel and the car body is  $1/32^{\text{nd}}$  of an inch. Before attaching the wheels you should construct a wheel spacer which is approximately  $1/32^{\text{nd}}$  of an inch thick.

First: Glue two or three business cards together (needs to be  $1/32^{\text{nd}}$  of an inch thick). Get a measuring tape or ruler that measures to  $1/32^{\text{nd}}$  of an inch. Make sure your stack of cards is the proper width.

Second: Cut a small slit in the top of the cards, as shown in Figure 18.



Figure 18:  
Business card wheel spacer.  
Two or three cards glued  
together =  $1/32^{\text{nd}}$   
of an inch thick.

Next, attach each wheel as shown in Figure 19. Use the wheel spacer to control the amount of space left between the wheel and the car body. Figures 20 and 21 illustrate wheels which have been spaced properly.



Figure 19: Using wheel spacer to attach wheel

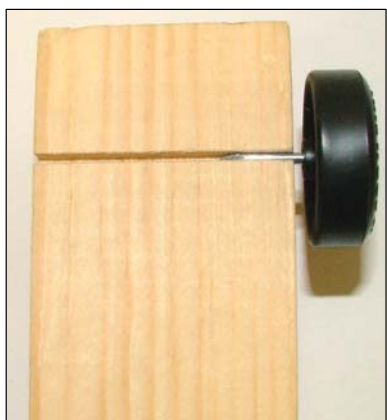


Figure 20: Wheel properly spaced 1/32<sup>nd</sup> of an inch from car body when using standard axle slots.



Figure 21: Wheel properly spaced from car body when using drilled axle holes. Drilled axle holes are discussed on page 45.

Do you have all four wheels attached to the car? Good! Place the car on a flat surface. The kitchen table or a counter top will work well. Get on your knees and look directly underneath the car, as shown in Figure 22. Each wheel should be resting flat and square on the table. If any of the wheels are not flat and square you will need to adjust them until all four wheels are properly positioned, see Figure 23.

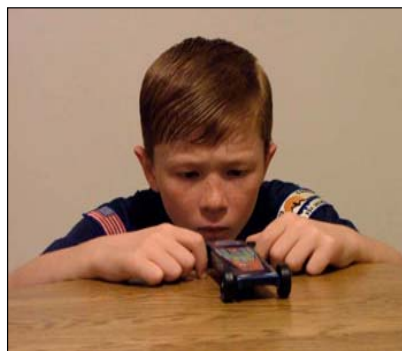


Figure 22: Place car on flat surface

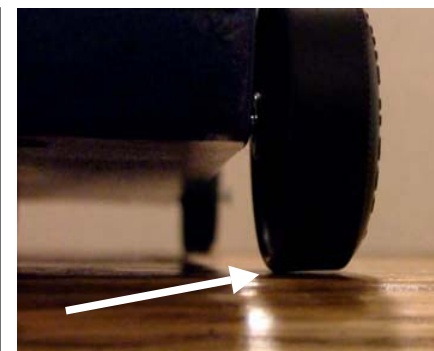


Figure 23: Wheel not resting flat on surface... Needs to be adjusted.

The final step is to glue the axles so that your wheels stay attached and don't come off during the race. Turn your car over on its back and apply one or two drops of glue in the center of each axle, as shown in Figure 24. Allow the glue to dry before turning your car back over. If using the standard axle slots, do not use instant glue. Being very thin and runny, it tends to run down the axle and get on the wheel hub. I prefer to use some type of quick drying cement or epoxy. Note: If you decided to use drilled axle holes then see page 54 for instructions on gluing the wheels properly.

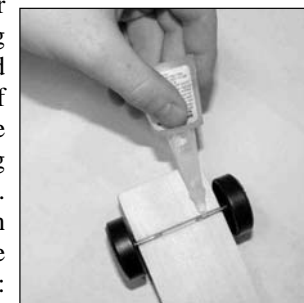


Figure 24: Apply glue to axles

## Basic Speed Tips for Beginners

In most Pinewood Derbies you can separate the cars into two basic groups: The Competitors and the Non-Competitors.

Cars in the non-competitive class simply don't compete. They lag behind in every race. Some have a hard time just crossing the finish line. It's clear that the people who built these cars have not paid attention to the basics of car building.

In order to build a competitive car, you must pay attention to four important speed tips: Weight Placement, Axle Preparation, Wheel Preparation, and Wheel Lubrication. If you don't have very much time to devote to the building of your car, then be sure to focus on these basic principles. Do these things and you will have a competitive car.

### Weight and Weight Placement

Correctly adding weight to your car is one of the most important things you can do to increase speed. The two most important rules dealing with weight and weight placement are

**Rule 1: The heavier your car is the faster it will go!**

**Rule 2: Rear weighted cars go faster!**

It's a fact! If you put the bulk of your weight in the back of the car, then it will go faster. By placing the weight in the rear of the car you increase the potential energy of the car when it's at the starting gate. In other words, you have a larger gravity engine propelling your car down the track.

The effect of placing the weight in the rear of the car is actually observable. Rear weighted cars will appear to accelerate at the bottom of the track where the ramp levels out. I have actually had parents standing next to me lean over and say, "What's up with your car? It accelerates at the bottom of the track."

Your car should weigh 5 full ounces and the bulk of that weight should be located in the rear of the car. If you weigh your car and it only weighs 4.9 ounces, then you need to add more weight. It will make a big difference in speed!

Weigh your car before going to the race. Buy a small digital scale, borrow one from a neighbor, or go to the local post office and ask them to weigh your car. Be sure your car weighs 5 ounces. I've seen cars show up on race day a full ounce over or under the limit. Some cars then get damaged as boys and parents try to find last minute ways to add or remove weight. Take care of all that before you ever show up at the race.

### Ways to Add Weight

There are many ways that you can add weight to your car. Figures 25 and 26 illustrate methods we have used to add weight to our cars. If you don't have access to a drill, the weights could be glued to the top of the car. You can be creative in how you attach the weight. If you decide to add a toy driver to the car, put him near the back. It will add weight in the correct location.

You will also need some adjustable weights. These will be used to fine tune the weight after the car is painted and assembled. Adjustable weights are also important when balancing the weight distribution (topic discussed in next section). Figure 27 illustrates using lead putty as an adjustable weight. In this example, we have drilled small holes in the bottom the car. The holes have been filled with lead putty. If we need a

little more weight, then we can just add a little more putty. If I need more weight moved toward the back I can do that too.

You could also use the hole configuration shown in Figure 19 to allow for adjustable weights. Simply put fishing weights in the center hole. Cover that hole with a piece of cork or modeling clay. If you need to add or remove weight you simply open the hole and make the weight adjustment.

You can be creative in how you accomplish this part of the process. Just be sure to do it! A small part of the weight needs to be free and adjustable.



Figure 25: Holes drilled in side of car. Lead wire or fishing weights fit into each hole. The holes are then covered with wood putty before painting.

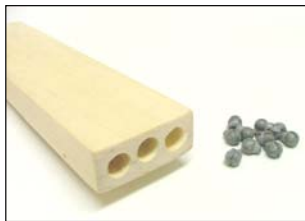


Figure 26: Holes drilled in rear of car.



Figure 27: Lead putty used as adjustable weight. Small bits of lead putty can be added or removed from these holes as necessary.

What type of weight should you use? For optimal speed, lead is the only choice! You simply cannot get enough weight in the rear of your car if you use anything else. There are several other types of “non-lead” weights being sold for Pinewood Derby cars. These weights are typically made of zinc and are only a little more than half as dense as lead. If you use zinc weights then you will end up putting some of your weight toward the front of the car, which will in turn reduce speed. I repeat... LEAD is the only choice! (Actually, some vendors are now offering Tungsten weights. Tungsten is denser than lead and is good for adding weight to very thin cars. However, if you want to use Tungsten be prepared to pay for it. Tungsten is very expensive.)

Please remember that lead is a toxic substance! Wear gloves when handling lead. Wash your hands after you are finished handling it. Keep all lead products out of the reach of children. Follow any and all warnings that accompany lead products. Do not use melted lead! There is absolutely no reason to melt lead. Melting lead is dangerous! You can safely add weight to your car using other lead products.

### Important Note:

Some people suggest you use weights that spread the weight distribution out across the full length of your car. Do not listen to this advice!

There are various types of weights sold in hobby stores and on the internet which attach to the car and run the full length of the body. Do not use these weights!

You want your weight located in the rear of the car! Any weight you place toward the front of the car is speed lost!

### Balancing Your Weight

When adding weight remember to follow these two rules:

- 1: Put as much of your weight in the rear of the car as possible
- 2: If you put the weight too far back, then your car will pop a wheelie as it goes down the track. It might even jump off the track... this would be bad!

So, how do you know if your weight is located properly? Well, it all has to do with the "Center of Gravity." The center of gravity is simply the spot on your car where it will balance, as illustrated in Figure 28.

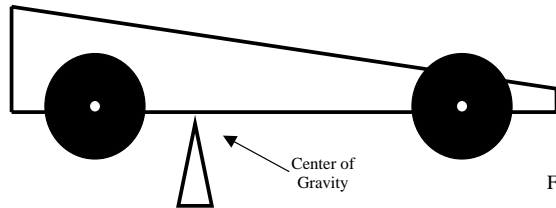


Figure 28

You can easily locate the center of gravity for your car by placing it on a thin piece of wood, a ruler, or a wooden dowel. Slowly move your car back and forth until you find the place where it will balance. I have experimented with weight location for many years and have come to the following conclusions: If the track you are racing on is a very high quality smooth track then place your weight so that the center of gravity is 3/4 inch in front of the rear axle. If your track has bumps and rough spots then move the center of gravity forward so that it is located approximately 1 inch in front of the rear axle. This will give your car a little more stability when it hits those bumps.

Important note: Optimizing weight placement in the rear of the car is actually one of the speed techniques that will turn your car into the Ultimate Car. Later in the section titled, "Building a Champion (The Ultimate Car)" I will show you how to take rear weight placement to the next level, which will give your car an energy boost the other cars in the race simply won't have!

### Axle Preparation

Correctly preparing your axles is the single most important thing you can do to increase the speed of your car! Remember... Friction is the enemy of speed. The largest source of friction is the contact made between the axles and the wheels. As the wheels turn they rub on the axles... constantly... all the way down the track. There are many things you can do to reduce this source of friction. Believe it or not, there is actually something you can do to completely eliminate part of it (I talk about that in "Building a Winner"). In this section, we will introduce the two basic steps in axle preparation. Advanced techniques will be discussed in later sections.

### Step 1: Remove Axle Burrs

The official scout axles, which come in the box, have a small set of burrs and deep scratches near the head of the axle, see Figures 29 and 30.

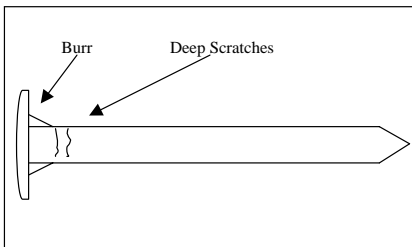


Figure 29: Diagram of official scout axle.

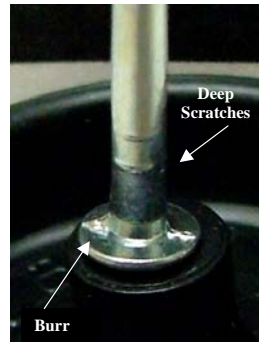


Figure 30: Photo of burrs found on scout axles

The small burrs **MUST BE REMOVED**, using an electric drill and a small triangular file. The scratches will be removed in step 2.

- Clamp your drill in a vise as shown in Figure 31. Be careful not to tighten the vise too much (you might damage your drill by doing so).
- Insert an axle into the drill, leaving about half an inch exposed, as shown in Figure 32.

- Turn the drill on medium to high speed. Use a triangular file to remove the burrs, as shown in Figure 33. Put light pressure on the file, so as not to damage the axle in the process of removing the burr.
- When completed your axles should look like the axle shown in Figure 34.



