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Junior Solar Sprint

Inside Tips on Parts and Construction

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Parts is Parts:

So you are ready to build the ultimate JSS car. You have the perfect design, and the ultimate gear ratio and tire size combination. But you just visited every hobby store in the Upper Valley and could not find a single gear or pulley that would fit your motor. Now what do you do? It is time to cannibalize!

The best place to find gears and pulleys of all different sizes is in old tape recorders and VCRs. The very kind that you may find in Thrift stores all over the Upper Valley. While you're pawing through the tape recorded stock at the local thrift store also consider electric mixers, and remote control cars as other possible donors to your JSS cause.

As you start taking apart these relics save any belts, shafts, or screws that you come across. They may prove to be useful! The large pulley in a VCR makes a good, light weight, wheel. You will find in the tape recorders flywheels also. The flywheel shaft may run in a bronze (gold colored) bearing, that could be used as a low friction axle and bearing for the next JSS champion. Getting these parts off without damaging them is a little tricky. Use a vise to support the outer part and tap lightly with a hammer and punch on the inner part to drive the shaft or bearing out.

Also keep your eyes peeled for old "Spirograph" kits. These have a range of gears that could be used. A word of caution in using Spirograph gears. The holes in those gears don't go through the center. Consequently, you will need to locate the center of the gear, and drill a hole there for mounting these gears to your motor or axle.

Getting wheels that are the right size is not easy either. I have found that you can make wheels out of wood or Plexiglas with hole saws. If there is a carpenter, or wood worker in your midst you may be able to coerce them into making some wheels of various sizes for your students. Usually hole saw kits can make wheels in sizes ranging from ½" in diameter to over 3". A wheel made from a hole saw may look like the one on the left below. You can make the wheel lighter by drilling it out to look like the one on the right.

You may be able to find wheels on old toys that can work too. Many times those wheels are mounted on solid steel axles that are more useful than the wheels are. Be careful not to bend the axle while you are removing the wheels.

Does your wheel need a little more traction? Put a rubber band, or an o-ring around the circumference to keep it from spinning on hard surfaces. You might want to glue it on so that it doesn't spin off the wheel during the race.

Those that are planning on using pulleys for their drive train may want to manufacture their own. This can be done using the hole saws mentioned above (cut a groove in the circumference of the wheel for the belt to ride in) or using various diameter dowels from the hardware store. With the dowels you must carefully drill a hole at the center of the dowel for the motor shaft or axle. You can make a very smooth running bearing/axle combination from brass tubing and shafts that are available in many hobby shops all over the Upper Valley. To further reduce the friction use some graphite lubricant in your bearing assembly.

For the students that want to have *the* part for their JSS car be prepared to pay the ultimate price. There are precision gears, bearings and pulleys out there, but they are not cheap ($5 + ea.), and you will need to order them. Plan on a month delivery time. Just locating a manufacturer may take at least that long.

The Chassis:

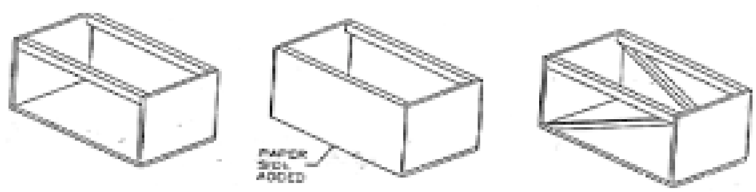
Now you need something on which to mount your solar panel, motor, gears, wheels and egg beater to. This main support structure is called the chassis. A few pointers on your chassis design. First, plastic soda bottles make good car bodies, but make a lousy chassis. It is too darn difficult to attach things to it. Better materials for the chassis are:

- Foam Core (available at most graphic arts places)
- Blue board installation (see lumber yards and hardware stores)
- Wood (Balsa and pine are good choices)
- Corrugated cardboard

This list isn't all inclusive, but gets you started. A note about Balsa, it is light, but splinters easily when it is drilled. Pine is a little heavier, but is stiffer, and is more "machinable". You may find that you will want to use a combination of the above materials in your car. Although "Legos" seem to offer an advantage in being versatile, you will pay a big penalty in weight. Nevertheless, you may find gears and axles from Lego sets that are useful.

A word about stiffness. The two beams below are the same size, but the orientation on the right is 19 times stiffer that the one on the left. Take home message: to make your chassis stiff and light, choose thin materials, and orient the long dimension vertically.

You can make a chassis stiffer just by skinning it with paper. The chassis on the left below would be very floppy. Adding paper to the outside of the frame (center figure) stiffens the chassis significantly. Another way to stiffen the chassis is to cross brace it as shown on the right.



What about putting it all together. Hot glue is great in the speed of assembly department, but you may find that wood glue is stronger and lighter. Screwing the chassis together works well too, but you'll pay a weight penalty there as well. If you do use screws put a little glue on the threads before screwing them in and they will hold better.

