Course: 3D Design
Title: The Rocket Steam Locomotive – Drive Chain
Blender: Version 2.6X
Level: Beginning
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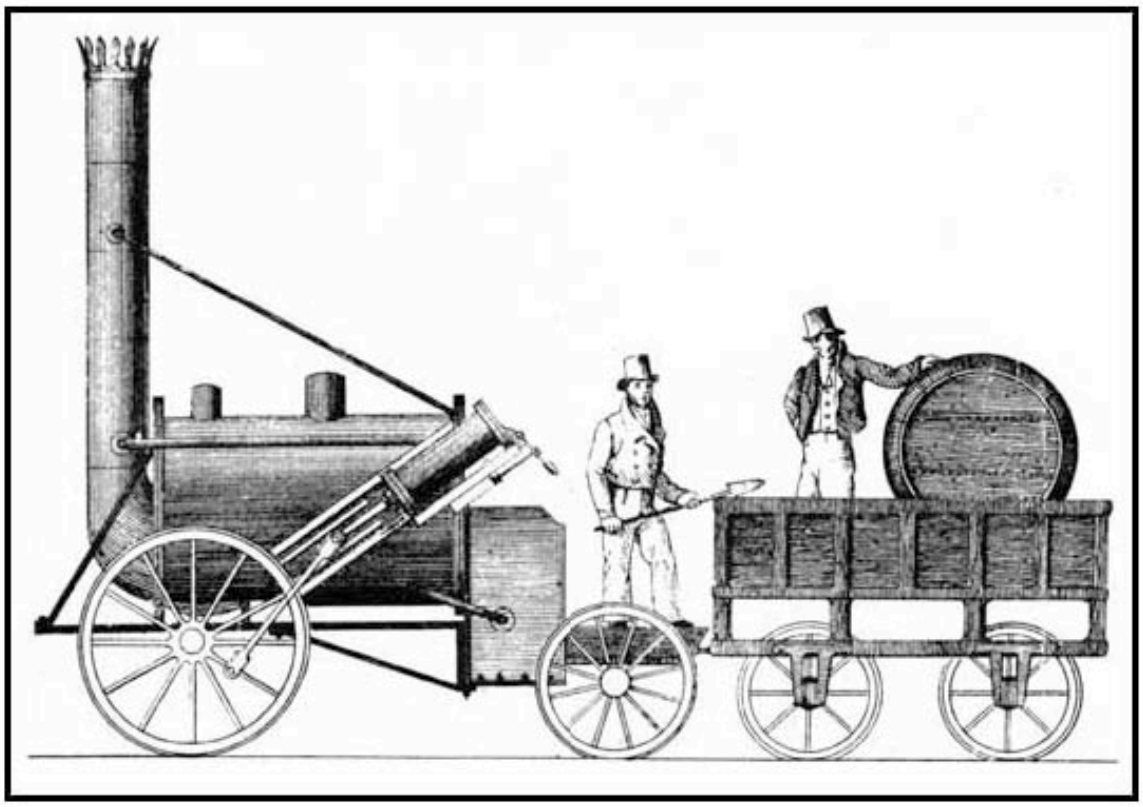
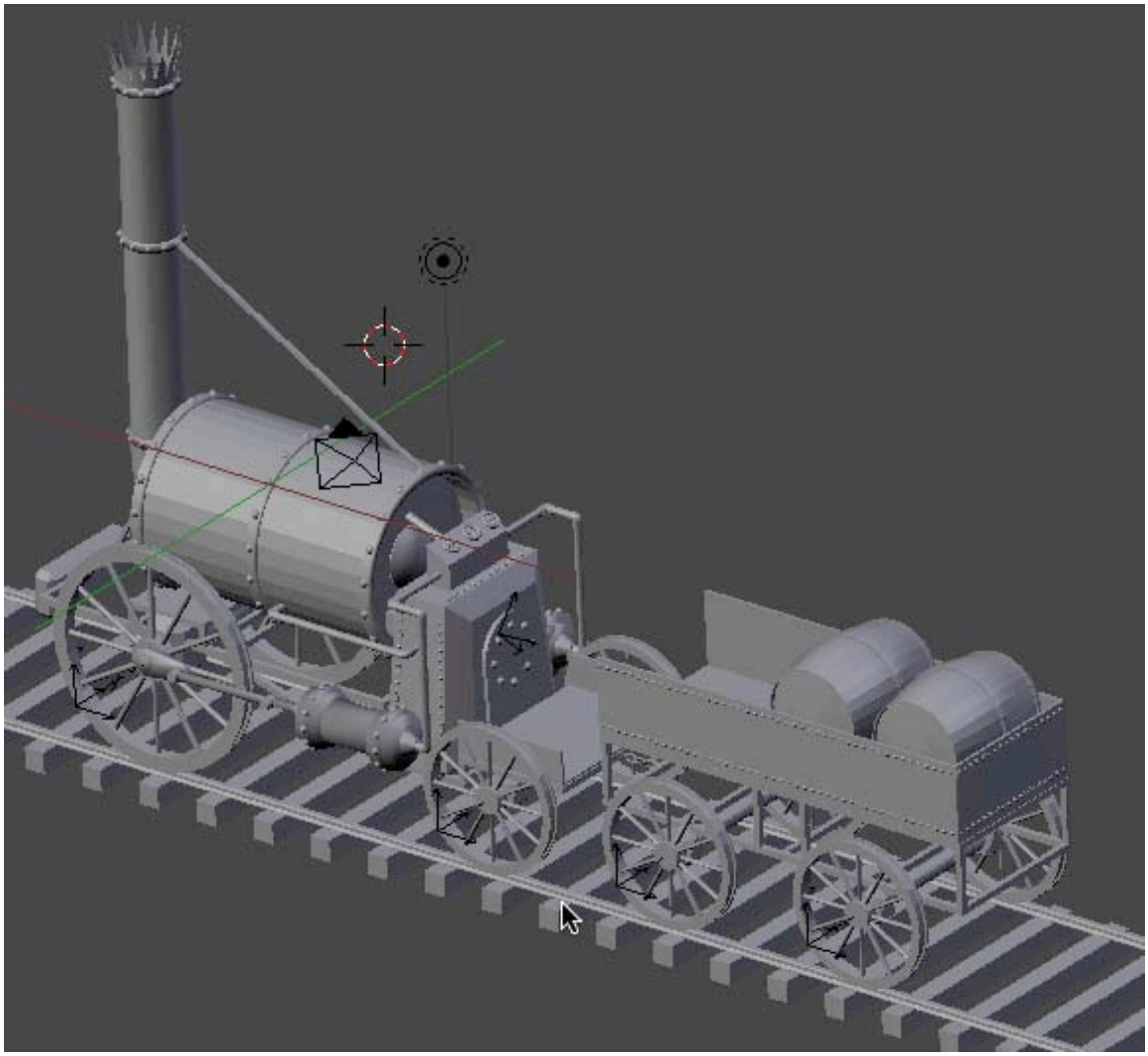
(June 2012)

"The Rocket" Steam Locomotive – Drive Chain



In this tutorial we will be modeling the Drive Chain portion of Robert Stephenson's Steam Locomotive named "The Rocket". The rocket was the most advanced steam engine of its day. It was built for the Liverpool & Manchester Railway in 1829. It achieved the unbelievable speed of 25 miles per hour.



This is the first of 3 PDF tutorials focused on the Rocket Steam Locomotive. The other 2 PDF tutorials are Rocket Steam Locomotive – Modeling, which focuses on the non-drive chain modeling for the Rocket locomotive and Rocket Steam Locomotive – Animation, which focuses on the non-drive chain animation.

SET-UP:

Open a new Blender file. Select the cube object and delete it. Select the camera and light objects and place them on Layer 20 to get them out of the way. Press the NKEY to display the properties panle on the right and press NUMPAD-5 to go into Orthographic Projection mode (if you are in perspective mode).

Go to front view.

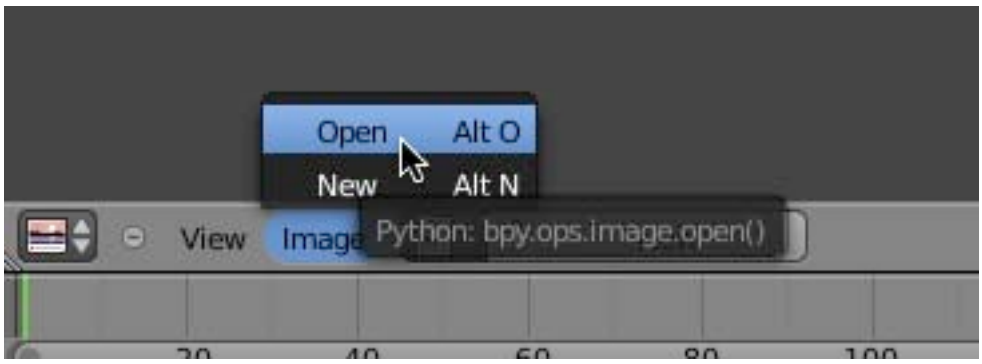
Background Image:

We will use a background image to give us the basic shapes and proportions of the Rocket. This image file is named "RocketDiagramSideView.png" and can be downloaded HERE.

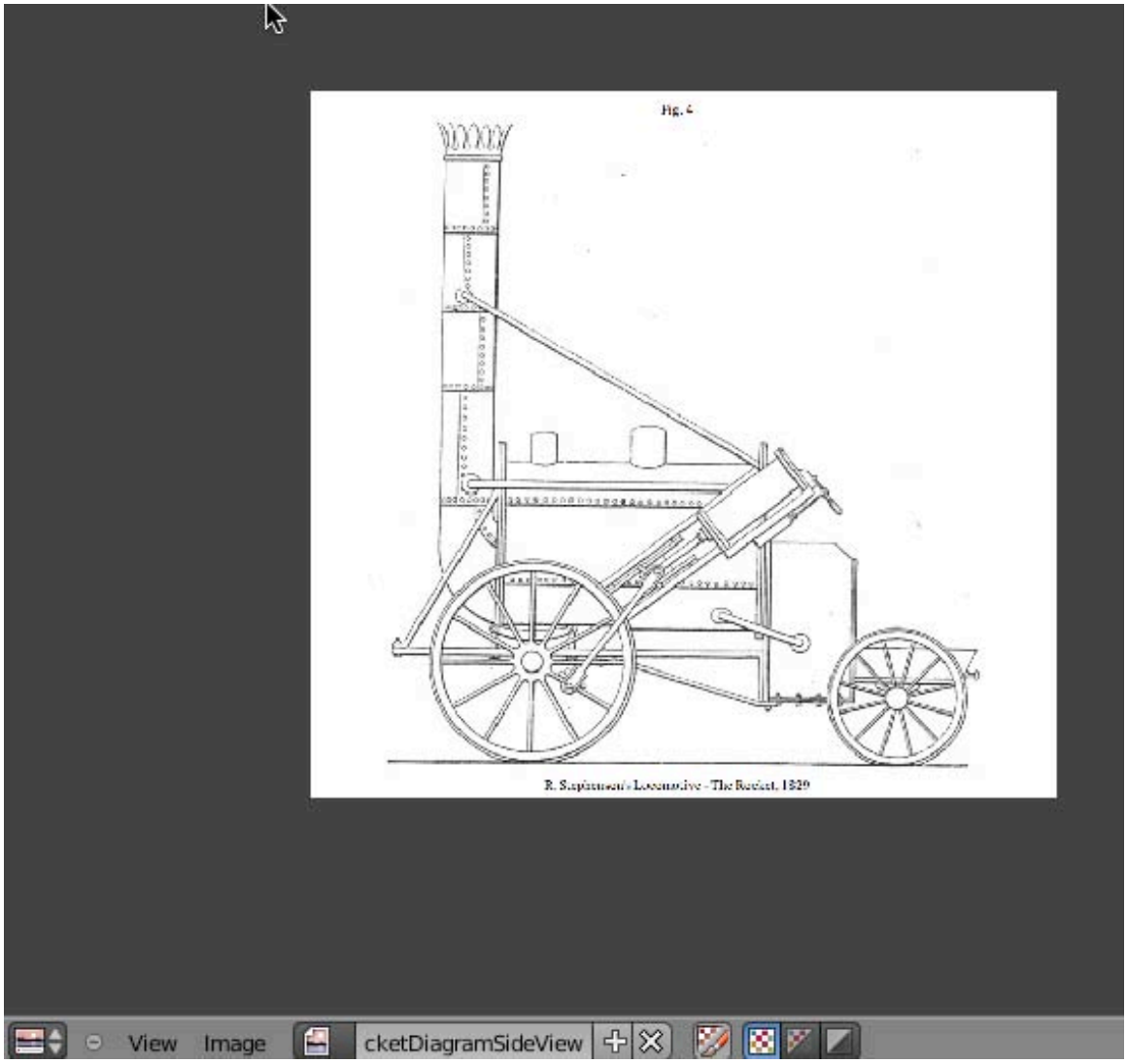
Before we can add a background image file to the Background Image tool we will first add the image to the UV editor.

Click on the Editor Type button in the lower left corner of the 3D Editor Viewport Header and select UV Image Editor.

Click on the Image Button in the UV Editor Header and select “Open”.

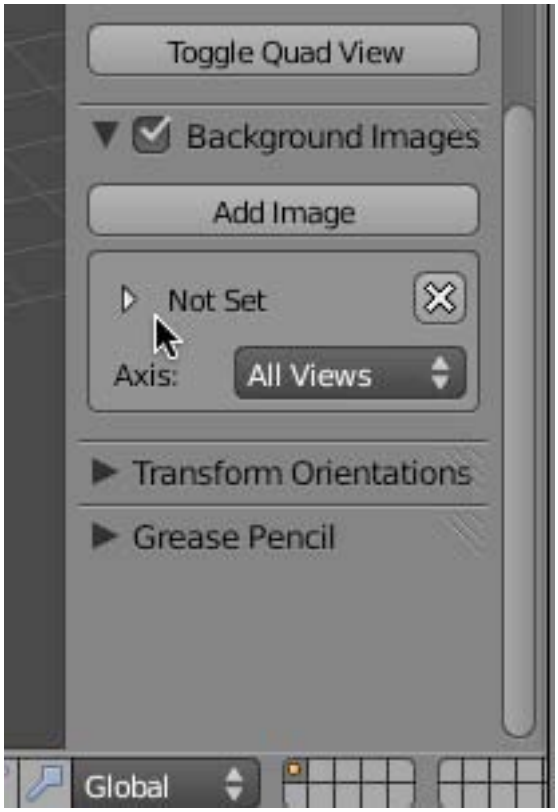


This will open Blenders file Browser. Locate the RocketDiagramSideView.png file, select it and press on the Open button. This will place the RocketDiagramSideView.png image into the UV Editor.

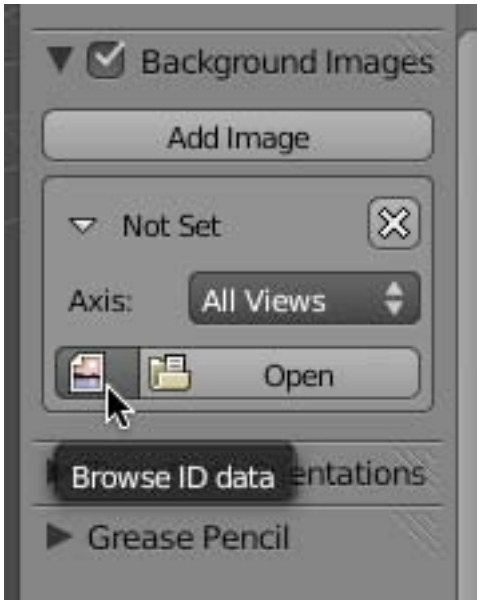


Click on the Editor Type button in the lower left corner of the UV Image Editor Header and return to 3D View.

To load the background image in our scene, first checkmark the Background image checkbox located in the 3D Editor Properties panel and then click on the small dropdown arrow to the left of “Not Set”.

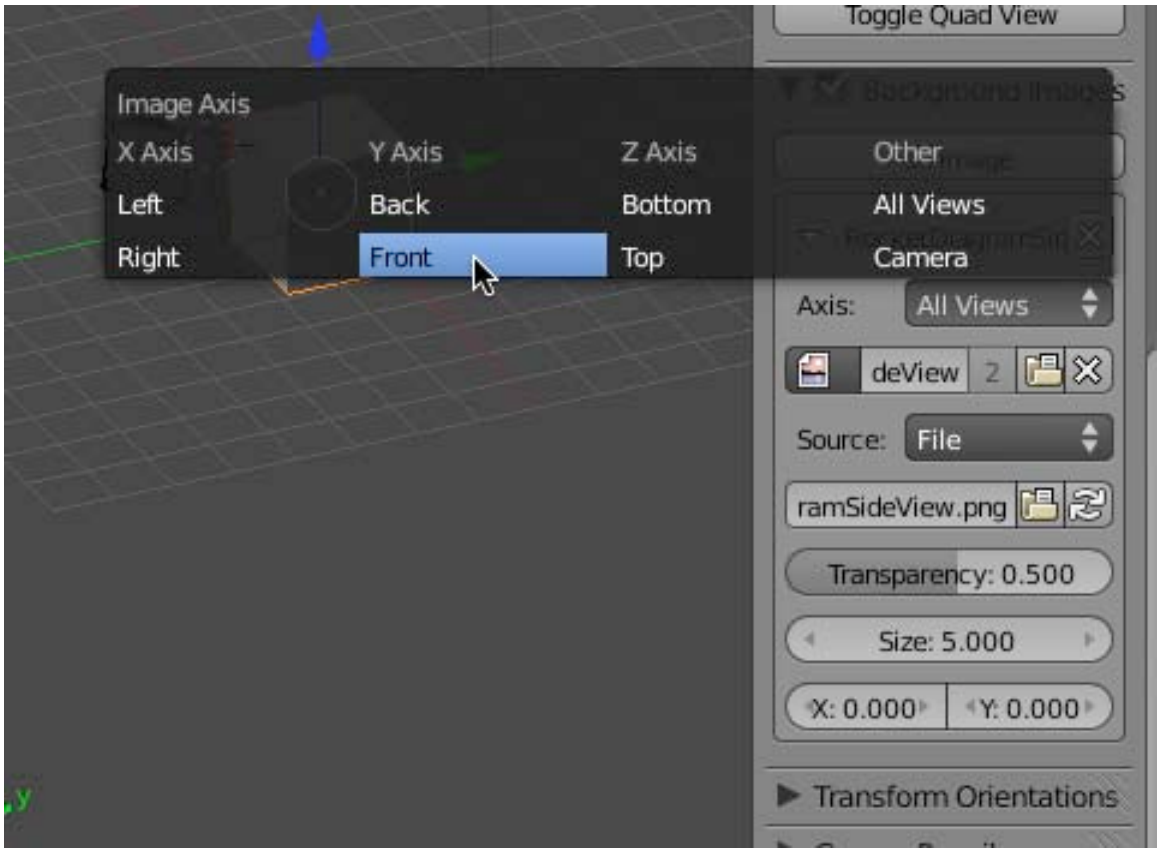


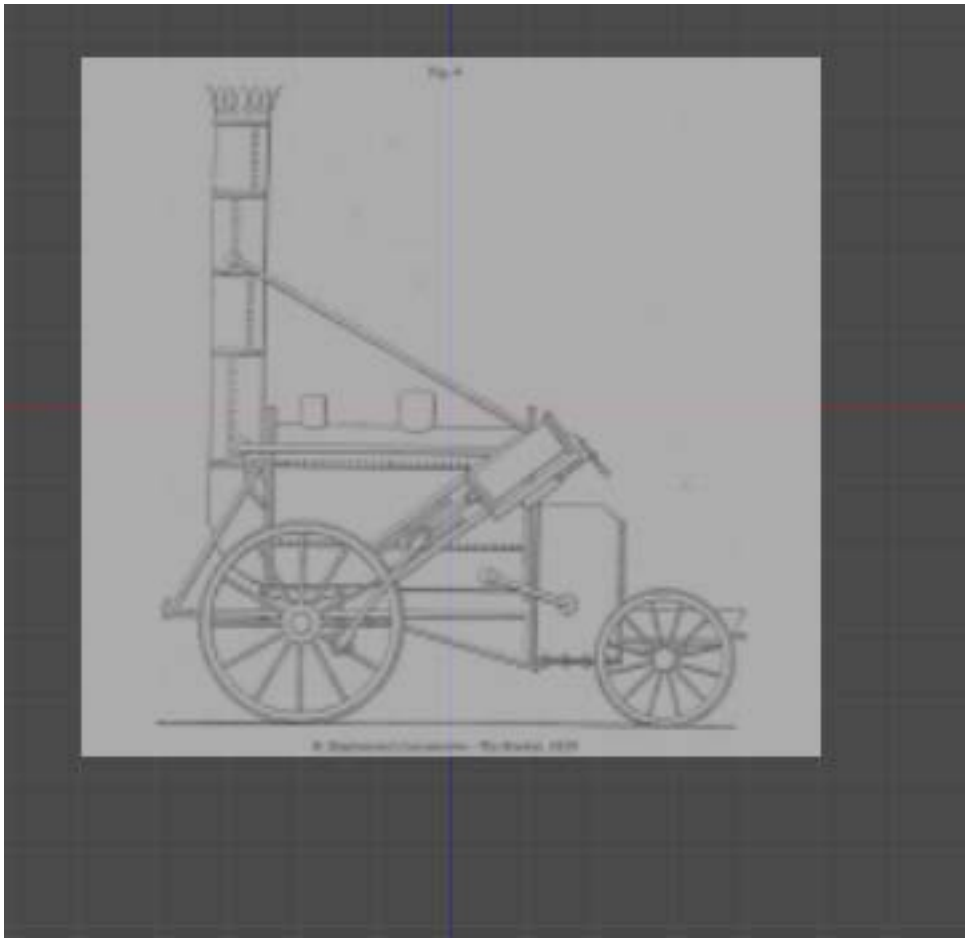
This will display reveal the “Open” button. Instead of clicking on the open button, click on the **Browse ID data** icon.



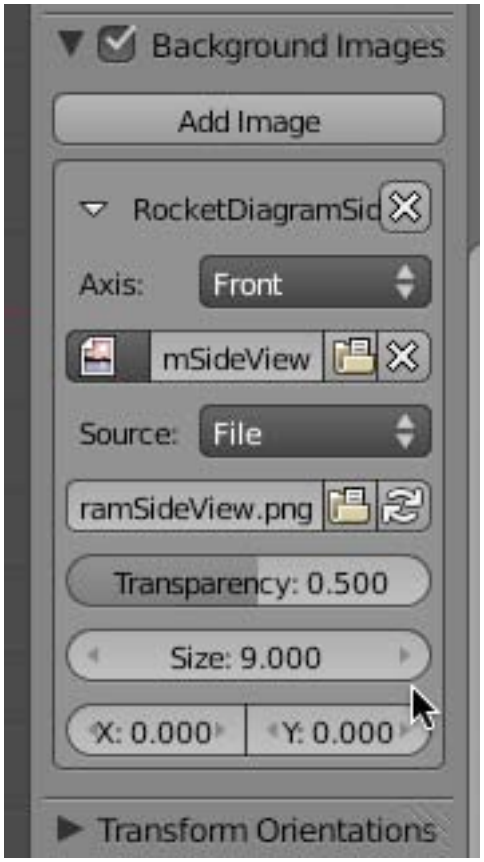
Select the RocketDiagramSideView.png file. This will then display the file listed in a path box along with additional controls.

Click on the Axis dropdown box (all views) and select Front view.
The background image should now appear in front view.





