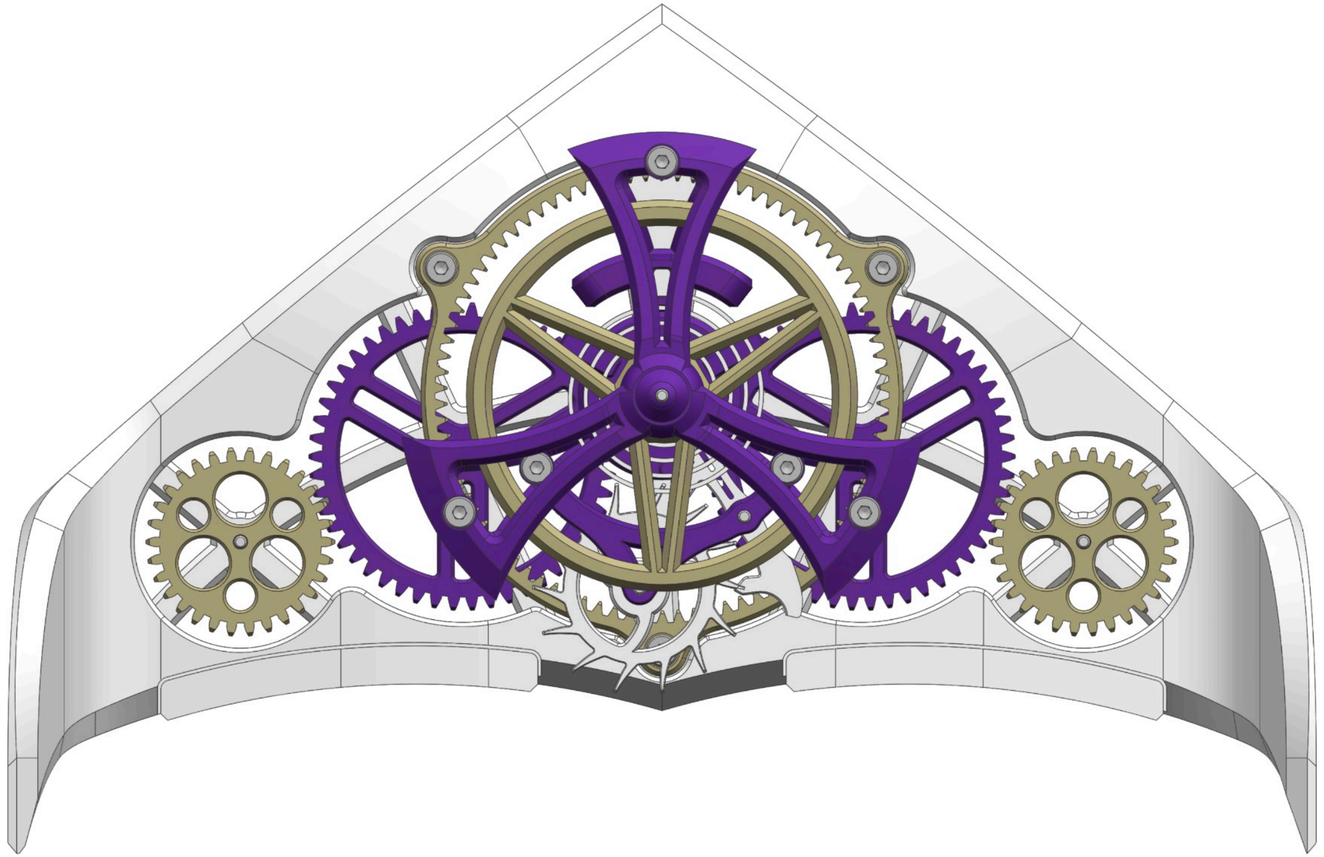
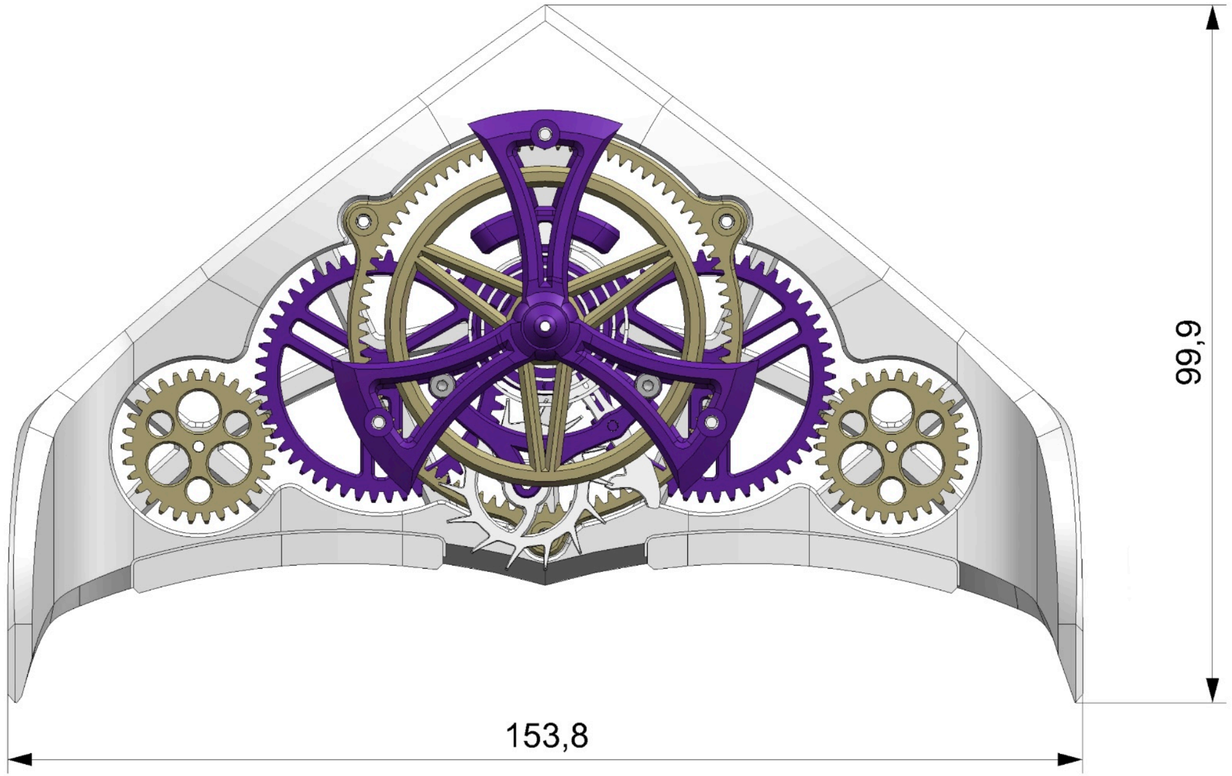
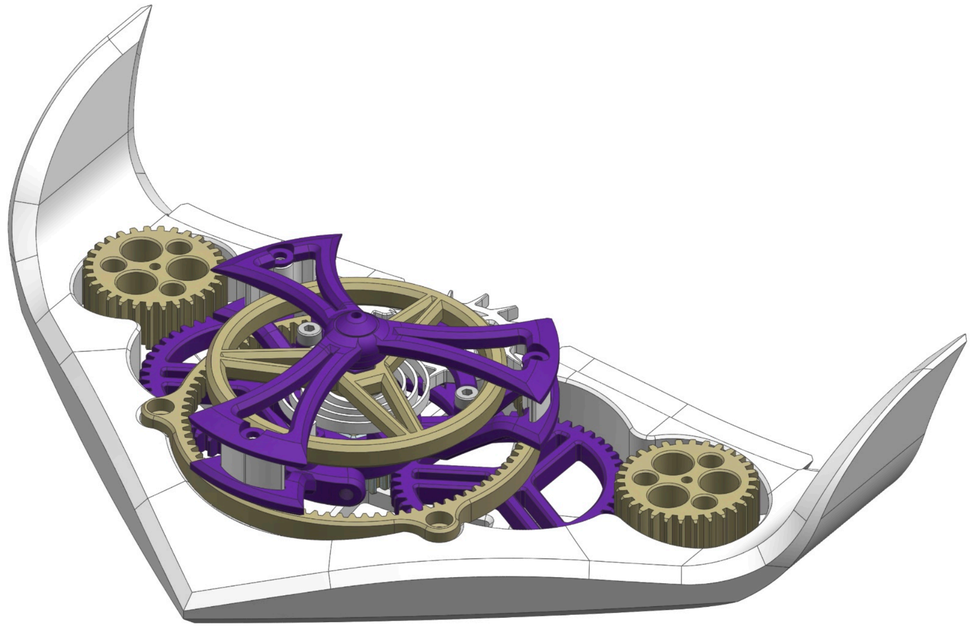
Aeria Mechanica Mini

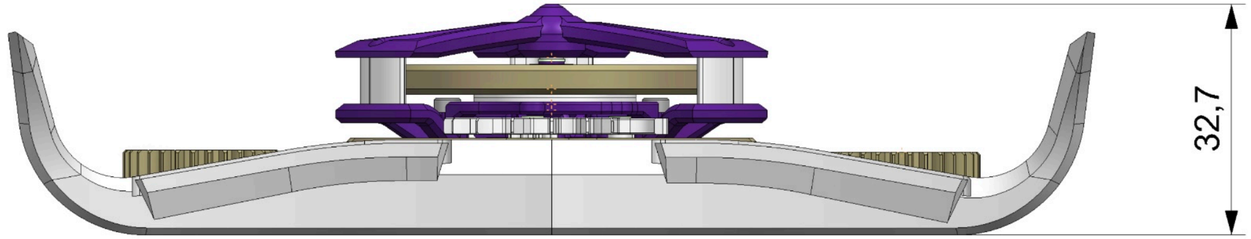
- Printing & Assembly Guide -



Design Overview



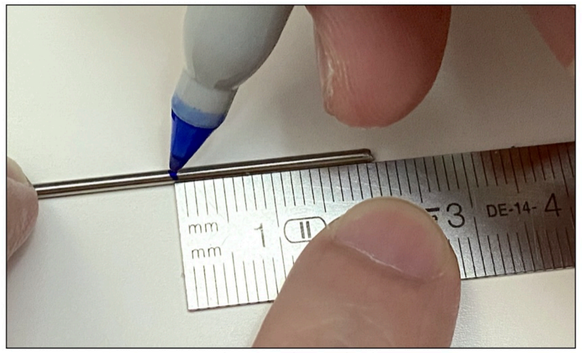




Preparation - Pin Cutting

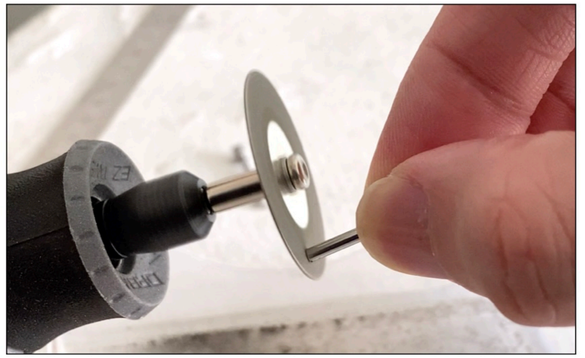
- Pin lengths are not required to be cut to high precision. +/- 0.5mm is fine.
- It is crucial to have a chamfered feature at each ends of the pin. If u are using a Dremel, simply use a grinding tool to grind the edges of the pin at an angle while rotating the pin with your other hand. If u do not have a Dremel, a file or sandpaper will also work although it will require more time and effort.
- If you do not have a Dremel, there is an alternative guide that was kindly shared by user Knorke74 via the link here
- The table below lists all the pins and non printed hardwares that are required for the assembly

Assembly Hardwares		
Part	**Qty**	**Link**
ø1.5 x 8 mm pin	2	Ali Express Amazon
ø1.5 x 10 mm pin	5	
ø1.5 x 20 mm pin	1	
M2X4 Screw	8	Ali Express Amazon



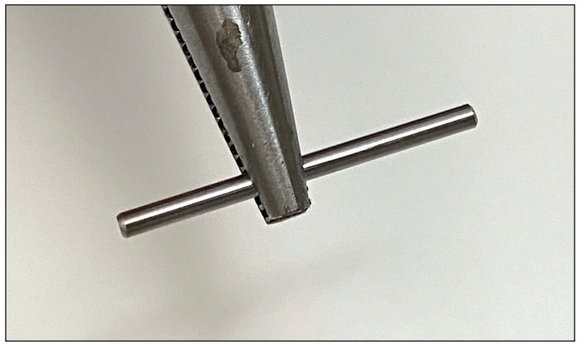
1) Measure the and mark the pins

2) Cut the pins to be slightly longer than the desired length



3) Measure the pin and grind it down to the correct length

4) remove burrs and introduce chamfer at both ends by grinding the pin at an angle while rotating it

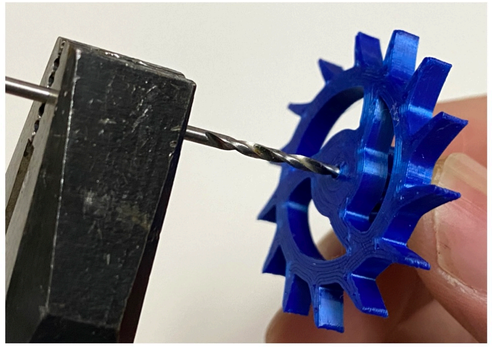


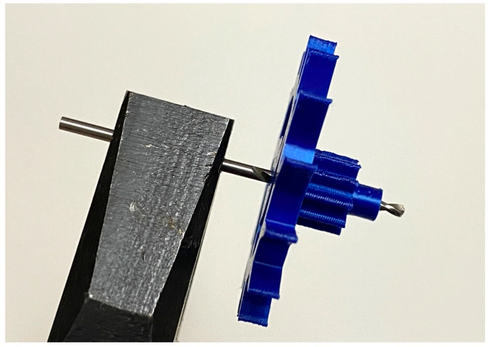
5) The pin should look like the one in the picture above, with both ends to have some chamfer

Printed Parts Preparation

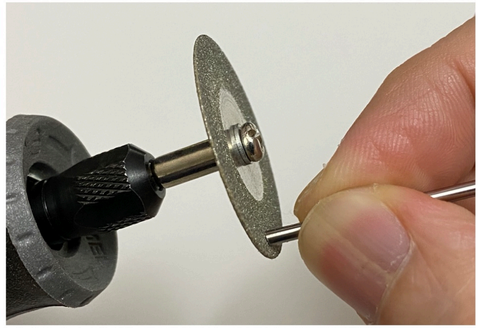
Pin-Hole Preparation

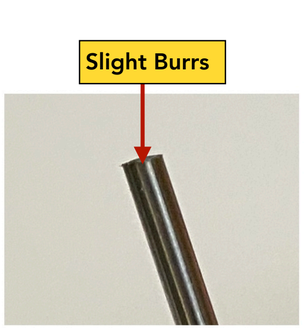
- All printed gears will require pin hole finishing to achieve the best pin fitting and smooth rotation with minimal friction.
- Due to printing tolerances, It is impossible to have a Ø1.5mm pin diameter that will yield a smooth transition fit right off the print bed. A loose pin-gear fitting will introduce significant backlash in the system. Hence Pin hole preparation is extremely critical as follows:

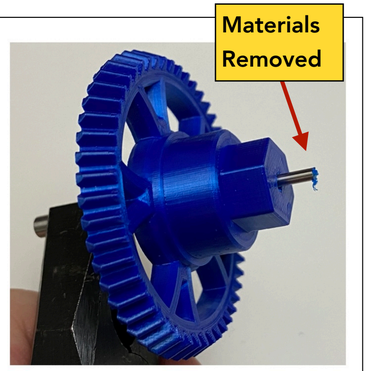




Step 1: Use a 1.5 drill bit with a hand plier or a drill bit holder. Hold the 3D printed gear with another hand and gently rotate the gear towards towards the drill bit. Be careful to not allow the drill bit to tilt along the way. Continue on till the drill bit exits from the other side of pin hole.

