

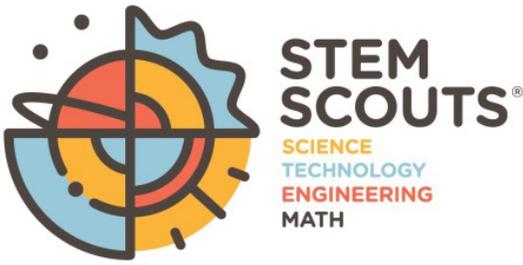
# STEM SCOUTS®

SCIENCE  
TECHNOLOGY  
ENGINEERING  
MATH

## Technology Lab: Leaders Guide – Off to the Races



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# Leaders Guide



## Off to the Races

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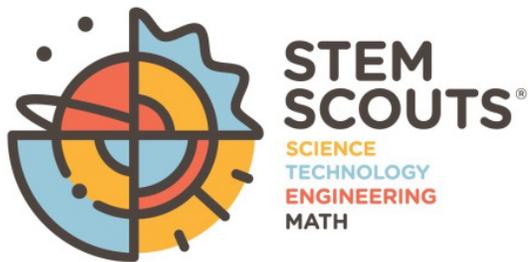
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# Leaders Guide



## Off to the Races

### Overview

In this module, Scouts will learn how to optimize the speed of a racing car. They will discover what friction is and how it affects the performance of a car, and they will learn about propulsion, acceleration and deceleration, and rocket-powered vehicles. They will design several race courses, build model cars to run on those race courses, and race each other.

This module takes six STEM Scout meetings of approximately 90 minutes each.

### Meeting 1: How to Go Fast

Scouts will learn the key principles of performance for their model cars and look at the different options available to tune the performance of their cars. They will also design different courses to race the cars on later in the module.

### Meeting 2: Design and Build

Scouts will design one or more cars, following the race rules, and then start to build them. They can take the cars home to work on prior to the next meeting.

### Meeting 3: Build Tracks; Test and Refine Cars

Scouts will build the different race tracks and test their cars on them. They can continue working on their cars or make some design modifications in this meeting and at home before the next meeting.

### Meeting 4: Race Day!

Scouts will compete with each other in racing their cars on the different tracks.

### Meeting 5: Design a “No-Rules” Race Car

Scouts will design modifications to their car to make it super-fast. For this activity, there are no rules! Anything goes! They will start on those modifications in the lab and can continue them at home before the final meeting.

### Meeting 6: No-Rules Race Day

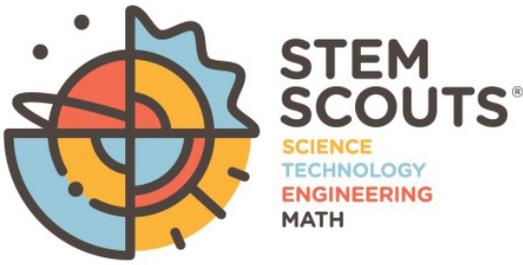
Scouts will compete with each other in racing their modified cars on the different tracks.

### Pre-Module Preparation

The adult leaders should read through all of the meeting activities ahead of time. If this is your first time managing a Lab, please review the Lab Leaders Operations Guide, which contains general instructions, lab setup information, the Scout Oath and Scout Law, and more.

Review each meeting plan and identify what you want your Principal Investigator, Co-Principal Investigator, and Program Manager to be responsible for in that meeting. A few minutes before the meeting, sit down with those Scouts and review what they need to do for that meeting.

Building the race cars requires working with wooden blocks as they are transformed into racing cars. There are a couple of options for accomplishing this. The best approach is to recruit a parent or other volunteer who has knowledge and woodworking tool access to work with the Scout teams during the meetings and provide working space and tool access between meetings. Talk to your local Scout council; Cub Scouts do a smaller, similar car-building activity called pinewood derby and they are a good source of expertise and equipment access. You can survey the parents to find out who may have access to a woodworking shop and see if you can hold the car-building meetings there, or let the Scouts meet there on a weekend to work on their cars together. If none of the parents have woodworking tools, check for any maker spaces in your community that you can go to. Other good places to check are technical schools or businesses that make wooden crafts or other similar objects.



# Leaders Guide



## Off to the Races

If this kind of assistance is not available, the Scouts should focus on much simpler car designs using the basic woodworking tools provided in the kit. The focus is more on understanding and experimenting with how cars move, accelerate, and have friction, and exploring those concepts. Making cool-looking cars can be fun and exciting, but it is very easy for Scouts to get bogged down in the building aspect and run out of time.

Scouts should be encouraged to be as creative as they want to be, as long as they follow the basic rules for the race. Painting is encouraged, but any painting supplies will be the responsibility of the Scouts themselves.

**Meeting 1:** You will need to identify and have access to an area that has room for a race course at least 50 feet long, up to 100 to 200 feet long. This can be either indoors (slick floor or carpeted) or outdoors (paved, gravel, packed or loose dirt). If possible, both flat and inclined spaces are ideal to allow for multiple courses to be set up. Each Scout team will be designing a race course.

Read the suggested race course descriptions and the “Things to Consider” section of the Blastcar™ Car Launch Kit guidelines to get ideas of what kinds of race courses your Scouts can create.

We recommend assembling the keyhole saws ahead of time by putting the blade on each saw. Save the extra saw blades provided in case one breaks.

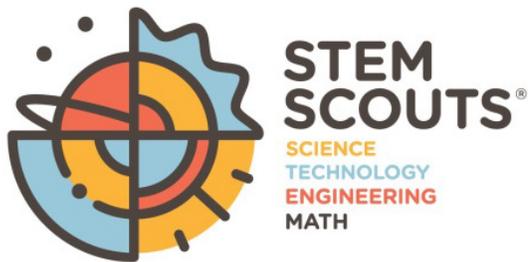
Decide how you will handle the woodworking aspects. There is a short tutorial on using the woodworking tools included in this meeting. Depending on your approach to the building of the cars, you can either use this or replace it with instruction from whomever is going to help the Scouts build their cars. Providing some scraps of wood will enable the Scouts to practice using the tools on them. This will generate sawdust. Plan how to best do this to be able to clean up the Lab meeting room afterward.

Set out a launch kit on a table so that the Scouts can look at what is included in it.

**Meeting 2:** Part of this meeting involves starting to build the cars. This will involve woodworking and will generate sawdust. Plan how to best do this to be able to clean up the Lab meeting room afterward. As discussed above, Scouts may want to get access to more woodworking tools, work as a team, work with their parents, etc., so have a plan for how to support the building of the cars.

**Meeting 3:** You will need to identify and have access to an area that has room for a race course at least 50 feet long, up to 100 to 200 feet long. This can be either indoors (slick floor or carpeted) or outdoors (paved, gravel, packed or loose dirt). If possible, both flat and inclined spaces are ideal to allow for multiple courses to be set up. You can always build simple inclines and ramps out of everyday objects and used cardboard boxes.

**Meeting 4:** You will need to identify and have access to an area that has room for a race course at least 50 feet long, up to 100 to 200 feet long. This can be either indoors (slick floor or carpeted) or outdoors (paved, gravel, packed or loose dirt). If possible, both flat and inclined spaces are ideal to allow for multiple courses to be set up. You can always build simple inclines and ramps out of everyday objects and used cardboard boxes.



# Leaders Guide



## Off to the Races

You should plan how the race is to be run and prepare a race results table to show winners of each individual race and the final winners. Each car should run on each course designed by the teams. Decide if you want to declare winners by course only, or course and overall. Plan the amount of time this will all take, which will depend on the size of your Lab.

The table in the Pre-Meeting Leader Preparation section lists the numbers of courses, rounds per course, total CO<sub>2</sub> cartridges required, and total supplied. The supplied number is roughly 10 percent higher to allow for a few reruns in cases of ties. You can see that the numbers of rounds and races grow significantly with the size of the Lab!

If you want to get more CO<sub>2</sub> gas cartridges, contact your local Scout shop and ask for the 10-pack of Blastcar 8-gram CO<sub>2</sub> fuel canisters (SKU 613276). These normally sell for about \$4.50. You can also get additional car kits, additional spools of race line, additional launchers, and other parts.

**Meeting 5:** Part of this meeting involves starting to build the cars. This will usually entail woodworking and will generate sawdust. Plan how to best do this to be able to clean up the Lab meeting room afterward. As mentioned above, Scouts may want to get access to more woodworking tools, work as a team, work with their parents, etc., so have a plan for how to support the building of the cars.

If the Scouts have fallen behind while building their initial cars, the no-rules activities can be dropped and the Scouts can just finish their cars and tracks and have a fun race. Allow the Scouts to make changes to the race course to accommodate their cars and have fun.

**Meeting 6:** You will need to identify and have access to an area that has room for a race course at least 50 feet long, up to 100 to 200 feet long. This can be either indoors (slick floor or carpeted) or outdoors (paved, gravel, packed or loose dirt). If possible, both flat and inclined spaces are ideal to allow for multiple courses to be set up. You can always build simple inclines and ramps out of everyday objects and used cardboard boxes.

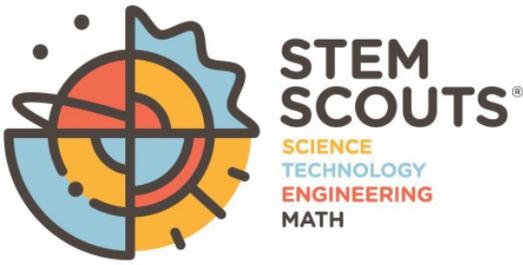
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If you want to get more CO<sub>2</sub> gas cartridges, contact your local Scout shop and ask for the 10-pack of Blastcar 8-gram CO<sub>2</sub> fuel canisters (SKU 613276). These normally sell for about \$4.50. You can also get additional car kits, additional spools of race line, additional launchers, and other parts.

Arrangements should be made to pick up computers and other council-supplied materials a few days before the lab and to return them as soon as possible after use. If software needs to be installed, be sure to allow adequate time for that in your preparation. If you are using your sponsoring organization's computers, make sure that you can access all links and arrange for any software to be installed ahead of time.

All materials needed for each weekly meeting are listed at the beginning of the meeting plan. You will want to check these well in advance and make sure nothing is missing.



# Leaders Guide



## Off to the Races

Scouts will be divided into teams of four members for this module. Material quantities are defined for each team. The following are the council- and unit-supplied materials for this module. Unit-supplied materials can often be supplied by parents, if requested well in advance.

### Meeting 1

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)
- Scraps of 2x2 or 2x4 wood for tool practice (unit-supplied)

### Meeting 2

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)
- 1 laptop for each team with internet access (unit- or, optionally, council-supplied)
- Pencils (unit-supplied)
- Paper towels and water (unit-supplied)
- Broom and dustpan (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)

### Meeting 3

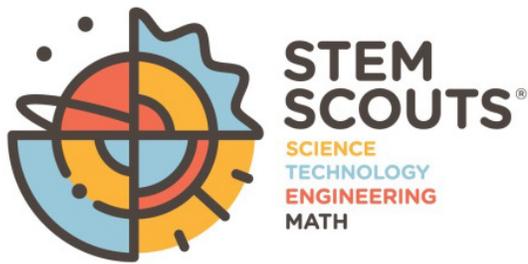
- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)
- Towel or blanket to provide a soft stop for each launch kit (unit-supplied)
- Optional: ramp-building materials (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)
- 1–2 cars previously built by the Scouts (unit-supplied)
- Paper towels and water (unit-supplied)
- Broom and dustpan (unit-supplied)

### Meeting 4

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)
- Towel or blanket to provide a soft stop for each launch kit (unit-supplied)
- Optional: ramp-building materials (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)
- 1–2 cars previously built by the Scouts (unit-supplied)
- Optional: extra CO<sub>2</sub> gas cartridges (unit-supplied) (see table in meeting prep for quantities)

### Meeting 5

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)
- 1 laptop for each team with internet access (unit- or, optionally, council-supplied)
- Paper towels and water (unit-supplied)
- Broom and dustpan (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)



# Leaders Guide



## Off to the Races

### Meeting 6

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)
- Towel or blanket to provide a soft stop for each launch kit (unit-supplied)
- Optional: ramp-building materials (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)
- 1–2 cars previously built by the Scouts (unit-supplied)
- Optional: extra CO<sub>2</sub> gas cartridges (unit-supplied) (see table in meeting prep for quantities)

### Service Project Idea

Service projects are a good way for Scouts to give to their sponsoring organization and community. Don't try to do more than one service project per module. Check on the STEM Scouts Portal for a list of service project ideas.