Figure 31: Clamp drill in vise. Be sure not to clamp too tight.



Figure 32: Insert axle in drill leaving half an inch exposed.



Figure 33: Burrs being removed using a triangular file.



Figure 34: Photo of axle with burrs removed.

## **Step 2: Polish Axles Until They Shine Like Mirrors**

As the car moves down the track, the wheels turn and rub on the axle shaft continually. It is essential that the axle surface be as smooth and shiny as possible. You need to polish... polish... polish! Polish those axles until they shine like mirrors! All competitive cars have polished axles, but some are polished better than others. Below, I will show you two methods for polishing axles, the Ultimate Polish and the traditional polishing method. We have used the Ultimate Polish method for several years and find it to be vastly superior to any other method out there.

P.S. This is a really great place for your child to do a major portion of the work. Be sure to teach principles as you work. It's important that they understand why each step in the building process is being performed. You might even have a contest to see who can make their axles shine the brightest! Remember to make the building process FUN!

- Clamp your drill in a vise as shown in Figure 31. Be careful not to tighten the vise too tight (you might damage your drill by doing so).
- Insert an axle into the drill, leaving about half an inch exposed. Be sure the axle is tightly secured in the drill.

### **The Ultimate Polish**

- 1: Cut a piece of 400 grit sandpaper into strips 1/4<sup>th</sup> inch wide and 4 inches long.
- 2: Turn on drill. Dip a piece of the 400 grit sandpaper in water to make it moist. Use the sandpaper strip to sand and smooth the axle as it spins in the drill. Be sure to sand all of the axle, including the inside surface of the head, as shown in Figure 35. This step should take about 15 seconds.
- 3: Turn off drill. Look at the axle with a good magnifying glass. Are there any deep scratches left? If so, then turn the drill back on and polish some more! Do not move to step 4 until all deep scratches have been removed.
- 4: Repeat steps 2 and 3 using a strip of 600 grit sandpaper. Be sure to look at the axle with a magnifying glass after each step to be sure the axle shaft is as smooth as it can be after each step.

### **Traditional Method**

- 1: Cut a piece of 400 grit sandpaper into strips 1/4<sup>th</sup> inch wide and 4 inches long.
- 2: Turn on drill. Dip a piece of the 400 grit sandpaper in water to make it moist. Use the sandpaper strip to sand and smooth the axle as it spins in the drill. Be sure to sand all of the axle including the inside surface of the head, as shown in Figure 35. This step should take about 15 seconds.
- 3: Turn off drill. Look at the axle with a good magnifying glass. Are there any deep scratches left? If so, then turn the drill back on and polish some more! Do not move to step 4 until all deep scratches have been removed.
- 4: Repeat steps 2 and 3 using a strip of 600 grit sandpaper. Be sure to look at the axle with a magnifying glass after each step to be sure the axle shaft is as smooth as it can be after each step.

\*\*\* Note: this is where the two methods separate. From here on the Ultimate Polish method is superior to the traditional method.

5: Repeat steps 2 and 3 several more times using 1000, 1200, 1500, 2000, 2500, and 3000 grit sandpaper. Please note that sandpaper with grit over 1000 are not normally available at your local hardware store. These are industrial products sold by companies which specialize in selling abrasives. You can also obtain these products by visiting [www.derbychamp.com](http://www.derbychamp.com)

5: Apply a final finish by using some type of polishing compound. Most people use a paste made of pumice. Put the compound on a strip of smooth cloth. Use the cloth to polish the axle until it has a high gloss finish. If using pumice, you will need to mix with water to make a paste, kind of like runny peanut butter.

The advantage in using the ultra fine grit sandpaper is clear. Polishing compounds, like pumice, are really on the same level as 1800 grit sandpaper. The traditional method recommends that you use 600 grit paper, and then complete the process by using something like pumice (1800 grit). To go from 600 grit to 1800 grit is a huge jump. You simply are not going to be able to polish those fine scratches left behind by the 600 grit paper, if you skip all the way down the line to a polishing compound that is 1800 grit. By using successively finer sandpaper you obtain a much higher quality polish!

Finally, by completing your process using 2500 and 3000 grit sandpaper you will obtain the Ultimate Polish, which pumice cannot provide! These are higher quality, finer abrasives. Your axles will shine so brightly, you might need to wear sunglasses when looking at them. You will be amazed at the difference!



Figure 35: Polish axles using strips of wet/dry sandpaper.

## Basic Wheel Preparation

To be competitive you **MUST** prepare your wheels for success. Official BSA wheels, straight out the box, have a number of undesirable features.

Every wheel has a rather large divot or bubble which is left behind as part of the manufacturing process, see Figure 54. The stock wheels can also have other abnormalities, which if left intact, will reduce the speed of your car. These defective features must be removed. The wheel should also be lightly sanded to make it smooth. To accomplish this you will need to use a Wheel Mandrel, see Figure 36. These handy tools are available at most Official BSA Scout shops, hobby stores, and Pinewood Derby on-line stores. **DO NOT ATTEMPT TO SAND WHEELS WITHOUT THE USE OF A WHEEL MANDREL!** You will only create other problems which are worse than the problem you are trying to solve by sanding.



Figure 36: Derby Worx Pro Wheel Mandrel

(The Pro Wheel Mandrel is manufactured by derbyworx.com. I find it to be superior to other mandrels available on the market (available on [www.derbychamp.com](http://www.derbychamp.com))

To sand and smooth your wheels follow the directions below.

- 1: Attach a wheel to the mandrel as shown in Figure 37.
- 2: You can use the mandrel in either an electric drill or in connection with a Dremel Tool. If you choose to use a drill, clamp it in a vise as shown in Figure 31. Be careful not to tighten the vise too much (you might damage your drill by doing so).
- 3: Attach a small sheet of 600-grit wet/dry sandpaper to a flat block of wood or sanding block. Apply water to the sandpaper to make it moist.
- 4: Turn on the drill or Dremel tool.
- 5: Allow the spinning wheel to gently rub against the surface of the sandpaper. Add more water to the paper when it starts to look dry. You need to be very careful not to apply too much pressure while sanding, as it will cause your wheel to become deformed. The plastic will become hot and actually melt unless you keep the sandpaper damp and keep the pressure to a minimum. Sand until the mold bubble is gone and wheel looks smooth, as shown in Figure 38.
- 6: Rub a small amount of graphite into a soft piece of cloth. Polish the wheel with the graphite cloth until your wheel shines. Be sure to wear a breathing mask when working with graphite. Finished product should look like the one shown in Figure 39.

Note: Advanced methods of wheel preparation are discussed in later sections of this book. The steps outlined in this section are the very basic steps of wheel preparation. However, you would be surprised to learn how many people either don't bother with wheel preparation at all, or if they do, they end up doing it wrong and creating more problems in the process. Just follow the steps outlined above, and you will be in good shape.



Figure 37: Attach wheel to drill using mandrel

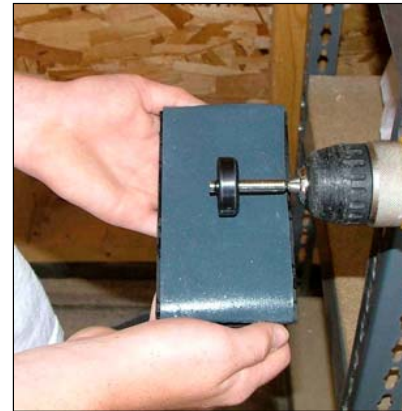


Figure 38: Lightly sand wheel using moistened 600 grit sandpaper

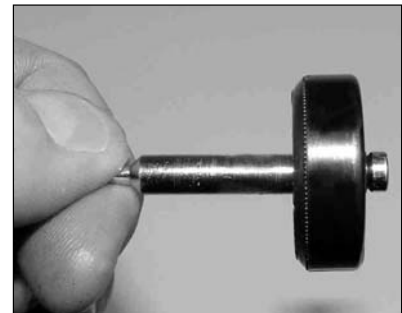


Figure 39: Wheel polished using 600 grit sandpaper and graphite.

## Wheel Lubrication

No matter how much you polish your axles, there will still be friction as they make contact with the wheels. So, your next step in making a competitive car is to further reduce that friction by lubricating the axles.

**Types of Lubricant:** There are several types of lubricant out there to choose from. These are generally classified as either liquid or dry lubricants.

**Liquid Lubricants:** If your local rules allow the use of liquids then you need to be very careful about the type of lubricant you use. I would recommend NyOil II, a refined synthetic oil that works very well in derby cars. NyOil II does out perform graphite by a significant margin when used correctly. However, I advise you to be very careful. Liquids attract dust, dirt, and other particles. Mix any liquid with dirt and what are you going to get? Answer: Some type of paste that will act like cement in your axles. Exercise caution in the care of your wheels and axles to avoid letting dust or other particles get inside your wheel bore.

**Dry Lubricants:** There are actually several dry lubricants out there. I've seen people use all of them. However, **Graphite-Molybdenum** is by far the most widely accepted and time proven lubricant for Pinewood Derby cars. Molybdenum is actually a substance which acts like microscopic ball bearings.

Another dry lubricant is white Teflon powder. I remember when this stuff first hit the market. People were talking about it like it was some kind of miracle. Teflon works in frying pans, so it should work in Pinewood Derby car wheels too... right? **WRONG!** Teflon powder doesn't work! It simply does not lubricate wheels as well as graphite. Stay away!

My recommendation is to use **Graphite-Molybdenum** to lubricate your wheels and axles. Apply graphite to all wheel locations, as shown in Figure 40. You especially need to try and get the lubricant down inside the wheel bore as much as possible.

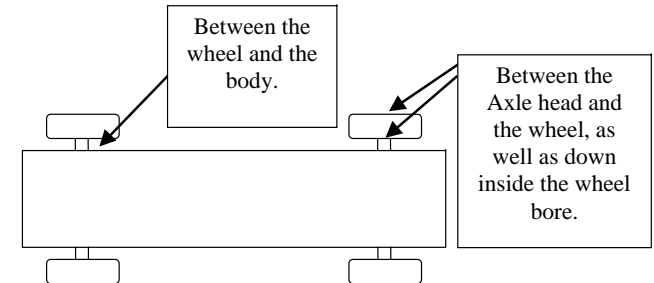


Figure 40: Apply graphite to all four wheels as shown above.

Believe it or not, the method you use to apply the graphite can also make a difference in the speed of your car. In order for the graphite to be effective, it needs to be placed inside the wheel bore. However, once the wheel has been attached to the car, inserting graphite into the small space between the wheel and car body can be somewhat of a problem. Most people will tell you to squirt the graphite into the wheel using the pointed tip on the end of the tube. In my experience, this doesn't work very well. Precious little graphite actually makes it down inside the wheel where it belongs.

The very best method I've found is to use a small paint brush to apply the graphite (those small brushes that come in water color kits work great). Take your tube of graphite and empty it into a small dish. Dip the brush into the graphite and then gently transfer the graphite from the brush to the car. As you apply the graphite, gently shake or tap each wheel. This will help move the graphite down inside the wheel bore.

Note: When using graphite, it is important to wear a breathing mask. Graphite particles are very light. As you work with graphite, some of the particles become suspended in the air, where they get inhaled. Graphite is also one of those substances which tend to get all over everything. So, when using it be sure you are either outside, or that you cover the surface you are working on with newspaper, cloth, or plastic.

Summary: Weight placement, Axle preparation, Lubrication, and Wheel prep are the keys to building a competitive car. If you do these four things correctly, you will probably win some races. Your car will be numbered among the group of cars that actually presented competition. You will have a car you can be proud of.

If you want to go the extra mile and turn your car into a winner, then move on to the next section of the book... Building a Winner!



Figure 41: Now It's Your Turn!

## ***Building a Winner***

To be a winner you need to do several things above and beyond what the rest of the people in your derby have done to their cars. You must separate yourself from the rest of the pack.

This section of the book is devoted to the speed tips and methods used by winners. The top cars will have incorporated many of the tips discussed in this section.

