PROJECT – Chopper Bicycle

www.gwellwood.com

image from:
www.wonderlandclassics.com

PROJECT – Chopper Bicycle

Function Follows Form

PURPOSE....

In this activity you will build a custom and unique Chopper Bicycle. You will research terminology used in bicycle construction, as well as the geometry required to make the bike a safe and predictable ride. You will explore the five elements of design, and then construct a high quality unique Chopper Bicycle.

This project is intended for Senior Metalwork classes where students have established basic critical thinking, problem solving, design and fabrication skills. The intent behind this project is to provide an inexpensive, simple, durable, portable, conversational toy to have fun with and impress friends and family, whilst learning far more about design, fabrication and engineering.

Use of a frame jig and a fork jig are required to ensure a good fit-up, and to ensure geometric accuracy and alignment of the important parts. A document entitled "PROJECT – Chopper Bicycle (Instructor)" outlines the construction of both jigs used in this document. Use the jigs.

The cost can range from $25 to the depth of your pockets, depending on your resourcefulness.

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image from: www.vancruisers.ca

MATERIALS LIST

Planning ahead

For this project you will need the following:

- Pen and paper
- Tape measure and ruler
- Angle-finder
- Hammer and Centre Punch
- Scriber
- Hacksaw
- Demonstrated safe use of MIG Welder
- Demonstrated safe use of Oxy-Acetylene torch
- Demonstrated safe use of Machine Lathe
- Demonstrated safe use of Drill Press
- Demonstrated safe use of Angle Grinder
- Demonstrated safe use of Bench Grinder
- Demonstrated safe use of Zip Disk
- Used bicycle (preferably single-speed with coaster brake)
- SCH40 pipe for forks (size and length as required)
- 16ga round tubing for frame (size and length as required)
- 10" - 3" x 3/16" flat bar
- 4 – 3/8" x 1" UNC cap screw
- Paint
- Whatever else I forgot

READ these instructions!

90% of the problems students encounter are because they didn't read the instructions.

READ these instructions!

image from: www.alibaba.com

TERMINOLOGY QUESTIONS

Whatchoo talkin bout Willis?

Your First Assignment!

Each technology has its own language. In order to fully understand the design of a bike, it is important to know what you are talking about.

Research to find the names for the following component parts of a bicycle frame:

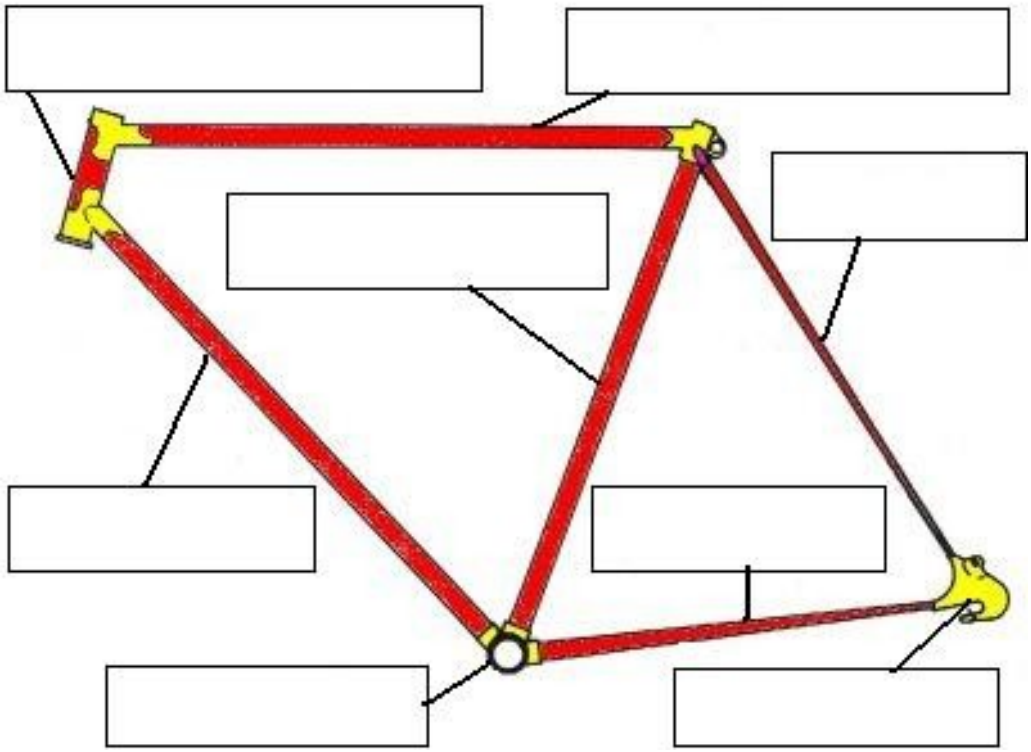


image from: www.motorera.com

Two critical terms used in bike geometry are RAKE and TRAIL. In your own words, define each:

Rake: _____

Trail: _____

image from: www.bikeforest.com

THE DESIGN PROCESS

"A good product starts with a good design. Start with nothing less than awesome."

I cannot stress the importance of The Design Process enough!