A suggestion is to take your race cars to a children's hospital, set up a track, and hold a race.



## Meeting 1: How to Go Fast



### Meeting 1: How to Go Fast

#### Pre-Meeting Leader Preparation

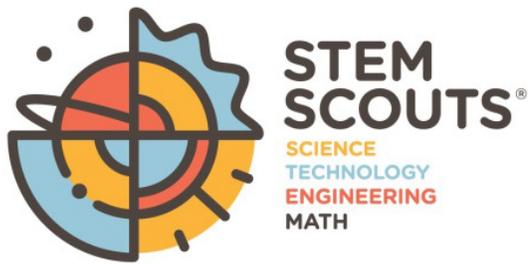
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Read the suggested race course descriptions and the “Things to Consider” section of the Blastcar™ Car Launch Kit guidelines to get ideas of what kinds of race courses your Scouts can create.

We recommend assembling the keyhole saws ahead of time by putting the blade on each saw. Save the extra saw blades provided in case one breaks.

Decide how you will handle the woodworking aspects; see the discussion in the Pre-Module Preparation section in the Overview. There is a short tutorial on using the woodworking tools included in this meeting. Depending on your approach to the building of the cars, you can either use this or replace it with instruction from whomever is going to help the Scouts build their cars. Providing some scraps of wood will enable the Scouts to practice using the tools on them. This will generate sawdust. Plan how to best do this to be able to clean up the Lab meeting room afterward.

Set out a launch kit on a table so that the Scouts can look at what is included in it.



# Leaders Guide



## Meeting 1: How to Go Fast

### Materials and Tools Needed

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)

The following items are displayed by the Lab Manager so Scouts can become familiar with them.

- 1 Blastcar Car Launch Kit (shared between two teams)
- 1 trundle wheel (shared between two teams)

Scouts will be divided into teams of four for this set of experiments. Material quantities are defined for each team.

- 4 Blastcar Car Kits
- 1 Blastcar CO<sub>2</sub> fuel cartridge
- 1 ruler
- 1 pin vise
- 1 3/32-inch drill bit
- 1 keyhole saw
- 1 rasp
- 1 sheet each of coarse and fine sandpaper
- 1 8-inch long, 5/8-inch diameter wooden dowel
- Scraps of 2x2 or 2x4 wood for tool practice (unit-supplied)

### Opening

Have the Principal Investigator lead the group in reciting the Pledge of Allegiance and the Scout Oath and Scout Law.

### Applying the Scout Law

Choose one of the 12 points of the Scout Law to discuss in application to today's lab. A suggested theme for this meeting is *helpful*, as in *I will be helpful to my teammates in working together to design race courses*.

Ask the Scouts what being *helpful* means to them, and how they might apply that to today's lab.

### Activity Overview

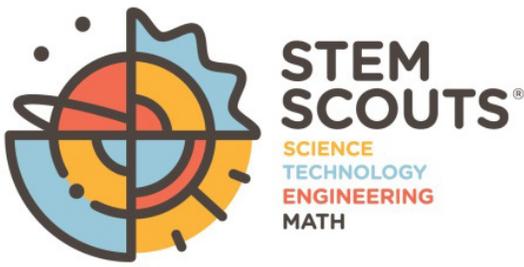
There are three activities in this lab. In the first activity, Scouts will learn all about the model car kits and what affects the performance of model cars.

In the second activity, Scouts will learn how to use woodworking tools.

In the third activity, Scouts will design different race courses, taking into account what is available around their Lab meeting room.

### Background

Racing unpowered cars by youth goes all the way back to the first days of automobile racing. In 1914, the Vanderbilt Cup was an established important race event for early cars. That year, the city of Santa Monica, California, decided to hold a junior version for younger people that included some cars with no engines and a ramp to get the cars moving.



# Leaders Guide



## Meeting 1: How to Go Fast

According to the Soap Box Derby® website, a newspaper photographer in Dayton, Ohio, came across a group of boys racing homemade cars in 1933. The event so impressed him that he decided to establish a national program.

This was the start of the All-American Soap Box Derby, an annual race for unpowered cars driven by young people, initially only boys ages 11 to 15. Today, race participants must be between 7 and 21 years old, depending on the race division, and the races are open to both girls and boys.

In 1953, the first Cub Scout pinewood derby was held. Most Cub Scouts at that time were too young to participate in soap box derbies, so a Cubmaster came up with the idea of building a miniature wooden car that raced down a ramp. The idea became very popular and was adopted by the Boy Scouts of America as an official program for Cub Scouts. The pinewood derby is still very popular today, and many BSA councils across the country hold adult or corporate races for the many adults who fondly remember building cars as Cub Scouts.

In 2011, the BSA developed a larger version of the Pinewood Derby® Car Kit for older boys that added a CO<sub>2</sub> gas cartridge to power the cars to high speeds and add a whole new dimension to the kinds of races that were possible. That car is the Blastcar, which is the basis for this module.

Although the Blastcars are “jet propelled” by the CO<sub>2</sub> gas cartridges, all of the speed and performance principles that make for winning Soap Box Derby cars and pinewood derby cars still apply.

### Engaging Questions

Use the following question, and any others of your choosing, to get the Scouts engaged. (*Typical answers are in italics.*)

What do you think are important considerations in designing a race car to make it fast, aside from the motor? (*Look for answers like “reducing friction,” “reducing wind resistance or drag” [another form of friction], “reducing weight,” or “reducing inertia.” Get discussions going on the ideas that are brought up.*)

### Safety Moment

Tell the Scouts:

NEVER insert the CO<sub>2</sub> fuel cartridges in the wood block until instructed to do so.

The saw has sharp teeth. Never grab the blade or put the blade on any part of your or anyone else’s body.

The drill bits are also sharp; handle them with care.

You will be using sharp woodworking tools today. Always look at the area you will be working in and set it up so that you are not going to accidentally cut the table, other furniture, yourself, or anyone else.

Sawdust and wood shavings will probably get on the floor and can make the floor very slippery. Clean up regularly and take care when walking around.

When you are sanding, be careful to not get sawdust in your eyes. If you do, get help from a Lab Manager to wash your eyes out.



## Meeting 1: How to Go Fast

### Experiment

Get the Scouts into teams of four. They will stay in these teams for all six meetings in this module.

Ask them to follow the instructions in their Lab Notebook, reproduced below.

**Lab Manager Note:** Lay out one of the launch kits on a table where the teams can look it over. Also lay out one complete set of tools (keyhole saw, pin vise, drill bit, trundle wheel, and rasp) for them to look at.

Explain to the Scouts how they will be cutting and shaping the cars, so that they can account for that in their discussions.

### Activity 1: Examine Kits and Guidelines (10–15 minutes)

#### Materials List

- 4 Blastcar Car Kits
- Blastcar CO<sub>2</sub> fuel cartridges

Open one of the car kits. Your team will be building several of these cars during this module. Each car kit has the following items:

- 1 block of wood, predrilled for the fuel cartridge
- 4 wheels
- 1 axle kit (4 screw axles, 1 Allen wrench, 2 eyelets)
- 1 copy of Blastcar Guidelines and Instructions

Your Lab Manager will have one of the launch kits opened up where your team can go inspect it. The launch kit includes:

- 1 2-car launcher
- 1 race line reel
- 2 start/finish plates
- 4 start/finish screws
- Launch instruction guide

Look at the Blastcar Guidelines and Instructions (open all four kits so each team member has one). Read each section individually and then discuss it with your team. Make sure you all understand the principles and guidelines.

- Review the Suggested Race Courses section and discuss the differences between them and what that means for a car design. Look at the space available to you to design and build a course.
- Review the Design Car Kit section and discuss it with your team.
- Review the Event section, paying close attention to the rules. Discuss the rules and how the race is to be run with your team.
- As a team, decide how you will work together to design and build a course, and to design and build your cars.



## Meeting 1: How to Go Fast

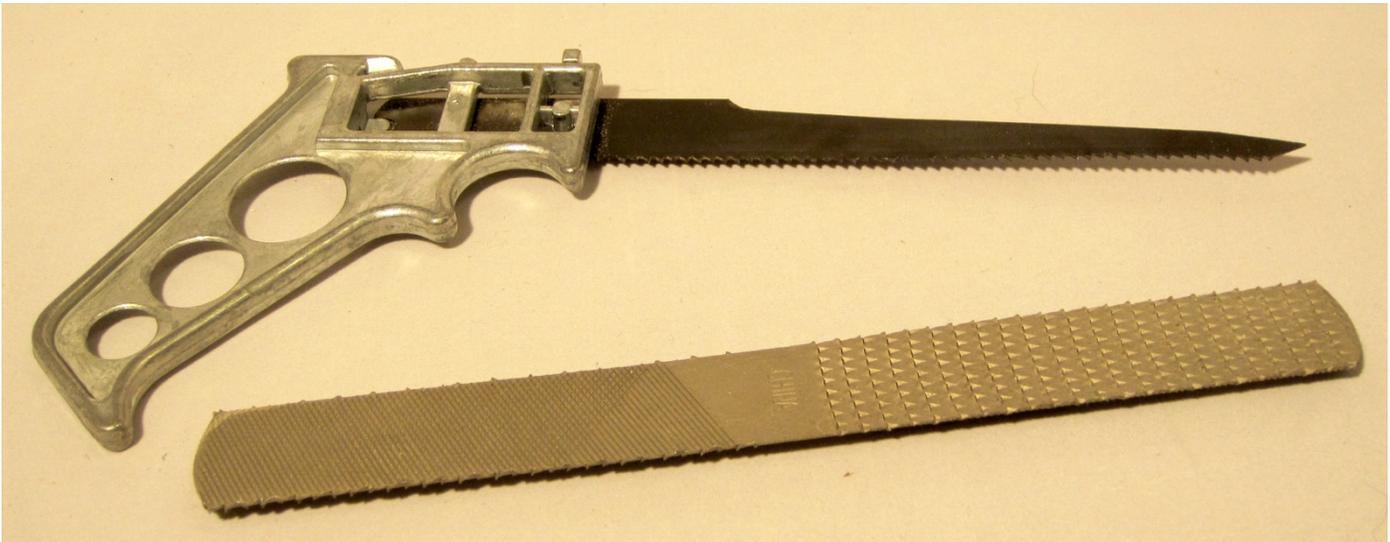
### Activity 2: Woodworking Tool Tutorial (30 minutes)

#### Materials List

- 4 Blastcar Car Kits
- Blastcar CO<sub>2</sub> fuel cartridges
- 1 pin vise
- 1 3/32-inch drill bit
- 1 keyhole saw
- 1 rasp
- 1 sheet each of fine and coarse sandpaper
- 1 8-inch long, 5/8-inch diameter wooden dowel
- Scraps of wood to practice on

The tools you have in the kit are a keyhole saw, a coarse/medium wood rasp, a pin vise with a 3/32-inch drill bit, and coarse and fine sandpaper, as well as a piece of wooden dowel. These are shown and explained below. Your Lab Manager may give you some scraps of wood that you can use to practice using the tools on. Don't practice on the Blastcar kits!