### **Question: How do you eat an elephant?**

Believe it or not, this is an important question that everyone who really wants to build a winner needs to understand and know the answer to. So, how do you eat an elephant? Answer: One bite at a time! You don't accomplish the task by devouring half of the elephant in one sitting. Applied to Pinewood Derby racing, this little bit of wisdom basically suggests that winning the derby is accomplished in small incremental steps. I wish I had a dollar for every person who has come up after a race, looked at our car and then said, "So what magic thing did you do to this car?"

There is no magic step or secret that will turn your car into a winner. There aren't any two magic secrets that will do the job. You win races by doing a whole list of things to your car, each of which might shave 1/1000<sup>th</sup> of a second off of your race time. It's very important to understand this principle! Many of the speed tip books and internet sites seem to have forgotten this entire idea. There are a lot of people out there who will tell you not to bother with certain speed tips, because they only change the speed of the car by a fraction of a second. In their book, these tips simply aren't worth doing. They want you to focus on the big speed tips and forget about the small ones. Well, that's exactly why cars built using their advice are never able to beat our cars! We pay attention to the little things, and it adds up one fraction of a second at a

time, until it becomes virtually impossible for someone else to beat us. We have done the little things, and they haven't. It's as simple as that!

Keep in mind that if anyone at your derby has studied up on the winning secrets of Pinewood Derby cars, you will still need to take your car to an even higher level of performance if you want to take home the first place trophy. These exclusive secrets that turn a winning car into Champion, are found in the last section of this book.

OK, let's learn how to build a winner!

## Modifications to the Body

To build a winner you need to prepare the body of your car for maximum speed. Below are four speed tips that will help you do just that... design your car for maximum speed!

### Extend the Wheel Base

One of the most powerful things you can do to your car is to extend the wheel base. By this I mean, move the wheels so that the front wheels are closer to the front, and the rear wheels are closer to the back, as shown in Figures 42 and 43.



Figure 42: Standard Wheel base



Figure 43: Extended Wheel base

Extending the wheel base will give your car two powerful advantages over other cars. First: It allows you to place the weight farther to the rear of the car. The farther back you place the weight, the faster your car will go. The reasoning behind this tip is that as you push the weight farther up the track, your car gains potential energy.

More Energy = More Speed

Second: A longer wheel base will make your car travel in a straighter line as it rolls down the track. The straighter it rolls, the less likely it will be to weave around and bump into the center guide rail. The shortest distance between the start and finish is a straight line.

Fewer Bumps = More Speed

In order to accomplish this modification you will need to drill a new set of axle holes in your wood block. The holes must be perfectly straight and aligned with each other on opposite sides of the car. This is best accomplished by using a drill press or the Derby Worx *Pro-Body Tool*, which is specifically designed for drilling axle holes. Both methods are briefly described on the next page.

The holes need to be drilled  $\frac{5}{8}$ <sup>th</sup> inch from either end of the block and  $\frac{1}{8}$ <sup>th</sup> inch up from the bottom, as shown in Figures 44 and 45. Distances shown are measured to where the middle of each hole should be located. The holes should be drilled using a #44 sized drill bit.

You can also visit [www.derbychamp.com](http://www.derbychamp.com) where pre-drilled pine blocks and wedges are available.

Note: Please note that when you extend the wheel base, the center of gravity rule still applies. The center of gravity for your car should be between  $\frac{3}{4}$  inch and 1 inches in front of the rear axle. In this case, that location will be located farther to the rear of the car.



Figure 44: Location of new holes for extended wheel base.



Figure 45: Wood block with holes drilled for an extended wheel base.

### Drill Holes using a Drill Press

If you decide to drill the holes using a drill press, please take note of the following instructions.

1: You will need to construct a “jig” to hold the block in place when you drill each hole. These holes need to be exactly lined up with each other on either side of the block. If you do not use a jig, I can almost promise you that you will not be successful in drilling the holes correctly. The idea here is to create a repeatable process so that when you drill each hole, you know exactly where that hole is going to be drilled when you put your car block on the drill press table. Building a jig can be as simple as clamping a square on the drill press table, as shown in figure 46.

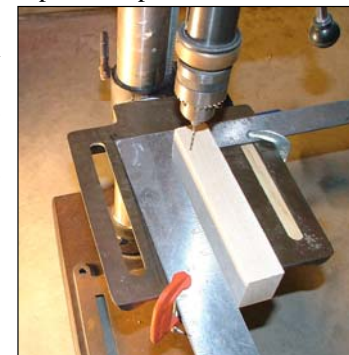


Figure 46

2: Once you have the jig in place, drill some practice holes in another block of wood. Measure the location of the hole and be sure it is being drilled in the exact location you want it to be drilled. When you are confident in the location of the hole, then you can proceed to drill the hole in your actual car block.

3: Some people try to accomplish this task by using a long drill bit to drill one hole that goes all the way through the block. **DO NOT DO THIS!** A #44 drill bit is thin and weak. In most cases, it will not drill a straight hole all the way through the block. The bit will wander or curve

slightly. When this happens the drill exits the opposite side of the block slightly out of position from where it was supposed to be. Drill each hole independently.

4: When all four holes are drilled measure them all one more time to be sure they are correctly place. Measure up from the bottom of the car as well as from the front or back of the car.

### Drill Holes using the Derby Worx Pro Body Tool

The Derby Worx Pro Body Tool will enable you to drill perfectly aligned axle holes using your hand held power drill. Figure 47 illustrates how the tool fits on a standard block. With the Pro Body Tool in place you simply insert a #44 bit and drill the hole with your hand held drill. If you don't have a drill press then the Pro Body Tool is going to be your best option for drilling the axle holes. For complete instructions on using the Pro Body Tool see Appendix #2.

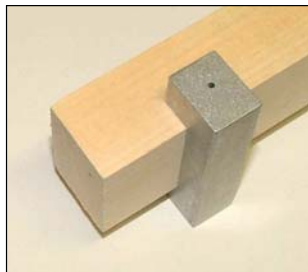


Figure 47: Derby Worx Pro Body Tool

## **Death by Glue**

If you choose to extend the wheel base of your car, then I highly encourage you to also pay attention to this little tip. I call it Death by Glue. One of the worst things that can happen on race day is to have a wheel get knocked off of the car. Truthfully, I've seen this happen a lot of times. Similarly, if you spend time aligning the wheels, then you need to be absolutely sure the axles will stay put once you have them aligned properly. You don't want to have your car get bumped a little in the first race and then be totally out of alignment. Hence, the axles need to be firmly glued in the holes. A lot of people end up killing their prospects of winning when they try to glue the axles. If any glue whatsoever gets on the wheel hub or on the car body where the hub will touch, then you will lose significant speed. That glue will act like sandpaper. Here's a technique that we have used for years to avoid death by glue.

Simply drill two small (5/64 inch) holes through the bottom of the car body and into each axle hole as shown in Figures 48 and 49. After inserting the axles, apply one drop of instant glue to each glue hole. Allow the glue to dry before turning your car right side up. The glue will cement the axles firmly without the risk of getting glue anywhere near the wheels.

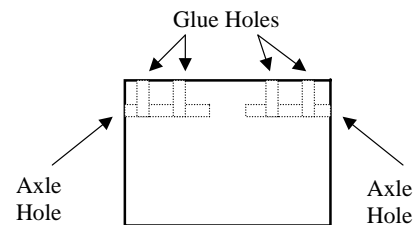


Figure 48: Diagram of glue hole configuration

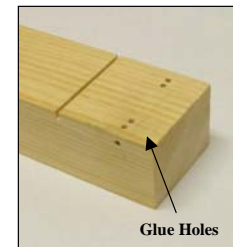


Figure 49: Photo of completed glue holes.

## Smooth, Smooth, Smooth

Remember, friction is the enemy of speed. One of the highest friction spots on your car is the small area where the wheel hub rubs against the car body. Every time contact is made in this area, you lose speed... **BIG TIME!**

So, you need to make this area as smooth as possible. Sand the area around the axle hole until it is smooth, smooth, smooth. Follow the directions below to accomplish this.

- 1: Before painting your car, lightly sand the area around the axle hole with 400 and then 600 grit sandpaper, as shown in Figure 50.

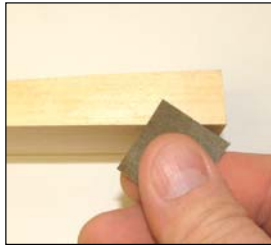


Figure 50

- 2: Put a small piece of tape over the axle hole area to protect it when you paint the car. After paint is applied you can remove the tape, as shown in Figures 51 and 52.



Figure 51: Tape applied before painting



Figure 52: Tape removed after painting

- 3: Lightly sand the area again with 600-grit sandpaper.
- 4: Using a smooth piece of cloth, gently rub graphite into the wood around the axle hole area, as shown in Figure 46. Continue to apply graphite until the area looks as smooth as it can be. Look at it using a magnifying glass to be sure you don't have any big scratches or bumps. If you do, sand them down and reapply graphite.

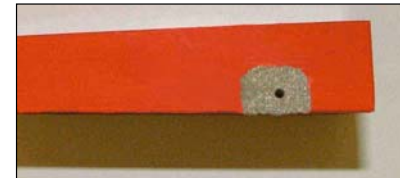


Figure 53: Rub graphite into the wood around the axle hole area.

## Wheel Modifications

The stock wheels that come straight out of the box, have a lot left to be desired when it comes to building a winning car. Listed below are a number of things you can do to improve them.

## Lathe Turned Wheels

One of the most powerful things you can do to improve the speed of your car is to use **Lathe Turned Wheels**. Wheel rule number 1: Stock wheels straight out of the box are not round! This fact can have a large effect upon how your car performs in competition. If you want to see the effect that non-round wheels have upon your car, then try this experiment.

Find a basketball. Let a little air out so that if you sit or push on it, it will keep a portion of its deformed shape. Now, roll the deformed ball across the floor. What happens? Does it roll straight? Does it roll smooth? Does it look like it has hiccups as it rolls? Does it wobble? Do you want your wheels to look like that as they roll down the track?

Lathe turned wheels also have the advantage of weighing less than stock wheels.

Less Weight = Less Inertia

Less Inertia = Faster Starting Speed

Wheels with less inertia will begin turning faster. In other words, at the top of the track, lightweight wheels will start rolling down the track before heavier wheels even begin moving.

For those who have never seen or used a lathe before, here is a short description of what a lathe does. A lathe is a machine which spins the wheel. With the wheel spinning, a cutting tool or blade is used to machine the wheel so that it is perfectly round. Figure 54 shows a lathe turned wheel side by side with a stock wheel. The lathed wheel is smooth, round, and defects have been removed.

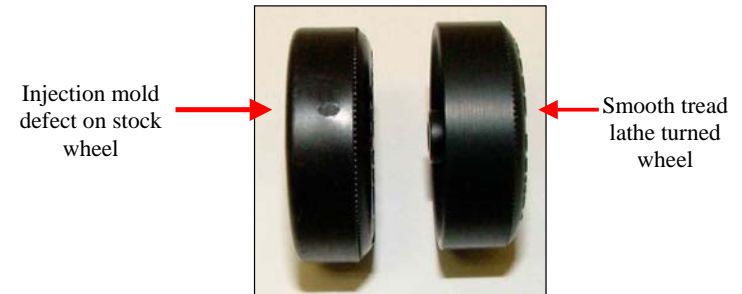


Figure 54: Stock BSA wheel and lathe turned BSA wheel.

In presenting this powerful speed tip, I have struggled with what to say. Having thought it through, I've decided to give you my opinion and be to the point about it. Make no mistake, this is a very powerful speed tip! If your rules allow it and you can find a way to accomplish it, then by all means do it! It will make a huge difference in the speed of your car!

However, there is one small catch to this speed tip. It requires the use of a machine lathe. Most people don't have a machine lathe lying around the house. A machine lathe is very expensive and requires skill to use it. So, here is my honest advice about lathe turned wheels.

