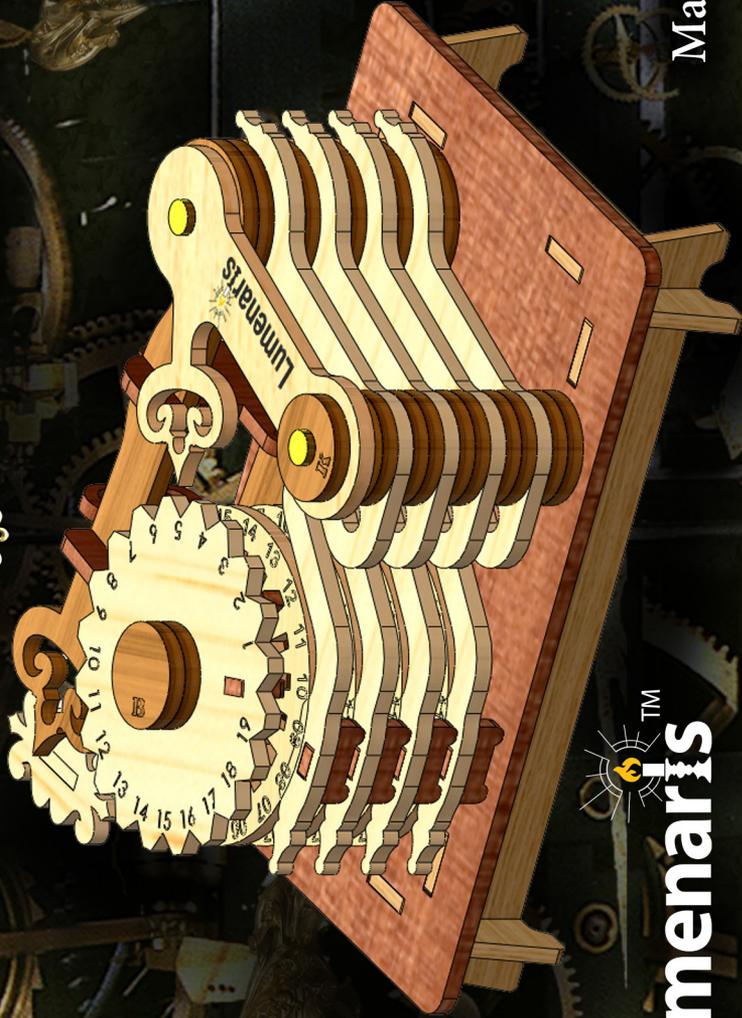


**COMBINATION LOCK MECHANISM**  
1860 STYLE - PRECUT KIT



**Lumenaris**<sup>TM</sup>

Made in USA

## About Combination Locks

Everyone has seen a combination lock. They are found on lockers, bank safes, house front doors, lock boxes for keys, and many other places.

Compared to a lock with a physical key, the key to a combination lock is a set of numbers you have to memorize. It's easy to make a copy, where a lock with a physical key usually needs a duplicator machine to cut from a blank another copy.

There are a number of different types of combination locks, some that go back thousands of years. This combination lock is from the 1800's and is called a code wheel combination lock. This model has four code wheels, one for each number you dial.

As you turn the dial, a pusher underneath of the dial can engage the pin sticking up from the code wheel. When the dial turns and they meet, the dial then pushes the code wheel in the same direction. To push it in the opposite direction the dial has to turn all the way around until the pusher hits the other side of the pin to cause the code wheel to turn.

Just as the pin on the dial turns the first code wheel, each code wheel has a pin to turn the wheel underneath.

To get the top code wheel to move, you rotate the dial one full turn past zero. Two full turns of the dial gets the next wheel to move, and so on. The top code wheel is for the last or fourth number in the combination and the bottom code wheel is for the first number.

Let's say your combination is 12-4-11-10. Start by turning the dial clockwise four times past zero, then stop at 12. This moves the bottom code wheel into the unlocked position. The lock is still locked until all four code wheels have moved to the unlocked position.

Next go counter-clockwise three turns past 12, then stop at 4. This gets the third wheel into the unlocked position.

Now turn clockwise two turns past 4 and stop at 11, putting the second wheel into the unlocked position.

Finally, turn counter-clockwise once past 11 and stop at 10. This lets the fence drop into position and unlock the lock.

A simple way to change the combination is to move code wheels between levels. Another way to change a combination is to remove the “up” pin from a code wheel and put it into a different position. If you glued your pins in place, simply assemble another code wheel. The kit includes some extra code wheels for this purpose.

## Finishing

This model does not require any finish, paint, stain, or dye. However, if you would like, you may apply a variety of different wood stains, aniline dyes, or paints to the wooden parts of this model. Using such chemicals is outside the scope of these instructions, so make sure to **have adult supervision** and read and **follow the manufacturer’s instructions**.

