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**J. Michael Caskey**

**161 Cari Lane  
Matthews, NC 28104  
(704) 846-8424**

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**Cub Scout Pinewood Derby  
Advanced Seminar**

**I. Introduction**

- A. The purpose of the Pinewood Derby**
  - 1. For the kids to have fun
  - 2. To learn how to have clean competition working with the rules
  - 3. To develop sportsmanship
  - 4. To develop a sense of accomplishment in a job well done
  - 5. To learn how to work on a multi-phase project.
  - 6. To develop the skills required to build a car which may be used in other tasks
  - 7. To be able to appreciate the work, talents, ingenuity, and perseverance of others
  - 8. To encourage the parents, especially the dads, to spend time with their children
- B. Always check your local rules before employing any of the techniques described in this seminar.**



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## II. Body

### A. Aerodynamics

1. Choose a thin shape <sup>1</sup>
  - a. Many sources that I have read on the internet say that aerodynamics at speeds under 30 mph are negligible.
  - b. A few sources say that aerodynamics means a little
  - c. One source said that the difference between the original block and the most aerodynamic shape is only a few hundredths of a second<sup>2</sup>.
2. What does a hundredth of a second represent?
  - a. The track is approximately 30 feet long start to finish.
  - b. I clocked my 2003 grand champion car at 2.29 seconds from start to finish.
  - c. This means that the car travels at 360 inches in 2.29 seconds or:
    - i. 157.21 inches per second
    - ii. 1.57 inches per 1/100<sup>th</sup> of a second.
    - iii. 8.9 miles per hour
  - d. If my car picks up 1/100<sup>th</sup> of a second by being more aerodynamic than my competitor, I'll take it. I have won races by far less than an inch.
3. My car shape is like a modified airplane wing
  - a. The front is blunted to ¼" diameter to prevent the front of the car from floating unevenly as it slicing through the air.
  - b. The bottom is flat except for a slight up slope on both ends outside the axle positions.
    - i. This reduces suction under the car
    - ii. I do not want any pressure added to the axles
    - iii. Racecars on an oval track want suction under the car to hold them down on the turns. This is a straight drag race.

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<sup>1</sup> Hodges Hobby House

<http://www.winderby.com>

<sup>2</sup> Pinewood Bible

[http://www.fastpine.com/pinewood\\_derby\\_car\\_pinewood\\_bible\\_order.asp](http://www.fastpine.com/pinewood_derby_car_pinewood_bible_order.asp)



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- c. The top is a continuous curve from end to end with a maximum height of  $7/16^{\text{th}}$  of an inch.
  - d. The rear come to a sharp point at the center of the body looking at it edge wise.
  - e. The car is created by sawing the block to  $7/16''$  thick on a table saw.
    - i. I can get (3) bodies out of one block
    - ii. Next, I draw my shape on the side.
      - (a) Be symmetrical
    - iii. Then I fix a belt sander in a vise and shape the car in a few minutes.

**B. Long wheel base**

- 1. The longer the wheel base<sup>3</sup>, the less the effect of any deviation from perpendicular the axles have.
- 2. Make the wheel base as long as possible
  - a. Either recut the axles slots, or drill holes for the axles on a drill press.
  - b. Note: The original slots provided with the block are rarely perpendicular to the block.
    - i. If you plan to use the original slots, check them first.

**C. Check the Block**

- 1. All blocks are not created equal
- 2. I have seen blocks shaped like parallelograms in end section
- 3. In the 2004 race, I had a tow in problem that I could not correct
  - a. After the race, I found that the block that I had used was  $1/32''$  wider at one end. All the corrections that I tried just made the tow in problem worse, because the two sides were not parallel.

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<sup>3</sup> Hodges Hobby House

<http://www.winderby.com>



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#### D. Weight

1. The heavier the car the faster it goes <sup>4</sup>
2. The maximum weight is 5 oz
3. Bring your car to the race heavy and drill out weight to the legal limit
  - a. Scales vary from place to place and day to day
4. Add lead or other heavy metals to bring your car to 5 oz
5. The position of the weight depends on the shape of the track
  - a. Most tracks consist of a swoop curving down to a level finish
    - i. The weight for this track should be in the rear<sup>5</sup>, providing a balance for the car including wheels and axles of approximately 1 1/4 inch<sup>6</sup>
      - (a) If your weight is placed in the rear on this track, the energy of the momentum created on the slope will continue on the flat
        - (i) Your car will pass cars with different weight balances on the flat as they lose energy
    - b. If the track is a tilted plane, place the weight in the middle<sup>7</sup>
    - c. If the track is "S" shaped, place the weight in the front<sup>8</sup> 3.
6. The weight should be placed into the body by carving, drilling, or sawing out wood.
  - a. Do not place the weight under the car body. You need the 3/8" clearance to avoid the center raised strip on the track
  - b. If you use my shape, the body will be so thin that you can see light through it.
    - i. Leave enough material to support your axles, approximately 1/4" of width.
    - ii. The weight should be balanced from side to side.

