Sustainable Chair

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***Abstract*—This paper discusses the process of designing and fabricating a sustainable chair that can hold an 80kg person. The sustainable chair is comprised of 1/8" foam core board, cut out from 18" x 24" sheets, and the chair weighs less than 500g. The parts of the sustainable chair are designed to be joined together without the use of any fasteners, glue, or tape, and they fit within a set of specified dimensions. Three conceptual designs are sketched on isometric papers and the aspects of stability, strength, weight, and simplicity of assembly are evaluated during the development of our sustainable chair design. A Pugh Chart is utilized to determine the most suitable design that fulfills the functional requirements. The constructed chair is tested by having an 80kg person to sit on it and leaned on the back of the chair. The test showed that the chair is able to withstand the load applied on the chair by an 80kg person.**

I. Introduction

A sustainable chair was designed to hold a 80kg person. (see Fig. 1) The chair had to be fabricated using only foam core board, no fasteners or adhesives were allowed. It must weigh no more than 500g and had to meet a set of height and width requirements, as follows: a leg height between 0.48 m and 0.53 m, a seat width between 0.38 m and 0.42m, a seat depth between 0.38 m and 0.42m, and a back height between 0.25 m and 0.45m (from seat) . The final design (see 1) successfully held an 80kg individual and stayed within the parameters required for the assignment.

II. Concept Generation and Evaluation

Three conceptual designs were sketched on an isometric paper. (see Fig. 2 & Fig. 3) The final design of the chair was selected by using the final results of the Pugh Chart(Table I). Chair 1 was chosen as the datum.The concepts that were evaluated were based on the complexity of assembly, stability, mass, and strength. Design 3 was selected as the final design for its simplicity in assembly, high stability with minimal stress concentration, low mass, and high strength.

III. Analysis

The strength of the chair was being determined by drawing lines of forces on the sketches conceptual chair designs (see Fig. 4). This method identified the stress concentration along the body of the chair. A stress concentration was present at the center of the hour-glass shaped leg due to a sharp edge. The addition of a fillet at that point reduced the magnitude of the stress concentration.

A finite element analysis (FEA) was carried out on the chosen design (see Fig. 5) by using Autodesk Inventor 2019 to find out the stress concentration.The finite element analysis showed many areas of stress concentration and also areas where excess material could be removed to make the chair more lightweight. After multiple alterations to the design, the chair that showed the least stress concentration was laser cut.

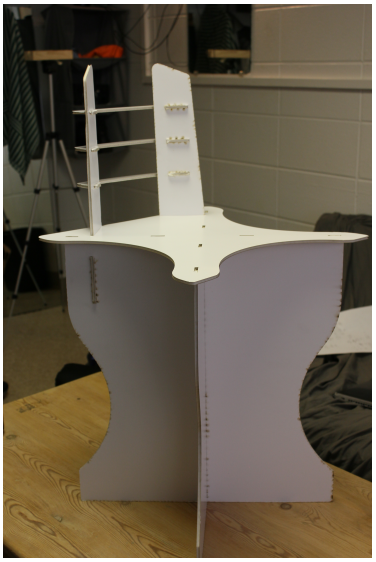

Fig. 1. Final Chair Design.

TABLE I
Pugh Chart

Parameter	Weight	Chair 1 (Datum)	Chair 2	Chair 3
Simplicity of Assembly	4	0	-	+
Stability	3	0	0	0
Mass	2	0	-	+
Strength	3	0	+	-
Net Score	0	0	-3	3
Rank	0	2	3	1

IV. Experimental Results

The chair consisted of eight parts. This feature contributed to a quick and simple assembly of the chair.

The final weight of the chair was 381g. The chair was then being tested by having myself, with a mass of 68-kg, to sit on the chair. No bending or deformation was being observed, it succeeded. Professor Spenko sat on the chair who demonstrated as the 80-kg man. The chair displayed an

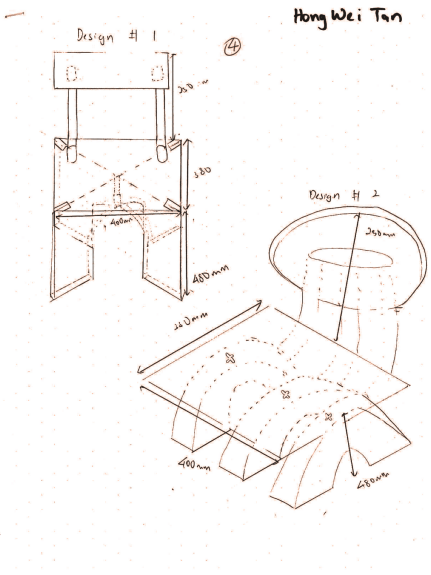

Fig. 2. First and Second Chair Design.

