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# A Cart for Pennsic<sup>and other</sup>

## Events of the Society for Creative Anachronism Being a

### woodworking project by the Honourable Sergeant Avery Austringer

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Who, loaded down with armor, provisions or gear, has not wished for a cart to help them with the various loads that seem to be the fundamental units of SCA camping events? This design could easily serve the needs of a modest sized group.

The Cart now has an [addendum](#) page. See my thoughts on this project after a year in the field.

**This design has a number of features:**



Reasonably Simple -

I managed to do it in a few days.

Common Tools -

A [drill](#), a jigsaw and a miter box are the most exotic tools you need.

Not too expensive -

I managed to bring mine in for about \$50 with minimal efforts to hold down costs.

Spoked Wheels -

OK, not exactly, but the illusion of spoked wheels.

A Sturdy Axle and Hubs -

Wheels that don't wobble - the bane of many SCA carts!

#### **General Construction Notes:**

- **READ EVERYTHING BEFORE YOU START!** This is not the only way to make a cart. You may get some ideas of your own, come up with better ways of doing things, or discover mistakes in my instructions. It's easier to uncut a mental 2x4 than uncutting a physical 2x4.

- I've had the cart for about a year now and used it at three SCA wars - Gulf Wars, War of the Lilies and Pennsic. It has held up fairly well, but I've learned some things too. Check out the [Addendum](#).
- If you are unsure of yourself there are a large number of good books for the beginning woodworker. Get one! Also, many woodworking magazines and [supply houses](#) maintain web sites with lots of free tips.
- Your safety is your responsibility (another good reason to get that book). As a friendly reminder - Wear safety glasses. Watch long hair and loose clothing around power tools. Always cut away from yourself.
- For this work I am assuming the use of common dimensional stock of white pine - i.e. a 2x4 is actually 1-1/2 by 3-1/2, etc. For the most part, if you start with better wood (straight, free of defects, etc.) you will get better results and find the work a little easier - so take a few extra minutes to look over your lumber.
- All measurements are in US standard inches and feet.
- Wood and water are not friends. Planks warp, [plywood](#) delaminates, things go all higgledy-piggledy. Thompson's water seal and a big cheap paintbrush can be your friend.
- Carts are dynamic entities. A house, for the most part, has one force it must contend with - gravity. Your cart will be pushed, pulled, twisted and torqued. I recommend deck [screws](#) and carriage [bolts](#) (with flat AND lock washers) instead of nails.
- If you are going to buy a tool for this work (and expect to use it again) go ahead and buy the best one you can justify the cost of - but don't just spend money for the sake of spending money.
- If you're looking for museum caliber recreation, this ain't it. While the wheels I propose resemble those you might find on a medieval cart more than slab wheels, they still embrace the 10-foot rule like a long-lost brother. The skills of the wainwright are beyond the scope of this little project.

#### Bill of Materials:

- 3 - 2"x4" 8 foot long
- 1 - 2"x6" 10 foot long
- 1 - 4'x4' sheet of 5/8 or 3/4 inch BC Plywood
- 4 - 1"x4" 8 foot long
- 1 - a 3/4 inch pipe nipple (iron or galvanized) - 36" long
- 2 - 3/4 inch pipe caps (iron or galvanized)
- 2 - cotter pins
- 4 - 2 inch by 1/4 inch carriage bolts (plus nuts and washers)
- 8 - 3-1/2 inch by 1/4 inch carriage bolts (plus nuts and washers)
- 3" and 2" deck screws
- 2 - washers big enough to fit over the 3/4 inch pipe (not absolutely necessary)
- Waterproof Carpenter's Glue
- Assorted lumber and hardware for building the bed of the cart.

**Some Tools You'll Need:** I am assuming you have things like a ruler, a hammer and screwdrivers....

- Jigsaw
- Drill
- Rasp, Spoke Shave or other tool for shaping the handles
- Miter Box
- Chisel
- Clamps

- A Trammel Set (these are little critters that attach to a yard stick and make it into a giant compass - they don't cost much and beat the snot out of a loop of string, a pencil and a thumb tack!)

**Some Tools That Would be Handy:** You don't really need these, but they will make things go more quickly...

- A Table or [Miter Saw](#) (let's you make those mitered cuts with ease)
- A Dado set (for use with the [table saw](#) - useful for the half lap joints)
- A Router with a Circle Cutting Jig (allows you to round the inside of the wheels)

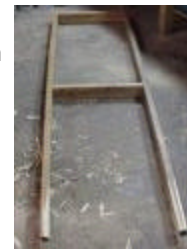
## Construction

### Part I - The Frame



1) Take two eight-foot 2x4's and cut down one end of each to make comfortable handles. Rough cut them with a jigsaw or coping saw and then shape them with a drawknife, plane and/or rasp. (If you don't have a drawknife ask local fighters - it is the tool for shaping rattan sword blades.) Once you have a shape you like

take out anything that looks like a painful splinter-to-be. Don't make them too thin or they will break.