- 1: In an attempt to show regular people how to take advantage of this speed tip, some other tip books suggest that you try to accomplish the task by turning the wheels with a mandrel and a power drill. You are then supposed to use some sort of blade to cut away a layer of plastic from the wheel. I advise you to ignore this advice! Attempting to modify your wheels without using a lathe is a recipe for disaster. You will almost certainly create problems which are worse than those you are trying to fix.
- 2: If you have a friend or neighbor who has a machine lathe, then thank your lucky stars!

3: You can call a local machine shop and ask them if they will help you turn your wheels. My experience suggests that most shops will be happy to work with you. However, in many cases it will cost a significant amount of money. They will want to charge you their normal work rate to do the job.

4: If you have no friends and no money, then I would suggest you consider purchasing lathe turned wheels off the internet. There are numerous web sites that offer Official BSA wheels, which have been turned on a lathe. In most cases, these wheel sets are affordable and cost a lot less than having a local machine shop do it. [www.derbychamp.com](http://www.derbychamp.com) has a good selection of lathed wheels)

Note: If your local rules will not allow lathe turned wheels then be sure to use the basic wheel preparation steps outlined on pages 42 through 44.

### Lathe Turned Wheels (H and V Configurations)

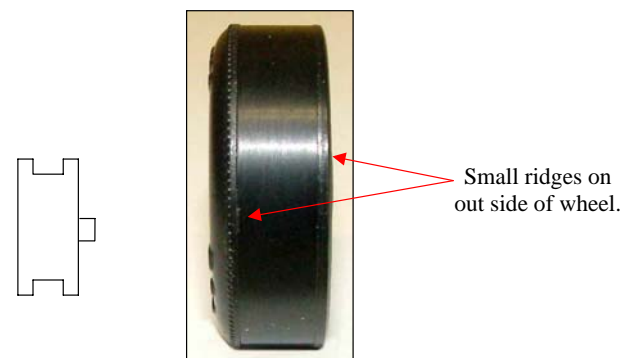
You can take lathe turned wheels to an even higher level of performance by machining the wheel to an H or V configuration.

Remember: Friction is the enemy of speed, and wheels that weigh less are faster off the starting line than heavy wheels.

V and H configured wheels will reduce the amount of friction the wheel has with the track by reducing the surface area of the wheel. It also reduces the weight (or inertia) of the wheel. Check your local rules.

### H Configuration:

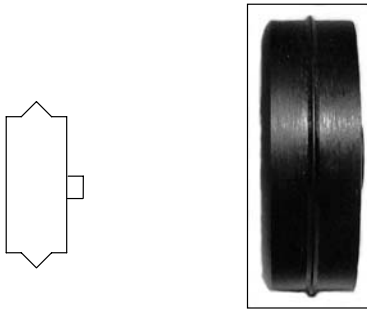
Figures 55 and 56 show wheels in the H configuration. In this case, the only parts of the wheel which actually touch the track are the small rims on the outside of each wheel. The wheel/track friction is reduced by over 70%.



Figures 55 and 56 H Wheel Configuration

## V Configuration

Figures 57 and 58 show wheels in the V configuration. In this case, the only part of the wheel which actually touches the track is the small point in the middle of the each wheel. The wheel/track friction is easily reduced by over 90%.



Figures 57 and 58: V Wheel Configuration

## Taper the Wheel Hub

One of the largest sources of friction is the spot where the wheel hub rubs on the car body. Anything you can do to reduce friction at this location will help your car go faster. To this end, one of the very best things you can do is to taper the wheel hub. This little trick reduces the contact surface area by over 50%. Tapering the wheel hubs can be accomplished using a small flat file or by using the Derby Worx Pro Hub Tool. Both methods are describe below.

## Using a Small Flat File

- 1: Using a smooth file create a tapered edge all the way around the wheel hub, as shown.



Figure 59: Tapered wheel hub

- 2: Sand the tapered edge with 400-grit sandpaper



Figure 60: Sanded wheel hub

- 3: Repeat step 3 using 600 and 1000-grit paper
- 4: Using a soft cloth, rub graphite into the tapered edge.

5: The final product should look something similar to Figure 61.



Figure 61:  
Completed wheel  
hub

#### Using the Derby Worx Pro Hub Tool

The Pro Hub Tool is designed to help you put a smooth uniform bevel on the hub of each wheel. The tool itself is shown in Figure 62. This handy tool will enable you to accomplish the task in much less time and leave you with wheel hub that looks very professional. For complete instructions on using the Pro Hub Tool see Appendix 2.



Figure 62: Derby Worx Pro Hub Tool

#### **Polish Inside Rim**

This is one of those little tips that most people just forget about. As your car rolls down the track, the inside wheel rim will occasionally make contact with the center guide rail. So, you need to polish the inside wheel rim so that it's as smooth as it can be. This will reduce the friction when contact takes place. Follow the steps below.

1: Attach the wheel to a wheel mandrel and then spin the wheel using a power drill or a Dremel Tool.

2: Gently sand the inside wheel rim using 400, 600, and then 1000 grit sandpaper.



Figure 63: Gently sand  
inside wheel rim.

3: Using a soft cloth polish the inside rim with graphite.

#### **Three Wheels on the Track**

This is an awesome speed tip! Attach your wheels so that only three of them actually ride on the track. The fourth is set about 1/16<sup>th</sup> inch higher so that it never actually touches the track itself. Remember our favorite Pinewood Derby rule? Friction is the enemy of speed. Well, a major source of friction is the contact your wheels make with the track as the car rolls and the wheel axle contact we have discussed before. You can reduce that friction 25% by only placing three wheels on the

track to begin with. If the wheels on your car are aligned and balanced, then you only need three wheels. The fourth wheel is just there to slow your car down, so get rid of it! The wheel you elevate needs to be one of the front wheels. Figure 64 shows a car with one wheel riding above the track.

To accomplish this do one of the following:

- 1: If you are using a standard wheel base, then simply cut the standard wheel grooves a little deeper so that the axle can be inserted higher up on the block.
- 2: If you are using an extended wheel base, then simply drill one of the front axle holes a little higher .
- 3: Use the front wheel that spins the worst. Every car has one wheel that just doesn't spin as well as the others. Use that wheel as the one you elevate. This will make your car go even faster because you have totally eliminated your worst wheel from consideration.

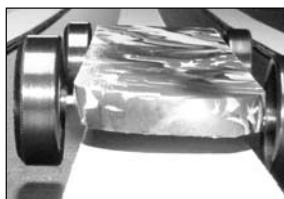


Figure 64

### **A Word Regarding Mold #13 and #9**

Official BSA wheels are manufactured using a plastic mold injection process with 16 individual molds. The mold number associated with each wheel is stamped on the backside of each wheel. Previous editions of this book have suggested that wheels produced from mold #13 and #9 were defective, as shown in Figure 65.

**IMPORTANT UPDATE:** It appears the quality issues associated with mold #13 and #9 have been corrected. I have examined thousands of wheels this year (2005). I have found very few defective wheels from these two mold numbers. I now feel confident in recommending both of these mold numbers for use in pinewood derby racing. However,

please examine your wheels to be sure you did not get a set of defective #13 or #9 wheels that came from last year's stock. If you did, then get a new set of wheels.

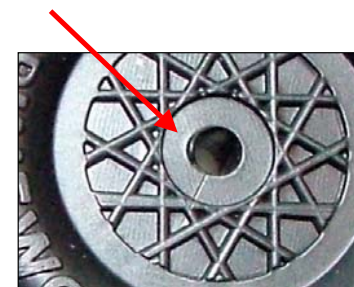
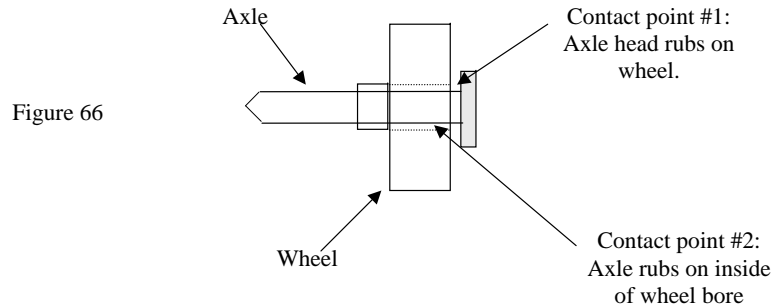


Figure 65: Close up photo of Defective Mold 13 Wheel. Arrow is pointing to defective location

## Axle Modifications

Another very powerful set of speed tips involve reducing the friction between the axle and the wheel. There are two contact points between the wheel and the axle.



Polishing your axles until they shine like mirrors, see pages 35 - 38, will help reduce friction at both contact points. But, don't stop there! You can do more... much more! Just take a look at these killer speed tips!

## Taper the Axle Head

The idea here is to reduce the amount of surface area available to rub at contact point #1. By tapering the axle head, we reduce the area so that only a small portion of the head can make contact with the wheel.

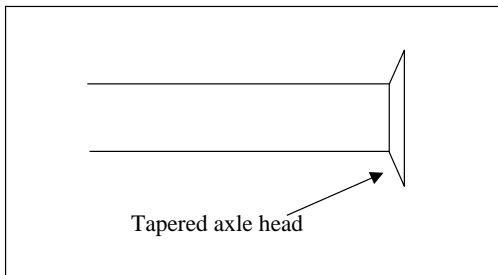


Figure 67: Diagram of tapered axle head

Follow these steps when tapering an axle head:

- 1: This step should be done prior to polishing your axles. Ideally you will taper the axle head and remove the unwanted burrs at the same time.
- 2: Clamp your power drill into a vise.
- 3: Insert and secure an axle in the drill. Be sure the axle is secured tightly.
- 4: Using smooth tooth file, gently file the axle head to an angle of about 30 degrees.

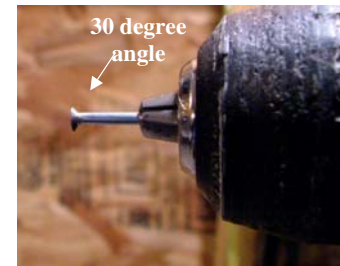


Figure 68: Axle head filed at 30 degree angle

- 5: Follow the steps on pages 39-42 to polish the axle until it shines like a mirror.

## Reducing Contact Surface Area

Another important thing you can do to improve the performance of your car is to reduce the contact surface area between the wheel and the axle. This is especially important if you are using a liquid lubricant. This is accomplished by altering the axle so that it looks like Figure 69.

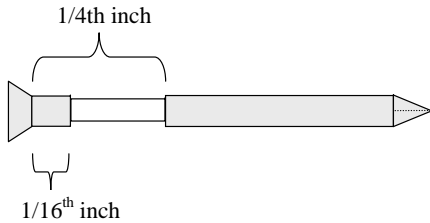


Figure 69: Measurements shown are those to be used when racing with standard BSA wheels and axles.

The part of the axle where the groove is cut never touches the wheel. This feature significantly improves the performance, especially when using liquid lubricants but also has benefits when dry lubricants are used as well.

Follow these steps to create lightning speed axles:

1: This speed tip is best accomplished with a drill press. However, if you are very careful and precise you can do it with a power drill as well. The cuts you make in the axle must be absolutely straight. If you cut the groove on an angle then the wheel will tend to wobble as it turns.

2: Place a dark mark on the axle at  $1/16^{\text{th}}$  of an inch from the head. Place a second mark at  $1/4^{\text{th}}$  of an inch, as shown in Figure 70.

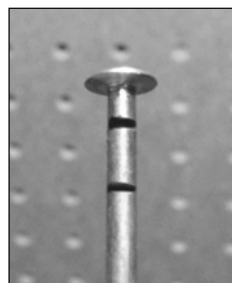


Figure 70: Marked axle

3: Clamp the axle in your drill press or power drill.

- 4: If using a drill press, line up the press table with the marks you made on the axle, as shown in Figure 64. Using a flat file, gently cut a groove in the axle to a depth of about  $1/16^{\text{th}}$  of an inch. Don't cut the groove too deep, as it will weaken the axle.
- 5: Polish the axle using the method shown on pages 39-42. The final product should look similar to the one shown in Figure 72.

