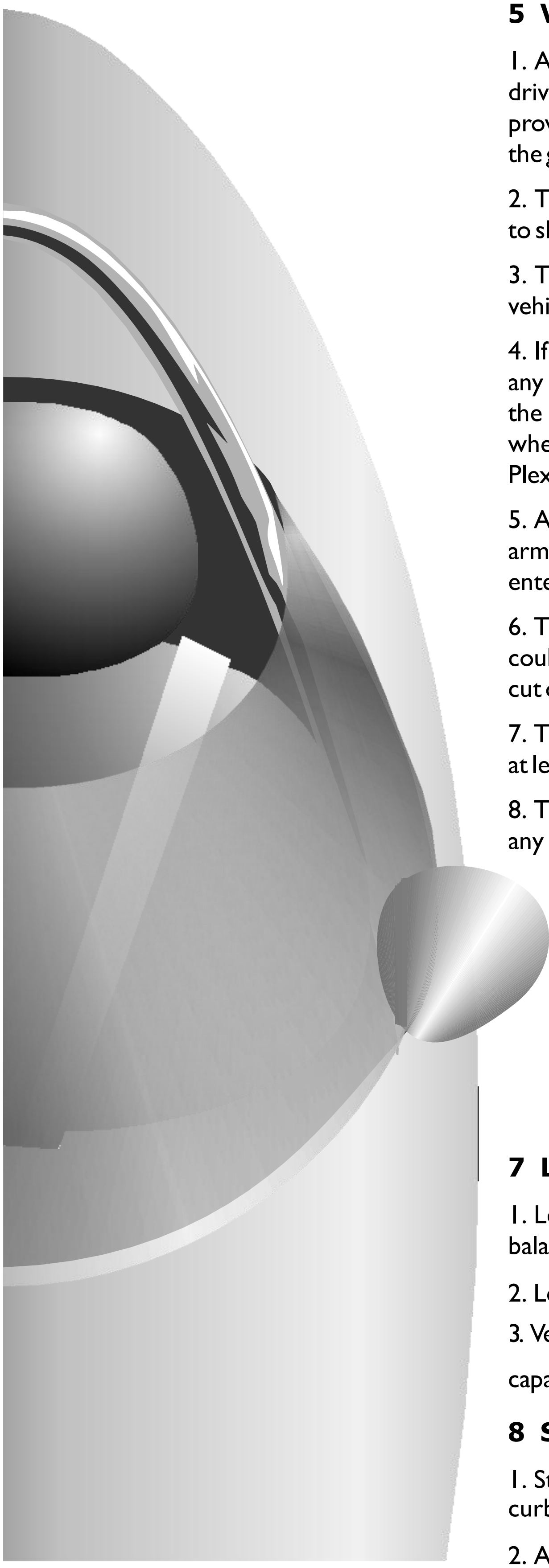


5 VEHICLE BODY

1. All vehicles must provide a body/chassis structure sufficient to protect the driver from impact from any side. A suitable structure or shell is required to provide a barrier between the driver and any contact with another vehicle or the ground.

2. This body or structure needs to protect the driver's legs, feet, and side up to shoulder level protecting the rib cage from side impact.

3. The legs and feet must be enclosed to prevent them from leaving the vehicle in an accident and provide protection against a frontal impact.

4. If the chassis contains a structural shell sufficient to protect the driver, then any body provided need not be structural. However, under no circumstances is the body to be made of cardboard, paper or any material that becomes weak when wet. Materials that are brittle, or produce sharp edges when broken (e.g. Plexiglas or brittle acrylic panels) are also not allowed.

5. A body is not required if the frame or chassis shell will prevent the driver's arms and legs from leaving the vehicle and prevent another vehicle's parts from entering the vehicle during an accident.

6. The vehicle must not have any sharp edges, corners or protrusions that could cause injury. Any questionable exposed portion of the vehicle should be cut off, rounded off or blunted with durable padding.

7. The nose area must have a minimum radius of 3 inches (6 inch diameter) in at least one direction and not be dangerously pointed in the other direction.

8. The vehicle must have a fixed floor pan of solid-rigid material that prevents any part of the driver's body from contacting the ground.

6 STABILITY

1. All vehicles must demonstrate stability at rest, while cornering, braking and at top speed.

2. Driver contact with the ground cannot be used for stability.

3. Vehicles must be positively balanced and stable at all times while moving and at rest. Stability is critical for safety and must be maintained in off- camber turns, high-banked corners and in windy conditions.

7 LEANING VEHICLES

1. Leaning vehicles are permitted provided the driver is not required to balance the vehicle and stability requirements are met.

2. Leaning vehicles must use a mechanical device for actuation.

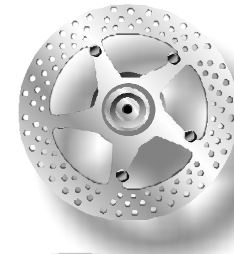
3. Vehicles which lean must have the ability to lock out the leaning capability of the vehicle for driver access and exit.