The background image will not render. It is used only as a guide. In the Background Images Panel set the Size to 9.0 and the transparency to .5

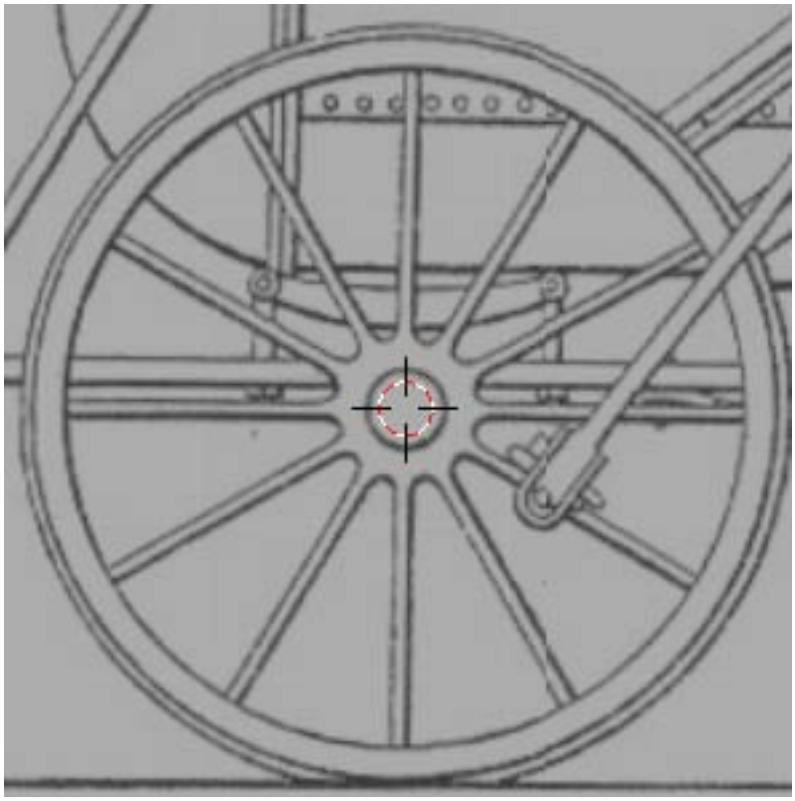


Modeling:

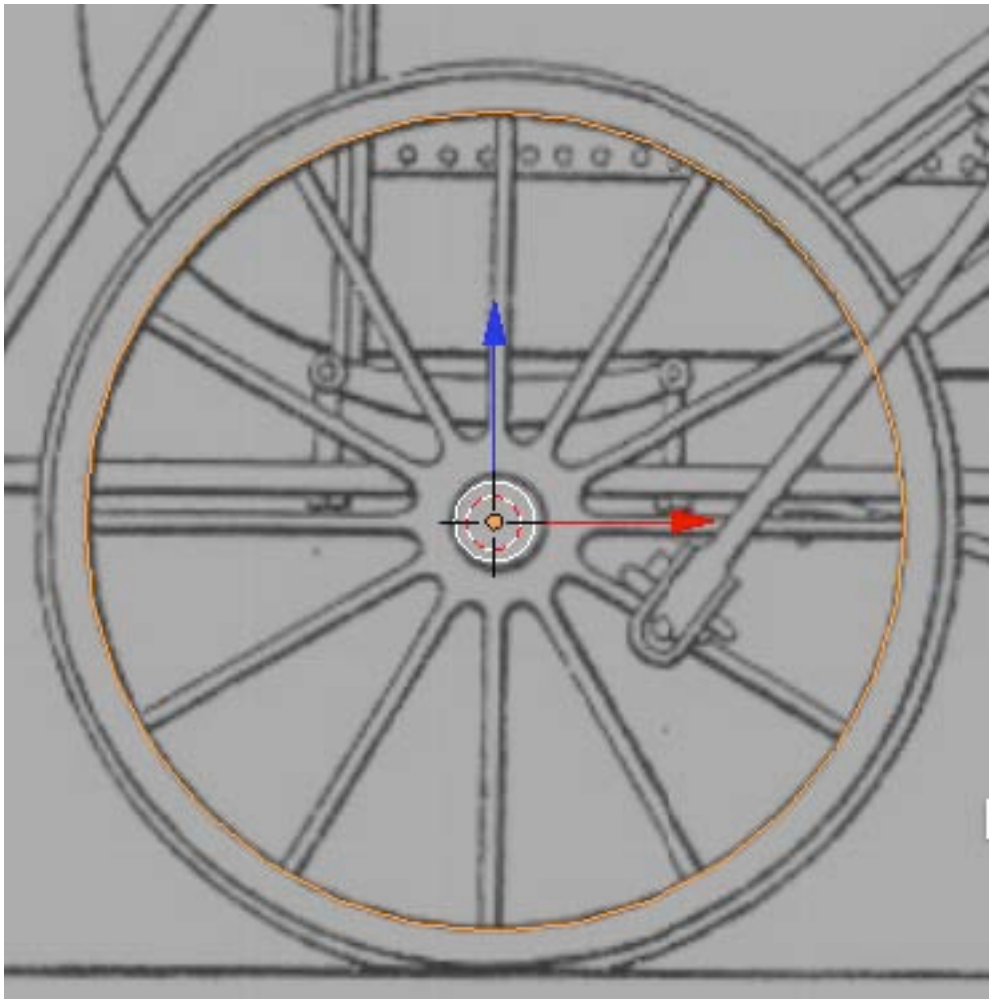
We will begin by modeling the drive train, which is the most critical part of the final animation.

We will deviate from the background image a bit and place the drive train in a horizontal position rather than at an angle as the background image represents. Stephenson himself made this alteration on the second version of "The Rocket" as it imparted more power to the wheel. Go to front view In the 3D editor Viewport properties panel, set your cursor at X, Y, Z = 0. (This will put your and my cursor on the same axis pane)

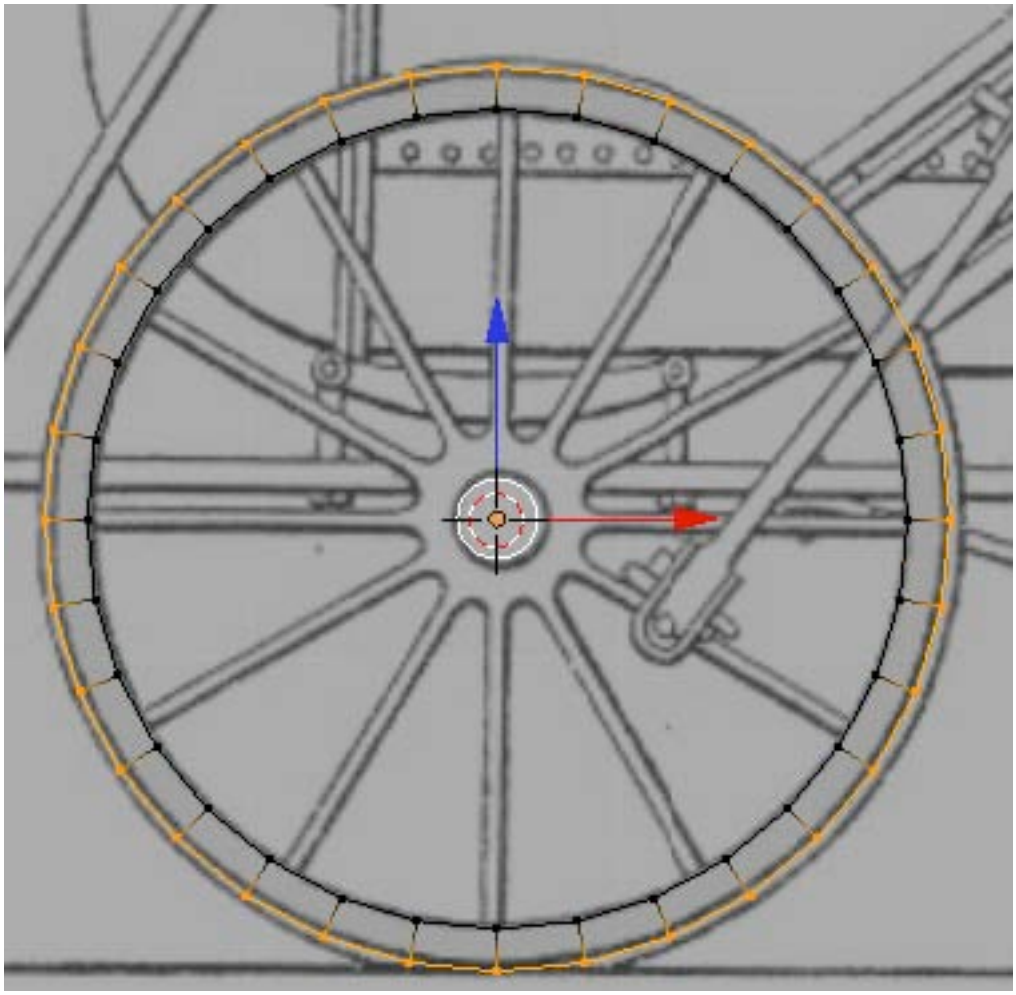
Next, place your 3D cursor in the center of the front wheel as seen through the background image.



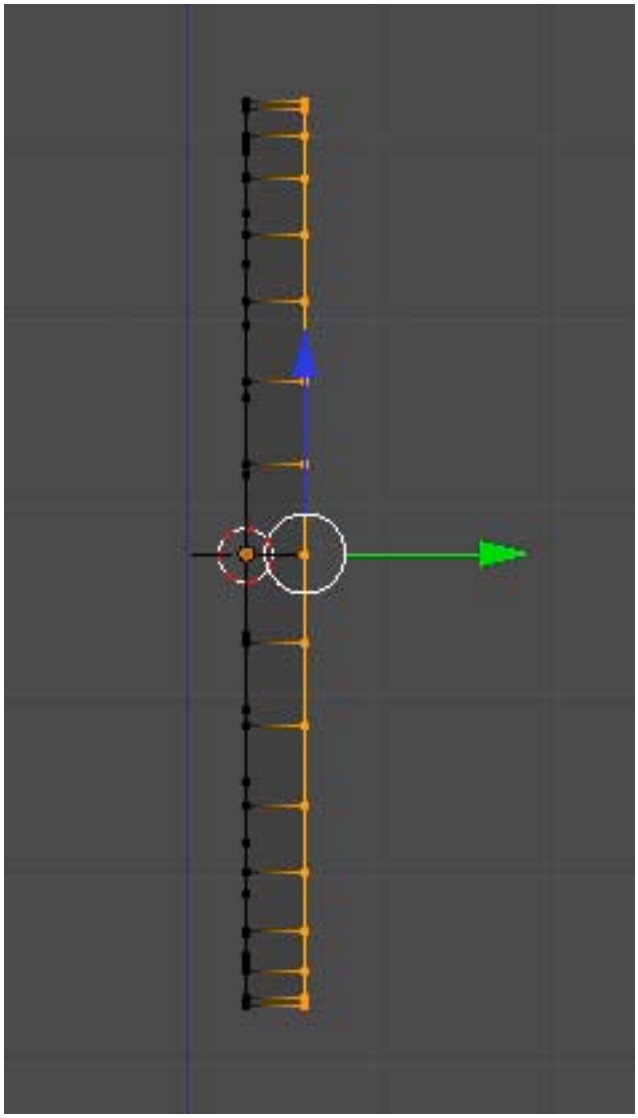
Press SHIFT-A and add a circle object. (Make sure it is not filled) In the 3D editor properties panel set the X rotation to 90 degrees. Scale the circle so that it fits the inside of the wheel rim as shown below.



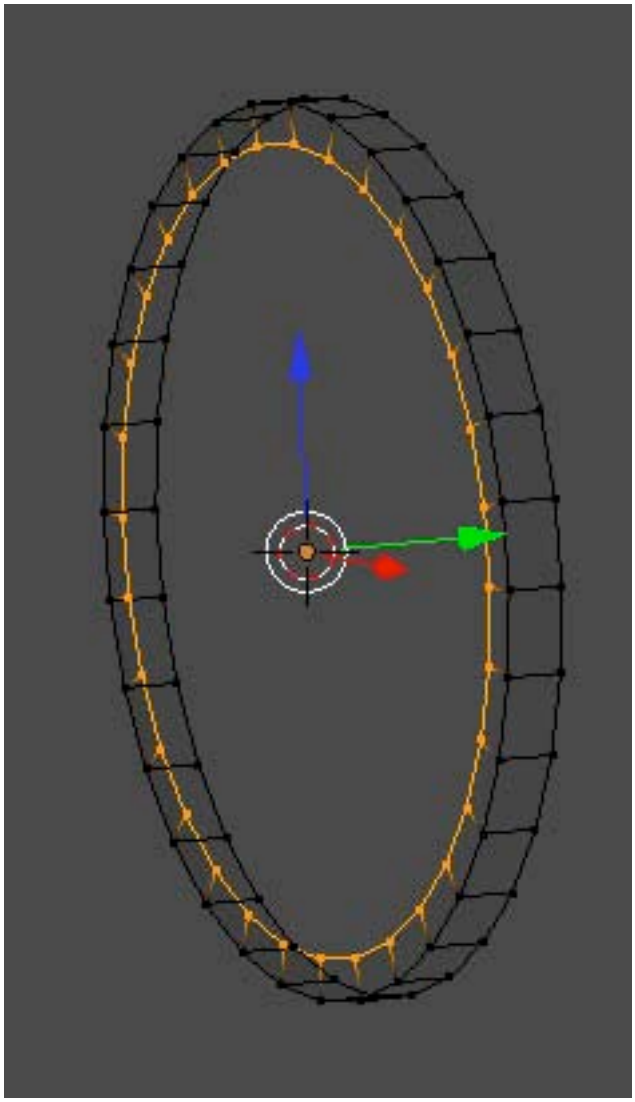
TAB into edit mode. With all of the vertices selected, Press the EKEY followed by the SKEY and extrude /scale the vertices out to the next edge of the wheel rim as shown below.



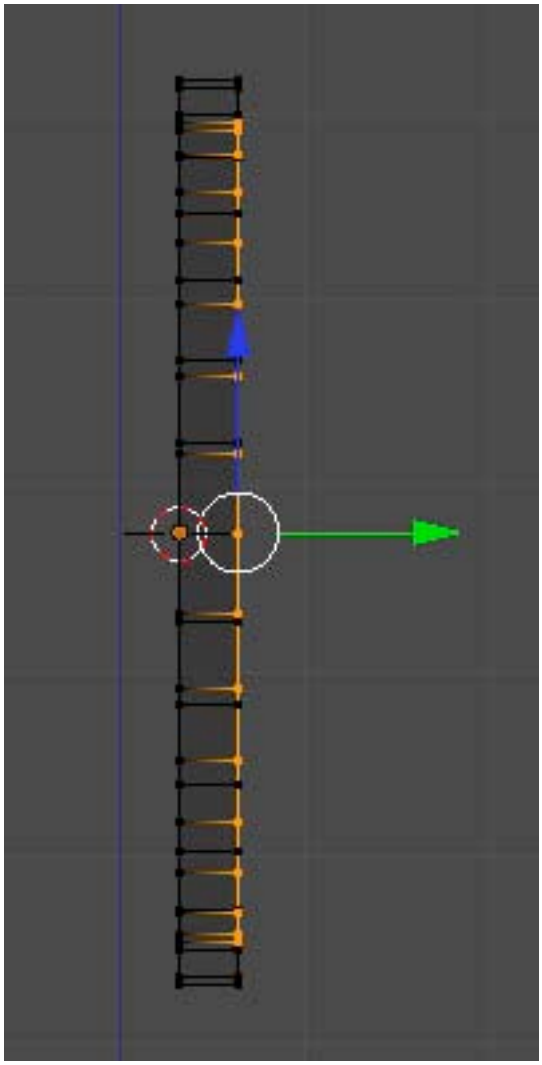
Go to side view. Extrude the vertices along the Y-axis a bit as shown below.



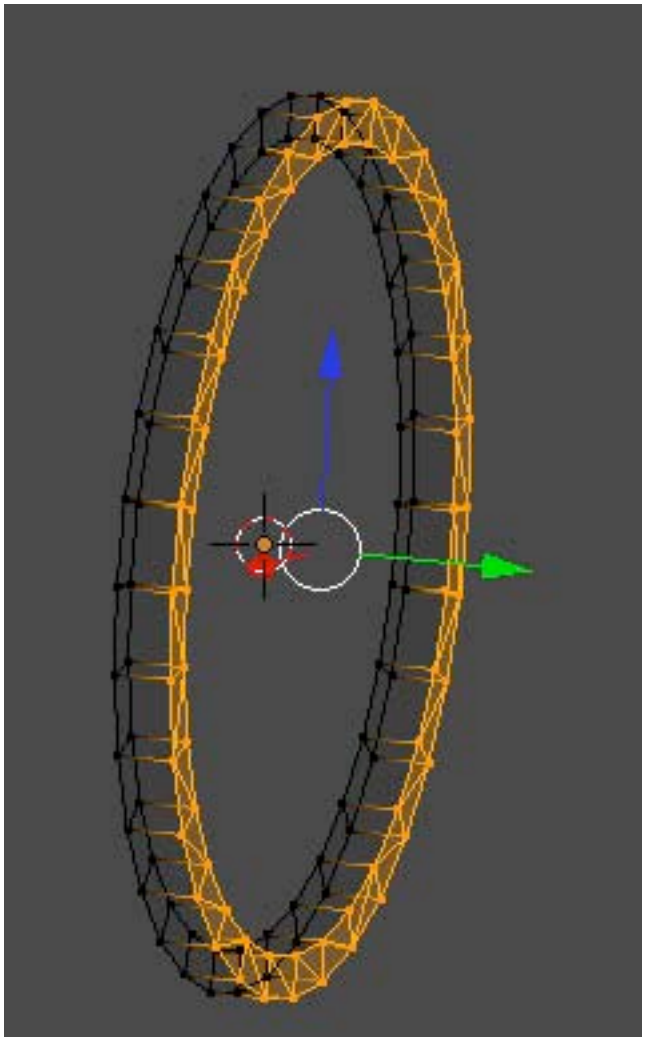
Deselect the vertices. Rotate your view a bit so you can see the original set of vertices. Hold your ALT button down and right-click select one of the vertices. This will loop select the ring of vertices.



Go to side view. Extrude the vertices along the Y-axis a bit as shown below.



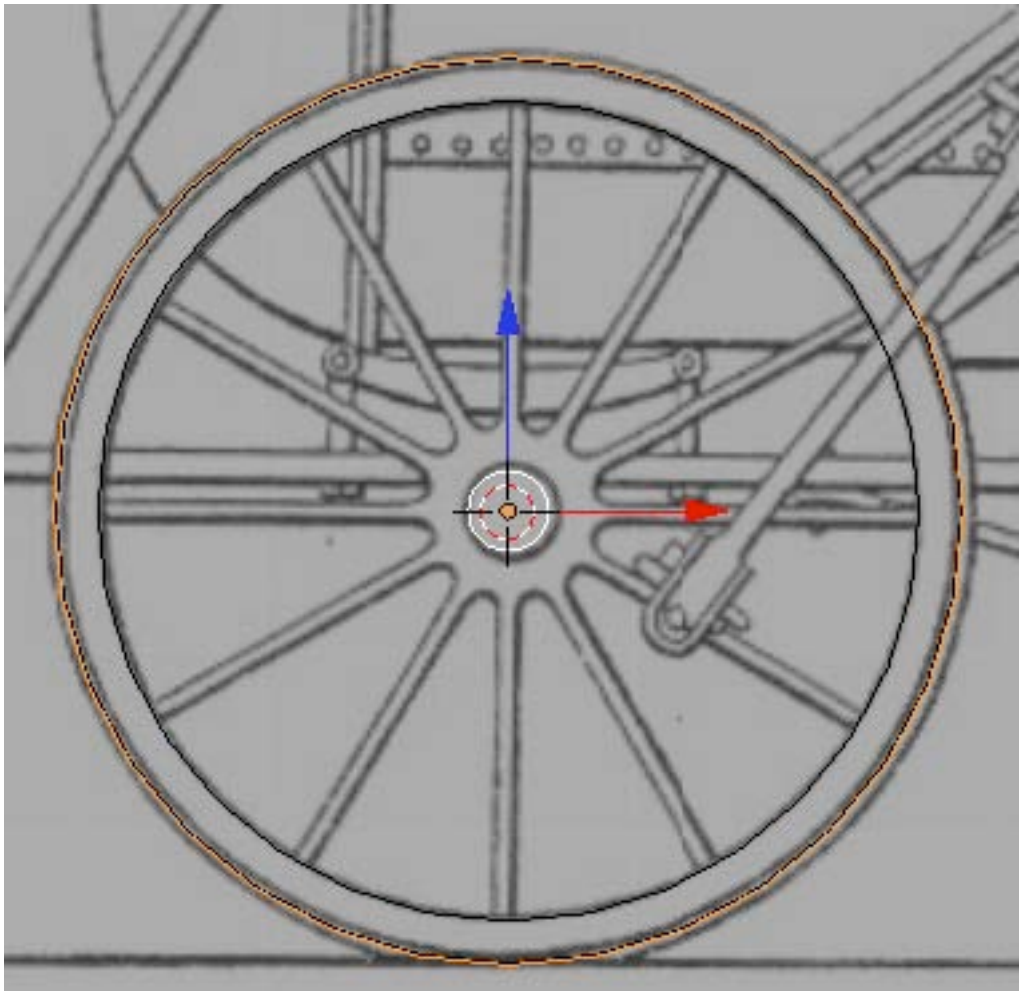
Deselect the vertices. Box select all of the right vertices and then press ALT-F, which will create faces for the right side of the wheel rim.



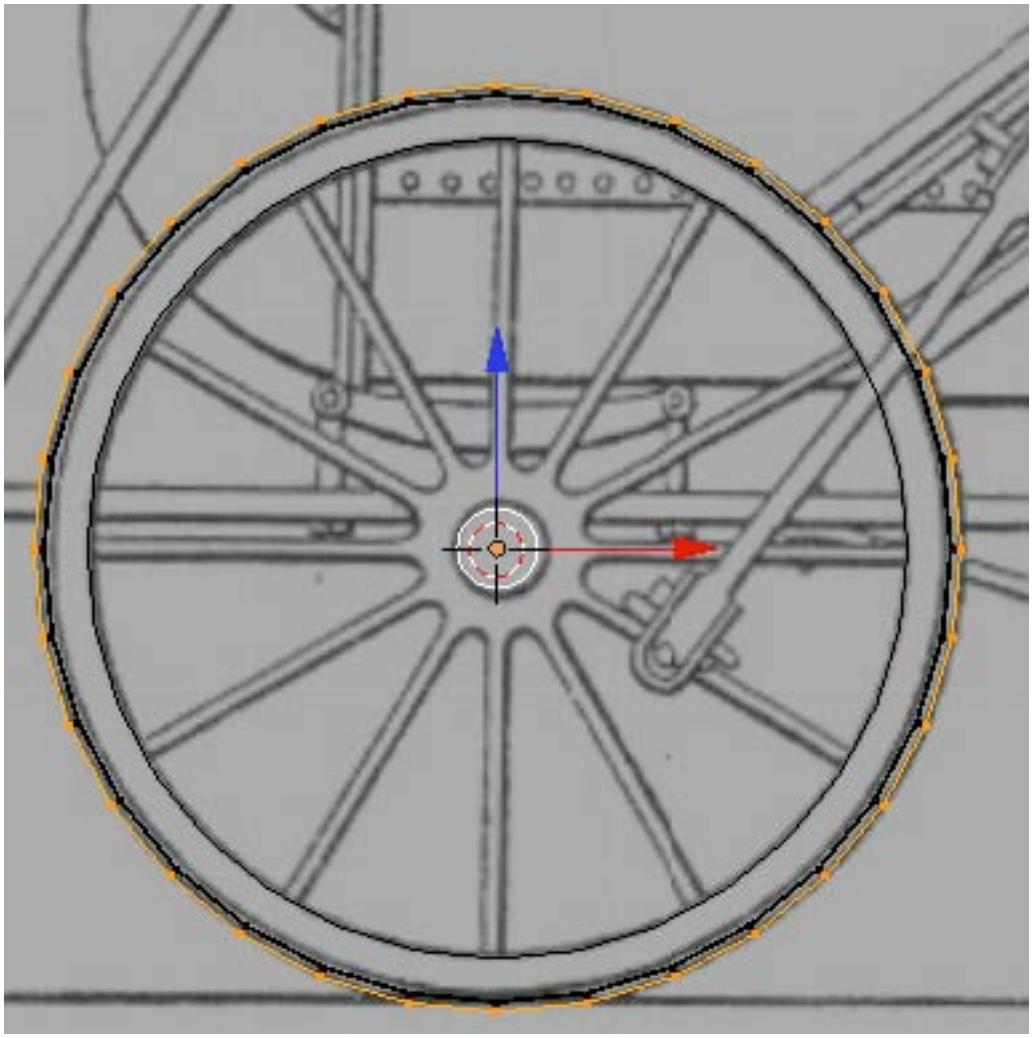
Deselect the vertices. TAB out of edit mode --Go to front view.

With the object still selected, Press SHIFT-S (Snap Menu) and choose “cursor to selected” this will place the cursor at the origin point of the object we are working on.