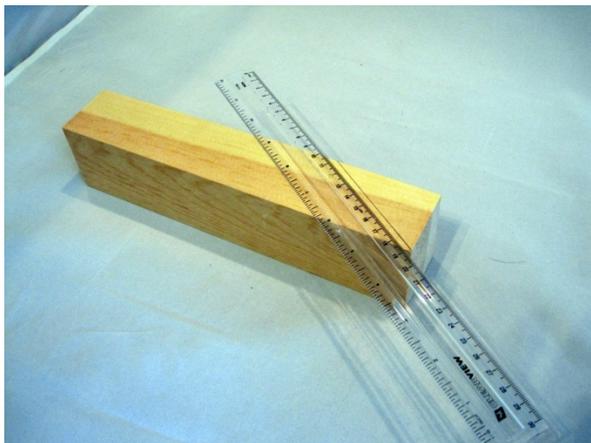
The keyhole saw is a rough cut saw for roughly shaping the wooden block. Never force or put pressure on a saw to try to make it cut faster. You will end up bending or breaking the blade, or it will get stuck. Put the saw on the cut line and slide it back and forth without pushing down on it. The saw's teeth will cut into the wood all on their own. Patience is key in using a saw properly. Long strokes give you cleaner and faster cuts than short strokes. Your arm should line up with the saw line so it is straight with the saw and there is no angle between your arm and the saw.





## Meeting 1: How to Go Fast

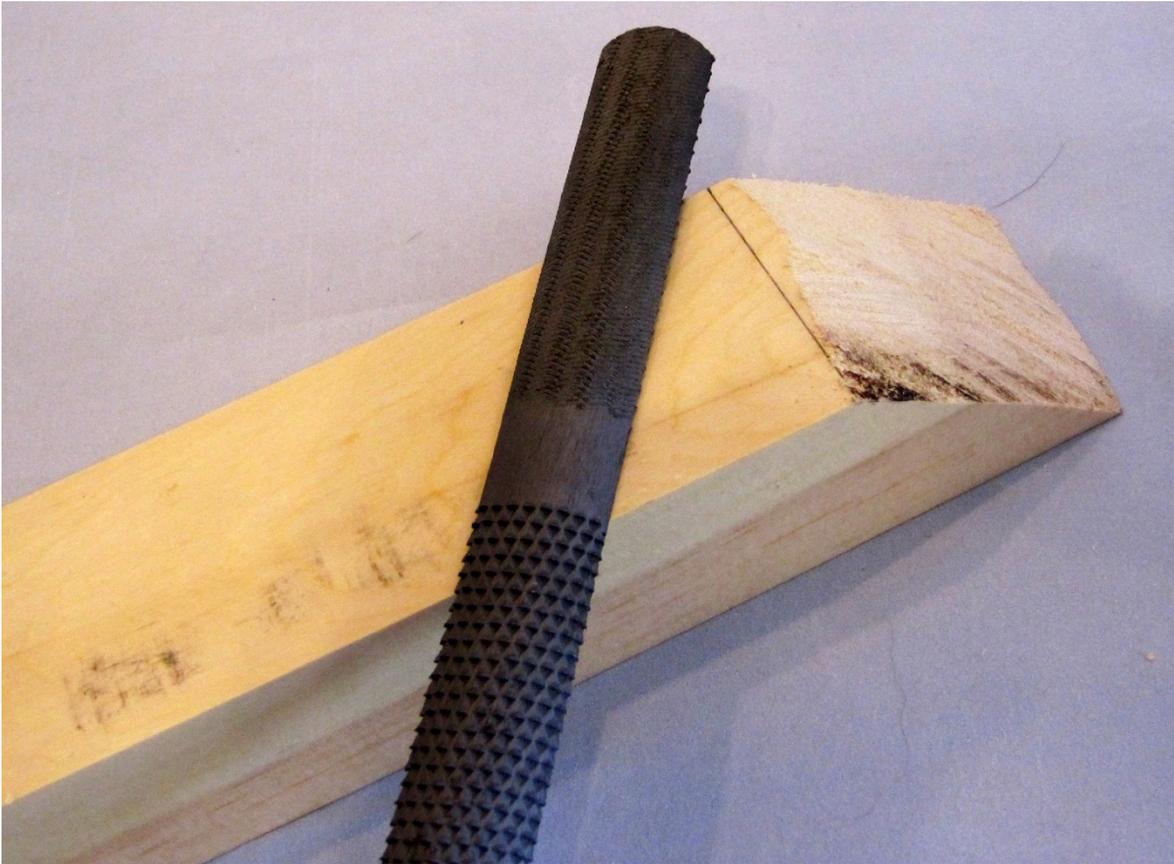
Draw your cut lines on the block of wood and, carefully holding down the block of wood with one hand (or getting a teammate to help you hold it), use the saw to make the rough cut.





## Meeting 1: How to Go Fast

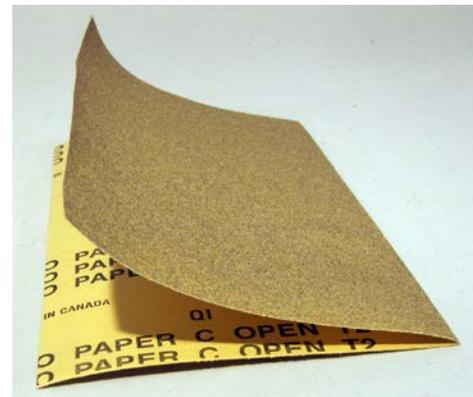
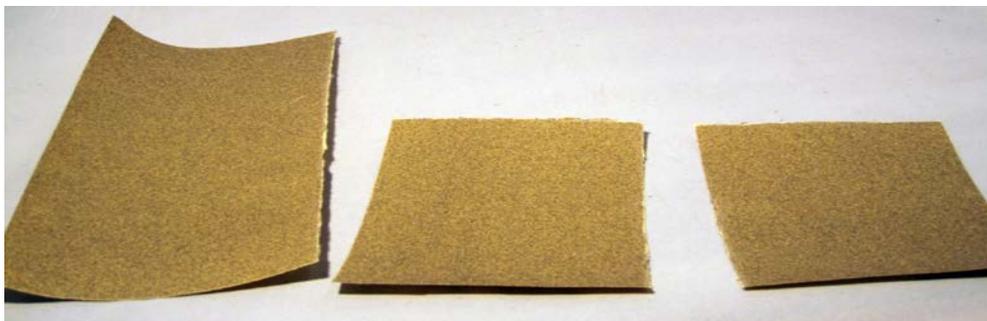
The wood rasp has a coarse set of teeth and a medium set of teeth. Use the coarse teeth to get your shape pretty close to the final shape wanted, then the medium teeth to finish the shape.





## Meeting 1: How to Go Fast

Use the coarse and fine sandpaper to smooth out the rasp tooth marks and to smooth the edges and bevel them so you don't get splinters. First, take a sheet of sandpaper and divide it into four pieces. Fold the sandpaper in half to make a crease, then fold it the opposite (so that the backing is out) to



for each half so you have four pieces from the sheet. These smaller pieces are easier to use.

crease it all the way through. Now, you can gently separate the two halves. Do the same





## Meeting 1: How to Go Fast

Here are a couple of simple “space shuttle”-like shapes you can easily make.



Next, measure and mark where the wheels will go. Drawing a straight line at a right angle from the wood block helps you to get the two wheels on each side lined up. It is important that all wheels be the same height from the block, so the axle holes need to be the same distance from the bottom edge.





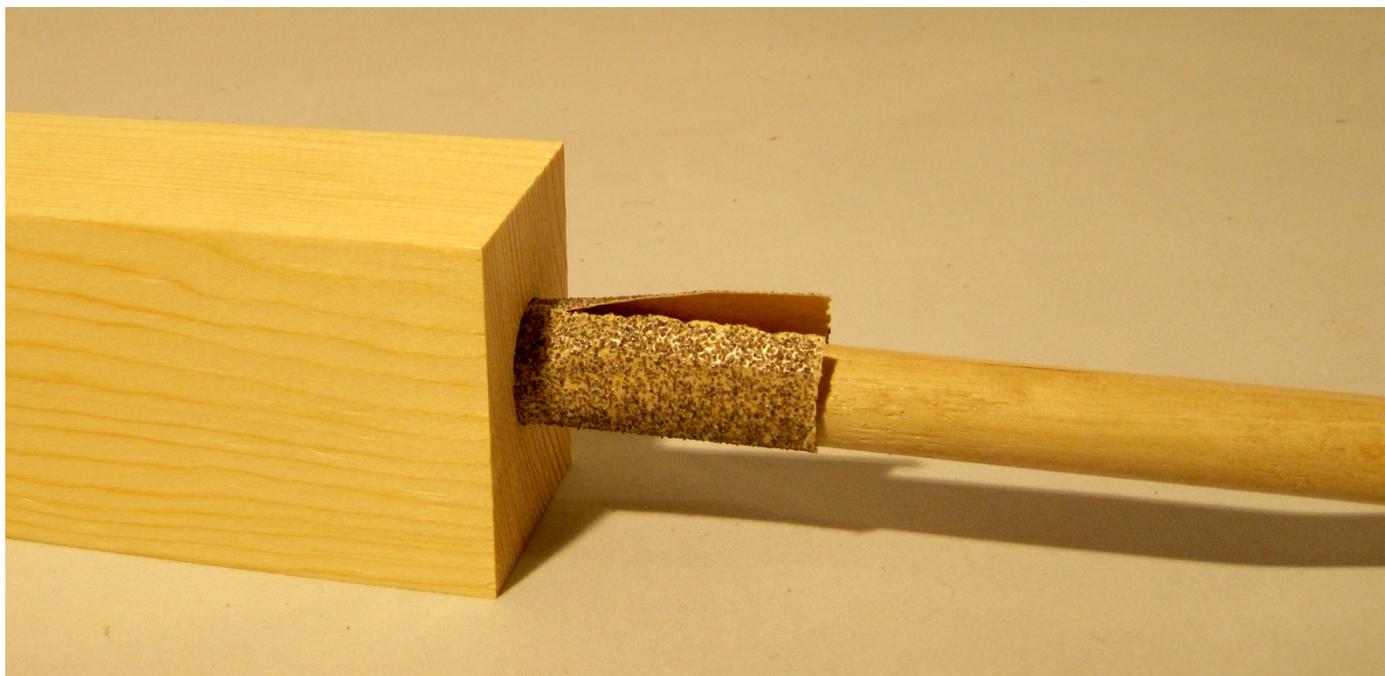
## Meeting 1: How to Go Fast

Use the pin vise and the drill bit to hand drill a pilot hole for the axles.



Next, check the fit of the CO<sub>2</sub> cartridge to the predrilled hole. It should fit snugly all the way into the hole, with only the neck sticking out, yet still be loose enough that you can pull it out again.