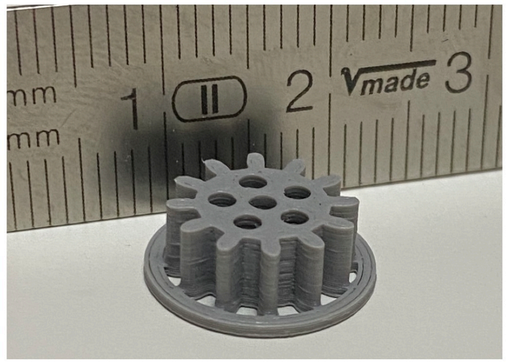


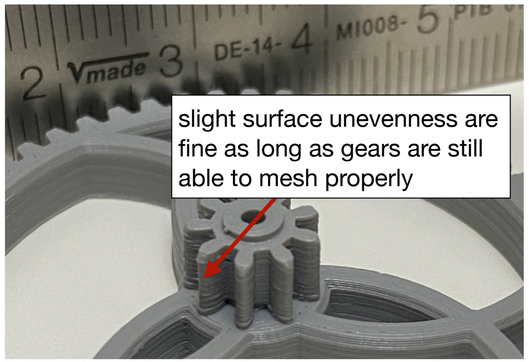




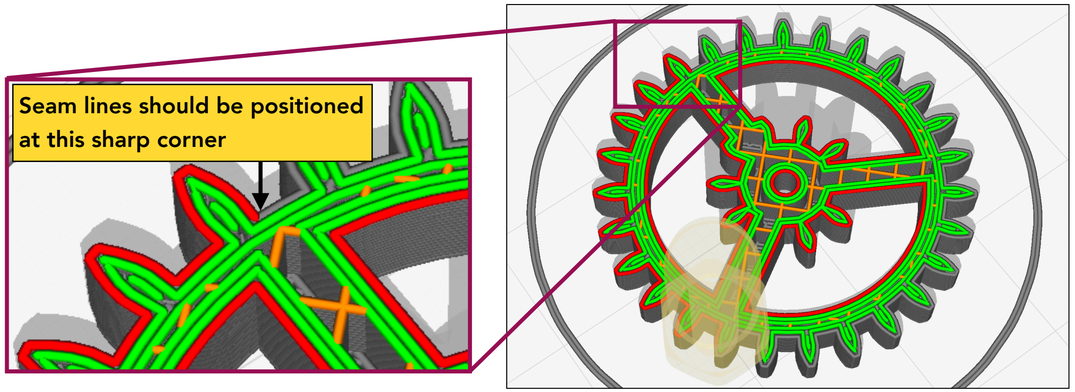
Step 2: introduce some burrs at the edge of a 1.5mm pin, either by using a Dremel or sandpaper as shown. Repeat Step 1 but replace the drill bit with the burred pin. You should notice some plastic material being removed with every pass. Try spinning the gear every time it is fully inserted through the pin. It should spin with minimal wobbling. At one point, it should spin smoothly without jamming. This indicates that the pin hole is sufficiently enlarged.

Inspection





- Printed gears should be free from blobs, stringing, excessive layer shifts, and elephant's foot. Blobs and small amount of elephants foot can be removed using a hobby pen knife. Minor layer inconsistencies are fine as long as the gear meshing is sufficiently smooth. An example of a good gear tooth is is shown below:
- If excessive stringing is observed, enable **"combing mode"** in Cura or **"Avoid Crossing Perimeters"** in Prusa Slicer and print one gear at a time to completely eliminate any stringing issues.
- Blobs can also be caused by seam lines if they are positioned at the gear tooth profile. Be sure to set the seam line to **"sharpest corner"** instead of random as illustrated below.

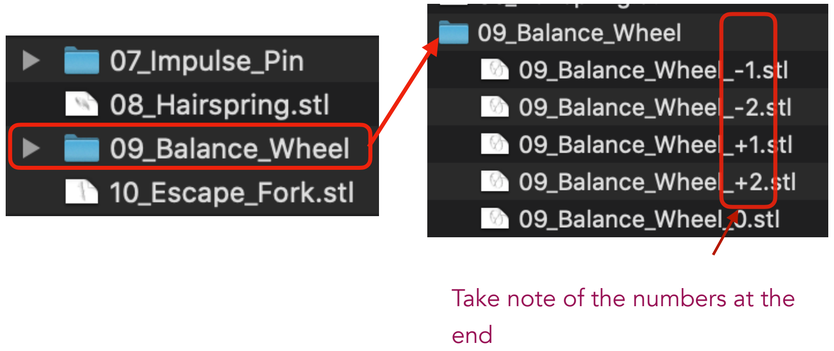


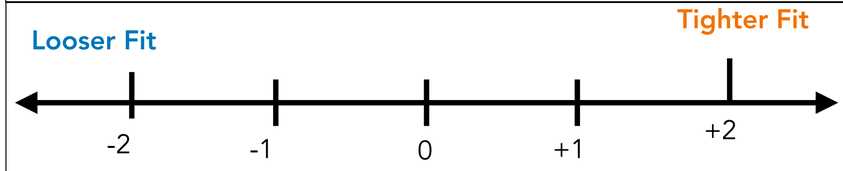
Printed Parts BOM & Recommended Settings

- All parts are exported in the correct Z print orientation. You may rotate the model along z if necessary.
- 3mf files (From Cura) are available for every part for print setting references. The files are generated for my Mk3s printers.
- Gears should be printed with 15-20mm/s outer perimeter speed. Generally, the slower the better.
- Enable "combing mode" (Cura) or "avoid printed parts travel" (Prusaslicer) to reduce stringing.
- Seam lines should always be aligned to the "sharpest corner."
- Ender 3 users who are using "Magic Number" layer height, swap 0.15 -> 0.16mm.

Part Name	Colour	Qty	Nozzle Diameter	Layer Height	Infill %	Print Support	Remarks
01_Base		1	0.3/0.4	0.15-0.2	20-25	Yes (Touching Buildplate)	
02_Tourbillon_Transmission		1	0.25	0.12-0.15		No	**Prusa Slicer** : Enable "Elephants foor compensation" (0.07 to 0.10) **Cura** : Enable "Initial Layer Horizontal Expansion" (-0.07 to -0.10)
03_Transmission_1		2				No	
04_Transmission_2		2				No	
05_Tourbillon_Lower_Cage		1				Yes (Touching Buildplate)	
06_Esc_Wheel		1				No	
07_Esc_Fork		1				No	
08_Cage_Bridge		1				Yes (Touching Buildplate)	
09_Cage_Spacer		3				No	
10_Hairspring		1				No	Turn off combing mode and Elephants for compensation for better print quality
11_Impulse_Pin		1				No	
12_Balance_Wheel		1				No	
13_Tourbillon_upper_Cage		1				Yes (Touching Buildplate)	
14_Tourbillon_Ring_Gear		1				No	

- **Critical Assembly Items -** parts that will be assembled with other printed parts (usually a hexagonal feature). It is critical to ensure the fitting is neither too tight or too loose. You will find these parts in a subfolder within the STL file package as illustrated below



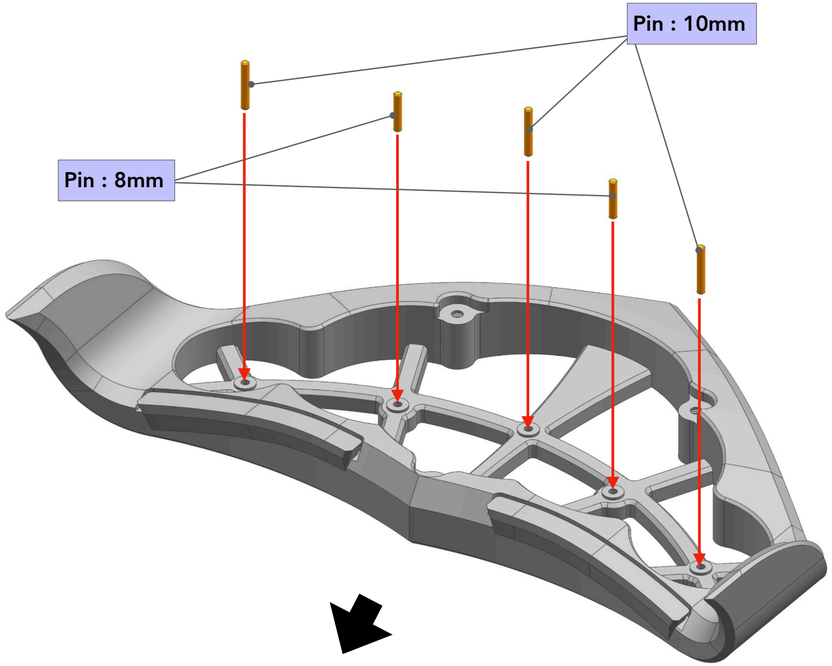


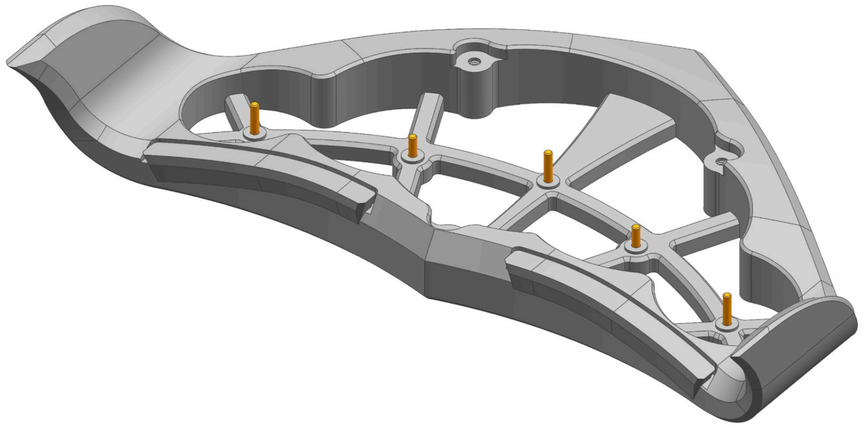
- The numbers at the end of filenames indicates the fitting variant of the same part in order to cater for tolerances
- I recommend printing the part "0" first as that should work for most people. If you find that the fitting is too tight, try the printing the -1 or -2 looser fit variant and vice versa.

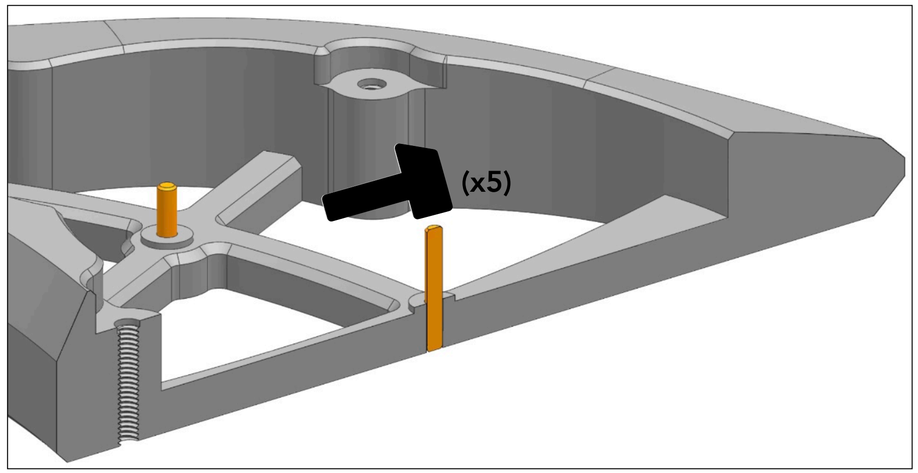
Assembly

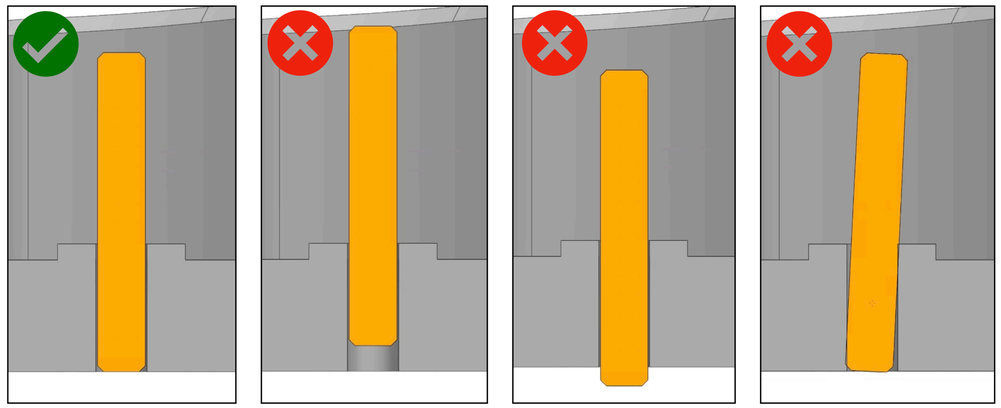
1) Force fit the following pins into the base and ensure that pins are not significantly tilted.

✳ProTip: you may use a 1.5mm drill bit to enlarge the upper 1-2mm section of the hole. This will aid with the alignment of the pins before applying force to fully insert them.