Any finish or coating applied should be very thin so as not to interfere with the mechanism, and should generally only be applied after gluing. Spray lacquer or spray shellac have been used by some model builders, but be sure to apply these only as a thin coat. Be very careful not to get finish in the ¼” diameter holes of the washers, dials, and wheels. Model builders usually mask these areas with 1” long piece from a drinking straw inserted into the holes before spraying. Once the finish is completely dry, wax will have to be applied to the moving joints, and holes may have to be sanded back to the proper size.

## Safety Instructions

When you assemble this model, you will use two different glues. You must read and follow the manufacturers’ instructions on the use of these products. The manufacturers of these products produce an MSDS (Material Safety Data Sheet) that contains safety information including first aid measures. Always wear appropriate safety equipment including safety glasses when building and testing models to prevent eye injury.

## Key Terms

Wood glue refers to yellow wood glue. Cyanoacrylate glue is a fast-acting glue, commonly sold under names like super glue or crazy glue. These glues can be found at any hardware or hobby store.

## Tab & Slot Joints

This model is designed with tabs that fit in slots. If they are too tight, a quick sand with sandpaper will easily loosen them up, but most times you will not need sandpaper. The same is true for the holes; we try to get nice tight joints, but if they are too tight, coil the sandpaper into a cylinder and lightly sand the inside of the hole. A small 2–4 oz hammer can be used to gently tap a joint together.

## Step 1 — Assemble the Legs

*Parts Used: 2 NARROW LEGS, 2 WIDE LEGS*

Assemble the four LEGS without any glue. A few light taps with a hammer will ensure they are fully seated and flush on the top over the joint.

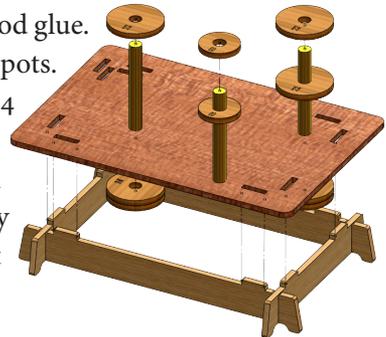


## Step 2 — Assemble the Base

*Parts Used: LEG ASSEMBLY, BASEPLATE, 4 N-WASHERS, 2 A-DISKS, 2 S-WASHERS, 1 POST*

Attach the LEGS to the BASEPLATE with wood glue. Use a damp cloth to wipe up any drips or spots.

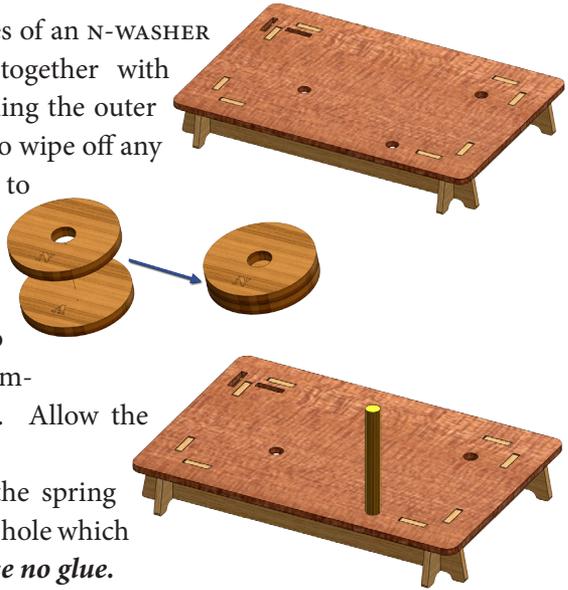
When dry, apply cyanoacrylate to the 4 leg joints. Apply the glue to the bottom, where you won't see it from the normal view. Turn the unit upside down and apply the cyanoacrylate to the inside leg joint seams. Allow to fully cure.



Make up two assemblies of an N-WASHER and an A-DISK, gluing together with wood glue, carefully aligning the outer edges. Use a damp cloth to wipe off any squeeze-out. Allow these to harden.

Use the same procedure and make up one assembly from two N-WASHERS, and one assembly from two S-WASHERS. Allow the glue to cure.

Insert one POST into the spring hole (this is the front right hole which is blocked by the legs). *Use no glue.*



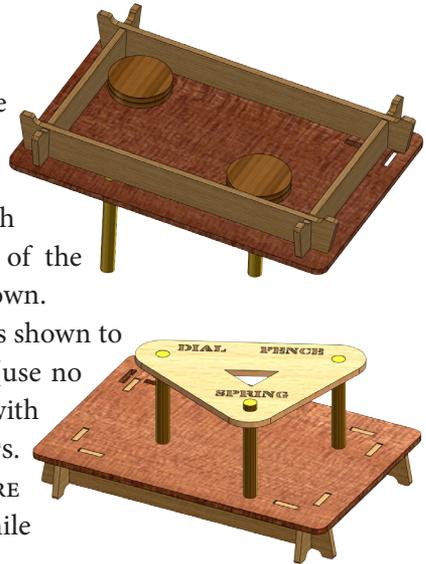
### Step 3 — Assemble the Post Support

*Parts Used: LEG-BASE ASSEMBLY, 2 N-WASHERS, 2 A-WASHERS, 2 POSTS*

Insert the remaining 2 POSTS into the BASEPLATE.