If you rush ahead to start working, but scrimp on design, your project will be unsatisfactory!

Procedure...

Designing any project begins as a process. When you design something, you go through these steps in your head naturally. A much more skilled and disciplined designer would express these thoughts on paper to enable them to work through the ideas in greater detail.

The design stage is probably one of the most critical stages of this project. As I mentioned, this is NOT a set of plans – you will have to custom build your bike according to what YOU want and have.

Note that the more effort you put into the design stage, the greater your success will be. Understand that your product will *always* turn out *less* than your design.

Awesome design	=	Good product
Good design	=	Average product
Average design	=	Poor product
Poor design	=	Unleashed Wretchedness

image from: www.bicycles365.com

There are five steps to design. You will be going through each of these steps several times on this project, in several different areas of the project.

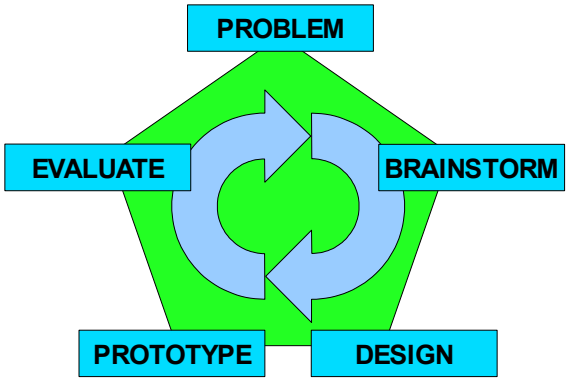


image from: www.alibaba.com

PROBLEM QUESTIONS

Starting the Foundation

You have decided to build a Chopper Bicycle. There are a few questions you need to be able to answer before you can begin Brainstorming your solution.

Your Second Assignment!

1. What are you using for a donor bike?

2. What are you using for brakes?

3. How will you be dealing with speeds (if more than one)?

4. How much rake are you after?

image from: www.schwinnbike.com

BRAINSTORMING

Putting Ideas Together

For most bicycles, the design must be functional first and foremost. In a chopper, Function follows Form. It is more important to get it looking completely wicked. Check out other designs, get ideas, but come up with something uniquely yours.

TIPS

These drawings will need to be good quality. Don't worry so much about how the frame tubes are attached at this point, merely focus on appearance

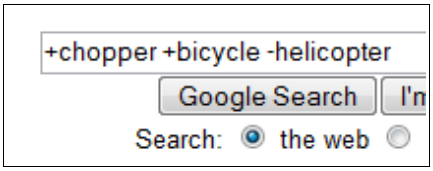
- ✔ A triangle is the strongest shape. Try to "triangulate" your frame as much as possible.
- ✔ Straight tubes are stronger than curved tubes. The more curved tubes you use, the more flex you will have in the frame.
- ✔ Try to shoot for a more "organic" look – natural appearing curves as if the bike itself was alive.
- ✔ Low seating positions will require positioning the pedals forward quite a ways.

If you need to explain your drawing, you need to re-draw it. This is not a Salvador Dali exhibit

TIPS

Do some research on how chopper bicycles are made. Learn to search the Internet more efficiently. Here are some TIPS:

- ✔ Use a PLUS symbol in front of the words you WANT, and a MINUS sign in front of the words you DON'T



- ✔ Use QUOTES to find phrases, or specific wordings

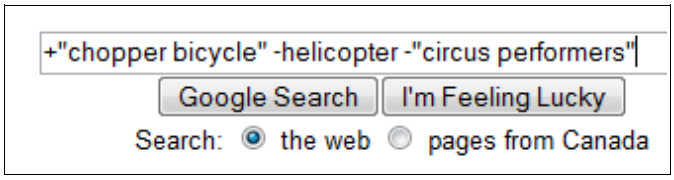


image from: www.allwebtoys.com

BRAINSTORM DRAWINGS

Putting Ideas Together

Using the "wheels" below, sketch four different potential designs for your chopper. These must be good quality, unique, and each one different.

Your Third Assignment!

Raleigh Chopper MKIII

MEASURMENT of PARTS

Fitting The Parts You Have

Once you have acquired your donor bicycle, you will need to take some measurements in order to properly design your bike.

If you use any alternate parts for your bike later on, you may need to re-visit your design. Steering geometry is critical.

Your Fourth Assignment!

List the following measurements below, and keep these references handy for later:

1. Front wheel diameter (inches):

2. Rear wheel diameter (inches):

3. Crank Arm Length (inches):

image from: www.homedepot.ca

4. Existing rake (degrees):

5. Neck height (inches):

image from: Tom Smykowski

THEORY - GEOMETRY

Math - Here It Comes....

Let's take some time to talk about making this chopper of ours work the best. Style is #1, of course. But speed wobbling into a bus full of nuns should be further down than #2.

TIPS

By now you should have an idea what kind of rake you want. Previously I asked you to research "trail." Next you will be looking at wheelbase as well.