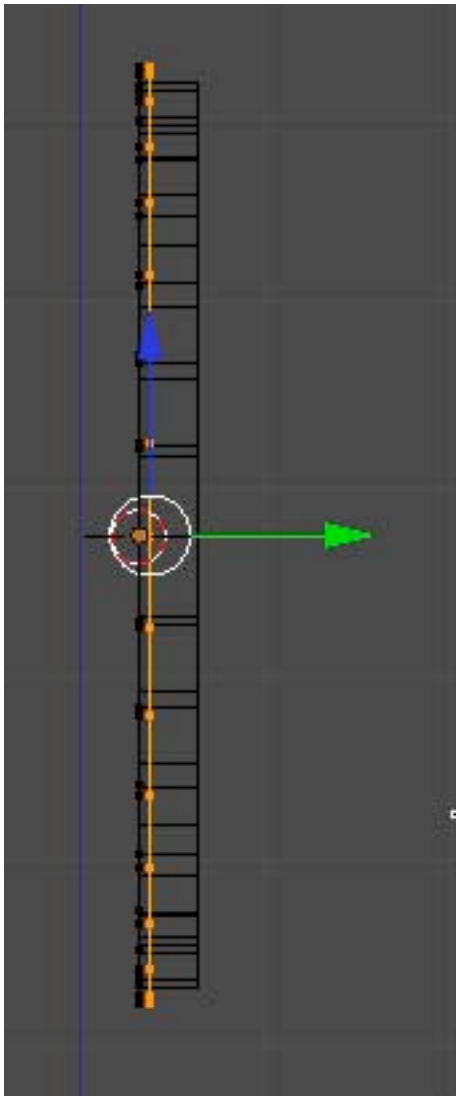
Press SHIFT-A and add a circle object. In the 3D editor properties panel set the X rotation to 90 degrees. Scale the circle to the edge of the rim as shown below.



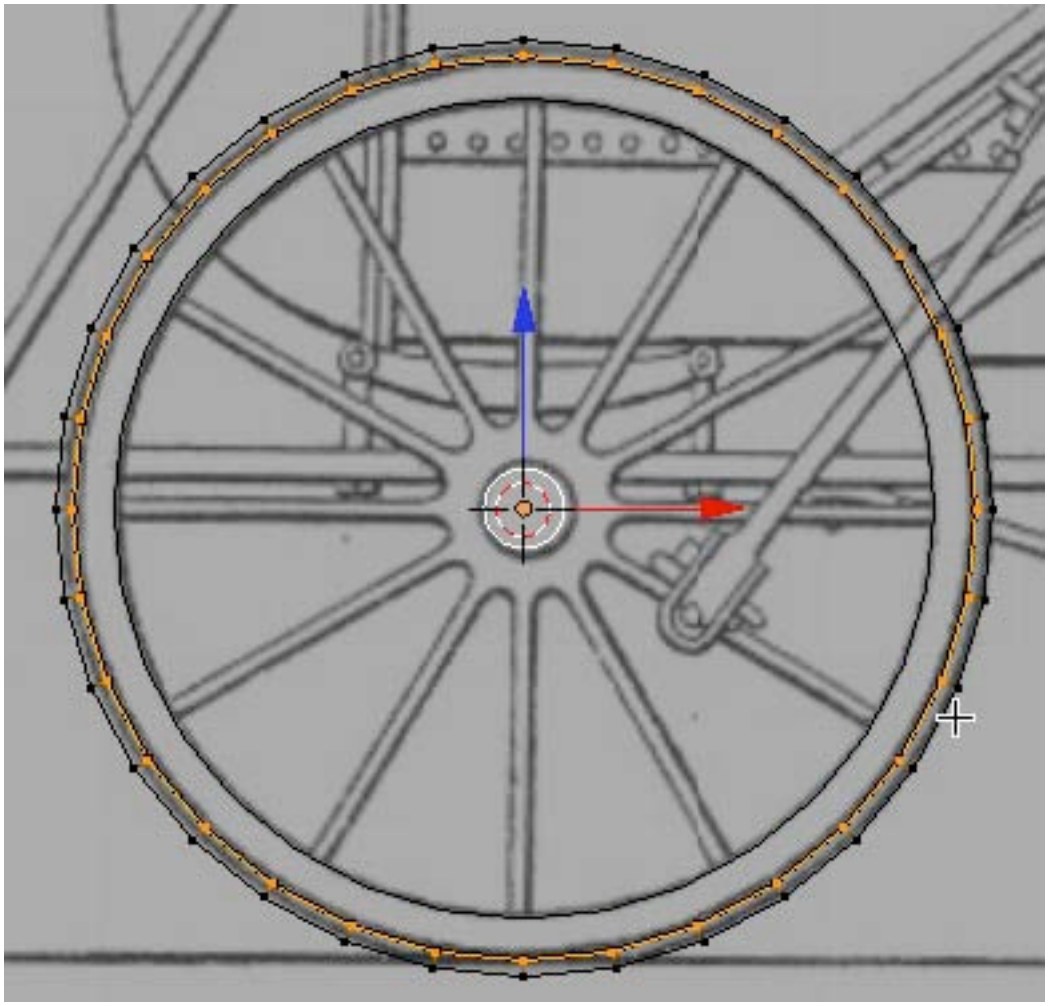
TAB into edit mode. With all of the vertices selected, Press the EKEY followed by the SKEY and extrude /scale the vertices out to the far edge of the wheel rim as shown below. (Note: this is ever so slight an extrusion. You may want to hold down your SHIFT key while extrude/scaling the vertices)



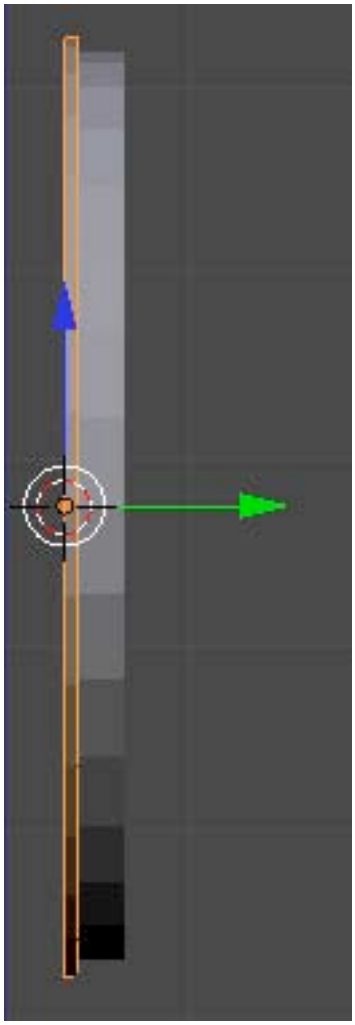
Go to side view. Extrude the vertices very slightly to the right along the Y-axis as shown below.



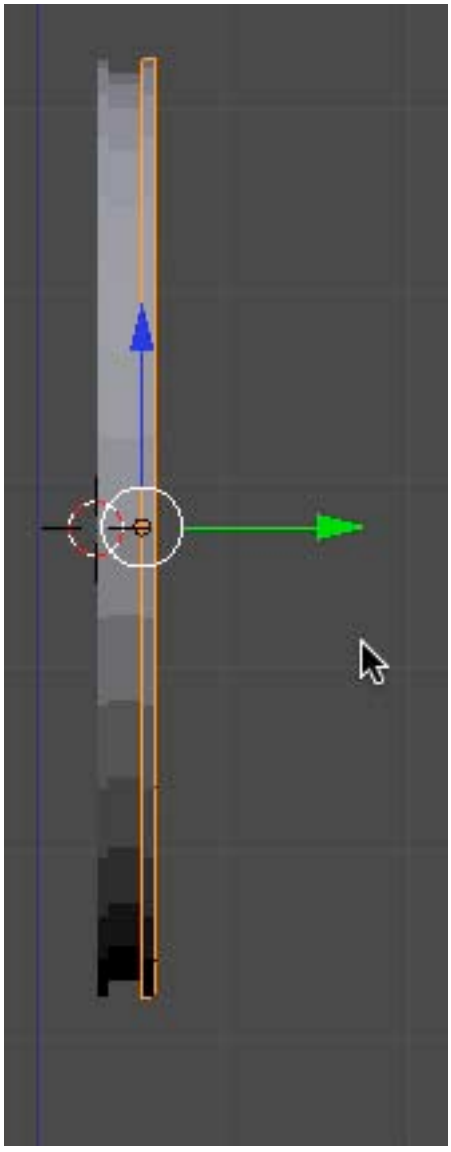
Go to front view. Extrude /Scale the vertices down a very slight bit as shown below.



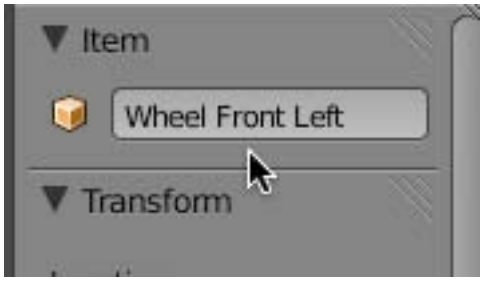
Deselect the vertices—TAB out of edit mode.—Go to solid display mode Go to side view This is one of the wheel edges that will extend over the railroad track.



With the object selected Press SHIFT-D followed by the YKEY and place the duplicate copy of this object on the other edge of the wheel as shown below.



Select all 3 objects and the press CTRL-J and join them into one object. Name this object “Wheel Front Left”.

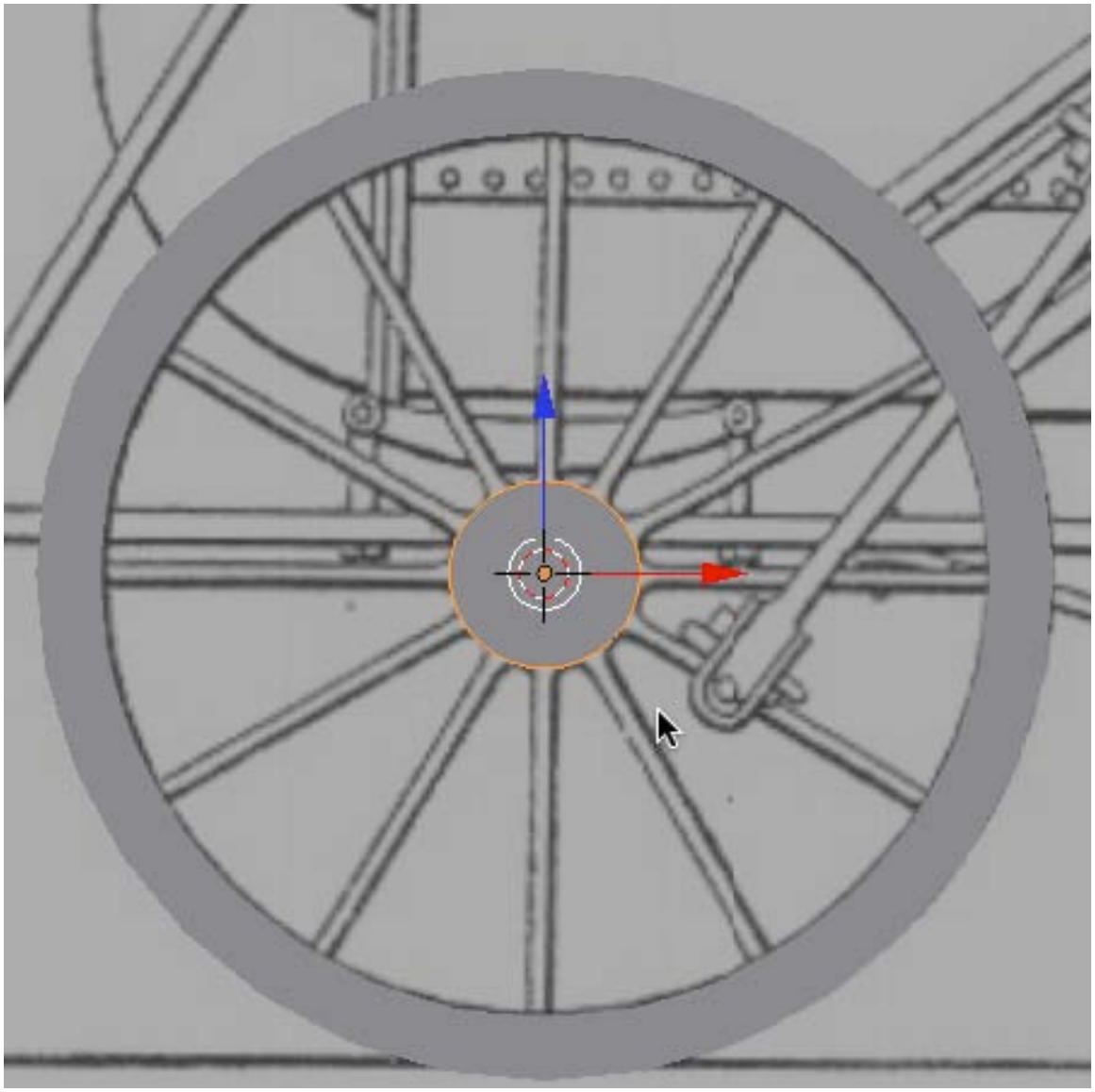


Go to front view.

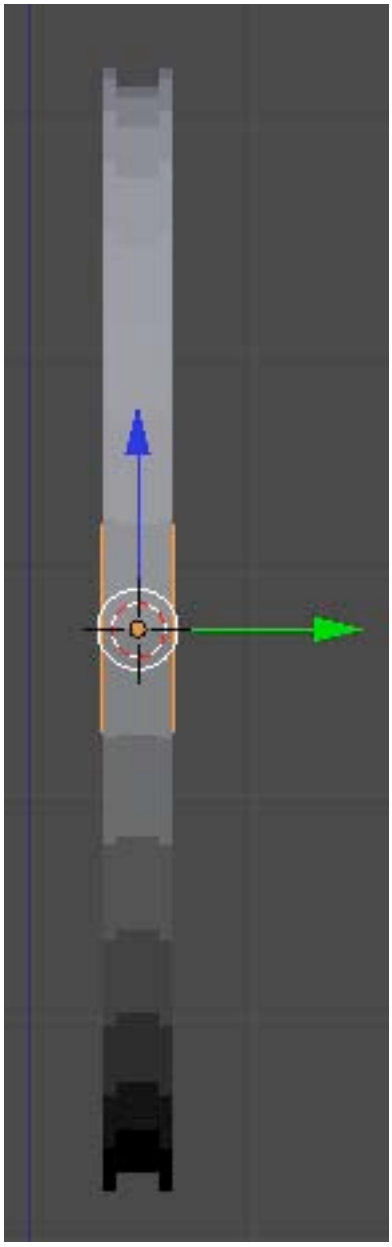
With the wheel front left selected, press SHIT-CTRL-ALT-C and select Origin to Geometry. This will place the center point origin in the center of the wheel front left object.

With the wheel front left still selected, press SHIFT-S and select cursor to selection. This will place the cursor at the wheels origin point.

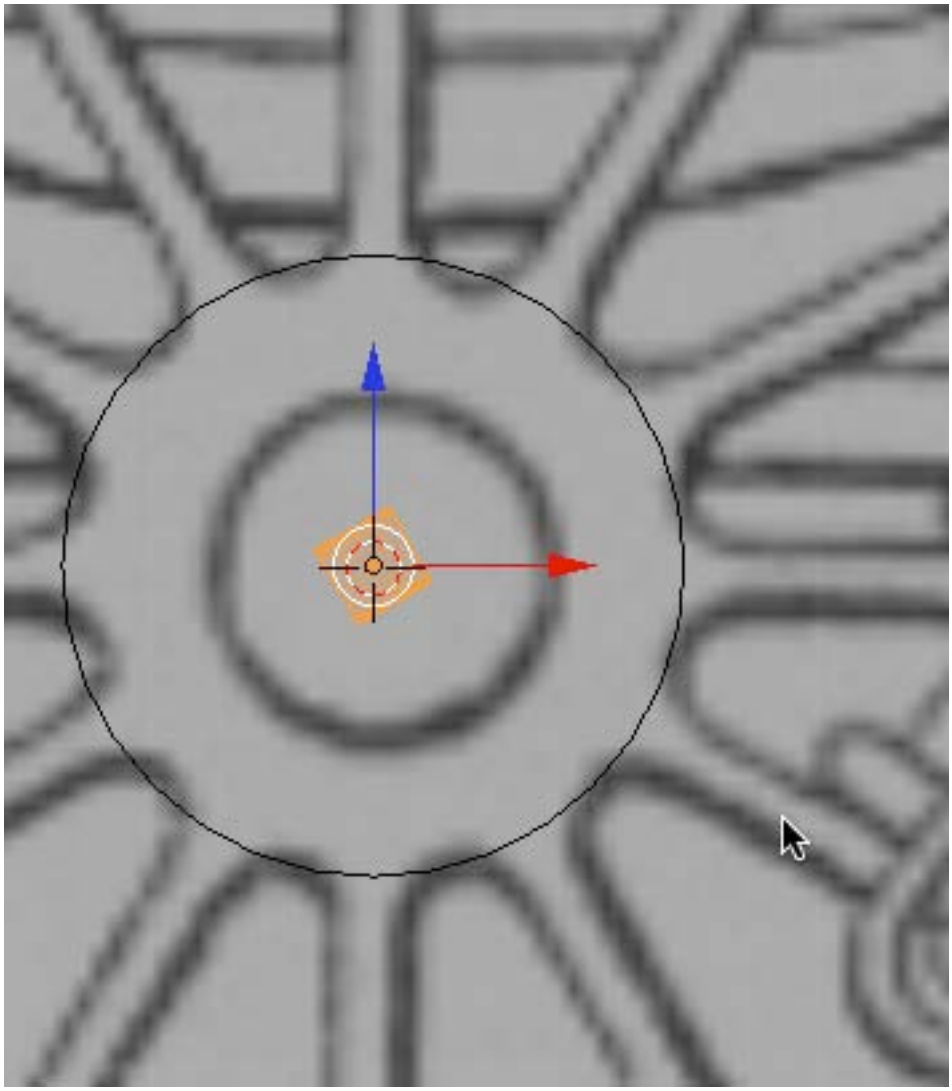
Press SHIF-A and add a tube object (make sure the tube object has its ends capped). In the 3D editor properties panel, rotate the tube 90 degrees around the X-Axis.
Scale the tube to the wheel hub as shown below.



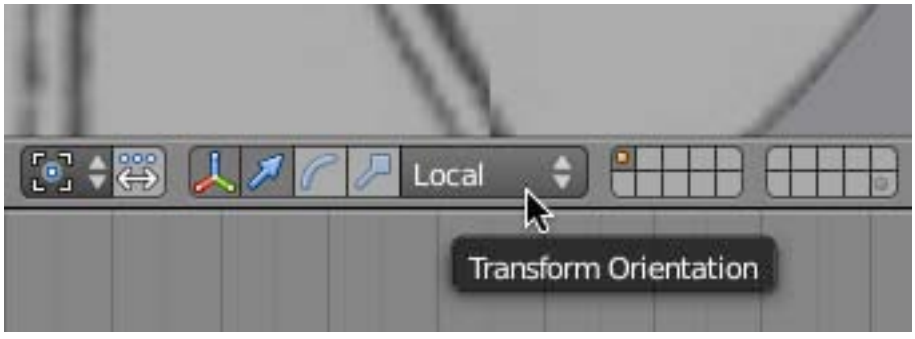
Go to side view. Press the SKEY followed by the YKEY and scale the tube to the width of the wheel as shown below.



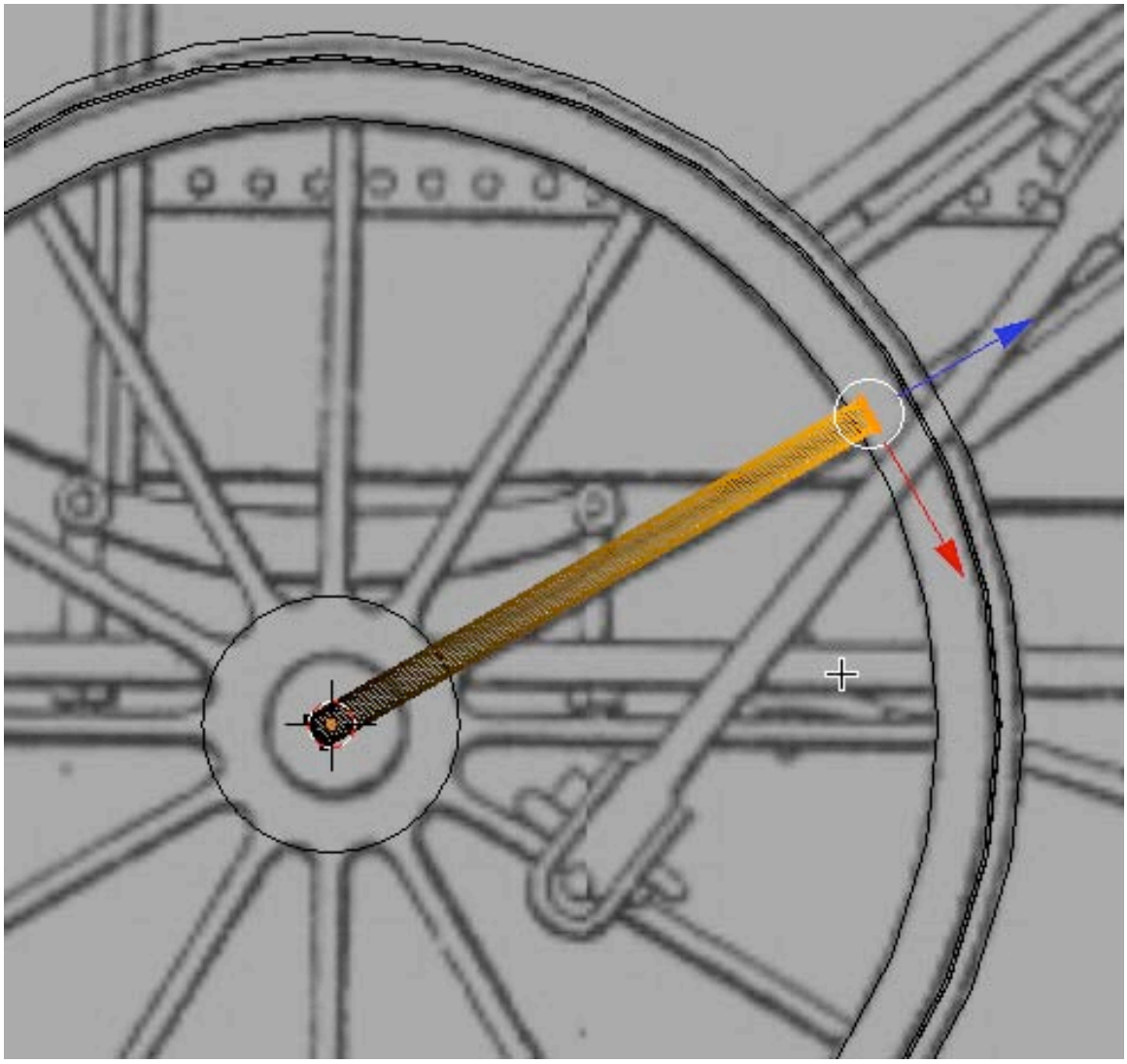
Go to front view. Press SHIFT-A and add a tube object. In the 3D editor properties panel, set the Y rotation to 60 degrees. Go to wireframe display mode. Scale the tube down to about the thickness of the wheel spokes as shown below.



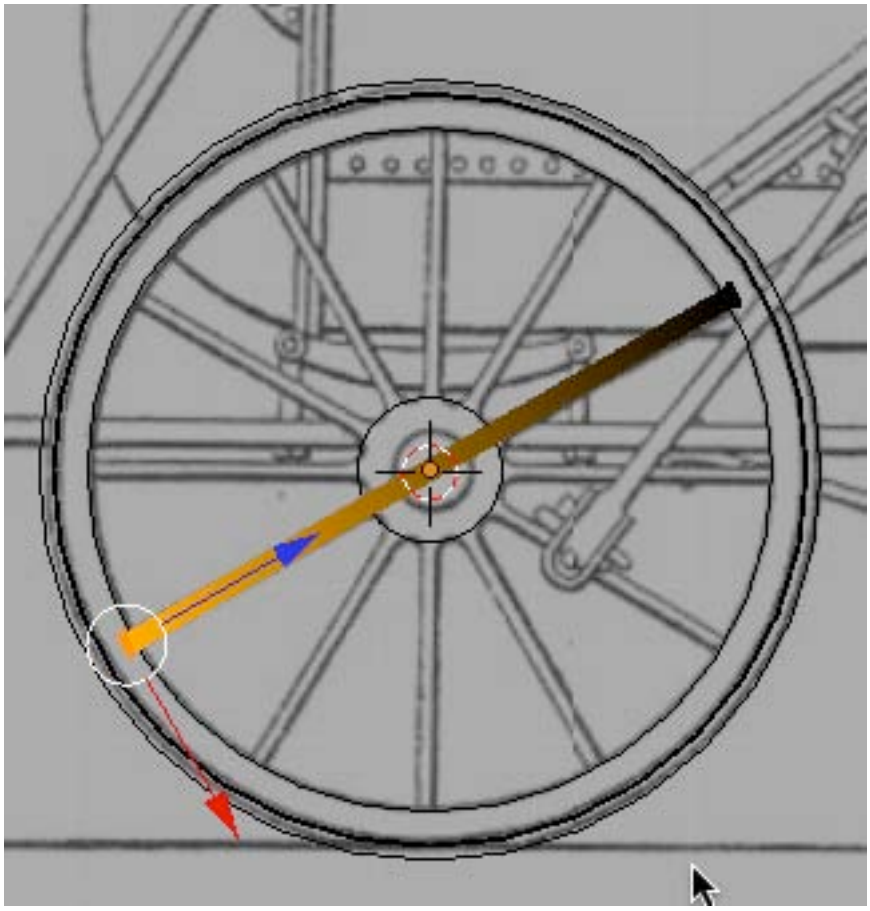
Change the transform orientation to Local.