Apply wood glue to the washer side of the two N-A ASSEMBLIES. Attach the N-A ASSEMBLIES to the bottom of the BASEPLATE using the two POSTS as shown.

Slide the FIXTURE over the POSTS as shown to make sure they are properly spaced (use no glue on the FIXTURE). Keep it even with the top of the DIAL and FENCE POSTS. Allow the glue to cure. The FIXTURE will keep the posts properly spaced while the glue cures.



## Step 4 — Assemble the Post Structure

*Parts Used:* LEG-BASE ASSEMBLY,  
3 N-WASHERS, 2 S-WASHERS

Apply wood glue to one side of an N-WASHER and attach to the base DIAL POST as shown. Slide FIXTURE back to keep posts properly spaced.

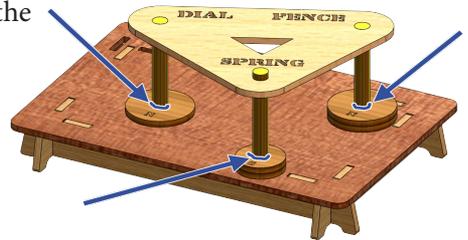
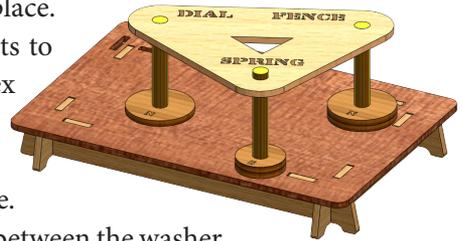
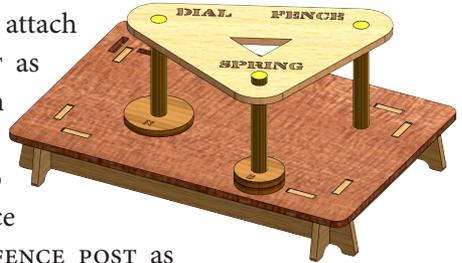
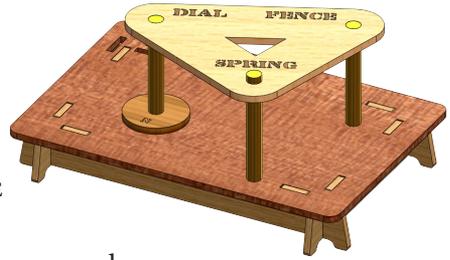
Wood glue together two S-WASHERS and apply glue to one washer's face and attach to the base over the SPRING POST as shown. Slide the FIXTURE back in place.

Wood glue together two N-WASHERS, apply glue to one face and attach to the base over the FENCE POST as shown. Slide the FIXTURE back in place.

Verify the squareness of the posts to the base with the corner of an index card or any item that has a 90 degree corner. Adjust if required.

Allow the glue to completely cure.

Apply cyanoacrylate to the joint between the washer and each post bonding the posts to the base as shown in blue.



## Step 5 — Assemble the Dial

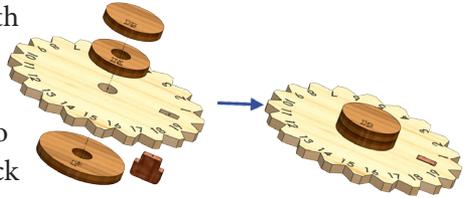
*Parts Used: DIAL, K-WASHER, B-DISK, F-WASHER, PIN*

Glue a K-WASHER to a B-DISK with wood glue. Allow the glue to set.

Apply wood glue to the hole o between location 19 and 1. It has no number. Insert a PIN from the back side into this hole. This pin is called the pusher because it pushes the code wheel beneath it to cause it to turn. Each pin pointing down is called a pusher.

Apply wood glue to the washer side of the K-B ASSEMBLY and attach to the front of the DIAL. Check the outer edges for alignment. Allow the glue to set.

Apply wood glue to an F-WASHER and attach to the bottom side of the DIAL. Check alignment using one of the posts on the base. Allow the glue to set.