This little speed tip, also has a hidden advantage. The groove you cut in the axle becomes a secret trough where graphite gets stored. Later on during the race, some of that graphite will work it's way out of the trough and be used to lubricate the inside of your wheels.

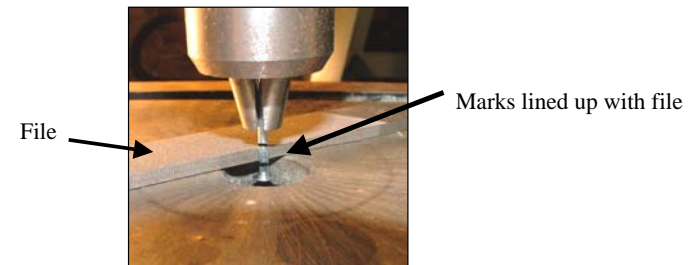


Figure 71: Axle marks lined up with file, using drill press.



Figure 72: Completed speed axle

## Speed Tips for Final Preparation

Now that you have built your car, and are preparing to put the whole thing together, there are a few really good speed tips that you need to be aware of. A lot of people don't pay any attention to these tips. However, take it from me... they are powerful tips! Don't sell them short. These tips will help turn your car into a rocket!

## Wheel Alignment

Wheel alignment is one of the most important things you can do to build a winner car. If the wheels on your car are not aligned, then the car will not go straight. It will weave back and forth as it rolls down the track. It will bump into the center guide rail over and over. Any weaving or bumping as the car rolls is very bad news for speed!

Before we go any further on this topic, you need to understand two things. First: This is one of those speed tips that can really put you out in front of the pack, because very few people understand wheel alignment and even fewer actually take the time to do it. Second: I highly recommend that you use the alignment method I'll be teaching you in this book. There are several other methods out there. However, my method has advantages that will give you a better alignment and higher performance than the other methods. The steps are outlined below.

- 1: The correct place for your wheels to ride is centered in the middle of the axle. As the wheel turns you don't want it to move toward the body of the car, as that will result in the wheel hub rubbing on the car body. Likewise, it's not much better if the wheel moves outward toward the axle head. In this case, the wheel rubs on the axle head all the way down the track. Our first task will be to

align the wheels so that they tend to stay centered in the middle of the axle as they turn.

- 2: Make an inclined ramp that is 7 to 10 feet in length. A large sheet of plywood or a dining room table are two good possibilities. We have always used the dining room table with all three leaves installed to make it as long as possible, see Figure 73. Use masking tape to mark a straight path down the middle of the ramp, as shown. The path should be about 6 inches wide.

Figure 73: Test Ramp with masking tape path



Books under one end of table.

- 3: Put some pillows at the bottom of the ramp. The pillows will stop the car when it reaches the end of the ramp.
- 4: Prop the ramp up on a very slight angle. Use a three or four foot level to be sure the table is horizontally level. If the table is tilted right or left then the car will tend to roll that direction and you will not be able to accurately align your wheels.

At this point you want the car to roll down the ramp very very slowly. Position the car at the top of the ramp. Make sure each wheel is centered in the middle of its associated axle. Let the car start rolling slowly down the ramp.

5: Allow the car to roll 2 or 3 feet. As it rolls, watch each wheel. Take special note of whether each wheel tends to move inward toward the car body, outward toward the axle head, or whether it just rolls in the middle of the axle. Repeat this process several times until you are confident that you understand how each wheel is moving as the car rolls.

6: If a wheel moves inward toward the car body, then the axle needs to be adjusted up.

If a wheel moves outward toward the axle head, then the axle needs to be adjusted down.

7: Making adjustments to the axles is the most important part of this process. **YOU MUST DO IT CORRECTLY.** The idea is to slightly bend the axle so that it angles up or down as needed. However, the bend needs to be done in such a way as to leave the portion of the axle where the wheel rides, absolutely straight. Follow the steps below to adjust the axle.

A: Before removing the axle from the car body, place a mark on the axle at exactly 12 O'clock. This will ensure that you always know the original orientation of the axle.



Figure 74: Mark axle at 12'Oclock

B: Before removing the axle, place a mark at the exact location where the axle meets the car body, see Figures 75 and 76.



Figure 75



Figure 76

C: Carefully remove the axle from the car body. Be very careful. Do not damage the wheels in the process.

D: Clamp the axle in a vise or an axle press. If the axle needs to be adjusted up, then make sure the 12 O'clock mark is away from you, as shown in Figure 77. If the axle needs to be adjusted down, then make sure the 12 O'clock mark is toward you. The mark you made in step B should be located slightly above the edge of the vise as shown in Figure 77.

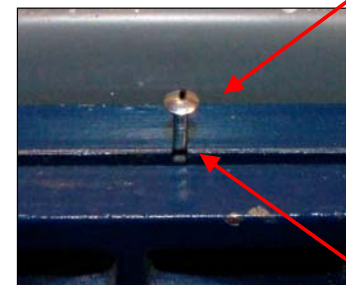


Figure 77: Clamp and align axle.

In this example, the axle needs to be adjusted "UP" so we have the mark facing away from us. The bend will be made in the direction of the mark.

If the axle needs to be adjusted "DOWN" then the mark would be 180 degrees from what it is shown in this picture. It would be facing you.

Second mark slightly above edge of vise. This is where the bend will be created.

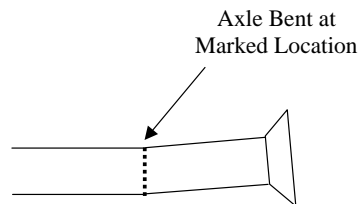
- E: Place a flat, regular screwdriver squarely at the base of the axle, slightly below the mark you made in step B, as shown in Figure 78



Figure 78: Gently tap axle

- F: Gently tap on the screwdriver with a small hammer or rubber mallet. This will create a slight bend at the marked location, see Figure 79. You don't want to bend the axle too much. Small adjustments are the key to the process.

Figure 79



- G: Remove the axle from the vise and reattach the axle and wheel to the car body. Be sure the 12 O'clock mark is pointing straight up.
- H: Place the car on the ramp and allow the car to roll down the ramp 2 or 3 feet. If the wheel stays pretty much in the center of the axle, then you are finished with "Up/Down" adjustments for that axle. If the axle continues to move in toward the body or out toward the axle head, then you need

to repeat the process until the wheel remains in the center of the axle. This may take some time. There have been occasions when we repeated this process 7 or 8 times before everything was perfect.

Do not move on to step I until all four wheels ride in the middle of the axle consistently.

- I: Now it's time to make your car go straight! Elevate your ramp so that when released, you car will roll down the ramp at a fairly good speed. Be sure you have pillows at the end of the ramp.
- J: Place the car at the top of the ramp. Make sure it is lined up straight in the middle of the taped path, as shown in Figure 80.

- K: Release the car and let it roll all the way down the track. Did it stay within the taped path? Did it roll to the right or to the left? If it didn't roll straight down the middle of the path, then you need to make some adjustments to the front axles.



Figure 80

L: If you only have three wheels touching the track, then you will need to adjust only the front wheel that is touching. If you have both wheels on the track, then you will need to identify which wheel is dominant (or in other words, which wheel is carrying most of the weight).

At this point, if you only have three wheels on the track, then you can move on to step 7M. Otherwise, follow these instructions to find the weight bearing dominant front wheel.

- 1: Place the car on a flat level surface.
- 2: Place your index finger directly on the front center of the car.
- 3: Gently press down. As you press down, you will feel the car slightly shift toward one of the front wheels. The dominant wheel is the wheel in the opposite direction of the shift. This is the wheel that carries the weight.

M: Be sure the axle head has a mark located at 12 o'clock, as shown in Figure 74.

N: Remove the axle and repeat the adjustment process described in steps 7D through 7H. However, this time you will be adjusting the axle left and right. If your car turns to the left as it rolls, then adjust the axle right. If the car rolls right, then adjust the axle left.

O: Repeat this process until your car rolls straight down the ramp consistently. Once we think we have it right, we usually roll the car down the ramp 5 or 6 times. If it rolls in a straight path consistently then we know we are finished.

P: When all four axles are adjusted to perfection, glue them in place using the glue holes you drilled previously, see Figure 49.

Q: Congratulations! You have a perfectly aligned car. I know it took some time, but it was time well spent. If you apply this speed tip correctly you will have a major speed advantage. Most people just don't spend the time to do this correctly.

### **Break Them In**

I love this speed tip! If you have ever been to a Pinewood Derby in the past, you may have noticed that a lot of cars will not do very well their first or second time down the track. However, by the end of the derby, those same cars will be running better and will sometimes even beat cars they lost to in the first or second heat. This isn't just your imagination playing tricks on you. It really happens. As a general rule, your car will get a little faster each time it goes down the track. Each time you race, the wheels and axles wear into each other a little bit more. They get smoother and smoother. Your car will be faster the 20<sup>th</sup> time it races than it was the 1<sup>st</sup> time.

So, hold on to your hat when you hear this speed tip! Race your car 50 or 100 times before you ever show up at the Pinewood Derby! How do you accomplish this without a track? It's simple. Just follow the instructions below.

There are two ways you can break in the wheels. One method requires a Dremel Tool with a large felt disk attachment. The second method requires your index finger and a good movie. I'll explain both methods. You can choose the method that works best for you. This is another really good step where your child can do almost all of the work on their own.

### Method #1 (Index Finger Method):

- 1: Go outside or in the garage and apply graphite to each wheel (outside because we don't want to get graphite all over the furniture or carpet). Spin the wheels a little bit.
- 2: Find a good movie and put it in your DVD player.
- 3: Sit down and start spinning your wheels. Hold the car level and spin them. Turn the car on its side and spin them. Turn the car over on the other side and spin them.
- 4: After 5 or 10 minutes, go back outside and apply some more graphite.
- 5: Watch your movie and spin your wheel some more! Spin them and spin them. Keep spinning the wheels until the movie is over. Periodically go outside and apply graphite.
- 6: By the time the movie is over, your car will have been in about 100 races. It will be a fine tuned racing machine!

### Method #2 (Using a Dremel Tool):

- 1: Obtain a Dremel Tool with a large felt disk attachment.
- 2: Apply graphite to the wheels.
- 3: Turn the Dremel Tool on high speed. Gently touch the spinning felt disk to one of the wheels. Let it spin and spin.
- 4: Turn the car over on its side and spin the wheels. Turn it over on the other side and spin the wheels, see Figures 81 and 82 and 83. Every minute or so apply more graphite.

- 5: Spin each wheel for about 5 minutes on high speed.
- 6: When you are finished, your car will have run a good 100 races or more. It will be a fine tuned racing machine!



Figures 81, 82, and 83: Spin the wheels in all three positions.

### The 20 Second Test

Basically, the 20 second test is the final test you will give your car to be sure everything is correct and ready to go. After the wheels have been lubricated, aligned, and broken in, you should perform the 20 second test. Spin each wheel as fast as you can. Time how long each wheel spins. Repeat this procedure 5 or 6 times for each wheel. If everything is "right" your wheels should spin for at least 20 seconds. If you find one wheel that just doesn't measure up, then try adding more graphite. Spin that wheel again for a minute or so to break it in. When finished, try the 20 second test again. If the wheel now spins for 20 seconds, great! If it's still slow, I would recommend you remove that wheel/axle pair and replace them with another set. We have replaced wheel/axle sets many times over the years when they didn't pass the 20 second test (if you end up replacing a wheel then you will need to re-align your car).

In my experience, if a wheel will not spin for at least 20 seconds, then something is wrong. It's not performing at the level it should, if you want to build a winner. If you have done everything correctly, then it will not be uncommon to see wheels spin for more than 20 seconds. We regularly have wheel sets spin for up to 34 seconds.