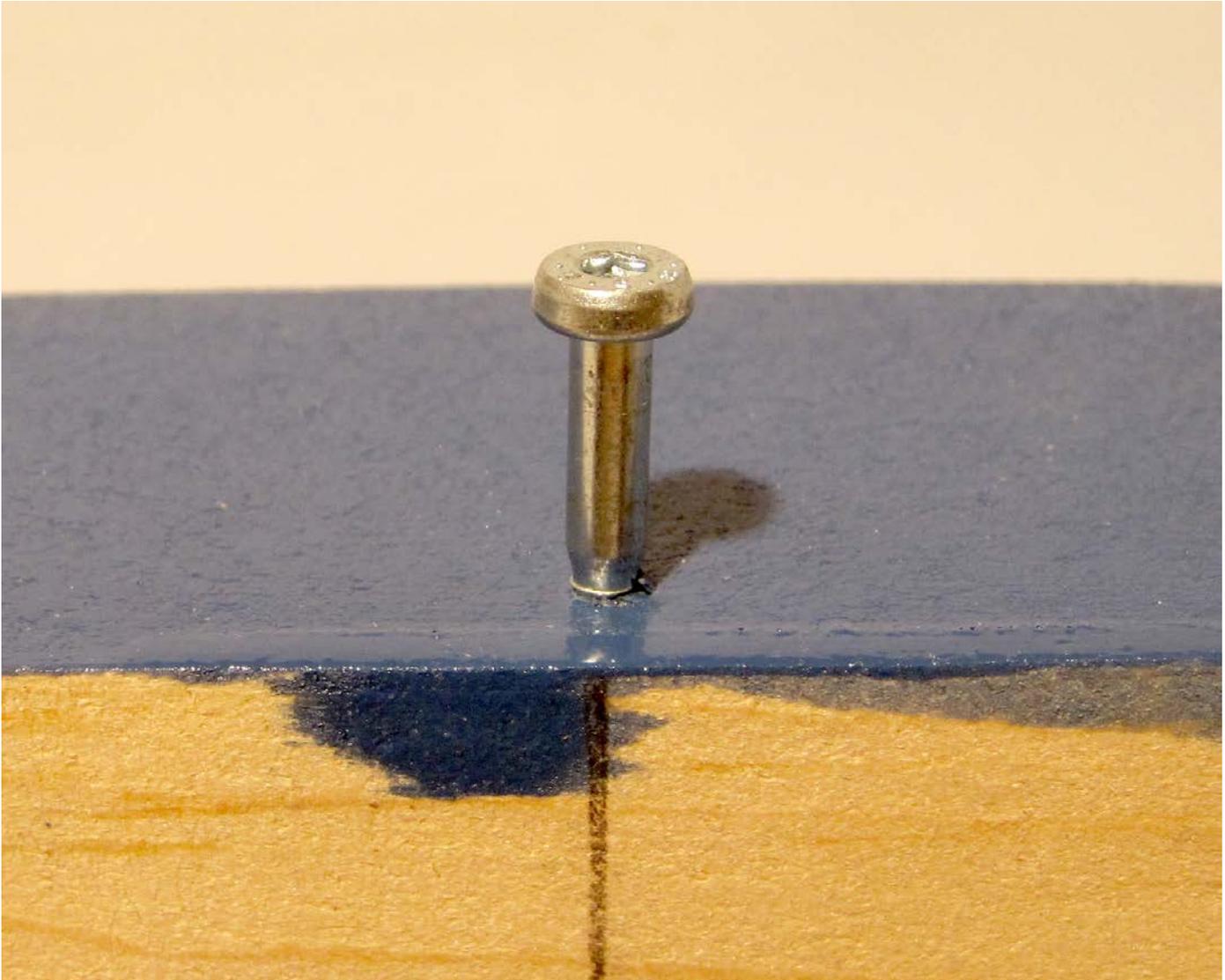
If you cannot get the cartridge all the way into the hole, cut a section of the coarse sandpaper (grit #60), wrap it around the wooden dowel, and use that to sand open the hole a little bit. Do a little sanding at a time and check the fit.





## Meeting 1: How to Go Fast

If you are going to paint or decorate the car, do that as the next step and let the paint dry completely before you mount the wheels. To mount the wheels, take the axle screws provided with the Allen wrench and screw one into each hole you drilled until you can't see the threads anymore, then unscrew it. This makes mounting the wheels easier.



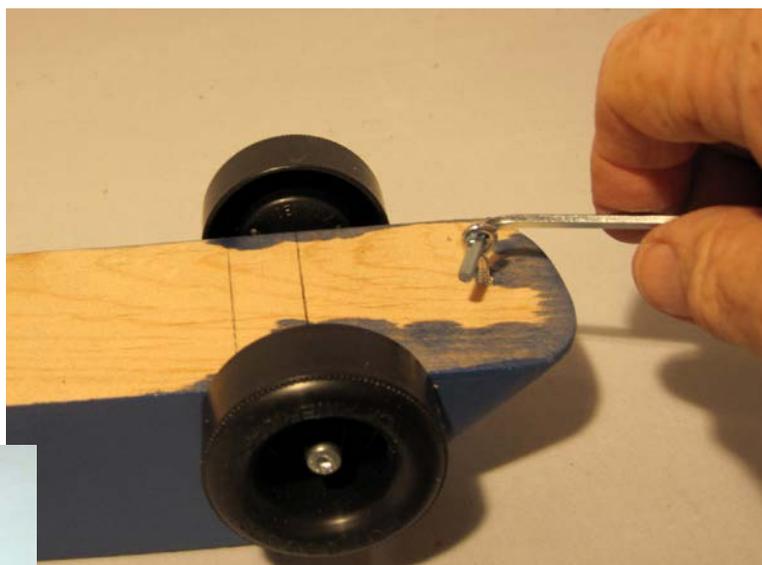


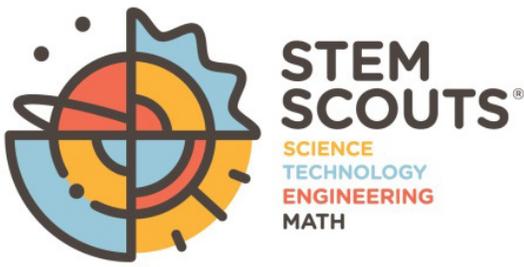
## Meeting 1: How to Go Fast

Now, you can mount the wheels with the axles.



To mount the eyelets, use the pin vise and drill bit to make two shallow holes on the underside of the car—one up front and one at the back. Don't drill a deep hole; you just need a starter hole. Then take the eyelets and start screwing them into that shallow hole by hand. As they screw into the wood, it may get hard to turn them by hand. In that case, put the Allen wrench through the eye to get some leverage turning the eyelet. You want the eyelets to be centered on the car body so that the fishing line can slide through as the car races down the track.





# Leaders Guide



## Meeting 1: How to Go Fast

### Activity 3: Design a Race Course (20 minutes)

For this activity, form groups of eight Scouts (two teams) to jointly design a course.

#### Materials List

- Trundle wheel
- Ruler

Two teams will work together to design a race course, taking into account the space available, the incline, surfaces, etc. You can use one of the basic courses described in the guidelines, make a variation of those, or design something unique. You will build your race course in Meeting 3 and race your first car on it to test your designs. Then, during Meeting 4, you and the other teams will race your cars on all the race courses designed by each pair of teams.

Sketch out the race course in your Lab Notebook. You can use the trundle wheel to measure the distance available.

Once you have the course designed, define how much race line you will need (you will need two lines, one for each car), how and where you will locate and attach the start and finish plates, and any other details. If you need materials not provided in the kit, identify exactly what you will need and discuss how you will find and acquire these materials.

#### Discussion

Lead a discussion on what the Scouts have done and their results. Ask open-ended questions to get them thinking about what they have done and learned, and what they might do differently next time.

#### Discussion Questions

What is inertia and how does it affect a car's race performance?

What is thrust and how does it affect a car's race performance?

What is drag and how does it affect a car's race performance?

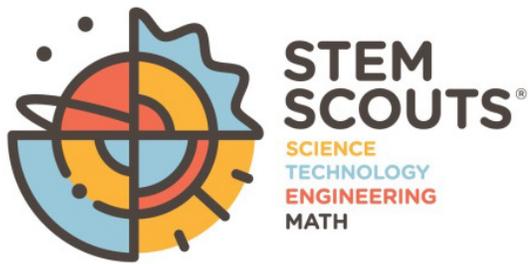
What is friction and how does it affect a car's race performance?

What is velocity and how does it affect a car's race performance?

#### Cleanup

Put the kits and instructions back into their boxes. Return them to your Program Manager.

Clean your area, and be sure no trace is left behind.



# Leaders Guide



## Meeting 1: How to Go Fast

### STEM Innovator Moment

The Scouts should hear from or about a person who has expertise on the topic of the day's activities about how this topic applies to everyday life and careers. The person could visit the Lab or use teleconferencing software such as Skype. You can also use the innovator information below.

*Carroll Shelby is famous for designing high-performance cars, notably the Shelby Cobra and then, under contract to Ford Motor Co., the Shelby Mustangs. He wanted to go into aeronautical engineering after high school, but enlisted in the United States Army Air Corps during World War II, serving as a flight instructor and test pilot. He tried his hand at working on oil wells in Texas, then raising chickens, before he got involved in automobile racing. He won many awards and set records as a race car driver, until a heart condition forced him to stop racing. In 1959, he opened a high-performance driving school and created the Shelby American company. His first car design was the AC Cobra—known as the Shelby Cobra—and he also worked for Ford, General Motors, and Chrysler, developing performance car designs.*

Reference: [https://en.wikipedia.org/wiki/Carroll\\_Shelby](https://en.wikipedia.org/wiki/Carroll_Shelby)

You can play a retrospective of Carroll Shelby's life and cars at: [www.youtube.com/watch?v=Befw8E6rKoc](http://www.youtube.com/watch?v=Befw8E6rKoc) (6:55).

### Closing

Discuss an ethical situation that occurred during the meeting as well as how the Scout Oath and Scout Law could be applied to deal with the issue. Remember to focus on things that occurred among the Scouts rather than on controversial issues in science today.



## Meeting 2: Design and Build

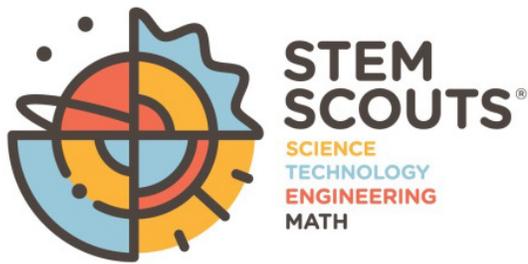


### Meeting 2: Design and Build

#### Pre-Meeting Leader Preparation

Part of this meeting involves starting to build the cars. This will involve woodworking and will generate sawdust. Plan how to best do this to be able to clean up the Lab meeting room afterward. As discussed in the Overview, Scouts may want to get access to more woodworking tools, work as a team, work with their parents, etc., so have a plan for how to support the building of the cars.

The instructions provided assume no access to woodworking tools other than what is supplied in the kits and presents a simpler design of the cars to be commensurate with what can be done by most youth with these simple tools.



# Leaders Guide



## Meeting 2: Design and Build

### Materials and Tools Needed

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)

Scouts will be divided into teams of four for this set of experiments. Material quantities are defined for each team.

- 2 Blastcar Car Kits
- 1 pin vise with 2 3/32-inch drill bits
- 2 wood rasps
- 2 keyhole saws
- Coarse and fine sandpaper
- 1 8-inch long, 5/8-inch diameter wooden dowel
- 1 digital scale (shared between up to four teams)
- 1 laptop with internet access (unit- or, optionally, council-supplied)
- 1 ruler
- Pencils (unit-supplied)
- Paper towels and water (unit-supplied)
- Broom and dustpan (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)

### Opening

Have the Principal Investigator lead the group in reciting the Pledge of Allegiance and the Scout Oath and Scout Law.

### Applying the Scout Law

Choose one of the 12 points of the Scout Law to discuss in application to today's lab. A suggested theme for this meeting is *obedient*, as in *I will be obedient and follow all the rules for the race in designing our cars*.

Ask the Scouts what being *obedient* means to them, and how they might apply that to today's lab.

### Activity Overview

There are two activities in this lab. In the first activity, Scouts will design one or more race cars based on all they have learned from Meeting 1.

Then, Scouts will start to build the cars they have designed. They can continue working on these at home between this meeting and the next one.

### Background

The background information for this meeting is included in the Experiment section.

### Engaging Questions

Use some of the following questions to get the Scouts engaged. (*Typical answers are in italics.*)

Has anyone ever built a small wooden model car of any kind?

What do you think are the most important things to do as you prepare to carve your car out of the wooden block? (*Listen for designing it, marking the block with your design, using different tools, having a plan, etc., and discuss those ideas with the group.*)



## Meeting 2: Design and Build

### Safety Moment

Tell the Scouts:

You will be using sharp woodworking tools today. Always look at the area you will be working in and set it up so that you are not going to accidentally cut the table, other furniture, yourself, or anyone else.