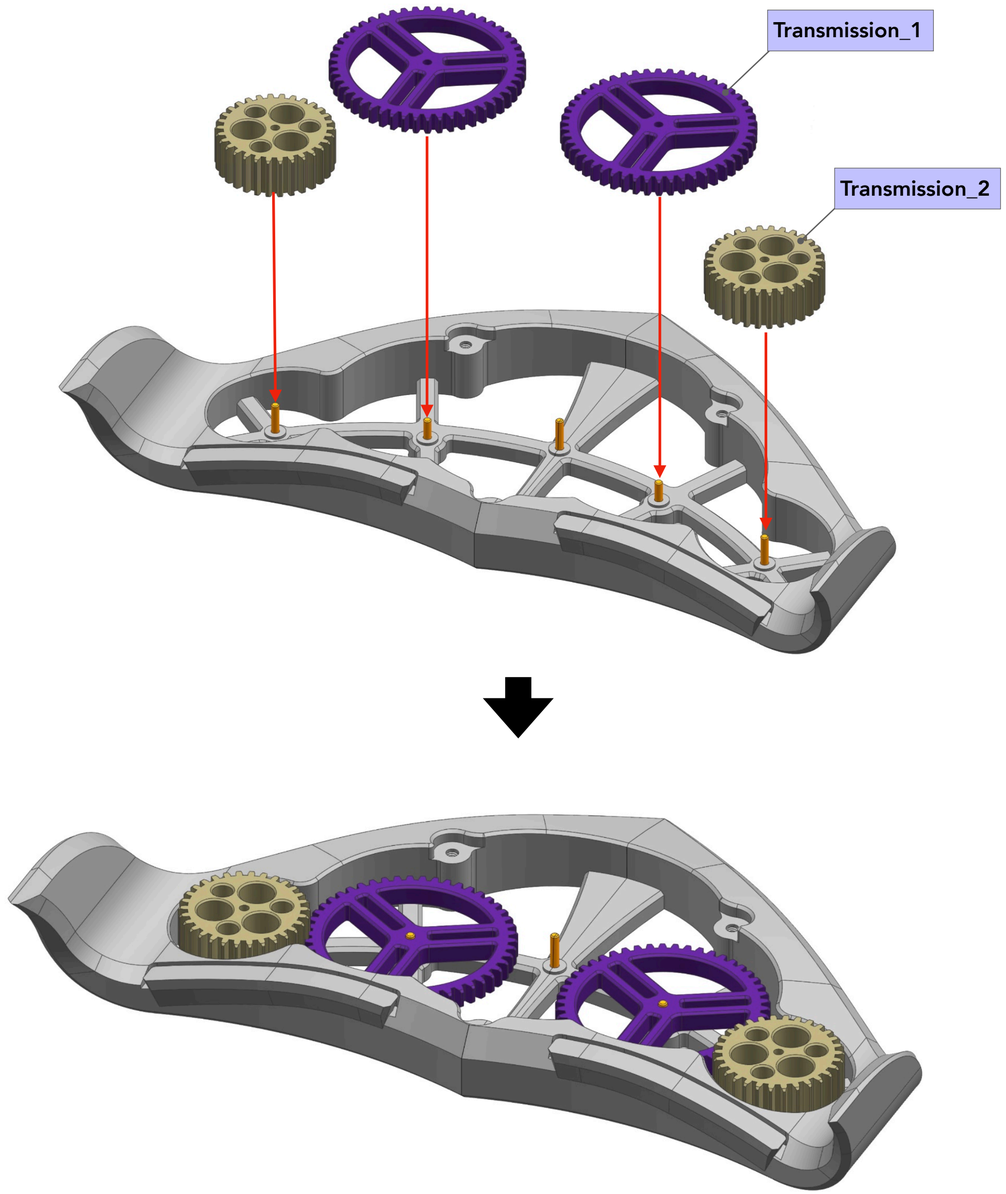






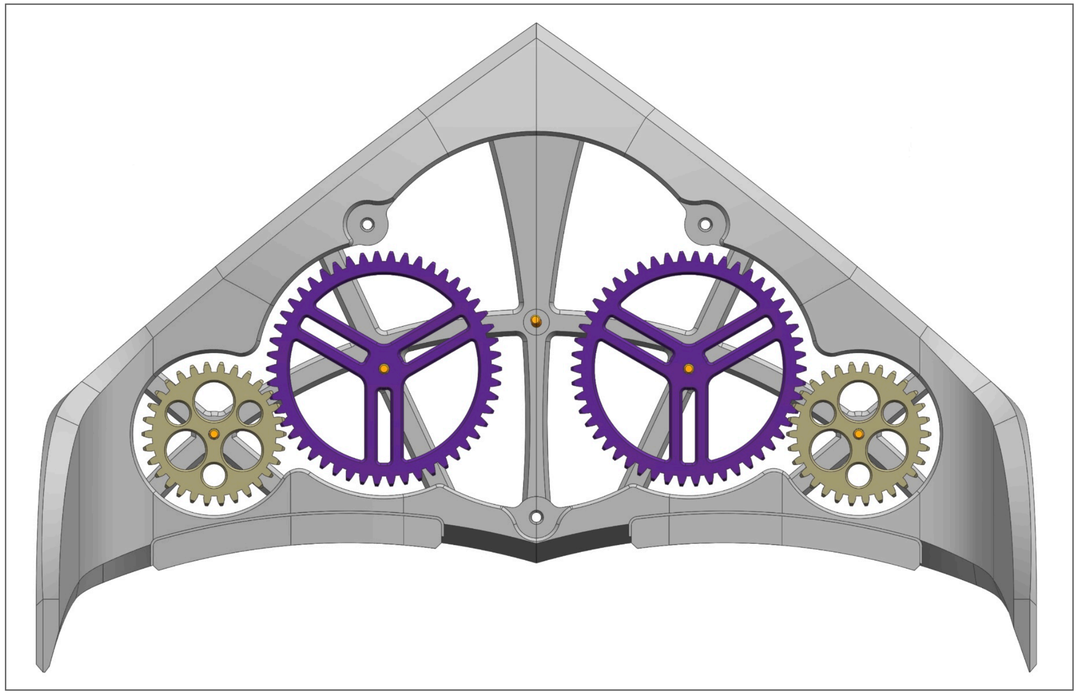
* Applicable for all pin insertion*

Assembly



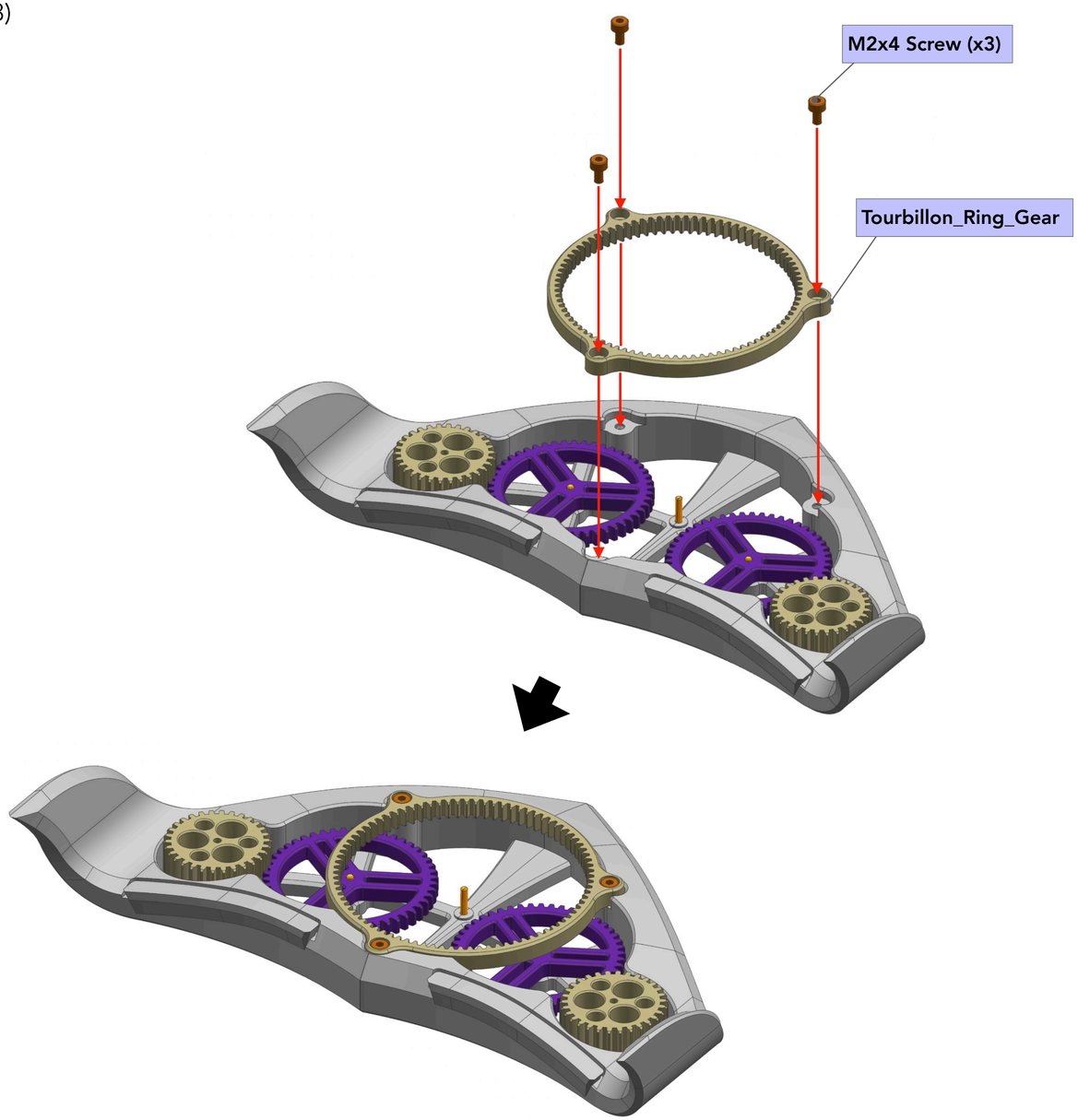
2) Insert the following transmission gears and perform a mesh check.

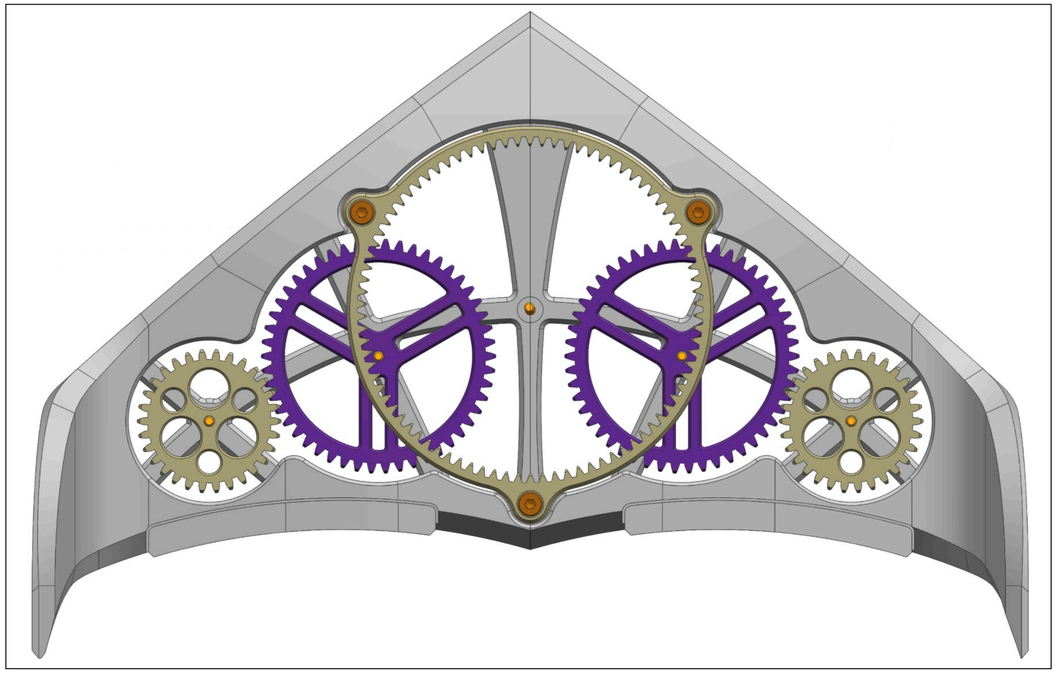
★ [Mesh Check] - Rotate one of the gears to drive all the other connected gears for at least one complete revolution. All gears should rotate smoothly. If there are intermittent jams or resistance at specific positions, check gear tooth for potential bobs, elephants foot, or layer shifts and clean them accordingly. Mesh check will be performed for every gear assembly as we move along the guide.



Assembly

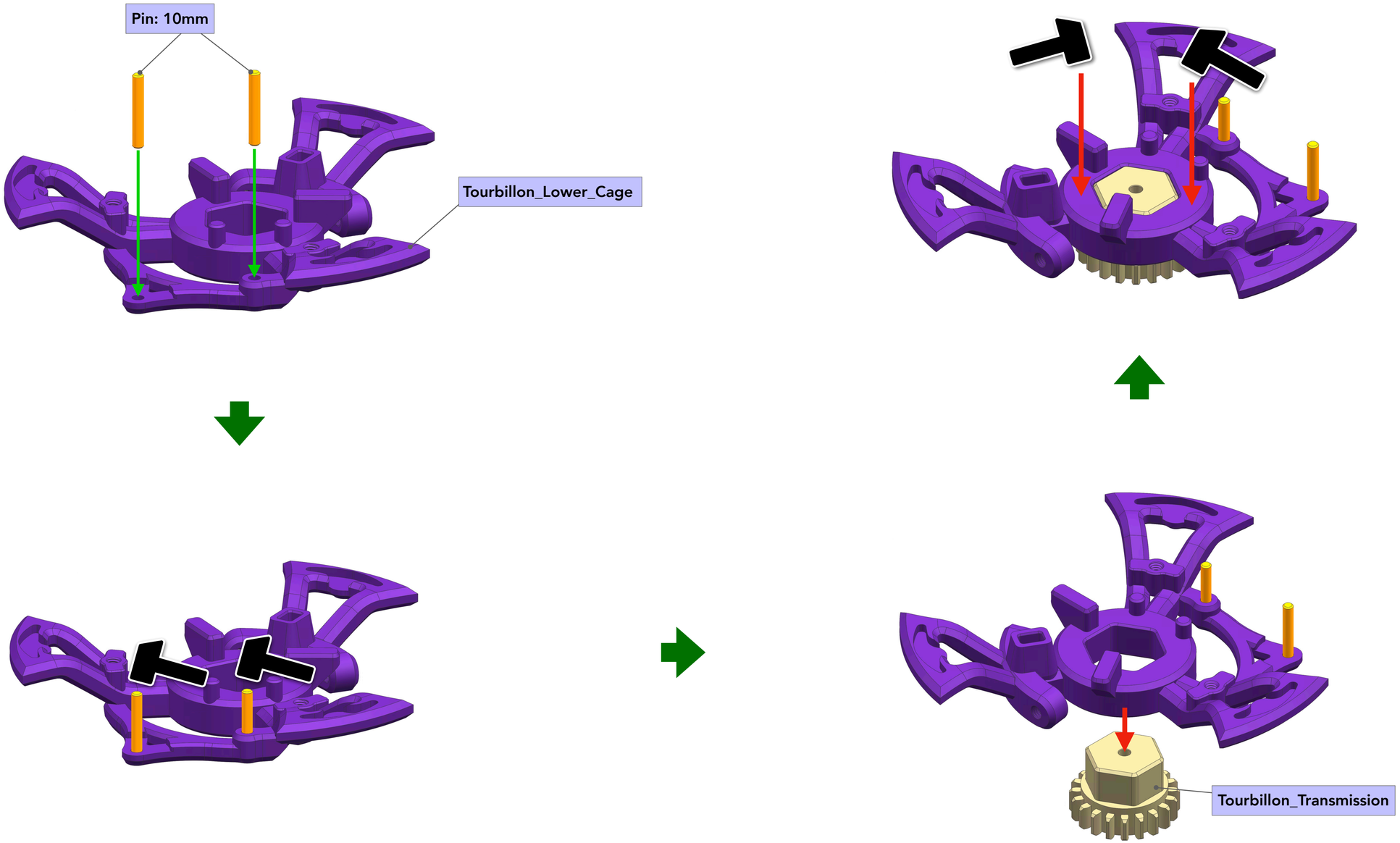
3)