A Word about the Panel:

A trouble free way to attach your solar panel is using "velcro". It will make it easy to remove and re-attach your panel to your chassis. Alligator clips on your power leads from your panel to your motor allow you to quickly detach the entire panel from your car, and are a convenient on/off switch.

JSS Drive Train Design Tips

Robert Haehnel

So you want to build a JSS car, but have no idea what you should choose for the wheel size or gear ratio. Here are a few tips on how to get started. First off we need to start with what we know.

Known:

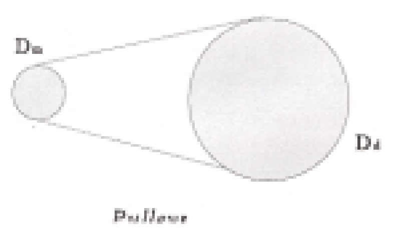
Motor Speed, ω	*8300 revolutions per minute (rpm) under load (0.278 in.-oz. torque at the speed)*
Vehicle Speed, V:	*The finishing times for the 1994-95 Upper Valley Race were around 6.5 seconds*

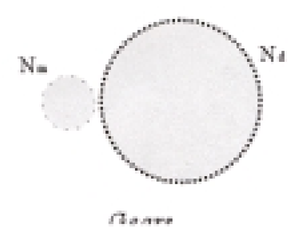
Track Distance = 20 m (65.6 ft)

$$V = \frac{20m}{6.5s} \approx 3m/s = 300cm/s$$

Gear Ratio Known:

If we have a set of pulleys or a couple of mating gears then we already have the gear ratio. Now we just need to find out what size drive wheel(s) we need to be competitive. The below figure shows how a pulley or gear system might look.





The variable **D** is the diameter of the pulley, variable **N** is the number of teeth on the gear, subscript **d** refers to the gear attached to the drive axle, and subscript **m** is the gear attached to the motor.

$$D_m = 1/4cm \qquad D_d = 1-1/4cm$$
$$N_m = 8 \qquad N_d = 40$$

Step 1: Determine the gear ratio.
For a pulley system the gear ratio is:

$$R = \frac{D_d}{D_m} = \frac{1.25cm}{0.25cm} = 5$$

And for a gear system

$$R = \frac{N_d}{N_m} = \frac{40}{8} = 5$$

Step 2: Find out the speed of the wheel.
If the motor spins at 8300 rpm then the wheel will spin at:

$$\omega_d = \omega_m = \frac{8300rpm}{5} = 1660rpm$$

But we need the wheel speed in revolutions per second (rps)

$$\omega_d = 1660rev/\min = 27.6r/s$$

Step 3: Calculate the wheel circumference.

To determine the wheel diameter we first need to know the circumference of the wheel (the distance the JSS car will travel each time the wheel turns one full revolution). This is simply:

$$C = \frac{V}{\omega_d} = \frac{300cm/s}{27.6r/s} = 11cm$$

Step 4: Determine the wheel diameter.
Now we can find out what diameter wheel, D_w, we need. The wheel diameter is determined from the calculated circumference:

$$D_w = \frac{C}{\Pi} = \frac{11cm}{3.14} = 3.5cm(1.4inches)$$

Step 5: Check calculation.
Now check to make sure the diameter of your wheel is bigger than the diameter of the drive gear. If it is, you're up and running. If it is not, you need to choose smaller pulleys or gears.

Wheel Size Known:
In this example we already have a tire size we want to use. We just need to find a suitable gear ration. Our wheel diameter, D_w, is 8cm (3.1inches).

Step 1: Calculate circumference.

$$C = \Pi D = 3.14(8cm) \approx 25cm$$

Step 2: Find the wheel speed.

$$\omega_d = \frac{V}{C} = \frac{300cm/s}{25cm} = 12rps$$

Now we'll convert that into rpm

$$\omega_d = 60\,\text{sec}/\text{min}(12 rev/\text{sec}) = 720 rpm$$

Step 3: Determine the gear ratio.

$$R = \frac{\omega_m}{\omega_d} = \frac{8300 rpm}{720 rpm} = 11.5$$

Step 4: Design transmission.

Since the drive pulley/gear Robe be no larger than the drive wheel, we need to select a pulley/gear accordingly. For a pulley system we will make the drive pulley 10 cm in diameter. The diameter of the motor pulley then is:

$$D_m = \frac{D_d}{R} = \frac{10cm}{11.5} = 0.9cm$$

Notes: In these calculations friction and wind drag were not considered. In rt HaJSS car friction and drag will affect performance. To compensate we need to make the wheel diameter smaller, or the gear ratio bigger if we are going to get the best performance. This fine tuning of the cars performance will need to come from experience gained by testing the car, but these calculations will give you an idea of where to start.

Notice that we came up with two different combinations of gearing and wheel size. There is a host of different combinations that will work well. What you come up with for your car depends on what you have available to you for constructing your car.