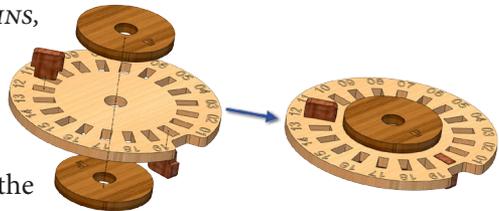


## Step 6—Assemble the Code Wheels

*Parts Used: 4 CODE WHEELS, 8 PINS, 8 F-WASHERS*

Apply wood glue to hole o, the position next to the notch (it has no number) and to one of the PINS. Put the PIN into this hole from the back (non-numbered) side. This is the pusher.

Put a second PIN in a different hole (your choice) using glue as before. This is the code pin and it is inserted from the top (numbered side) of the CODE WHEEL (this example shows it is placed at position 12).



Apply wood glue to one side of two F-WASHERS and attach one to each side of the CODE WHEEL. Wipe any squeeze-out with a damp cloth and immediately place the assembly on the DIAL POST on the BASEPLATE, press it down firmly. This will force the WHEEL ASSEMBLY to sit flat and true on the shaft and against the base.

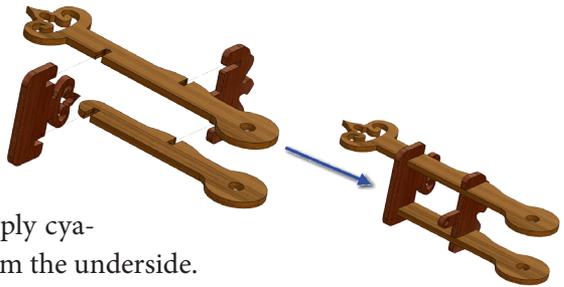
Repeat for all four CODE WHEELS. On wheels 2, 3, and 4 put the code PIN in a different hole (your choice). Remove after the glue has cured.

Your package contains 2 extra CODE WHEELS, 4 PINS and 4 F-WASHERS that will be used later.

## Step 7 — Assemble Fence

*Parts Used: CURLY LATCH, FENCE, BOTTOM LATCH, SPRING LOOP WASHER*

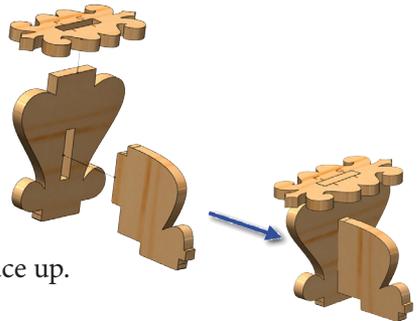
Assemble the four fence parts as shown ensuring joints are fully seated. Apply cyanoacrylate to the joints from the underside.



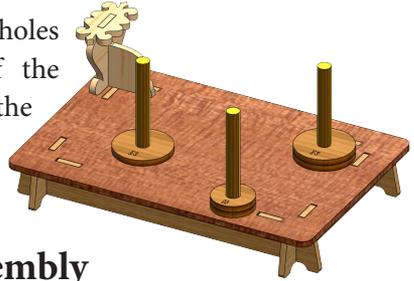
## Step 8 — Assemble the Indicator

*Parts Used: INDICATOR SCALE, INDICATOR SUPPORT, INDICATOR BRACE, BASE ASSEMBLY*

Apply wood glue to the holes in the SCALE and SUPPORT and assemble as shown. Make sure the SCALE shows the “U” (unlocked) and “L” (locked) face up.



Apply wood glue to the two open holes in the BASEPLATE and the foot of the INDICATOR ASSEMBLY and attach to the BASE ASSEMBLY as shown. Use a damp cloth to remove any squeeze-out glue.



## Step 9 — Mount Fence Assembly

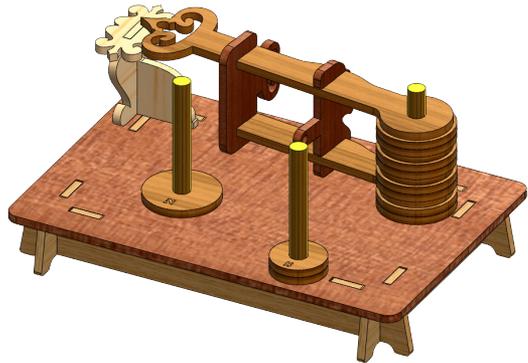
*Parts Used:* FENCE ASSEMBLY, 6 C-WASHERS, 2 L-WASHERS, BASE ASSEMBLY

Assemble the washer stack by placing washers in the following sequence: C-C-L-C-C-L-C-C. **Do not use glue.**



Assemble the washers inside the FENCE ASSEMBLY as shown. **Do not use glue.**

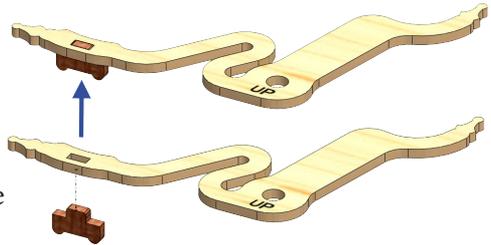
Slip the combined FENCE and WASHER STACK over the FENCE POST. **Do not use glue.**



## Step 10 — Pressure Spring Assembly

*Parts Used: 4 PRESSURE SPRINGS,  
4 SPACERS*

Apply wood glue to the rectangular hole in the PRESSURE SPRING and to the SPACER. Insert the SPACER from the bottom side.