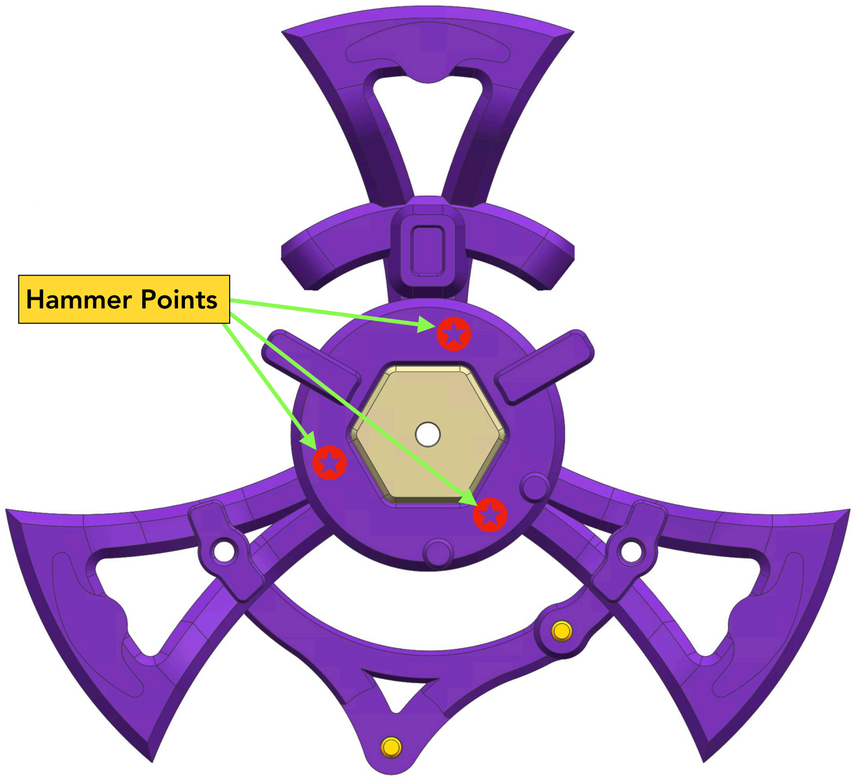
Assembly

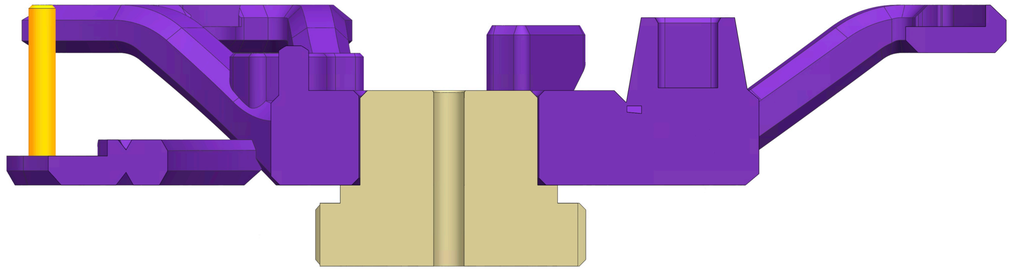
4)

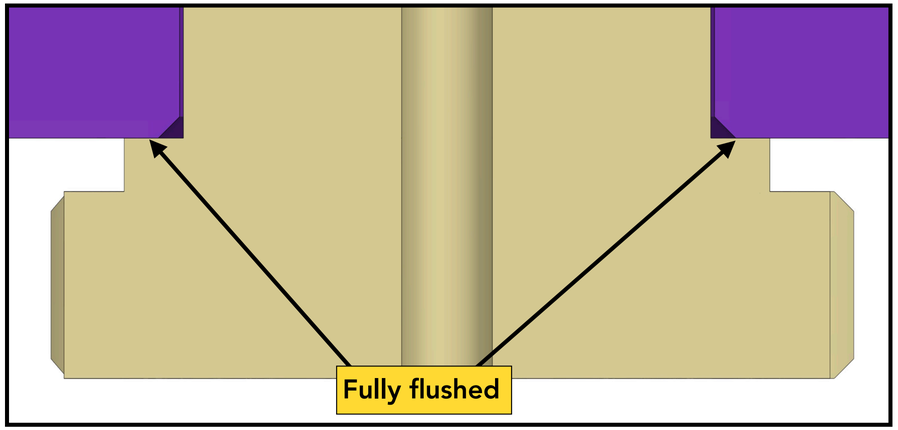


Assembly

5) Use a small tool such as a screw driver or allen key to target the hammer force at the following positions, one at time sequentially, to ensure that the bottom side of the lower cage is seated flushed with the shoulder on the gear. This is critical to ensure that there parts are not relatively tilted.

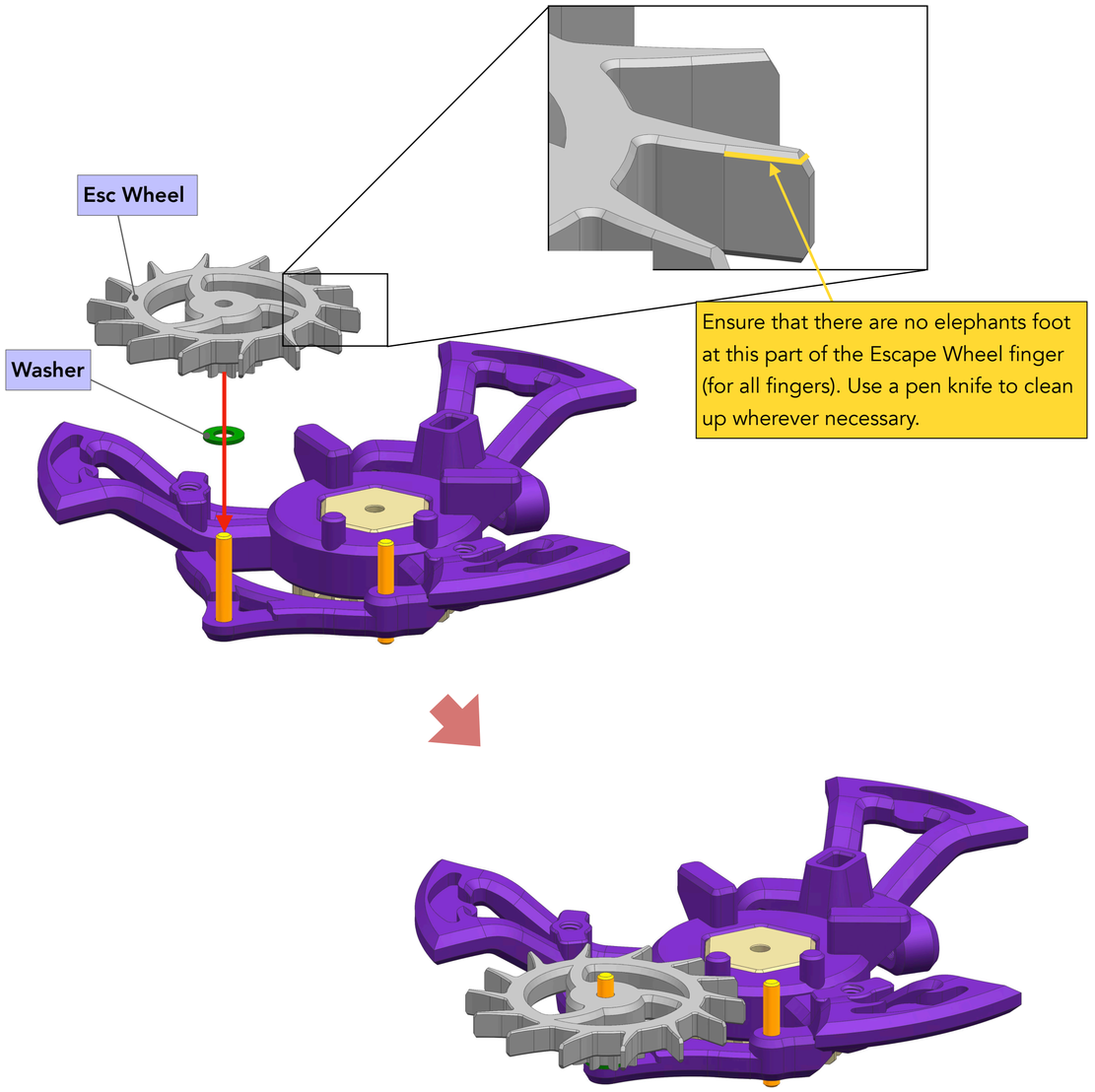






Assembly

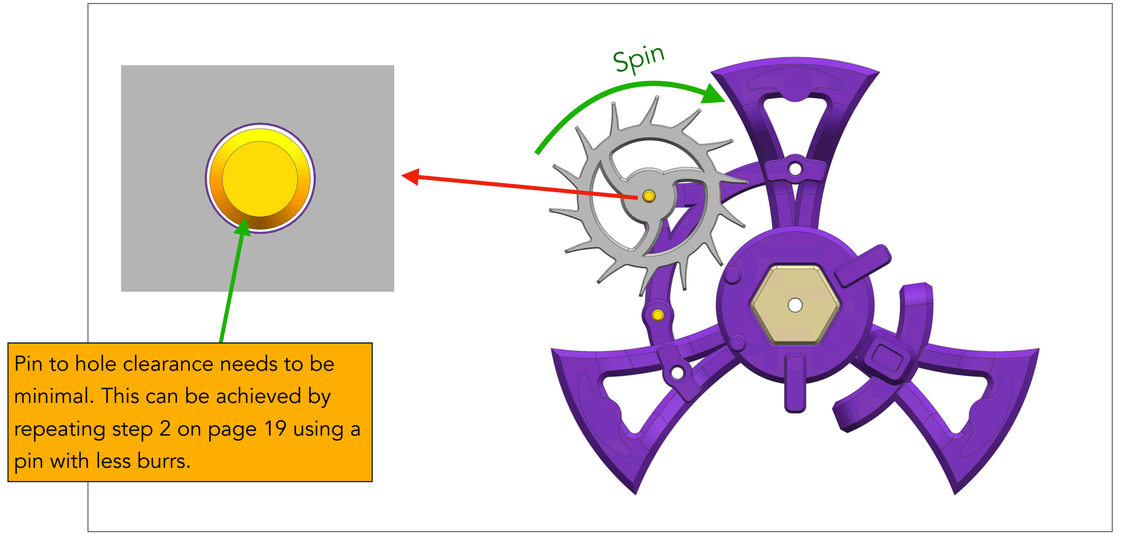
6) Inspect the Escape wheel carefully and ensure that there are no elephants foot or blobs on the fingers of the wheel. Insert 2x washers to the 2 shorter pins followed by the Escape wheel.



[Checkpoint #1]

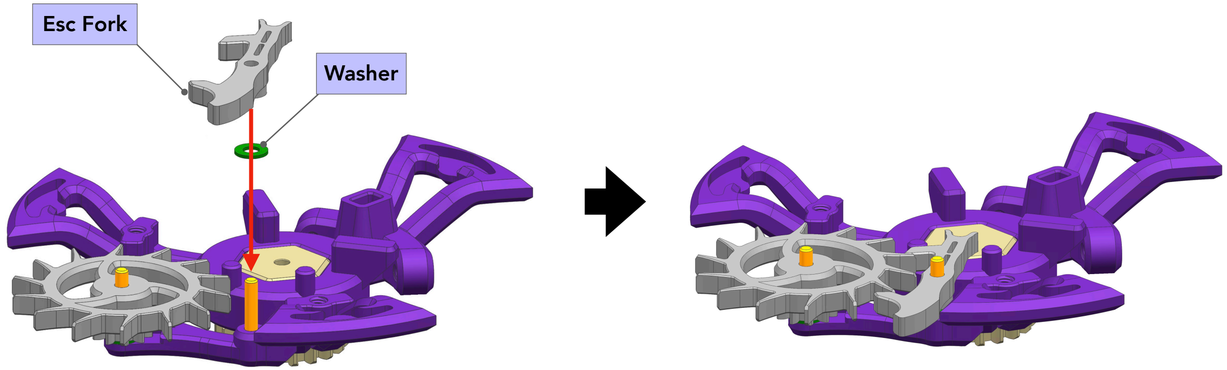
Spin Check : Give the wheel a good spin and it should rotate freely for at least 3 secs before stopping.

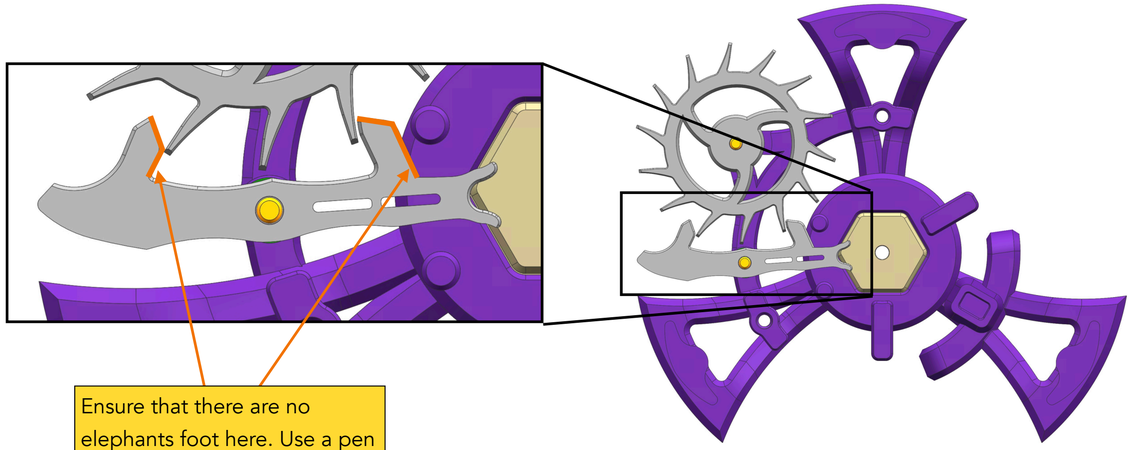
Pin - Hole Clearance Check : There should be minimal clearance between the pin and hole on the escape wheel (just enough to provide a minimal friction spin). Try to wobble the wheel around the pin, you should not feel significant movement.



Assembly

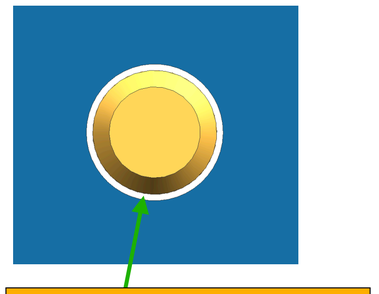
7) Inspect the Escape fork carefully and ensure that there are no elephants foot or blobs at the highlighted areas below. Clean up with a pen knife if necessary and insert the fork as illustrated below

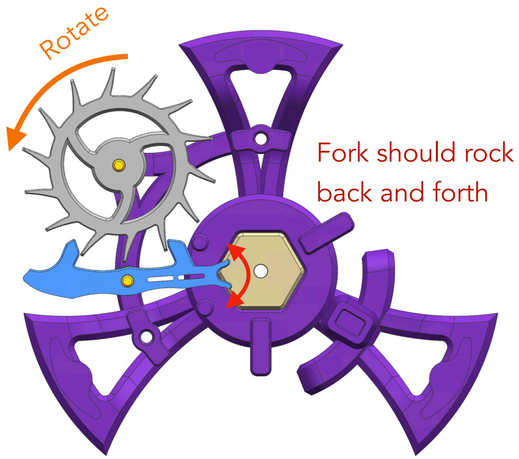




[Checkpoint #2]