### **The Maximum Allowed!**

I've said this before, and I'll say it again. The heavier your car is the faster it will go. You need to have every fraction of a gram worth of weight the judges will allow you to have. Show up at the check-in station with your car slightly under weight, say 4.95 ounces. Place your car on the scale and then slowly add small bits of weight to the scale. Continue to add small bits of weight until the scale reads more than 5.0 ounces. Then remove the last bit of weight you added.

There is an important principle at work here. On a scale that measures to the nearest 0.1 ounces a car that weighs 4.96 ounces and a car weighing 5.04 ounces both register as 5.0 on the scale. So, make sure you have the maximum amount of weight allowed.

We like to use lead putty for this part of the process. Lead putty is dense and easily molded to fit into one of the small holes we have previously drilled in the bottom of the car (if you use lead putty be sure to wash your hands and follow safety precautions during and after its use).

The other reason this speed tip will help propel you to the front of the pack is this: A lot of people show up with cars that weigh too much. In order to reduce the weight of their car, they end up cutting wood off of the car or drilling holes in the bottom. If wood chips or saw dust get into your wheels, you can kiss your chances of winning goodbye! Why would anybody spend so much time preparing their wheels and axles

and then blow saw dust on them ten minutes before the race? Show up a little under weight, and then add to it.

A note to parents: Most of the time at weigh-in you will see parents lining up to place their "child's" car on the scale. Don't do this. This evening belongs to your child! Allow them to place their own car on the scale. I actually practice this activity with my sons at home. We put our scale on the table and I allow them to practice carefully placing the car on the scale, upside down so that it won't roll off. They practice putting small bits of lead putty on the scale until it reads 5.1 ounces. When we show up at weigh-in, my sons know exactly what they are supposed to do and how to do it. It's their car!



Figure 84: Car placed on scale upside down with small bits of lead putty added for maximum weight.

# Building a Champion

## The Ultimate Car

### Championship Car Designs

When it comes to derby racing, car design is a controversial topic... but it shouldn't be! There are car designs which produce faster cars than others, and that's a fact! If you want to build the Ultimate Car, then you need to select a fast design. So, what are the key factors of a fast car design?

**Design Factor #1:** Choose an aerodynamic design. We have discussed this principle in a previous section, see pages 20 and 21. However, I wish to emphasize this point again. Use a design which has a low, aerodynamic profile. Aerodynamics does make a difference in speed.

**Design Factor #2:** Maximize the amount of weight placed in the rear of the car. This means removing as much wood from the middle and front of the car as possible. Remember, any weight placed in the middle or front of the car is badly placed weight. Moving that weight to the rear of the car will increase speed!

This is seriously, one of those speed tips to which almost no-one pays attention. Think back to last year, or pay attention when you see all of the cars this year. How many people made any attempt whatsoever to remove wood from the middle or front of the car? Every sliver of wood or pinch of saw dust that you move from the middle to the back of the car will increase the speed!

Figure 85 shows one car design which adheres to the design factors outlined above. Notice this car is aerodynamic and contains very little wood in the center or front of the car. This is just an example. Please be

creative and find your own ways to incorporate these design tips. It could make the difference between taking home first or second place!



Figure 85: Aerodynamic, very little wood in center or front of car

### Polish the Wheel Bore

You may think that you have polished every single location on your car that can possibly be polished. However, there is still one place that needs to be polished! That location is the wheel bore, see Figure 86.

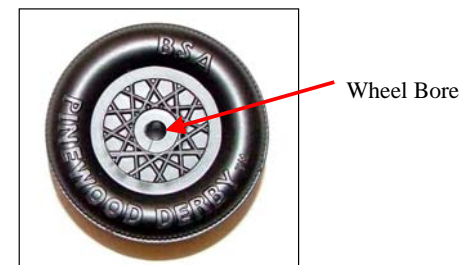


Figure 86

I have actually looked down inside the wheel bore using some powerful magnifying equipment. Take my word for it... it's not a pretty sight!

The inside of the wheel bore is anything but smooth! Some wheels even have long deep scratches down the bore.

You spend tons of time polishing your axles and now you are supposed to insert them into a wheel bore that looks like sandpaper? I don't think so!

I've spent years experimenting with methods for polishing the wheel bore. I've tried every method I can find! The method I'm going to teach you is the best. Some of the other methods being pushed on the internet don't work. They sound really good, but they don't work. I know because I've tried them all.

Follow the instructions below to obtain an ultra fine polish:

1: Things you will need:

A: Power drill

B: A pipe cleaner with moderately stiff bristles. You don't want to use a pipe cleaner with really smooth soft bristles. I like to use the type of pipe cleaners that are actually made from twisting two smaller pipe cleaners together.

This is very different from the advice you find on most internet sites. Most other people tell you to use a very soft pipe cleaner. Some people even suggest you go down to a tobacco store and buy an ultra fine smooth pipe cleaner. Ultra soft pipe cleaners don't work! Think about it. You need to use something that can polish scratches out of plastic.

C: A tube of whitening toothpaste. You MUST use whitening toothpaste. Most whitening toothpaste products contain a fine abrasive polish. We will use the toothpaste as our polishing compound.

2: Secure the drill in a vise, as discussed previously

3: Insert and secure a 5 inch section of pipe cleaner in the drill, as shown in Figure 87

4: Coat the pipe cleaner with whitening toothpaste.

5: Feed the pipe cleaner down through the wheel bore of one wheel, as shown in Figure 88.



Figure 87: Insert pipe cleaner

6: Hold the wheel between your fingers and then turn on the drill using medium speed. Slowly move the wheel up and down the pipe cleaner as it spins. Polish each wheel for about 45 seconds. Don't over polish. 45 seconds will do just fine.



Figure 88

7: Turn off the drill and remove the wheel from the pipe cleaner. Using warm water and a clean pipe cleaner, wash the wheel thoroughly. You must remove ALL of the toothpaste from inside

the wheel bore. Wash and rise, Wash and rinse! Get the wheel totally cleaned out.

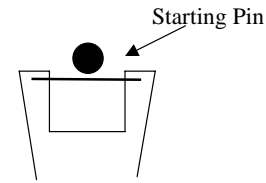
- 8: Using a third clean, dry pipe cleaner make sure you dry the inside of the bore. Do not leave water droplets inside the bore. As they dry, residue may be left behind. The idea is to completely clean and dry the wheel after polishing.
- 9: Repeat this process with all 4 wheels.
- 10: If you have a really good magnifying glass you may be able to hold a wheel up to the light and look down inside the wheel bore. If you do, you should be able to see a very smooth polished surface. Perfect for Racing!

I've tested many other methods. This one works the best! It will leave the wheel bore with a mirror-like finish.

### Quick Start

How would you like it if your car had already rolled 1 full inch down the track before any of the other cars even started moving? To the casual observer it will simply look like your car is just really really fast off of the starting line. However, the truth is that your car really does start rolling down the track before the others even have the chance to move.

This is accomplished by cutting a channel in the nose of the car. A bar is then positioned above that channel. As soon as the starting pin drops below that bar, the car becomes free to start rolling. Figures 89 - 93 illustrate this technique.



Front of Car

Figure 89

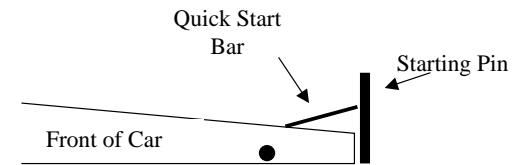


Figure 90

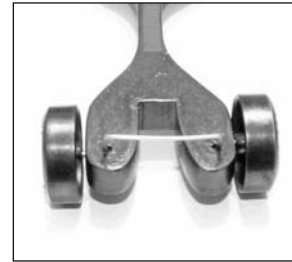


Figure 91: Close up of quick start



Figure 92: If you are racing with an electronic timing system, then you may want to use a quick start bar like the one shown in this photo. The wider bar will help the electronic sensors detect the front of the car as it crosses the finish line.



Figure 93: Real-time derby photo of quick start in action. Our car is the third car from the left.

We have raced in 4 Cub Scout packs in two states. Every single one of these packs has allowed us to use this speed tip. We have never been questioned. It's been a wonderfully powerful speed advantage! Try to make the channel and bar look like a natural part of your car design. However, if for some reason you discover that your local pack will not allow you to implement this technique as described above, there is a simplified version that will still give you a quick start and should be legal anywhere.

Instead of cutting a channel in the nose, simply undercut the nose as shown in figures 94 and 95. As soon as the starting pin drops below the lip, the car will begin to roll.

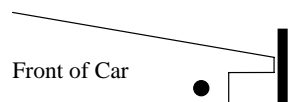


Figure 94: Alternate way to use quick start.



Figure 95: Alternate way to use quick start. You are looking at the bottom of the car.

### All Axles are Not Created Equal

The title of this section pretty much says it all. Simply stated, there's no such thing as a straight Official Scout Axle, but some are much straighter than others. This is very important to understand. If you use axles which are curved or bent your wheels will wobble as they go down the track. It will also affect the alignment of your wheels.

Bent Axles = Less Speed

The difference between a good axle and a bad axle is not normally visible to the naked eye. Can you tell the difference between the axle sets in Figures 96 and 97? The axles in Figure 96 are NOT straight. Your car will have less speed if you use these axles. The axles in Figure 97 are actually quite close to being straight. They're about as good as you can get straight out of the box. Your car will go faster if you use this set of axles.



Figure 96: This set of axles is NOT straight.



Figure 97: This set of axles is straight.

In order to find a good set of straight axles you will need to start with about 20 raw axles.

- Take each axle and put a small mark on it about one half inch down from the sharp pointed end.
- Clamp your power drill in a vise, as discussed previously.
- Insert one axle into the drill, clamping the axle at the previously marked location. This will ensure that each axle is clamped at the same relative location during this process.

- Turn on the drill. Observe the spinning axle. Bent axles will wobble as they turn in the drill, making them appear similar to the axle shown in Figure 98. Relatively straight axles will look more like the axle shown in Figure 99.
  - Please note that all axles will wobble to some degree. The idea here is to pick the four axles which appear to wobble the least amount. These will be the four axles which are the straightest. If you start with 20 axles you will be able to find 4 that are really quite good.
- Once you have identified the 4 best axles, place them aside to be used later. You will need to prepare this set of axles for top speed using the speed tips found on pages 36 through 42.

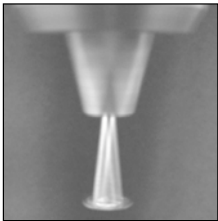


Figure 98: Bent axle spinning in drill

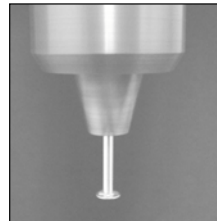


Figure 99: Relatively straight axle spinning in drill

### The Derby Worx Pro Axle Press

You can further straighten and improve your axles by using the Derby Worx Pro Axle Press. This nifty tool enables you to straighten bent BSA axles. The tool is shown in Figure 100. You put your axle in the press, tap it with a mallet, and presto you have straight axles. It works best if you start out with the best axles you can find, so be sure to follow the instructions outlined on the previous page before you use the Pro Axle Press. I've used this tool for several years and find it to be everything it claims to be. For complete instructions on how to use the Pro Axle Press see Appendix 2.

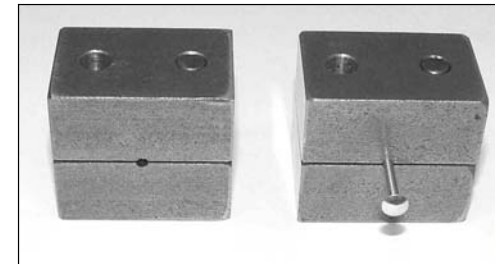


Figure 100: Derby Worx Pro Axle Press

## **Bake The Block**

I have said this several times now. The more weight you put in the rear of the car, the faster the car will go. However, did you know that even after you have done all of the other things I have suggested, there is still more weight located in the front half your car which can be moved to the rear? All wood blocks contain water. Water is a very heavy substance. Just a little bit of it can weigh a lot, relatively speaking. All of the water locked up in the front half of your car, is badly placed weight, so move it!