Long Wheelbase	PRO: Stable and Predictable at all speeds CON: Large turning radius
High Rake Angle (upwards of 45°)	PRO: Stable at high speed CON: Poor low speed stability CON: Large turning radius
High Trail	PRO: Stable at speed CON: Fiendishly large turning radius

Trail must be positive like a shopping cart.

Trail *forces* the wheel to follow the steering axis.

Zero or negative trail? Speed wobble city. Might want to wear a helmet....

Most bicycles and motorcycles have about 30° rake and run 2-6" trail. Trail is how much the wheel centreline follows (or, *trails*) the steering axis.

The steering axis must *always* lead the wheel centerline.

A good example of why is a shopping cart caster wheel – the wheel always flips around to follow the (zero raked) pivot.

Min. Trail: 2" Max. Trail: 14"

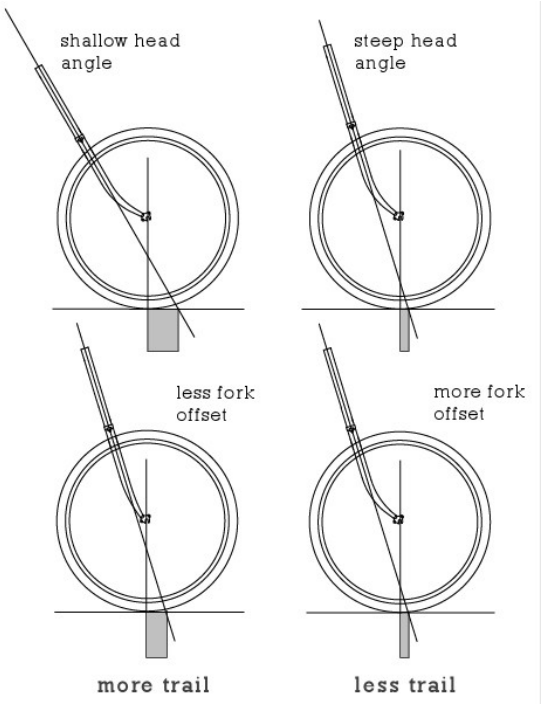


image from: www.wikipedia.org

image from:
www.streetlowrider.com

FINAL DESIGN

Your Road Map To Success

On page 14, draw a high quality version of your best design. Last minute changes are welcome. Some "issues" may show up as you work through the drawing – refine them so they work for you.

Remember – a chopper is all about style. The whole thing needs to look good *together*. As such, it needs to be designed *together*. The first place to start is the wheels.

Your Fifth Assignment!

Position the wheels first.

The "look" of the frame will only look good if sized to the wheels.

Use your measurements from Page 10 to help you!

1. USE the grid on the next page to draw out your chopper. Scale your drawing such that one square is 6" of the real world.
2. DRAW the size and location of the rear wheel. Use a Compass or a Circle Template to draw the size and location of the wheels first.
3. PICK a wheelbase that suits the size of the wheels. A low, stretched frame will require a long wheelbase.
4. DRAW the frame tubes using a Ruler and a French Curve. Give it some *style!*
5. RAKE must be no more than 45° (won't turn), and no less than 20° (won't stay straight).

TIPS

6. TRAIL – The Fork Jig is designed to give you 2" trail. This cannot be altered.
7. MEASURE your hand, butt and foot position riding the imaginary bicycle to get an idea where things should go.

Before you get too far...
Structural Issues you need to know about:

image from: unknown

FAILURE

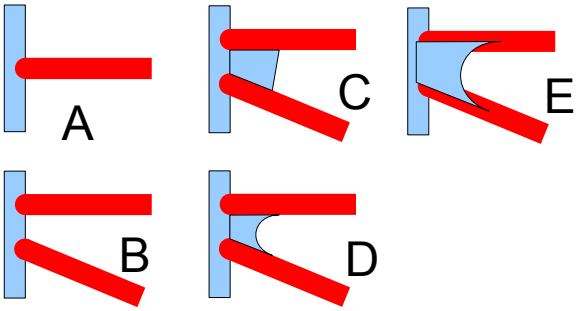
Is Not An Option

The title picture above is from an early Lotus 7 being restored. Colin Chapman (the founder of Lotus) had a philosophy that the perfect race car would be so light it would cross the finish line (in first place), then fall apart. If nothing broke, the car was over-built and thus too heavy. Lotus has always made exceptionally light, exceptionally fast cars. Colin has also been criticized for building "unsafe" race cars.

Engineers use scientific knowledge, natural laws and physical resources in order to design and fabricate something that will perform a specific task under specific criteria.