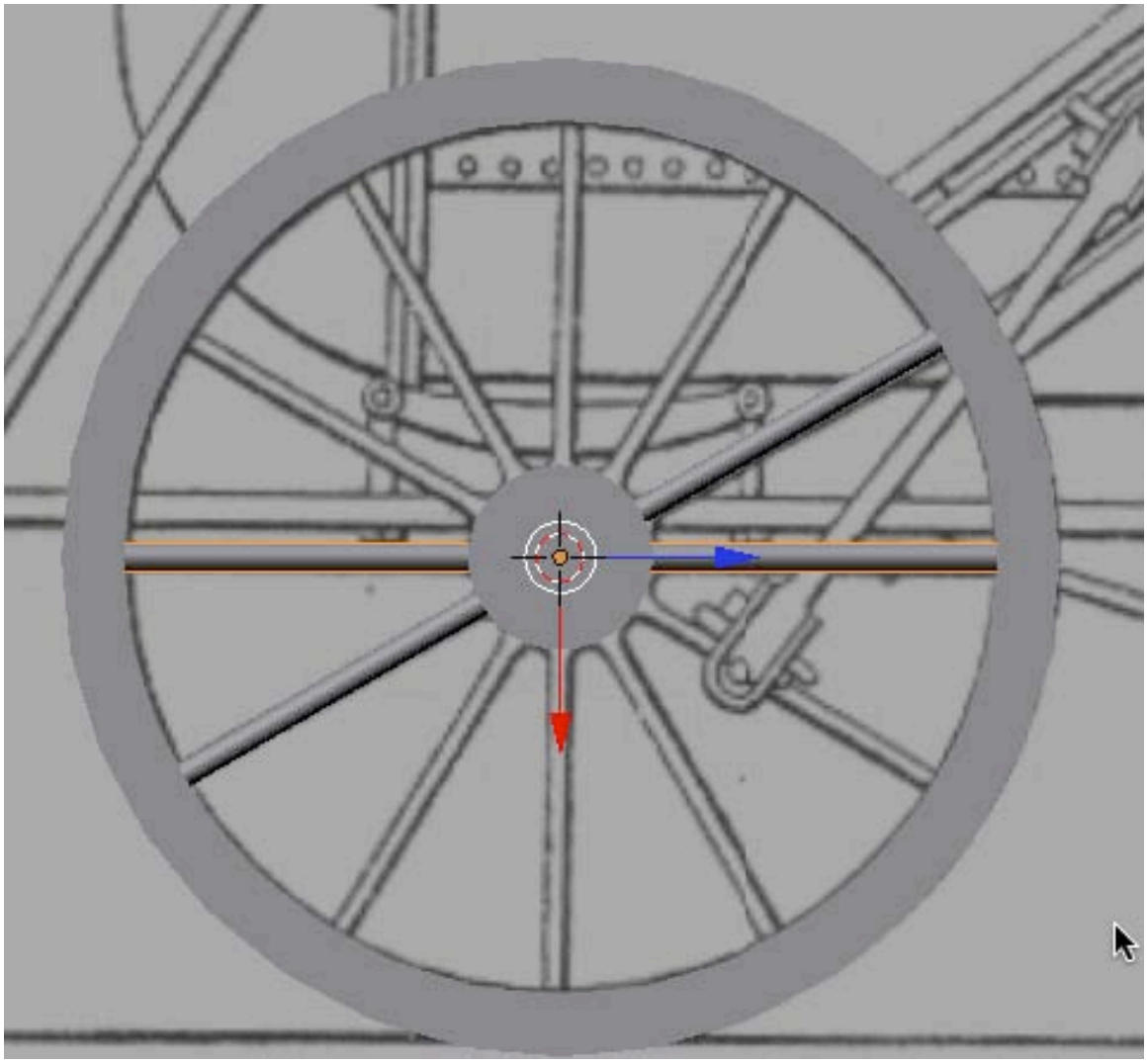
Tab into edit mode.—Deselect the vertices
Box select the right vertices of the tube and move them up along the Local Z-axis as shown below.



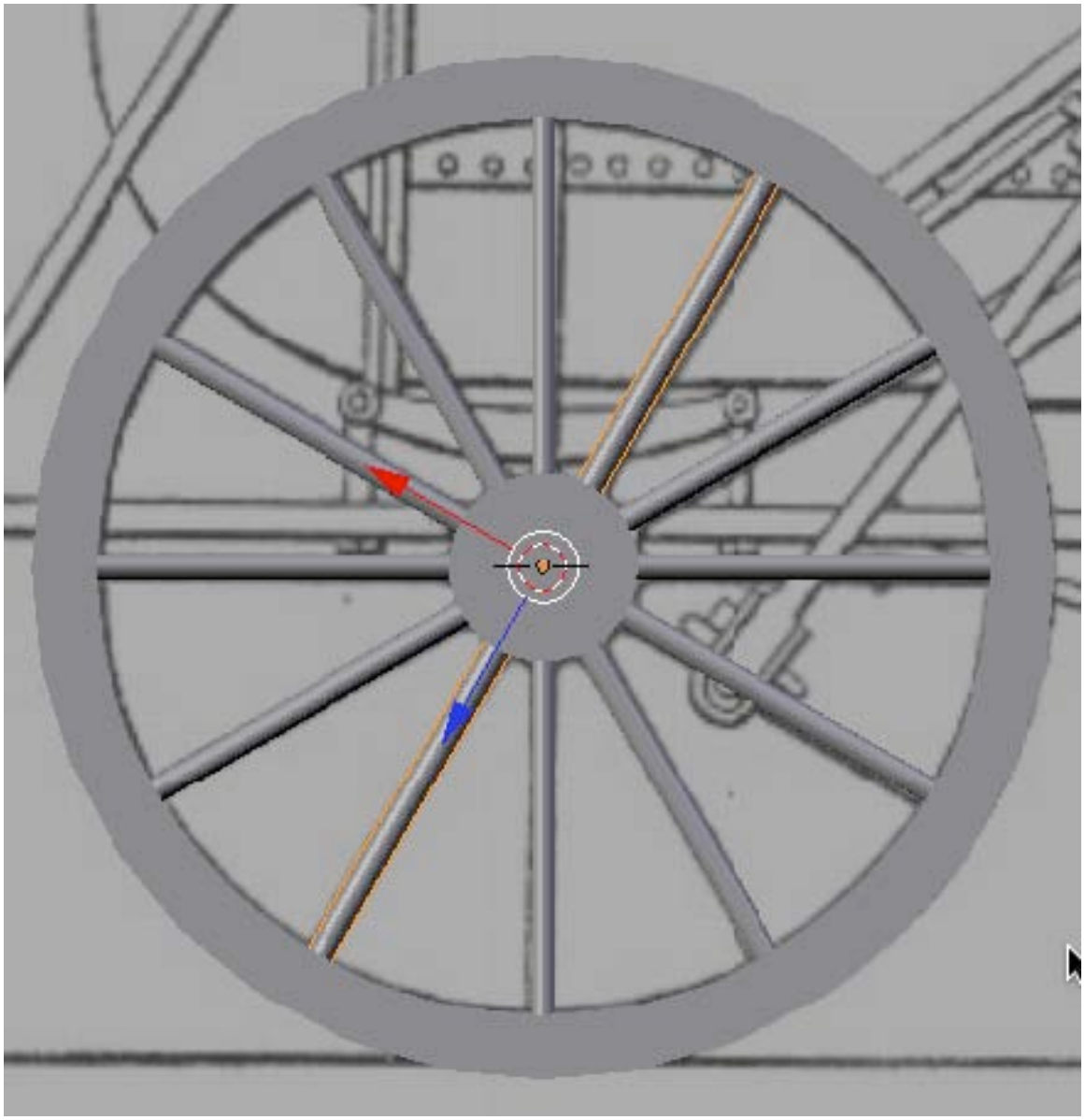
Deselect the vertices. Box select the left set of the tube's vertices and move them the opposite direction along the Local Z-axis as shown below.

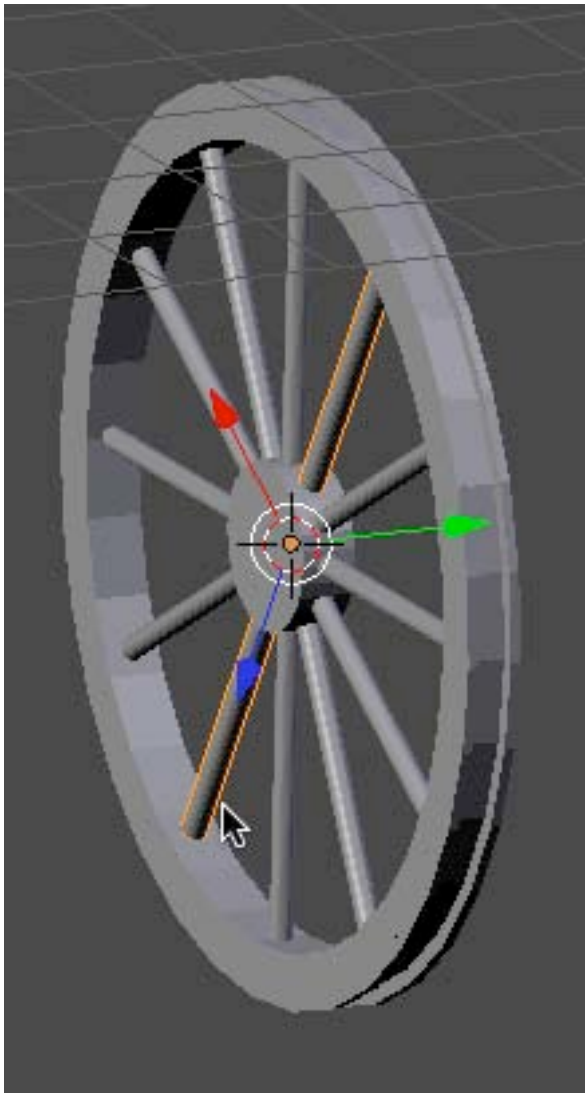


Deselect the vertices.—TAB out of edit mode.—Go to solid display mode.
With the object selected press SHIFT-D followed by R-30 then press the ENTER button. This will make a duplicate copy of the spoke object and rotate it 30 degrees.

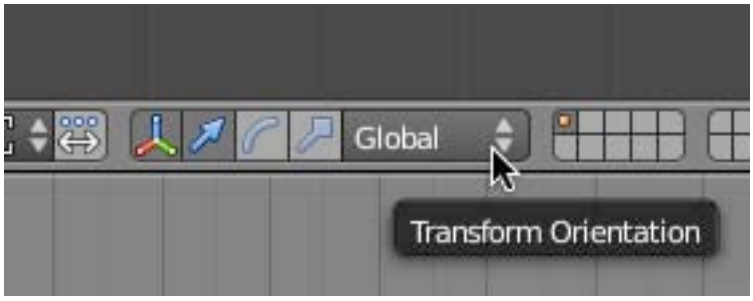


Repeat this duplication procedure 4 more times. This will create all of the wheel spokes/ If you rotate your view a bit you will see the spokes are in the center of the wheel.





Go to front view. Select all of the spokes, then add the center hub object to the selection and finally add the wheel front left to the selection. Then press CTRL-J and join the objects into one object (This should be the Wheel Front left object).
SWITCH BACK TO GLOBAL TRANSFORM ORIENTATION.



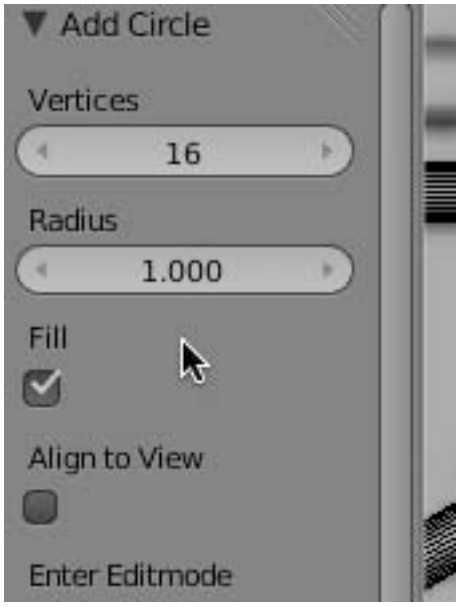
Save your Blender file.

The steam engine drive chain consists of 7 objects (wheel, crank, crank pin, connecting rod, locking pin, piston rod and piston).

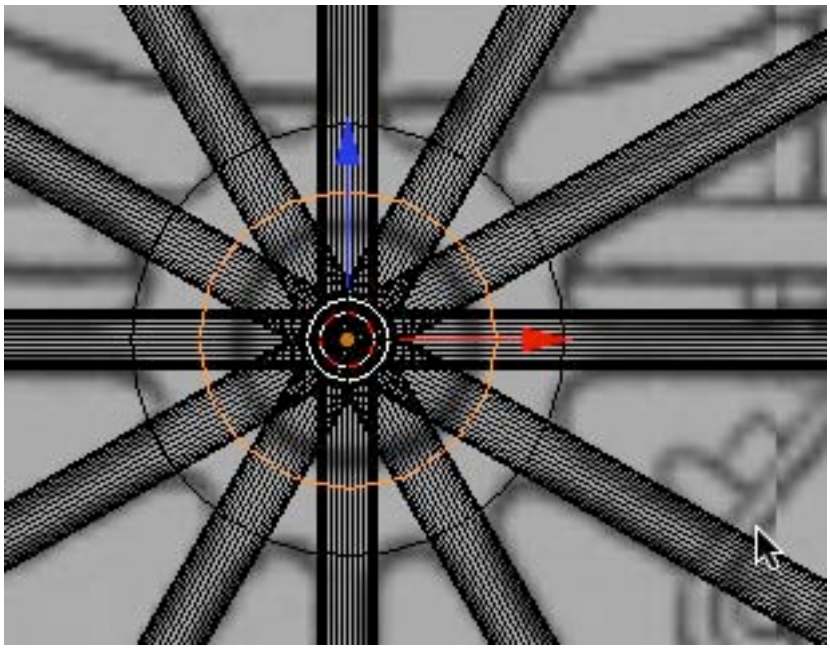
We have modeled the wheel and will now model the crank. Select the wheel front left object.

Press SHIFT-CTRL-ALT-C and select origin to geometry.

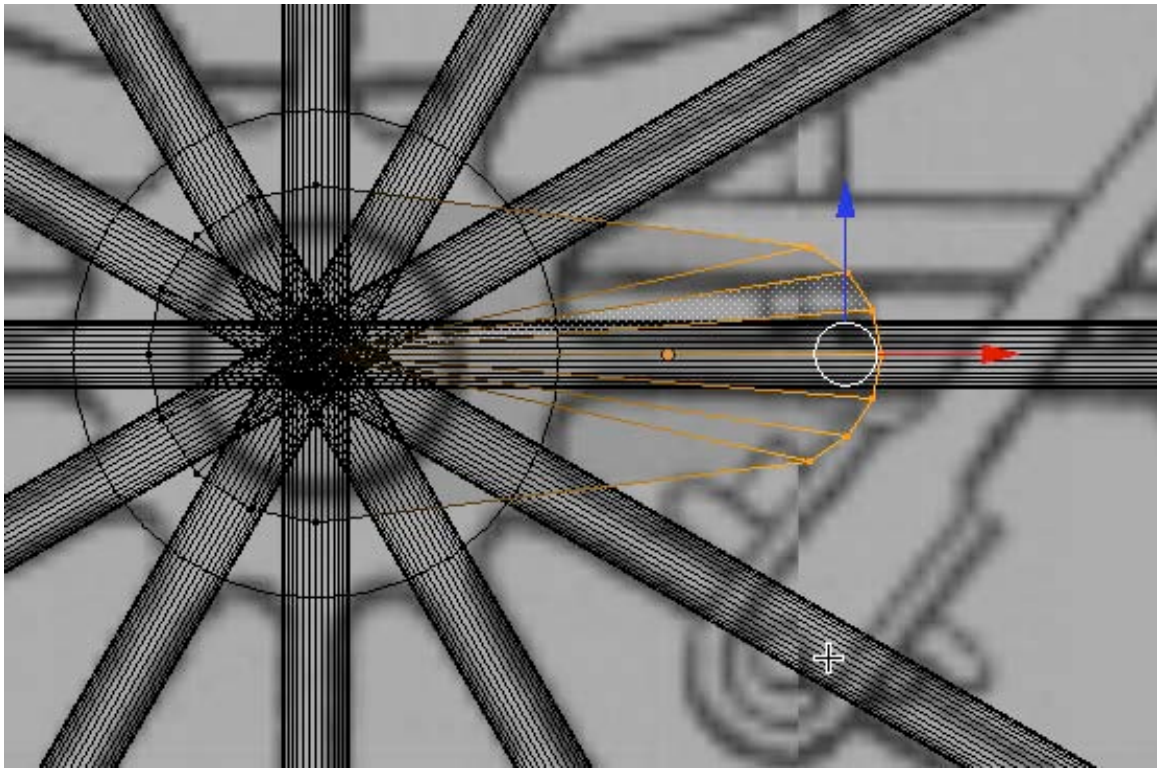
Press SHIFT-S and select cursor to selected. Deselect the object—Go to wireframe display mode. Press SHIFT-A and add a circle object (MAKE SURE THE CIRCLE OBJECT IS FILLED). In the 3D editor tools panel set the vertices to 16.



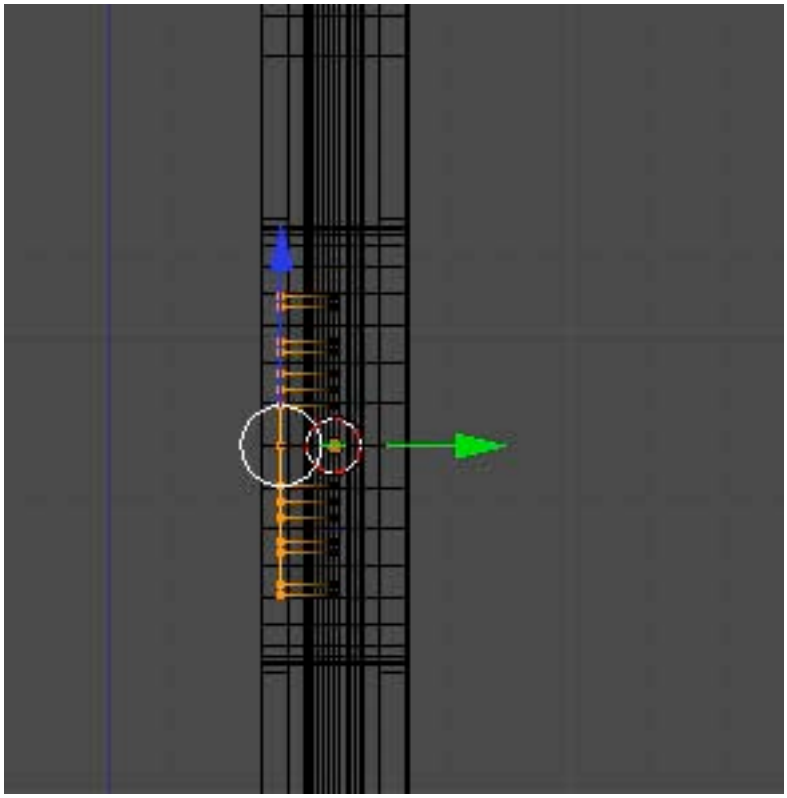
In the 3D editor properties panel set the X rotation to 90 degrees. Scale the object down to a bit smaller than the wheel hub as shown below.



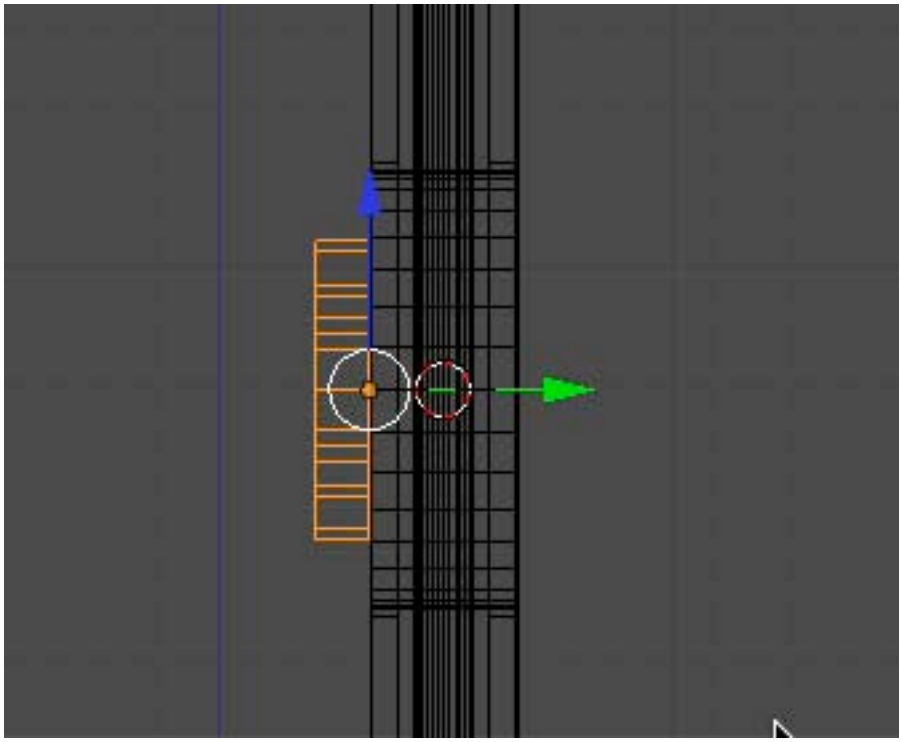
TAB into edit mode. Deselect the vertices. Box select the 7 right vertices and move them to the right along the X-axis, then scale them down a bit as shown below.



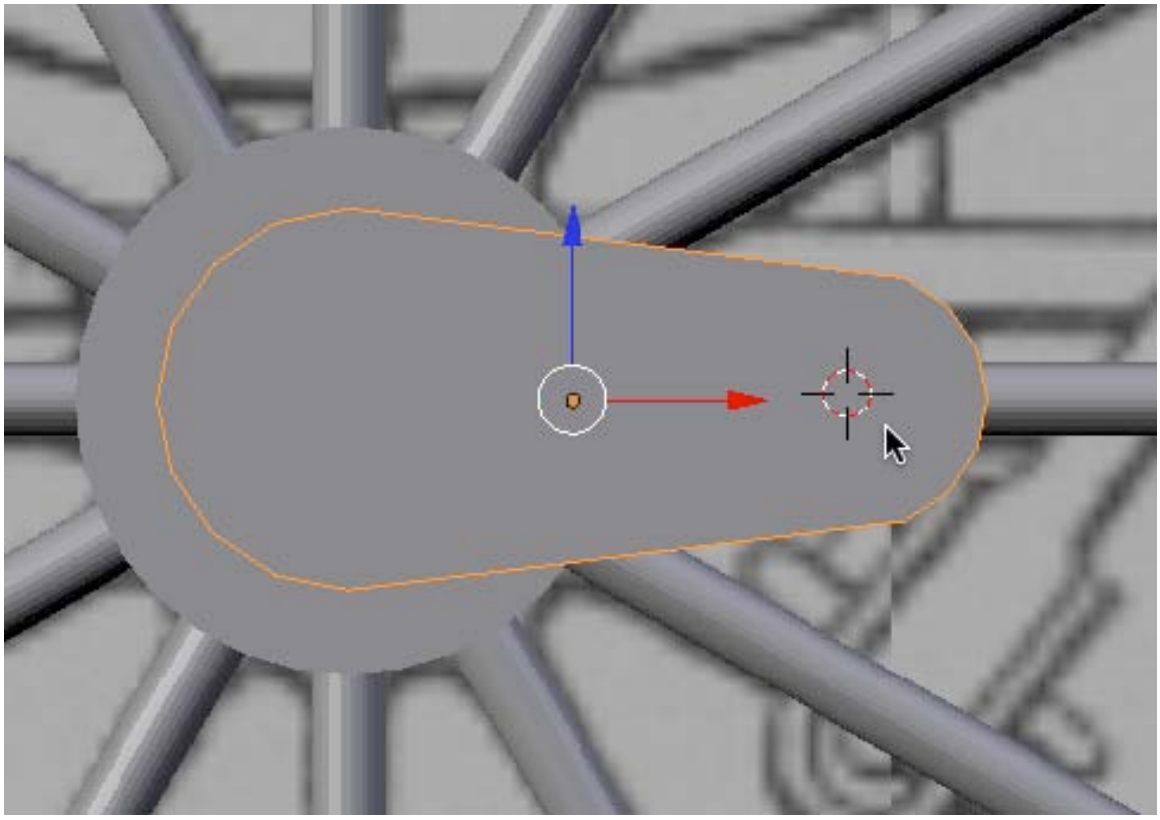
Select all of the vertices. Go to side view. Extrude the vertices to the left a bit along the Y-axis as shown below.



