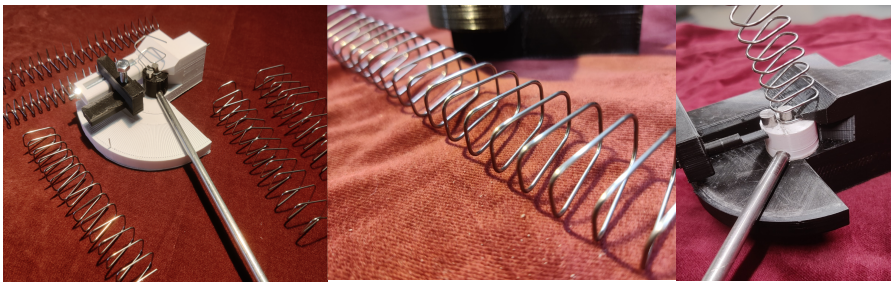
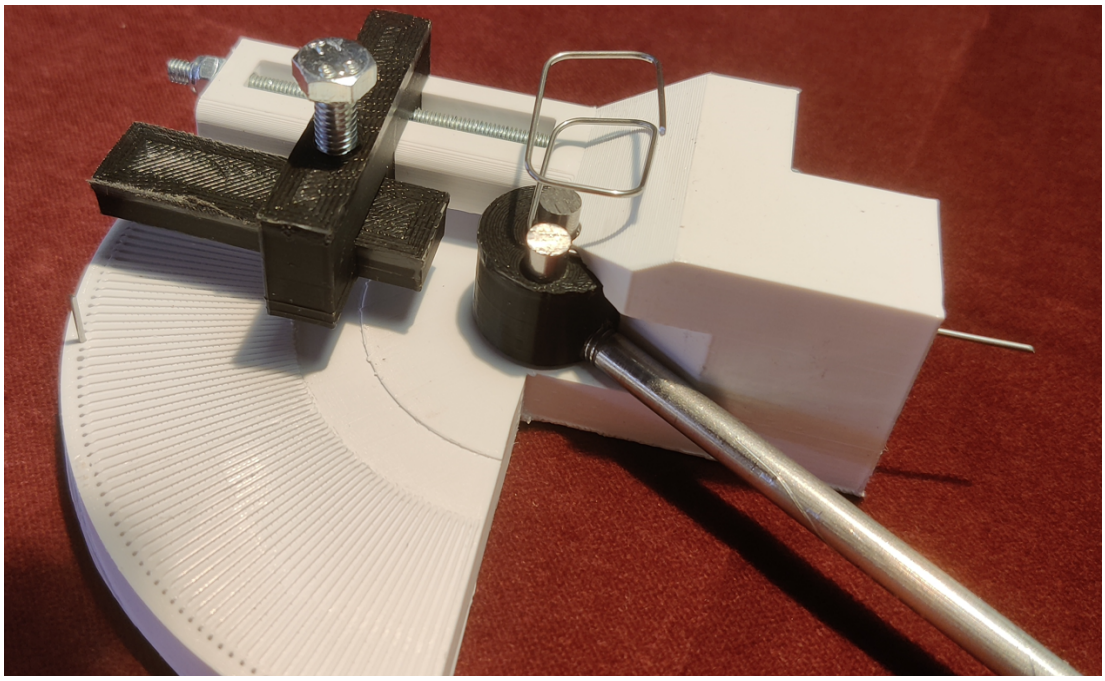
# The SpringFactory V 1.0

*The Universal Spring Bender By HW Enterprises © 2021*



Pictures have V.1.0 and V.0.9

This device was developed in need of rectangular springs, such as magazine springs. The device, once calibrated, has one moving part, which is the rotary, and it is most suited for doing bends up to 90deg angle. **The device has been designed to adapt 1.3mm or 0.051" spring wire**, but it can be scaled to any wire by opening the STEP file and enlarging the feed hole and adjusting the radial distance of the bending mandrel from the center accordingly. The bender has a fixed slope that will result in about 30 degrees rise to the spring.



The bender is operated by feeding wire through the body, using gauges to set it at nominal distance, holding the wire with pliers and performing a bending operation to specified angle determined by the angular table.