Engineers need to understand materials, processes, loads and forces in order to come up with the *best* design

In our case, while we want light, we also need strength. When designing a bike frame, consider these attachments (HEADSET as example):



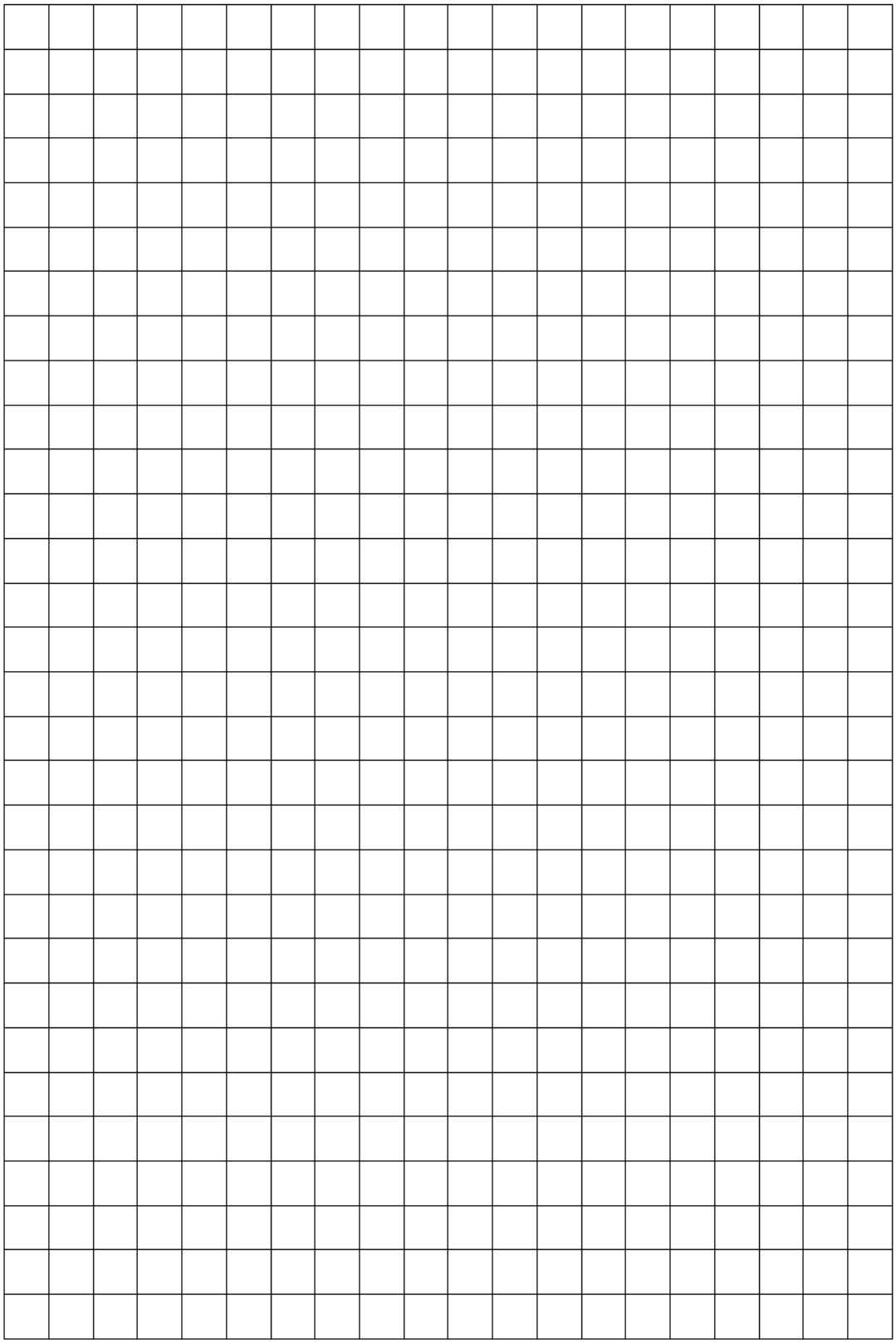
A) The weakest of all of these, zero triangulation. Any load on the top tube severely stresses the weld joint.

B) Better, and the standard for most bicycles.

C) Use of a GUSSET between all three tubes adds considerable strength, and very little additional weight. However, the straightness of the open side is a sudden change in cross-section – the tubes will fail right where the GUSSET ends.

D) Curving the inside of the GUSSET spreads the loads out more gradually and prevents joint failure.

E) The strongest of all – Curved GUSSETS welded on BOTH sides. Larger size, more weld area, and curved edges improve strength considerably, with minimal weight gain.



□ = 6″ SQUARE

image from: Tom Smykowski

JIG MEASUREMENTS

Preamble to the Postamble

You will need to know where to place the various fixtures on the FRAME JIG to build your chopper as designed.

Your Sixth Assignment!

Using the drawing you just completed, count the squares and record the dimensions to the following locations:

NECK

(vertically, ground to center): _____inches

CRANK

(horizontally, neck to center): _____inches

(vertically, ground to center): _____inches

REAR AXLE

(horizontally, neck to center): _____inches

(vertically, ground to center): _____inches

WHEELBASE

(horizontally, center to center): _____inches

RAKE

(angle): _____degrees

FORK LENGTH

(axle centerline to TOP of NECK):_____inches

Accurate measurements here will REALLY speed up the component placement and setup of the the jig.

KEEP THESE numbers as a reference!!

You will need these dimensions to fix your bicycle parts onto the FRAME JIG later.

image from: Tom Symkowski

FABRICATION STAGE

Go Big or Go Home

Here is where it comes together. As you start building your chopper, you may run across details that require further study – you will discover things you may have overlooked in the design stage. No problem. Just be sure to figure them out now.