8 STEERING

1. Steering must permit a turning circle diameter of less than 50 feet curb to curb.

2. Any steering system must be well constructed and provide reliable steering action without looseness or binding.

9 BRAKES and AXLES



1. At least two wheels must have brakes.

2. Brakes must be fitted to two wheels of the same axle. Either both front wheels or both rear wheels depending on vehicle construction.

3. The two brakes must have separate actuation cables. If both brakes are to be actuated by a single hand or foot lever then both cables should be attached to the lever.

4. Regenerative braking is permitted in addition to conventional brakes.

5. The vehicle must not roll if pushed while brakes are applied. The vehicle must also be able to demonstrate a straight stop from a speed of 25 MPH in less than 40 feet.

6. Axles supported at both ends must have a diameter of at least 3/8"(10mm).

7. Axles supported only on one end must have a diameter at least ½"(12mm)

8. Safety wire or cotter pins must be used to secure cantilevered wheel axle nuts. Nylon lock nuts and double nuts alone are not acceptable.

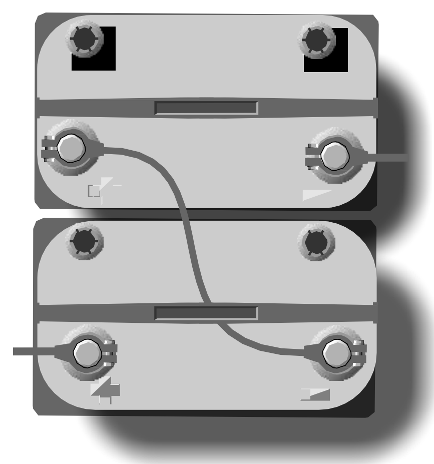
10 WHEELS and TIRES

1. Tires must be a pneumatic (inflatable) type.

2. Wheels and tires of any diameter or width may be used.

3. The minimum ground clearance is to be judged by the cars ability to roll over a 2x2 that is milled to be 1½" x 1½". This is to prevent the vehicle from sliding on the ground in the event of failure of any or all of the tires.

4. While in driving position the driver's body must not be able to come in contact with tires, wheels or spokes.



11 BATTERIES

1. Batteries must be lead acid only. Only batteries that will not leak if punctured, such as gel cell or AGM (Absorptive Glass Mat) will be allowed to participate at events in practice or in competition.

2. Battery number and voltage is not limited, but must meet specified weight limits, or must be the accepted battery types listed.

3. Batteries must display all original manufacturer's labels.

4. Batteries must be commercially retailed and available to any competitor. Custom built or specialized batteries are not allowed.

5. Batteries must be stock and unmodified in any way, and meet all conditions of the manufacturer's written warranty.

6. Total battery weight can not exceed 73 pounds. Total battery weight includes any batteries used for controls actuation, or functioning of the vehicle. Computers, radios or similar equipment are not included.

7. Batteries cannot be exchanged or recharged from an outside source during a competition. Batteries may be recharged by regenerative braking, or, in the Solar Class, through use of solar panels.

8. Batteries must be securely attached to the vehicle in such a manner to withstand an impact or roll-over.

The following list of batteries are accepted as standard, meaning two of the following batteries will be allowed regardless of actual weight:

- Optima Yellow Top **D35, D75/25**
- Optima Red Top **SC25A, SC35A, SC75/35**
- Odyssey Genesis **G42 (VP, VPX, EP, EPX)**
- MK **40**
- Exide Orbital Model **75/35**
- Champion Vortex **75/35**

STEERING SYSTEMS

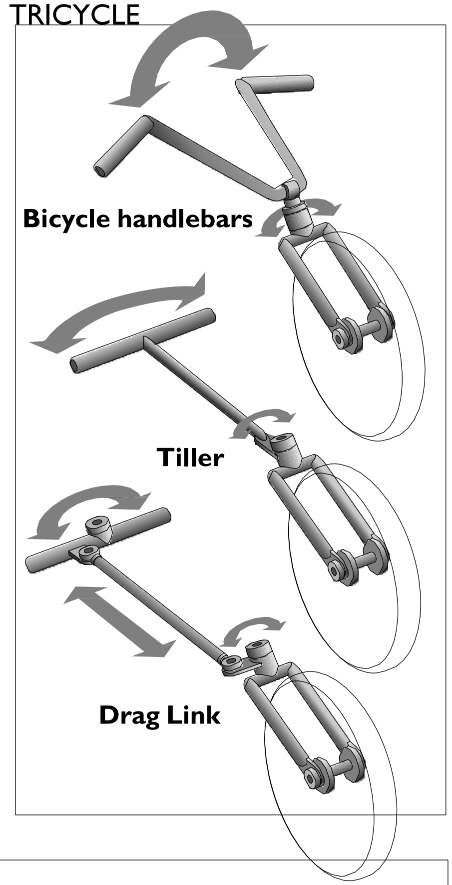
There are a lot of steering systems out there, going into the choices and their variations would be a book in itself. Some vehicles use a steering wheel, some have a joy-stick like a plane, some use a tiller like a boat, and many use some sort of bicycle handlebar. Take a look at other Electrathon vehicles, go-karts, ATV's, and full sized cars. Talk to automotive technicians. Spend time on this aspect, and devise a good reliable system.