Before you add weights or paint your car, put the wood block in your kitchen oven and bake it. Baking will cause most of the water locked up inside the wood to evaporate. With that water gone, you will be free to put more weight near the back of the car. Children should not perform this task without adult supervision.

I would recommend that you bake the block at about 250 degrees for about 2 hours (You will need to experiment and find what works best for you). The impact this speed tip has upon the weight of the block will be affected by the humidity in your local area. However, even in the Sahara Desert, a wood block will have some water in it. Every gram of weight you move to the rear of the car will make your car go faster.

**Safety Note:** When baking a block you need to keep a close eye on what's going on in the oven. If you neglect the block you could start a fire or over bake the wood.

## **Use Premium Wheels**

We discussed earlier the fact that BSA wheels are manufactured using a 16-mold plastic injection process. Wheels are numbered 1-18. Mold numbers 6 and 7 are not included. Wheels coming from die molds 2, 5,

and 17 are better than other wheels. These wheels are normally defect free. They are also the most truly round wheels, and have a larger wheel bore size. A larger bore size means these wheels generate less friction with the axles.

You can purchase extra wheels at your local BSA Scout Shop. Sort through the wheels and select those from mold numbers 2, 5, and 17. Set these wheels aside and use them to build your car.

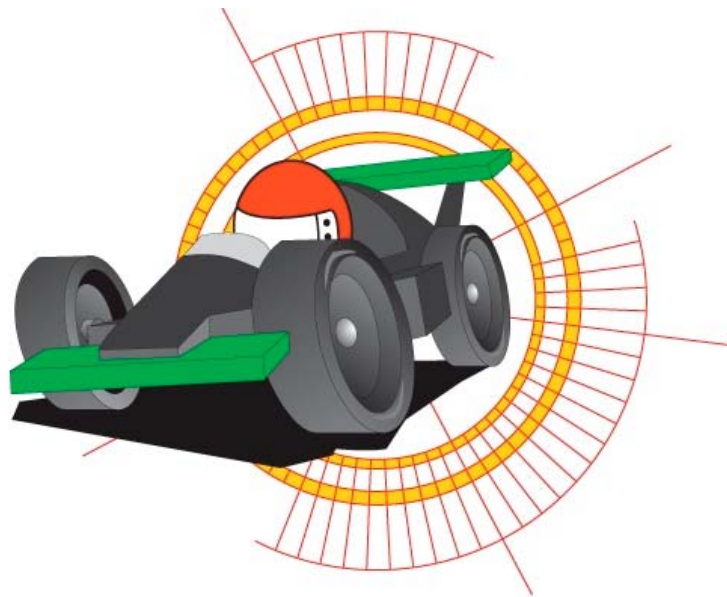


Figure 101

## The Final Product... The Ultimate Car!

Here is an example design we have used several times. It brought home the gold every time it raced!

You are free to copy this design and use it yourself. However, don't feel like you have to use this design. Be creative! Find ways to incorporate speed tips into your own car designs.

### Ultimate Car Speed Tips Checklist

- ✓ Aerodynamic design
- ✓ Wheels correctly spaced, aligned, and cemented in place
- ✓ Maximum possible weight located in rear of car
- ✓ Center of gravity 3/4 – 1 inch in front of rear axle
- ✓ Maximum possible allowed total weight
- ✓ Car does not have a pointed nose
- ✓ Axle burrs and scratches removed
- ✓ Axles polished to mirror-like finish
- ✓ Zero friction groove cut in axles
- ✓ Axle head filed to 30 degrees
- ✓ Wheel bore polished
- ✓ Lathe turned wheels
- ✓ Wheels tread and rims polished
- ✓ Wheel hub tapered and polished
- ✓ Axle diameter reduced
- ✓ Graphite-Moly applied to all contact points
- ✓ Wheel base extended
- ✓ Body/Axle contact area polished
- ✓ Three wheels on the track
- ✓ Used wheel mold number 2, 5, or 17
- ✓ Wheels broken in for at least 50 races
- ✓ Wheels pass 20 second test
- ✓ Maximum wood removed from middle of car body
- ✓ Block baked to remove water
- ✓ Used straight axles
- ✓ Quick start design
- ✓ **FIRST PLACE TROPHY**  
This car has beaten over 100 other cars, winning every single heat it has ever raced in. We have a fleet of other cars for which similar stories can be told!



Figure 102: The Ultimate Car

## **“Speed Tips” to Avoid**

There are a lot of Pinewood Derby web sites and “How to Win” books/videos out there. Quite a few people have thrown their hat into the ring and are offering advice on methods they believe will help you win the Pinewood Derby. However, some of the techniques being recommended are actually bad advice. These techniques are either dangerous, will not help you win the derby, or both. Below is a partial list of those techniques. I’m sure there are others which could be added to the list. Just be careful about the advice you listen to.

### **Wheel Canting or Angling**

This method has received quite a bit of press on numerous web sites and books. The idea is to angle the axles upward so that the wheels are forced toward the axle head. Supporters of this idea suggest that it’s better to have the wheel always rubbing on the axle head than it is to ever let it touch the car body. They also suggest that canted wheels go faster because less of the wheel actually touches the track. Well, it is true that contact with the axle head is better than contact with the car body. It’s also true that having less wheel contact with the track is better.

However, there are two big issues they seem to overlook. First, angling the axle causes the wheel to ride in an orientation which is not parallel to the axle. This results in tremendous binding and friction between the wheel and the axle. Second, although it is preferable to have contact with the axle head, it is NOT preferable to have contact with the axle head 100% of the time. The moral of the story is that canted wheels create more friction than non-canted wheels.

### **Melting or Sanding Lead**

There are several books and videos out there which advocate melting lead as part of the car building process. Believe it or not, there is actually a commercially available video which promotes melting lead. But, that’s not the end of it. Once the lead has been melted and put into the car body, the video host uses sandpaper to shape and smooth the lead. By the end of the process his hands, the car, and workbench are layered with lead dust! Lead is very poisonous! Melting lead is very dangerous. DO NOT MELT LEAD! DO NOT SAND LEAD! You can safely add weight to your car without melting or sanding lead.

### **Axle Hardening**

The idea behind this technique is to heat an axle to “red hot” using a propane torch. You then drop the axle in water to cool it off quickly. This makes the metal harden and thus is more scratch resistant.

This is another one of those techniques which on the surface, sounds really cool. It’s so “High Tech.” I’ve tested this method several times. There is a negative side effect to this method, which nobody seems to have noticed. I’m the only person currently suggesting that it’s a bad idea. Here’s why - the hardening process tends to warp the axles. After the hardening process, the axles are no longer straight. If you spin the axles in a drill press and observe them spinning, the effect is very obvious. In my opinion, axle hardening does little to help you win the derby, while at the same time doing a lot to help you lose.

### **White Teflon Powder**

White Teflon Power was introduced as an alternative lubricant to graphite some years ago. Teflon works in frying pans so it should work on Pinewood Derby wheels too...Right? Actually, it’s much worse than graphite. Just say “No” to Teflon Powder.

## Conclusion

So, there you have it... The Ultimate Car! You are free to use any combination of speed tips you wish. If you follow the instructions I have outlined, you will have a fast car! I cannot guarantee that you will win. However, I can say with 100% certainty, that these speed tips have enabled my sons to win every single race they have competed in, over a racing career that spans many years! Some of those Pinewood Derbies have sported over 100 cars and we beat them all! However, I'll have to admit that I was not completely truthful in my introduction to this book. We do have one second place trophy. Yes, I'll have to admit it. We got that trophy the year both of my sons were racing at the same time. That year we took first and second place! We have had some wonderful times together building cars!

In closing, please remember that the most important aspect of the Pinewood Derby is to have fun! Have fun by being safe, being honest, and in showing good sportsmanship. Even though we have spent a lot of time talking about principles that will help you win the Pinewood Derby, don't forget that your derby experience is only a success if you enjoy the ride.

Happy Racing!

Sincerely,

David Meade

## Appendix 1

### Examples of Winning Designs

One important principle everyone should understand is that some car designs are better than others. They have the features that maximize potential energy and reduce wind drag, while at the same time look good. Below are examples of three winning car designs in both standard and extended wheel base configurations.



Figure 103: Three Winning Designs in Both Extended and Standard Wheel Base

### The Talon X (extended wheel base)

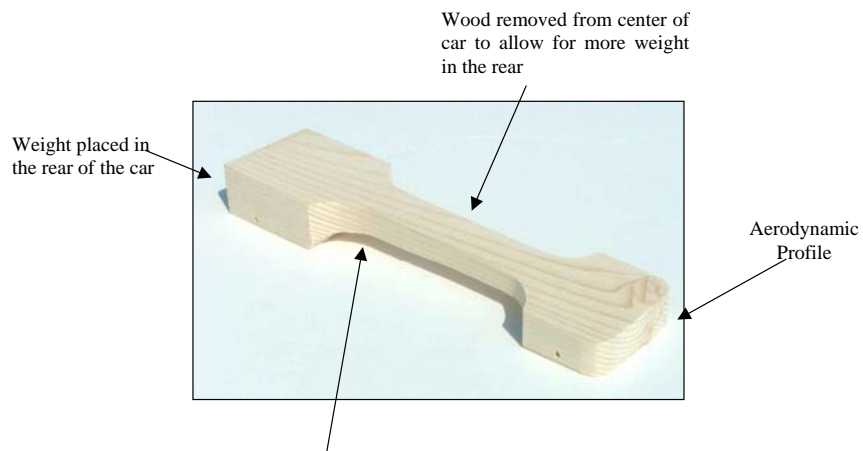


Figure 104: Bottom cut in an upward scallop to remove even more wood from center of car

### The Talon (standard wheel base)

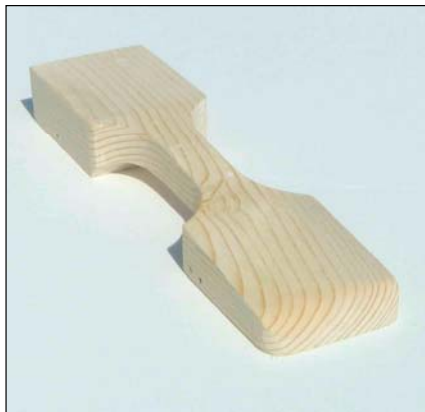


Figure 105: Talon design with standard wheel base

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### Twin Arm Slider X (extended wheel base)

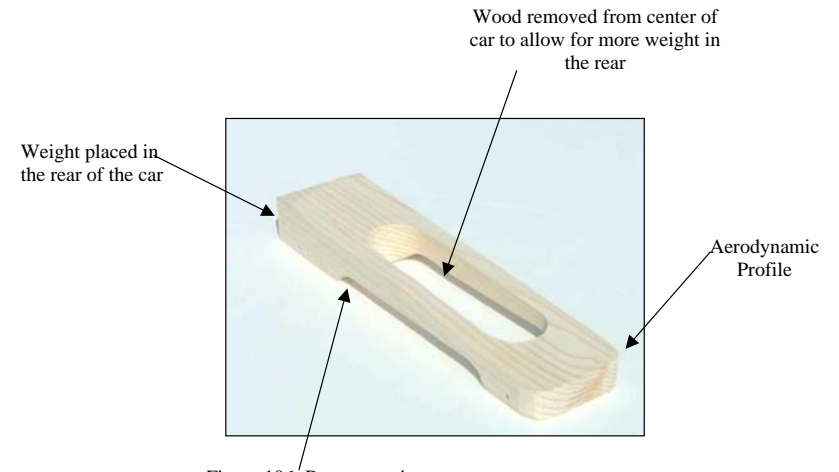


Figure 106: Bottom cut in an upward scallop to remove even more wood from center of car