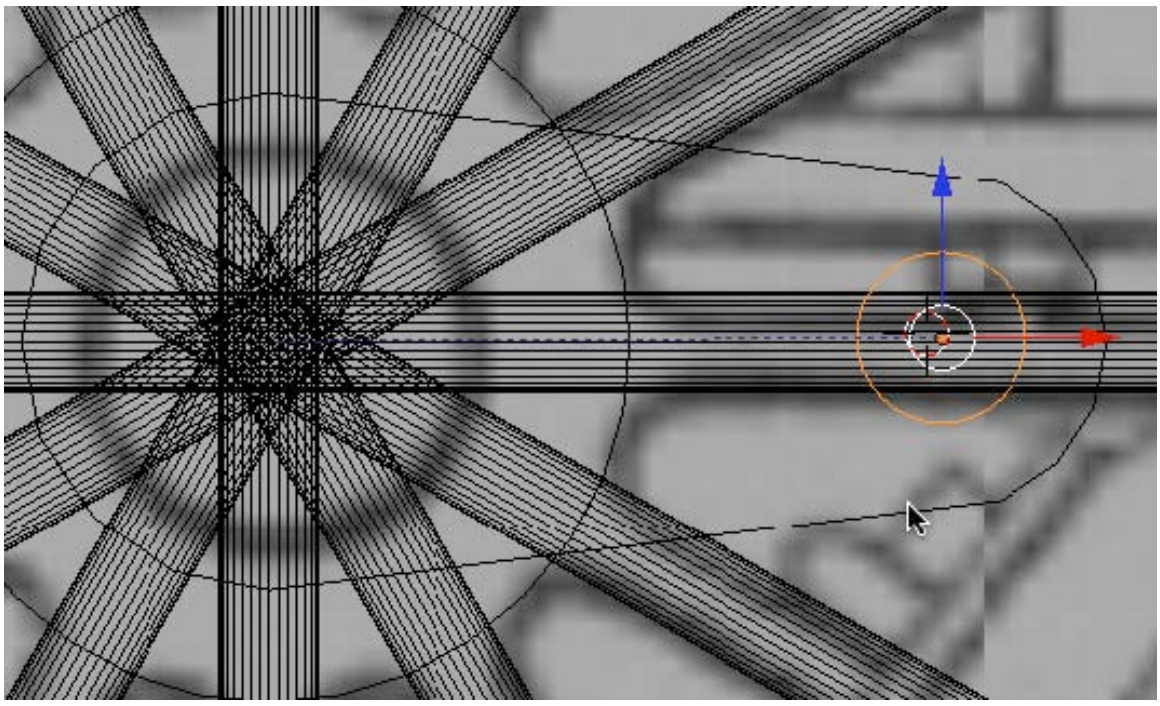
Deselect the vertices.—TAB out of edit mode Move this object along the Y-axis to the left edge of the wheel hub as shown below.



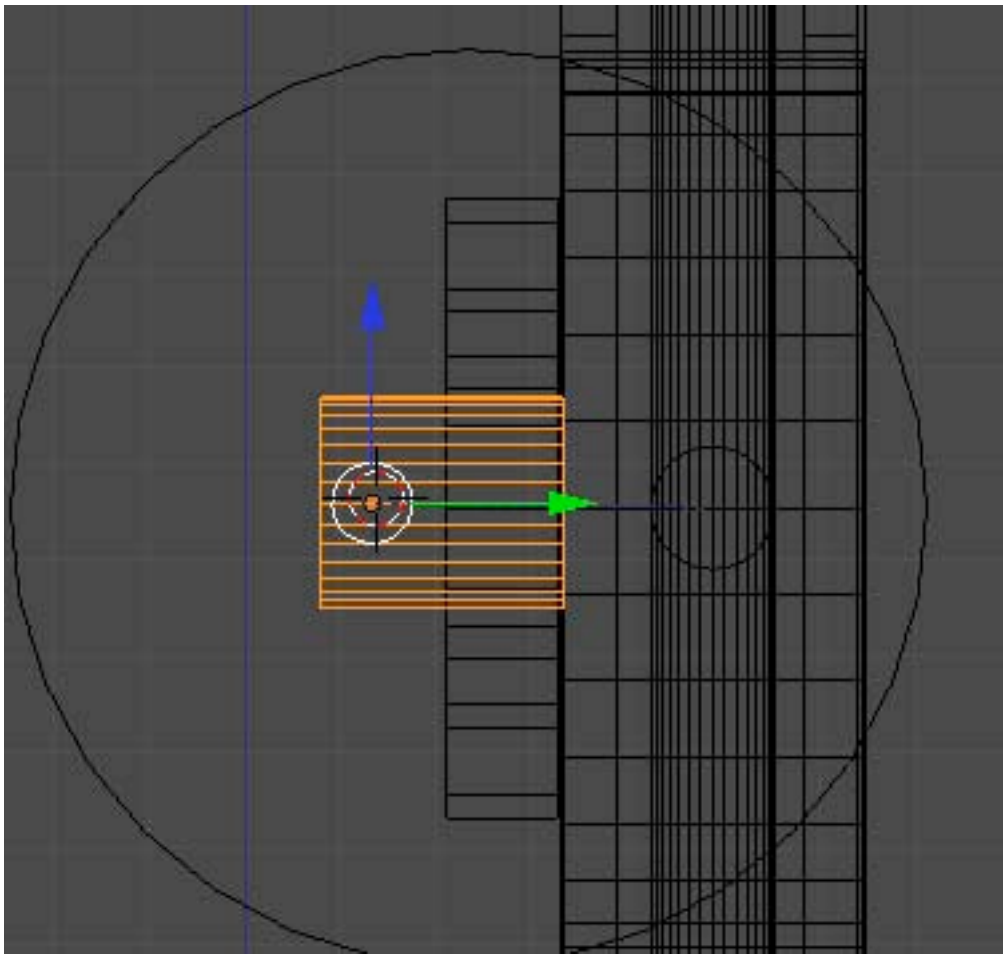
Name this object “Crank”.—Go to front view—Go to solid display mode. Place your 3D cursor near the end of the crank object as shown below.



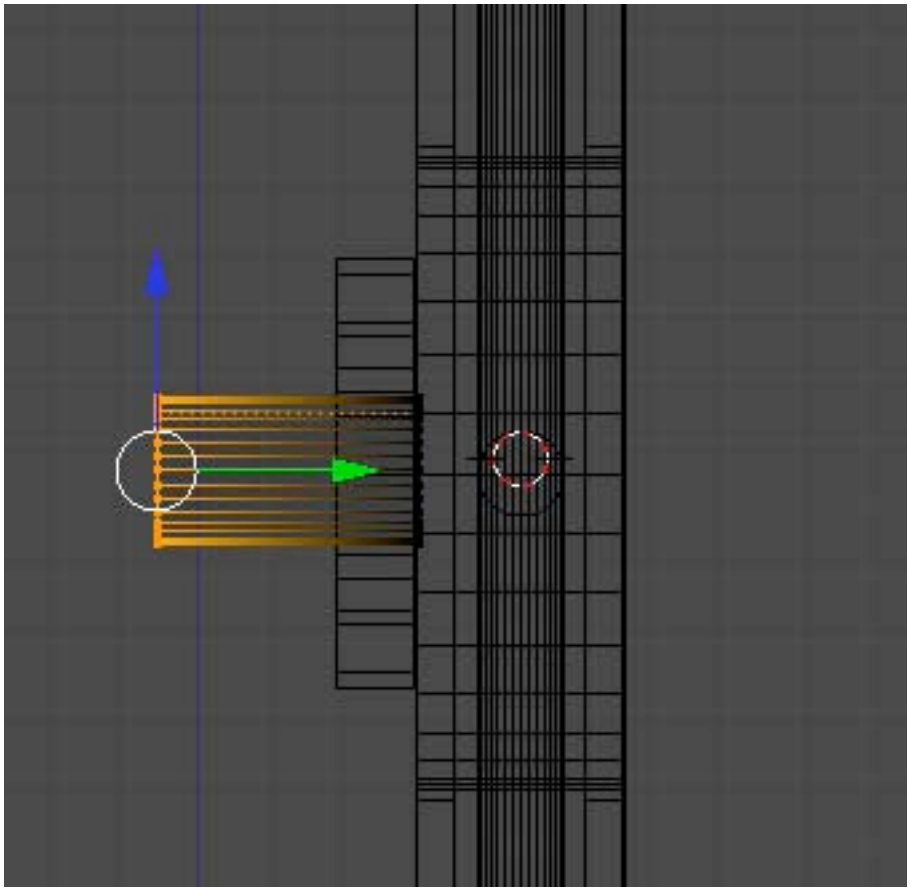
Go to wireframe view. Press SHIFT-A and add a tube object (make sure the tube object is capped). In the 3D editor properties panel set the X rotation to 90 degrees. Scale the tube object down a bit as shown below.



Go to side view. Move the object along the Y-axis so that its right side aligns with the right side of the crank object as shown below.

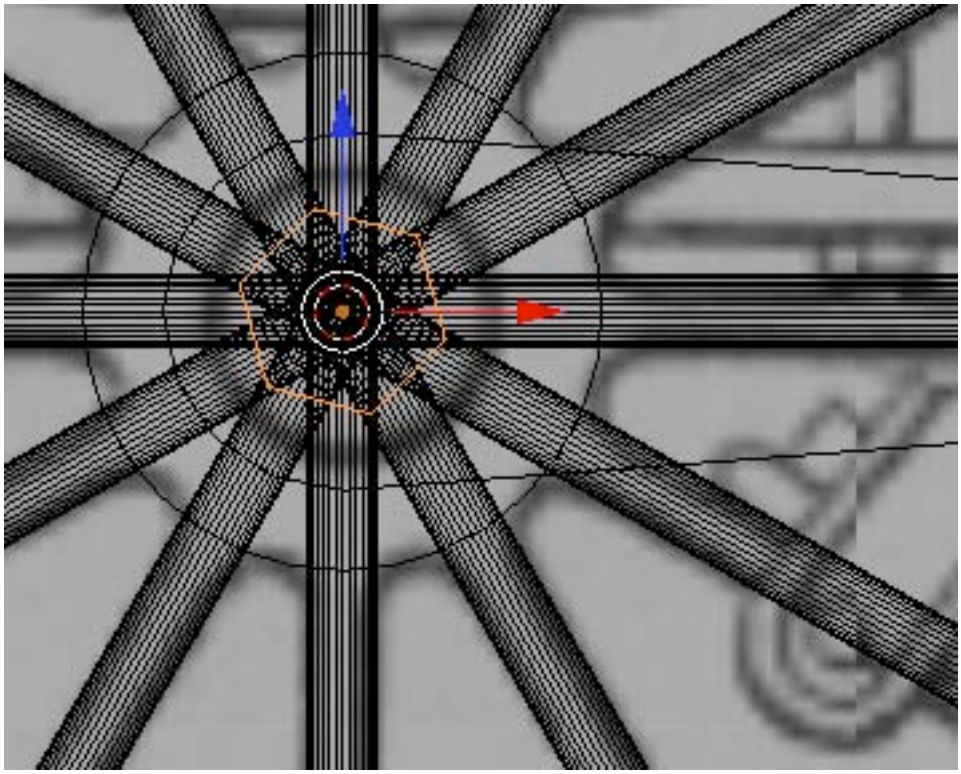


TAB into edit mode. Deselect the vertices. Box select the left vertices and move them to the left a bit along the Y-axis as shown below.

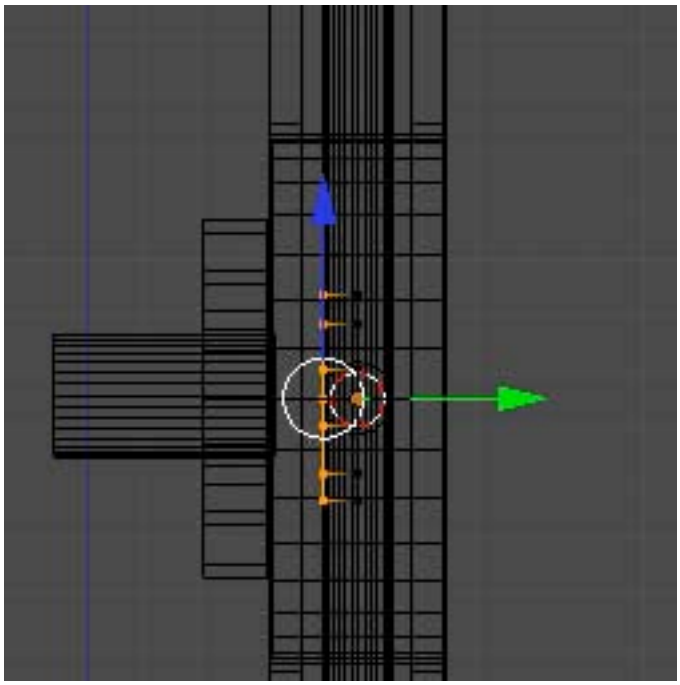


Deselect the vertices.—Tab out of edit mode.—Name this object “Crank Pin”.

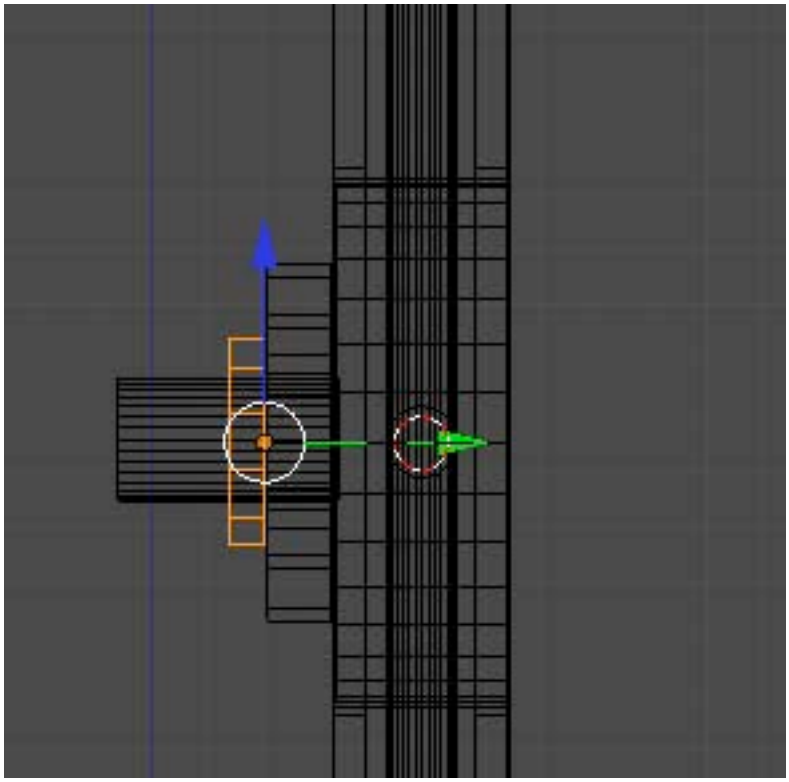
With the crank pin object selected, press SHIFT-CTRL-ALT-C and select origin to geometry. Go to front view. We will model a little nut to fit at the end of the crank object. Select the wheel front left object. Press SHIFT-S and select cursor to selected. Press SHIFT-A and add a circle object (make sure the circle object is filled). Set the vertices at 6. Set the X rotation to 90. Scale the object down smaller than the crank diameter as shown below.



Go to side view. TAB into edit mode. With all the vertices selected, extrude them to the left a bit along the Y-axis as shown below.

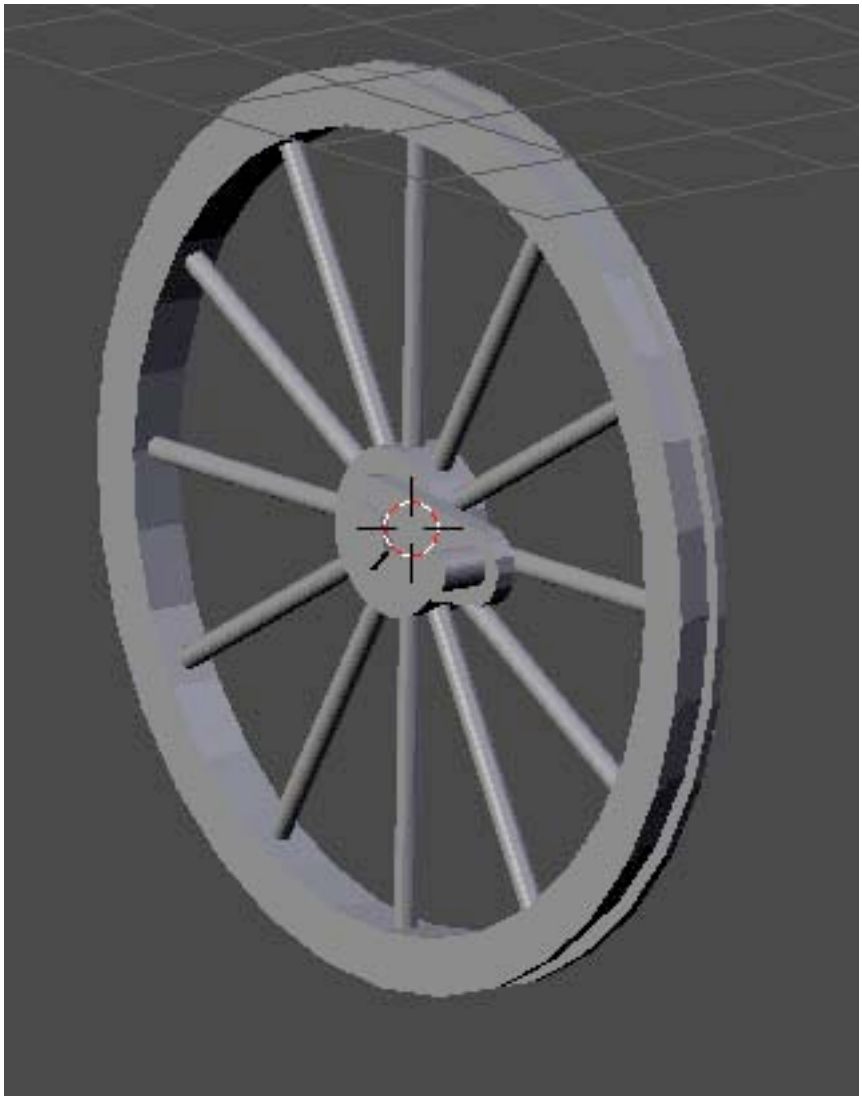


Deselect the vertices. – TAB out of edit mode. – Move the object to the left along the Y-axis as shown below.

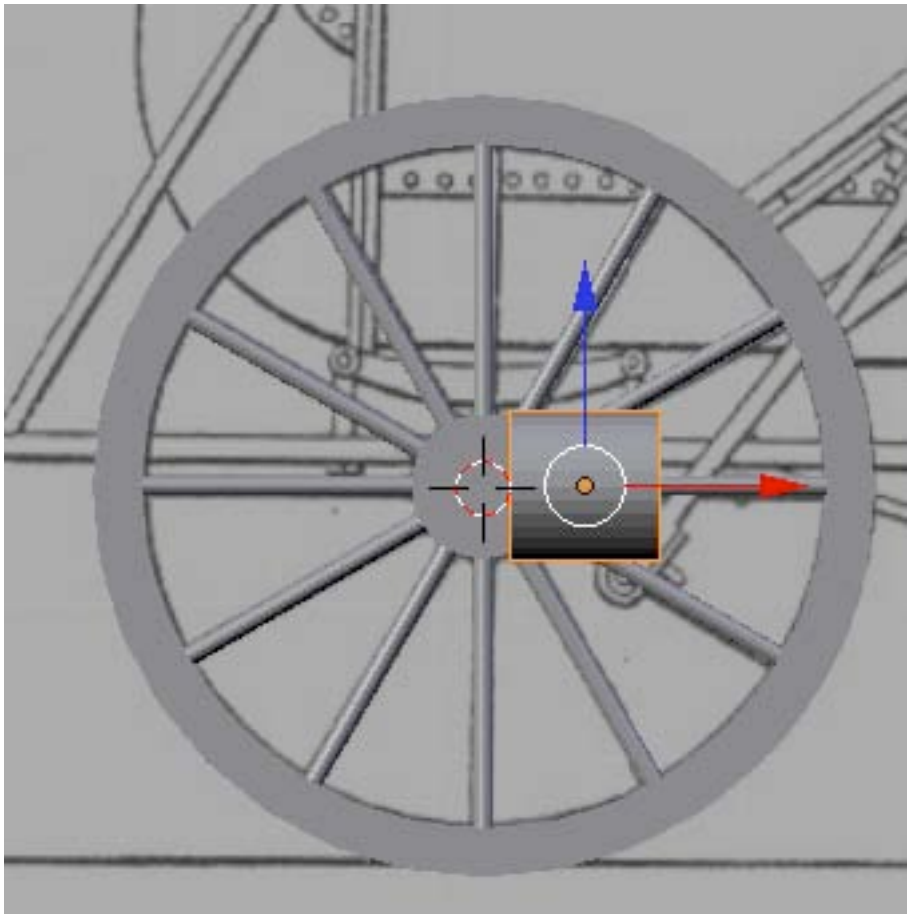


Go to solid display mode. – Rotate your view a bit to see it more dimensionally Select this nut object then add to the selection the crank object, then press CTRL-J and join them into one object (which should be the Crank object).

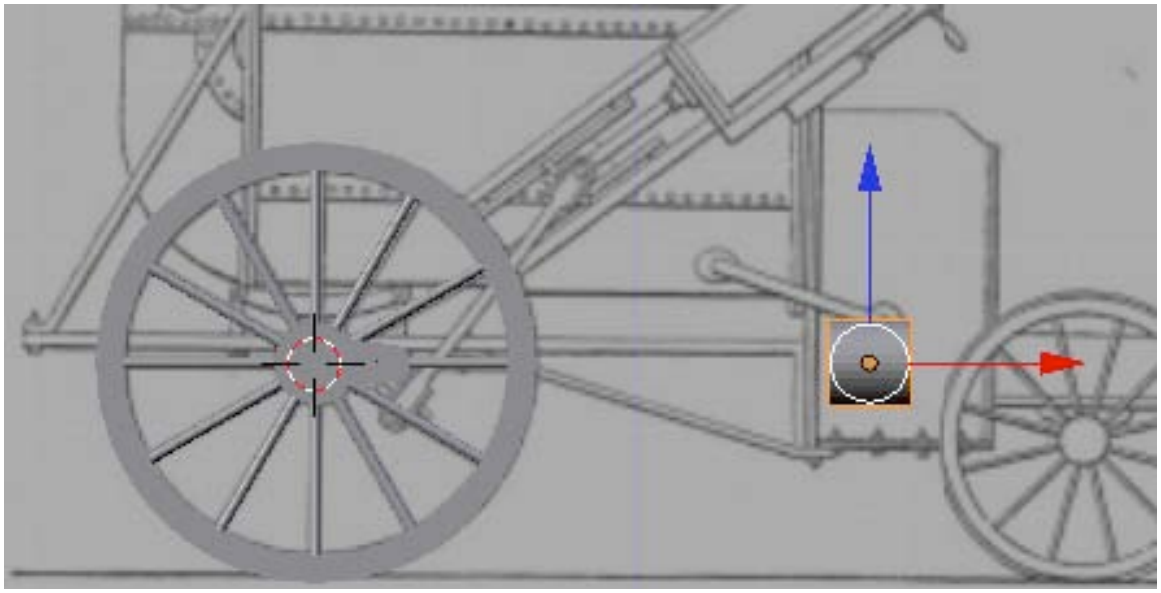
With the crank object selected, press SHIFT-CTRL-ALT-C and select origin to geometry.
We should now have 3 objects (wheel front left – crank and crank pin).



