

Guidelines For Good Hand Pedaled Tricycle Drivetrain Design & Ergonomics

(This is a longer and more detailed explanation of the 6 basic rules for designing and building your own hand pedaled trike.)

What size of crank arm should we select (and what is actually available?). What size of wheel gear would we at HWI recommend? How about the upper gear by the pedals, what size should it be? Finally, what about wheel diameter, and how does that affect me? To most of us, all this can be very confusing. Maybe we just want to know what usually works best.

Let us begin by stating that the drivetrain that we now use on our DOTT trikes has evolved over many years of experimentation. We would strongly recommend it as a good, reasonably safe starting point for most users. We will describe it below, piece by piece, and discuss some of the options that might be considered if certain parts that we used are not available to you.

Selecting The Crank Arms (Rule #1)

Crank arms can be the most trouble to try and find in the right size. Most crank arms that come from bicycles are actually a bit too long for safe use as hand pedal crank arms. They will often be around 160 mm long (about 6.5") as measured from the center of the hub to the center of the pedal mounting hole.

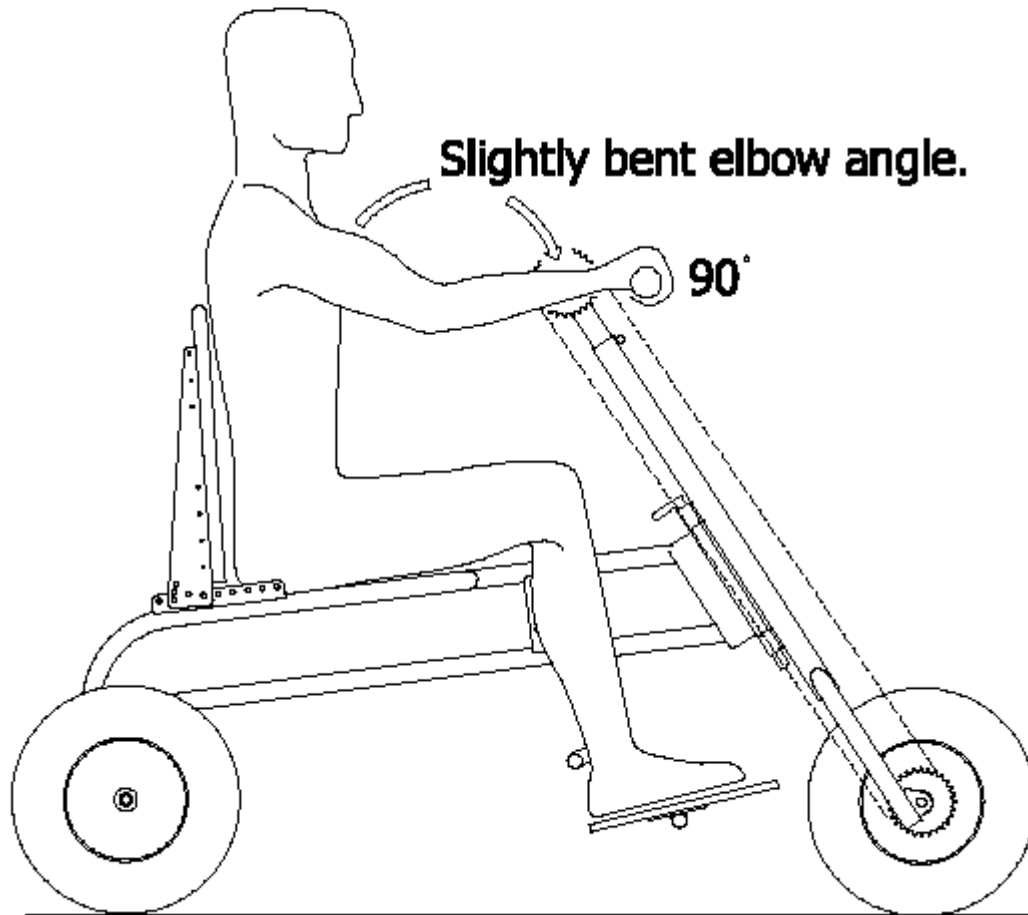
So, why are these crank arms too long for us to use with hand pedals? Think about it. Bicycle crank arms are as long as they are because they are designed for our longest limb...our legs. Our legs develop the most power when they can travel up and down a fairly long distance during the pedal stroke (such as on a bicycle).

Now let's consider our arms. If we were to imagine our arms traveling in as big a circle as our feet do when we pedal a bicycle...we would really have to stretch our arms out pretty far in front of us at a certain point. In fact, in trikes that have been made with bicycle cranks (most of them out there!) the user can often be seen with one arm stretched until it is straight out in front of them.