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<sup>4</sup> Hodges Hobby House

<sup>5</sup> World for Christ

<sup>6</sup> Hodges Hobby House

<sup>7</sup> World for Christ

<sup>8</sup> World for Christ

<http://www.winderby.com>

<http://www.worldforchrist.org/races>

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#### E. Axle position and orientation

1. Decide whether to use the original slots or modify them
2. The original slots are usually not perpendicular to the body
  - a. If you use slots, turn the block up side down and recut the slots perpendicular to the body
3. If you drill holes for the axles, you will need a drill press to be accurate
  - a. Drill axle holes straight through the body to make sure that the axles are lined up with one another
    - i. The Cub Scout rules do not allow tilting of axles
4. 2007 I purchased a Derby Worx Pro Body Tool II
  - a. If you order one you must specify the one for the Cub Scouts Pinewood Derby. There is also a tool for the Awana Grand
  - b. This tool allows you to bore a perpendicular hole parallel to the track. It does not allow you to tilt axles
  - c. The alignment is not perfect. I found one axle to be perpendicular and the opposite side was a little off.
  - d. I used a speed square against the aluminum block and clamped the aluminum block to the car body
  - e. Then I drilled the 3/16" holes through until they met
  - f. I pushed the axles into the holes without the wheels until they met in the middle.
  - g. This technique shows up the alignment problems. The shafts should meet so that they look like one continuous shaft.
  - h. Check the shafts with the Pine Car alignment tool
  - i. As mentioned elsewhere, you should carve or drill away about 1/2" of the body in the center between the axles to expose them for examination and to allow you to glue them in place.
5. If allowable, **move axles** to the maximum spread<sup>9</sup>
  - a. Measure in from each end of the block 5/8" and set the axle.

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<sup>9</sup> Hodges Hobby House

<http://www.winderby.com>



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### III. Axles

#### A. Basics

1. Polish axles with 600 grit water proof sand paper on a drill
2. Use a strip of sand paper approximately 3/8" wide dipped in water
3. Apply all surfaces of the sand paper to the area next to the hub for about a minute
4. Polish with metal polish

#### B. Advanced

##### 1. Hub

- a. File inside of hub to an angle back from the wheel while spinning on a drill fixed in a vise or on a lathe<sup>10</sup>
- i. You can make a very effective lathe by fixing a drill in a Black and Decker Work Mate, then screwing a small piece of wood to the top to make a lathe rest.
- ii. Filing the hub reduces the surface contact of the hub with the wheel, thus reducing friction.

##### 2. Shaft

- a. Polish 1/2" of the axle shaft from the hub inward
- b. Place axle in the drill or lathe with 1/2" exposed
- c. Apply wet sand paper in 3/8" wide strips for approximately 1 minute per strip in the order shown below
  - i. 320 grit sand paper
  - ii. 400 grit sand paper
  - iii. 600 grit sand paper twice
  - iv. 1000 to 1200 grit sand paper
    - (a) My old notes had pumice in this slot, but I found out that the pumice was actually 325 grit. I have eliminated it from the regiment
  - v. 1500 grit sand paper
  - vi. 2000 grit sand paper
  - vii. Non Abrasive metal polish on (dry cloth). Polish until it turns dark<sup>11</sup>

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<sup>10</sup> Hodges Hobby House

<http://www.winderby.com>

<sup>11</sup> The Ultimate Pinewood Derby Site <http://members.aol.com/randywoo/pine/>