DO NOT attempt to "rush" through
to make things magically fit
-- They Won't --

Sit down, relax, clear your mind, and approach your problem methodically. Sketch. Research. Discuss. You can do it!

Your Seventh Assignment!

TIPS

Since your shop does not have enough equipment for everybody to be doing the same thing, here's a TIP:

Try to multitask. If you planned on doing some welding, and the welders are full, find something else to work on like machining your triple-trees, cutting out frame materials, or stripping paint. *You will not get the project done in time if you don't use your time efficiently.*

In the real world, time is money. Use your time wisely!

Employers want people who will make them the most money during their shift.

Make your employer money, and they will do everything they can to keep you with them!

Here are the instructions to get started on a chopper, Remember, **YOUR** design may be different than this one.

NOTE:

- The chopper is designed to fit YOU (plans are not "to the letter")
- The chopper is made to fit YOUR bike parts (make sure you have them!)
- The chopper requires critical thinking skills, design skills, planning, and a systematic approach

image from: "Short Circuit" (movie)

DISASSEMBLY

Disemboweled and Discombobulated

Completely disassemble your entire bicycle, including the headset and crank assembly. The chain will need to be removed either by separating links, or cutting frame tubes.

KEEP TRACK OF EVERYTHING!

It might be a while before it all goes back together.

The biggest mistake people (of all ages) make is not keeping everything organized. You *cannot* rely on your memory over time. Here are some TIPS to help you stay organized:

- Take pictures
- Sketch pictures
- Label the small stuff
- Place parts in Ziploc® bags
- Thread fasteners back into their holes
- Store everything in a box so everything is together
- PUT YOUR NAME ON IT!

Once the bike is disassembled, use a hacksaw, cutting torch, plasma cutter or cut off wheel to cut out the useful bits and CAREFULLY grind smooth:

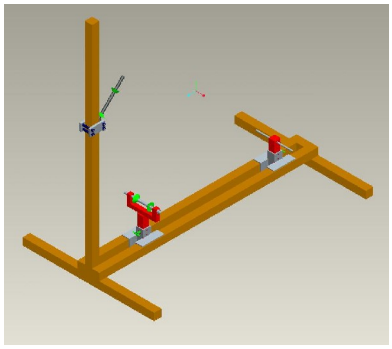
- Neck
- Crank
- Axle mounts
- Tubing
- Steer Tube (from forks, but leave the stub at the bottom)

Disassembly Tips:

Be very careful not to ruin any threads, clips, brackets, fasteners, cables, clamps, bearings, nuts, sleeves, retainers, etc.

Don't destroy anything until the bike is finished.

If you can't get it apart – ask your instructor for help.



FRAME JIG

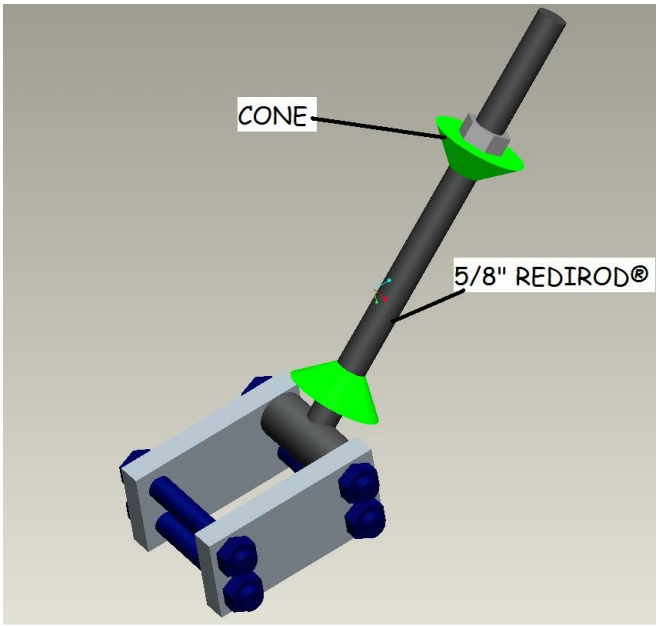
Setup & Assembly

NECK JIG

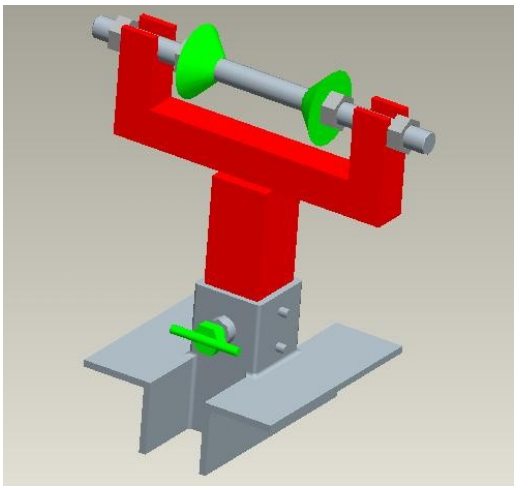
ADJUST the NECK JIG to the HEIGHT off the ground recorded in "JIG SETUP" (Page 15).

SET the NECK JIG to the desired RAKE ANGLE and HEIGHT and tighten securely.