So, you might ask, what is wrong with that? Basically, two things: First, the muscles in the arm cannot develop as much power (to contract the arm) in this fully extended position. This actually has to do with physics principles and leverage...but we will skip that part. Take our word for it. However, the second thing to know is that such "over extension" places considerably more stress on the joint also. Such stresses often lead, over time, to various injuries that can then prevent the user from being able to use the trike. Needless to say, **we must design our trike to avoid these types of crippling**

injuries at all costs. Just because the user can hop on the trike right now, and does not “feel” the stress immediately does not mean that damage will not occur over time. Please keep this fact in mind!

Basically, in a well-adjusted seating arrangement with cranks of the correct length, the users arms should still be just slightly bent when the pedal is all the way forward (see picture below).



Often, the next question we will ask is this. Why can't we just move the seat forward, a bit closer to the pedals, so that the arms are not “over-extended” during the normal pedal stroke? Well, sometimes we can if that person has unusually long arms. But for most of us, if we were to move the seat position close enough to the pedals to prevent this “stretching” of the arms, then we will be so close that the pedals (with the longer crank arms) will hit us in the chest as they go around...because those crank arms are still too long. The only way to solve this problem is to use shorter crank arms that will allow us to both sit closer, but not be hit in the chest by the pedals.

So, how do we avoid these problems when we design or build our own trike?

The only real answer to this problem is to find a source for shorter crank arms. As we noted before, typical crank arms, as used on bicycles, are around 170 mm in length. Ideally, we would like a crank arm that is no longer than about 140 mm if we could find one. On our own DOTT trikes we use a crank arm that measures about 140 mm (5.5”).

Shorter crank arms could probably be made by cutting a “too long” crank arm shorter, maybe by removing a section from the middle and re-welding.

Gear Sizes For The Pedal Assembly And The Front Wheel (Rule #2)

Finding appropriate gears for the front wheel and the pedal/crank assembly can be another difficulty. One problem that should be avoided is having a larger gear (with more teeth) on crank than the gear on the front wheel has. This usually means that the trike will be difficult to pedal, unless the ground is very smooth, level and hard. It also means that considerable stress will be put on the arm joints and muscles. Ideally, whatever gears we use, the best solution would be to have a larger gear (more teeth) on the front wheel than the one the crank assembly has. The exact number of teeth is not important here, as long as the gear on the wheel has at least as many teeth as the gear on the crank, or more...even up to twice as many.

For example, let’s say you have a crank gear up by the pedals that has 28 teeth on it. You should then try to find a gear for the front wheel that has *at least* 28 teeth on it, or more. If the area where the trike will be used is hilly, it may be even better to have a front wheel gear that has up to 40 or 50 teeth on it, as it will make pedaling much easier. It will also be easier on the user’s arms and joints.

Usually, we do not have much choice about the size of gear attached to the crank. Maybe, in some cases, we can cut it off and carefully weld a new, smaller gear to our crank. This will help, and make it easier to find a gear of the right size for the front wheel.

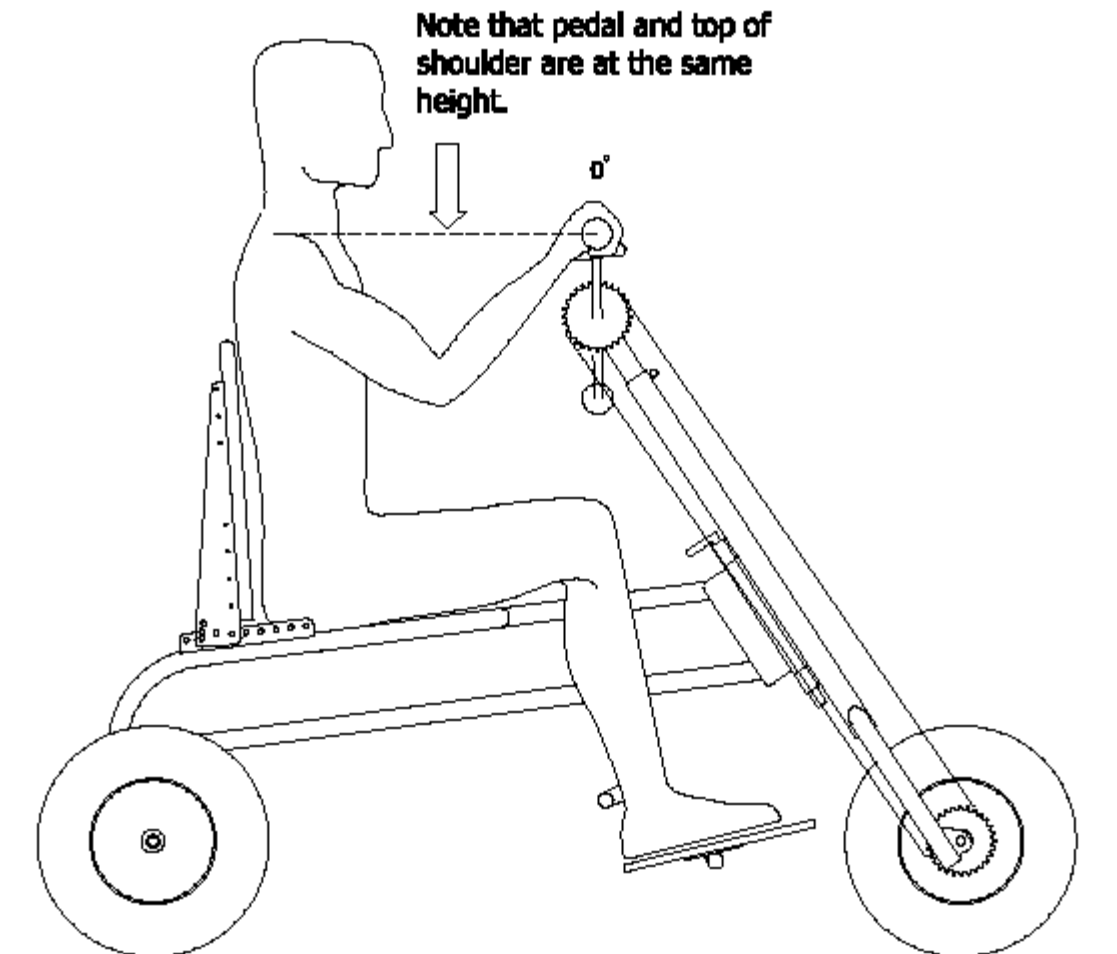
If all this “gear talk” proves a little confusing, and you would like a little more explanation, just contact us and we will help you work thru the issues.