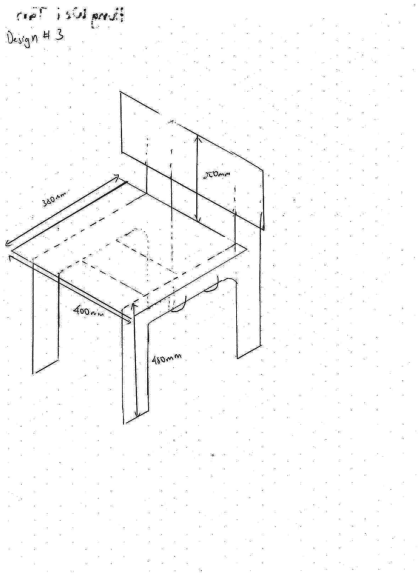

Fig. 3. Third Chair Design.

insignificant impact of deformation. Therefore, it passed the test.

V. Discussion

The light-weighting strategy in this chair designs to have as least amount of parts as the chair could. In addition, practicing strengthening concepts such as creating tension force on the joint was stronger than a joint that was compressed. For example, the back ribs at the back seat had minimal weight and a tension force is present at the joint between the rib with the back arm. Moreover, the seat was curved inwards which eliminated the excessive surface of the seating region. There

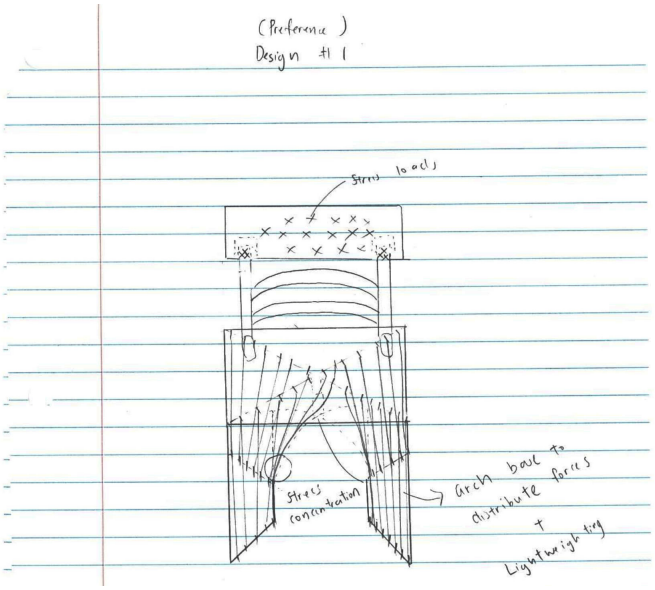

Fig. 4. Lines of Force for Final Chair Design

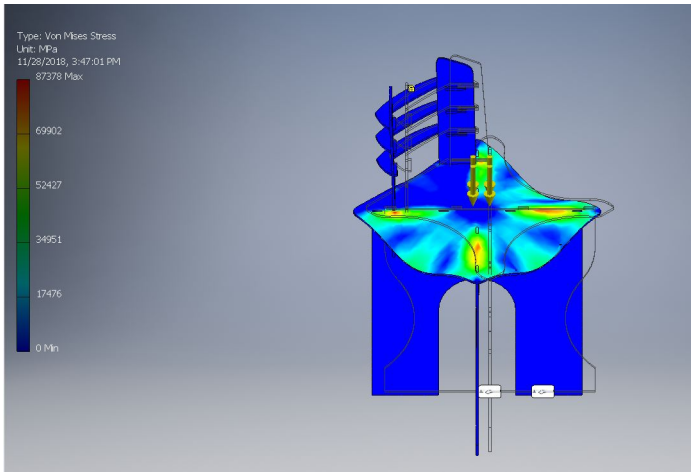

Fig. 5. Von Mises FEA stress analysis of chair 1.

were no additional supports or joints attached to the body of the chair, which preserved the light weight of the chair.

VI. Conclusion

This sustainable chair design fulfilled all the functional requirements and the final weight was lesser than the minimum weight by 19g, total weight of 381g. The actual deformation from the load applied by Professor Mathew Spenko is similar to the theoretical deformation from the load applied in the finite element analysis.

