

# Mini-Excavator

By Ho Tin Chau

## Description:

I always wanted to operate an excavator. However, it is very expensive and takes time to go through the training. With my knowledge about motor, gears and linkage, I can build this table-top excavator and enjoy it anytime. It has three independent motors, so that it can simulate the motion of an excavator. With electronics, it can be operated remotely by controller, or even program it to achieve automation.

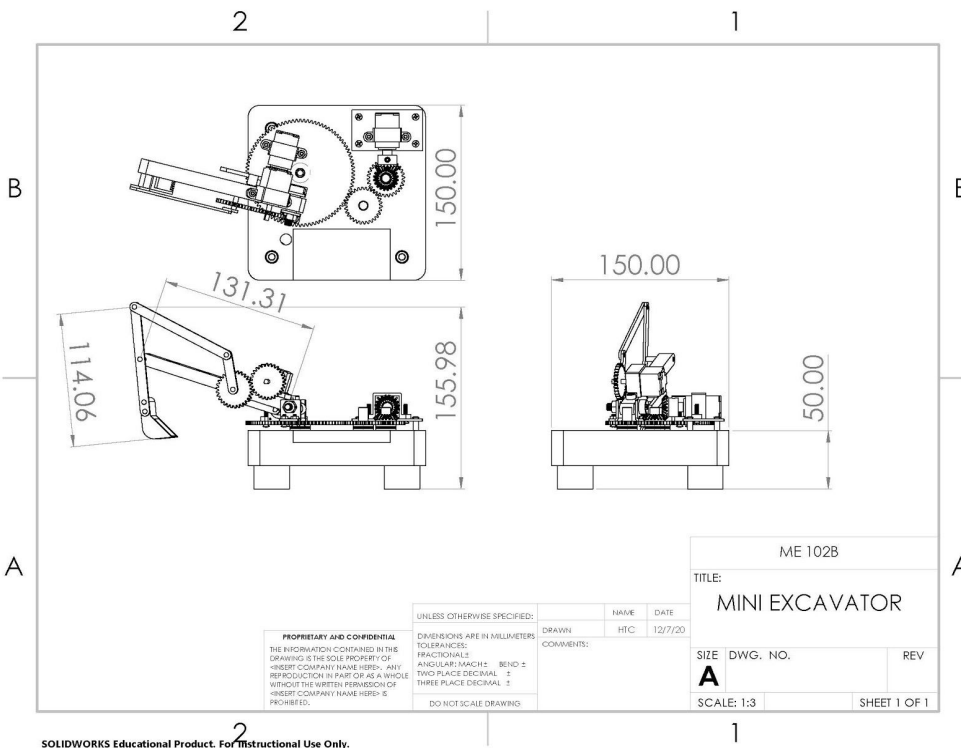
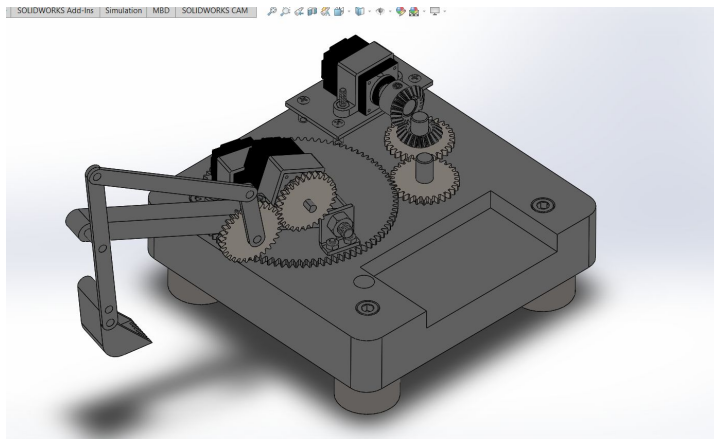


Figure 1: Isometric view (top), drawing with key dimensions in mm (bottom)