Sawdust and wood shavings will probably get on the floor and can make the floor very slippery. Clean up regularly and take care when walking around.

When you are sanding, be careful to not get sawdust in your eyes. If you do, get help from a Lab Manager to wash your eyes out.

### Experiment

Get the Scouts into the same teams of four that they were in for the previous meeting.

They will use the STEM Scouts Engineering Design Process throughout this module.

Ask them to follow the instructions in their Lab Notebook, reproduced below.

### Activity 1: Design Race Cars (30 minutes)

#### Materials List

- Course design your team made in the previous meeting
- 1 copy of Blastcar Guidelines and Instructions from the car kits
- Team laptop with internet access
- 1 ruler
- Pencils

#### Step 1: Define the Problem

You and your team want to design the fastest race car.

#### Step 2: Conduct Background Research

Review the information you learned in Meeting 1 on the different courses, race car tips and woodworking basics. Here are some useful websites that have information and performance tips you can use.

<https://auto.howstuffworks.com/auto-racing/motorsports/co2-powered-dragster2.htm>

[www.science-of-speed.com/How-To/Tune?art=8021](http://www.science-of-speed.com/How-To/Tune?art=8021)

[www.co2dragsters.co.nz/assets/Uploads/CO2-Dragster-Design-and-Construction-Notes-for-Students.pdf](http://www.co2dragsters.co.nz/assets/Uploads/CO2-Dragster-Design-and-Construction-Notes-for-Students.pdf)



## Meeting 2: Design and Build

### Step 3: Specify Requirements

Review the Blastcar Guidelines and Instructions for the rules you have to follow in the first race.

You and your team have a critical decision to make at this point. What race course are you trying to win? Are you going to design a race car with optimal performance and speed for the course you and your team designed or one that is good on all race courses? Or are you going to try to make two different cars? Discuss this among yourselves and make a decision. Then add in the requirements pertinent to the kind of car you decided to design.

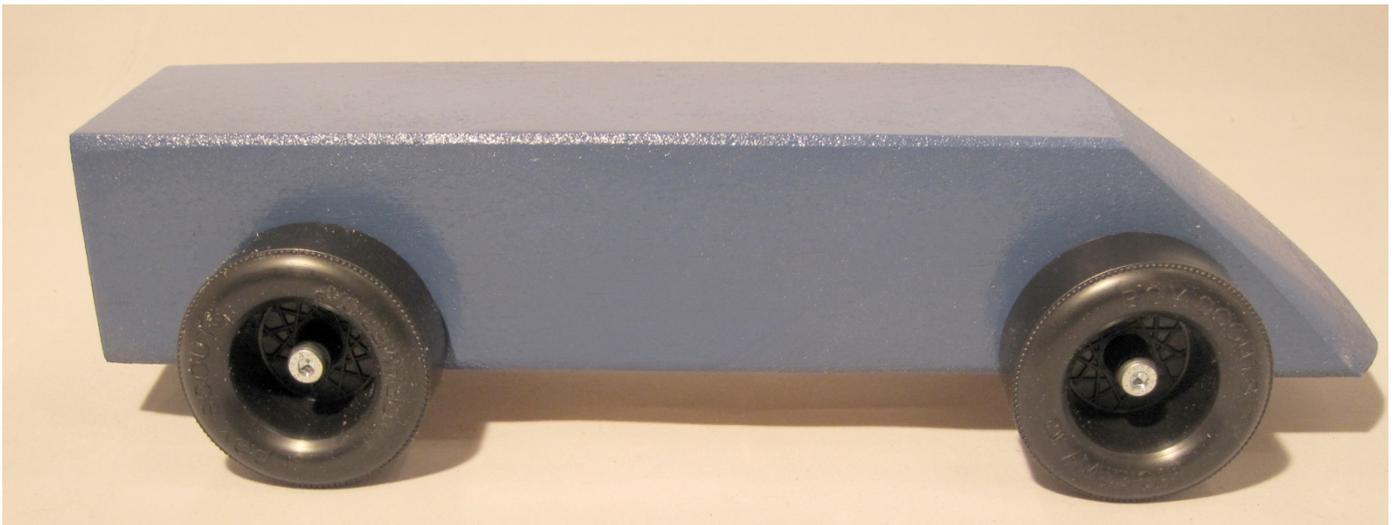
Make sure you pay attention to the spacing, tolerances, and clearances specified in the guidelines.

You and your team have a total of four car kits to work with for the entire module. You will need to have at least one car for the full rules race and one for the no-rules race. You will have to decide how to allocate the four kits among those activities.

### Step 4: Create Alternative Solutions

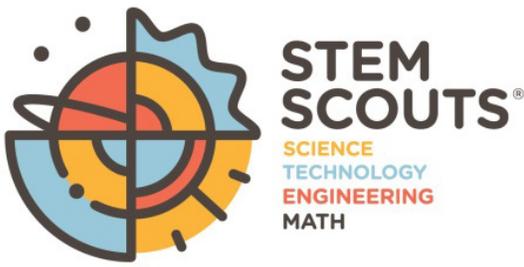
You and your team should plan a baseline design, and, as you are discussing that design, make note of alternative designs you might want to try if the baseline does not work as well as expected. Capture the design and the alternate ideas in your Lab Notebook.

If you have access to a wood-working expert and tool shop, you can plan a fancier shape of a car. But if you are going to use the basic tools supplied in the kit, we recommend you stick to a simple, basic shape, as shown below.



Discuss whether you are going to need any special tools to build your cars and where you can get access to them.

Once you have your designs and plans created, move on to the next activity, where you will start building the car.



# Leaders Guide



## Meeting 2: Design and Build

### Activity 2: Start Building Your Prototype (30 minutes)

#### Materials List

- 1–2 Blastcar Car Kits
- 1 pin vise with 2 3/32-inch drill bits
- 2 wood rasps
- 2 keyhole saws
- Coarse and fine sandpaper
- 1 8-inch long, 5/8-inch diameter wooden dowel
- 1 digital scale (shared between up to four teams)
- Paper towels and water
- Broom and dustpan
- Optional: clamps and other woodworking tools as needed

You will continue with the STEM Scouts Engineering Design Process started in the first activity.

**Lab Manager Note:** Keep an eye on how long it takes your Scouts to build a car. We have provided a total of four cars per team to allow for two designs for the rules-based race and two designs for the no-rules event. Building the cars can go quickly or take a long time, so if your Scouts are taking a while to build one car, tell them to not do a second design.

#### Step 5: Build a Prototype

Using the primary design you and your team created in Activity 1, start to build your prototype (or multiple prototypes). You will almost certainly not finish the prototype in this activity. You and your team can take your kits and tools home with you to get together and work on the cars between this meeting and the next or arrange to meet at someone's home or wood shop where you have access to other tools.

#### Discussion

Lead a discussion on what the Scouts have done and their results. Ask open-ended questions to get them thinking about what they have done and learned, and what they might do differently next time.

#### Discussion Questions

How are your prototype builds going so far?

What kind of help do you need to complete your prototypes?

What are your plans between now and the next meeting to complete your prototypes?

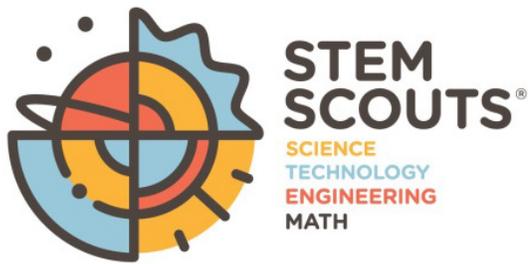
#### Cleanup

Clean up any wood shavings and sawdust.

If you are going to work on your cars between now and the next meeting, check out any tools and let your Program Manager know what you are taking with you.

Exit all applications on the laptop, fully power it down, and return it to your Program Manager.

Clean your area, and be sure no trace is left behind.



# Leaders Guide



## Meeting 2: Design and Build

### STEM Innovator Moment

The Scouts should hear from or about a person who has expertise on the topic of the day's activities about how this topic applies to everyday life and careers. The person could visit the Lab or use teleconferencing software such as Skype. You can also use the innovator information below.

*Hermann Tilke is a German engineer, racing driver, and race track designer who has designed 29 racetracks all around the world, including the most Formula 1 race tracks of any designer. Tilke got his civil engineering degree, specializing in transport and traffic management, and then established Tilke Engineering, combining skills in architecture, civil engineering, and electronic engineering to provide complete solutions for motor racing and waste disposal projects.*

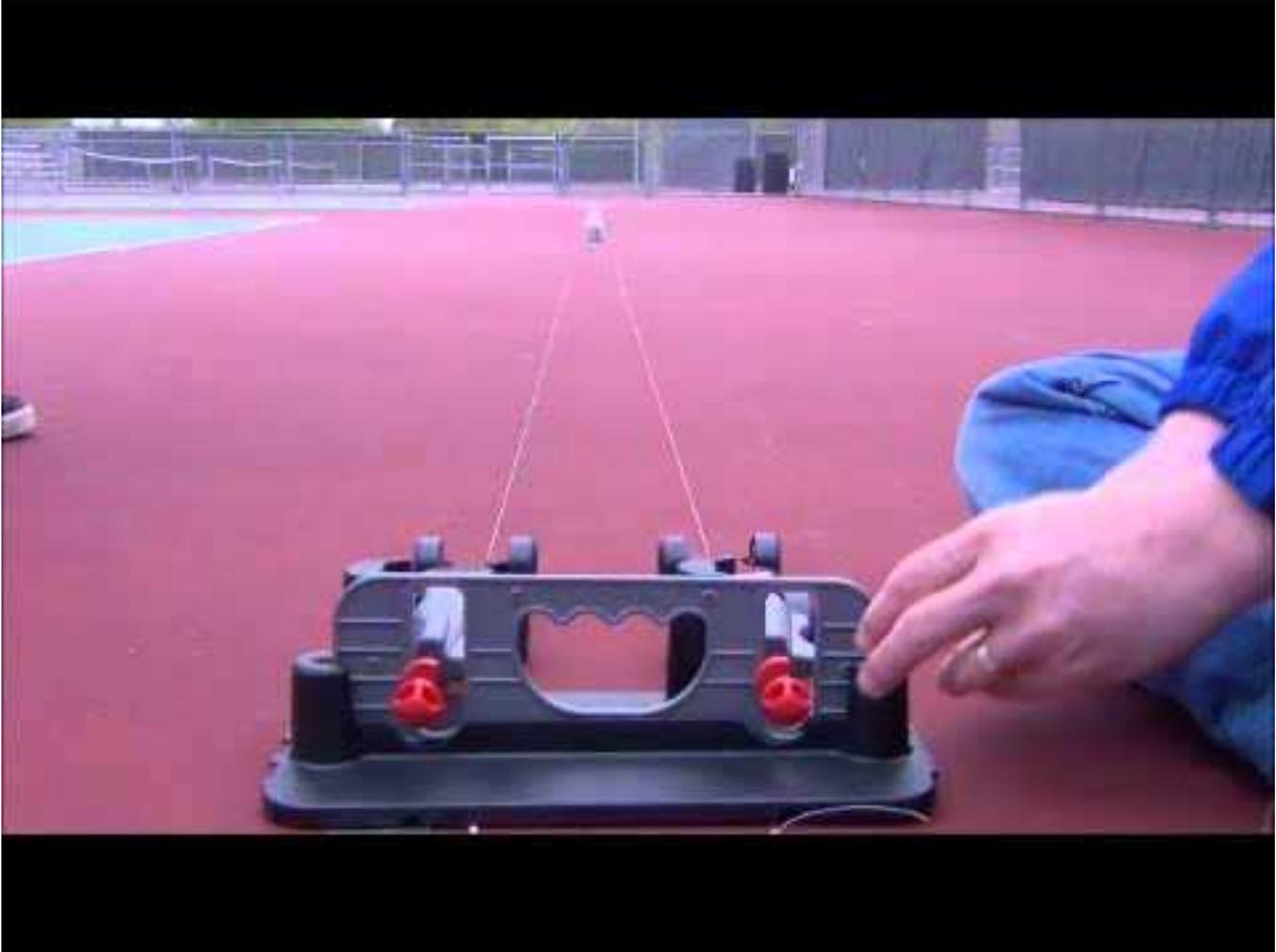
Source: [https://en.wikipedia.org/wiki/Hermann\\_Tilke](https://en.wikipedia.org/wiki/Hermann_Tilke)

### Closing

Discuss an ethical situation that occurred during the meeting as well as how the Scout Oath and Scout Law could be applied to deal with the issue. Remember to focus on things that occurred among the Scouts rather than on controversial issues in science today.