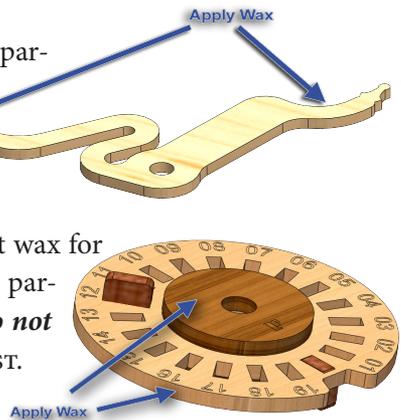


This is a good point to stop for the day or night and allow the glue in all of the parts to fully harden. If you have to continue, make sure everything with glue has cured at least one hour before proceeding.

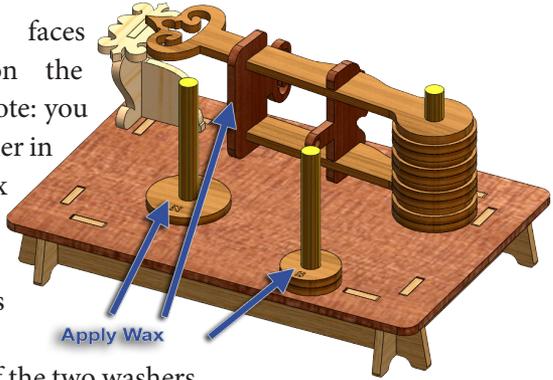
## Step 11 — Lubricate the Components

*Parts Used: 4 CODE WHEEL ASSEMBLIES, 4 PRESSURE SPRING ASSEMBLIES,  
BASE ASSEMBLY*

Apply a light coating of candle wax (paraffin) to the inside curved surface of the PRESSURE SPRING ASSEMBLIES. Just rub a used candle on these surfaces for a few seconds and it will apply sufficient wax for lubrication. Brush off the candle wax particles from the rest of the assembly. **Do not** apply wax to the hole for the SPRING POST.



Apply wax to the faces of the two washers on the CODE WHEEL ASSEMBLY (note: you cannot see the bottom washer in this image). Also, apply wax to the rim or circumference of the CODE WHEEL using the same process as above.



Apply wax to the faces of the two washers on the BASE ASSEMBLY. One is on the DIAL POST and one is on the SPRING POST. Also, rub some wax on the edge of the FENCE. **Do not apply wax to the spring post.**

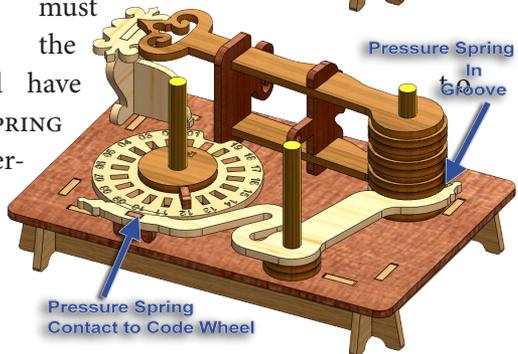
## Step 12 — Load Code Wheels and Springs

*Parts Used: BASE ASSEMBLY, 4 CODE WHEEL ASSEMBLIES, PRESSURE SPRING ASSEMBLIES, 6 S-WASHERS, SPRING LOOP WASHER*

Slip a PRESSURE SPRING ASSEMBLY over the SPRING POST. Slip the CODE WHEEL ASSEMBLY over the DIAL POST.



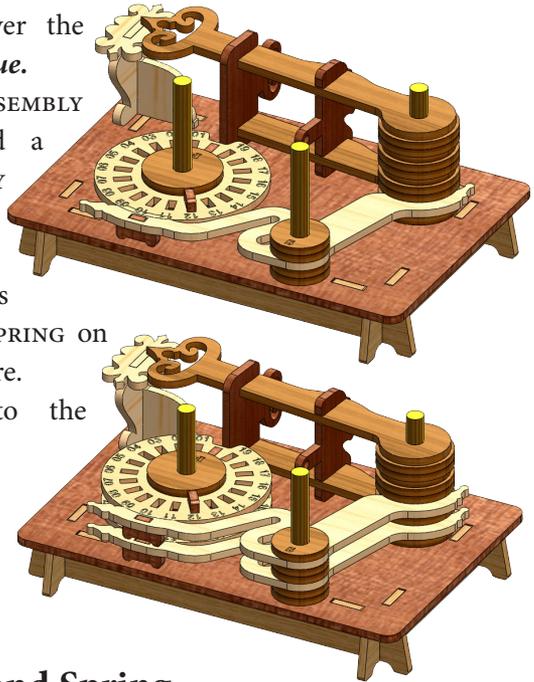
The PRESSURE SPRING must fit in the groove on the FENCE POST and you will have slightly pull the PRESSURE SPRING out so it sits on the circumference of the CODE WHEEL. **Do not glue.**