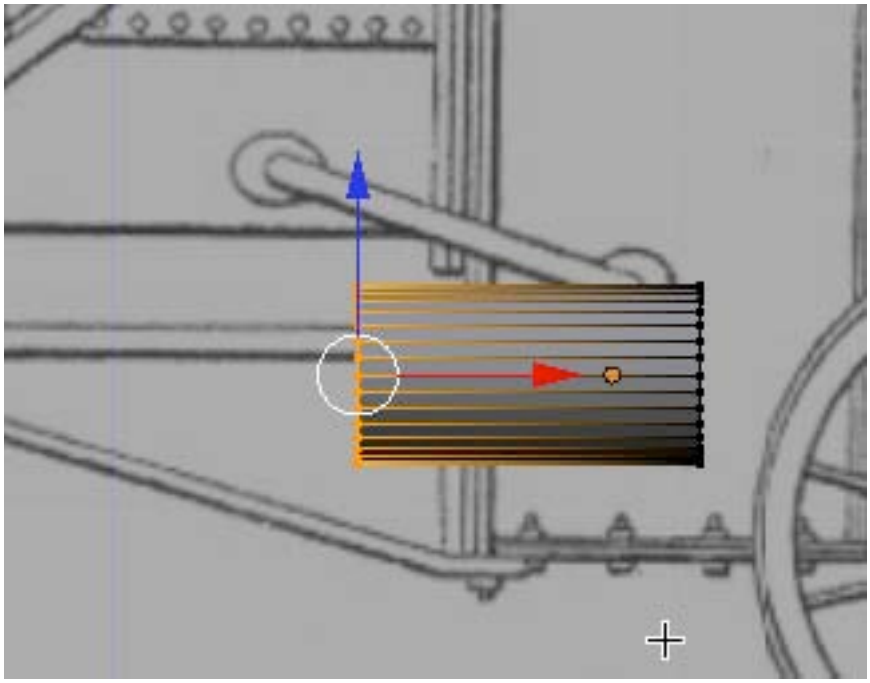
Save your Blender file. Go to front view. Select the crank object. Press SHIFT-S and select cursor to selected. Press SHIFT-A and add a tube object (make sure the tube object is capped). Set the Y rotation to 90 degrees. Scale it down a bit as shown below (slightly wider than the crank object).



Using your translate widget, move the tube along the X-axis to the position as shown below. NOTE: If you are having difficulty moving things precisely, click on the translate arrow for the direction you want to move it, then hold your SHIFT key down and move your mouse. The movement will be constrained.

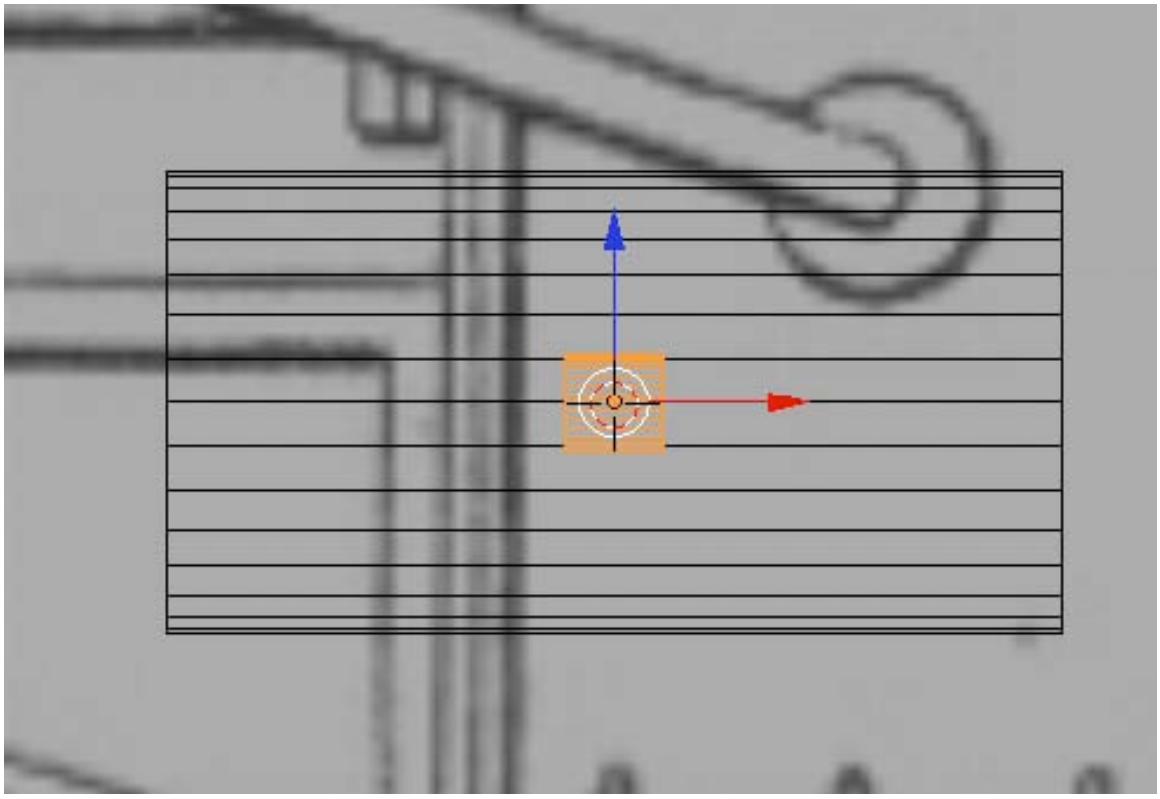


TAB into edit mode. Deselect the vertices. Box select the left set of vertices and move them along the X-axis as shown below.

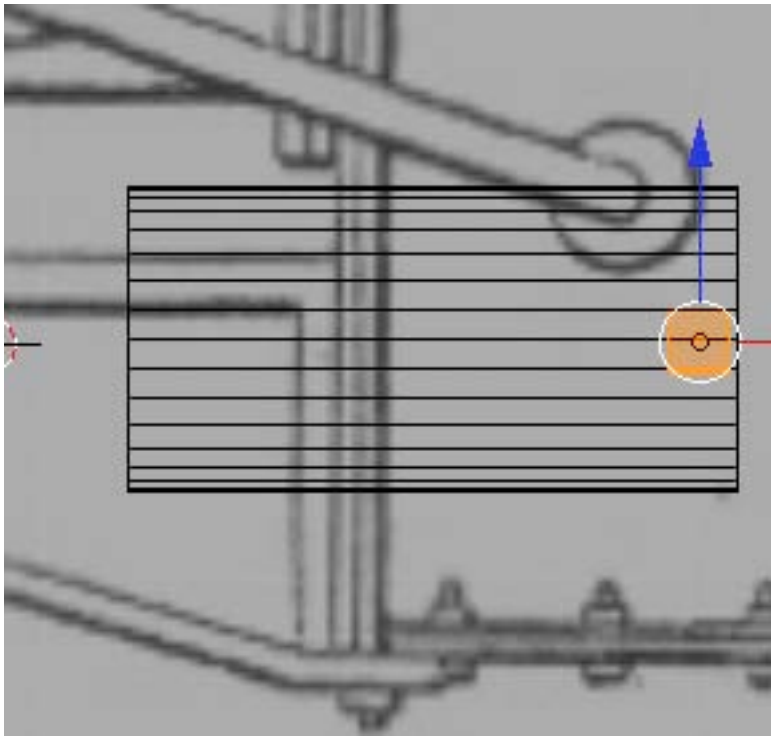


Deselect the vertices. TAB out of edit mode. Name this object “Piston”.
With the piston object selected, press SHIFT-CTRL-ALT-C and select origin to geometry.
Go to wireframe display mode. With the piston object still selected, press SHIFT-S and select cursor to selection.

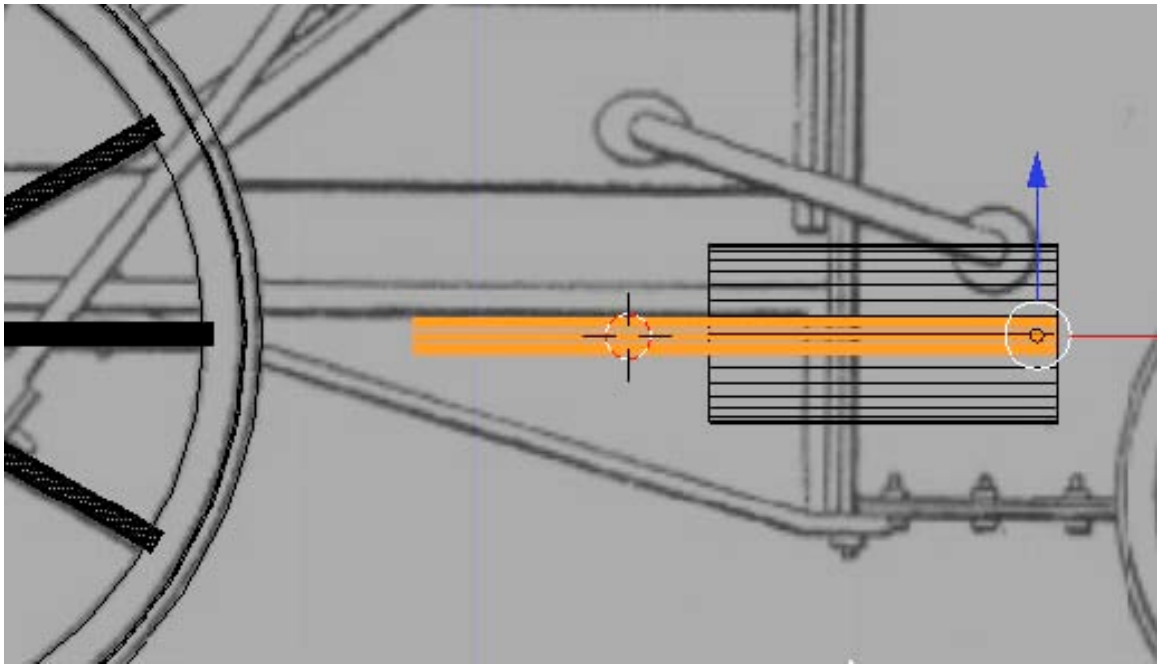
Press SHIFT-A and add a tube object (make sure the tube object is capped). Set the Y rotation on the tube object to 90 degrees.
This will become our piston rod. Scale the tube down as shown below.



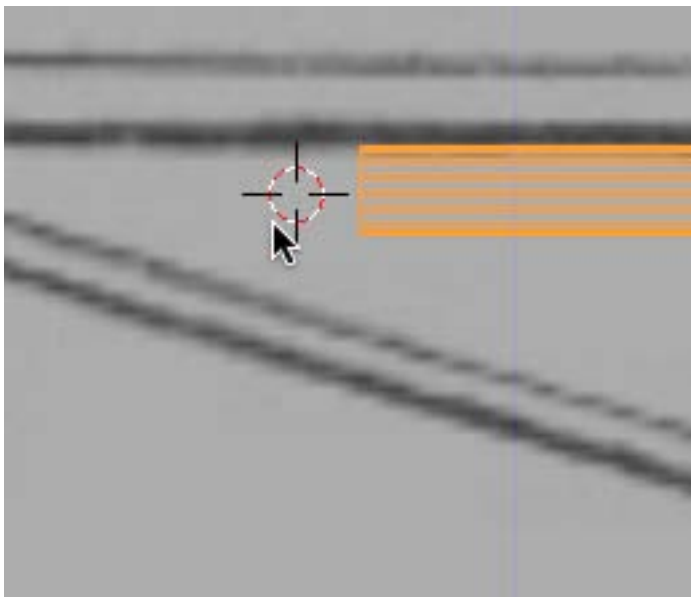
Move the tube to the right along the X-axis as shown below.



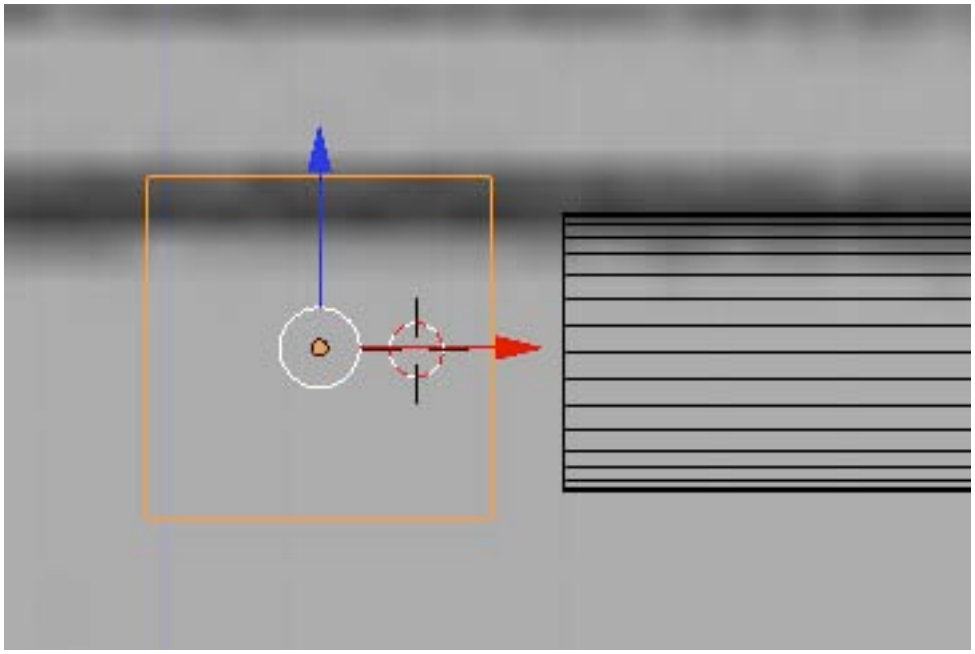
TAB into edit mode. Deselect the vertices. Box select the left vertices and move them along the X-axis as shown below.



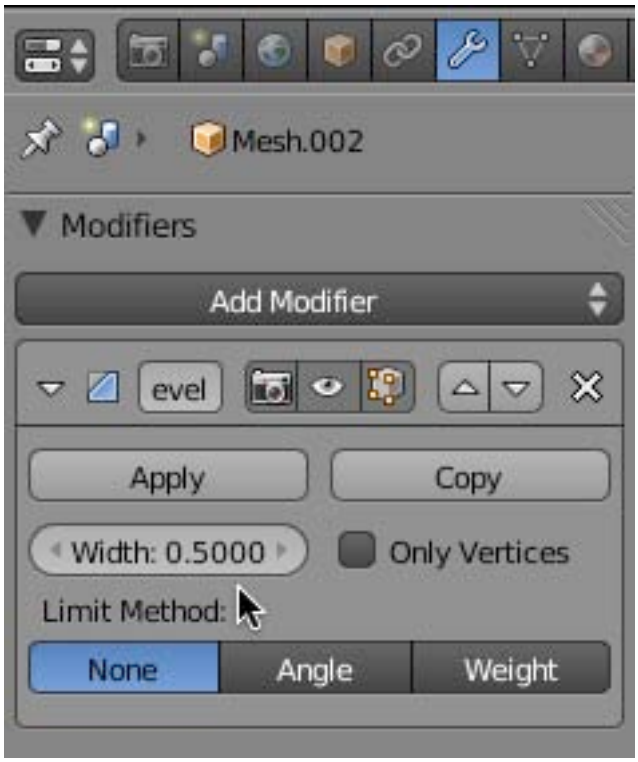
Deselect the vertices. TAB out of edit mode. Place your 3D cursor to the left of the tube as shown below.



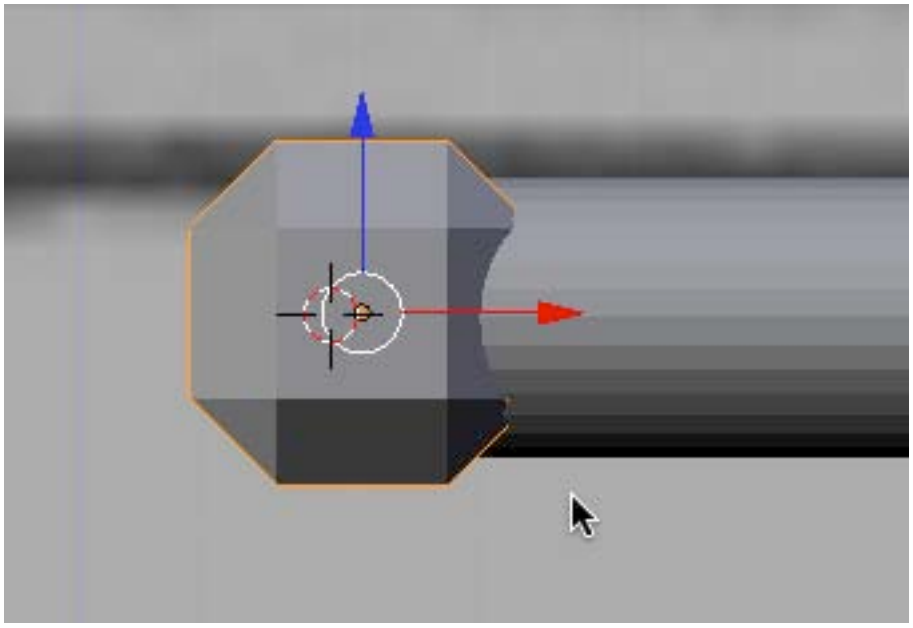
Press SHIFT-A and add a cube object. Scale down the cube as shown below (slightly larger than the tube diameter).



Go to solid display mode. Press on the modifier button on the Properties editor and add a bevel modifier to the cube. Set the bevel width to .5



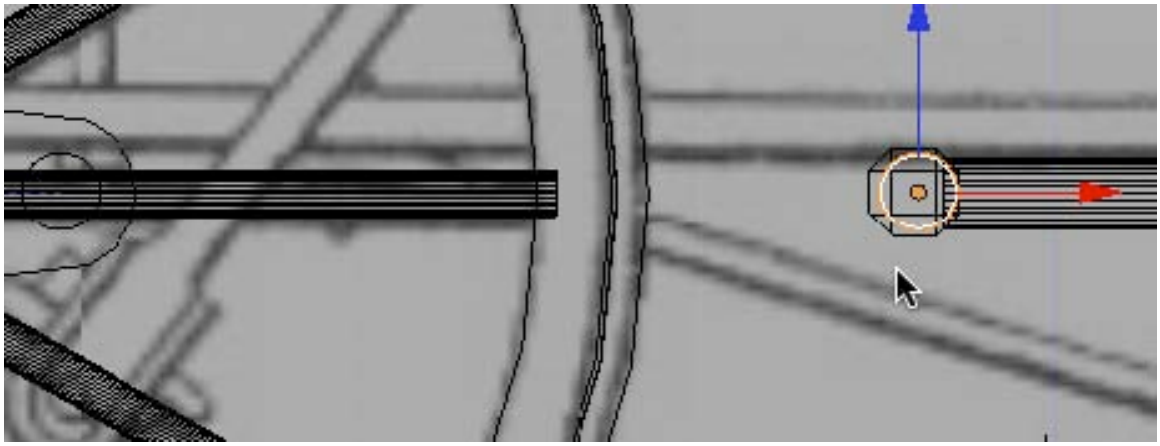
Position the cube as shown below.



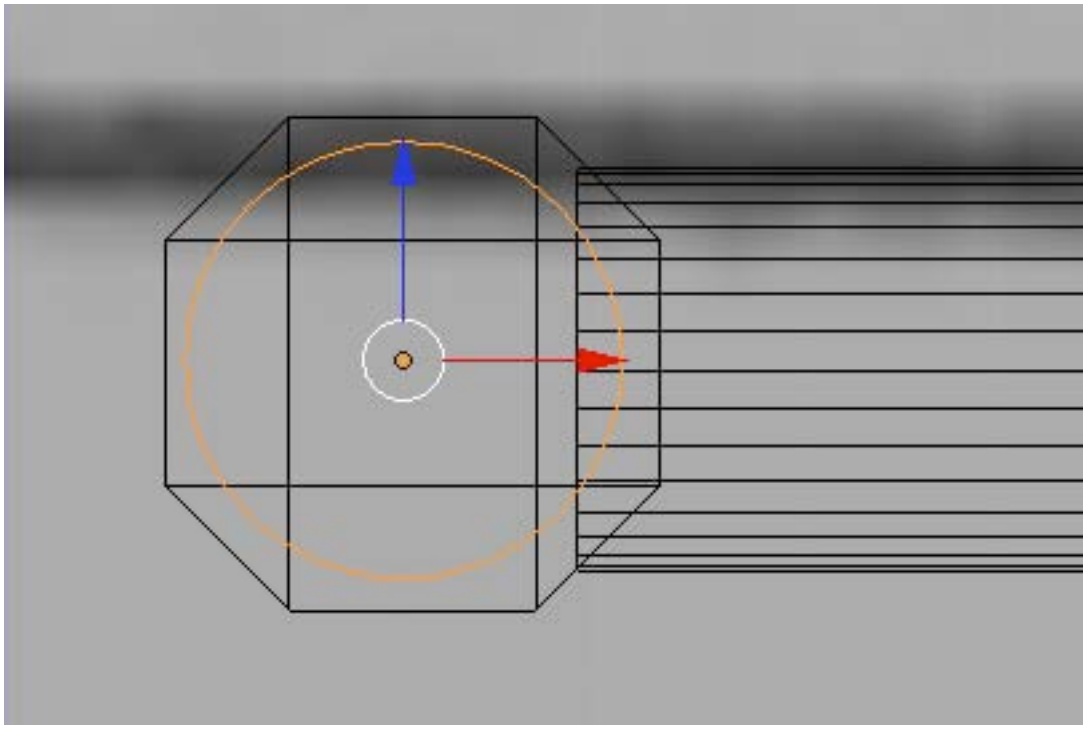
In the modifier panel press the “APPLY” button. This will permanently apply the bevel to the object and it will remain beveled during the next step.

Select the cube and add the rod to the selection. Press CTRL-J and join them into one object. Name this object “Piston Rod”.

With the piston rod object selected, press SHIFT-CTRL-ALT-C and select origin to geometry. Go to wireframe display mode. Select the **crank pin** object. Press SHIFT-D followed by the XKEY and move the duplicate pin object along the X-axis to the end of the piston rod object as shown below.

