PROJECTS by CARVEWRIGHT™

Synchronicity Clock

PROJECT DIFFICULTY: ADVANCED

Synchronicity is a pendulum wall clock that features a second hand. All of the moving parts are exposed so you can see it operate. A magnet hidden in the back of the pendulum is repelled by an electromagnet hidden in the base to give the pendulum a gentle push each swing to drive the clock. Advanced electronics measure pendulum speed and make small adjustments to keep timekeeping accurate. The clock is powered by 4 D cells.

This design won the 2013 "Everyone's a Winner" Carvewright contest.

All of the wood parts are made with the Carvewright/CompuCarve machine using the two standard 1/8” cutting and 1/16” carving bits, plus a few hand tools and a drill press. A 1/16" cutting bit is recommended.

Centerline and a 60 degree V bit are optional but required to produce the font illustrated here.

A complete hardware kit of all non-wood parts is available from www.carveshop.com.

This project was created using Designer version 1.187.

Materials List

Project Files

- quarter_parts.mpc
- half_parts.mpc
- base_parts.mpc
- face.mpc
- frame.mpc
- pendulum.mpc

Boards:

- (1) ¼” x 12” W x 22” L Baltic birch plywood
- (1) ½” x 6” W x 15” L hardwood
- (1) 1” x 3” W x 10” L
- (1) 1” x 6” W x 26” L
- (1) 1” x 6” W x 10” L
- (1) 1” x 12” W x 12” L

All dimensions nominal.
See instructions for actual.

Materials:

- sleds (see instructions)
- hardware (see instructions)
- electronics (see instructions)
- finish (e.g. lacquer, varnish)

Hand Tools:

- small hand saw
- files
- screw drivers
- hammer

Power Tools:

- drill, drill press, drill bits
- sander (optional)

Introduction

Synchronicity is a wood gear clock driven by an electromagnetic pendulum. A magnet hidden in the pendulum swings past an electrical coil hidden in the base. An electronic circuit detects this, and injects a short current pulse into the coil. This electromagnetic coil then repels the magnet, giving the pendulum a small "kick" each time it passes by. This keeps the clock running.

Synchronicity operates safely on 4 D batteries for up to four months.

This CarveWright project's difficulty is categorized as Advanced because tools other than the CarveWright, such as a drill press, are required. Also, there are a quite a few parts to make and assemble. However, the clock has been designed to be somewhat forgiving, and can be successfully built by first-time wood gear clock builders.

In addition to the wood parts that you will fabricate, hardware such as a rare earth magnet, brass threaded rod, brass tubing, bearings, and electronics are needed. You can get a complete kit of all hardware from www.carveshop.com. Visit that web site to find out how to order the hardware kit.

The hardware kit comes with all hardware parts necessary to build the clock, including the electronics.

Step 1

Hardware

Here is a list of hardware in the hardware kit, or what you need to assemble to build the clock:

Quantity	Description
1	#6 ¾" brass round head wood screw
4	#6 1" wood screws
3	6-32 2½" pan head machine screws
6	#6 brass washers
3	6-32 brass acorn nuts
6	#8 brass washers
3	8-32 brass nuts
3	8-32 brass acorn nuts
3	8-32 x 4-5/8" brass threaded rod
1	10-32 6" brass threaded rod
2	10-32 knurled nut
1	10/32 acorn nut
8	3/16" x 3/8" x 1/8" ball bearings
1	.016" x 5/16" x 1-3/4" compression spring
1	5/16" x .062" nylon washer
1	vinyl tube, 1/4" OD x .170 ID x 3/8" long
1	3/4" diameter ¼" thick rare earth magnet
	brass tubing (see below)
	electronics (see below)

Some of the screws and threaded rod will be near a powerful magnet, and they must be non-ferrous. Use solid brass. Do not use brass-plated screws or rod. Hold the parts near a magnet to test if uncertain.

Brass tubing

quantity	diameter	length	description
1	3/16	1 5/16	moving pawl shaft
4	3/16	1 ½	(3) frame mounting posts, (1) lever shaft
1	3/16	1 15/16	fixed pawl shaft
1	3/16	2	lever to pendulum bearing shaft
1	3/16	5 ½	second hand shaft
4	7/32	1/8	spacer
2	7/32	1/16	spacer
1	7/32	½	moving pawl bearing
1	7/32	1	fixed pawl bearing
1	7/32	1 1/8	lever-pendulum bearing spacer
3	7/32	3 ½	gear set shafts
1	¼	5/8	12 tooth pinion with clutch
1	¼	1 3/16	gear set 1
1	¼	1 ½	gear set 2
1	¼	2	gear set 3
1	¼	3 1/8	gear set 4
1	¼	3 3/4	minute hand shaft
1	9/32	1 7/8	hour hand shaft

Tubing in the hardware kit is precut. However, you must de-bur and chamfer the ends a bit with a flat file on the outside and a small round file on the inside of the moving parts. It is essential that moving parts pivot or rotate freely.

Electronics

The hardware kit includes an advanced pendulum drive circuit. Accuracy and stability of the clock are improved with this more advanced pendulum drive circuit. This advanced circuit is unique to carveshop.com clocks.

If you want to source all of your own hardware parts, including the electronics, email dick@carveshop.com for instructions to build a basic circuit yourself or to purchase the advanced electronics separately.

Either the basic or the advanced circuit will make for a very nice clock. I've run a couple clocks with the basic circuit, but the advanced one has some nice features. Here's an explanation of each.

Basic pendulum circuit

The basic pendulum drive circuit is triggered solely by the pendulum itself and is not adjustable on the fly. Therefore, with this circuit, clock accuracy is adjustable only by the movable bob on the pendulum, which requires a manual tuning effort. It may take several days or weeks to adjust the pendulum properly, and accuracy may change over time. But the circuit does provide for a very functional clock.

Advanced pendulum control circuit

The advanced pendulum control circuit, included with the hardware kit, is run by a microcontroller with a watch crystal time base. It constantly monitors the pendulum period and adjusts the coil drive to keep the clock as accurate as the reference watch crystal, within 20 parts per million. (While the period of the pendulum in this clock is regulated primarily by the effective length of the pendulum, the period also can be adjusted somewhat by how the electromagnetic coil is driven.)

The advanced circuit also has a simple LED indicator to help you set up your clock faster. More on that later.

Batteries

You'll need 4 alkaline D cells to power your clock. Non-alkaline batteries will not last long. Batteries are not included with the hardware kit.

Step 2

Wood

Here is a table of the boards that you will need for this project:

Thickness		Width			
Nom.	Act.	Nom.	Act.	Len.	.mpc
¼"	¼"	12"	11½"	30"	quarter_parts
½"	7/16"	6"	5½"	15"	half_parts
1"	¾"	3"	2½"	10"	pendulum
1"	¾"	6"	5½"	26"	base_parts
1"	¾"	6"	5½"	10"	frame
1"	¾"	12"	11½"	11½"	face

Nominal thickness and width are what you will typically see in a lumber yard or home center – for example, a 1" thick by 6" board will actually be ¾" thick by 5½" wide.

Decide what type of woods you will use for your clock.