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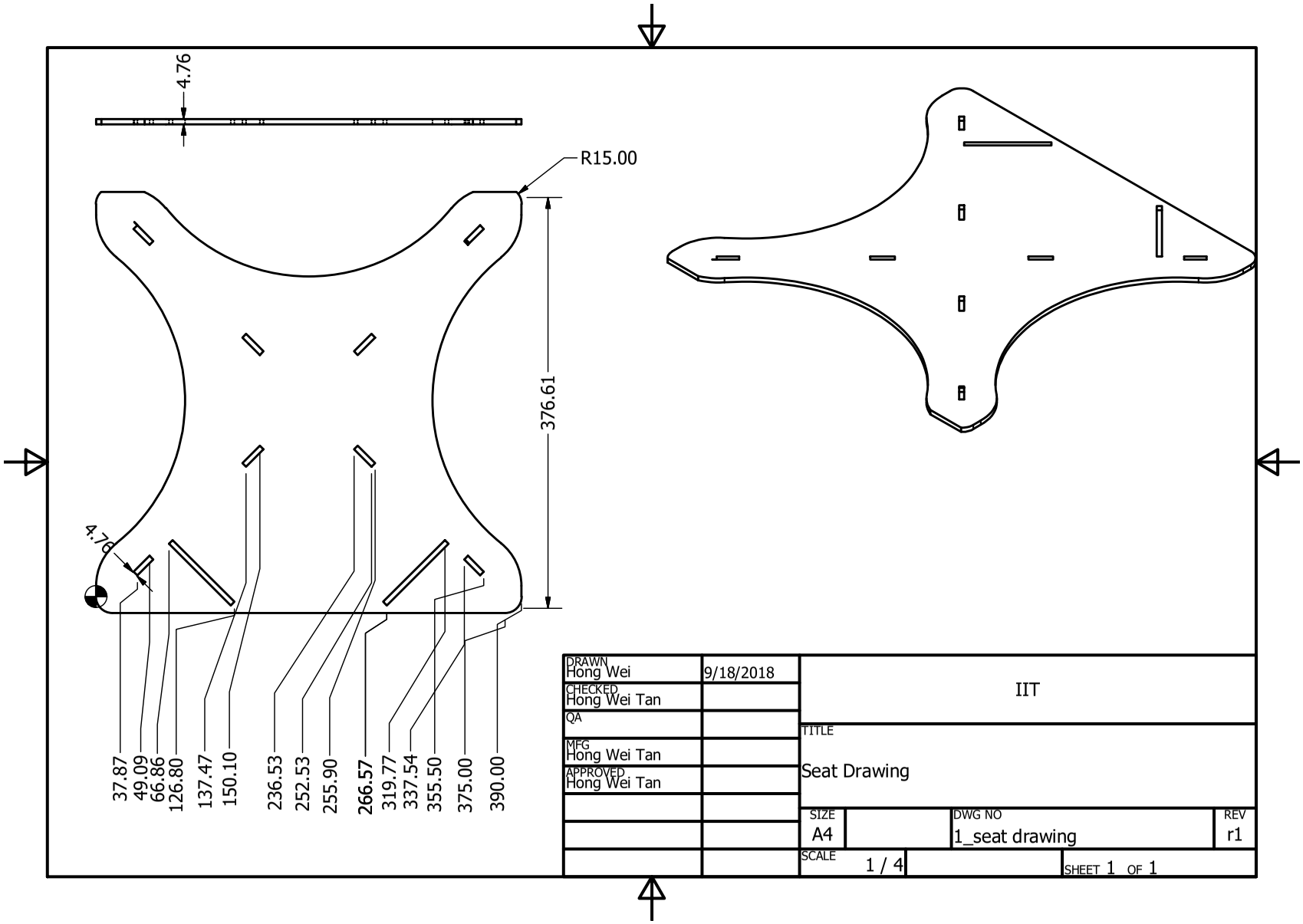
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CHECKED Hong Wei Tan
QA
MFG Hong Wei Tan
APPROVED Hong Wei Tan
IIT