Add two s-WASHERS over the PRESSURE SPRING. **Do not glue.**

Add a PRESSURE SPRING ASSEMBLY to the SPRING POST and a CODE WHEEL ASSEMBLY to the DIAL POST. Fit the PRESSURE SPRING into the groove on the FENCE POST as before. Fit the PRESSURE SPRING on the CODE WHEEL rim as before.

Add one s-WASHER to the SPRING POST. **Do not glue.**

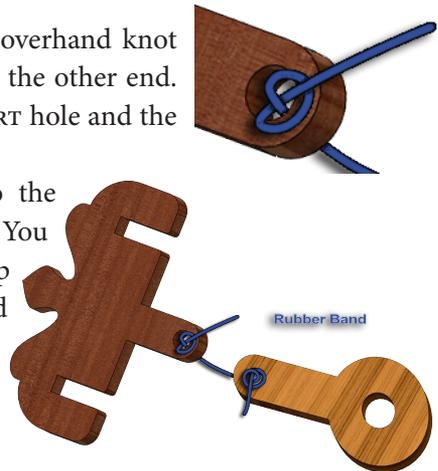


## Step 13 — Rubber Band Spring

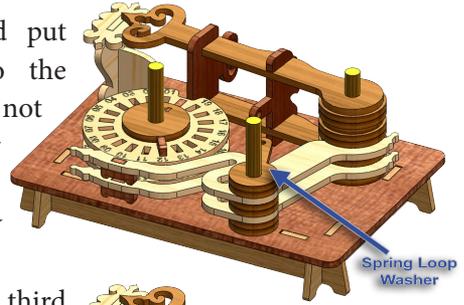
*Parts Used: RUBBER BAND, LATCH SUPPORT, SPRING LOOP WASHER, BASE ASSEMBLY*

Cut a RUBBER BAND open. Tie an overhand knot in one end. Cut a tapered point on the other end. Thread it through the LATCH SUPPORT hole and the SPRING LOOP WASHER.

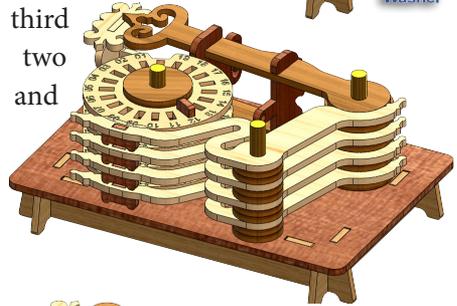
Tie a second overhand knot so the two parts are almost touching. You only need about  $\frac{1}{8}$ " to  $\frac{1}{4}$ " gap between the LATCH SUPPORT and SPRING LOOP WASHER. Trim away the excess rubber band material.



Stretch the RUBBER BAND and put the SPRING LOOP WASHER onto the SPRING POST. (Note: rubber band not shown). The FENCE ASSEMBLY should now be held against the CODE WHEEL by the force exerted by the RUBBER BAND.



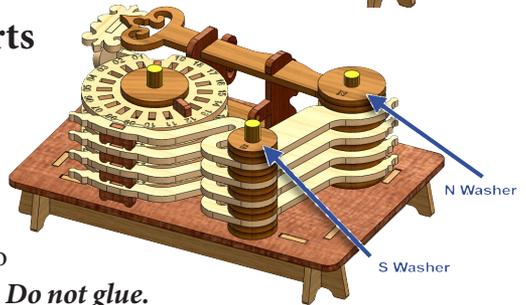
Repeat the process adding a third CODE WHEEL, PRESSURE SPRING, two S-WASHERS, fourth CODE WHEEL, and PRESSURE SPRING.