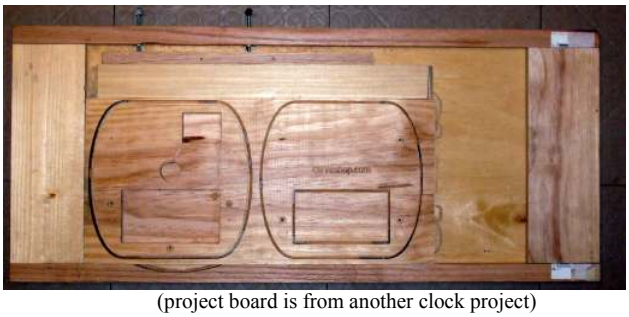
For the larger gears (wheels) and other parts on the file quarter_parts.mpc, I highly recommend using ¼" Baltic birch plywood (left), compared to standard plywood (right). Baltic birch is special plywood that is constructed from multiple thin layers that are free of voids. This makes the plywood dimensionally stable, and gears cut from it will be flat and true. Some home centers may carry it, but it can also be ordered and shipped from many sources.

I have had good luck by applying a coat of finish – for example, polyurethane varnish – to both sides of the Baltic birch before machining it. This tends to add some strength to the wood fibers and helps prevent splintering. Minwax also offers a Wood Hardener that works well.

For the pinions and other parts on half_parts.mpc, you'll need a board that is nominally ½" thick and 6" wide, actual dimensions 7/16" thick and 5½" wide. I find 7/16" oak in the local home centers such as Home Depot, and oak is what I used for my clock.

The face, base, and pendulum are made from standard 1" boards (actual thickness ¾"). I used clear pine for the face and maple for the other 1" parts on my clock.

Step 3



(project board is from another clock project)

Sled or jig

The .mpcs of this project could be machined without jigs or sleds, but to conserve wood, a sled is recommended. If you're an experienced sled user, you'll have no trouble modifying the project files to your own style of jig or sled. If not, I suggest that you study the *CarveWright Tips and Tricks Issue 7 April 2008 Carving Jigs – Carrier Boards, Sleds and Rails.* You can find this at www.carverwright.com under Learning – Tips and Tricks. Then build a sled or sleds for this and future projects.

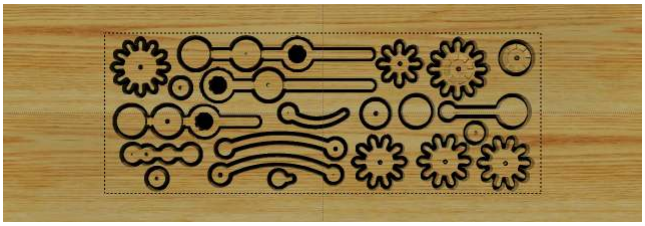
I myself typically use adjustable sleds like the one pictured above. Mine are similar to the type in Figure 4 of the *Tips and Tricks Issue 7*, with 1" wide side rails and 4" wide end filler pieces. **The 1" nominal board project files are all set up for sleds of this type.** If you use a different size sled, you will need to adjust the mpcs appropriately.

Note that my sled is oversize, to fit a variety of projects, rather than being exactly the dimensions required for any one project. I simply respond Place On Corner to make use of the one sled for many projects. I use a couple of thumbscrews and scrap wood to secure the project boards in the sled, *with the project board in the lower left corner as shown*. This is required to make use of the .mpc files as is.

The machine prompts and responses in these instructions are all based on using a sled that is larger in width and length than the virtual project boards. If you use something different, the prompts may be different.

My sleds are not adjustable for height, so I have different sleds for ¼", ½", and ¾" boards. In these instructions, I show you how to quite easily make sleds for the ¼" and ½" boards for this project. You will need to have or make a sled for ¾" boards that can accommodate boards up to 11½" wide and 26" long for this project.

Step 4



Half inch parts

Because we are using nominal ½" wood which is actually 7/16" thick, we need to use a sled, as the machine requires ½" minimum board thickness.

The easiest way to make a sled for this part of the project is to use a piece of ¾" plywood or MDF 23" long and 7½"wide. Carve the sled using the project file half_sled.mpc. You may upload and carve the sled project in draft mode to save time. Respond No to Stay Under Rollers? and Place on Corner if your board is oversized (just be sure to orient the sled the same way in the machine when you cut your parts).

To cut the parts, cut your 7/16" x 5½" material 15" long. Place it in the sled, and hold it in place by taping the edges.

Upload the half_parts.mpc project file in Best mode.

Load the sled into your machine. On the machine main menu, press 0 for Options and 5 for Jog Touch, and then press Enter if needed to set Jog Touch (On). When running the project, touch the bit down on the 7/16" board, and not the surface of the sled, to get an accurate reading of the board's surface.

If your sled was slightly oversize, respond 1) Keep Original Size after the board is measured, and 3) Place On Corner. At the prompt Cut Board To Size?, respond 2) No.

At the prompt Select Drill Bit: ←→ select the offered choice 1/8" Cutting. Load the 1/8" cutting bit when prompted. Use the arrow keys to touch the bit down onto the 7/16" stock, not the sled.

After the machine finds the board thickness, respond to the prompt Select Cut Through Depth by choosing 1) Project.

At the prompt Select Vector Bit: ←→ select the offered choice 1/8" Cutting.

If you have a 1/16" cutting bit, at the prompt Select Drill Bit: ←→ select the offered choice 1/16" Cutting. Load the bit when prompted.

If you don't have a 1/16" cutting bit, select the 3/16" cutting bit, but load your *1/16" carving bit* instead. It will work just fine, because it will be used to drill only very shallow pilot holes.

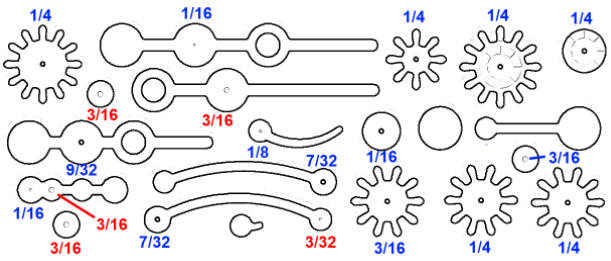
At the prompt Select Cutting Bit: ←→ select the offered choice 1/8" Cutting. Load that bit when prompted.

At the prompt Select Carving Bit: ←→ select the offered choice 1/16" Carving. Load that bit when prompted.

Remove the board after machining is completed.

Because the pinions and other parts are going to be pressed onto brass tubing when assembling the clock, their center hole diameters must be precise – even more precise than the CarveWright is capable of doing. We need to use precise drill bits. However, we had the CarveWright drill 1/8" or 1/16" pilot holes for us to locate the positions of these critical holes.

Before removing the parts from the board, use a drill press to drill holes according to this drill guide:

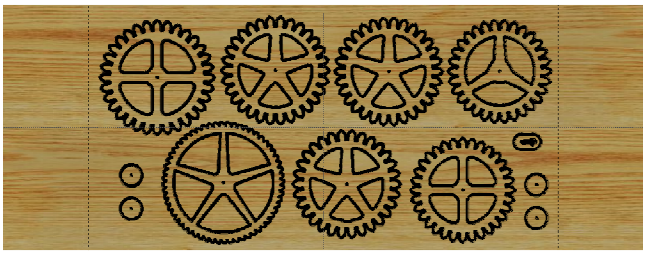


The holes with numbers in blue are drilled completely through the board. The holes with numbers in red are drilled only 3/8" deep.

Mark the center of the back side of the lever as shown, and drill a 3/16" hole 3/8" deep.

After drilling, cut the tabs to remove the parts and sand them. If you have a scroll saw, I've found that Olson ScrollSander sanding belts work well for pinions, wheels, and other parts:

Step 5



Quarter inch parts

The wheels and other parts are cut from a ¼" piece of Baltic birch 11½" by 30". This thin stock cannot be loaded into the machine by itself.