ATTACH the NECK TUBE to the NECK JIG using the two centering cones and tighten securely.



CRANK JIG



ADJUST the CRANK JIG to the HEIGHT off the ground, and DISTANCE from the NECK recorded in "JIG SETUP" (Page 15).

ATTACH the CRANK TUBE to the CRANK JIG using the two centering cones and tighten securely to the shaft, and tighten the shaft to the CRANK JIG.

ENSURE that the jig is sitting level and square, and adjust as necessary.

AXLE JIG

ADJUST the AXLE JIG to the HEIGHT off the ground, and DISTANCE from the NECK recorded in "JIG SETUP" (Page 15).

ATTACH the AXLE BRACKETS to the AXLE JIG using the nuts and washers and tighten securely to the shaft.

> *Axle Brackets may be taken from the donor bicycle, or fabricated to suit. 3/16" flat steel is recommended*

ENSURE that the jig is sitting level and square, and adjust as necessary.

Place a seat of some sort over the jig and "ride" the bike – see how it feels, how the seating position is, how your feet will fit the pedals. Don't forget you need enough ground clearance for your feet when you lean in a corner. If you need to make location changes, NOW is the time to do it.

Once you have the Neck, Crank and Axle pieces mounted, you are ready to begin fitting the tubes.

Most of the tubes will be cut and bent to fit. Pay particular attention to the joints - "fishmouth" the ends of the tubes for a perfect fit. *You cannot weld air.*

WinMiter is a free program you can download which prints fishmouth cutting templates you can wrap around the tubes and mark.

image from: www.stockcarracing.com

If your design calls for curved tubing, you will need to bend the tubes for your frame.. There are many types of benders available.

If you are lucky enough to have a Hossfeld bender (top), you bend just about anything. They are a joy to have, and are reasonably affordable. The dies, however, get quite expensive.

The Pipe Bender (middle) is really intended for pipe, and does a poor job bending tubing. Good luck – you will need it.

If you have no bender and are up for a little grunt-work, drill a couple holes in a piece of wood (bottom) and bend by hand just a bit at a time. It works very well for some gentle bends, but don't get too greedy or you will kink it.

You could even make your own bender using plywood curves to pull against....

image from: www.hossfeldbender.com

image from: www.northerntool.com

image from: Jon Winterhalter

TIPS

A rule-of-thumb in bending tubing:

> *The bend radius should be no less than 4 times the tubing diameter*

Keep checking your progress with your drawings and for fit.

Grind, file, or sand the ends to be welded – the metal must be clean!

Watch that you have chain clearance past the tubes and the width of the rear tire.

WELDING THE FRAME

TACK–WELD your frame tubes together with your Neck, Crank and Axle Bracket.

As you add tubes, stop and check your progress. "Ride" the bike and check it for fit. Are you happy with it? Will you be able to reach the handlebars? Will you be able to reach the pedals?

You will not fully weld the frame until you have finished tack–welding everything together and are 100% happy with the result.

It is MUCH easier to cut a tack-weld apart to move a tube than to cut a complete weld.

Once the frame is complete and tacked, carefully remove it from the jig so others can start theirs.

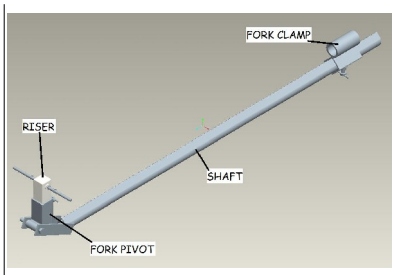
Tips when welding:

TIPS

- Welding distorts metal – weld 1" beads at a time, moving around all over the frame to reduce heat buildup.
- Welding needs clean metal.
- **MIG** – Fast speed, easy, looks ok.
- **TIG** – Slow speed, most difficult, pretty welds.
- **Brazing** – Slow speed, medium difficulty, prettiest welds. Many bikes are brazed.

image from: www.mytoolstore.com

image from: www.millerwelds.com



Fork Jig

Setup & Assembly

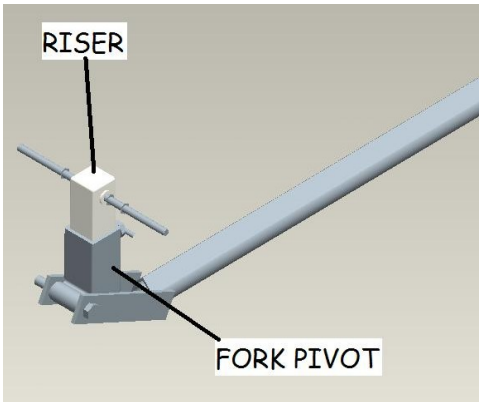
Adjust the FORK PIVOT to the angle of RAKE on your frame. The pivot is marked for angle.