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- viii. Graphite on (dry cloth)
  - d. There is a packet of sanding cloths that can be purchased from several sources over the internet which includes grits up to 3000
  - e. Clean axle with cloth after each grinding to remove abrasives.
  - f. Clean all abrasives off axle when you are finished
  - g. Check axles for smoothness before applying graphite, and repeat fine polishing if necessary
  - h. NOTE: In my 2005 Awana District race, the car did not do well. It placed 6<sup>th</sup> in it's race and 7<sup>th</sup> over all. I removed the axles from the car and learned the following:
    - i. I had used sanding strips that were too narrow.
    - ii. I short shanked the ground down section of the axle
    - iii. To make matters worse, the axles were slightly tapered inward from the hub toward the body
    - iv. I noticed a slight tow in problem, which may have been caused by the irregularly shaped axles
    - v. I came up with the following corrections
      - (a) I used a caliper to check for uniform shape and thickness with the axles
      - (b) I ripped several 7/16" x 7/16" square sticks 16" long
      - (c) I wrapped the sticks with waterproof sandpaper of various grits and pinned one side with push pins
      - (d) Then I reground the axles using the flat surfaces
      - (e) My intent was to use (3) sides of the paper; however, I found that by the 3<sup>rd</sup> side, the wet paper began to bunch up on the stick
      - (f) The technique did work, giving me a smooth, uniform shank at least 7/16" wide
3. Direction of sanding and polishing to eliminate effect of burrs<sup>12</sup>

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<sup>12</sup> World for Christ

<http://www.worldforchrist.org/races>



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- a. Look at axle with hub end pointed away from you and your car is facing you
  - b. CLOCKWISE for RIGHT side
  - c. COUNTERCLOCKWISE for LEFT side
  4. Use a magnifying glass to check each axle for smoothness
  5. Grade axles A, B, C
  6. Reduce the diameter of the axle to about .075"<sup>13</sup>
  7. Seal axles in zip lock bag until use to prevent rusting
  8. Repolish axles with metal polish if they are made well in advance.
  9. Keep axles in a sealed container like a zip lock bag
    - a. Label container for right and left axles
    - b. Label containers A,B, and C

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<sup>13</sup> Hodges Hobby House



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## IV. Wheels

### A. Basics

1. Sand and polish wheels on drill to get as round as possible
2. Remove all mold extrusion plastic.

### B. Advanced

#### 1. Wheel bores

- a. Burnish wheel bores by placing a rod or polished axle inside the wheel and pressing down and rolling over a hard smooth surface<sup>14</sup>
- b. I do this by placing the polished axle in a drill and rotating the wheel on the axle with pressure against the axle
- c. This removes burrs of plastic inside of the wheels
- d. Check with a magnifying glass before and after. Repeat if necessary
- e. 2007 notes:
  - i. I purchased a Derby Worx Pro Bore Polisher
    - (a) This is essentially a shaft with a pipe cleaner and some liquid polish
    - (b) It did not have the effect the I thought it would
    - (c) The polisher actually lifted up the burrs of plastic inside the bore
    - (d) I found out that the burrs are at the edges of the hole bore
    - (e) Instead of pressing them down as I had been told I IV.b.a, I took a small piece of 600 grit sandpaper and made a small cone. I twisted it around in each end, checking it with a magnifying glass, until the burrs were gone
    - (f) This turned several wheels that were bumpy and slow into very good fast wheels
    - (g) Since the polish is an abrasive, you should thoroughly wash the wheels in water when you finish

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<sup>14</sup> World for Christ

<http://www.worldforchrist.org/races>



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2. Set Up
    - a. Place wheel on a wheel mandrel.
    - b. Mandrels are available on the internet
    - c. If you can find a local hobby shop that carries Pine Car accessories, they have an inexpensive mandrel.
      - i. I tried the Derby Worx Pro Wheel Mandrel, but I prefer the Pine Car mandrel
      - ii. The Derby Worx mandrel has a cone shaped centering device
        - (a) The centering cone deforms the plastic bore pressing it against the axle
        - (b) In both cases, I file off the threads on the shaft except for the threads needed to tighten the nut
        - (c) Then I wrap the filed area to the diameter of the wheel bore
        - (d) This insured a tight, centered fit and the threads do not scratch the hole bore
    - d. I used to make a mandrel by placing a piece of inner tube rubber on both sides on a wheel on an axle.
      - i. Then I would press the assembly against the drill chuck as I tightened the chuck
        - (a) Take care, if you press too hard, you can break the wheel.
      - ii. Remove the chuck key and check for alignment
    - e. Place drill in fixed vise or use lathe
    - f. If drill is used, add lathe rest as described in axles above.
  3. Rounding wheels
    - a. Sand or lathe wheel to round the wheel
      - i. The wheel must remain flat for the entire width of the original wheel, but it can be rounded to center it on the axle
    - b. If you don't have the equipment to lathe the wheel, use sand paper or a file to round the wheel.