(project board is from another clock project)

You can make a simple sled for ¼" stock by cutting a piece of ½" or ¾" plywood, and temporarily fasten oversize birch to the plywood. You can see from the photo of my sled that I reuse 4" wide pieces of birch plywood for the ends of the sled to minimize waste, as I make a lot of clocks. Make sure that the plywood for the sled is smooth on the bottom, warp free, and cut square. This will ensure that the board will track properly in the machine.

Fasten the birch to the plywood base with four countersunk screws in the corners of the plywood. You may instead use tape on the plywood edges or double-sided tape on the surface of the sled. Whatever method that you use, make sure that the birch is securely attached. (Note that the project uses tabs to keep the gears in place, so double-sided tape is not required if you use screws or edge taping to secure the birch.)

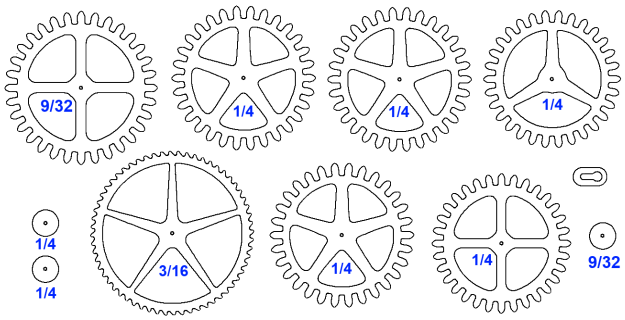
Load the sled into the machine and use the quarter_parts.mpc file, uploaded in Normal mode. Respond No to Say Under Rollers? and 1) Keep Original Size then 3) Place on Corner if your board is oversized. At the prompt Cut Board To Size? respond 2) No.

At the prompt Select Drill Bit: ←→ select the offered choice 1/8" Cutting. Load that bit when prompted.

At the prompt Select Cut Through Depth, choose 1) Project.

At the prompt Select Cutting Bit: ←→ select the offered choice 1/8" Cutting At the prompt Select Vector Bit: ←→ select the offered choice 1/8" Cutting.

After machining has completed, with a drill press, drill holes per the following drill guide:



Carefully remove the gears by cutting the tabs. Sand the parts as needed. Make certain that the tabs on the gears are completely removed from the teeth and flush with the nominal gear outline. This is critical to ensure that the clock will operate properly.

Step 6

Base parts

If you have the Carvewright Keyhole Function Software and Bit, you may want to delete the keyhole slot that uses a plywood insert and substitute your own.

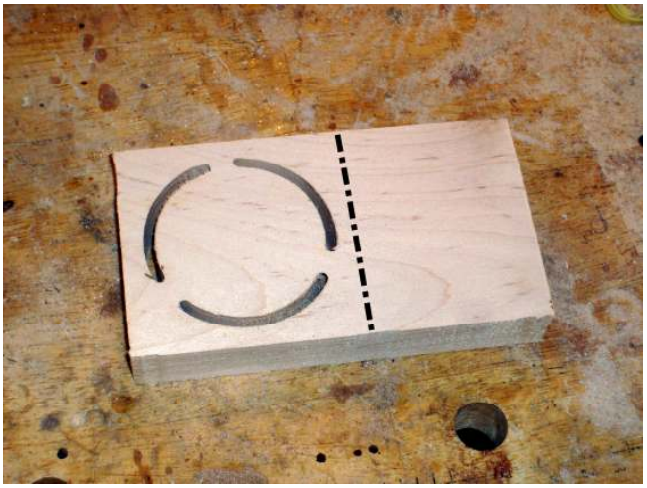
Load a ¾" board 26" long and 5½" wide into your sled. Load the sled into the machine and use the base_parts.mpc file (you may upload in Draft mode). Respond No to Stay Under Rollers?. As your sled is sure to be larger than the virtual project board, you will get scaling-related prompts. Select the option 1) Keep Original Size and 3) Place on Corner. At the prompt Cut Board To Size? respond 2) No.

At the prompt Select Vector Bit: ←→ select the offered choice 1/8" Cutting. Load the 1/8" cutting bit.

As the machine finds the board thickness, prompts will depend upon the thickness of your sled. If you use a thick sled, with a ¾" plywood base for example, you will be asked if the sliding plate is in position, and you will be prompted to Enter Board Thickness: Respond by entering .75. If your sled is thinner, with say a 1/8" Masonite base, you will be asked to Select Cut Through Depth. In that case, choose 1) Project.

At the prompt Select Drill Bit: ←→ select the offered choice 1/8" Cutting. At the prompt Select Cutting Bit: ←→ select the offered choice 1/8" Cutting. At the prompt Select Carving Bit: ←→ select the offered choice 1/16" Carving. Load that bit when prompted.

When machining has completed, remove the board, cut the tabs, and remove the parts. However, you may want to leave the bob in the rectangular part.



I cut the rectangular part as shown.

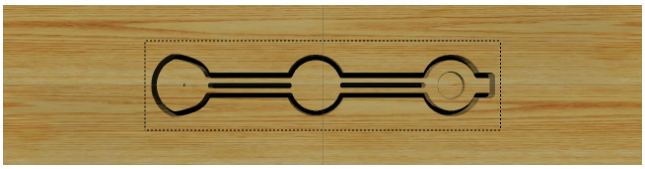
I marked the center of each end and clamped the part into a simple jig. I used a drill press to drill a 7/32" hole into the bob, top then bottom. Then I separated the bob.

Sand these parts. I find it convenient to temporarily fasten the two base parts together with the prescribed #6 wood screws when sanding the edges of these parts.

On the front base part, locate the three recessed mounting holes at one end. Drill these through with a 9/64" drill bit.

Glue the plywood keyhole slot cover in its recess.

Step 7



Pendulum

Load a ¾" board 10" long and 2½" wide into your sled. Load the sled into the machine and use the pendulum.mpc file uploaded in Normal mode.

Respond No to Stay Under Rollers?. Select the option 1) Keep Original Size and 3) Place on Corner. At the prompt Cut Board To Size? respond 2) No.

At the prompt Select Drill Bit: ←→ select the offered choice 1/16" Cutting. *Make that selection even if you don't have that bit*. If you have a 1/16" cutting bit, load the bit when prompted. If you don't have a 1/16" cutting bit, load your *1/16" carving bit* instead. It will work just fine, because it will be used to drill only a very shallow pilot hole.

At the prompt Select Drill Bit: ←→ select the offered choice 1/8" Cutting. Load the 1/8" cutting bit when prompted.

After the machine finds the board thickness, prompts will depend upon the thickness of your sled. If you use a thick sled, with a ¾" plywood base for example, you will asked if the sliding plate is in position, and you will be prompted to Enter Board Thickness: Respond by entering .75. If your sled is thinner, with say a 1/8" Masonite base, you will be asked about Cut Through Depth. In that case, choose 1) Project.

At the prompt Select Cutting Bit: ←→ select the offered choice 1/8" Cutting. At the prompt Select Vector Bit: ←→ select the offered choice 1/8" Cutting.

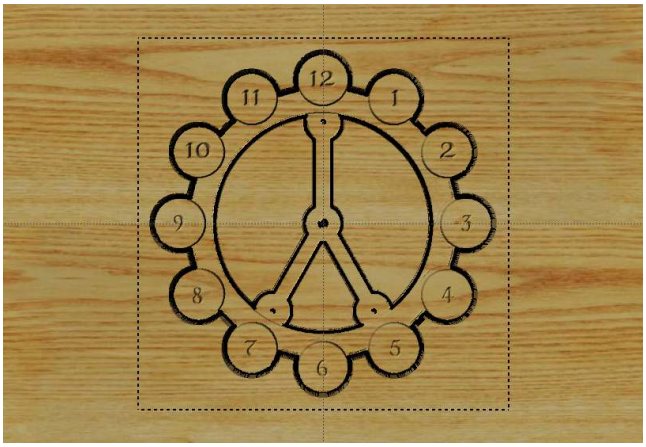
When machining has completed, remove the board, cut the tabs, and remove the pendulum. Sand the part.