If you decide to build a cycle car your design will get a little more complex because you are steering two wheels. Tricycles, with a single steered wheel, can be simpler, unless you opt for front wheel drive, which can make the system even more complicated. Either way you need to design a proper geometry to be stable, maneuverable, and minimize tire wear.

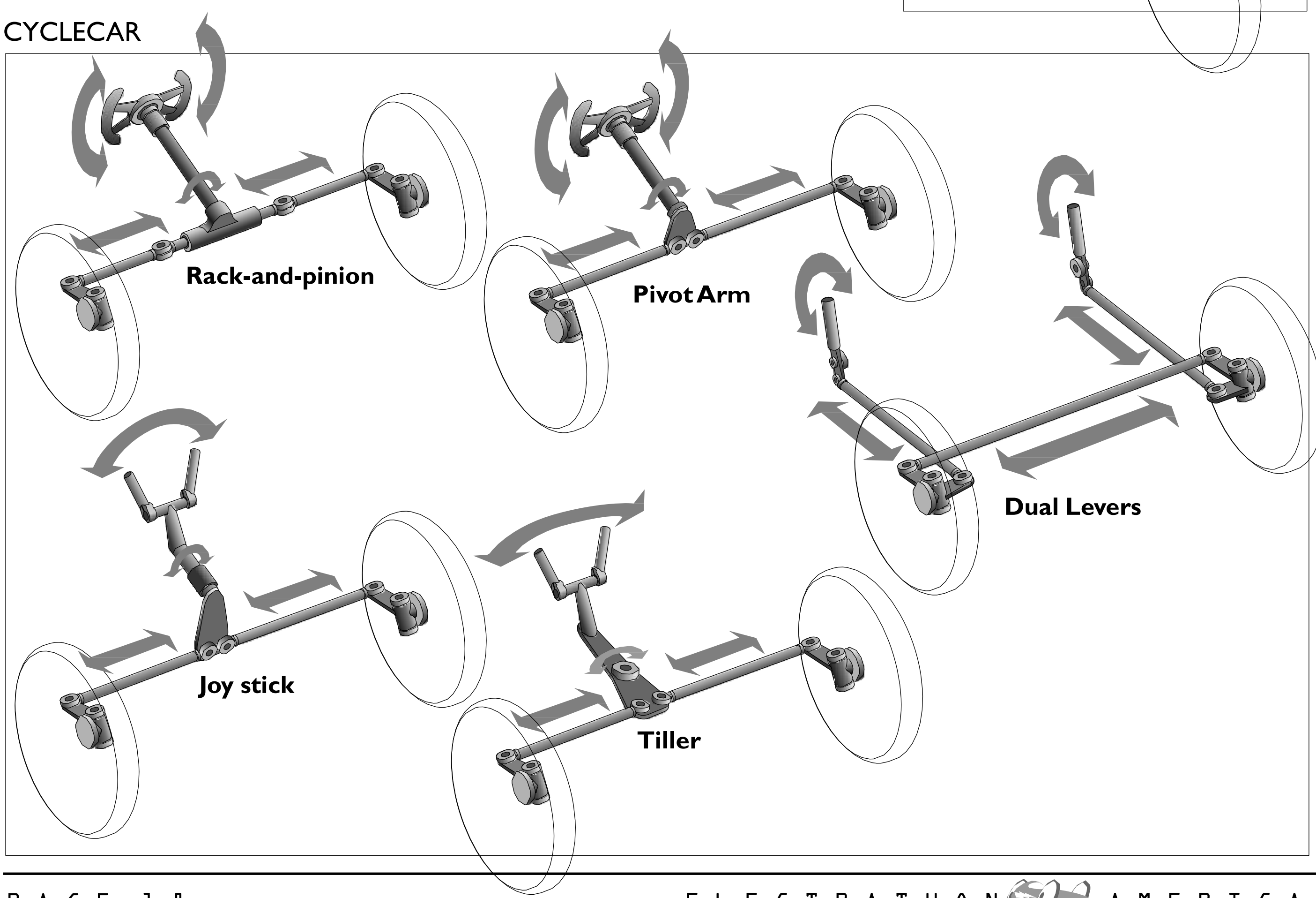
There is no 'best', system, only what works best for the comfort and control of the driver. Determining the length and position of all the elements is probably best determined by trial and error, so build in as many extra mounting holes as you can. Good steering geometry is very important for control at any speed. On tight, short courses you generally want a quick and light response, but on longer, fast courses you want a heavier, more stable feel.