## Bill of Materials and Manufacturing process:

	A	B	C	D	E	F
1	Part number	Part name	Part/Raw material vendor URL	Quantity	Manufacturing method	
2	1	Main platform	<a href="https://www.mcmaster.com/8975K979-9246K623/">https://www.mcmaster.com/8975K979-9246K623/</a>	1	Waterjet, Milling, Drilling, Tapping	
3	2	Big base gear		1	3D-print	
4	3	Compound miter gear		1	3D-print	
5	4	Miter Gear with set screw	<a href="https://www.mcmaster.com/2600N1/">https://www.mcmaster.com/2600N1/</a>	1		
6	5	Stepper motor	<a href="https://www.pololu.com/product/1204">https://www.pololu.com/product/1204</a>	3		
7	6	Motor mount bracket		3	3D-print	
8	7	Motor mount spacer	<a href="https://www.mcmaster.com/94669A103/">https://www.mcmaster.com/94669A103/</a>	4		
9	8	Motor mount platform	<a href="https://www.mcmaster.com/9146T11/">https://www.mcmaster.com/9146T11/</a>	1	Laser-cut	
10	9	M3 nut	<a href="https://www.mcmaster.com/90592A085/">https://www.mcmaster.com/90592A085/</a>	10		
11	10	M3 screw 16mm	<a href="https://www.mcmaster.com/90258A187/">https://www.mcmaster.com/90258A187/</a>	10		
12	11	Miter Gear adapter		1	3D-print	
13	12	Main platform Legs	<a href="https://www.mcmaster.com/89535K43-89535K432/">https://www.mcmaster.com/89535K43-89535K432/</a>	4	Turning, Drilling, Tapping	
14	13	M6 screws for legs	<a href="https://www.mcmaster.com/91290A332/">https://www.mcmaster.com/91290A332/</a>	4		
15	14	thrust bearing for base gears	<a href="https://www.mcmaster.com/7806K64/">https://www.mcmaster.com/7806K64/</a>	3		
16	15	Solid base shaft	<a href="https://www.mcmaster.com/4634T35/">https://www.mcmaster.com/4634T35/</a>	2	Turning	
17	16	Hollow base shaft	<a href="https://www.mcmaster.com/4634T35/">https://www.mcmaster.com/4634T35/</a>	1	Turning	
18	17	L-brackets	<a href="https://www.mcmaster.com/9146T11/">https://www.mcmaster.com/9146T11/</a>	2	Laser-cut, bending, Drilling	
19	18	fix link		1	3D-print	
20	19	drive link		1	3D-print	
21	20	intermediate link	<a href="https://www.mcmaster.com/7701T27/">https://www.mcmaster.com/7701T27/</a>	1	Laser-cut	
22	21	output link	<a href="https://www.mcmaster.com/7701T27/">https://www.mcmaster.com/7701T27/</a>	1	Laser-cut	
23	22	crank link	<a href="https://www.mcmaster.com/7701T27/">https://www.mcmaster.com/7701T27/</a>	1	Laser-cut	
24	23	bucket		1	3D-print	
25	24	shoulder screw	<a href="https://www.mcmaster.com/90278A225/">https://www.mcmaster.com/90278A225/</a>	1		
26	25	shoulder screw nut	<a href="https://www.mcmaster.com/90592A016/">https://www.mcmaster.com/90592A016/</a>	1		
27	26	spacers	<a href="https://www.mcmaster.com/4634T35/">https://www.mcmaster.com/4634T35/</a>	2	Turning	
28	27	M3 screw 10mm	<a href="https://www.mcmaster.com/90258A181/">https://www.mcmaster.com/90258A181/</a>	4		
29	28	plastic shaft	<a href="https://www.mcmaster.com/8701K37/">https://www.mcmaster.com/8701K37/</a>	2	Turning	
30	29	plastic shaft short	<a href="https://www.mcmaster.com/8701K37/">https://www.mcmaster.com/8701K37/</a>	2	Turning	
31	30	Plastic pin for bucket	<a href="https://www.mcmaster.com/8701K37/">https://www.mcmaster.com/8701K37/</a>	2	Turning	
32	31	30T gear		3	3D-print	

## Installation process:

Starting with subassembly 2, first mount the stepper motor on the small platform using the motor mount bracket with m3 nut and screw. Insert the motor shaft into the miter gear adapter. The adapter has a D-shape hole that matches the motor shaft. Then, insert the miter gear into the adapter. There is a flat spot on the adapter so the set screw on the miter gear can lineup with that and lock itself.

To assemble subassembly 1, a shoulder bolt is used to connect two L-brackets and the fixed link by going through the bigger hole on both components. Two spacers are placed in between the L-bracket and each side of the fixed link to constraint the position of the fixed link. A nut is used to constraint the shoulder bolt. The fixed link should rotate freely around the shoulder bolt. Next, mount another stepper motor on the fixed link again using the motor mount. Insert the 30T gear into the motor shaft. Attach the bucket with the bucket link using 2 pins. Attach the crank link and another 30T gear with the fixed link. Align the gears so that the motor can drive the crank link. Then, attach the bucket link with the fixed link using the middle hole on the bucket link. Finally, attach one end of the intermediate link with the crank link and the other end with the bucket link. The crank link, intermediate link, fixed link, and the bucket link forms a crank-rocker four bar linkage mechanism.