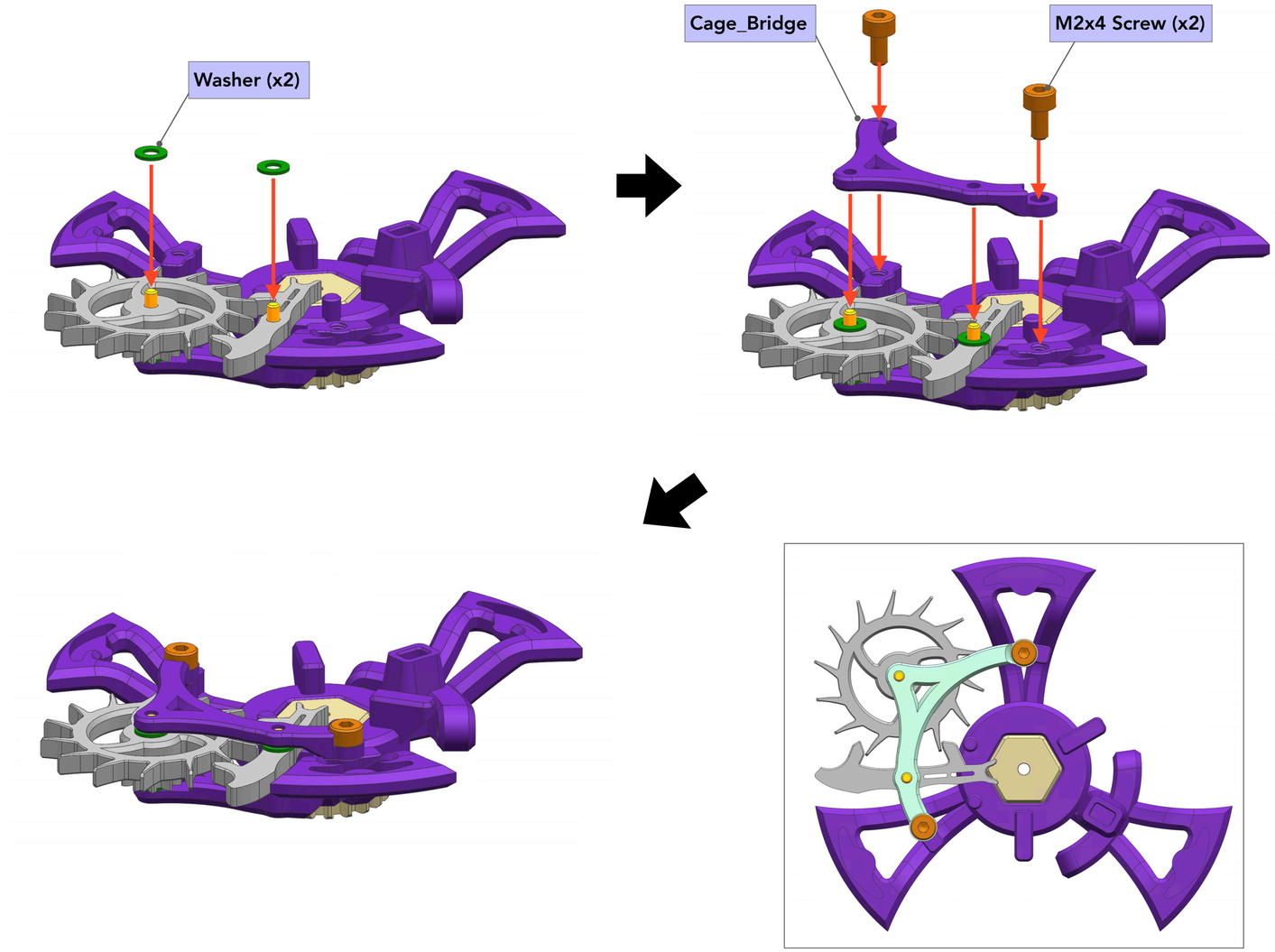
1. Spin Check : Give the wheel a slow and steady spin clockwise and the escape fork should rock forward and backwards with little resistance as it interacts with the escape wheel fingers.You could refer to my detailed assembly video guide for better demonstration on the expected behavior. If there are intermittent jams, use a pen knife to carefully remove materials from the escape fork on the interfering areas.
2. Pin - Hole Clearance Check : There should be minimal clearance between the pin and hole on the escape wheel (just enough to provide a minimal friction spin). Try to wobble the fork around the pin, you should not be able to feel significant movements.





Assembly

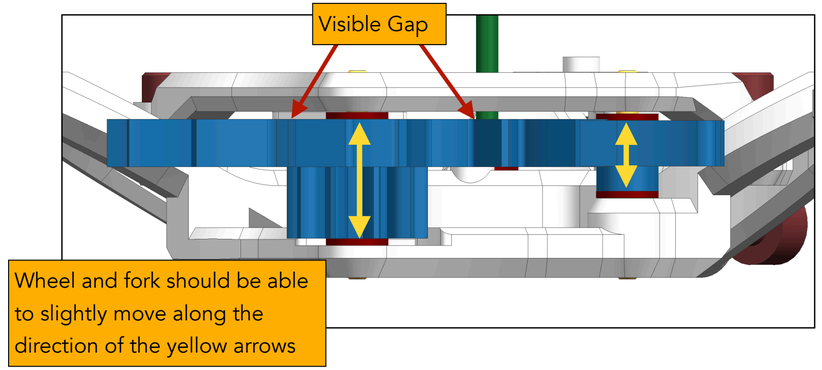
8) Insert 2 washers to the top of the wheel and fork followed by the cage bridge. If the pins are too tightly fitted into the corresponding holes on the bridge, use a 1.5mm drill bit to loosen the holes. Secure the bridge using M2x5 screws. Be careful not to over-tighten the screws



[Checkpoint #3]

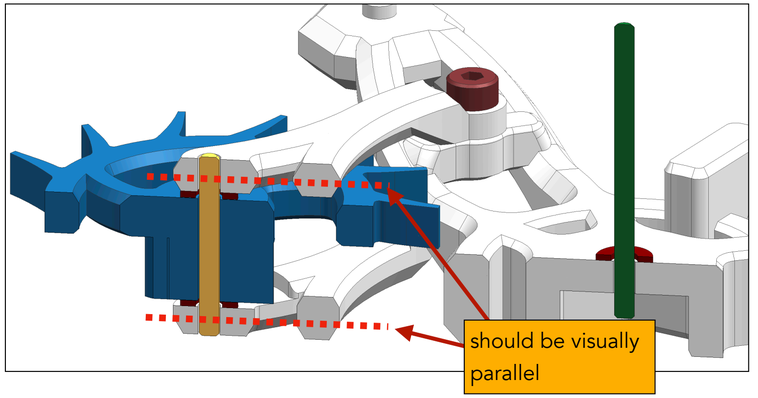
Inspect the wheel and fork from the side, there should be a gap between the bridge and the washers as illustrated. It does not have to be a visible gap; you could try moving the escape wheel and fork along the length of the pin and you should feel a slight allowable movement. Reprint thinner washers by scaling them along z if binding is observed.

Perform the steps from Checkpoint #2 one more time.



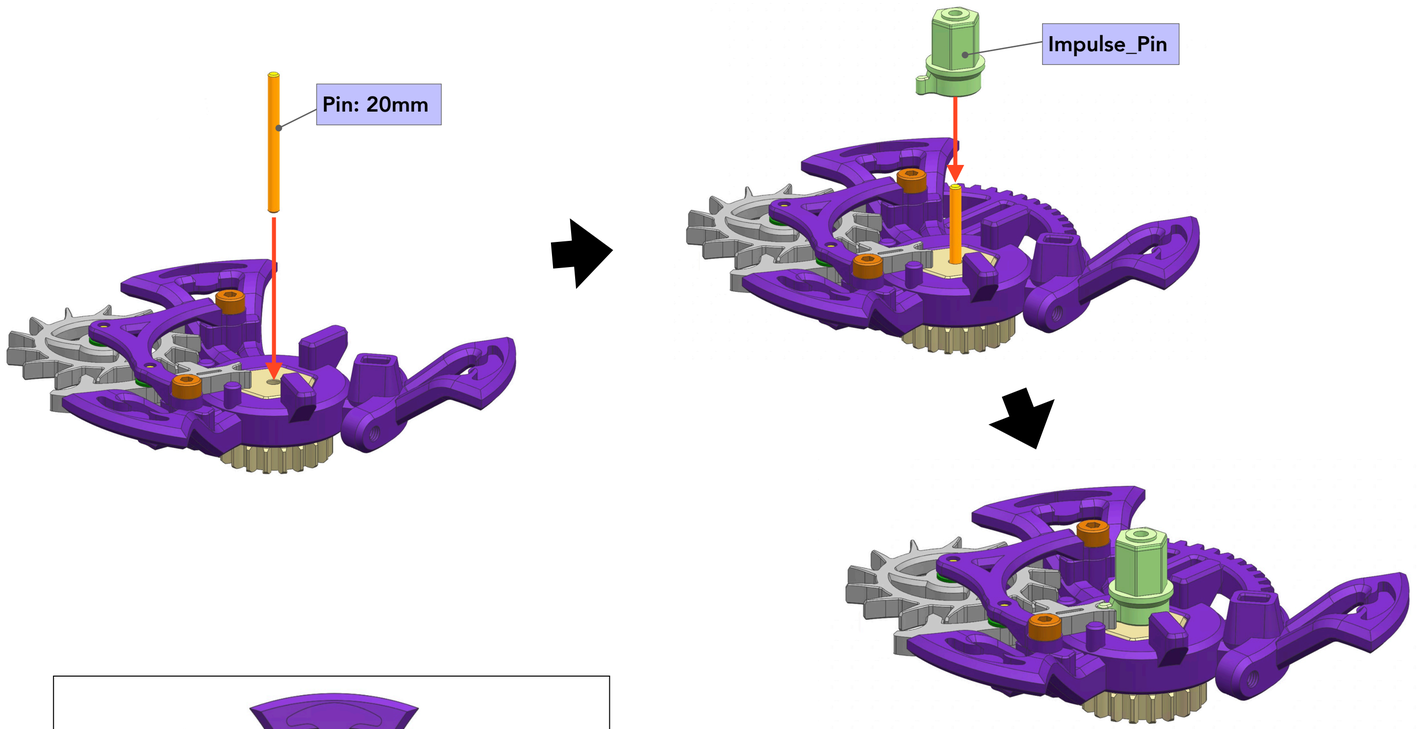
[Checkpoint #4]

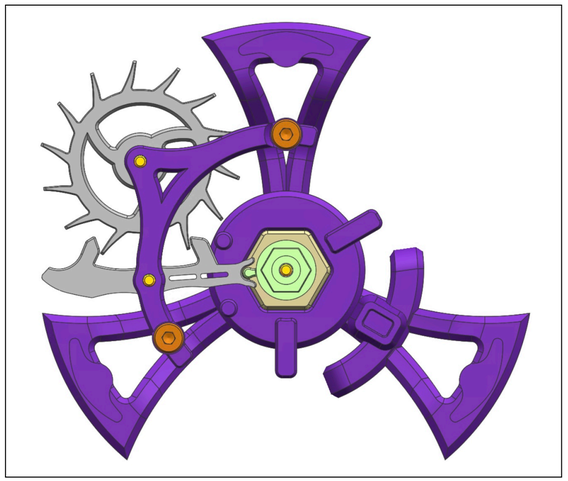
Ensure that the bridge is visually parallel to the bottom side of the base

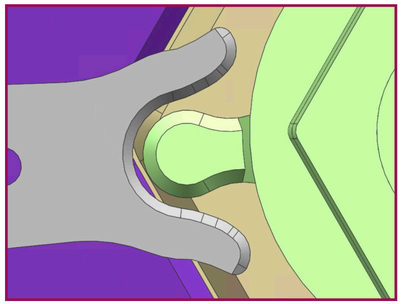


Assembly

9) Insert the 20mm pin into the central pin hole, followed by the impulse pin. The pin fitting will be loose due to the gear's pin-hole prep, but its fine since we will only be running thorugh the escapement cycle for checkpoint #5.

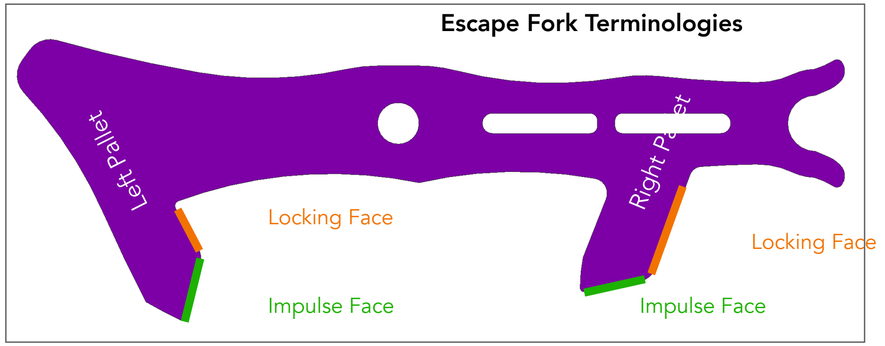


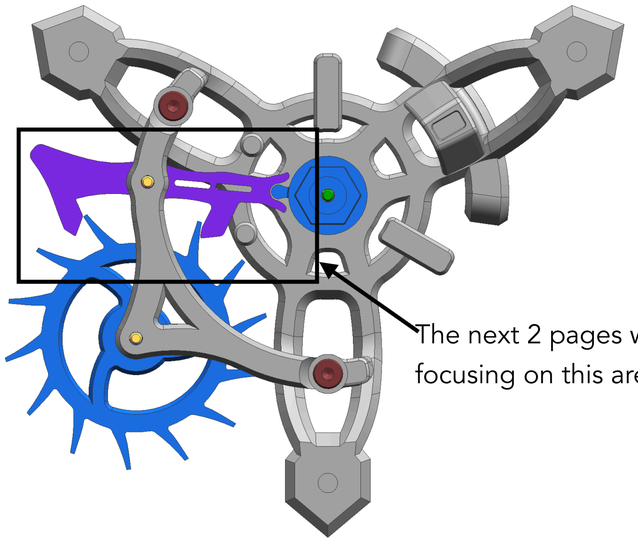




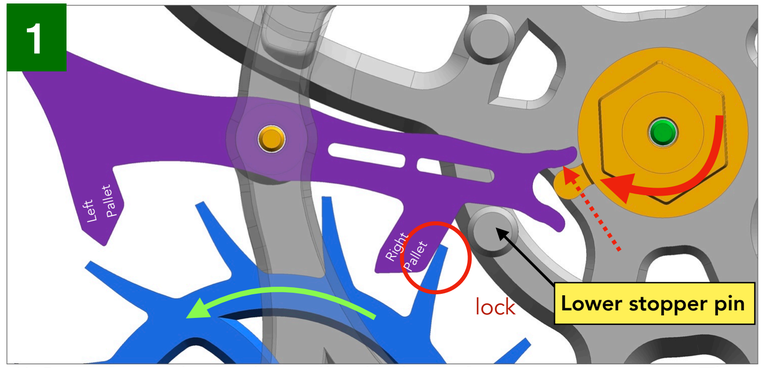
[Checkpoint #5]

you will be guided to cycle through all the phases of the fork, pin and wheel interactions the step by step guide on the next slide to ensure that the mechanism works well. It will be helpful to first understand the basic terminologies of the fork as shown below. I also highly recommend watching this video https://www.youtube.com/watch?v=Wmk2mA6dg3o of the Swiss Lever escapement in action.

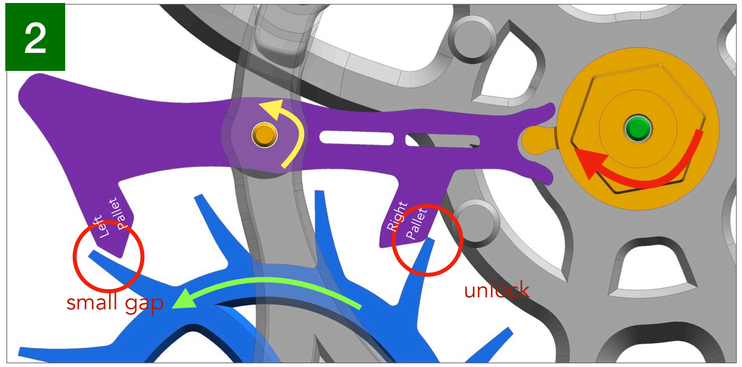




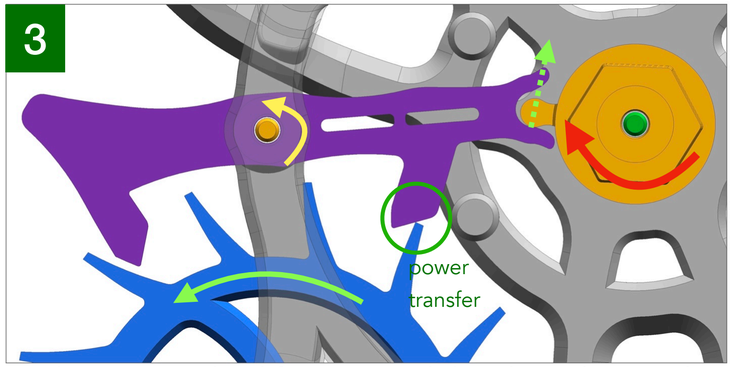
Checkpoint #5 : The Escapement Mechanism



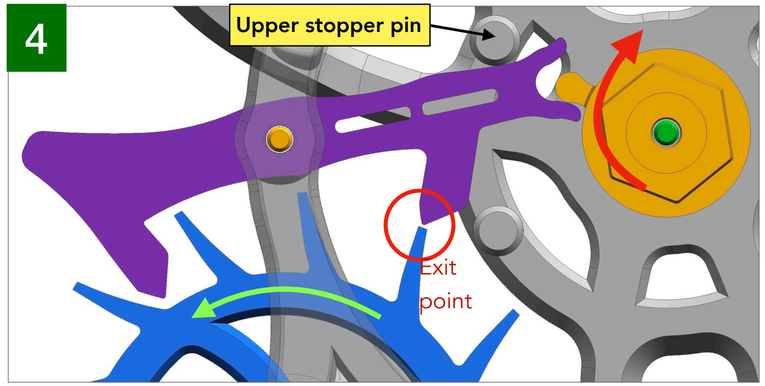
1) Start from the right pallet locking face engagement. The fork is in contact with the lower stopper pin. Escape wheel always tries to rotate counter-clockwise (CCW) and is in locking contact with the fork as shown, thus unable to rotate.