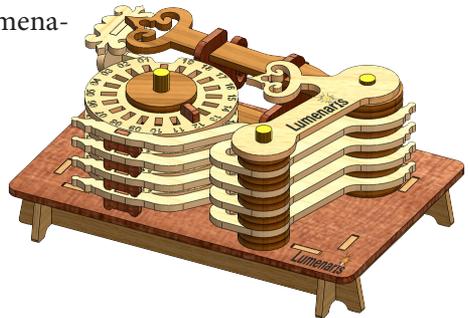
## Step 14 — Top Supports

*Parts Used:* BASE ASSEMBLY,  
2 S-WASHERS, 2 N-WASHER,  
POINTER

Add two S-WASHERS to the SPRING POST and two N-WASHERS to the FENCE POST. **Do not glue.**



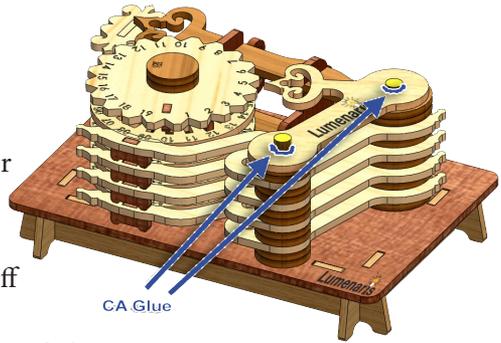
Add the POINTER as shown (Lumenaris logo up).



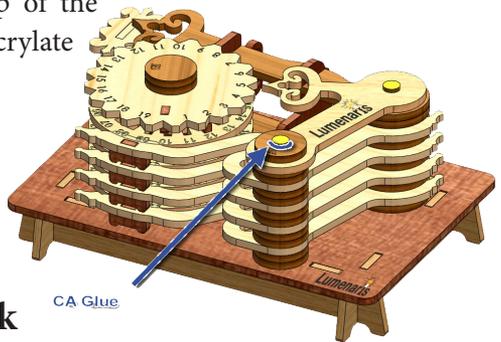
## Step 15 — Dial

*Parts Used:* BASE ASSEMBLY,  
DIAL ASSEMBLY

Slide the DIAL ASSEMBLY over the DIAL POST. Apply cyanoacrylate to the SPRING POST and FENCE POST as shown. Wipe off all excess glue.



Add a K-WASHER to the top of the SPRING POST and apply cyanoacrylate to it. Wipe off all excess glue.



## Final Alignment Check

If you have sanded the code wheels and spacer washers, you can alter the alignment of the code wheel top surface to the top of the top pressure spring. If these are not in the same plane, it makes the lock harder to operate and can cause the dial to touch the fence. To bring the code wheels back into alignment with the pressure spring, take the single thin washer and insert it under the bottom code wheel. This raises the code wheel stack into alignment.

Here is why this type of misalignment can happen. There are 24 layers that make up the code wheels plus the washers. Each layer is approximately 0.120" thick. If you sand 0.0025" off of the wood when you sand (roughly the thickness of one sheet of copy paper), you will lose  $24 \times 0.0025"$  or 0.060" which is half of the thickness of one layer. Adding the thin washer raises the stack back into alignment. If you apply lacquer to

the sanded parts, it adds about 0.0025" per side which generally offsets the material lost in sanding. Check the alignment and add the washer only if it is needed.

## **Congratulations**

You have just completed building your Combination Lock Model. Now the fun starts with seeing how it works.

## **Observation**

- Can you figure out how to unlock the combination lock?
- How does the code pin position relate to the combination?
- Make a chart of code wheel number, code pin position, and combination digit.
- Swap two code wheels — what happens to the combination?
- Experiment with other code wheels that have pins in different positions.

What happens to the combination?

- What works in the design and what does not?
- What time period is this code wheel design from?
- Are there different types of combination locks?
- How far back in time did combination locks exist?
- Can you generate a timeline of the different types of combination locks?
- What are the personal safety items that one should be aware of when working on a model and what protection should be used? Did you use them?

## **Environment**

- Describe the environmental impact of the product and its packaging. What materials were used? How can it be properly disposed of? How could the product be made better from an environmental point of view?
- Speculate on how you would figure out how much wood is lost in the kerf produced during the cutting of the product, from the sheet the parts are cut out of?

## Questions to Think About

- How can the US compete in a world with low cost labor?

## Analysis

- Explain what happens to the combination when two code wheels are swapped.
- Explain what happens to the combination when the code pin of a code wheel is moved to another position.
- Generate a table for a digit of the combination vs. code wheel code pin position.
- Graph the data from the table of combination as a function of the code pin position. Is the relationship linear? Are there discontinuities?
- Write a mathematical expression that relates the code wheel number and its code pin location to the combination digits.
- The pointer is offset from the fence; the code pin on a wheel is offset by the width of the pusher from a higher wheel or dial. When calculating a combination from the code pin position on a wheel, a math function that returns the remainder after one or more full or partial turns is needed. Do you know what that function is? How is it used?
- What could be improved in the design? Why?
- How could we add a time clock to the lock which would not allow it to be unlocked except at specific times?

## Results

Write a technical report describing the construction project, your observations, analysis, environmental impact, conclusions and recommendations.