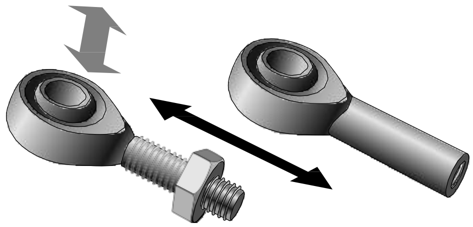
Don't even think about rear wheel steering. It works for fork lifts, but there are good good reasons you don't see it on anything faster than that. It's been tried, and usually ends in disaster.

TRICYCLE



CYCLECAR

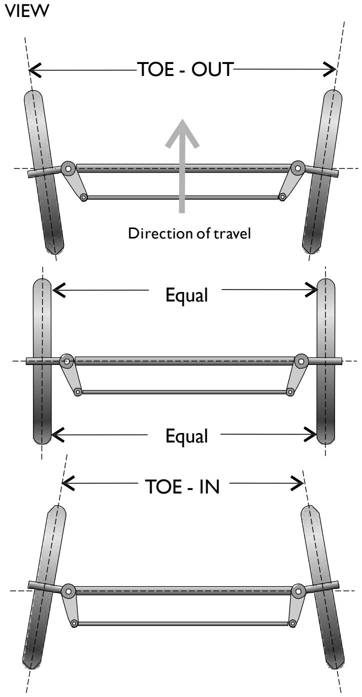




STEERING GEOMETRY

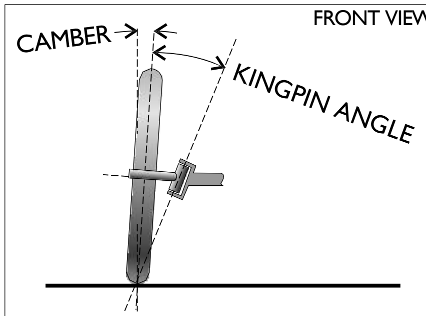
SPHERICAL ROD END BEARINGS
Also called Heim Joints, these are a very common and convenient way to link together all sorts of steering and suspension parts because they swivel and the threads allow you to adjust the length of your part. They come in various sizes, male and female, left or right hand threads. Using a left and right hand thread at either end of a rod means you can turn it to adjust the length without removing it.

They are meant to be used as links, so they are very strong in the horizontal, push/pull direction. They are not really built to take a lot of force in the vertical direction, but are often used as 'ball joints' anchoring a kingpin, which means they are supporting the weight of a bouncing car. If you use them this way, buy the biggest size and hardest grade you can afford, and check them often...they will get mashed with heavy use!

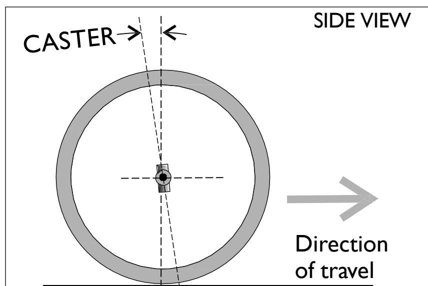


Although some race cars may handle better with a little toe-in or out, keeping it as neutral as possible will minimize rolling resistance.

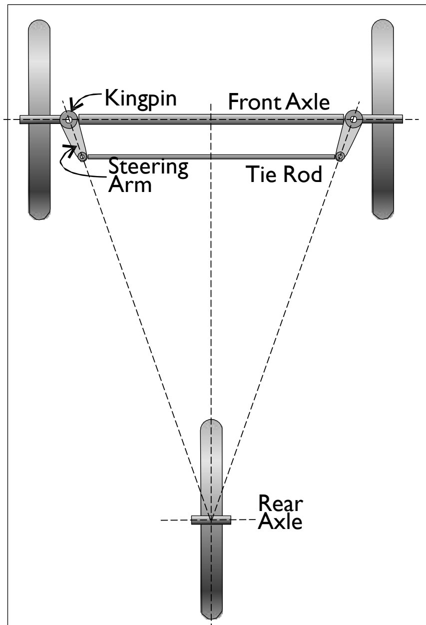
When measuring the toe-in., always measure the front and back of the tire at the same distance above the ground because the wheels may be cambered.



The centerline of the kingpin should intersect the point where the tire contacts the road to minimize tire scrub and insure proper steering action.