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Seat Drawing
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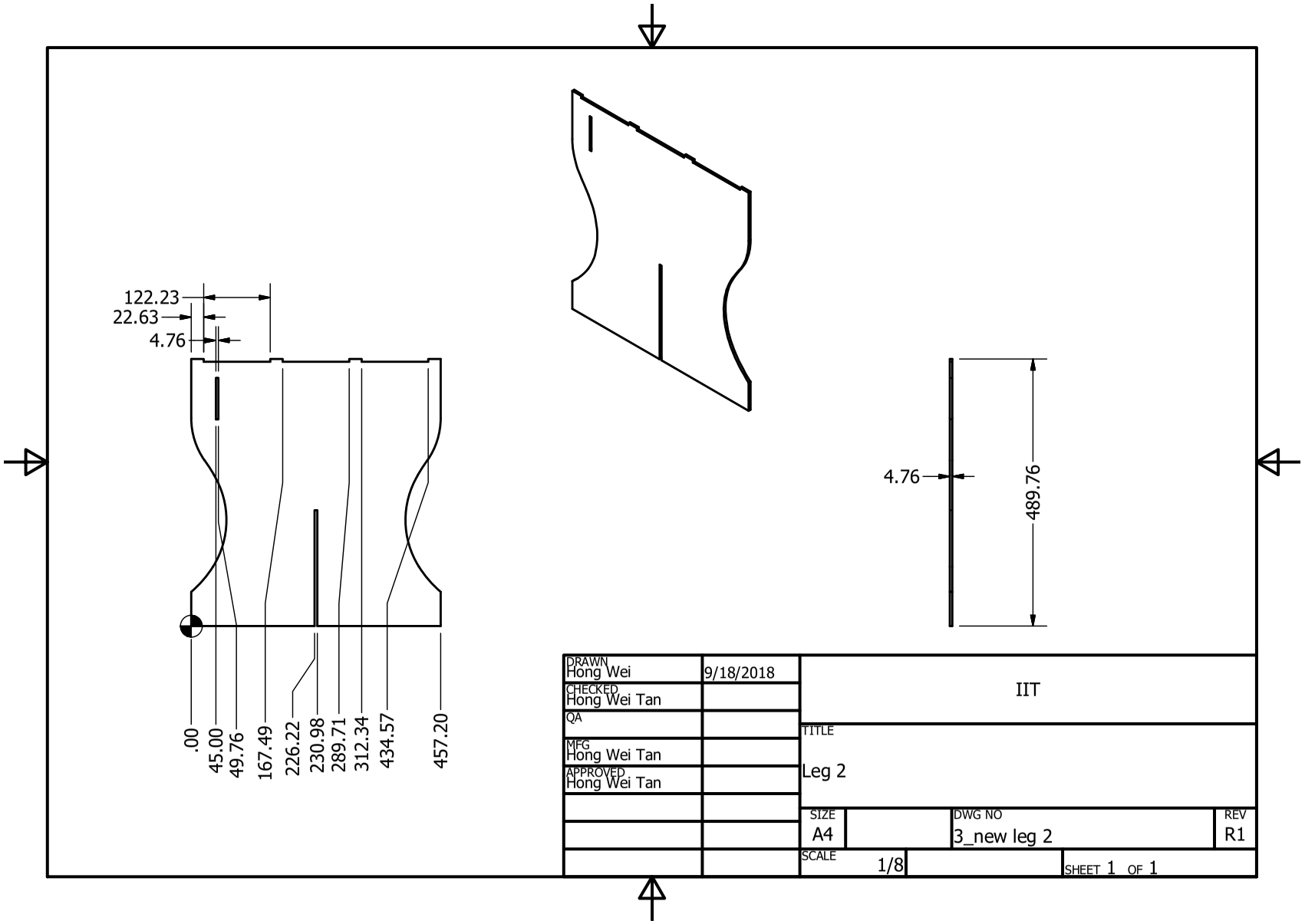
DWG NO 1_seat drawing
REV r1
SCALE 1 / 4
SHEET 1 OF 1