## Suitable wire

A spring wire of any kind that is sold for spring bending is suitable for use. Commonly also known as piano wire or music wire, it is sold in different diameters or gauge, and it's availability varies between different countries. Common spring materials suitable consist of medium carbon steel and certain stainless steels. If the intention is to make any more of springs, it is recommended to buy a coil instead of short strips, because a single spring can easily use 2 meters of wire, and a spring cannot be joined once cut. Also, short strips can be very expensive compared to a full coil.

## Format

The device is supplied in file formats .STL and .STEP for being readily 3D-printable, and can be further edited for specific needs, including changing wire diameter.

## Print instructions:

Proof of concept V.0.8 and V.0.9 and the final V.1.0 were printed with eSun PLA+, 0.2mm variable layer thickness. In Cura, scale to 1000% uniformly. For body, use 20% infill, place the body in it's natural orientation. The rotary will be printed either face up. Slide is printed either face down. Depth gauge is printed wider face down. **Use 100% infill for the small parts.** If elephant foot effect is noticed, it can be shaved off with chisel or file or mitigated using thick raft with 3-4 layers. Use supports where necessary.

## Parts list *(3D Printed)*: METRIC

1) *Bender body*
2) *Rotary*
3) 25mm Main pivot, 6mm round bar, steel, if hardened shaft or HSS is available, is preferred
4) 15mm Mandrel, same material as pivot
5) Lever, 6mm steel rod, threaded at the end, 200mm or longer
6) *Slide*
7) *Gauge*
8) Wood screw, sharp head, to fit 4mm hole
9) 4mm threaded rod, 120mm minimum length,
10) 2x 4mm Nyloc nuts
11) 1x 4mm nut
12) Pliers for locking the wire

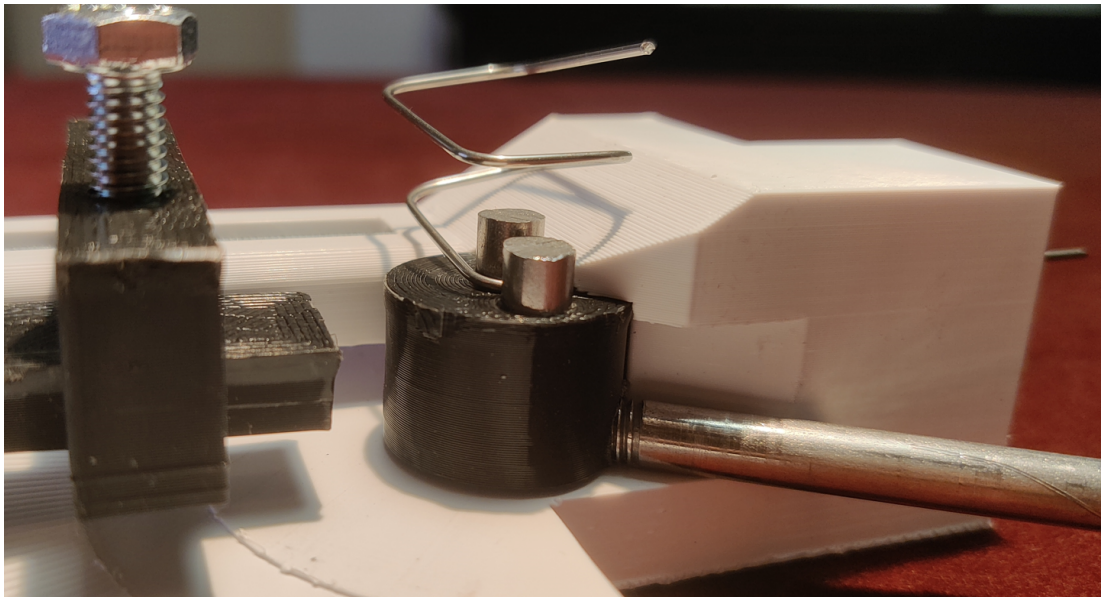
## Assembling the SpringFactory:

1) It may be necessary to do some fitting to the parts, including drilling holes larger, filing, etc. Printer tolerances may vary.
2) To a post-processed 3D-printed body, the rotary is placed, and a 6x28mm pivot is carefully pressed in so that it protrudes about 3mm above the surface. *(too high will interfere with the spring coil)*
3) The mandrel is carefully pressed in so that it protrudes about 3mm above the surface.
4) The lever is directly threaded to the rotary right behind the mandrel at the side, being careful not to strip the threads.
5) A 4mm threaded rod is pushed through the gauge adjustment channel, and the slide, with 4mm nut installed within the slot, is placed in and the rod is screwed through so it passes through the whole device.
6) Nyloc nuts are threaded to the ends to lock the rod in place. The movement of the slide is tested by rotating the rod.
7) Threads are cut through the slide hole to V-slot, and the gauge is pushed to the slot. A short 6mm bolt with sharp head is screwed in, so it locks the gauge, but not too tight or it will break the gauge body.