## Meeting 3: Build Tracks; Test and Refine Cars

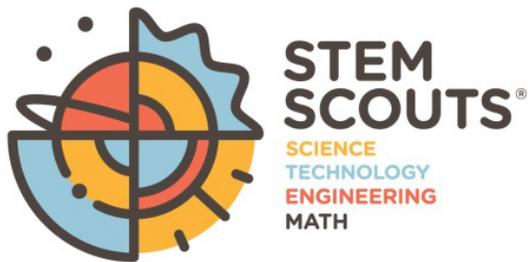


### Meeting 3: Build Tracks; Test and Refine Cars

#### Pre-Meeting Leader Preparation

You will need to identify and have access to an area that has room for a race course at least 50 feet long, up to 100 to 200 feet long. This can be either indoors (slick floor or carpeted) or outdoors (paved, gravel, packed or loose dirt). If possible, both flat and inclined spaces are ideal to allow for multiple courses to be set up. You can always build simple inclines and ramps out of everyday objects and used cardboard boxes.

The Scouts will need to get back into the same two teams of four that designed a course in Meeting 1 to build that course. There is one launch kit for every eight Scouts.



# Leaders Guide



## Meeting 3: Build Tracks; Test and Refine Cars

### Materials and Tools Needed

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)

The following materials are shared between multiple teams.

- Blastcar Car Launch Kit (shared between two teams)
- 1 digital scale (shared between up to four teams)
- 1 stopwatch (shared between two teams)
- Duct tape (shared between two teams)
- Trundle wheel (shared between two teams)
- Towel or blanket to provide a soft stop for each launch kit (unit-supplied)
- Extra launch line (if needed)
- Optional: ramp-building materials (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)

Scouts will be divided into two teams of four (the same pair of teams that got together in Meeting 1) for this set of experiments. Material quantities are defined for each team.

- 1–2 cars previously built by the Scouts (unit-supplied)
- 3 CO<sub>2</sub> gas cartridges per car
- 1 pin vise with 2 3/32-inch drill bits
- 2 wood rasps
- 2 keyhole saws
- Coarse and fine sandpaper
- 1 8-inch long, 5/8-inch diameter wooden dowel
- 1 tube graphite lube
- Paper towels and water (unit-supplied)
- Broom and dustpan (unit-supplied)
- 1 copy of Blastcar guidelines and instructions (in Blastcar kit)
- 1 ruler

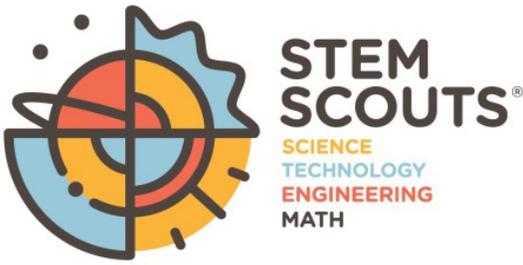
### Opening

Have the Principal Investigator lead the group in reciting the Pledge of Allegiance and the Scout Oath and Scout Law.

### Applying the Scout Law

Choose one of the 12 points of the Scout Law to discuss in application to today's lab. A suggested theme for this meeting is *courteous*, as in *I will be courteous in sharing use of the launcher with other teams*.

Ask the Scouts what being *courteous* means to them, and how they might apply that to today's lab.



# Leaders Guide



## Meeting 3: Build Tracks; Test and Refine Cars

### Activity Overview

There are three overlapping activities in this lab. In the first activity, Scouts will build the race courses they designed in Meeting 1.

In the second activity, the Scouts will test their cars on the race courses.

In parallel with this, Scouts can continue working on their cars, design some modifications based on test results, and take the cars home to work on them between this meeting and the next. The next meeting is the race day, so cars must be finished by then.

### Background

There is no additional background information for this meeting.

### Engaging Questions

There are no questions at this point. Please allow the Scouts the maximum amount of time to build courses and test and work on cars.

### Safety Moment

Tell the Scouts:

You will be using sharp woodworking tools today. Always look at the area you will be working in and set it up so that you are not going to accidentally cut the table, other furniture, yourself, or anyone else.

Sawdust and wood shavings will probably get on the floor and can make the floor very slippery. Clean up regularly and take care when walking around.

When you are sanding, be careful to not get sawdust in your eyes. If you do, get help from a Lab Manager to wash your eyes out.

The race courses will have fishing line stretched for the entire length for the cars to connect to. This line can be almost invisible, so be careful that you don't trip over the line when walking near a race course.

NEVER put CO<sub>2</sub> cartridges into the cars until the cars are ready to race and are already tethered to the race line. Once the car is tethered to the race line, insert the CO<sub>2</sub> cartridge and then carefully move the car onto the launcher.

Everyone must stay at least 10 feet away from the launcher and race course.

Only Lab Leaders should operate the launcher.



## Meeting 3: Build Tracks; Test and Refine Cars

### Experiment

Get the Scouts into the same two teams of four that they were in for previous meetings.

Ask them to follow the instructions in their Lab Notebook, reproduced below.

### Activity 1: Build Race Courses (15–20 minutes)

#### Materials List

- Blastcar Car Launch Kit (one for every two teams)
- Extra launch line (if needed)
- 1 digital scale (shared between up to four teams)
- 1 stopwatch (shared between two teams)
- Duct tape (shared between two teams)
- Trundle wheel (shared between two teams)
- Towel or blanket to provide a soft stop
- Optional: ramp-building materials
- 1–2 cars previously built by the Scouts
- 3 CO<sub>2</sub> gas cartridges per car
- 1 tube graphite lube
- 1 copy of Blastcar Guidelines and Instructions (in Blastcar kit)
- 1 ruler

Your Lab Leader or the Principal Investigator will go around the lab numbering all cars, so that each has a unique number.

Using the plans developed in Meeting 1, you and the other Scouts in your group of eight should go to the course area designated by your Lab Manager and set up your course. Follow the instructions in the Blastcar Guidelines and Instructions for **Setting Up the Track**. Use the trundle wheel to measure the distance of the course and write that down in the Course Information Table.



## Meeting 3: Build Tracks; Test and Refine Cars

Course Information Table

Course No.	Designed By	Type (from guidelines)	Description	Length (feet)



## Meeting 3: Build Tracks; Test and Refine Cars

Your team has three CO<sub>2</sub> gas cartridges for each car you built previously. Plan with your group of eight how you want to test your cars and use these cartridges. They have to last through this entire meeting.

Inspect each car and record the weight and measurements in Car Data Table 1. As you test and modify your cars, use this table to keep track of the changes you make. Use the **CO<sub>2</sub> Car Inspection Guide** and check the **Rules of the Event** section in the Blastcar Guidelines and Instructions.

**Car Data Table 1**

Car No.:						
Version	Length (inches)	Width (inches)	Height (inches)	Weight (ounces)	Pass Inspection	Modifications

You will be able to test two cars at a time on the course. When you are ready to test a pair of cars on the course, get a Lab Leader to oversee the launcher.



## Meeting 3: Build Tracks; Test and Refine Cars

### Activity 2: Test and Refine Cars (40–45 minutes)

#### Materials List

- Blastcar Car Launch Kit (one for every two teams)
- 1 stopwatch (shared between two teams)
- Duct tape (shared between two teams)
- Towel or blanket to provide a soft stop
- Optional: ramp-building materials
- Optional: clamps and other woodworking tools as needed

Scouts will be divided into two teams of four for this set of experiments. Material quantities are defined for each team.

- 1–2 cars previously built by the Scouts
- 3 CO<sub>2</sub> gas cartridges per car
- 1 pin vise with 2 3/32-inch drill bits
- 2 wood rasps
- 2 keyhole saws
- Coarse and fine sandpaper
- 1 8-inch long, 5/8-inch diameter wooden dowel
- 1 tube graphite lube
- Paper towels and water
- Broom and dustpan
- 1 copy of Blastcar Guidelines and Instructions (in Blastcar kit)
- 1 ruler

Once you have a Lab Leader ready to help, connect the eyelets of the cars to the guide lines, put the CO<sub>2</sub> cartridges in the cars, and back them into the launcher, following the instructions in the **Running the Race** section of the guidelines.

Inspect the course area for safety compliance and make sure nobody is within 10 feet of the launcher or course.

Put one Scout at the end of the course (off to the side) with the stopwatch.

With your Lab Leader's help, call out a launch countdown and make sure that the person who is timing can clearly hear the "launch" command to start the stopwatch.

Use the Car Data Table 2 on the next page to record each test.



## Meeting 3: Build Tracks; Test and Refine Cars

Car Data Table 2

Car No.:					
Version	Course No.	Course Length (feet)	Time to Complete (seconds)	Problems	Improvement Ideas

After each test, discuss with your extended team (team of eight Scouts) the test run and any concerns or problems observed, and agree on what, if any, modifications you want to make.

Make your modifications and run another test. After the second test, identify any further changes you and your team want to make before the next meeting, and where and when you will get together to make those modifications.

### Discussion

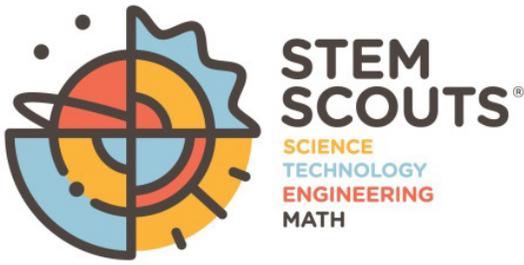
Lead a discussion on what the Scouts have done and their results. Ask open-ended questions to get them thinking about what they have done and learned, and what they might do differently next time.

### Discussion Questions

What kinds of problems or concerns did you run into in your first test?

What did you decide to do about them?

What performance enhancements did you initially build into your car and have you made any more performance enhancements?



# Leaders Guide



## Meeting 3: Build Tracks; Test and Refine Cars

### Cleanup

Carefully take down the courses and save all materials so that they can be used at the next meeting.

Put used CO<sub>2</sub> cartridges in the trash.

Clean up any wood shavings and sawdust you created when you modified your cars.

If you are going to work on your cars between now and the next meeting, check out any tools and let your Program Manager know what you are taking with you.

Clean your area, and be sure no trace is left behind.

### STEM Innovator Moment

The Scouts should hear from or about a person who has expertise on the topic of the day's activities about how this topic applies to everyday life and careers. The person could visit the Lab or use teleconferencing software such as Skype. You can also use the innovator information below.