Using the 1/16" pilot hole at the pendulum pivot, drill a 1/16" hole through to the other side with a drill press.

A threaded brass rod is to be attached to the bottom of the pendulum. There are two ways to do this. If you have a 10-32 tap, drill a 9/64" hole into the center of the bottom, about 3/4" deep. Tap the hole. Screw one end of the threaded rod into the hole, securing it with superglue. Or, drill a 7/32" hole and secure the threaded rod with epoxy. Either way, make sure the hole is centered and straight. If you

can't drill the hole with your drill press, make a simple drill guide.

Step 8



Face

I used the font Black Chancery, which can be found at www.dafont.com for free, for the numerals. If you don't have that font installed, the numerals will default to a different font. Consult your operating system help if you don't know how to install fonts.

I also used Centerline and the 60 degree V bit. You may edit the file to switch to the 90 degree bit if you don't have a 60. If you don't have Centerline, use the file face_raster.mpc (it uses a simpler, standard font).

Load a ¾" board 11½" long and 11½" wide into your sled. When machining this part, orient the board in your sled so that the wood grain is running 90 degrees from the above illustration. The grain should run parallel to the top spoke under the numeral 12 and parallel to the rollers in your machine.

Load the sled into the machine and use the face.mpc or face_raster.mpc file. Respond No to Say Under Rollers?. Select the option 1) Keep Original Size and 3) Place on Corner. At the prompt Cut Board To Size? respond 2) No.

If you are using Centerline, at the prompt Select Vector Bit: ←→ select the offered choice 60 Degree V. Load the bit.

At the prompt Select Drill Bit: ←→ select the offered choice 1/8" Cutting. Load the bit when prompted.

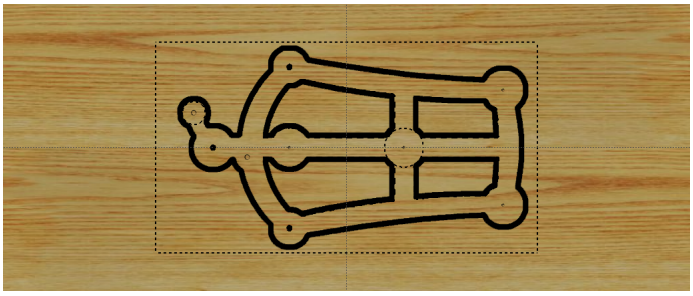
After the machine finds the board thickness, if asked about Cut Through Depth, choose 1) Project.

At the prompt Select Vector Bit: ←→ select the offered choice 1/8" Cutting. At the prompt Select Cutting Bit: ←→ select the offered choice 1/8" Cutting.

At the prompt Select Carving Bit: ←→ select the offered choice 1/16" Carving. Load that bit when prompted.

After machining, cut the tabs and sand the piece. Drill the center hole with a 5/16" drill bit and the three mounting holes with an 11/64" drill bit.

Step 9



Frame

Load a ¾" board 10" long and 5½" wide into your sled. Load the sled into the machine and use the frame_parts.mpc file uploaded in Normal mode. Respond No to Say Under Rollers?. Select the option 1) Keep Original Size and 3) Place on Corner. At the prompt Cut Board To Size? respond 2) No.

At the prompt Select Drill Bit: ←→ select the offered choice 1/8" Cutting. Load the bit when prompted.

After the machine finds the board thickness, enter either the project board thickness of .75 or for Cut Through Depth choose 1) Project.

At the prompt Select Cutting Bit: ←→ select the offered choice 1/8" Cutting.

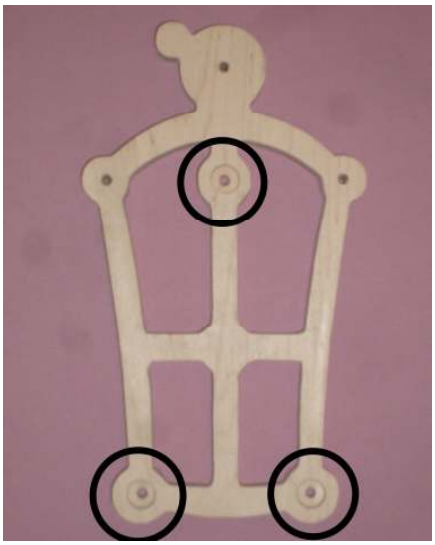
If you have a 1/16" cutting bit, at the prompt Select Drill Bit: ←→ select the offered choice 1/16" Cutting. Load the bit when prompted.

If you don't have a 1/16" cutting bit, select the 3/16" cutting bit, but load your *1/16" carving bit* instead. It will work just fine, because it will be used to drill only very shallow pilot holes.

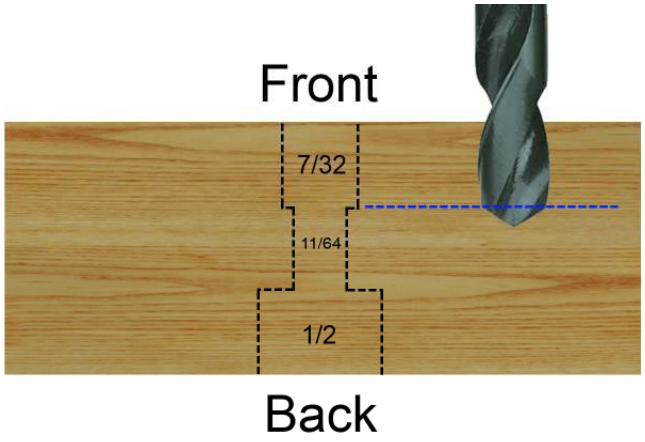
Load bits as prompted during the machining processes.

After machining, cut tabs, remove the frame and sand.

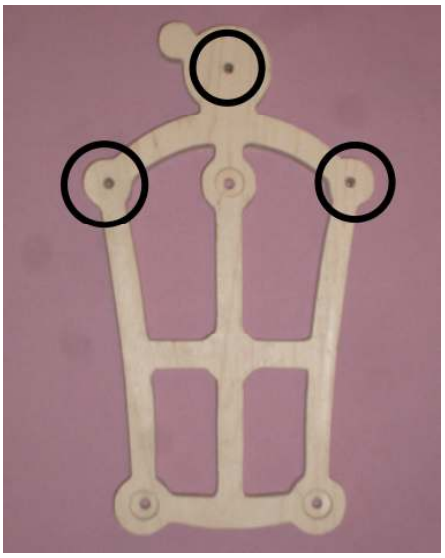
From the front of the frame, using the three pilot holes illustrated, drill a 1/16" hole through the frame with a drill press.



From the back of the frame, using the 1/16" pilot holes that you just drilled through from the front (circled), drill recesses for the three shaft retaining rod nuts using a ½" Forstner bit and drilling only ¼" deep. (A standard bit can also be used.)