2) Cut out two 24-inch crossbars from another 2x4. Mount one of them at the very back of the two handle boards (the end away from the handles), the other at about the half way mark. These should be fastened with 3-inch screws.

*Hint - drilling a small pilot hole, say 1/8th of an inch wide, wherever you plan on putting a screw will help them drive easier and will prevent splitting.*

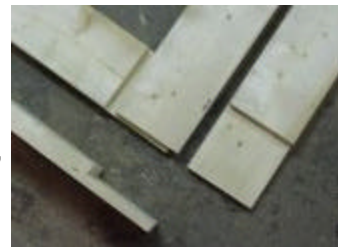
*Hint - putting a little beeswax on the end of a long screw will cause it to drive easier.*

### Part II - The Trusses

The Trusses hold the frame of the cart up, away from the axle so that the cart is level when you are pulling the handles.

3) Cut four 24 inch long pieces from your 2x6.

4) Measure in one 2x6's width (about 5-1/2") from the end and cut HALF of one 2x6's thickness (about 3/4") through each of the 24 inch long 2x6 pieces. (The squarer and more even the cut here the better, but none of this is going to be absolutely critical.) After you have these cuts made, cut away the excess with a mallet and chisel and clean things up with a rasp.



*Hint - Cut so that the grain of the wood angles upward from the end of the board towards the face you are cutting into. That way, if the chisel splits the wood rather than cutting it, the split goes through wood you were going to cut away anyhow.*

*Hint - Many [circular saws](#) allow you to adjust the depth of cut, so you can get this exact (though play around with some scraps before you start carving on wood you plan on using to make sure you've got it where you want it).*

**Hint** - Making multiple cuts will allow you to chisel away smaller bites, thereby making your life a little bit easier. The logical conclusion of this technique is to use a table saw with a dado set and remove all the waste with the saw.



5) Take two of your pieces, turn them 90 degrees to one another and set them so that the cut out portions overlap one another. Ta Da! Half Lap joints! Put a little yellow glue into the joint, clamp it and put a pair of 2 inch by 1/4-inch carriage bolts through the assembly. When the glue is dry, drill a 1-1/8 inch hole in the center of the overlapped area for the axle. Repeat this process with the other two pieces.

**Hint** - Spade bits, which you will probably be using to drill your 1-1/8 inch hole, have a habit of going in clean, but coming out the other side like a brick through a plate glass window! You can minimize the damage by drilling most of the way through from one side, so that the lead point just penetrates the wood, and then flipping the work over and finishing by drilling from the other side. Put a masking tape flag on your drill bit so that when the lead point penetrates the other side of the work, the flag is brushing against the work. Then, flip the work over; insert the tip of the lead point in the hold it made coming from the other side; and finish drilling your hole. Hocus-pocus! Clean hole!

6) Lay a yardstick across one of the trusses so that there are two triangles of 2x6 sticking out. Mark these and cut them off. Repeat with the other truss.

7) Clamp the first truss to the bottom of the frame so that it is centered between the two cross bars. Drill a pair of holes through the frame and each of its legs and mount it in place with some 3-1/2 inch by 1/4-inch carriage bolts. Now put the second one roughly in place and slide the axel through the two holes. Adjust things until the axle is at a right angle to the two handles, clamp the second truss and bolt it into place as well.



8) Cut a 21 inch spacer bar from the 2x4 left from the two cross bars. Mount it between the two trusses, about 1/2 inch above the axel using some 3-inch [deck screws](#).

### Part III - Spacers for the Wheels

The spacers hold the wheels out a bit from the cart's frame so that they don't rub.

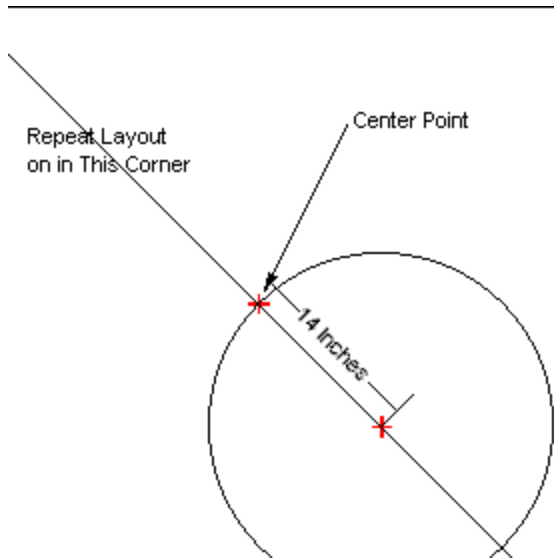
9) Cut two chunks of 2x4 each about a 2x4's width long (about 3-1/2 inches) and drill a hole big enough for you axle through each.