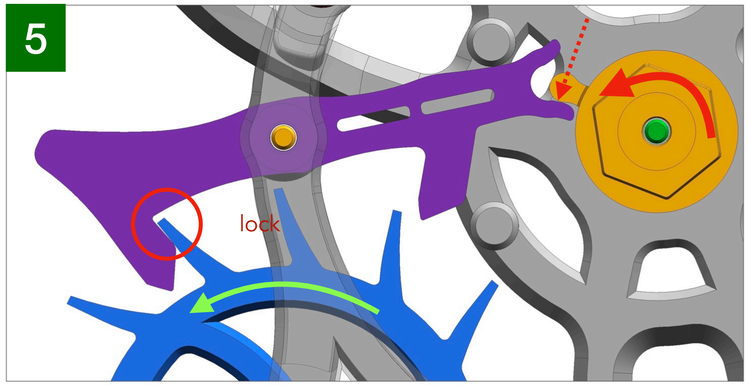
2) The balance wheel + impulse pin swings back clockwise (CW) and nudges the fork to rotate CCW. The nudge will cause the escape wheel finger to be released from the locked position. There should be a small gap between the left pallet and wheel finger



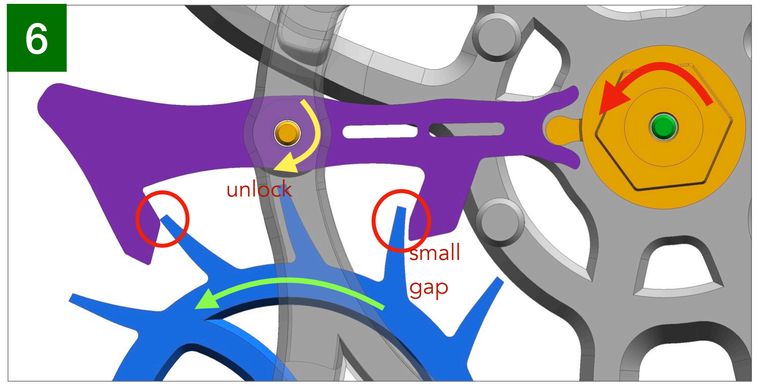
3) The escape wheel finger now slides along the impulse face of the right pallet. the energy from the mainspring that is transferred all the way to the escape wheel is now partly being transferred to the fork and finally to the impulse pin + balance wheel



4) The escape wheel finger eventually exits the right pallet when the fork fully swings to the upper stopper pin. There should be a small gap at the exit point as illustrated. You may use a pen knife to carefully remove some material at the fork if no gap is observed

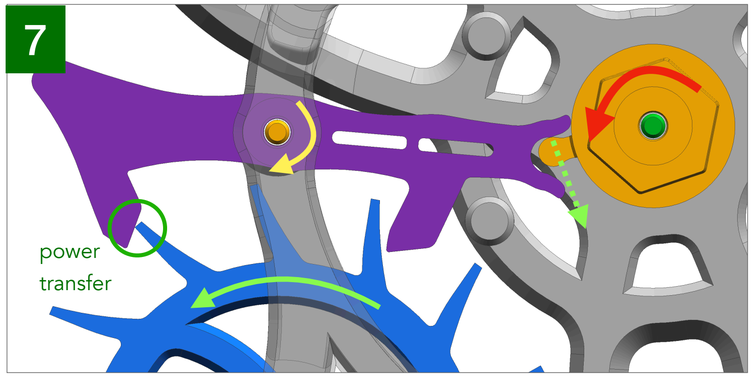


5) The escape wheel finger then strikes the left pallet locking face and will remain in this position till the balance wheel makes another full swing, rotating back CCW

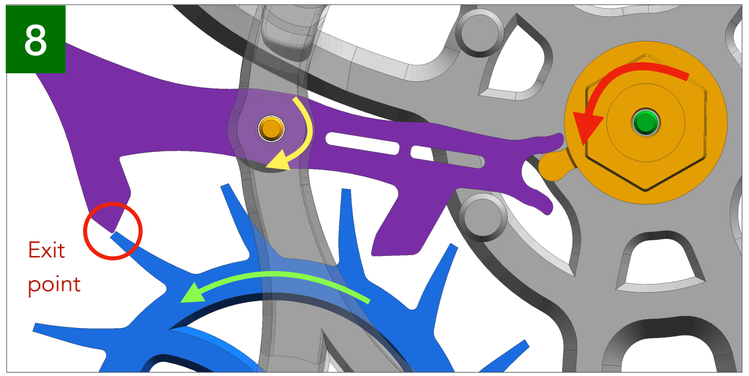


6) The impulse pin nudges the fork again. Escape wheel + fork will unlocked at the left pallet. At this position, check that a gap exists between the right pallet with the wheel fingers

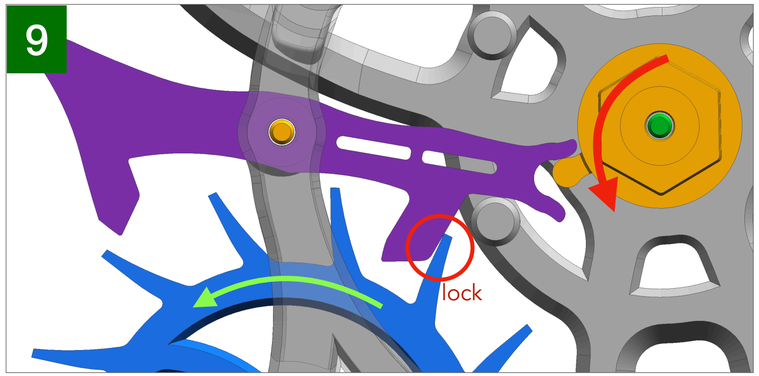
Checkpoint #5 : The Escapement Mechanism



7) Escape wheel finger slides along impulse face of the fork, transferring energy once again to rotate the fork clockwise.



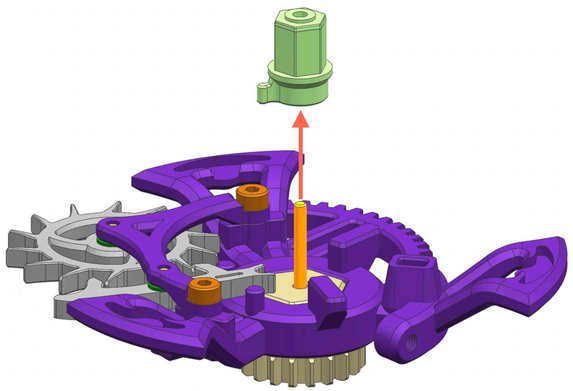
8) The wheel finger then exits the left pallet as the fork is fully swing to the right. Ensure that there is a gap at the exit point. You may use a pen knife to gently remove some material at the fork at the point of interference if necessary.

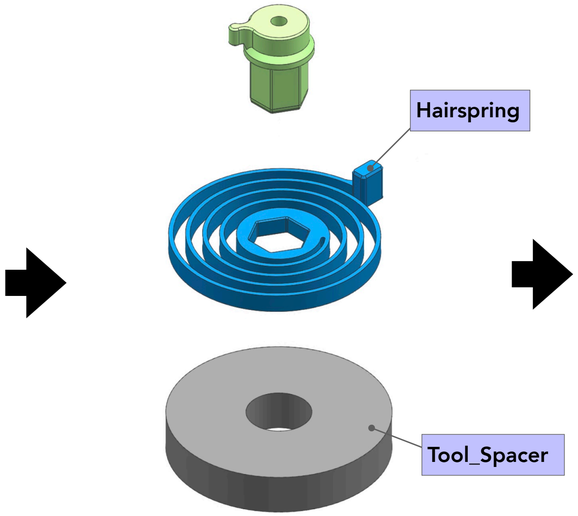


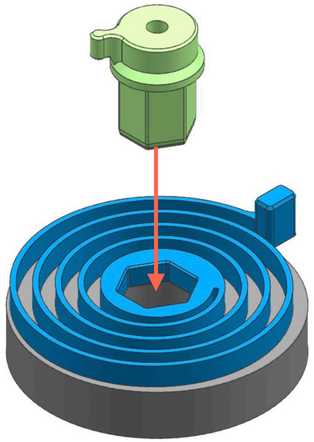
9) The wheel eventually locks with the fork again on the right pallet and the mechanism completes a full cycle that repeats itself.

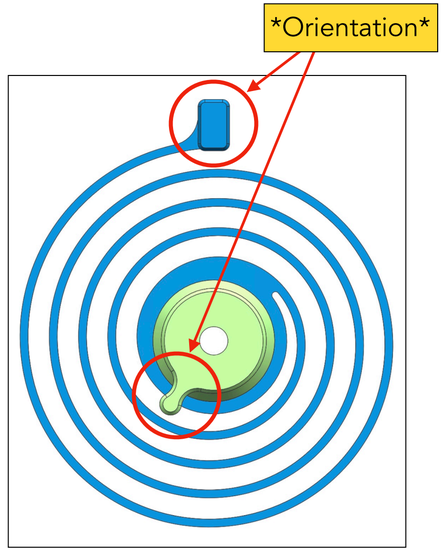
Assembly

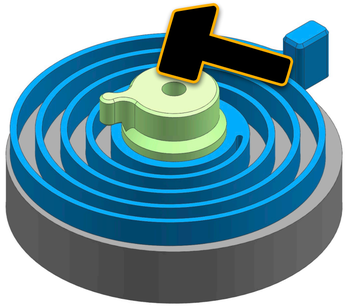
10)

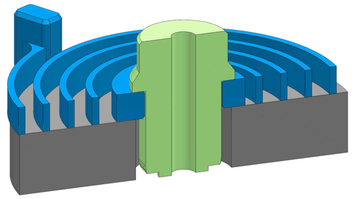


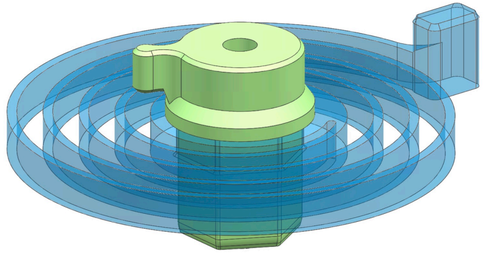






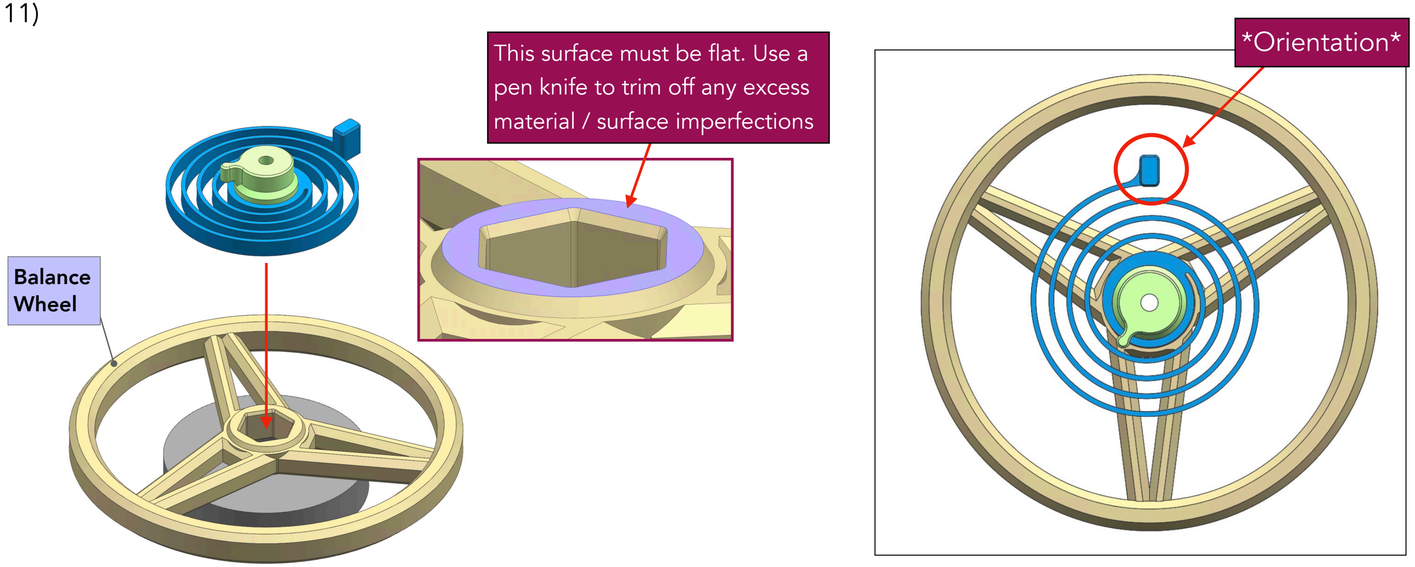


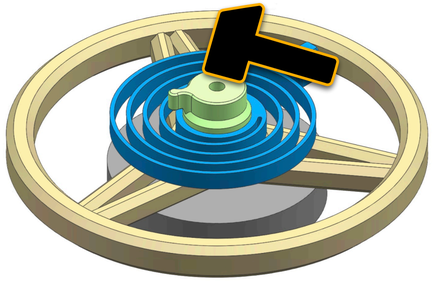


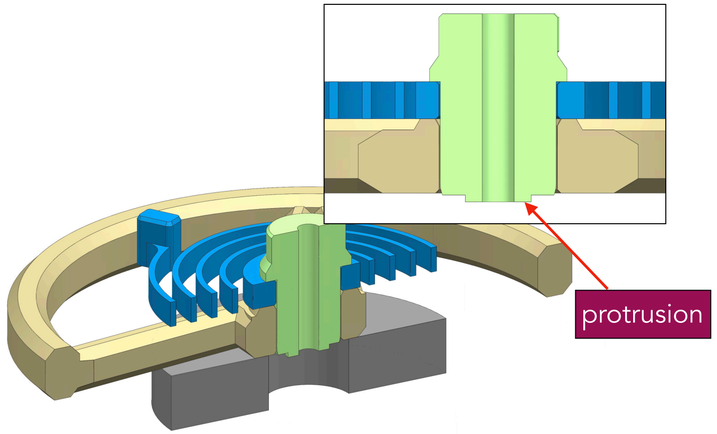


Assembly

11)