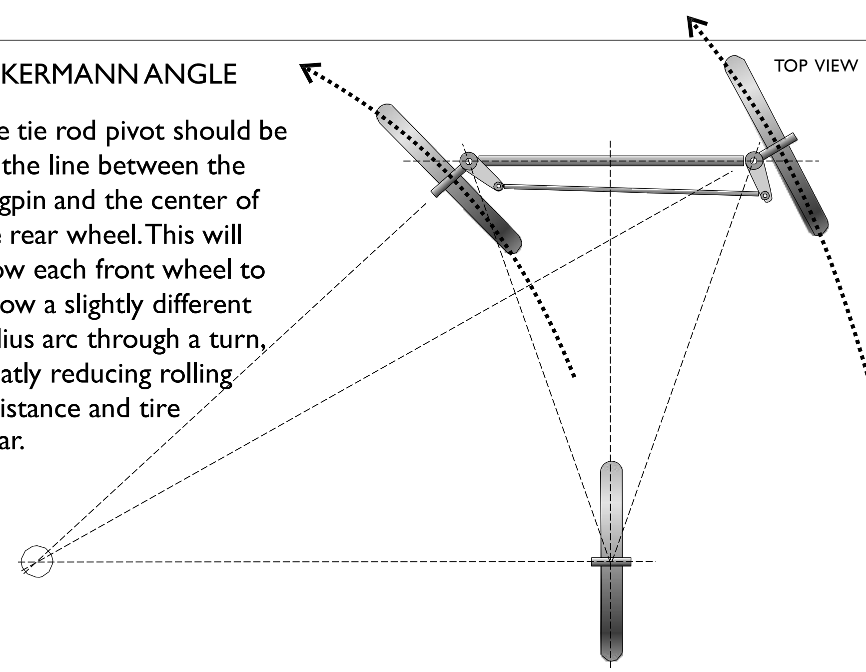


Increasing the caster, or rake angle, will increase straight line stability. Reducing it will improve maneuverability.



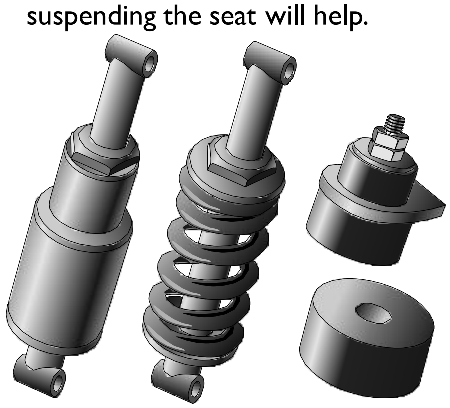
ACKERMANN ANGLE

The tie rod pivot should be on the line between the kingpin and the center of the rear wheel. This will allow each front wheel to follow a slightly different radius arc through a turn, greatly reducing rolling resistance and tire wear.

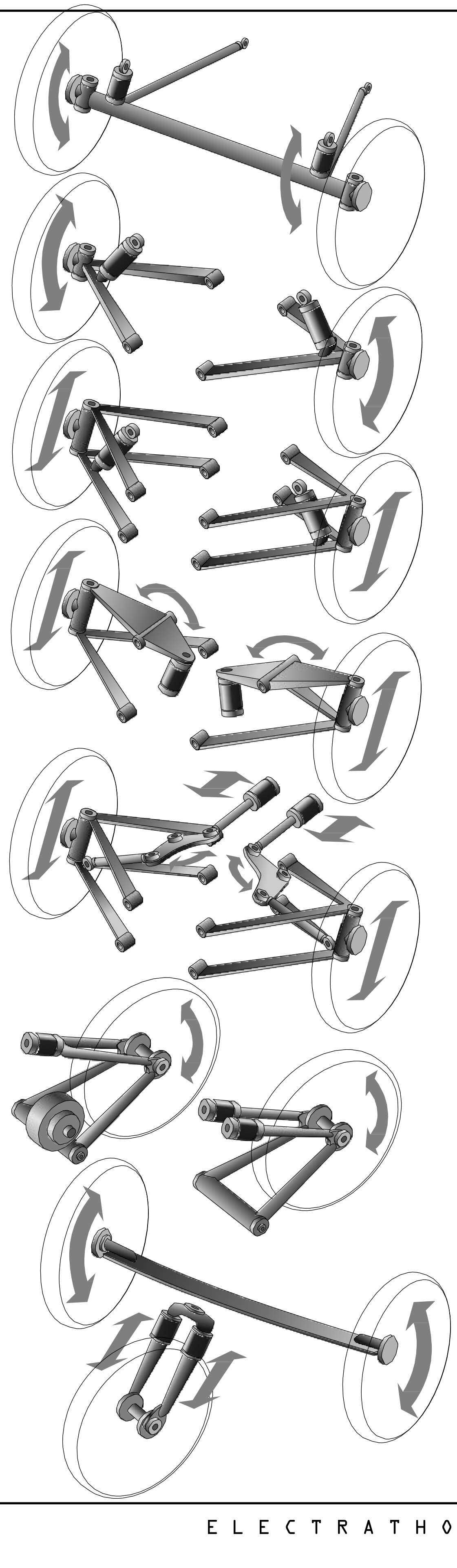


SUSPENSION

If you enjoy devising the linkages of a steering system, you will love getting into suspension. You don't need suspension in Electrathon, but it makes the ride better. Suspension is an advanced project. One of the unique characteristics of three wheeled vehicles is that the wheels will always be on the ground, no matter how uneven the ground may be. A three wheeled vehicle undergoes no twisting or torque in its chassis due to uneven terrain. A four-wheeled vehicle, on the other hand, needs a suspension in order to keep all its wheels on the ground and reduce stress on the chassis. Remember though, simplicity = reliability! You don't need much suspension travel, on a smooth track, the thickness of your tires may be all you need. Even a simple system can reduce vibration and jarring. Just suspending the seat will help.