### Part IV - The Wheels

The wheels are where a lot of SCA carts go wrong, both in terms of engineering and authenticity.

For a wheel to function like a wheel it needs things besides roundness. If the axle doesn't meet it in the center your cart will bounce. If it doesn't meet it at a right angle or if the bearing surface is too small or not sturdy enough your wheels will wobble. If the rims aren't wide enough the wheel will sink in soft ground.

At the beginning of the SCA's period the spoked wheel was closing on 3000 years old! Slab wheels - solid disks of wood - were only used for very heavy loads that a spoked wheel could not handle. For general use a slab wheel would have only been a lot of extra weight.



What you're going to do here is make a sort of sham-spoked wheel. It is probably the hardest part of the cart, but nothing compared to the difficulty of making a real spoked wheel. The more accurate and precise your work here, the better. But hey, it's not like this thing is gonna flip over and disintegrate while trying to break the land speed record! It's a cart to schlep gear around at an SCA war. **Relax!**

#### 10) Making the Spoke Disk

The spoke disk is a plywood disk from which eight roughly pie-piece shaped pieces will be cut. These cutouts are the spaces between the spokes.

a) On your half sheet of 3/4 plywood draw a diagonal line from one corner to the other (a chalk line is ideal for this task). Find the midpoint of that line and, from there, measure 14 inches out each way back along the diagonal. These two points are the center of your wheels. Clearly mark them and then draw a circle 14 inches in radius around them. Using a jigsaw cut out the two circles.

b) Drill a small hole (1/8 inch) through the center of each of your plywood disks.

c) Draw an 8" and a 24" in diameter circle around the center point of one of your disks. Then, draw eight evenly spaced lines out from the 8" to the 24" circle. There should be 45° between each of these lines. They define the centers of your spokes.

**Hint** - with a little planning you can eliminate some of the big, ugly knots and other surface defects in your plywood by carefully choosing which way you draw your diagonal (step 10a) and where you establish your spokes (step 10c).



d) Draw two parallel lines, 1-1/4 inch out from either side of each spoke center from the 8" to the 24" circle. When you are done the disk should have 2 inch wide rim and an 8 inch wide hub between which are eight truncated pie-piece shapes separated by 2-1/2 inch wide strips. These pie-pieces will be cut out and the strips will be your spokes. Mark the second

wheel just like the first.

**Hint** - if your yardstick is 1-1/4 wide this step goes very quickly!

e) Drill a 3/8 inch hole at the point and a 1-inch in the two outer corners of each pie-piece. The edges of the hole should just meet the edges of the lines that define the pie-pieces. See the hints in step 5 for tips about drilling with a spade bit.



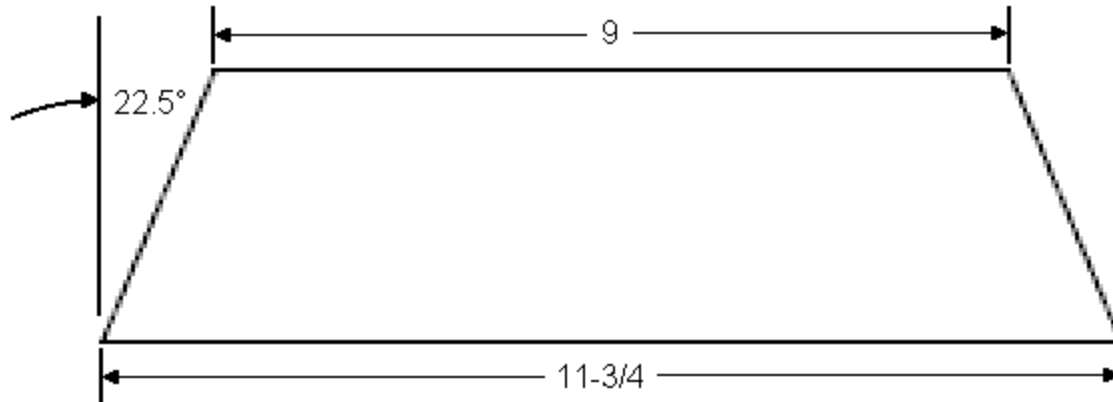
f) Cut out the eight pie pieces from each wheel using a jig saw.