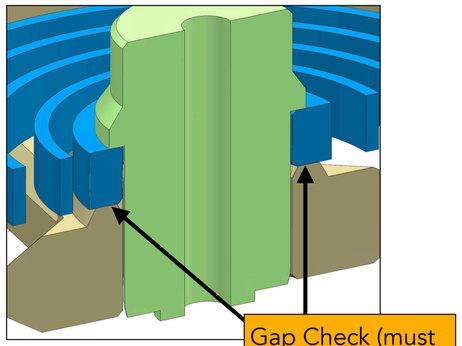


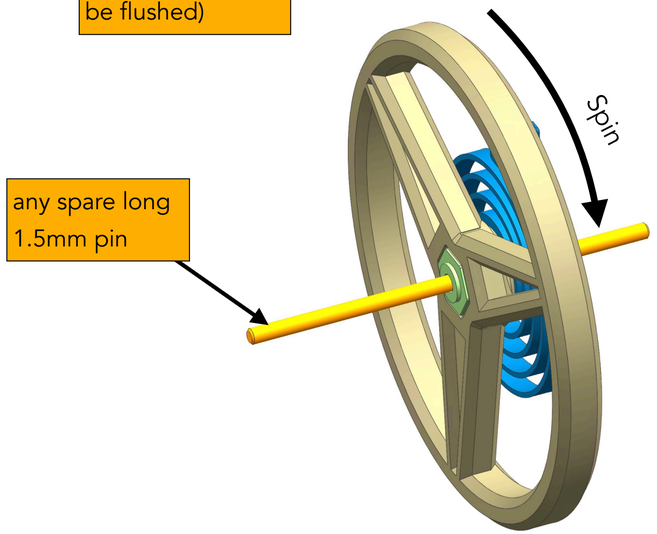




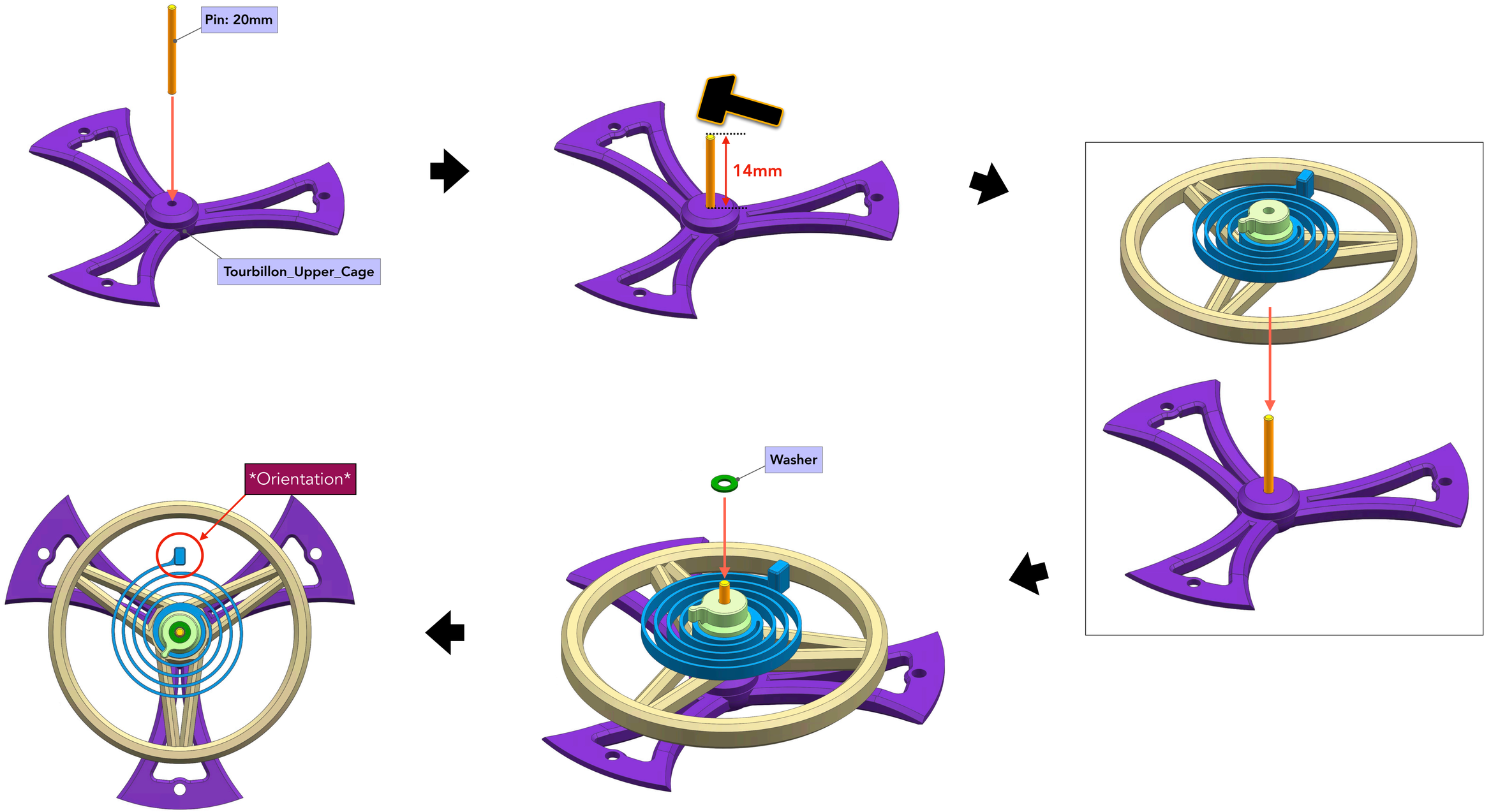
[Checkpoint #6]

- Ensure that there are no visible gaps between the impulse pin flange,
- Run a spare 1.5mm pin through the assembly and give it a spin. Look from the side and ensure that the balance wheel does not wobble too much. It excessive wobble is observed, it is likely that it is not fully inserted or the impulse pin hole is tilted during the reaming process on page 11.