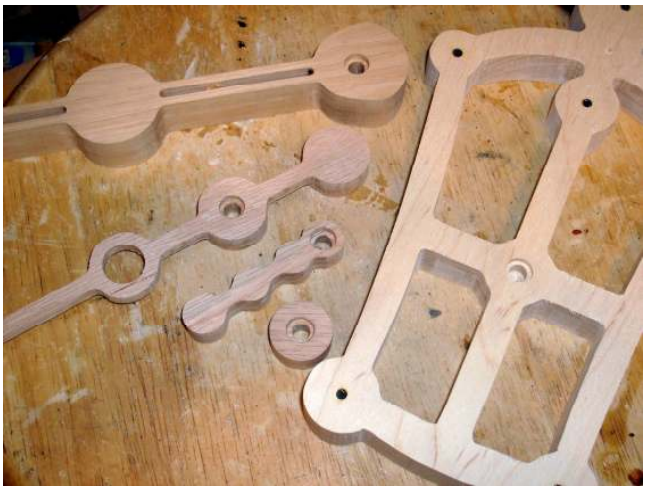
From the front, at the same positions, drill 7/32" holes ¼" deep. If using a standard drill bit, measure depth to the shoulder of the bit as shown, not the tip. This is a critical dimension in order for the precut brass tubing in the hardware kit to fit properly. Finally, drill these holes through with an 11/64" bit.



From the back of the frame, drill the three post mounting holes (circled) with a 3/16" bit exactly ½" deep. Then drill through with a 5/32" bit.

On the front of the frame, drill the two shaft mounting holes (circled) with a 3/16" bit exactly ½" deep.

Step 10



Bearing recesses

Several parts hold bearings, and these parts need to have recesses for the bearings drilled.

The Carvewright has machined 1/16" pilot holes for these parts, and in the case of the pendulum and lever, which will have two bearings each, one on each side front and back, you have drilled these pilot holes through to the other side the part.

Using a 3/8" Forstner bit, drill recess holes in each part 1/8" deep. (A standard bit can also be used.) Drill both sides of the pendulum and lever. Drill the front (flat) side of the minute hand, hub, and frame.

Next, drill a ¼" diameter hole through the center of each these recesses. Drill about ½" deep on the frame; drill through to the other side of the other parts.

Step 11

Gear Set 1

The shaft for Gear Set 1 is a ¼" diameter tube that is 1-3/16" long. Insert the shaft into the 12-tooth pinion that does *not* have the clutch face carved into it and secure with superglue. Set the shaft flush with the face of the pinion. (I put a couple of drops of superglue inside the pinion hole - the wood will adsorb some - and a drop around the end of the shaft. You must assemble quickly and accurately. I insert the shaft by hand a bit, set the pinion down on the bench whit shaft sticking up, use a wood block on top of the shaft and drive the shaft home with a hammer.)

Slide one of the 5-arm 30-tooth wheels on, and secure to the shaft and pinion with superglue. (I put a couple drops of superglue on the face of the pinion and a drop around the shaft, assemble, then clamp the wheel to the pinion with two Irwin Quick-grip clamps.)

Step 12

Gear Set 2

Part A

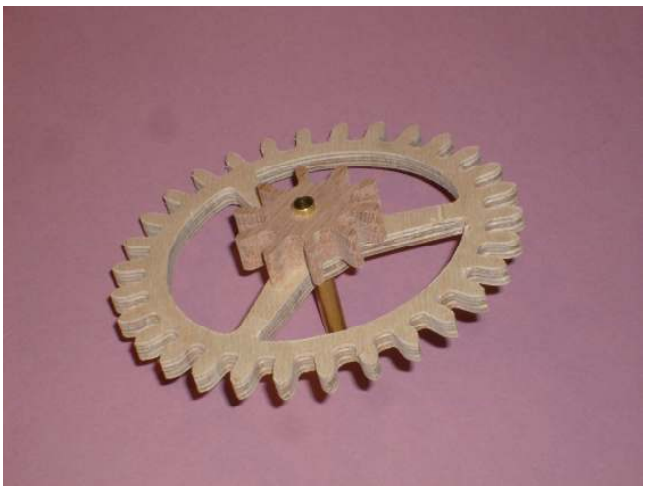
The shaft for Gear Set 2 is a ¼" diameter tube that is 1½" long. Insert the shaft into the one-way round clutch as shown, so that the end of the shaft protrudes from the wheel exactly 7/8". Secure with superglue.

Next, slide the 32T12 four-armed wheel onto the shaft. (Note that the 32T12 four-armed wheel is smaller in diameter than the 32T8 wheel - use the correct one!) Secure it to the shaft and hub with superglue.

Part B

The 12-tooth pinion with the one-way clutch face is the mate to this gear set. The shaft for this pinion is a ¼" diameter tube that is 5/8" long. Insert it into the pinion so that the end of the shaft is flush with the clutch face.

Step 13



Gear Set 3

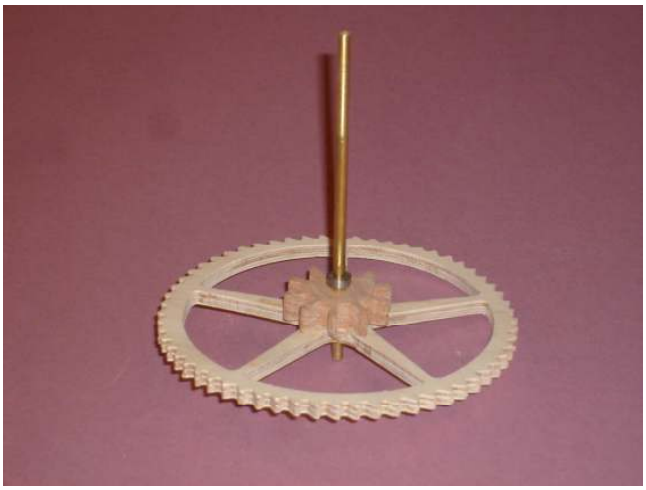
The shaft for Gear Set 3 is a ¼" diameter tube that is 2" long. Insert the shaft into a 10-tooth pinion so that 1/16" of the shaft protrudes from the pinion. Secure with superglue. next, slide the 3-arm 30-tooth wheel onto the shaft, and secure it to the shaft and pinion with superglue.

Step 14

Gear Set 4

The shaft for Gear Set 4 is a ¼" diameter tube that is 3-1/8" long. Insert the shaft into the 8-tooth pinion so that the shaft protrudes ¼" from the face of pinion. Secure with superglue. Next, slide a 5-arm 30-tooth wheel onto the shaft and secure it to the shaft and pinion with superglue.

Step 15



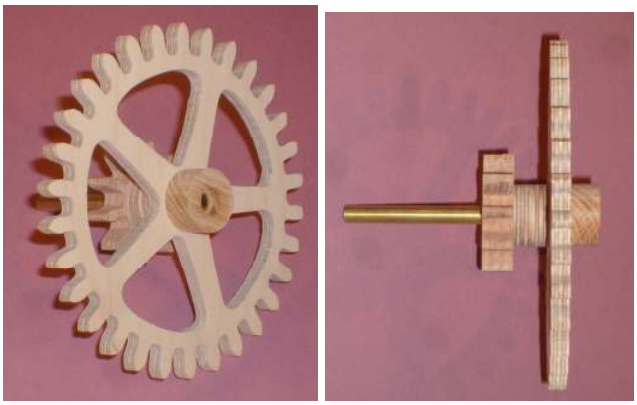
Second shaft and gears

The second hand shaft is a 3/16" diameter tube that is 5½" long. It is supported by three bearings. Start by test fitting bearings on both ends of the shaft. If the bearings don't slide on, reduce the diameter of the shaft slightly. I use fine sandpaper or emery cloth with the shaft inserted into my drill press. You don't need to worry about the center of the shaft, just the ends.

Slide a bearing onto one end of the shaft so that it is at least 1¼" from the end of the shaft. Slide a 7/16" diameter, 1/8" long brass spacer on next. Slide the 10-tooth pinion with the 3/16" hole on next, so that exactly ½" of the shaft protrudes from the pinion. Secure with superglue.