*Danika Patrick is perhaps the best-known woman racing car driver in the world. She is the most successful woman in the history of American open-wheel racing—her victory in the 2008 Indy Japan 300 is the only win by a woman in an IndyCar Series race.*

*Patrick began karting at the age of 10 and achieved early success by winning her class in the World Karting Association Grand National Championship three times in the mid-1990s. She dropped out of high school with her parents' permission in 1998, and moved to the United Kingdom to compete in Formula Vauxhall and Formula Ford before returning to the United States in 2001. In 2004, Patrick finished third in the championship standings for the Toyota Atlantic Series and became the first woman to win a pole position in the series.*

*She first drove in the IndyCar Series in 2005 and took three pole positions, equaling Tomas Scheckter's record of poles in a rookie season. She was named the Rookie of the Year for both the 2005 Indianapolis 500 and the 2005 IndyCar Series. In 2009, Patrick finished a career-high third at the Indianapolis 500, the best performance by any woman at the race.*

*Patrick stepped away from IndyCar after the 2011 season to focus on stock car racing. Her best result in NASCAR was a fourth-place finish at Las Vegas Motor Speedway in 2011. She became the first woman to win a Cup Series pole position by setting the fastest qualifying lap for the 2013 Daytona 500, finishing eighth.*

Source: [https://en.wikipedia.org/wiki/Danica\\_Patrick](https://en.wikipedia.org/wiki/Danica_Patrick)

A good video on her racing career is at: [www.nascar.com/video/franchise/up-to-speed/take-look-back-danica-patricks-racing-career/](http://www.nascar.com/video/franchise/up-to-speed/take-look-back-danica-patricks-racing-career/) (1:34).

### Closing

Discuss an ethical situation that occurred during the meeting as well as how the Scout Oath and Scout Law could be applied to deal with the issue. Remember to focus on things that occurred among the Scouts rather than on controversial issues in science today.



## Meeting 4: Race Day!



### Meeting 4: Race Day!

#### Pre-Meeting Leader Preparation

You will need to identify and have access to an area that has room for a race course at least 50 feet long, up to 100 to 200 feet long. This can be either indoors (slick floor or carpeted) or outdoors (paved, gravel, packed or loose dirt). If possible, both flat and inclined spaces are ideal to allow for multiple courses to be set up. You can always build simple inclines and ramps out of everyday objects and used cardboard boxes.

The Scouts will need to get back into the same two teams of four that designed a course in Meeting 1 to build that course. There is one launch kit for every eight Scouts.

You should plan how the race is to be run and prepare a race results table to show winners of each individual race and the final winners. Each car should run on each course designed by the teams. Decide if you want to declare winners by course only, or course and overall. Plan the amount of time this will all take, which will depend on the size of your Lab.

The table on the next page lists the numbers of courses, rounds per course, total CO<sub>2</sub> cartridges required, and total supplied. The supplied number is roughly 10 percent higher to allow for a few reruns in cases of ties. You can see that the numbers of rounds and races grow significantly with the size of the Lab!

If you want to get more CO<sub>2</sub> gas cartridges, contact your local Scout shop and ask for the 10-pack of Blastcar 8-gram CO<sub>2</sub> fuel canisters (SKU 613276). These normally sell for about \$4.50. You can also get additional car kits, additional spools of race line, additional launchers, and other parts.



## Meeting 4: Race Day!

Lab Size	No. Teams	No. Courses	No. Rounds/ Course	No. Cartridges/ Round	Total Cartridges Needed	Total Cartridges Supplied
8	2	1	3	2	6	8
16	4	2	7	2	28	32
24	6	3	11	2	66	72
32	8	4	15	2	120	128

### Materials and Tools Needed

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)

The following materials are shared between multiple teams.

- Blastcar Car Launch Kit (shared between two teams)
- 1 digital scale (shared between up to four teams)
- 1 stopwatch (shared between two teams)
- Duct tape (shared between two teams)
- Trundle wheel (shared between two teams)
- Towel or blanket to provide a soft stop (unit-supplied)
- Optional: ramp-building materials (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)

Scouts will be divided into two teams of four (the same pair of teams that got together in Meeting 1) for this set of experiments. Material quantities are defined for each team.

- 1–2 cars previously built by the Scouts (unit-supplied)
- CO<sub>2</sub> gas cartridges (see table above for quantities)
- 1 tube graphite lube
- 1 copy of Blastcar guidelines and instructions (in Blastcar kit)

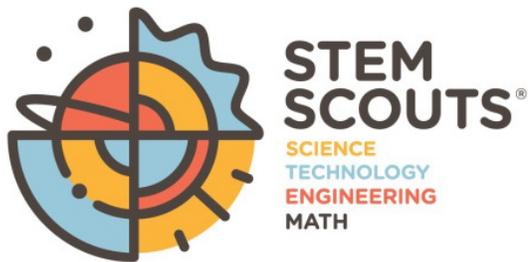
### Opening

Have the Principal Investigator lead the group in reciting the Pledge of Allegiance and the Scout Oath and Scout Law.

### Applying the Scout Law

Choose one of the 12 points of the Scout Law to discuss in application to today's lab. A suggested theme for this meeting is *cheerful*, as in *I will be cheerful even if my team's car is not winning*.

Ask the Scouts what being *cheerful* means to them, and how they might apply that to today's lab.



# Leaders Guide



## Meeting 4: Race Day!

### Activity Overview

Today is race day! Scouts will reassemble their race courses if necessary and run races on the different tracks.

### Background

There is no additional background for today's lab.

### Engaging Questions

Let the Scouts get started on setting up their courses so they have as much time as possible to race.

### Safety Moment

Tell the Scouts:

The race courses will have fishing line stretched for the entire length for the cars to connect to. This line can be almost invisible, so be careful that you don't trip over the line when walking near a race course.

NEVER put CO<sub>2</sub> cartridges into the cars until the cars are ready to race and are already tethered to the race line. Once the car is tethered to the race line, insert the CO<sub>2</sub> cartridge and then carefully move the car onto the launcher.

Everyone must stay at least 10 feet away from the launcher and race course.

Only Lab Leaders should operate the launcher.

### Experiment

Get the Scouts into the same two teams of four that they have been in for previous meetings.

Ask them to follow the instructions in their Lab Notebook, reproduced below.

### Activity 1: Set Up Courses (15 minutes)

#### Materials List

The following materials are shared between multiple teams.

- Blastcar Car Launch Kit (shared between two teams)
- Duct tape (shared between two teams)
- Trundle wheel (shared between two teams)
- Towel or blanket to provide a soft stop
- Optional: ramp-building materials

Each pair of teams should set up their course that they tested in the previous meeting.



## Meeting 4: Race Day!

### Activity 2: The Great Race (45–60 minutes)

#### Materials List

The following materials are shared between multiple teams.

- 1 digital scale (shared between up to four teams)
- 1 stopwatch (shared between two teams)
- Optional: clamps and other woodworking tools as needed

Scouts will be divided into two teams of four (the same pair of teams that got together in Meeting 1) for this set of experiments. Material quantities are defined for each team.

- 1–2 cars previously built by the Scouts
- CO<sub>2</sub> gas cartridges (see table above for quantities)
- 1 tube graphite lube
- 1 copy of Blastcar Guidelines and Instructions (in Blastcar kit)

Start racing! A Lab Leader will run the launcher at each course.

#### Discussion

Lead a discussion on what the Scouts have done and their results. Ask open-ended questions to get them thinking about what they have done and learned, and what they might do differently next time.

#### Discussion Questions

How did your final designs work?

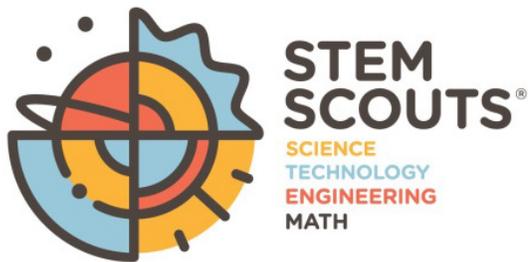
What might you do differently next time?

#### Cleanup

Carefully take down the courses and save all materials so that they can be used in Meeting 6.

Put used CO<sub>2</sub> cartridges in the trash.

Clean your area, and be sure no trace is left behind.



# Leaders Guide



## Meeting 4: Race Day!

### STEM Innovator Moment

The Scouts should hear from or about a person who has expertise on the topic of the day's activities about how this topic applies to everyday life and careers. The person could visit the Lab or use teleconferencing software such as Skype. You can also use the innovator information below.

*Adrián Fernández is one of the top racing car drivers from Mexico. Born in Mexico City, Fernández began racing motocross as an 8-year-old. He entered his first auto race in 1981 at the "24 Hours of Mexico," and made the permanent move to cars in 1982 at the age of 15. From 1982 to 1984, Fernández competed in the Formula Vee Championship, taking the title in '83 and '84. He also raced in the Formula K Series from 1984 to 1986, finishing in the top four in the standings all three years.*

*In 1987, he ran one race in the Benelux Formula Ford 1600 Championship and one race in the British RAC Formula Ford 1600 Championship and competed in the Formula Ford Festival at Brands Hatch. In 1988 and 1989, he ran the British RAC and Esso Formula Ford 1600 Championship series before moving to the Mexican F3 Championship for 1990 and 1991, winning the title in '91.*

*In 1992, Fernández came to the United States to compete in the Firestone Indy Lights Championship. He finished third in the points by winning four races, a rookie record, and took the "Indy Lights Rookie of the Year" honors.*

Source: [https://en.wikipedia.org/wiki/Adri%E1n\\_Fern%E1ndez](https://en.wikipedia.org/wiki/Adri%E1n_Fern%E1ndez)

A video of Fernandez showing off his "007" car can be viewed at: [www.youtube.com/watch?v=wvkIgTGsEwA](http://www.youtube.com/watch?v=wvkIgTGsEwA) (1:58).

### Closing

Discuss an ethical situation that occurred during the meeting as well as how the Scout Oath and Scout Law could be applied to deal with the issue. Remember to focus on things that occurred among the Scouts rather than on controversial issues in science today.



## Meeting 5: Design a “No-Rules” Race Car



### Meeting 5: Design a “No-Rules” Race Car

#### Pre-Meeting Leader Preparation

Part of this meeting involves starting to build the cars. This will usually entail woodworking and will generate sawdust. Plan how to best do this to be able to clean up the Lab meeting room afterward. As mentioned in the Overview, Scouts may want to get access to more woodworking tools, work as a team, work with their parents, etc., so have a plan for how to support the building of the cars.

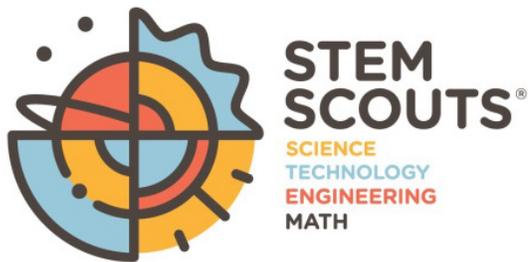
If the Scouts have fallen behind while building their initial cars, the no-rules activities can be dropped and the Scouts can just finish their cars and tracks and have a fun race. Allow the Scouts to make changes to the race course to accommodate their cars and have fun.

#### Materials and Tools Needed

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)

Scouts will be divided into teams of four for this set of experiments. Material quantities are defined for each team.

- 2 Blastcar Car Kits
- 1 pin vise with 2 3/32-inch drill bits
- 2 wood rasps
- 2 keyhole saws
- Coarse and fine sandpaper
- 1 8-inch long, 5/8-inch diameter wooden dowel
- 1 digital scale (shared between up to four teams)
- 1 laptop with internet access (unit- or, optionally, council-supplied)
- Paper towels and water (unit-supplied)
- Broom and dustpan (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)



# Leaders Guide



## Meeting 5: Design a “No-Rules” Race Car

### Opening

Have the Principal Investigator lead the group in reciting the Pledge of Allegiance and the Scout Oath and Scout Law.

### Applying the Scout Law

Choose one of the 12 points of the Scout Law to discuss in application to today’s lab. A suggested theme for this meeting is *thrifty*, as in *I will be thrifty in my use of materials and shared tools in building my no-rules race car*.

Ask the Scouts what being *thrifty* means to them, and how they might apply that to today’s lab.

### Activity Overview

Scouts will design a “no-rules” race car—where anything is allowed! They can start building the car in the lab and continue working on it at home.

### Background

There are many websites dedicated to extreme performance tricks for CO<sub>2</sub> cars and pinewood derby cars.