**Hint** - if you have a router and a pattern following bit, you could make a plywood pattern, rough cut the holes with the jig saw and trim the between-the-spoke areas that way. It would take a little longer, but the results would be a bit cleaner.

### 11) Making and Installing the Rims

The wheel rims are going to be two octagonal frames, one attached to either side of the spoke disk and offset from one another so that the seams on one side are matched with solid wood on the other and vice-versa.

a) From your 1x4's cut 32 pieces as per the diagram below:



The lengths of these pieces do not need to be super accurate, but the closer your angles to 22.5 degrees (or 67.5 degrees depending on how you want to look at things) and the closer to vertical your cuts the better.

**Hint** - Remember what I said about a table or miter saw being a big help? This is the sort of task at which those tools really excel! There are also protractor type accessories for circular saws that would make this job much easier.

**Hint** - a draftsman's adjustable triangle is a handy way to draw lines or set a saw at very precise angles. As with the trammel set - you'll wonder how you lived this long without one!

b) Take one of your spoke disks and lay it nice side up (unless you bought the REALLY expensive plywood, one side should look nicer than the other). Arrange eight of your pieces on one of your spoke disks so that the pieces form an octagon with the seams between them being roughly centered on the lines you drew between the spokes. Move thing around so that the octagon is more or less centered on your wheel with a bit of 1x4 hanging over the edge all the way around.



c) Remove one of the rim pieces and apply some glue to one side of it and to the section of the spoke disk that it will cover. Spread the glue evenly with your finger, press the rim piece to the disk and clamp it in place.

d) Repeat step 11c for each of the rim pieces. Put a little glue on the end that will abut the preceding piece. In the perfect world we'd all have dozens and dozens of clamps and could do all eight pieces of both spoke disks at once. Since this is not the perfect world do as many as

you can securely clamp at a time, giving the glue plenty of time to dry before you remove any clamps (I like overnight myself.) If the last piece doesn't quite fit, feel free to trim it a bit.

e) After all eight pieces are glued in place and the glue has had time to dry thoroughly, flip the wheel over and cut off the 1x4 that is sticking out from behind the plywood disk. Be careful not cut into the plywood.

**Hint** - A router with a pattern following bit or laminate cutting bit or a band saw with some sort of circle cutting jig might make the task of trimming the wheel edge a bit easier, but are not required.

**Hint** - If you have access to a router with circle cutting jig you can trim the inside of the rim round too. Tack down a riser block of 1-by stock to the center of the wheel, then, working from the opposite side, drill through the hole in the center of the spoke disk and the riser block. Use the resulting hole in the riser block as a receptacle for the center pin of your circle cutting jig, adjust the jig so that the outside radius of the cut is 24 inches (the same as the inter-spoke cutouts), set your cut depth and away you go. You will find this goes easier if you make a bunch of successive shallow cuts rather than trying to make one big one. Be careful not to cut too deep - when I did this I removed the last thirty-second of an inch, or so, of plywood with a razor knife.

f) Now arrange and glue eight more pieces of 1x4 to the other side of the wheel, except instead of having them meet at the centerlines of the spokes, have them meet between the centerline of the spokes (in other words, offset this side 1/16 of a turn from the other side). Glue and clamp these as well.

g) This time you need not be limited by the number of clamps you own. After you get a piece glued in place, put a pair of 2-inch screws through it. Drill a small pilot hole for each screw. Try to place the screws so that they are not too near any of the edges of the plywood disk, the rim piece you are fastening in place, or the two pieces on the other side of the wheel that you are fastening into. (The X's in the diagram below are about right.)



h) Now cut off the overhanging 1x4 from this side of the rim, just as you did on the other side.

## 12) Making and Installing the Hubs

a) Cut off four pieces of 2x6 (these could be square, but I made mine round) and drill a 1/8 inch hole through the center of each one. These holes should be as close to 90° with the face of the pieces as you can manage. Use a drill press if you have access to one.



b) Apply some glue to one side of each of the hubs. Using a long nail or a piece of heavy wire to line up the holes in the center of the two hubs and the spoke disk, place a hub on each side of the spoke disks. Clamp these in place and let the glue dry.

c) After the glue is dry, drill a couple pilot holes and reinforce your glue joints with a fistful of 3 1/2 inch deck screws - be careful not to put any screws through where the axle is going to go.



d) Remove the nail/wire/whatever-you-were-using-as-a-guide from the hole in the center of the wheel and drill a 1-1/8 hole through the center of each of your wheels for the axle. Again, the closer to 90° with the plane of the wheel the better. The 1/8 holes you drilled

earlier should help to keep your bit centered and on the right track.