Springs carry the weight, shocks, or dampers, control the natural tendency of a spring-and-mass system to bounce. Often they are built together. Mountain bikes and ATV's are a good source because they are about the same weight as an Electrathon. You could just drill a bolt hole through a chunk of solid rubber...it doesn't even have to be round! Adding another chunk on the other side of your mount will increase its effectiveness by allowing for rebound.



Solid Axle
Probably the simplest, but another link may need to be added if side loads are severe.

Swing Arm
Pretty simple, and works well with a rubber block. Having a lot of travel will create a lot of camber, so keep it short.

Upper and Lower A-Arm
The conventional set-up in real race cars, it keeps the tire perpendicular to the ground... very important for wide tires, but not an issue for thin, round profile tires. It involves a pretty complex geometry and a lot of time to build it right.

Rocker Arm
This set-up enables the spring and shock to be placed inside the car and out of the airflow, and works well with compact rubber blocks.

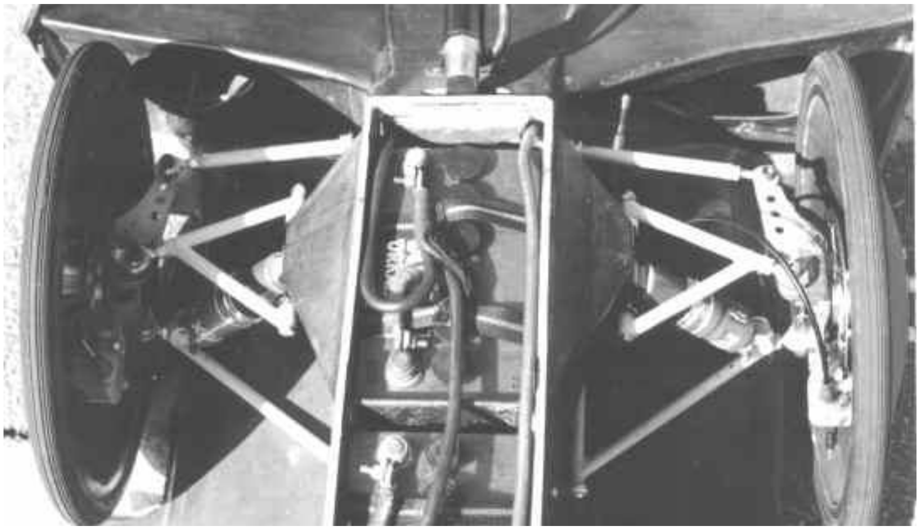
Rocker Arm/Pushrod
This is the modern Formula 1 arrangement, and allows room for a full coil/shock.

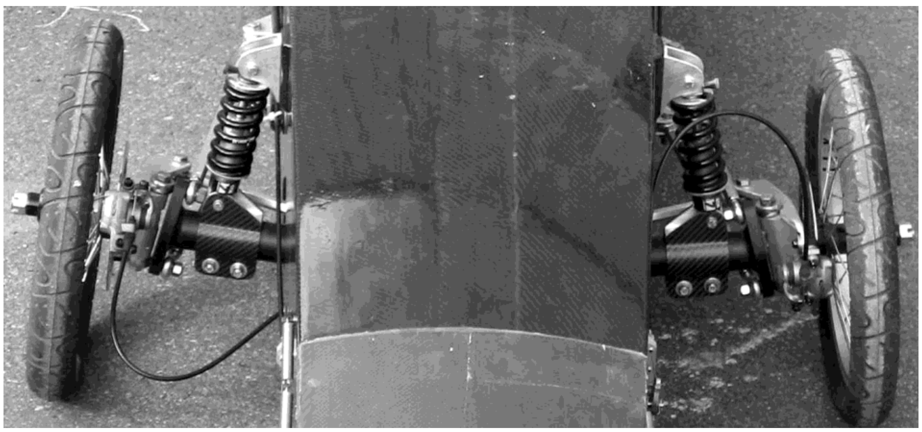
Rear Suspension
With many variations, this is the most common set-up for cyclecars. Using two dampers looks cool, but it allows the wheel to flex more under heavy side loads. Positioning the motor just forward of the hinge point will balance it with the weight of the wheel.