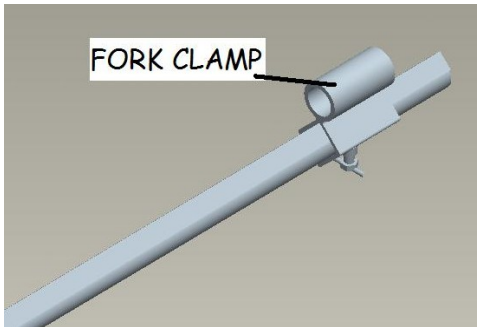
Adjust the RISER to the diameter of your FRONT WHEEL. The riser is marked for diameter.

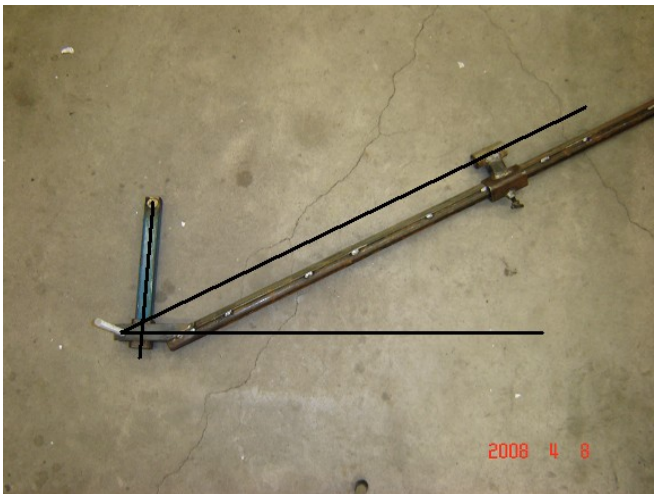
Slide the FORK CLAMP to your FORK LENGTH as measured between the FRONT AXLE and the top of the NECK.

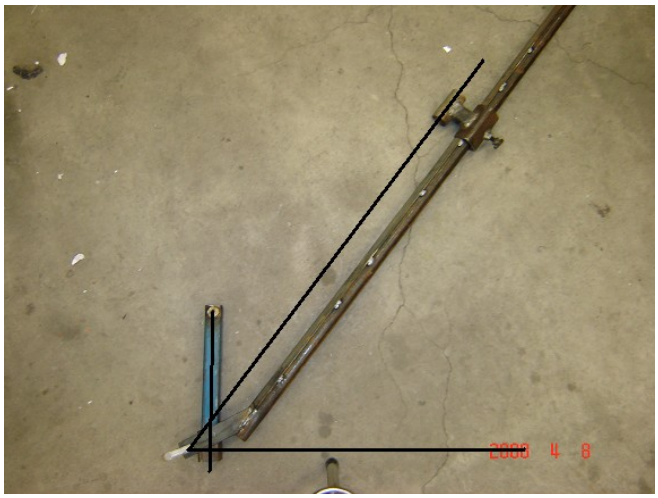
These settings will ensure the bike can steer properly. Notice in the pictures below, regardless of the wheel size, fork rake or fork length, the correct amount of trail is produced.

This jig is fool-proof IF you set it up correctly. Ask your instructor for help if you are unsure. Mistakes here can be brutal to undo.









FORK TUBES

If the fork tubes will be quite long on your chopper, you should select material that will not bend very easily. I recommend 1" SCH40 pipe. It's heavy, but it's cheap and rigid and the size suits the rest of the bike.

Larger diameter thin wall tubing has a much greater strength than small diameter thick wall tubing. 1-1/2" thin-wall tube might be an idea. Shorter forks can get away with smaller tubing as there is less bending load on them.

There are many types of forks you can build. I will cover rigid forks. If you want to build a "Springer" front end, or a "Girder" front end, you will need to research that one on your own. They are more complex and add more time to the project. Their "cool factor" is significantly higher though!

1. Acquire or fabricate (3/16" thick) axle brackets, and attach to the RISER.

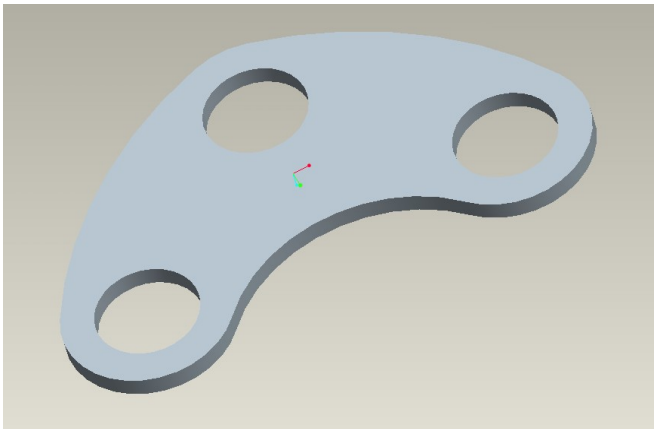
2. WELD the AXLE BRACKETS to your FORK TUBES – be accurate!! Make sure you have room for the axle shaft nuts!

3. FABRICATE the lower Triple-Tree to support the top end of the fork tubes.

4. TACK the lower Triple-Tree to the STEER TUBE as accurately and as squarely as possible.

5. INSERT the STEER TUBE, and FORK TUBES into the jig and check for fit.

6. MAKE SURE the FORK TUBES extend to the TOP of the HEAD SET NUT



TRIPLE-TREES

Proper geometry will be determined by the jig.