**Hint** - If this project seems a little overwhelming, there are corners you could cut to save work and/or money. Thinner or lower grade plywood could be used if you chose to do away with cutting out the spokes. If you choose to do this, you could also skip the adding the rims. Either way - make the hubs!

**Hint** - An iron tire could be added to the wheels by wrapping a sheet metal strip around the wheel and holding it in place with a few tacks or screws. You'll have to countersink these a little bit so that their heads don't get worn away, but a few solid whacks with a center punch should take care of the job.

## Part VI - The Bed

It's not much of a cart without a place to put cartage, now is it? There are a number of ways this can be done. Here is a brief description of how I did mine and some pitfalls to avoid.

**Hint** - Skip ahead and test fit the whole wheel/axle assembly now. If you do have a problem and need to modify the frame, it will be easier to do before the bed is in place.



13) Fit a deck to the top of the frame so that the area between the two crossbars is covered. A sheet of plywood would work here. I chose some old pallet decking and other 1-by scrap lumber for a more authentic look (more work, but cheaper - it helps that I had access to a planer). Try to keep your deck from overhanging the frame or it might interfere with the installation of the bed walls or the wheels.

14) For each side of the deck I made a 15 inch high wall out of 1-by stock that is attached to a pair of 2x4 uprights. The uprights are each fastened to the frame by a 1/4 by 5-1/2 inch carriage bolt. As you assemble these pieces, test fit them and your wheels to make sure they will not interfere with one another.



## Part VII - Final Assembly

15) Put the axle through the holes in the trusses. Then put a spacer, a wheel, a washer (if you could find one that would fit) and finally a pipe cap on each side of the axle (you may want to turn the cart over or have a friend lift the back end for you while you do this. Tighten the pipe caps. When you are done there should be a little play in the axle (room for the axle to move from side to side - a half an inch or so is good). If the pipe caps are binding the wheels to the frame, back them off a turn or so. If that doesn't help, or there isn't room for your pipe caps at all, make sure you have a 36 inch pipe nipple. If you do, try taking the frame apart and cutting a little bit off of the three cross bars.

16) Drill a small hole that goes all the way through the pipe cap and axle. Stick one of your 1/8 inch bolts through this hole and put a self-locking nut on it. Tighten the nut. Repeat for the other side of the axle. These will keep the pipe caps from unscrewing themselves while the cart is in use.

Ta Da! It's a cart.

**IMPORTANT SAFETY NOTE!!!:** This cart was not designed with the same sorts of safety engineering that goes into most modern products. While the center of gravity of the unloaded cart is significantly in front of the axle, if you lift the handles high enough or put a heavy enough weight in the back of the bed of the cart then the cart will flip backwards! If that load is a person

then the back of their head is going to come into conflict with the pavement. They will be less impressed with your handiwork after this happens!

When loading the cart, always try to keep the majority of the load in front of the axle, and think twice before using this cart to carry a person or something fragile.

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Ok, I've had the cart for one year and have learned a number of things. For example, you can only fit so many suits of sweat soaked armor in a given volume. Also, [once you put up a web page, you get more spam, but it gets more interesting too!](#)

Anyhow, some real tips for people who might really make one of these things:

- When you have a cart you will wonder how you ever got by without one. At it's inaugural event (Gulf Wars) it was used to move two injured fighters out of the Ravine battle site, haul our entire region's helms and shields to and from the battle field and move TRM Midrealm's thrones and other gear any number of times.
- Much overloading did a number on the hubs, and despite my best hopes I'm getting some wheel wobble. I'm thinking that either a hardwood, or some kind of metal bearing might be appropriate.
- Carriage bolts can be a real pain to put on/take off. Nuts will evaporate the moment they hit the grass! At Pennsic a gentle from Pentamere showed me a cart he made based on my design. He put cutouts in the deck and just stuck the uprights through them.
- I only secured the bottom edge of my sideboards. As a result, the tops tend to gap when you are hauling a really big load. Either a metal retaining clip at the upper corners, or perhaps some kind of cord all the way around the box seems in order. Tie down points around the perimeter might also be a good idea.
- Remember those iron tires I said were, "you might want to" items? I was wrong - after you put that much work into the wheels you are definitely going to want to do something to protect them. I used 1/8 cold rolled stock for my tires. Another gentle used 18 ga. galvanized steel. Just something to protect the wheels from the road.
- A gentleman from the East made his wheels out of the two cutouts left over from the ring he made for the center of his yurt. His wheels were a little smaller than mine, but the cart looked pretty good.