The objective today is for Scouts to design and start building the fastest car they can come up with. It is allowed to break all the rules except for the following:

- It must weigh at least 5 ounces.
- The eyelets must have 1/4-inch clearance to the race surface.
- The CO<sub>2</sub> cartridge hole cannot be modified, and the cartridge must completely fit inside the hole.

Scouts must use the wooden block and eyelets that are in the kit. They can replace anything else. Some websites that may be of interest are:

<https://gizmodo.com/the-science-behind-making-the-fastest-possible-pinewood-1563716398>

<https://auto.howstuffworks.com/auto-racing/motorsports/co2-powered-dragster2.htm>

[www.science-of-speed.com/How-To/Tune?art=8021](http://www.science-of-speed.com/How-To/Tune?art=8021)

[www.co2dragsters.co.nz/assets/Uploads/CO2-Dragster-Design-and-Construction-Notes-for-Students.pdf](http://www.co2dragsters.co.nz/assets/Uploads/CO2-Dragster-Design-and-Construction-Notes-for-Students.pdf)

[www.abc-pinewood-derby.com/basic-guide.php](http://www.abc-pinewood-derby.com/basic-guide.php)

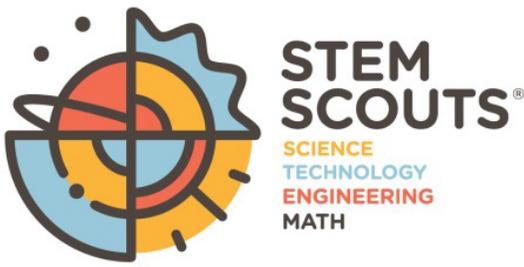
[www.wired.com/2009/02/5-easy-tips-for/](http://www.wired.com/2009/02/5-easy-tips-for/)

[www.maximum-velocity.com/fivekeys.htm](http://www.maximum-velocity.com/fivekeys.htm)

### Engaging Questions

Use the following question, and any others of your choosing, to get the Scouts engaged. (*Typical answers are in italics.*)

Describe the key performance areas for these cars that you have learned about. (*Listen for discussions around inertia, thrust, drag, friction, velocity, and precision tolerances.*)



# Leaders Guide



## Meeting 5: Design a “No-Rules” Race Car

### Safety Moment

Tell the Scouts:

You will be using sharp woodworking tools today. Always look at the area you will be working in and set it up so that you are not going to accidentally cut the table, other furniture, yourself, or anyone else.

Sawdust and wood shavings will probably get on the floor and can make the floor very slippery. Clean up regularly and take care when walking around.

When you are sanding, be careful to not get sawdust in your eyes. If you do, get help from a Lab Manager to wash your eyes out.

### Experiment

Get the Scouts into the same teams of four that they have been in for previous meetings.

Ask them to follow the instructions in their Lab Notebook, reproduced below.

### Activity 1: Design Anything Goes Racer (20 minutes)

#### Materials List

None

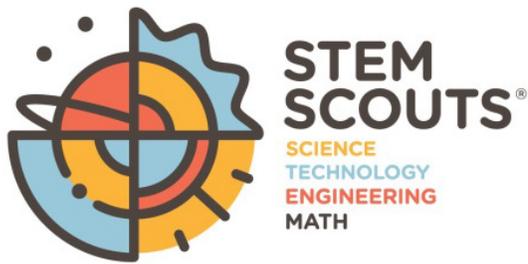
Based on everything you have learned, you and your team should design the absolutely fastest cars you can think of and that you have the ability to build between now and the next meeting.

### Activity 2: Build New Racer (40 minutes)

#### Materials List

- 2 Blastcar Car Kits
- 1 pin vise with 2 3/32-inch drill bits
- 2 wood rasps
- 2 keyhole saws
- Coarse and fine sandpaper
- 1 8-inch long, 5/8-inch diameter wooden dowel
- 1 digital scale (shared between up to four teams)
- 1 laptop with internet access
- Paper towels and water
- Broom and dustpan
- Optional: clamps and other woodworking tools as needed

Start building your cars. You can take them home to work on more between now and the next meeting.



# Leaders Guide



## Meeting 5: Design a “No-Rules” Race Car

### Discussion

Lead a discussion on what the Scouts have done and their results. Ask open-ended questions to get them thinking about what they have done and learned, and what they might do differently next time.

### Discussion Questions

What are some of the best tips or techniques you found that you are considering for your car?

### Cleanup

Clean up any wood shavings and sawdust.

If you are going to work on your cars between now and the next meeting, check out any tools and let your Program Manager know what you are taking with you.

Exit all applications on the laptop, fully power it down, and return it to your Program Manager.

Clean your area, and be sure no trace is left behind.

### STEM Innovator Moment

The Scouts should hear from or about a person who has expertise on the topic of the day’s activities about how this topic applies to everyday life and careers. The person could visit the Lab or use teleconferencing software such as Skype. You can also use the innovator information below.

*Natalie Decker fell in love with racing when she was 7 years old, after she and her father pulled over and watched a go-kart race.*

*At 19, she was the youngest woman to become a professional race car driver.*

A short video showcasing her record is at: [www.youtube.com/watch?v=js7hCtp9Ovk](http://www.youtube.com/watch?v=js7hCtp9Ovk) (2:27).

### Closing

Discuss an ethical situation that occurred during the meeting as well as how the Scout Oath and Scout Law could be applied to deal with the issue. Remember to focus on things that occurred among the Scouts rather than on controversial issues in science today.



## Meeting 6: No-Rules Race Day



### Meeting 6: No-Rules Race Day

#### Pre-Meeting Leader Preparation

You will need to identify and have access to an area that has room for a race course at least 50 feet long, up to 100 to 200 feet long. This can be either indoors (slick floor or carpeted) or outdoors (paved, gravel, packed or loose dirt). If possible, both flat and inclined spaces are ideal to allow for multiple courses to be set up. You can always build simple inclines and ramps out of everyday objects and used cardboard boxes.

The Scouts will need to get back into the same two teams of four that designed a course in Meeting 1 to build that course. There is one launch kit for every eight Scouts.

You should plan how the race is to be run and prepare a race results table to show winners of each individual race and the final winners. Each car should run on each course designed by the teams. Decide if you want to declare winners by course only, or course and overall. Plan the amount of time this will all take, which will depend on the size of your Lab.



## Meeting 6: No-Rules Race Day

The table below lists the numbers of courses, rounds per course, total CO<sub>2</sub> cartridges required, and total supplied. The supplied number is roughly 10 percent higher to allow for a few reruns in cases of ties. You can see that the numbers of rounds and races grow significantly with the size of the Lab!

If you want to get more CO<sub>2</sub> gas cartridges, contact your local Scout shop and ask for the 10-pack of Blastcar 8-gram CO<sub>2</sub> fuel canisters (SKU 613276). These normally sell for about \$4.50. You can also get additional car kits, additional spools of race line, additional launchers, and other parts.

Lab Size	No. Teams	No. Courses	No. Rounds/Course	No. Cartridges/Round	Total Cartridges Needed	Total Cartridges Supplied
8	2	1	3	2	6	8
16	4	2	7	2	28	32
24	6	3	11	2	66	72
32	8	4	15	2	120	128

### Materials and Tools Needed

- 1 laptop for Lab Manager (unit- or, optionally, council-supplied)
- 1 projector for Lab Manager (unit- or, optionally, council-supplied)

The following materials are shared between multiple teams.

- Blastcar Car Launch Kit (shared between two teams)
- 1 digital scale (shared between up to four teams)
- 1 stopwatch (shared between two teams)
- Duct tape (shared between two teams)
- 1 trundle wheel (shared between two teams)
- Towel or blanket to provide a soft stop for each launcher (unit-supplied)
- Optional: ramp-building materials (unit-supplied)
- Optional: clamps and other woodworking tools as needed (unit-supplied)

Scouts will be divided into two teams of four (the same pair of teams that got together in Meeting 1) for this set of experiments. Material quantities are defined for each team.

- 1–2 cars previously built by the Scouts (unit-supplied)
- CO<sub>2</sub> gas cartridges (see table above for quantities)
- 1 tube graphite lube
- 1 copy of Blastcar guidelines and instructions (in Blastcar kit)



## Meeting 6: No-Rules Race Day

### Opening

Have the Principal Investigator lead the group in reciting the Pledge of Allegiance and the Scout Oath and Scout Law.

### Applying the Scout Law

Choose one of the 12 points of the Scout Law to discuss in application to today's lab. A suggested theme for this meeting is *friendly*, as in *I will remain friendly to all Scouts as we race against each other*.

Ask the Scouts what being *friendly* means to them, and how they might apply that to today's lab.

### Activity Overview

Today is race day! Scouts will reassemble their race courses if necessary and run races on the different tracks. For this race, anything goes! The rulebook just got thrown out the window!

### Background

There is no additional background for today's lab.

### Engaging Questions

Let the Scouts set up their courses so they have as much time as possible to race.

### Safety Moment

Tell the Scouts:

The race courses will have fishing line stretched for the entire length for the cars to connect to. This line can be almost invisible, so be careful that you don't trip over the line when walking near a race course.

NEVER put CO<sub>2</sub> cartridges into the cars until the cars are ready to race and are already tethered to the race line. Once the car is tethered to the race line, insert the CO<sub>2</sub> cartridge and then carefully move the car onto the launcher.

Everyone must stay at least 10 feet away from the launcher and race course.

Only Lab Leaders should operate the launcher.

### Experiment

Get the Scouts into the same two teams of four that they have been in for previous meetings.

Ask them to follow the instructions in their Lab Notebook, reproduced below.

### Activity 1: Set Up Courses (15 minutes)

#### Materials List

The following materials are shared between multiple teams.

- Blastcar Car Launch Kit (shared between two teams)
- Duct tape (shared between two teams)
- 1 trundle wheel (shared between two teams)
- Towel or blanket to provide a soft stop for each launcher
- Optional: ramp-building materials
- Optional: clamps and other wood-working tools as needed

Each pair of teams should set up the course they tested in the previous meeting.



## Meeting 6: No-Rules Race Day

### Activity 2: The Great Race (45–60 minutes)

#### Materials List

Scouts will be divided into two teams of four (the same pair of teams that got together in Meeting 1) for this set of experiments. Material quantities are defined for each team.

- 1 digital scale (shared between up to four teams)
- 1 stopwatch (shared between two teams)
- 1–2 cars previously built by the Scouts
- CO<sub>2</sub> gas cartridges
- 1 tube graphite lube
- 1 copy of Blastcar Guidelines and Instructions (in Blastcar kit)

Start racing! A Lab Leader will run the launcher at each course.

#### Discussion

Lead a discussion on what the Scouts have done and their results. Ask open-ended questions to get them thinking about what they have done and learned, and what they might do differently next time.

#### Discussion Questions

How did your final designs work? What might you do differently next time?

#### Cleanup

Carefully take down the courses and check with your Lab Manager or Program Manager as to what they want to save for any future races.

Put used CO<sub>2</sub> cartridges in the trash.

Decide within your team who gets to keep each of the four cars your team built over the course of this module.

Clean your area, and be sure no trace is left behind.

#### STEM Innovator Moment

The Scouts should hear from or about a person who has expertise on the topic of the day's activities about how this topic applies to everyday life and careers. The person could visit the Lab or use teleconferencing software such as Skype. You can also use the innovator information below.

***Wendall Scott** was the first African American race car driver to compete in NASCAR in a time where people of color were banned from many careers. His drive and determination overcame the adversity of his life and he went on to set many records. See a short animation of his life, narrated by his son and grandson, at: <https://storycorps.org/animation/driven/> (2:48).*

#### Closing

Discuss an ethical situation that occurred during the meeting as well as how the Scout Oath and Scout Law could be applied to deal with the issue. Remember to focus on things that occurred among the Scouts rather than on controversial issues in science today.