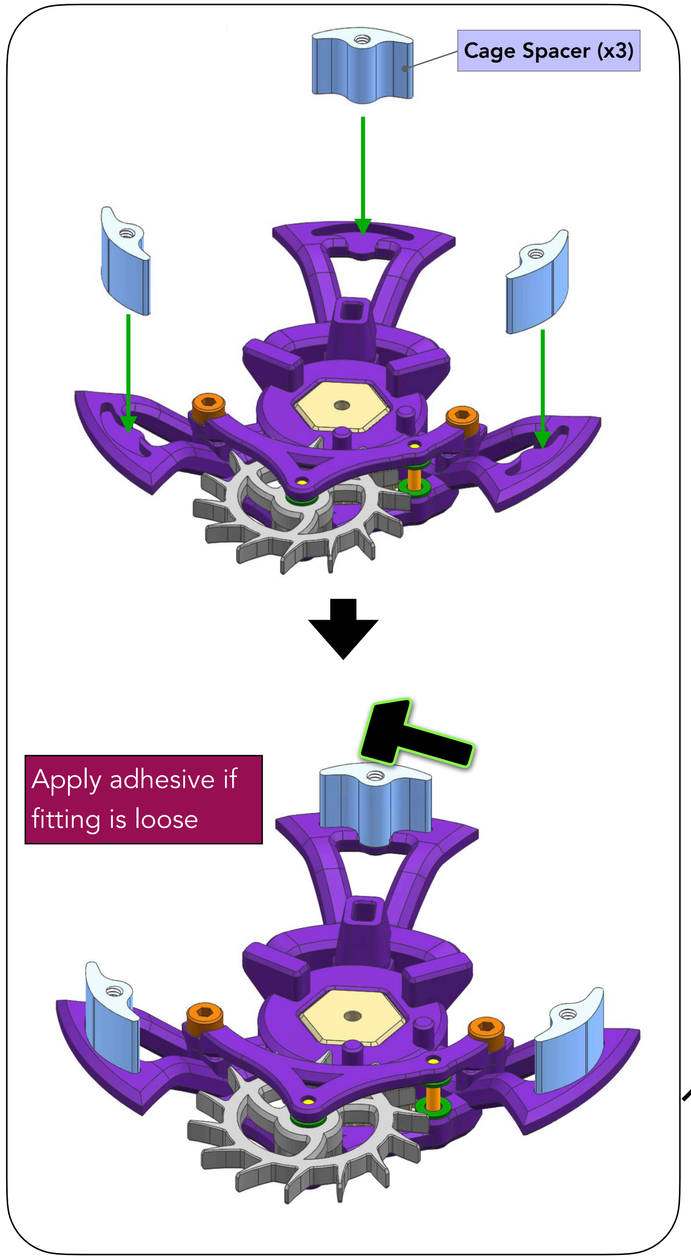


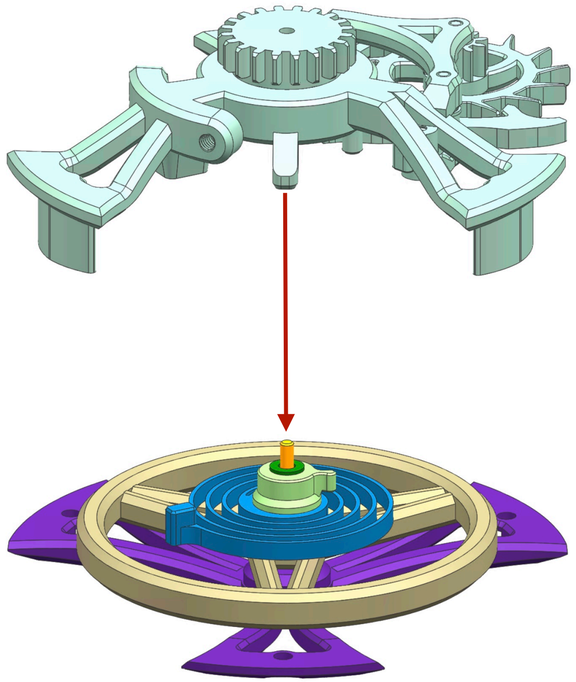


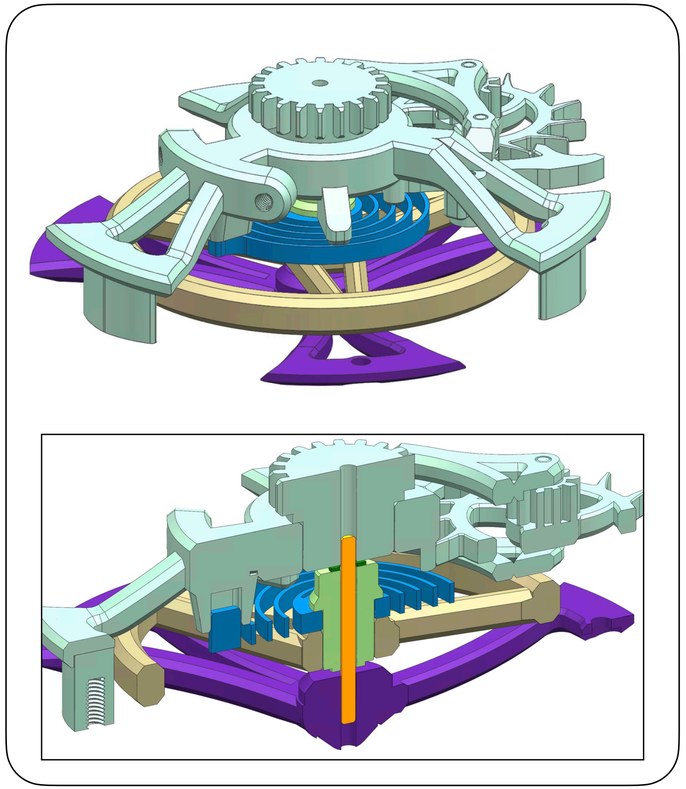
Assembly



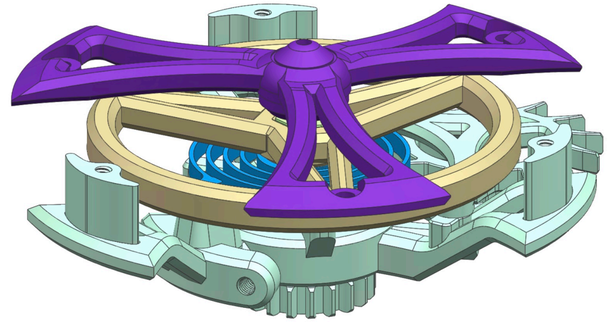
Assembly







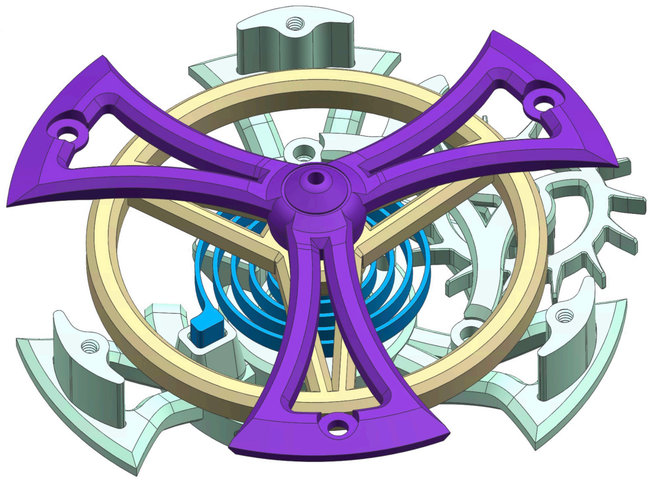
Flip

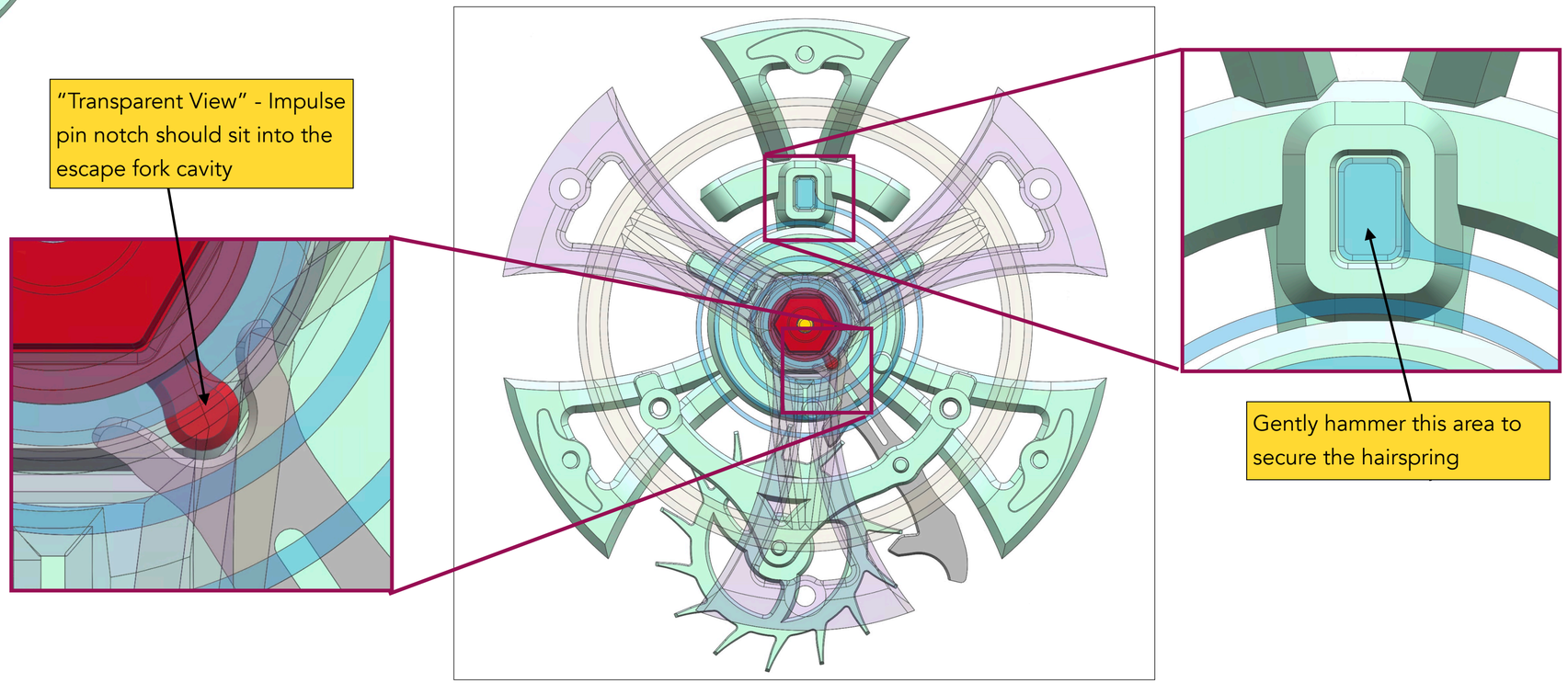


Continue to next page

Assembly

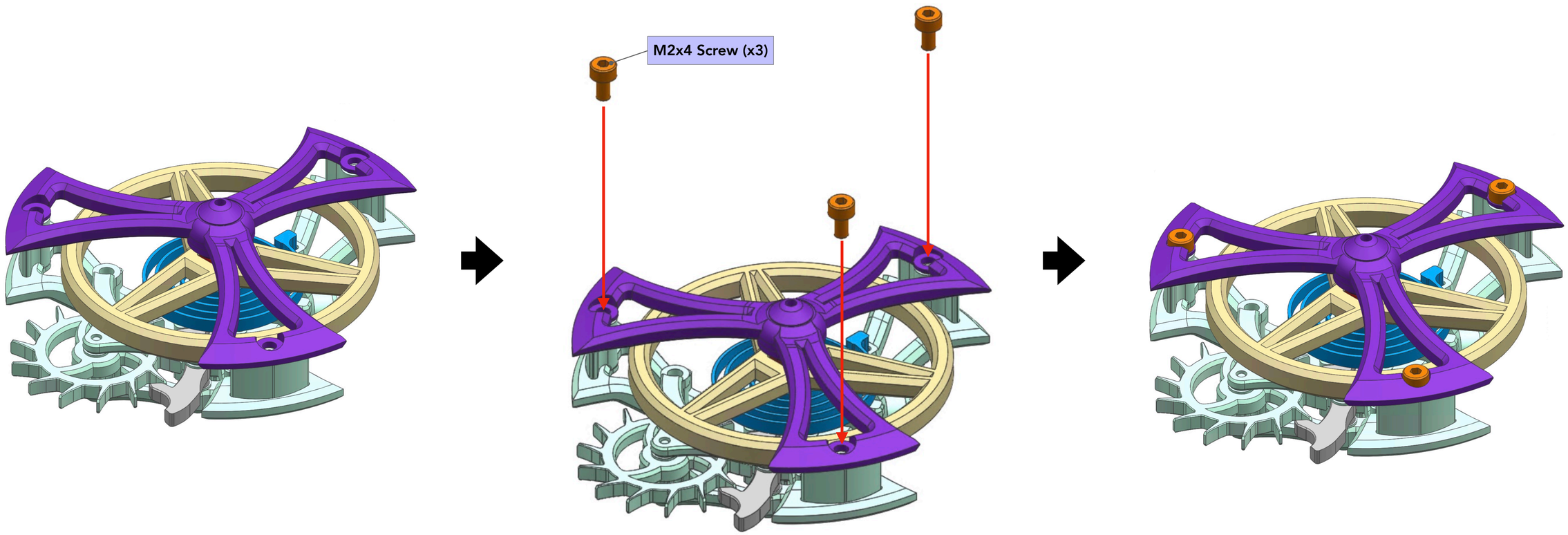
12)




"Transparent View" - Impulse pin notch should sit into the escape fork cavity
Gently hammer this area to secure the hairspring

Assembly

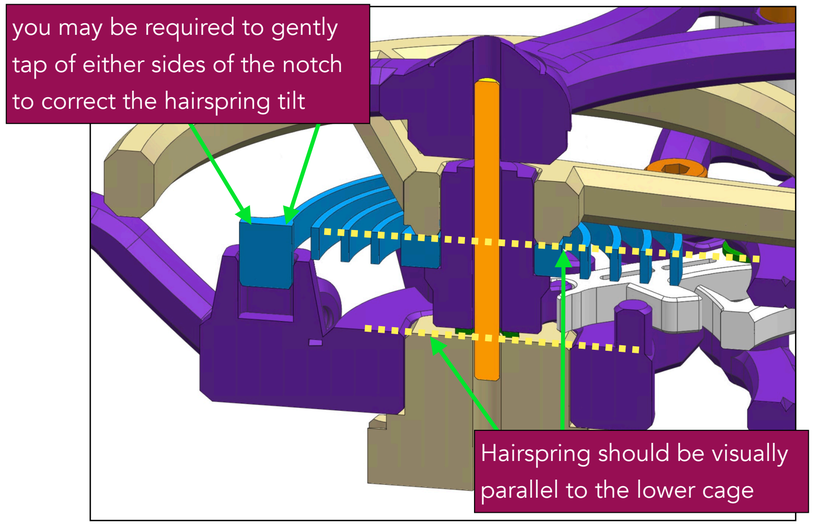
13)



Assembly

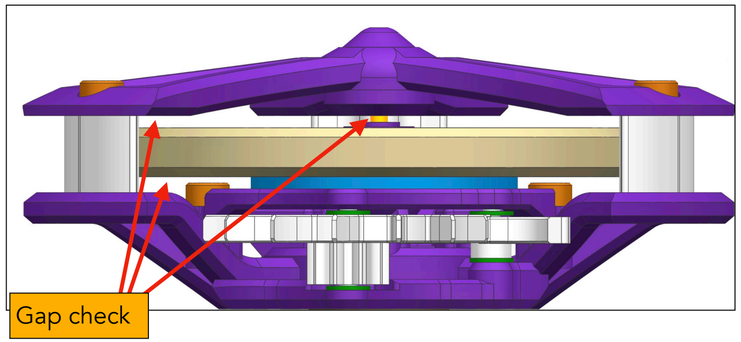
[Checkpoint #7]

Check the assembly from the side, the hairspring should not be tilted relative to the lower base. You may be required to gently tap on either the front or rear side of the hairspring notch to adjust the tilt.



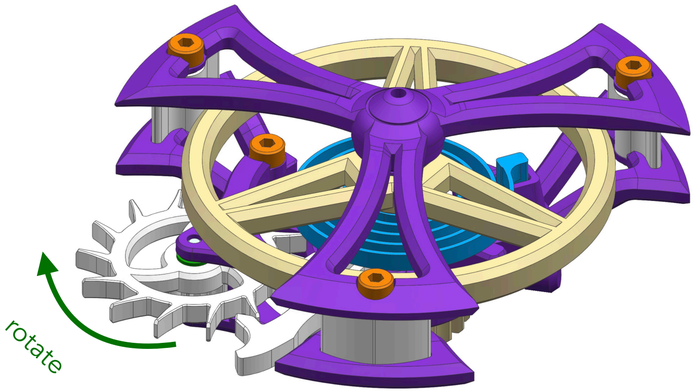
[Checkpoint #8]

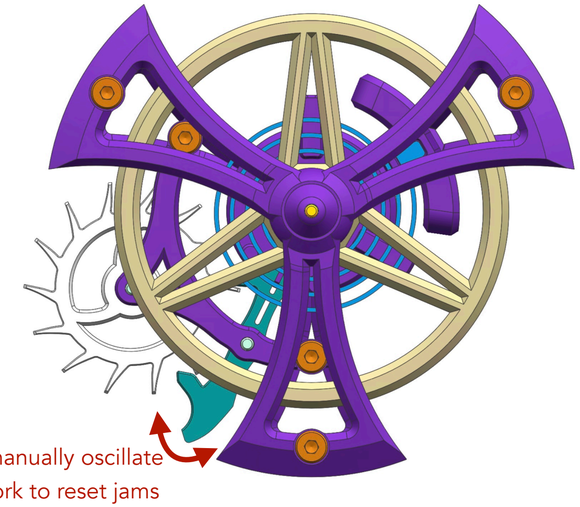
there should be balanced gap between the balance wheel and all 3 sides of the lower cage arms.



[Checkpoint #9]

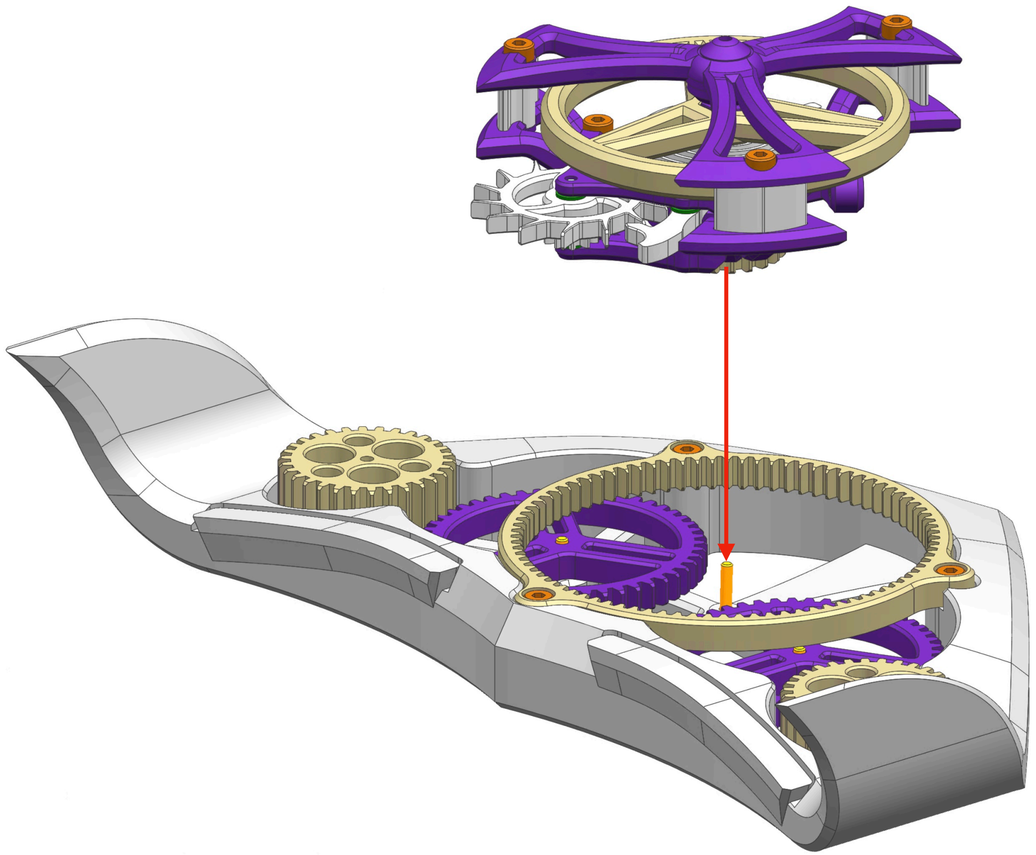
Give the escape wheel a very gentle and constant clockwise rotation as illustrated to activate the escapement mechanism. Take note that it is normal for the mechanism to have intermittent jams due to the difficulty to apply a constant force on the escape wheel. When that happens, nudge the tail of the fork to reset the position of the impulse pin.

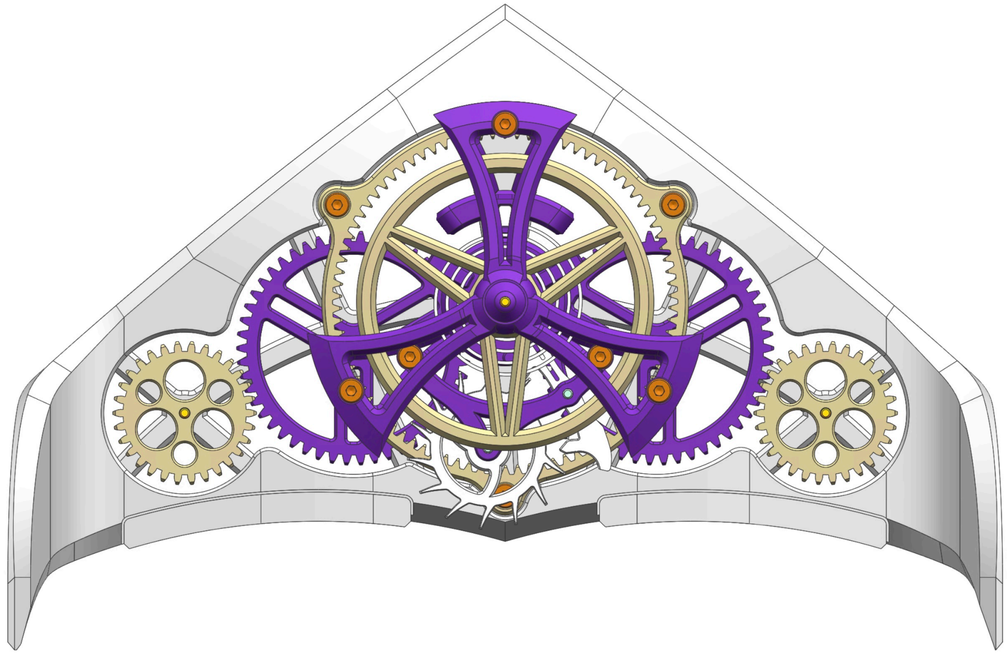




Assembly

14)

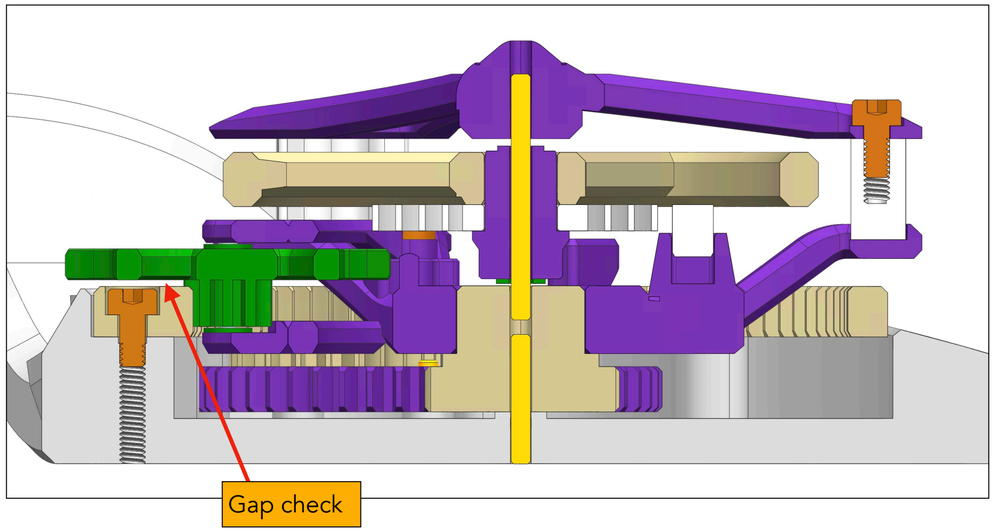




Assembly

[Checkpoint #10]

Inspect the gap between esc wheel & esc fork vs the ring gear from the side as illustrated below and you should observe a visible gap (approx 0.4mm). Othwerwise, you may add a washer to the tourbillon transmission-Base interface to increase the gap.



15) The assembly is now complete! You may activate the movement by rotating the tourbillon cage or transmission 2 gears counter clockwise.