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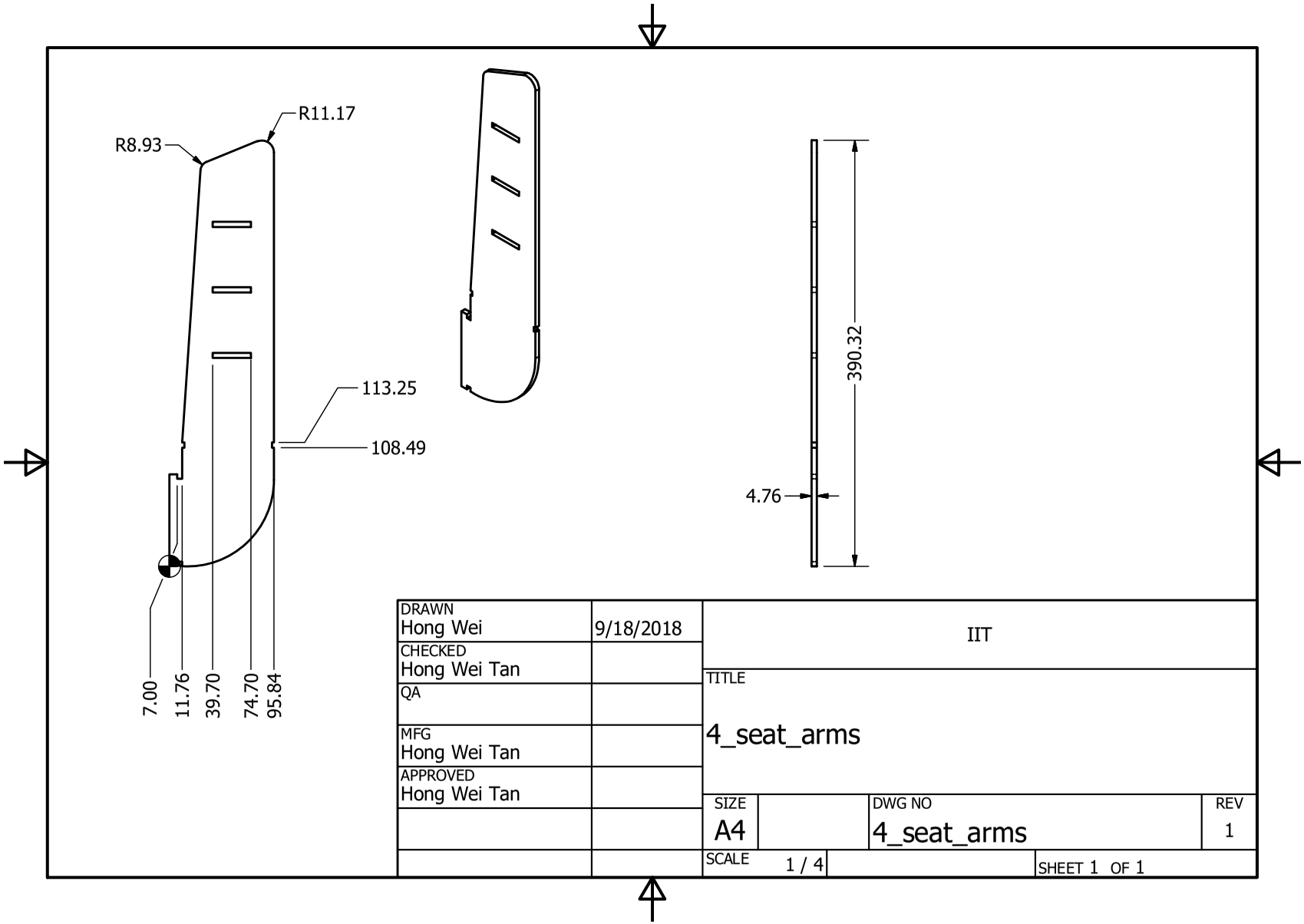