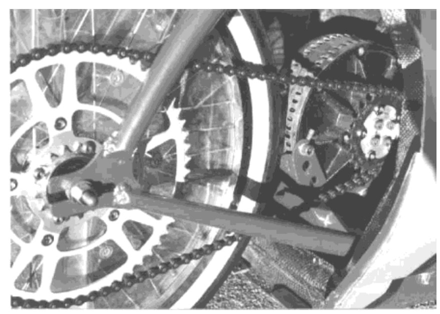
Tricycles
The front is the same as a bike or motorcycle, so either of those systems could be adapted. A solid axle with links would work on the back, or you could try a downhill ski.

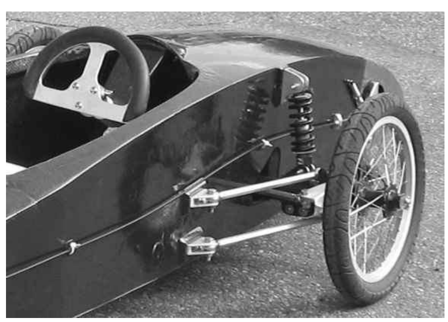
DRIVE TRAIN

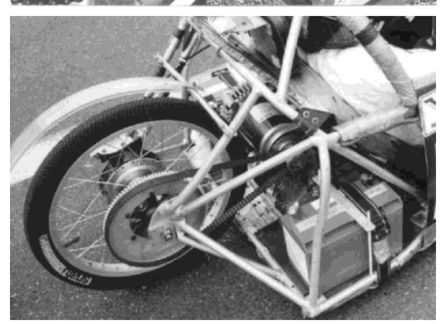
Most vehicles use a direct drive chain (usually bicycle) or belt drive adapted to fit a bicycle threaded rear wheel hub. Unless you are using regenerative breaking, you will want the drive to freewheel when you let off the power. Alignment and tension are critical. Too loose and it will pop off if the drive wheel flexes in turns and bumps; too tight and the friction will cost up to 5% power loss. Gear ratios are critical in tuning your performance and range, well worth the time spent experimenting. Each motor, battery voltage, wheel diameter and course type affects the gearing. A selection of sprockets or pulleys is a necessity. Some vehicles use multiple gear systems, although the added friction may cancel out that advantage.

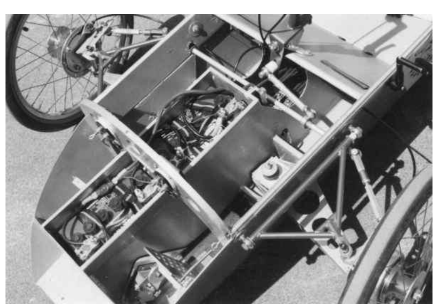












WHEELS

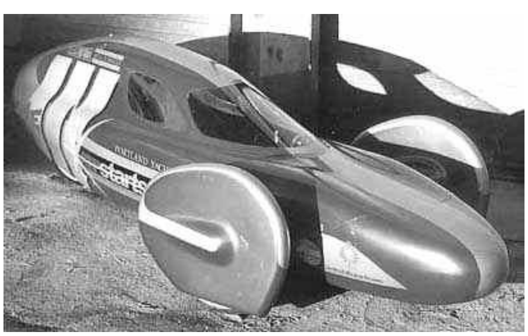
Most competitors use spoked bicycle, BMX or Moped wheels. Keep in mind that these two wheeled vehicles lean into corners so the force is always straight down the wheel. If those wheels are side loaded, they need to be much stronger.

There is no minimum or maximum allowable tire diameter. If tires are too small they do not work well on the road surfaces for Electrathon races. Tires of 10", 12", 16", 17", 20" 24", 26" and 27" have all been used with various levels of success. The larger diameter wheels have less rolling resistance, while the smaller diameter wheels have less wind resistance, and are typically stronger under cornering loads.

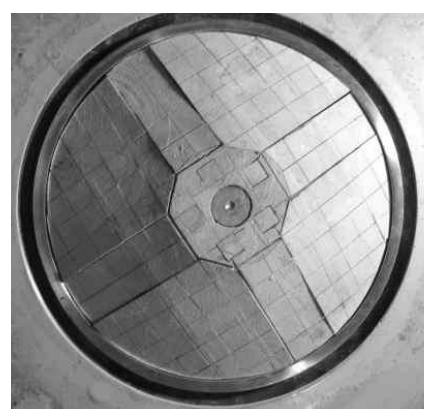
Spoked wheels should use heavy-duty spokes and lots of them. A good bicycle wheel mechanic can set you up with a very strong and light wheel. Remember to check them often for trueness and loose spokes. Wheel collapse is not uncommon, and a wobbly wheel won't go very fast. BMX type plastic wheels are maintenance free and quite strong (except at low temperatures), but heavier than spoked bicycle wheels and limited to lower tire pressure. Moped wheels are rugged and will take high tire pressure but weigh the most. While tire width and tread pattern are important, tire pressure is the biggest factor in rolling resistance. Obviously, the higher the better, but there are safety limits to consider. Choose the tires according to the track as well. Skinny tires work fine on smooth speedways but may not last the hour on a rough parking lot.