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- c. Polish the wheel with 600 grit sand paper and metal polish<sup>15</sup>
    - i. Wipe off excess and do not let dust or polish to get into axle hole.
  - d. Make more wheels than you need to have a choice
  - e. Check and grade wheels, A, B, C by spinning them on a finished axle
4. Wheel Hubs
- a. The inside of the hub should be rounded to take away the sharp edge as it spins against the side of the car
  - b. The outside of the hubs should be smooth and square to the axle
  - c. 2007 I purchased a Derby Worx Pro Hub Tool
    - i. I was not overly impressed with the effect of the coning side
    - ii. The boring end helped to straighten out the deformation created by the Pro Wheel mandrel
    - iii. If you are trying to make economic decisions about purchasing tools, place this one toward the bottom of the list
5. Check and grade wheels, A, B, C by spinning them on a finished axle
6. Keep wheels in a sealed container like a zip lock bag
- a. Label container for right and left axles
  - b. Label containers A,B, and C

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<sup>15</sup> Pinewood Bible

[http://www.fastpine.com/pinewood\\_derby\\_car\\_pinewood\\_bible\\_order.asp](http://www.fastpine.com/pinewood_derby_car_pinewood_bible_order.asp)



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## V. Assembly

- A. Set (1) front wheel off the floor.
  - 1. (3) wheels go faster than (4)<sup>16</sup>
  - 2. Less friction
  - 3. Use C axle and wheel on up wheel
  - 4. Check your local rules
    - a. Some Cub Scout Pinewood Derby organizations require all 4 wheels on the track
- B. Place your front A wheel and A axle on front active wheel.
  - 1. remember to choose the correct side for paired axles.
- C. Place your B wheels and axles on the rear
  - 1. Remember to choose the correct side for paired axles
- D. Tilted axles
  - a. Tilting axles are not allowed in Cub Scouts
- E. Spacing Wheels on axles.
  - 1. All wheels should be spaced the same, so use a thickness gauge to set the axles
  - 2. There is a divergence of opinion as to whether to set the gap wide or narrow.
    - a. A wide gap will allow more separation from the wheel and the body
    - b. A wide gap will also allow more separation between the wheel and the center strip.
    - c. A narrow spacing will allow less wobble
    - d. I have used gaps as thin as  $1/16^{\text{th}}$  of an inch, and as wide as maximizing the  $2\frac{3}{4}$ " width of the car with wheels
    - e. If you do not cut down the width of the wheel, I would use a wide gap

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<sup>16</sup> Hodges Hobby House



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## VI. Alignment (**VERY IMPORTANT**)

- A. Find a smooth, planer surface at least 5 feet long.
  - 1. Tilt the surface from end to end if possible about 4"
  - 2. Level the surface from side to side
- B. Create a straight line on the surface parallel to the length edge
  - 1. I use a thin string taped to both ends
- C. Make sure that the axle holes are perpendicular to the sides
  - 1. I have an alignment tool, from Pine Car that I have found very helpful
    - a. Sources: Michaels, Hobby Lobby, or internet sales
  - 2. Check for toe in and toe out
    - a. Toe in or toe out will make the car run on a curve against your alignment string
    - b. Tow in will cause a sharp pointed wheel to catch the center strip and spin or tumble
- D. Roll the car along the alignment table to check for straightness
  - 1. Make sure the the wheels are set out at the hubs
  - 2. Make sure that the body is aligned with the string.
  - 3. Check your planer surface occasionally to determine if is still level
  - 4. Deviation from the line should be 1/8" or less in 8'
- E. Alignment corrections
  - 1. If the axles are not tilted, place paper shims between the axles and the body to correct the alignment.
    - a. Cut a sliver of paper about as wide as the diameter of the axle and as half as long as the axle's contact with the body.
    - b. Curl or V the paper so that it slides in along the shaft
    - c. Place the paper shim in front or rear of the axles depending on the direction that you wish the axle to go
  - 2. If the axles are tilted, you will find that the thickness of piece of paper is much to thick to adjust the alignment.
    - a. I take a piece of steel wire, such as the wire used to hold up insulation, grind it to a point, the cut it off about 1/4" long to create a tiny nail