The upper TRIPLE-TREE will need to be fabricated to match the location of the FORK TUBES and the STEER TUBE.

Try to make it match the lower TRIPLE-TREE in appearance. It will likely be "shorter" because of the fork tube angle maintaining proper geometry.

MACHINE a threaded insert into the end of the FORK TUBE. This allows you to bolt the upper TRIPLE-TREE to the ends of the FORK TUBES.

The center of the upper TRIPLE TREE is held down by the top HEADSET NUT.

HANDLEBARS

There are two ways to attach handle bars.

1. Single post through the STEER TUBE just like a traditional bicycle.

2. Two risers like a motorcycle, attached to the upper TRIPLE-TREE

The choice is yours.

Using the original single post bicycle mount, you merely assemble the modified handlebars.

One way to attach risers is to fasten them with a cap screw from below the upper TRIPLE-TREE.

image from: www.bikewebsite.com

image from: www.chilhowee.net

Image from: www.vancrouisers.ca

ASSEMBLY

Putting It All Together

Now you want to trial-assembly the entire bike and make sure everything works. Make sure it RIDES, STEERS and STOPS. If you need to make changes, NOW is the time to do it.

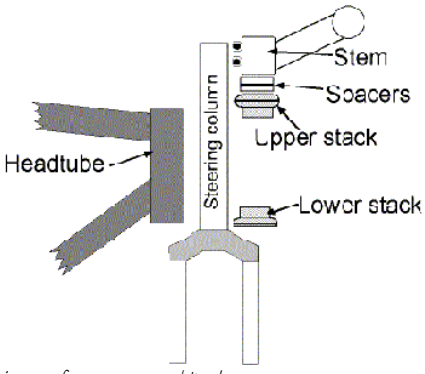


image from: www.parktool.com

It is a good idea to clean all the bearings, inspect them for wear, grease and reassemble.

If you are using TRIPLE TREES – the top tree will replace the SPACERS as shown above.

The CRANK should be assembled with ZERO play. You will need to fiddle with adjustments until this is so.

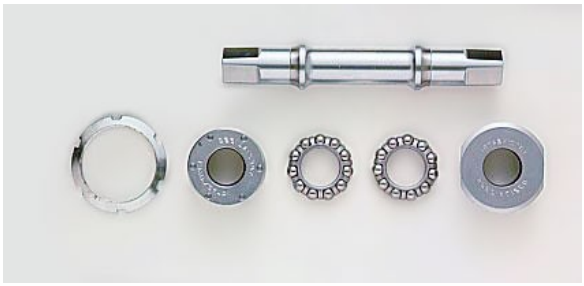


image from: www.dkimages.com

Ensure the wheels are pointing in the right direction and are aligned.

WEAR A HELMET!

image from: www.santiagochopper.com

Your Chopper Bicycle

WILL NOT BE MARKED

if it is:

- Unstable
- Unpedalable
- Unstoppable
- Unsteerable

Fix it!

PAINTING

Making It Look Good

Now that it works, the entire bicycle should be disassembled, cleaned, and sanded.

All your welds should be inspected. Nasty ones ground down and re-welded. Nice paint will REALLY show off BAD WELDING. If you chose brazing for assembly, your life will be much easier, since it can be one of the nicest welds to do.

image from: www.nlchoppers.com

Once the frame and forks are PERFECT,

CLEAN & DEGREASE

Paint will not stick to grease and oil. This includes finger prints!

SAND

Make sure everything is as smooth as possible. Old paint should be "feather-edged" with 1" strips remaining of each layer of paint.

PRIME

Bare metal must be primed first. Primer should be allowed to "cure" over a couple days before the final coat of paint is applied – primer "soaks into" any sanding scratches. You will sand any high spots down once the primer has cured.

images from: www.majewskiautobody.com

Wear a proper respirator!

PAINT

Follow the instructions on the can. USE LIGHT COATS!!! Rookie mistake: laying on WAY too thick a coat – runs, poor drying, looks bad. Lay down one light coat, let it setup 10-15 minutes Then come back and give it another medium coat, let it set up 15-20 minutes, then apply a third and final coat – *NOT TOO HEAVY!*

image from: Colin Weltin-Wu

image from: Kenny Prather

EVALUATION

Did I End Up Where I Wanted To Be?

At every stage of the build, you looked at what you created. If it wasn't awesome, you fixed it. Now here you are, all done. Did you accomplish that which you set out to do?

Terminology Questions Answered	/10
Problem Questions Answered	/10
Brainstorming Drawings Complete • Quality • Creativity	/20
Measurement Of Parts Complete	/10
Final Design • Quality • Detail • Aesthetics	/30
Jig Measurements Complete	/10
Frame • Alignment • Welding • Chain Alignment • Tube Fit • Finish	/50
Forks • Alignment • Welding • Geometry • Tube Fit • Finish	/50
Assembly • Steers • Stops • Pedals • Stable	/40
Paint	/10
What part of this project are you most proud of, and why?	/10
What part of this project are you least proud of, and why?	/10
TOTAL MARK:	/260