## Operating the SpringFactory:

The device is operated by first mounting it into a vise or other rigid structure.

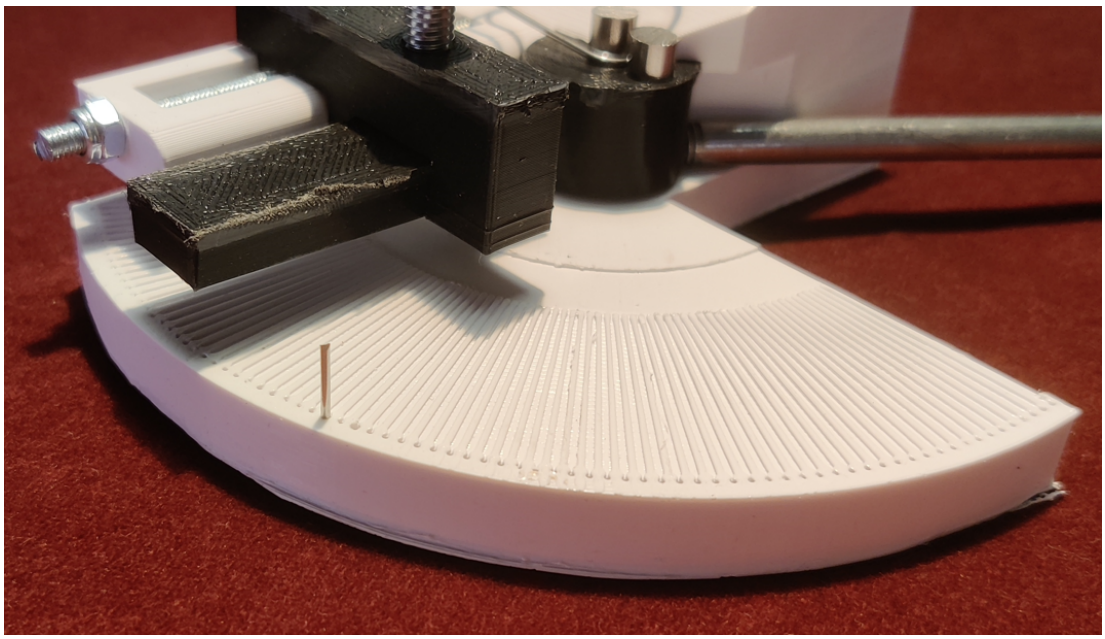
A wire, preferably straight, or from coil, is fed through a hole in the back, until it emerges between the bending mandrels, when the arm is turned to home position. If the small hole clogs, a piece of spring wire can be attached to power drill and the hole can be reamed open.



The wire is held from the back with strong pliers. Cutters that come with 3D-printers can be suitable, as they are made out of soft metal and will grip the wire very well. If the wire is not gripped, it will be pulled into the bender, and the bend length will be off about 3mm. The pliers can be used to feed more wire into the bender.

The bending is performed by rotating the arm, until a desired angle, here 90 degrees is formed. Due to springback of the wire, over-bending must be applied. The bending angle is carefully monitored from the radial table, and when it reaches 90deg, a pin is placed to act as an endstop.

A slight deviation will quickly build up, and it will show up as a spiral in the springform. This effect can be mitigated by carefully adjusting the endstop. If overbending is occuring, the endstop pin is moved one step closer to home. In case of underbending, opposite move must be done. When the calibration is on spot, the spring will coil out as a straight, rectangular column.



The depth gauge, which has two measurement steps, is adjusted by moving the slide with the threaded rod so that it determines the long side and the short side of the spring. The wire is moved to match the other gauge at every other bend step. The desired dimensions of the spring are measured, taking in account the radius of the mandrel, here 6mm round bar.

A test bend is done, and measurement is taken. Depth gauge is adjusted, until desired dimension is formed.

When the calibration is complete, the device should be capable of producing useful rectangular springs of almost any size from 6mm width.