After assembling the subassembly, attach the 4 legs with the main platform using M6 screws. The holes on the legs are tapped. Rotate the main platform so the side with the big slot is closer to you. Insert the compound miter gear into the solid shaft and then insert it into the thrust bearing. Repeat this step with a 30T gear. Insert the shaft assembly into the middle holes on the main platform like figure 1. Mount the subassembly 2 onto the main platform using the 4 small

holes with M3 screws and spacers. Mount the third motor and subassembly 1 onto the 90T big gear. Insert the drive link into the motor shaft. The drive link should go under the extruded part of the fixed link like shown in figure 2. A hollow shaft then goes through the big gear and goes into the main platform with a thrust bearing in between the gear and the platform. A gear train with a gear ratio of 1:3 is formed so that the motor in subassembly 2 can control the angular position of the subassembly 1 relative to the hollow shaft. The wires from the motor can go through the hollow shaft and go underneath the platform to connect the PCB/breadboard at the slot.

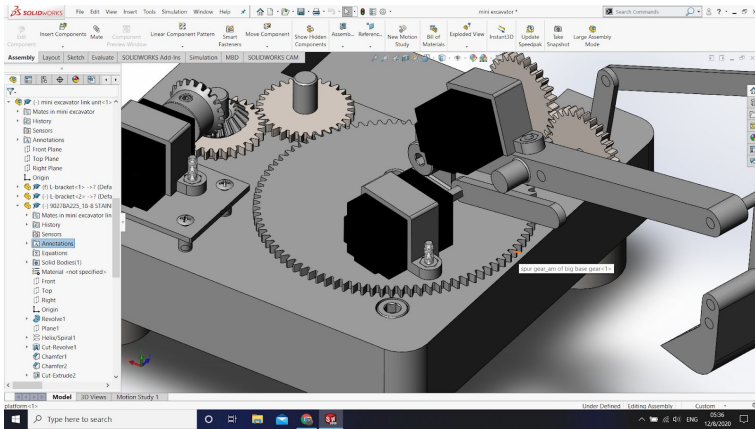


Figure 2: The drive link is attached so that it can lift the fixed link

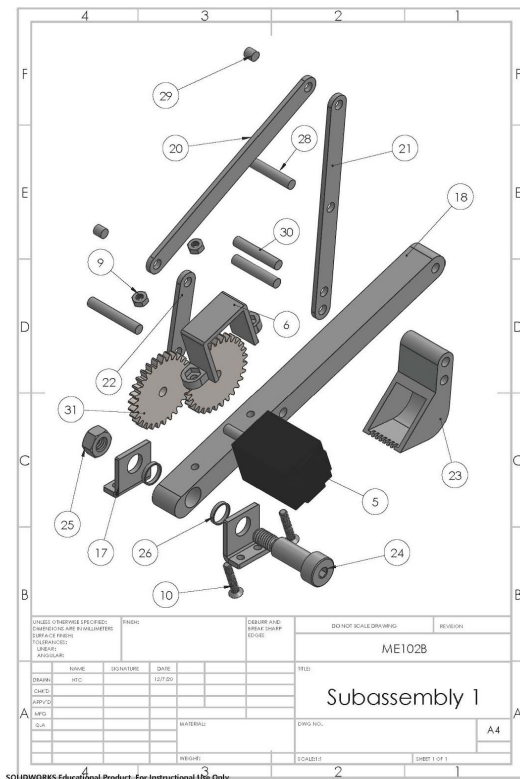
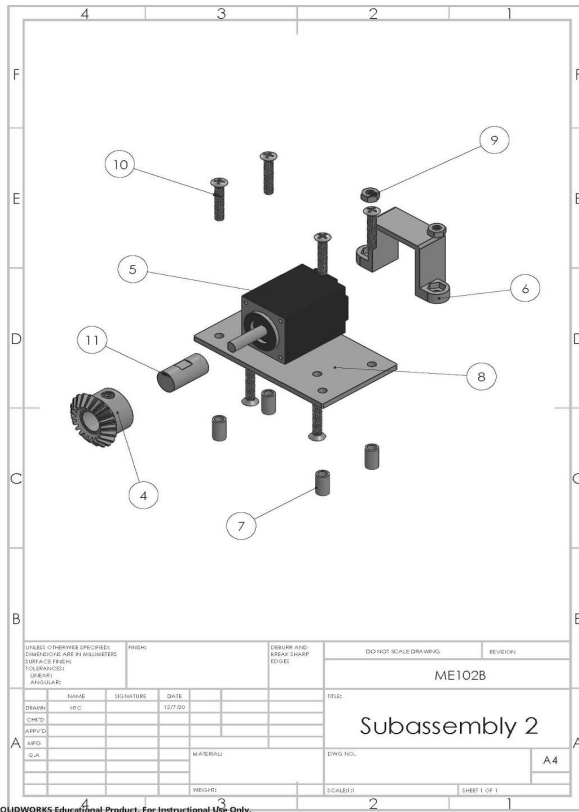
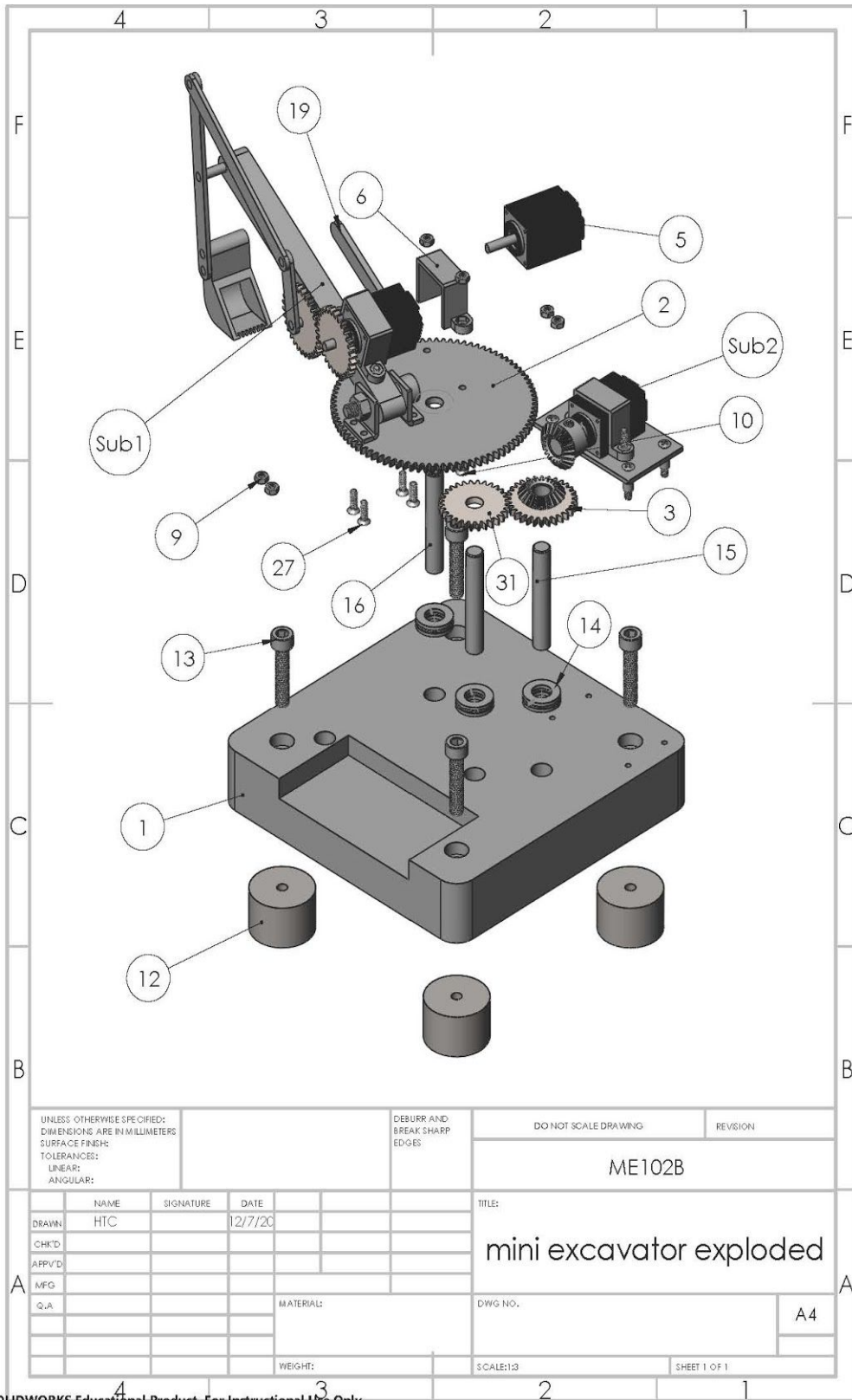


Figure 3: Exploded view of subassembly 2(left) and subassembly 1(right) label according to the BOM



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Figure 4: Exploded view of the mini excavator labeled according to the BOM