### Twin Arm Slider (standard wheel base)

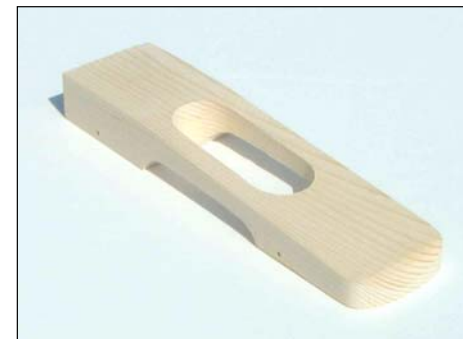


Figure 107: Twin Arm Slider design with standard wheel base

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### Z Bar X (extended wheel base)

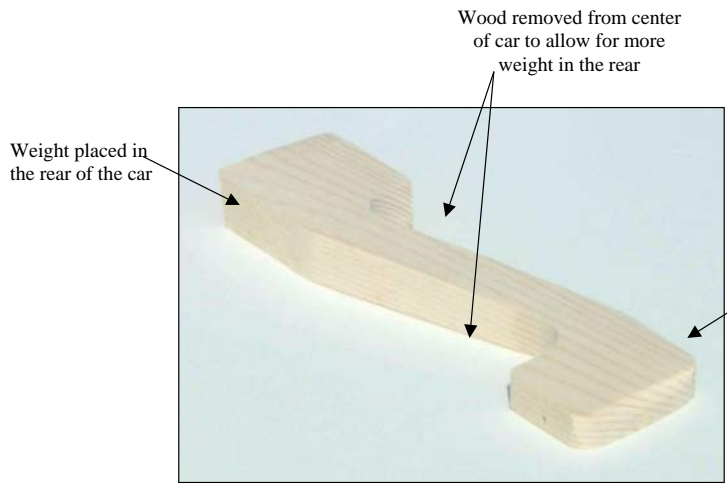


Figure 108:  
Aerodynamic  
Profile

### Z Bar (standard wheel base)

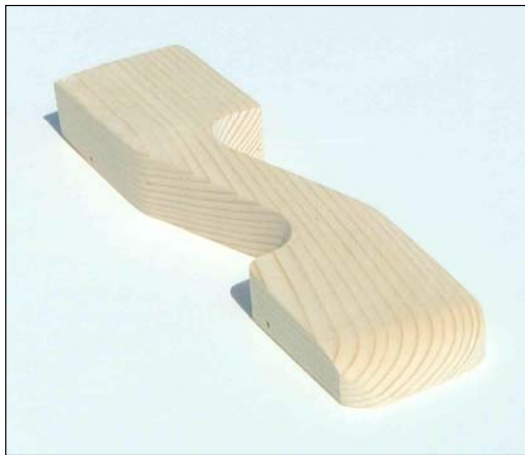


Figure 109: Talon  
design with standard  
wheel base

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### Improving Standard Designs

While some designs inherently possess the features that make them faster, it is possible to take a standard design with standard weights and improve it by making some small changes. For example, I've seen a lot of truck designs over the past several years. It's become a very popular design. Many people also add weight to the truck by attaching a long bar of metal to the bottom, as shown in the figures below.

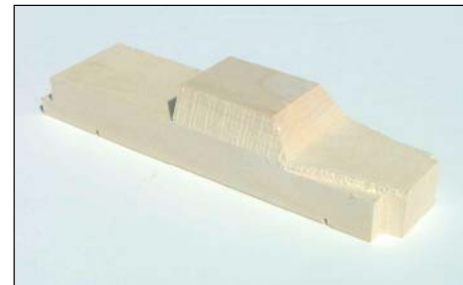


Figure 110: Standard truck  
design

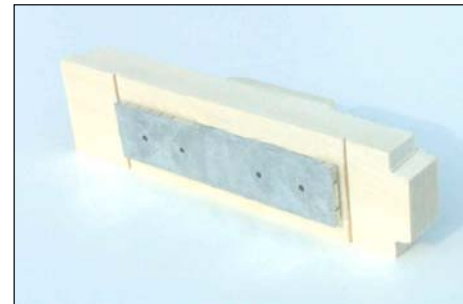


Figure 111: Truck design  
with bar weights attached  
to the bottom.

## Suggested Improvements

**Drill out Wood In Center of the Body:** Fast cars have as much wood removed from the center of the car as possible. This allows for more weight to be placed in the rear of the car. In the figure below we have used a drill to remove wood from the center of the truck. All of this weight is now free to be relocated to the rear of the truck.

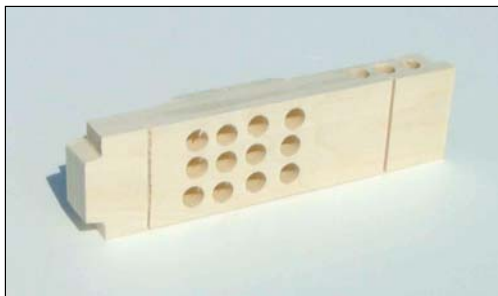


Figure 112: Truck with wood removed from center.

**Put the Weight in the Rear:** Remove the metal weight from the bottom of the truck and drill three holes in the rear. Fill these holes with lead. If you use a  $25/64^{\text{th}}$  inch drill bit then you will be able to easily slide standard lead wire into the holes.



Figure 113: Weight holes drilled in rear of truck design.

**Result:** You now have a truck design with the weight located in the rear of the car. This will dramatically improve the performance. These same techniques can be used to improve many of the standard designs you see at local pinewood derbies.

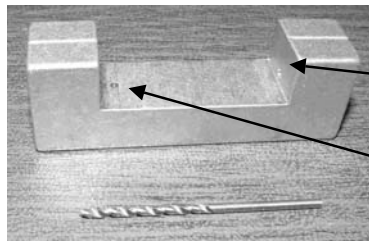
# Appendix 2

## Derby Worx Pro Tools

(Available at [www.derbychamp.com](http://www.derbychamp.com))

### Pro Body Tool

The Pro-Body Tool II is designed to accurately create pilot holes in existing axle slots or to create new axle holes using a hand drill on BSA and PineCar kits. The required #44 drill bit is included.



Use holes on either end to drill holes at the standard height.

Use hole on bottom to drill a raised hole if desired.

- 1: Test fit the tool on the bottom of the block with the two 'ears' positioned on the sides of the block. If the tool will not fit onto the block, use coarse grit sandpaper to reduce the width of the block until the tool fits snugly. If the tool is loose, tighten the fit by placing a piece of paper - folded as needed - between one 'ear' of the tool and the block, see Figure 1.

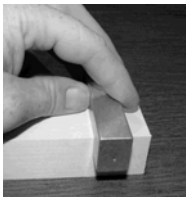


Figure 1: Test Fit Pro Body Tool on Block

### If Adding Holes Above Existing Slots:

- 2: Use a square to draw a straight line on the side of the car starting at the middle of the axle slot, and extending to the top of the car (or measure the distance from one end of the block to the middle of an axle slot and transfer that measurement to the top-side of the block. Then use a ruler to draw a line from that measurement to the center of the axle slot), in a similar manner to that shown in Figure 2.

Repeat step 2 for the other slot. Then continue with step 3.

### If Adding Holes New Holes Where Slots Do Not Exist:

- 2: Measure and mark the desired position of the new axle holes on the side of the block. Extend the mark from the bottom of the block to the top of the block using a square (or measure and mark near the bottom of the block and near the top of the block, and then join the line with a pencil and ruler). Holes for extended wheel bases are typically positioned 5/8" from the end of the block, see Figure 2.



Figure 2: Mark Block

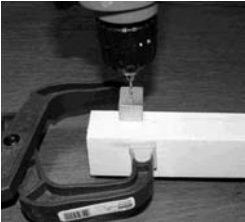
Repeat step 2 for the other end of the block. Then continue with step 3.

- 3: Position the tool on the bottom of the car with the two 'ears' on the sides of the block. Align the index mark on the tool with the line corresponding to the rear axle slot or hole on the block. Clamp the tool in place, see Figure 3.



Figure 3: Clamp tool to block

- 4: Hold the block firmly, position the drill bit in the hole, and slowly drill  $\frac{3}{4}$ " into the block, see Figure 3. Without releasing the clamp, turn the tool and block over, and drill the second hole.



**Figure 3: Drill Axle Hole**

- 5: Repeat these steps for the other holes in the block. If a raised hole is desired, drill only one of the front holes (either one) and proceed to step 6:

**If Drilling a Raised Hole Only:**

- 6: Transfer the line on the side of the block to the bottom of the block. Position the tool on the desired side of the block, and align the index mark on the tool with the line on the bottom of the block. Make sure that the third hole on the tool is positioned near the bottom of the block. Clamp the tool in place and drill the raised hole, see Figure 4.



**Figure 4: Drill Raised Axle Hole**

**Pro Hub Tool**

- 1: Identify the features of your tool. The Pro Hub Tool comes with a protective plastic cover on both ends. Remove the protective cover and view both ends. One end is flat as shown in Figure 6. The other end is coned, as shown in Figure 7.



**Figure 5: Pro Hub Tool**



**Figure 6: Flat End**



**Figure 7: Coned End**

- 2: Remove the protective cover from the flat side of the tool. Test fit each wheel by sliding it onto the tool pin. If the wheel bore is too small for the tool, use steady hand pressure and a twisting motion to work the wheel on to the tool. Remove the wheel and repeat 3 times, see Figure 8.



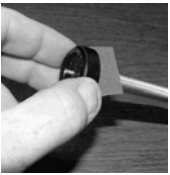
**Figure 8: Test Fit Wheels**

- 3: Dip the coarse-grit sandpaper in a cup of tap water. Remove the protective cap from the square end of the tool, pierce the sandpaper (grit facing outwards) and slide the sandpaper until it contacts the body of the tool. To minimize the risk of a hand injury, leave the protective cap on the coned end of the tool, see Figure 9



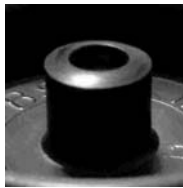
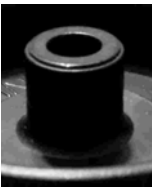
**Figure 9: Apply Course-Grit Sand Paper**

- 4: Place a wheel onto the square end of the tool, hub side first. With one hand hold the tool and the sandpaper, and with the other hand press the wheel against the sandpaper. Rotate the wheel back and forth for about 10 seconds.



**Figure 10: Insert Wheel and twist**

- 5: Replace the protective cap on the flat end of the tool. Remove the protective cap from the coned end of the tool.
- 6: Repeat steps 3 and 4 using course sandpaper on the coned end of the tool. Repeat the process until the hub has a nice defined cone shape.
- 7: Repeat steps 3 and 4 using fine sandpaper on the coned end of the tool. When finished the hub should look like Figure 11.



**Figure 11: Before and After photos of Wheels Hubs**

### Pro Axle Press

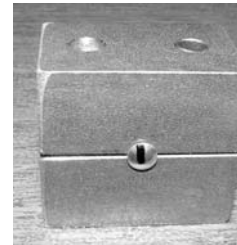
- 1: Insert an axle into the chuck of a drill, and use a file to remove the burr under the nail head, and any crimp marks on the axle shaft.

- 2: Make a mark on the head of the axle, as shown in Figure 11.



**Figure 11: Mark Axle**

- 3: Fully insert the axle - point first - into the Pro-Axle Press. Rotate the axle head such that the mark is located at the top (12 o'clock), and close the press, see Figure 12.



**Figure 12: Insert axle with mark at 12 O'clock**

- 4: Place the Pro-Axle Press on a solid surface, hold it in place, and strike the top of the press 4-6 times with a hammer. Don't strike too hard - medium strikes are fine, see Figure 13.



**Figure 13: Somewhat mildly strike press with hammer.**

- 5: Open the press and repeat steps 3 and 4 with the mark at the 4 o'clock position
- 6: Open the press and repeat steps 3 and 4 with the mark at the 8 o'clock position
- 7: After the last strike at the 8 o'clock position, lay the press on its back (axle head upward) and strike the axle head 2-4 times. This ensures that the axle head is square to the axle shaft, see Figure 14.



**Figure 14: Lay press on its back and strike axle head.**

- 8: Repeat for the other three axles, and then polish the axles to the desired finish.