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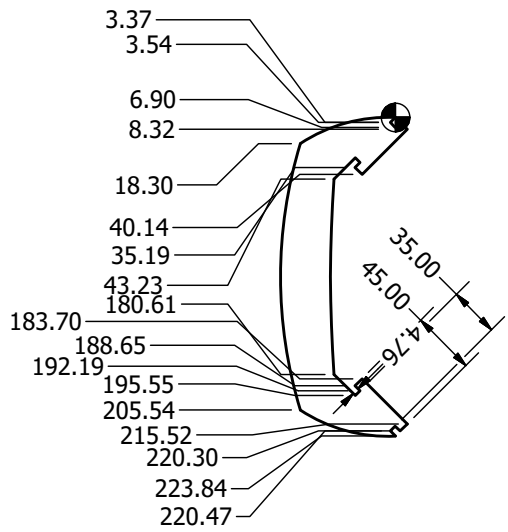

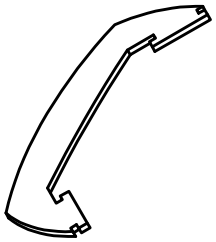

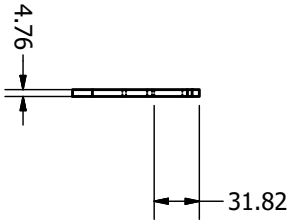

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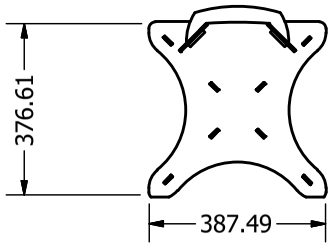
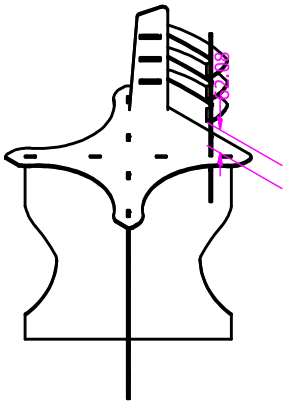
			APPROVED	MFG	QA	CHECKED	9/18/2018

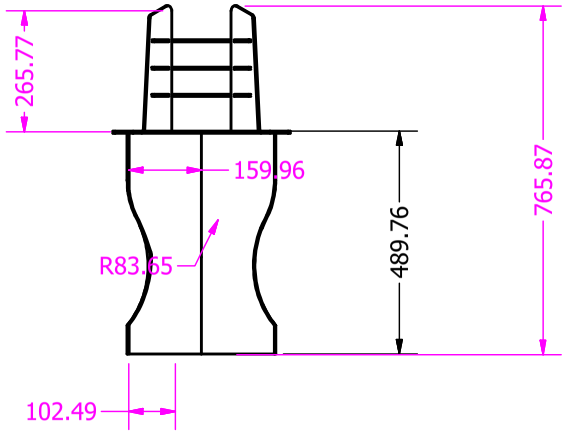
SCALE 1 / 4 | SIZE A4 | DWG NO 5_backskeleton | REV

TITLE: Back ribs

SHEET 1 OF 1







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CHECKED				
QA		TITLE		
MFG		Assembly		
APPROVED		SIZE A4	DWG NO 6a_assembly_1	REV
		SCALE 0.08 : 1		SHEET 1 OF 1

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
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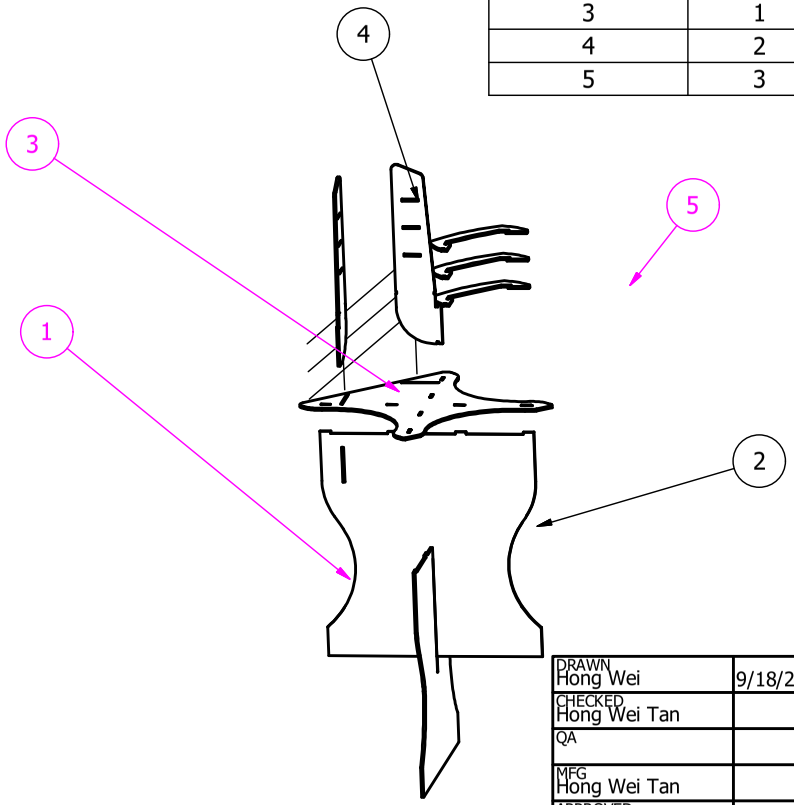
2	1	Leg 2	
3	1	Seat	
4	2	Back Support	
5	3	Back Ribs	



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QA		TITLE: Exploded View
MFG Hong Wei Tan		
APPROVED Hong Wei Tan		

SIZE		DWG NO	REV
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SCALE 1/12		SHEET 1 OF 1	