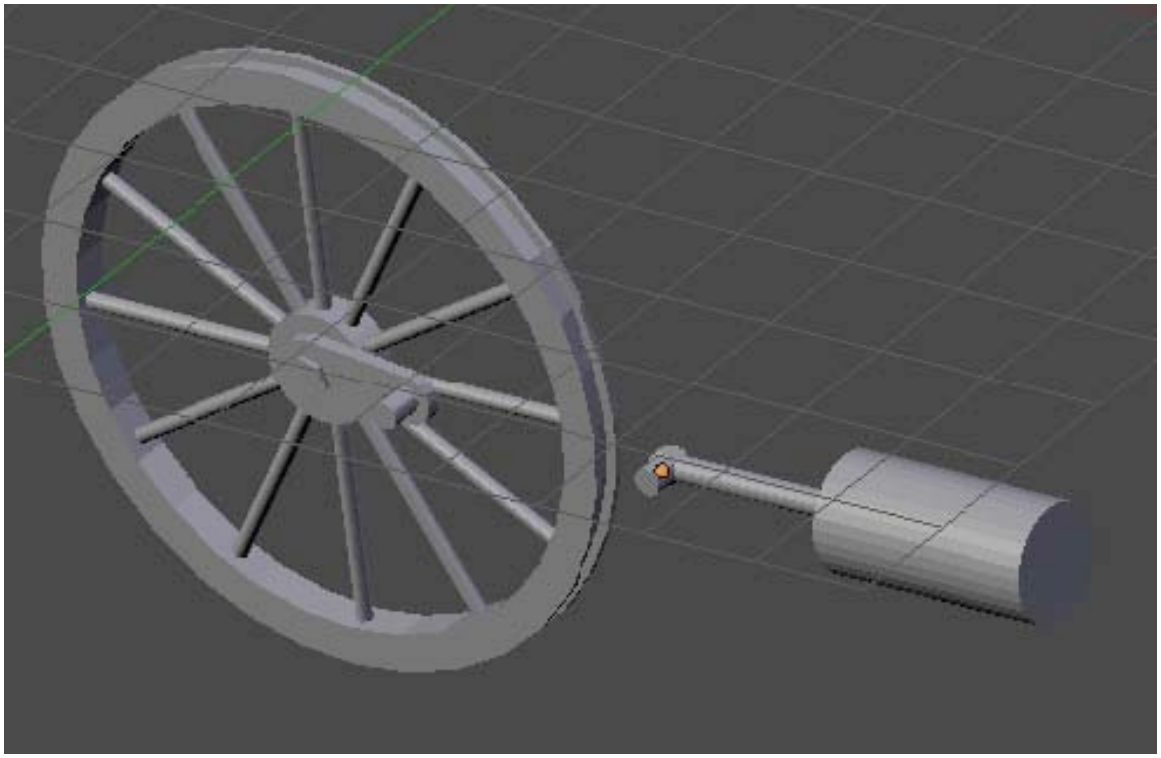


Close up:



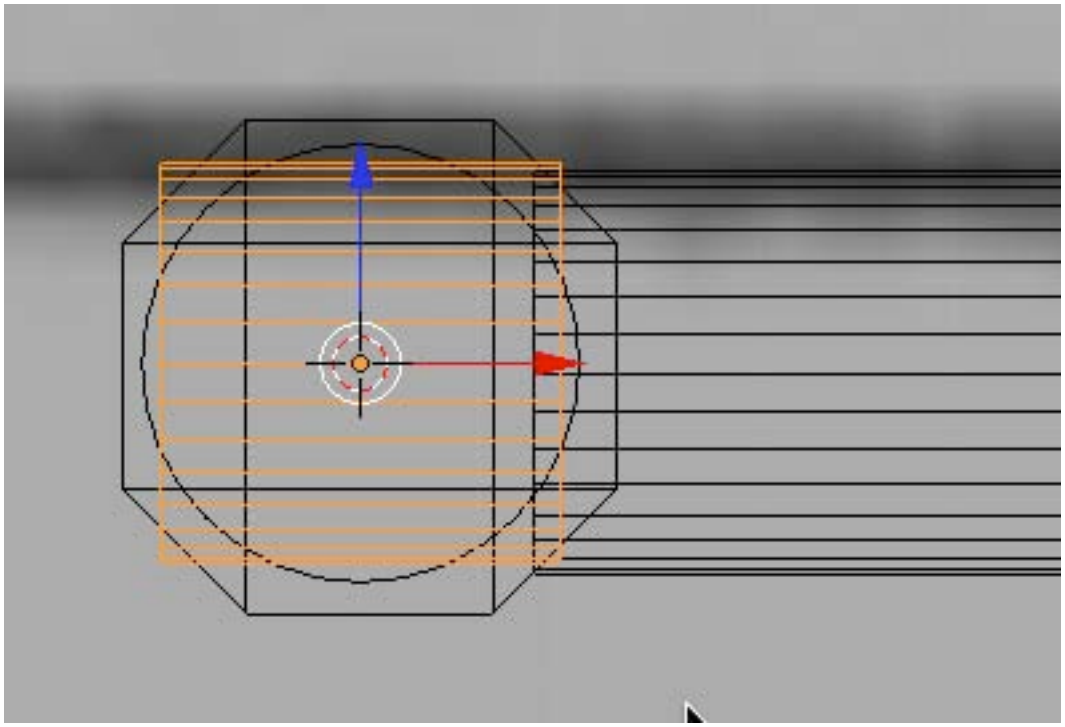
Name this object “Linking Pin”.

Go to solid display mode. Rotate your view a bit to see it more dimensionally. Our drive chain looks like this. We now have 6 of the 7 elements (wheel front left, crank, crank pin, linking pin, piston rod and piston)

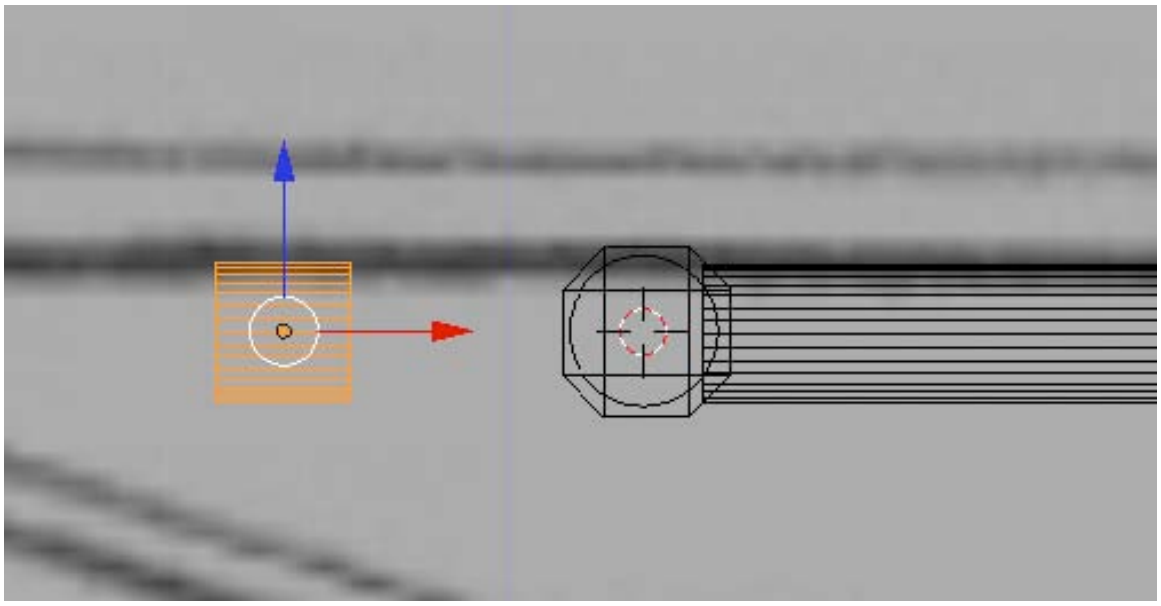


Save your Blender file.

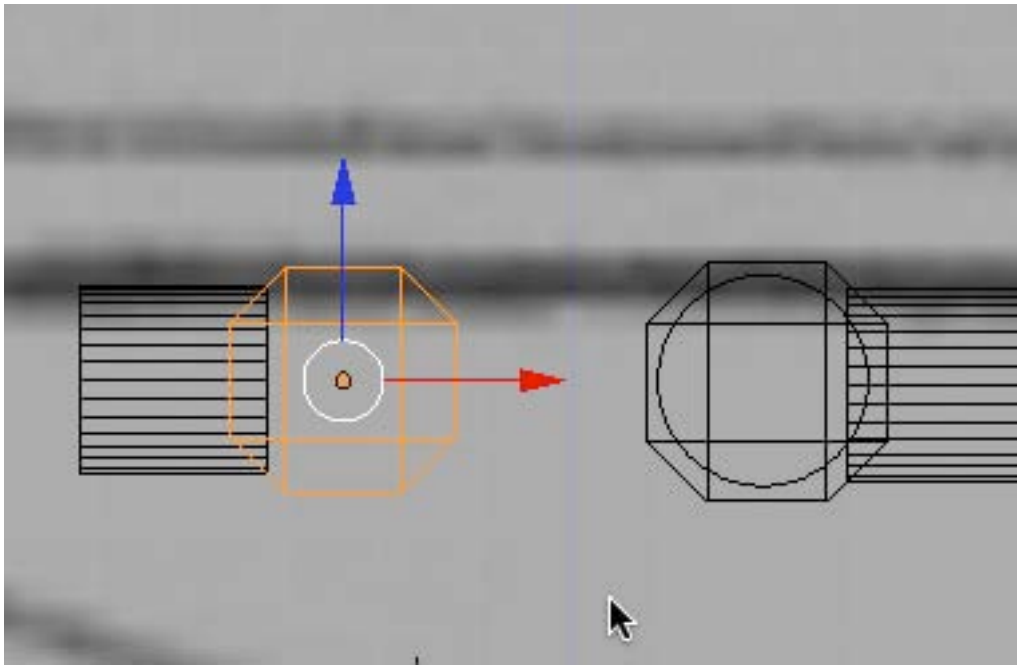
Next, we will model the connecting rod. Go to front view. Go to wireframe display mode. Select the linking pin object. Press SHIFT-S and select cursor to selection. Press SHIFT-A and add a tube object (make sure the tube object has its ends capped). Set the Y rotation to 90 degrees. Scale this tube down to about the same width as the piston rod tube as shown below.



Using your translate widget move the tube to the left along the X-axis as shown below.
NOTE: If you are having difficulty moving things precisely, click on the translate arrow for the direction you want to move it, then hold your SHIFT key down and move your mouse. The movement will be constrained.

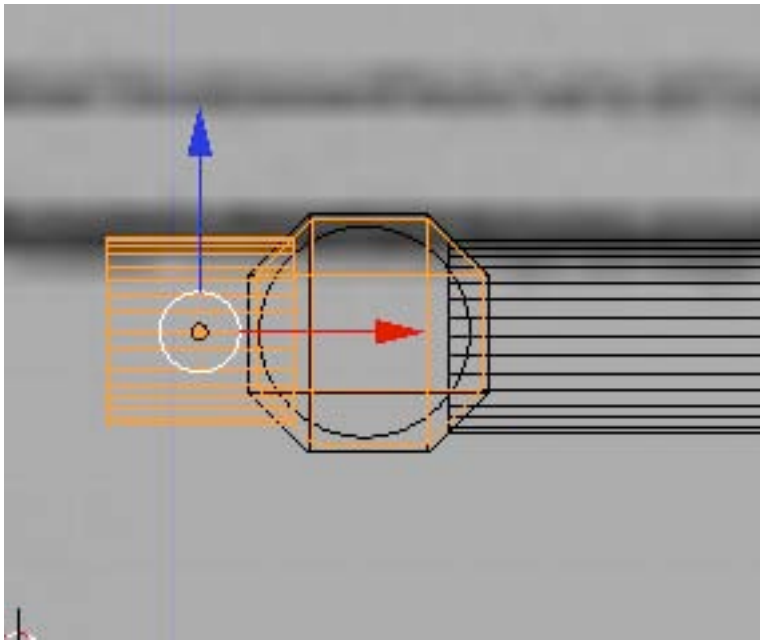


Place your cursor to the right of the tube. Press SHIFT-A and add a cube object. Scale the cube object down (as we did the last cube object on the piston rod). Add a bevel modifier with the width set at .5. APPLY the modifier to the cube. Position the cube at the end of the tube object as shown below.

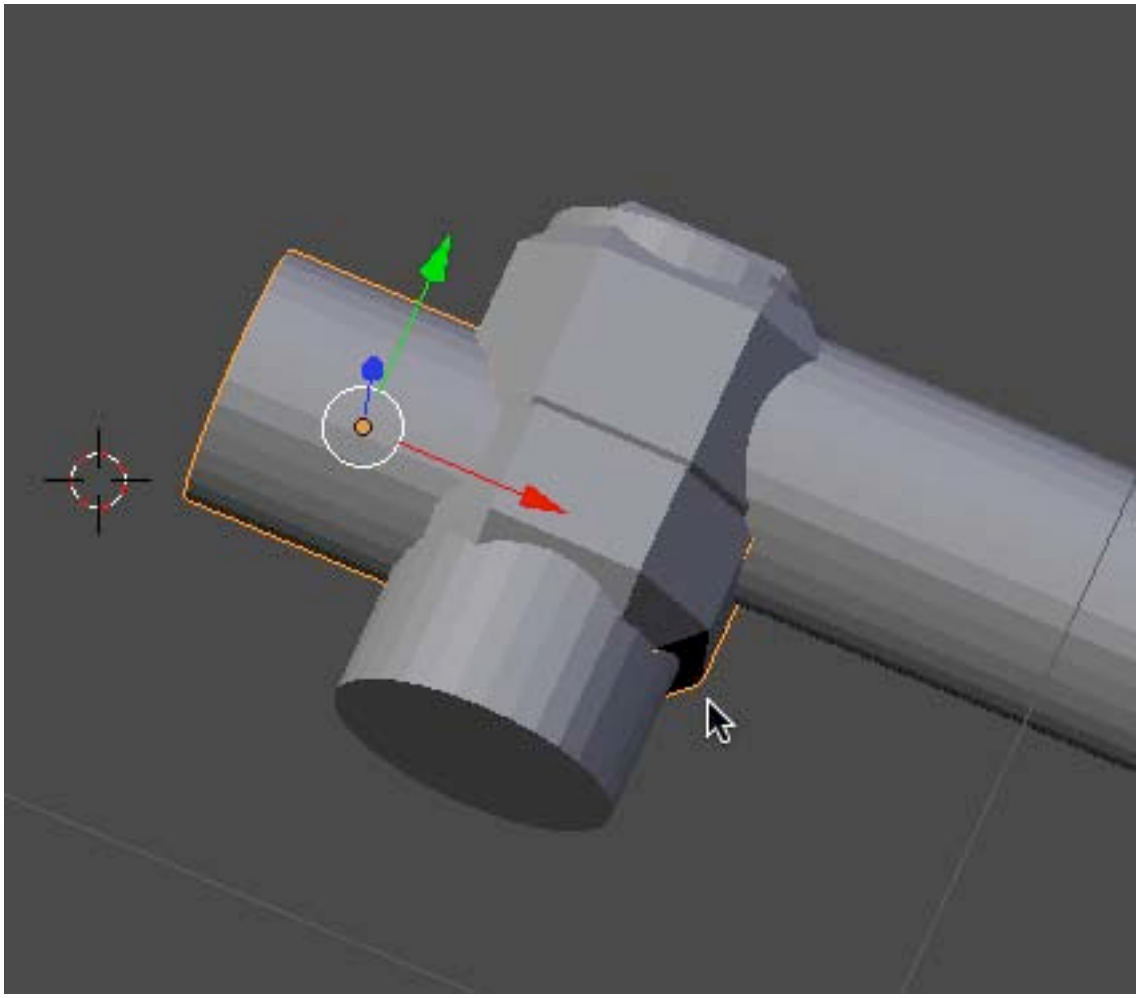


Select the cube and add the tube object to the selection and press CTRL-J and join the objects into one object. Name this object “Connecting Rod”.

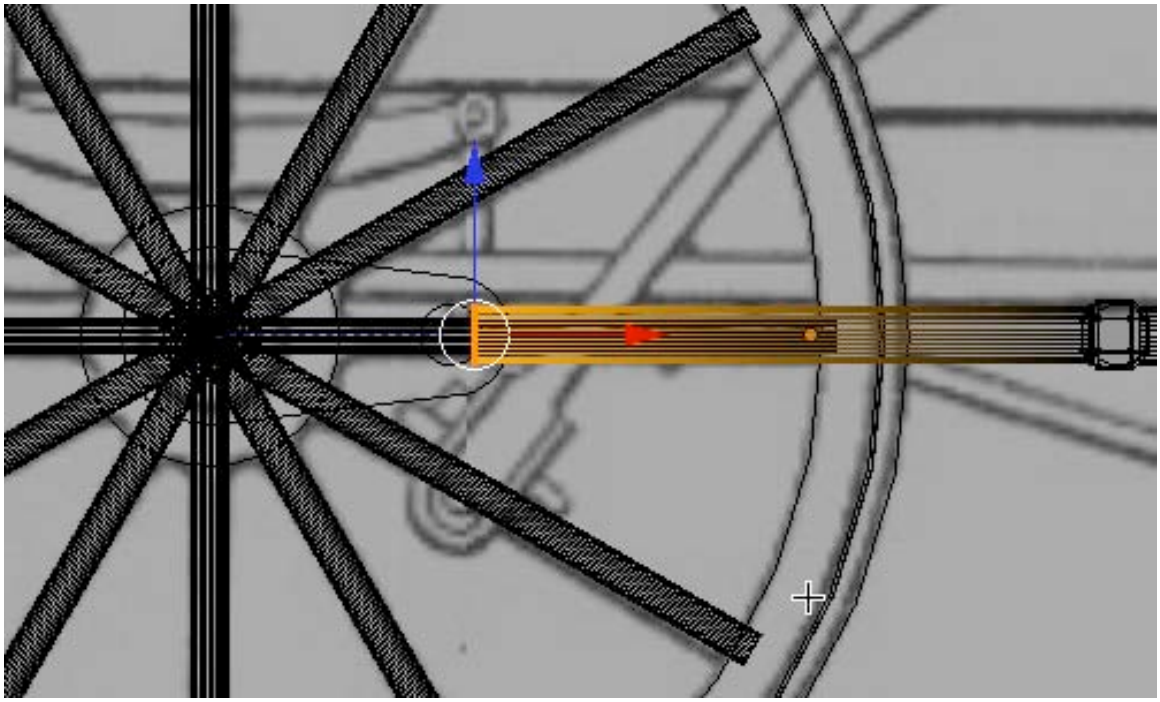
Use your translate widget to move the connecting rod to the linking pin object as shown below.



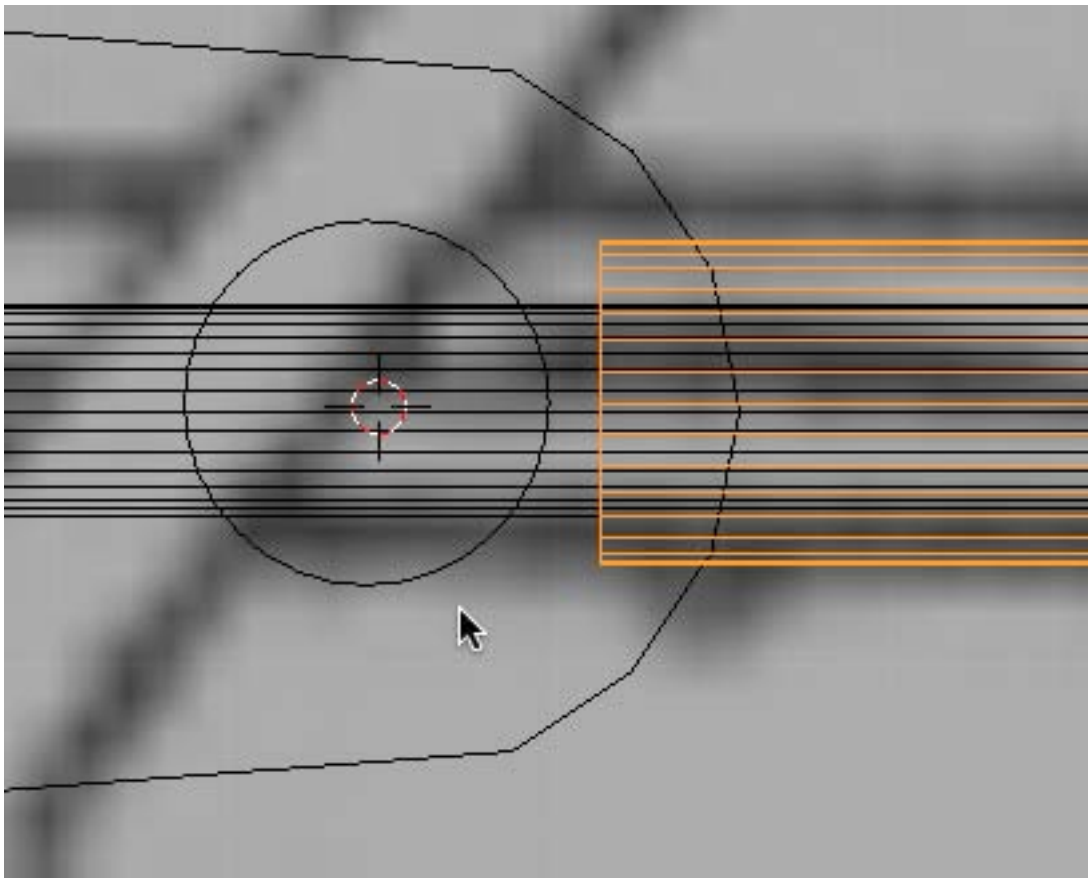
Another solid display view of this:



In front view, and in wireframe display mode and the connecting rod object selected, TAB into edit mode. Deselect the vertices. Box select the left group of vertices and move them along the X-axis to the right of the crank pin object as shown below.



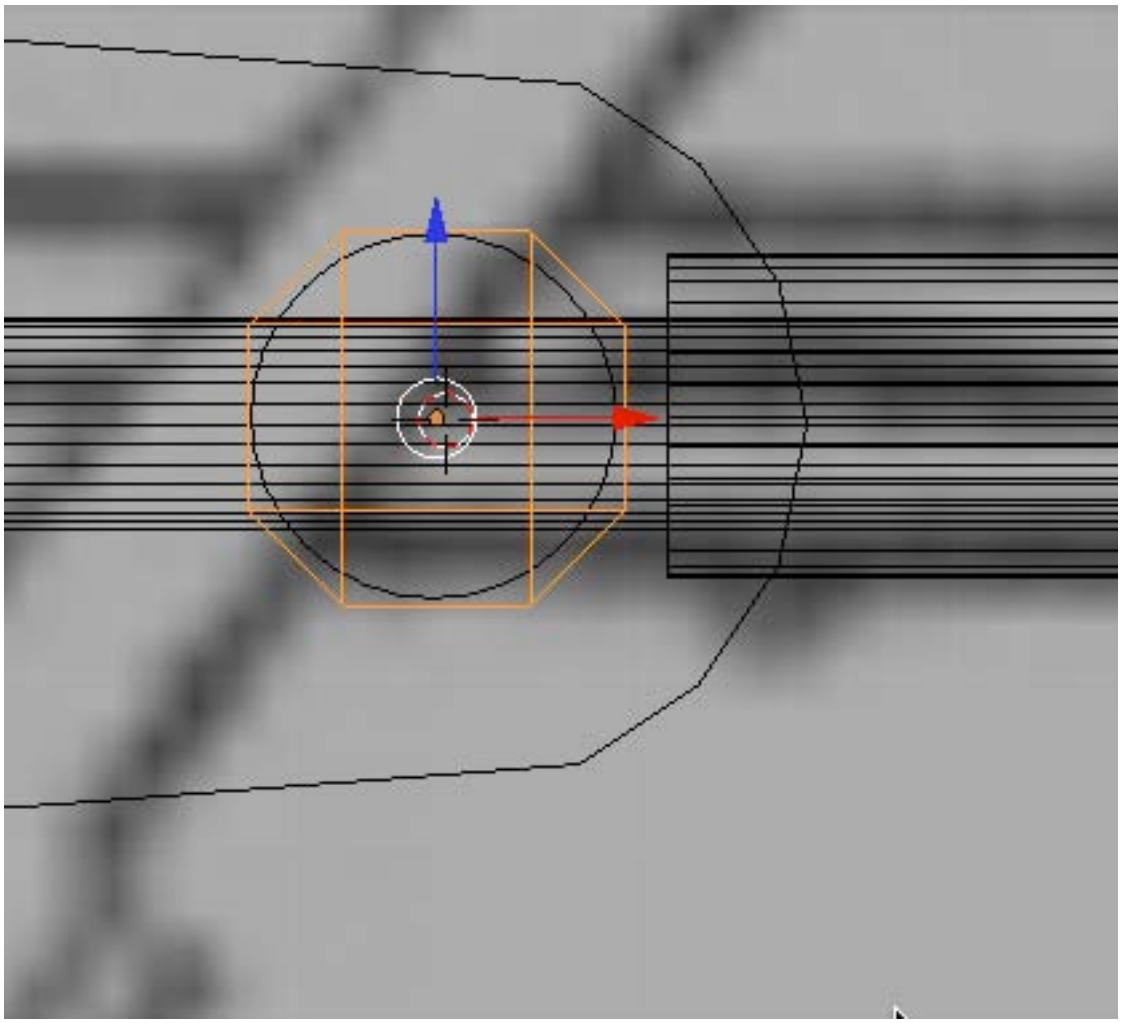
Deselect the vertices. TAB out of edit mode. Place your 3D cursor to the left of the connecting rod as shown below.