# Parts List

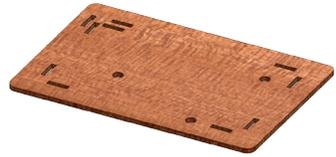
## Birch Wood Parts<sup>1</sup>



1 FIXTURE



1  
INDICATOR  
SUPPORT



1 BASEPLATE



1 POINTER



1 INDICATOR  
SCALE



2 WIDE LEGS



4 PRESSURE SPRINGS



1  
INDICATOR  
BRACE



2 NARROW LEGS



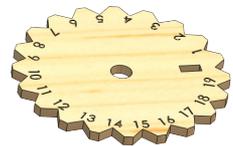
1 CURLY LATCH



13  
PINS



4 GAP  
SPACERS



1 DIAL



6 CODE WHEELS



1 FENCE



1 LATCH  
SUPPORT



1 BOTTOM LATCH

<sup>1</sup> Note: Parts shown are not to scale and are an approximate representation only, the parts in your kit are unfinished birch, the color and grain patterns shown here are for illustrative purposes to aid with assembly. Type fonts, engravings, and cut letters may be different in your kit than shown in this instruction manual.

## *Metal Parts*

3 POSTS

## *Other Items*

2 RUBBER BANDS

1 INSTRUCTION MANUAL

## **Warranty**

The Lumenaris Group, Inc. warrants that this product is free from defects in materials and workmanship for a period of one year from the date of purchase with proof of purchase. At the sole election of The Lumenaris Group, Inc. the only remedies available under this warranty are either replacement of the defective component or product or refund of the purchase price of the product. The warranty is valid only if the product has been assembled and used per the instructions. This warranty does not cover abuse, accident, cosmetic issues, damage from normal wear, or any other cause not arising from defects in material and workmanship.

You must provide us with proof of purchase, a photo and description of what you believe to be defective to start the process. Simply put this information in an email and send it to:

**[product.support@lumenaris.com](mailto:product.support@lumenaris.com)**

We reserve the right to have you ship us the defective part at your cost via the Post Office or UPS once you have obtained an RMA number from us and if it is confirmed by us that the part is defective, and not damaged by

improper assembly, handling, finishing, storage, use, or other causes, we will provide a replacement part and cover the shipping to you and if you paid shipping to us, cover that shipping as well.

**The Lumenaris Group, Inc.**  
**18675 Adams Court**  
**Suite G/H**  
**Morgan Hill, CA 95037**  
**408-591-4034**  
**[www.lumenaris.com](http://www.lumenaris.com)**

### *Special Warranty to Encourage Honesty in Youth*

Did you know that many manufacturers have warranty and replacement policies that put young people in a difficult situation about being honest?

If your son or daughter or the youth that is assembling a kit loses a part, glues two parts together wrong, or even if their dog chews up a part they can't put the model together.

If they tell other manufacturers that the part was missing, in most all cases, the manufacturer will send them the replacement part. But if they say they damaged or lost the part most manufacturers will ask you to buy another kit.

At Lumenaris, we don't want to place youth in a situation where being honest is discouraged. We strongly want to encourage everyone, especially young people, to be honest and ethical in their lives, whether at home, at school, when having fun, or at work.

That said, if you damage a part or two by accident, lose a part, your dog chews up a part, no problem, just have the youth, with your permission, give us a call, email, or write us and explain what happened along with what parts they need. We will send you the replacement parts, as long as the product is still in production, at our discretion, at no charge.

Yep that's right, most times, at our discretion, the part cost will be free. We want you to be successful with this model, have a great learning experience, open up the way you think about how things work, and maybe use this knowledge to create a better future.

# Lumenaris™ Combination Lock

## Learning Objectives:

1. Demonstrate how a code wheel combination lock works
2. Learn the terminology of locks
3. Hands on construction of a lock
4. Explain the concepts of setting a combination
5. Calculate the number of unique combinations possible
6. Calculate the time to try all possible combinations
7. Explain the mathematical relationship between the pin location on the code wheel to the dial position
8. Measure the environmental impact of building, using, and disposing of this product

**Assembly Time** - 3-5 hours

## Tools and Supplies Needed:

- \* Cyanoacrylate (CA) Glue - medium viscosity
- \* Yellow wood glue
- \* Used candle or paraffin wax
- \* Optional: 320 grit sand paper
- \* Safety Glasses
- \* 1 Bamboo wood skewer or tooth pick to use as a glue applicator
- \* Hammer - small 2 to 4 ounce - wood, metal, or plastic

## Lesson Plan:

A lesson plan covering the history, science, and math is available via email to purchasers of this lock. It contains additional experience, educational material, questions, and an answer sheet.

## Made in the USA

Of European Birch from ecologically managed forests  
Suitable for Age 13+

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**Lumenaris™**

**Made in USA**