Front Wheel Size (Rule #3)

Front wheel size can have an affect on how easy the trike is to pedal, similar to gear ratio. Without going into too detailed an explanation, a smaller front wheel makes the trike easier to pedal because it has an effect similar to improving the gear ratio, whereas a larger front wheel makes it more difficult.. However, because too small a front wheel will not ride as smoothly on rough terrain and over ruts in the road, there is a practical limit to how small we want to go. As we noted in the “rules”, a size between 300mm (12”) and 500mm (20”) in diameter is usually best in most situations involving rough roads.

Pedal Height (Rule #4)

The height of the hand pedals, relative to the user's shoulders, is very important. For this reason, any trike design should have a way to adjust the pedal height up and down. Why? In short, the higher a person must reach in order to operate the pedals, the less power they have and the more they will have to strain their joints and muscles. A good rule of thumb is to set the pedal height low enough that the pedals are never much higher than the person's shoulder. See the picture below.



Note that this will usually mean that the pedals will come close to the thighs at the bottom of the rotation (but should still have adequate clearance when used).

As we noted above, if necessary, adding height to the seat surface (with extra padding, etc) can have the same effect as adjusting the pedal height lower.

Adjusting The Trike To The Other Anatomical Needs Of The User (Rule #5)

For the best coverage of the many details of this subject, we would strongly recommend reviewing the *DOTT/Sanctus Project Fitting Manual* (found on the HWI website) and following the process shown in that manual when fitting the user to the trike. Likewise,

the assistance and supervision of a qualified medical person familiar with such issues will prove helpful. For those of us who are designing or setting up a trike design for production, we must be especially careful to design it in such way that these adjustments are as easy to make as possible.

We believe that an adjustable seat back position (for changing the user's distance from the pedals), adjustable pedal height and reasonable provision to support the user's legs (and a good crank length as covered in Rule #1 above) are the most important of these needs for most trike users.

Pressure Sore Prevention (Rule #6)

This is perhaps the most important issue of all. Pressure sores, or skin damage caused by sitting in a trike seat for too long that has not been properly padded, can result in infection and eventually death.

What makes this such an important subject to educate trike designers, builders and users on is the fact that most of us never really experience this problem. Whenever we begin to damage our skin somewhere on our bodies, we will usually feel it and stop. If the damage is noticeable, we are aware of it and can usually take care of the wound somehow. Thus, infections are usually easily prevented. However, for someone who has lost some of the feeling in the seat or leg area, this can be a much more serious problem. If the seat area of the trike has not been properly padded (or, if sharp surfaces can cut or scrape exposed skin) then such sore can develop undetected. If they get infected, they may go undetected until a serious or even fatal situation has developed.

Obviously, the best way to prevent this situation is with proper padding of the seat area, elimination or covering of any other edges or protrusions that can injure the user and finally education of the user and family members in checking for such sores on a regular basis.

For the local trike provider, builder and designer, the point here is to make sure that proper seat padding is being supplied to the user (if they do not have their own), that they are being properly fitted to the trike (with the help of qualified personnel if available) and that everybody is educated on pressure sore prevention and treatment.

This entire subject is treated more thoroughly in the *DOTT/Sanctus Project Fitting Manual* found elsewhere on the HWI website.