Finally, slide the ratchet wheel on, *paying attention to the direction of the teeth*. Secure to the shaft and the pinion with superglue.

Step 16



Minute shaft and gears

The minute hand shaft is a ¼" diameter tube that is 3¾" long. Start the assembly by attaching the 7/16" thick by 1" diameter hub to one end of the shaft. The bearing recess faces outward from the shaft, and the shaft itself is inserted up to the bottom of the bearing recess. Secure these parts with superglue.

Next, take one of the 5-arm 30-tooth wheels and slide it onto the shaft all the way down to the hub. Secure the wheel to the hub and to the shaft with superglue.

Next, assemble and fasten two ¼" thick by 1" diameter plywood hubs.

Finally, assemble and fasten a 10-tooth pinion as shown.

Step 17

Hour shaft and wheel

The hour hand shaft is a 9/32" diameter tube that is 1-7/8" long. Attach the 4-arm 32-tooth wheel to one end of the shaft. Set the shaft so that the end protrudes 1/8" from the back face of the wheel.

Next slide a ¼" thick by 1" diameter plywood hub onto the shaft. Secure these parts to each other and the shaft with superglue as you assemble them.

Step 18

Finish

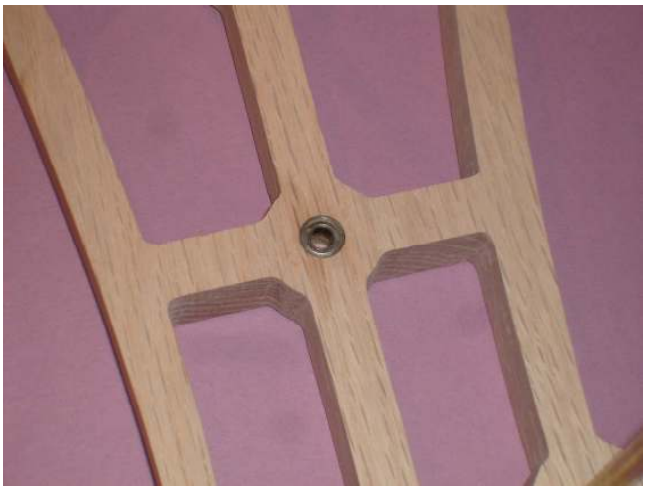
Most parts should be finished before assembly, but a few parts - for example the wheels and pinions - are best assembled first, as has been illustrated. But now would be a good time to apply finish.

You can use a variety of stains and/or finishes on your clock. I have used polyurethane and lacquer. Some wood gear clockmakers recommend no finish on gear teeth, but that is not a problem with this clock.

I have not provided specific steps for finishing. You may want to read the assembly instructions to help decide when to apply finish to your clock parts.

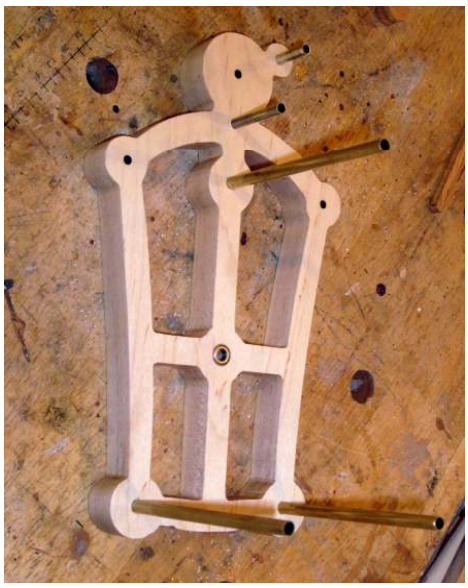
I recommend masking off the brass parts before applying finish.

Step 19



Frame assembly

Insert a bearing into the center of the frame.



Insert the three 7/32" diameter, 3½" long gear set shafts as shown. When fully seated, 3¼" should be exposed.

At the top right of the frame, insert a 3/16" diameter, 1½" long lever shaft. Before installation, check that a ball bearing will slide all the way from one end to within ½" of the other end. Remove some material from the shaft if necessary. I put the shaft in my drill press and use emery cloth or fine sandpaper..

Below that one and to the left-center, insert a 3/16" diameter, 1 15/16 fixed pawl shaft. Secure with superglue if necessary.

Step 20

Moving pawl assembly

Insert a 7/23" diameter/ ½" long brass tube pawl bearing onto the moving pawl, with equal lengths protruding from either side.

Insert ball bearings front and back into the lever.

On the back of the lever, insert a 3/16" diameter, 2" long lever-to-pendulum bearing shaft. Before installation, check to see that a ball bearing will slide at least 5/8" onto the end of the shaft, and remove some material from the shaft if necessary. Secure the shaft to the lever with superglue if necessary.

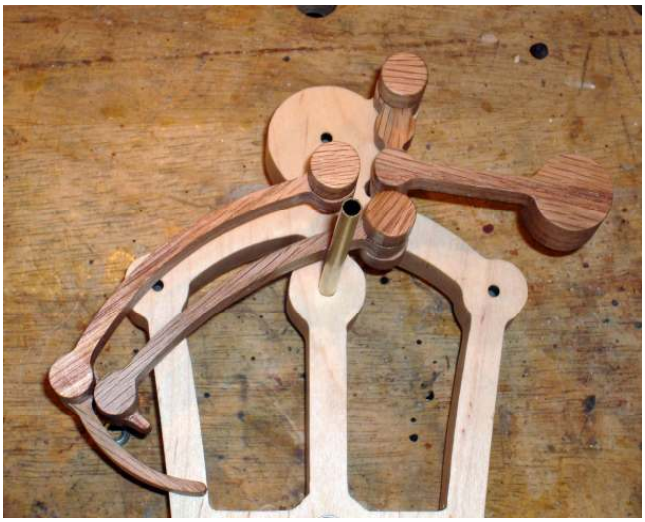
On the front of the lever, insert a 3/16" diameter, 1-15/16" moving pawl shaft. Secure with superglue if necessary. Slide the moving pawl onto the shaft as shown. Secure with a cap and superglue. Make sure that the pawl moves freely on the shaft. You may need to file the inside of the brass tubing with a small needle file to deburr the inside edge.

Step 21

Fixed pawl assembly

Fasten the fixed pawl tip to the pawl arm using a #6 3/4" brass round head wood screw. Insert a 7/32" diameter, 1" long fixed pawl bearing, leaving 1/16" protruding from the front of the arm.

Step 22

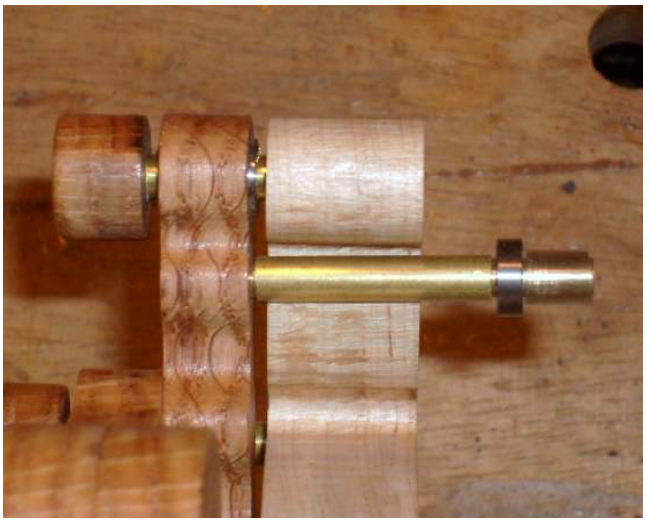


Pawls to frame

Slide a 1/16" spacer (a 7/32" diameter brass tube 1/16" long). Slide the lever (bearings) onto the shaft. Slide a 1/8" spacer on next. Secure a cap to the end of the shaft with superglue. Make sure the lever moves freely.