Wheel covers will reduce aerodynamic drag a great deal, as spokes tend to churn the air like egg beaters. There are commercially available models, but they are not difficult to make in fabric or plastic. It is even possible to heat shrink mylar directly to the rim.

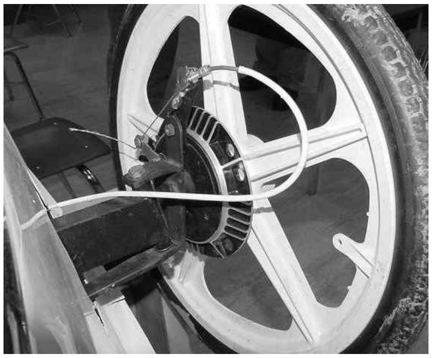
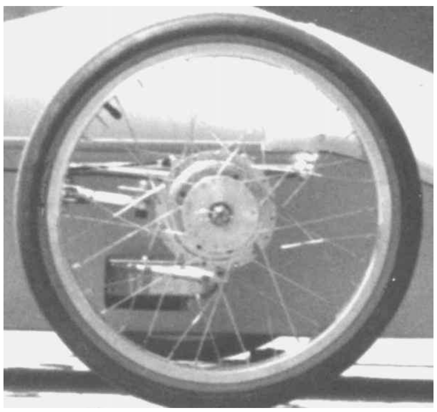
If you are really industrious and have some experience with composites, you can mold your own dish wheels on aluminum bicycle rims. End grain balsa and structural foam have been used as core material. Carbon fiber alone is too brittle and should be reinforced with kevlar. It is also a good idea to cut out a simple flower or spoke pattern so some of the fabric layers can pass from one side to the other, forming an internal web. Remember to use some sort of uncompressable filler material where the bolts go through.

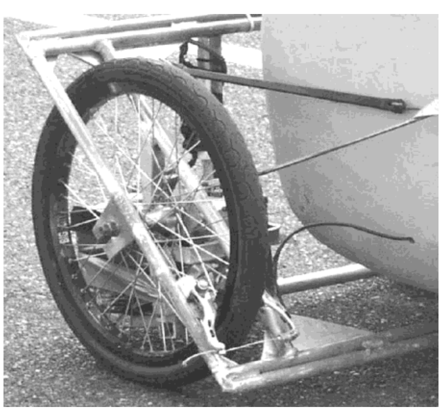


WHEEL PODS
They are called spats on airplanes and help to reduce the drag of an exposed wheel. Ever see the rooster tails flung from a wheel in the rain? The same thing is happening all the time in the air, we just can't see it. This turbulence greatly disrupts the airflow. Remember, the top of the wheel is actually moving through the air twice as fast as the axle.



BRAKES



If you can't stop, you can't go. Nowhere are brakes more important than in competition, although most competitors use their brakes as little as possible. From a safety and liability standpoint brakes are vital. In competition, your ability to brake well will help you make that critical pass to win, or avoid a certain collision. In designing your chassis you must resolve how you are going to mount the brakes to your vehicle and what kind of brake assembly will work. Luckily you have a variety of options:

BICYCLE CALIPER RIM BRAKES
The typical bike brake can be mounted out on arms from your axle to grip the wheel rim. Offset arm style calipers can often be modified to reverse the cable so it pulls back along the wheel to the axle and then into the vehicle. Although this is the least expensive way to go, it is also the least effective, requiring ongoing adjustment and pad replacement to keep them working properly.

BICYCLE DRUM BRAKES
These are harder to find, but most bike shops can get them for you. They are used on tandem bikes since the pads don't wear out as fast. They must be custom mounted to your bike rims. Their large hubs and internal (automotive type) brake shoes make them a popular solution for Electrathon use. They do require adjustment though, and you must keep your spokes tight. Another variation is to use moped hub drum brakes. If you can, try a used set from an old moped. They are made from an aluminum alloy and can be adapted to fit bicycle wheels, or the entire moped wheel can be used.

DISC BRAKES
There are many disc brakes available now for mountain bikes and tandems, both cable and hydraulically operated. They are very light and strong but can be expensive. Go-kart discs are another option, however they are quite large, heavy and difficult to adapt. Small motorcycle disc brakes are also a possibility although large and heavy.
Whatever you use, make sure you can actuate them both evenly. If one side or the other locks up you will spin out or swerve.

AXLES

One important note: DO NOT USE BICYCLE OR MOPED AXLES UNLESS SUPPORTED AT BOTH ENDS. If your axles are cantilevered (attached on one side only like a wheelchair) you MUST replace the stock axle with a 1/2" or12mm diameter bolt. Axle diameters less than 12mm are illegal. A bicycle or moped axle WILL break. It is easy to pull out the stock axle and replace it with a larger one. You must replace the wheel bearings with cartridge bearing assemblies. These can be found at bearing supply stores. Use an axle bolt and nut that accepts a cotter pin so your wheel doesn't come off. This is a rule requirement.