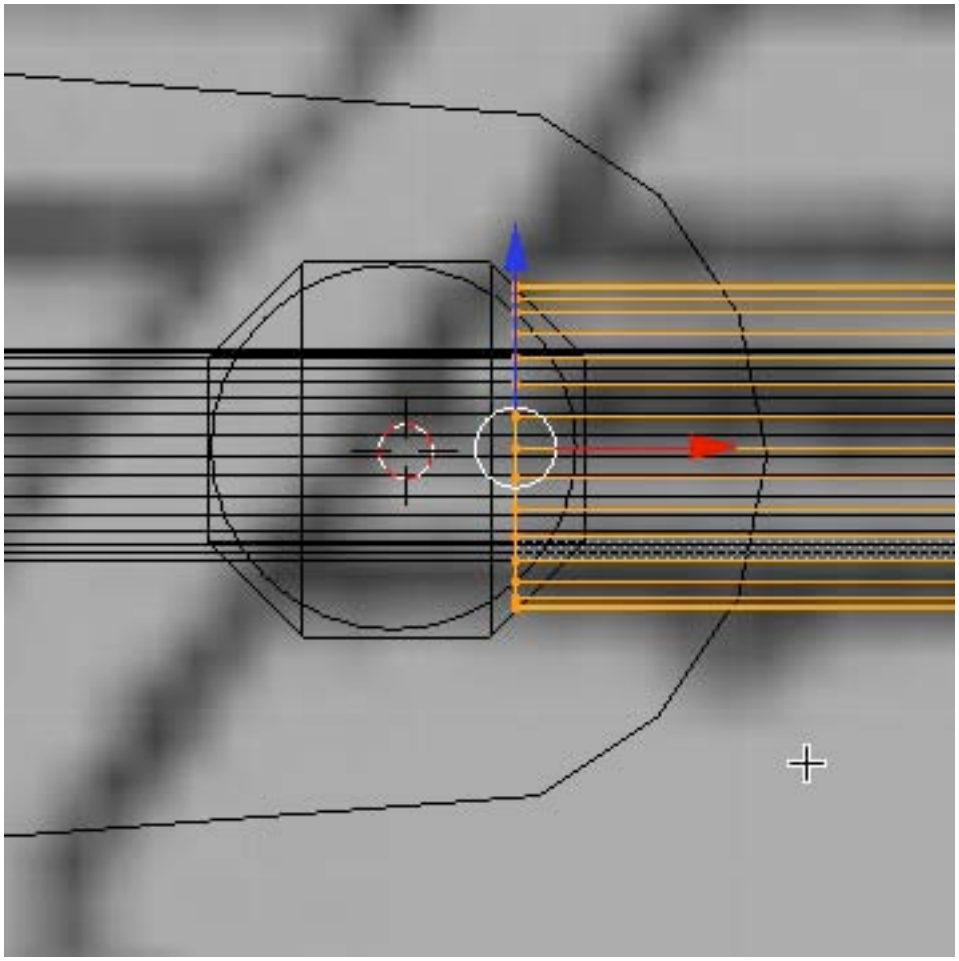
We will make another of those beveled cube objects.

Press SHIFT-A and add a cube object. Scale the cube object down (as we did the last cube object on the other end of the connecting rod). Add a bevel modifier with the width set at .5. APPLY the modifier to the cube.

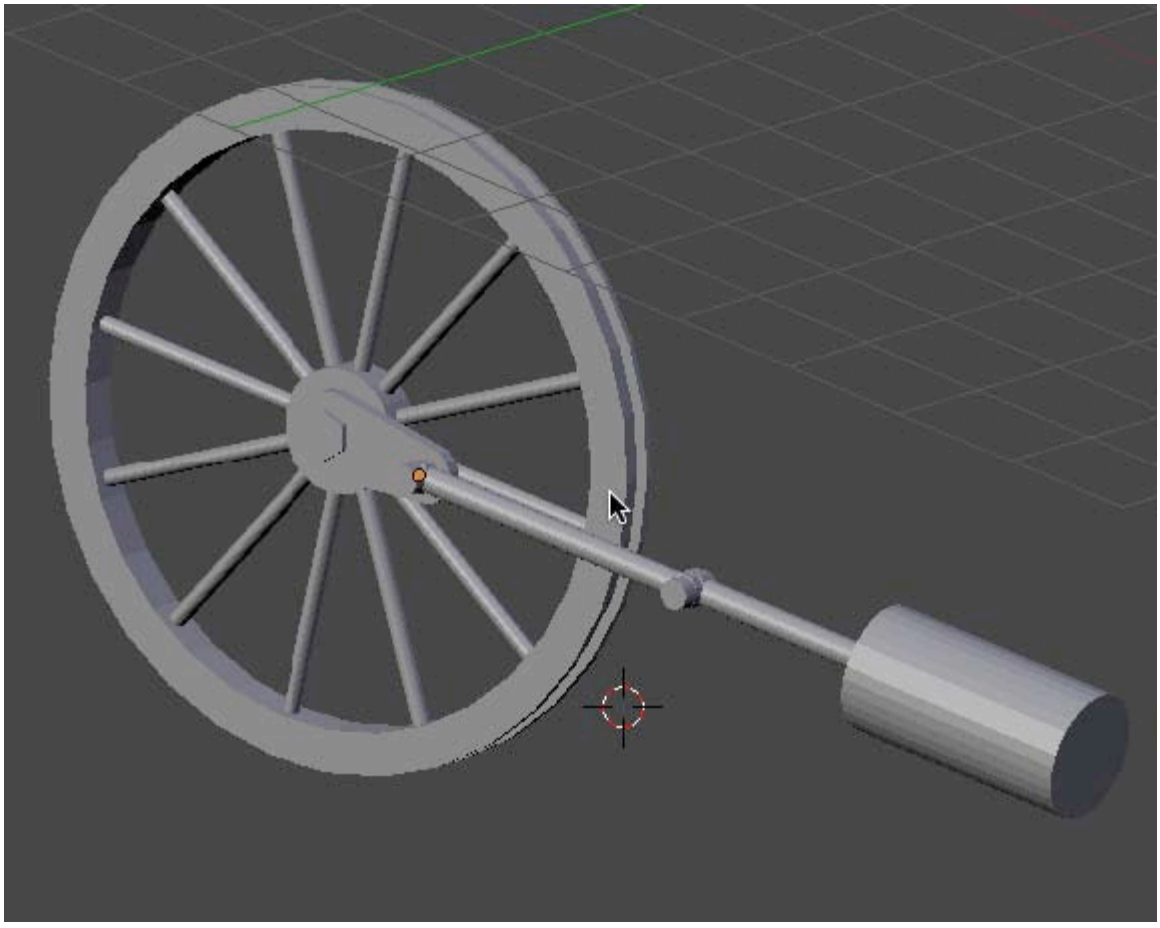
Position the cube directly on top of the crank pin object as shown below.



Select the connecting rod object. TAB into edit mode. Select the far left set of vertices and move them left along the X-axis as shown below.



Deselect the vertices. TAB out of edit mode.
Select the cube object and then add the connecting rod object to the selection. Then press CTRL-J and join the two objects into one. (This should be the Connecting Rod object).
With the connecting rod object selected, press SHIFT-CTRL-ALT-C and select origin to geometry.

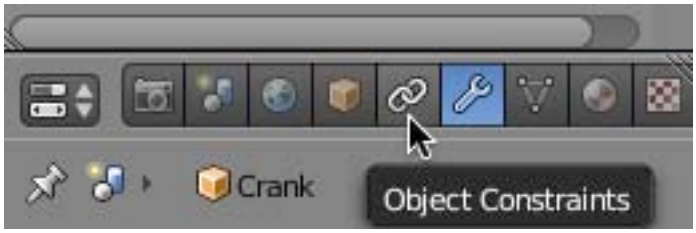


Note that we have taken care during the modeling of the drive chain to place the objects precisely and in alignment.

Save your Blender file.

Next we will add constraints to the drive chain so that it operates in unison. In the real world of Stephenson's steam locomotive, the back and forth motion of the piston drives the whole mechanism. In our animated 3D world we will do much the opposite. The wheel will rotate the crank and crank pin, which will pull and push the connecting rod, which will in turn pull and push the piston rod.

Go to front view. Go to solid display mode. Select the crank object. Press the Constraints context button in the Properties editor.



Press the Add constraint button and add a "Child Of" Constraint.

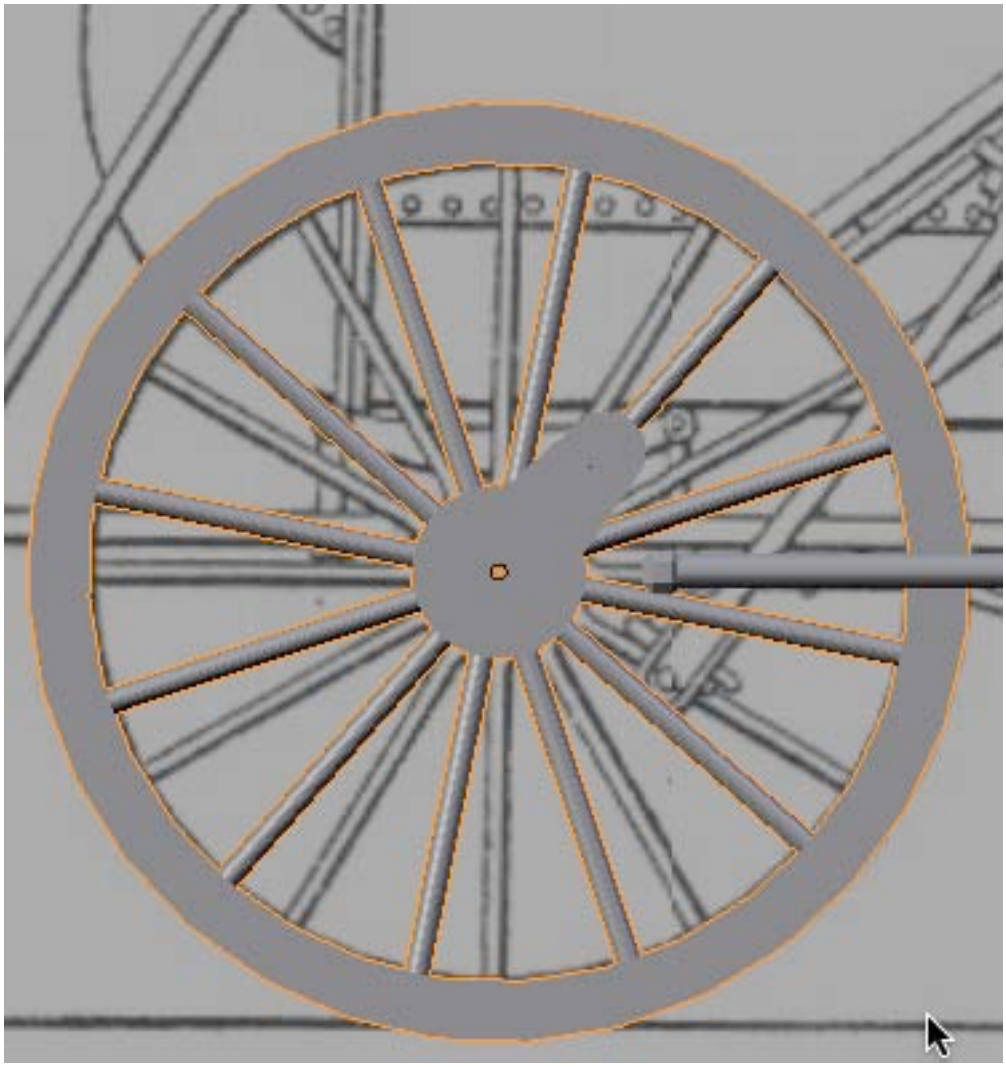
The Child Of constraint works much like parenting but contains many controls for configuring how the parent /child relationship operates.

Click on the Target box (there is a cube icon) and select the Wheel Front Left object. This means that the crank object will be a child of the wheel front left object.

Note that the crank object has moved in the 3D display. This is because the start position of the crank object is being affected by the transform settings of the parent. **CLICK ON THE SET INVERSE BUTTON**. This will set the crank object back to its proper position.

Select the crank pin object. Add a "Child To" constraint and make the Target the "Wheel Front Left" object. **CLICK ON THE SET INVERSE BUTTON**. This will set the crank pin object back to its proper position.

Now both the crank object and the crank pin objects are children of the wheel front left object. If you select the wheel object and press the RKEY and rotate the wheel, the crank and crank pin objects rotate with it.



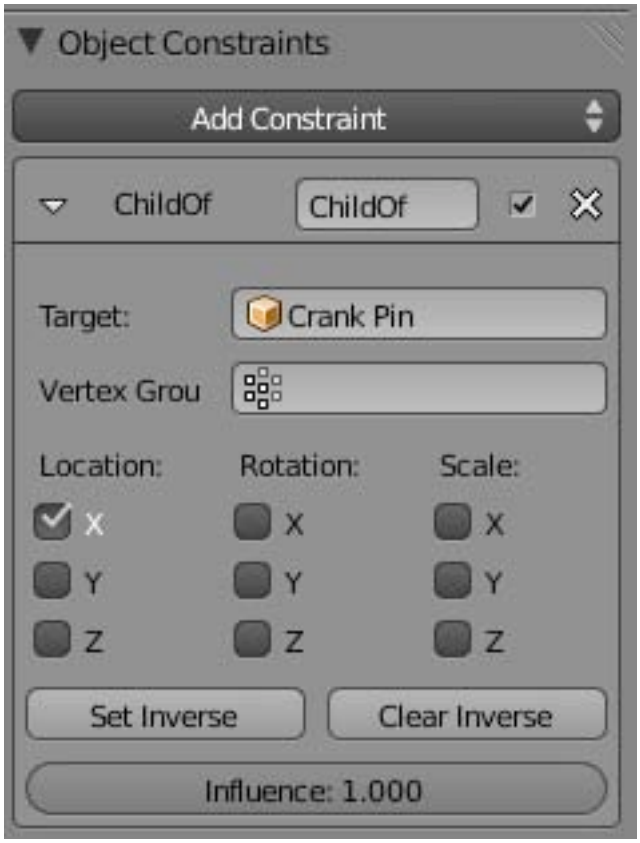
If you rotated the Wheel Front Left object to see this action, press CTRL-Z to undo the rotation and get back to the original position.

Now select the linking pin object. Add a "Child Of" constraint and make the Target the "Piston Rod" object. **CLICK ON THE SET INVERSE BUTTON**. This will set the linking pin object back to its proper position.

The linking pin object is now a child of the Piston rod object. When the piston rod moves, the linking pin will move with it.

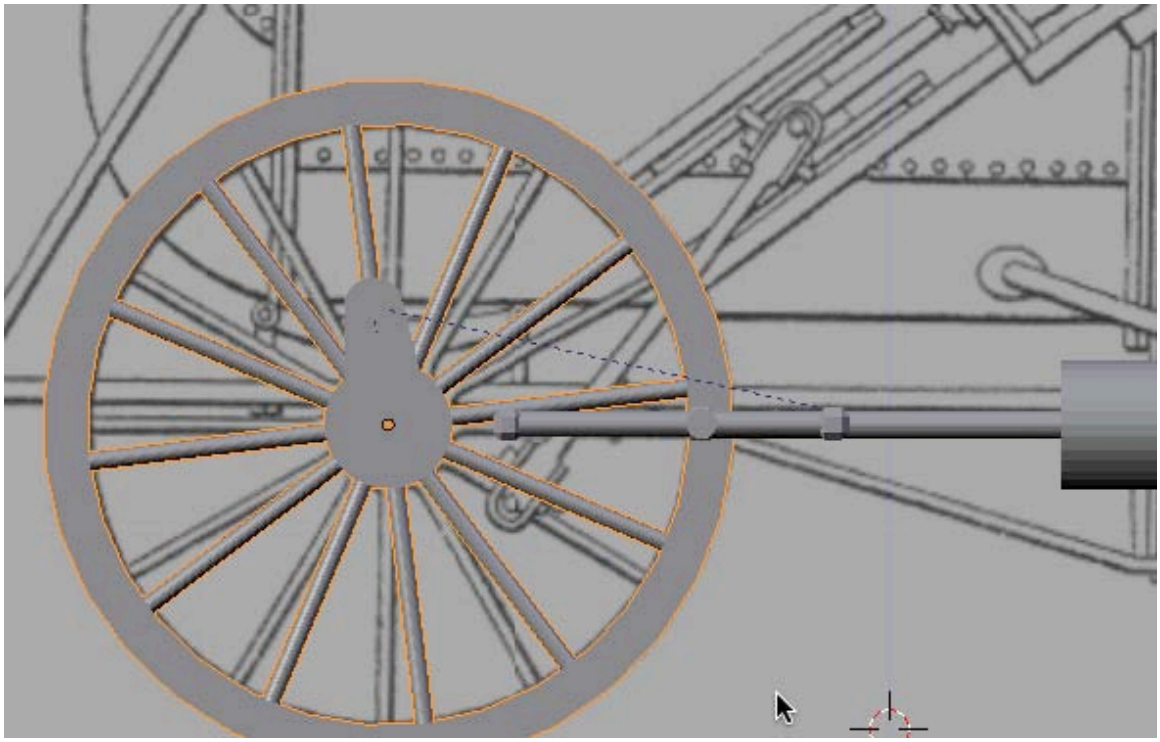
Next, select the piston rod. Add a "Child Of" constraint and make the target the "Crank Pin" object.

We want the connecting rod object to follow the parent (crank pin object) but only in the X direction. Uncheck all of the checkmark boxes except the Location X box.



Now, **CLICK ON THE SET INVERSE BUTTON**. This will set the piston rod object back to its proper position.

With this setting, the piston rod (and its linking pin child) will move along the X-axis as the wheel front left object (and its crank and crank pin children) is rotated.



If you rotated the Wheel Front Left object to see this action, press CTRL-Z to undo the rotation and get back to the original position.

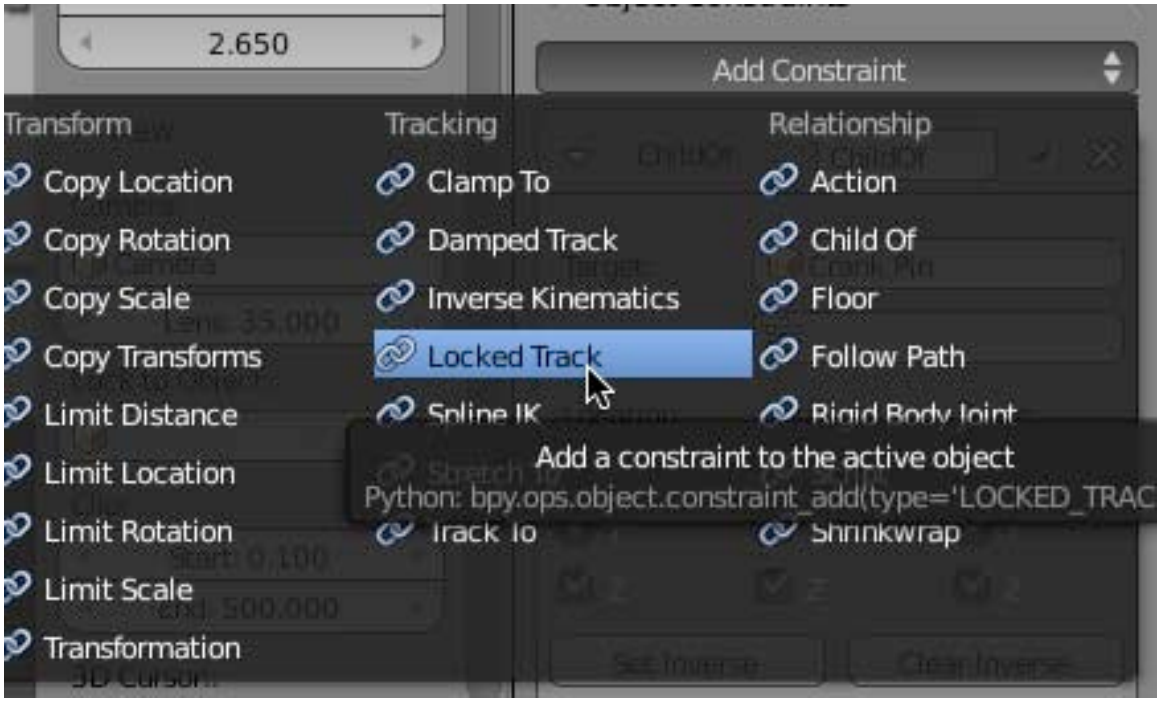
Next select the crank pin object. Press SHIFT-S and select cursor to selection.
Next select the connecting rod object. Press SHIFT-CTRL-ALT-C and select **"Origin to 3D Cursor"**.

This places the origin of the connecting rod in the exact location as the origin of the crank pin.

Next, add a "Child Of" constraint to the connecting rod object. Make the Target the "Crank Pin" object. **CLICK ON THE SET INVERSE BUTTON**. This will set the constraint rod object back to its proper position.

Finally, we need to constrain the other end of the connecting rod to the linking pin. We will do this by adding a second constraint to the connecting rod , however, we will use a different of constraint.

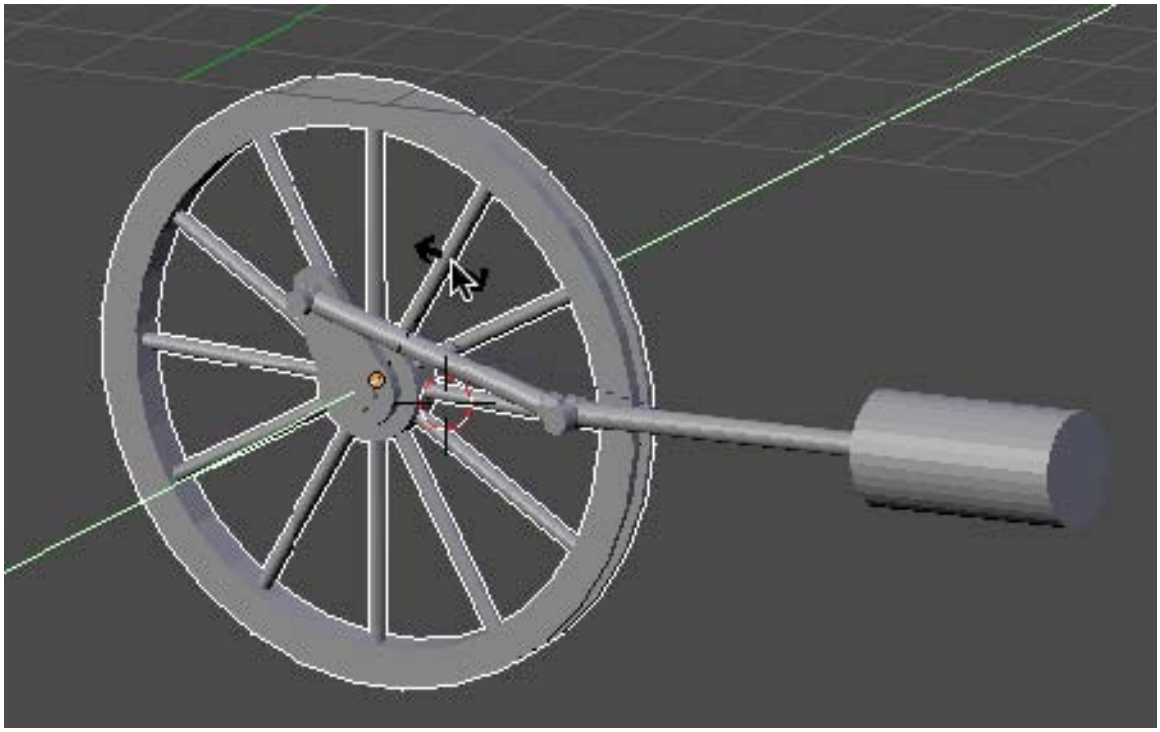
With the connecting rod selected, add a "Locked Track" constraint.



Make the Target the “Linking Pin” object. Set the “To” to “Z” -- Set the “Lock” to “Y”

The connecting rod is a child of the crank pin so it will move and rotate with the crank pin. The connecting rod is also “Locked Tracked” to the linking pin object, which (because it is a child of the piston rod) travels only along the X-axis. As the wheel turns, the connecting rod’s is changing its X and Z locations. The connecting rod is forced to rotate around its Y-axis so that it’s Z-axis remains facing in a constant direction (up).

Now, rotating the wheel front left object pulls the connecting rod along and it, in turn, is locked to the linking pin.



BTW: A special note of thanks to “Sundialsvc4” for providing an explanation of this constraint configuration on the Blender Artists forum discussions board.
http://blenderartists.org/forum/showthread.php?t=140734

Note some problems you may have:
It is critical that the origin point of the crank pin and the connecting rod be at the same exact location.

Depending on the lengths of the crank, connecting rod and piston rod the linking pin joint may not appear connected throughout the animation. You may have to adjust the lengths and locations of the elements a bit. If you do you will need to remove the constraints (clicking on the X in the panel) and re-setting them after you have made the adjustments.

(Note: You can add another constraint on the connecting rod, "LIMIT DISTANCE" leave the setting default and target the Linking Pin. That will hold the connecting rod in placing, limiting its wrong movement and keeping it the right place.)

Save your Blender file.

There is a completed .blend file containing just the locomotive drive chain named RocketDriveTrainComplete.blend that can be downloaded HERE.