Slide the fixed pawl assembly onto its shaft as shown. Make sure that it moves freely. Secure a cap to the end of the shaft with superglue.

Step 23



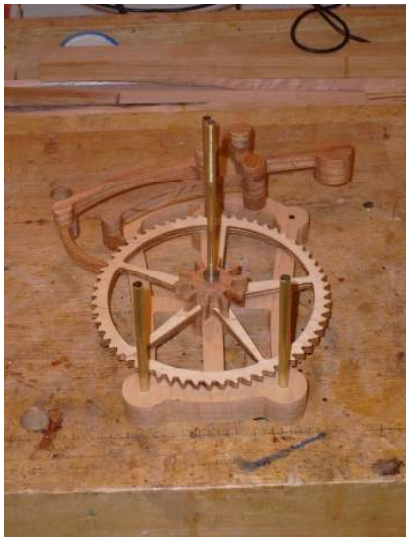
Lever to pendulum bearing

Slide the 7/32" diameter, 1-1/8" long brass tube bearing spacer onto the lever-pendulum bearing shaft. Slide a ball bearing on next. Finally, slide a small piece of vinyl tube on to secure the bearing.

Step 24

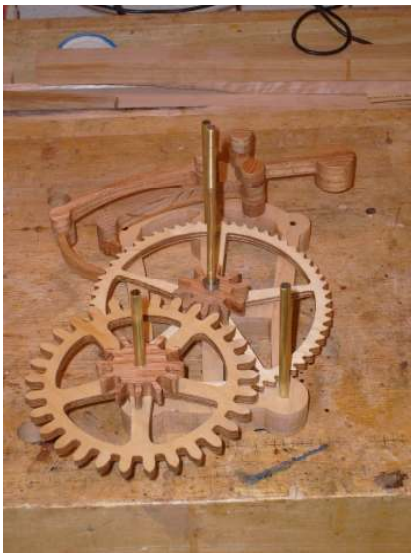
Install second hand assembly

Slide a 1/8" long spacer onto the shaft as shown.



Insert the assembly into the bearing in the frame.

Step 25



Install Gear Set 1

Install gear Set 1 as shown.

Step 26

Install Gear Set 2

Install Gear Set 2 as shown.

Step 27

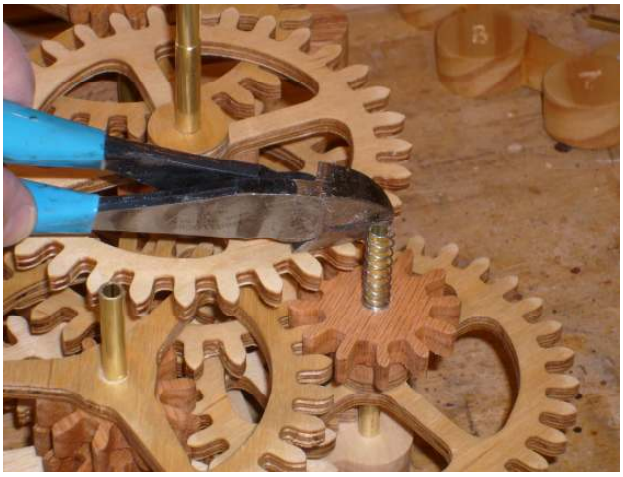
Install minute hand assembly

Install the minute hand assembly, pressing the arbor onto the bearing that is on the second had shaft.

Step 28

Install Gear Set 3

Install Gear Set 3 as shown. Install the 12-tooth pinion with clutch, clutch face down. Slide the clutch spring onto the shaft.



The hardware kit spring should be fine, but if your spring is excessively long, trim it. If too long and too tight, the clutch will not operate properly. The clutch works with very light pressure.

Step 29

Gear Set 4

Install Gear Set 4 as shown.

Step 30

Install hour hand assembly

Install the hour hand assembly as shown. Place a 5/16 nylon washer over the shaft.

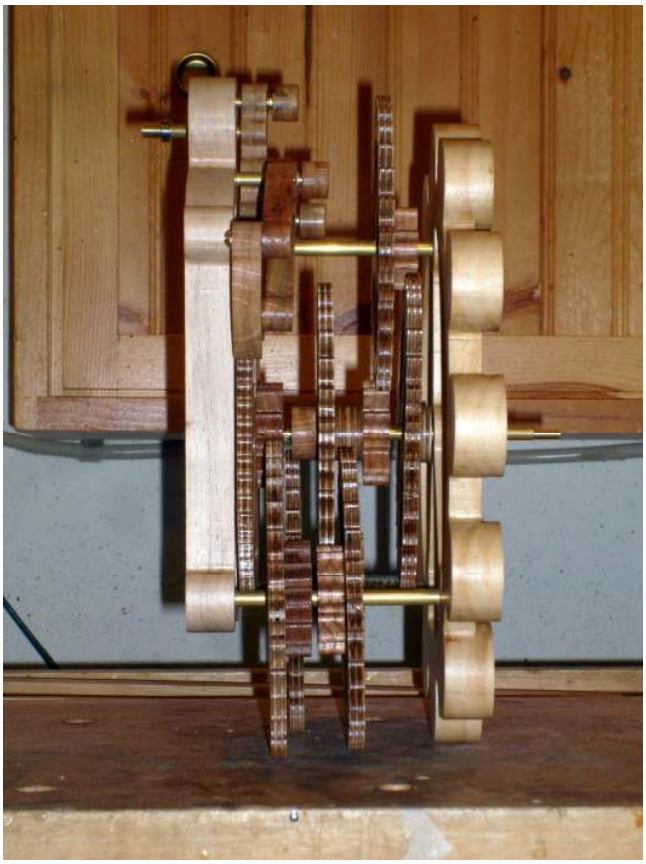
Step 31

Install face

Secure the face to the frame using the three threaded rods, acorn nuts on front, and nuts in the back.

Place washers on both sides of the face - that is, between acorn nuts and face front, and between face back and gear shafts. Do not over tighten.

Step 32



Alignment

Check the alignment of the assembly, making sure that there is sufficient clearance between wheels and pinions. Make sure that the pawls are centered on the ratchet wheel. Operate the gears manually. Make adjustments if necessary.

Step 33

Install hands

Install the hour hand on its shaft, securing with superglue as needed. Point the hand to the 12 o'clock position when gluing.

Insert a ball bearing in the minute hand. Install the hand on its shaft, slipping the bearing over the second hand shaft. Again align in the 12 o'clock position while gluing.

Install the second hand.

Step 34

Pendulum assembly

Press ball bearings into the pendulum front and back. Install the magnet with superglue. (If the polarity of the magnet is marked, install so that the marked face is exposed.) Install and secure the brass threaded rod.

Screw a 10-32 brass knurled nut onto the threaded rod, followed by the bob and another knurled nut. Locate the bob halfway up the threaded rod. Cap the threaded rod with a 10-32 acorn nut.

Step 35

Frame mounting posts

Insert the three frame mounting posts into their respective holes. Ball bearings slide onto the center post, so reduce the diameter if necessary. Exactly 1" of the posts should protrude, and they must be all exactly the same height.