## Post processing of a bent spring

Cold bending will cause work hardening of the material, which is larger the smaller the bend radius is. A 90 degree sharp bent spring wire will usually snap when bent by hand, but a sufficient radius of 2x diameter or larger does not weaken the spring. This bender is designed for 6mm bend radius, which does not likely work harden the spring to any significant degree. *For the moment no data was found if industry tempers spring wire after it is CNC machine formed, so this step might turn out unnecessary.*

| Temperature | | Color of Heated Carbon Steel | |
|---|---|---|---|
| (°F) | (°C) | | |
| 600 | 316 | | Scrapers, spokeshaves |
| 560 | 293 | | Screwdrivers, springs, gears |
| 540 | 282 | | Cold chisels, center punches |
| 520 | 271 | | Taps <= 1/4 inch |
| 500 | 260 | | Axes, wood chisels, drifts, taps >= 1/ inch, nut taps, thread dies |
| 480 | 249 | | Twist drills, large taps, knurls |
| 460 | 238 | | Dies, punches, bits, reamers |
| 450 | 232 | | Twist drills for hard use |
| 440 | 227 | | Lathe tools, scrapers, milling, cutters, reamers |
| 430 | 221 | | reamers |
| 420 | 216 | | Knives, hammers |

However, different hobby groups suggest to temper the wire after bending to reduce stresses. They suggest to **heat up to 300C until a purplish-blue oxidation occurs, or 2 hours, which criteria is met first**. For more controlled heating, it might be better to use a closed oven, and use the broiler

element and placing the spring up close to reach higher temperature if the oven is gapped for example at 250 or 275C which is common for home baking ovens. However, tempering at such temperature would still be better than leaving it in cold state, if any tempering turns out to be beneficial at all.

If the spring is heated too much, it will anneal to a point it will lose significant tension and be unsuitable for spring.

The spring may change it's shape a little during tempering, for example by curling, and this can be fixed by manually bending the coils one by one until a straightened form is achieved.

For the record, if fully annealed medium carbon steel wire is available, it can be usually wound directly over a solid mandrel, because it is free forming. It will be heated to cherry red (+800C, magnet test) and quenched in oil and annealed by the same procedure described here. However, the hardening and quenching procedure must be well controlled and uniform, or the spring will be too soft or have variable spring tension, and making springs from scratch requires a bit more dedication and experience than buying a ready tempered piano wire. The most hardcore way is to get soft steel wire, bend it and carburize it by immersing it in 70:30 C:$CaCO_3$ powder mix and heating to cherry red for 4 hours.

## Notes for development

Pliers were found to be the fastest way to lock and operate the wire. First concept included a locking nut, but it was slower to use. The pliers can be used to feed the wire into the bender as it is operated. Developers may find a yet better way.

The bending mandrels will burnish during use, because spring steel is significantly harder than cold rolled steel (HRC20+ vs HRC40+). Even single spring coiling leaves noticeable burnishing to the bars. This can be fully mitigated by using hardened steel pins of corresponding size, or yet better, HSS round bars, which will last forever in this use.

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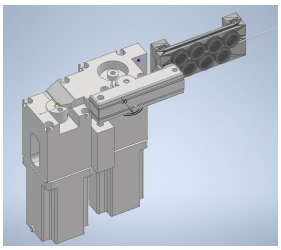
For example, a stepper motor operated, fully automatic bender could be built from the platform. The hand crank arm can be replaced by attaching a stepper directly to the main pivot and fixing the rotary to it. It would be encouraged to make the mandrel and the pivot from single piece of steel stock with lathe and drill for longevity. The depth gauge can be completely eliminated, if stepper motor actuated precision extrusion is used for the wire. This kind of bender is likely able to at least 10-fold the production rate.



The device, being 3D-printed from soft plastics, will likely not last prolonged use, and the rotary and possibly other parts must be eventually replaced.

**Spring wire is highly tensile material that can withstand up to 200kg/mm2 of pull. Pulling thin spring wire with bare hands is extremely dangerous and will freely cut through soft tissue. Free wire end can be needle sharp, almost invisible when sprung in air and due to the nature of spring steel, can build up large amount of tension when coiled, handled or formed over a mandrel, which can suddenly release, causing lacerations and pucturing of skin and eyes, resulting in serious injury and permanent blindness. Wires of larger diameter can have tension stress that is sufficient to break bones and kill upon sudden release.**

**Proper PPE must be worn at all times.**