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- b. I drive these nails into the body next to the axle alternately front and back of the axle to adjust the alignment
  - c. The alignment has to be adjusted just before the race with technique because it will tend to move.
- F.** You should correct the rear axles first and concentrate on the down front axle for fine tuning
- G.** Drill a ¼” diameter hole on the underside of the body the depth of the axle at the end of the axle away from the hub
- 1. This will allow you to glue the axles away from the wheels when the axles are set
  - 2. You may also use the side walls of the holes for pressure points to add small amounts of material to move axles very small distances
- H.** After the 2005 race, I met a man who slightly bends his front axle, tilts it 2 degrees in a slot, then rotates the axle forward or backward to steer the car.
- 1. He had access to equipment far more precise than mine
  - 2. I am not sure that I could control the bend, but it is a good idea.
  - 3. He set his axles in epoxy the slots.
- I.** Rail riding
- 1. There is a new technique that I heard about at the last Awana District race (11/07). It is called rail riding.
    - a. I have not tried it but some racers are having good success with it.
    - b. The technique assumes (2) things
      - i. No car runs perfectly straight and differences in the track can cause a straight car will still bump the center rail.
      - ii. If the car rides the rail on one side it will run straighter, with less distance to the finish line.



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2. Rail riding is initially causing the car to turn to one side slightly in order to cause the wheel to stay against the raise center strip.
    - a. Many sources also recommend shaving 1/32" to 1/16" off of the hub face of the car on the steering front wheel, then steering the car towards the steering wheel, forcing it against the rail.
      - i. This also means that the heavier rear wheels never touch the center strip.
    - b. I heard various versions of slight, which were approximately 2 inches in 3 feet.
  3. I do not necessary agree with the technique for the following reasons:
    - a. Rail riding will cause continuous friction on the inside face of the wheel coming in contact with the center strip
    - b. Use of this technique on older tracks with wooden center strips, particularly at the track joints could cause the car to bump hard, fish tail, or even derail.
  4. I will be testing my championship cars to determine which way they veered in there much straighter alignment.
  5. Please check the following links for more information.

<http://derbytalk.com/viewtopic.php?t=2460>

<http://derbytalk.com/viewtopic.php?t=2824>

<http://derbytalk.com/viewtopic.php?t=2806>

#### J. Setting axles

1. When you are happy with the alignment, place a small amount of super glue at the end of the axle away from the hub, to set the axle
2. Make sure that the glue does not bleed through to the wheel or the active surface of axle.
  - a. If the glue seeps out you will ruin the axle or glue the axle to the wheel.



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## VII. Lubrication

- A. Use graphite or graphite / moly lubricant and NOTHING ELSE to lubricate axles and wheels.<sup>17</sup>
- B. You cannot use too much
- C. Make sure to lubricate your car just before the race.
- D. In the 2004 race, our car had a tow in problem that I could not correct (see Body for details)
  - 1. Our car was initially losing heats, but as the race progressed, the cars that were initially winning ran out of lubrication, and our car won the race. We had heavily lubricated the car before the race.
- E. Spin wheels on axles with graphite before and after placing them on the car
- F. Any oil or silicone based lubricant can soften plastic on the wheels and cause them to slow down<sup>18</sup>
  - 1. They can also drip on the track causing a mess for your car and other cars.
- G. I read one report that teflon is worse than no lubricant at all
  - 1. I cannot see how the teflon surface on the axle can remain round

## VIII. Transportation

- A. Bring your car to the race in a box with padding below and above
- B. Do not leave your car sitting on the wheels until the race. Block it up.
- C. Do not play with the car before the race.
- D. Treat it like the trophy that it is.
- E. Arrive early to weigh in. There will be a crowd at the weight table and the weigh-in table.

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<sup>17</sup> Hodges Hobby House

<http://www.winderby.com>

<sup>18</sup> Pinewood Pro

<http://www.pinepro.com/>



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## Internet Resources

1. Hodges Hobby House <http://www.winderby.com>
2. Winning Edge <http://www.win-edge.com>
3. World for Christ  
<http://www.worldforchrist.org/races> This is no longer available on the internet.
4. Maximum Velocity <http://www.maximum-velocity.com/>
5. Pinewood Bible  
[http://www.fastpine.com/pinewood\\_derby\\_car\\_pine\\_wood\\_bible\\_order.asp](http://www.fastpine.com/pinewood_derby_car_pine_wood_bible_order.asp)
6. Pinewood Derby Car Design  
<http://www.members.aol.com/StanDCmr/pwdesign.html#e>
7. The Ultimate Pinewood Derby Site  
<http://members.aol.com/randywoo/pine/>
8. Pinewood Pro <http://www.pinepro.com/>
9. Awana Western Piedmont Conference website for RULES  
<http://www.awanawpnc.org>
10. Derby Worx: <http://www.derbyworx.com>

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