Step 36

Install pendulum

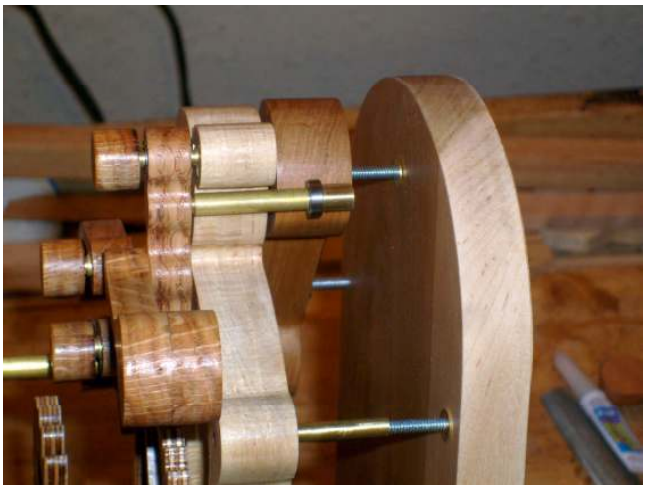
Slide a 1/8" spacer onto the center post.

Slide the pendulum bearings onto the center post. Follow with a 1/16" spacer.

Step 37

Assemble frame to base

Insert three #6 2½" machine screws into the back of the base. Place one brass washer each onto the screws.



Slide the screws into the posts. Secure with #6 brass acorn nuts on the face, placing washers under the acorn nuts. Tighten securely.

Step 38

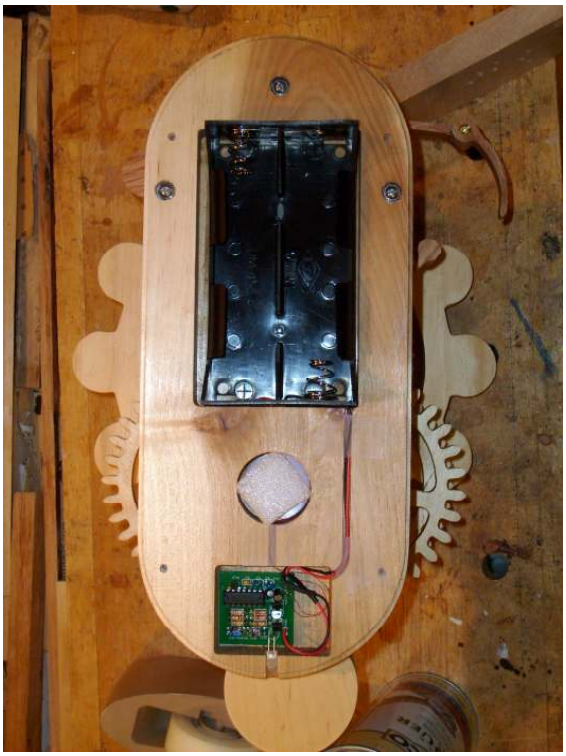
Pawl adjustment

Manually swing and hold the pendulum to the left. The driving pawl should rotate the ratchet wheel clockwise. Look at the locking pawl and ratchet wheel interface. The locking pawl should clear a tooth on the ratchet wheel and land about halfway onto the next tooth with the pendulum swung well to the left. Adjust the angle of the locking on its arm until this is the case.

Next, swing the pendulum and hold to the right. The ratchet wheel should freeze movement, and the driving pawl should skip onto the next tooth. The driving pawl should land about halfway onto the tooth as shown. Adjust the angle of the locking pawl on its arm as needed.

Move the pendulum back and forth several times, and check both the driving and locking pawl for proper action. When satisfied, tighten the screw securing the locking pawl to the arm.

Step 39



Install the electronics

Remove the protective film from the double-sided tape on the battery box and install the box. Place the coil in its recess. The side of the coil with the wire exiting near the center faces the front of the clock. Place the circuit board in its recess with the LED in its slot. (I secured by circuit board with hot melt glue.) Rout the wires in the channels, and secure with tape if need be. (The battery box wires run straight across the top of the coil, not to the side as in this earlier photo.) Place a square of foam on top of the coil to hold it against the face of the base. Install the back of the base and secure with four #6 wood screws.

Step 40

Setup and adjustment

Install batteries in your clock. When power is first applied, the LED will blink red and then green as a check. A pulse of current will then be delivered to the coil. If the magnet and coil are oriented in the correct polarity, the pendulum will be repulsed and may start swinging on its own. if not, the pendulum will be attracted to the coil and may just shudder. In that case, flip the coil over.

There is no on-off switch to the clock. As long as the pendulum is not swinging, the circuit (basic or advance) draws only minimal current. The swinging pendulum triggers the circuit.

Adjust the bob to the center of its travel, and lock it in place with the knurled nuts. Give the pendulum a gentle swing. If it doesn't start and run, consult the Troubleshooting section below.

Check the LED after a minute or so. If it is consistently blinking red, the pendulum is swinging too slowly. Raise the bob to speed up the pendulum by loosening the top knurled nut and then tightening the bottom one, and then try again. Conversely, if the LED is consistently blinking green, the pendulum is too fast. Lower the bob a bit. Keep the pendulum stopped for at least 3 seconds between adjustments to allow the electronics to reset itself.

When the LED no longer consistently lights, the pendulum is initially set using short-term measurement. (It's OK if the LED occasionally flashes red or green, as long as it is off most of the time.) The LED is disabled after 5 minutes. However, the pendulum speed is then measured with a more dependable long-term measurement. The LED may start blinking again after a period of time. If so, adjust the pendulum slightly, using as little as one turn of the knurled nuts. Keep the pendulum stopped for at least three seconds after adjusting, and restart it. It's probably best to ignore the short-term measurement blinking of the first 5 minutes after this adjustment. But watch for additional long-term warnings and then adjust again if needed.

Once the LED stays off for an extended period, the electronics will generally compensate, and no further adjustment will be needed.

To set the time, just rotate the minute hand in the clockwise direction.

Due to variations in wood density and weight, you may be unable get the clock to run slow or fast enough with the bob at the extent of its travel. If the bob is all the way down and the clock runs too fast, try a bigger or flatter bob. or add some weight by drilling a cavity in the back of the bob to hold it. If the bob is all the way up and the clock runs too slowly, add some weight to the round near the top of the pendulum. It may be helpful to temporarily attach a weight to determine what is required. (Avoid magnetic weight near the pendulum magnet.)

Troubleshooting

If you can't get your clock to run or keep running, check the following possible causes:

- Improper magnet or coil polarity
- Weak batteries
- Pendulum contacting frame or base
- Pendulum pivot contacting frame to base posts at large swing angles
- Gears not meshing properly
- Rough or misshaped gear teeth
- Faces of wheels rubbing on another gear or the frame
- Bearings or shafts binding

(How do I know what to troubleshoot? I've built several clocks, and I've had each of these problems at one time or another!)

You may find it helpful to temporarily disassemble parts of the clock to isolate problems. For example, remove the driving pawl to see if the pendulum will operate on its own. If it does, the gear train is probably binding somewhere.

If your clock runs but then stops, carefully examine the clock at the stopping point. It may be helpful to release the pawls and move the ratchet wheel or gears back and forth to locate the source of binding, rubbing, etc.

If you find the clock ticking to be too loud, you can quiet it a bit by modifying each of the two pawls. Cut off the tips of the pawls and replace them with cork. This can introduce some extra friction, so it's best to get the clock running without this modification first.

RESOURCES...

There are numerous resources for the CarveWright/CompuCarve owner to make their experience with these machines much more enjoyable.

Every owner should join the CarveWright User Forum (http://forum.carvewright.com/index.php) where fellow users share their experiences and knowledge with these machines on a daily basis. It is a FREE service that you will surely appreciate. A handy Search Feature helps you find answers to any questions you may have.

You can also visit the forums for up-to-date status on this project.