(|EDPT501|) Engineering design I

Scissors Lift Project

Mechatronics, T-31

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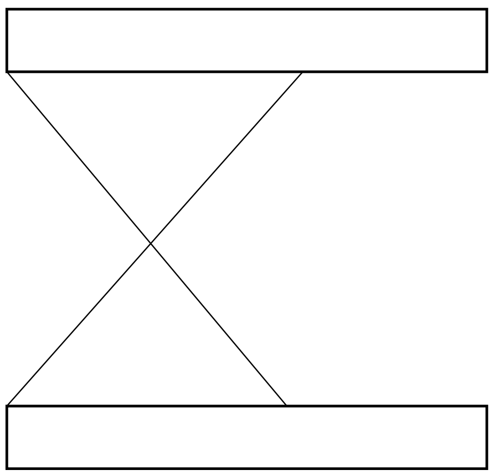
Introduction

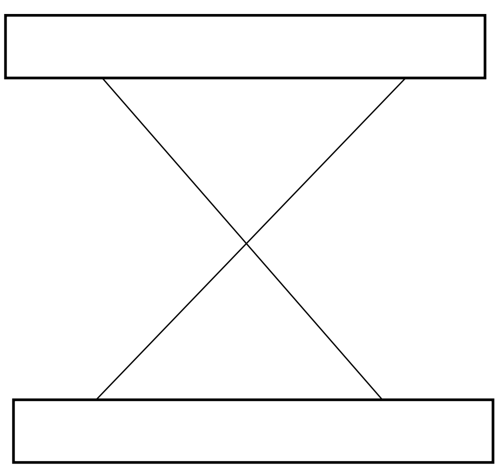
The widespread design of scissor lifts is based upon one fixed side and one that is free to move (using rollers). We found that this design's loading results in inequal stress distribution at the 4 wheels when fully extended at the highest elevation (most critical point).



Inequal distribution

And so, the ratio of the 2 wheels where the load would roll towards to the 2 wheels at the back would not be exact and thus might cause inaccurate analysis. To avoid this inaccuracy, we designed with a different approach yet achieved the same mechanism. Except that now we could divide the load equally on each of the 4 wheels.

To achieve the same scissors like motion with both sides moving, we divided the threads of the screw at the middle and reversed their directions. So, the members move opposing each other making the most critical point at the middle of the table and not at one of the corners.

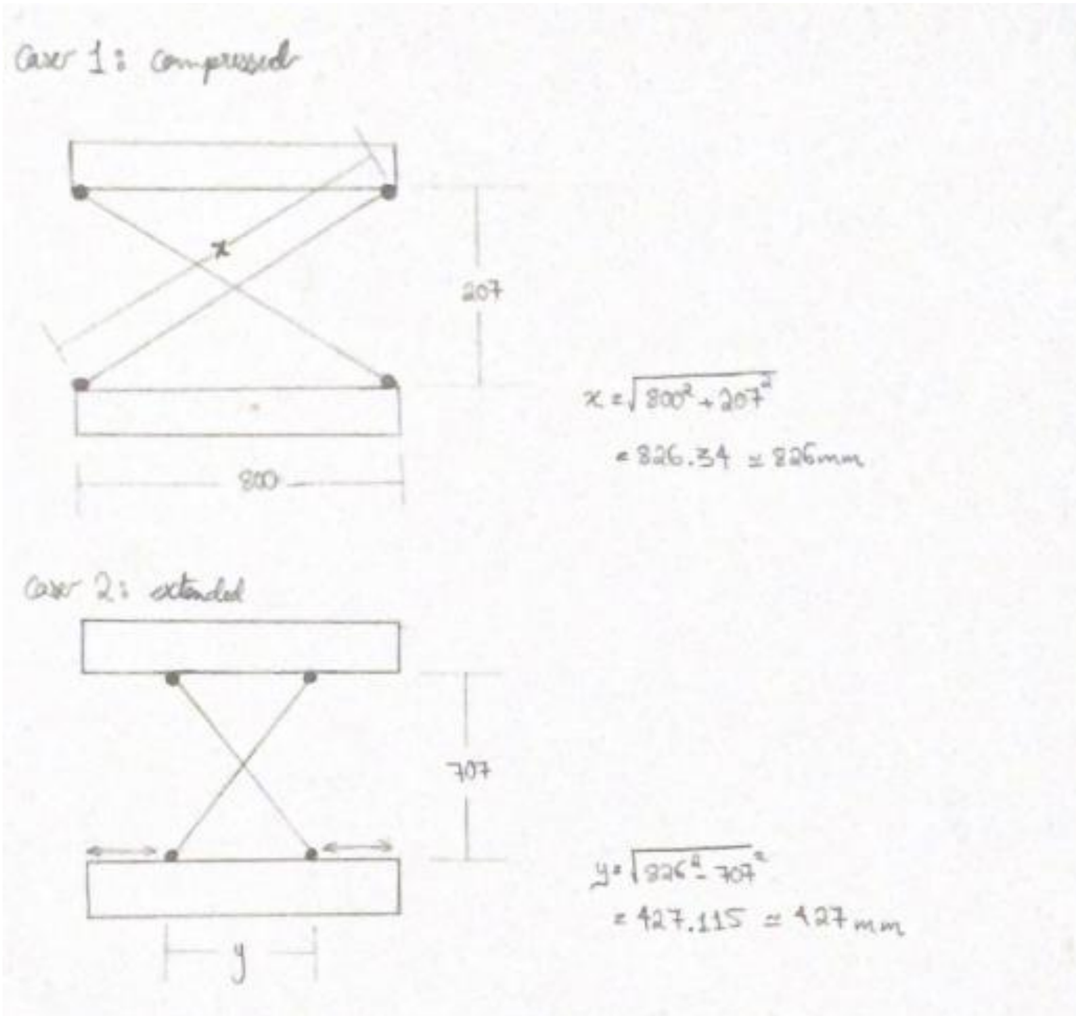


equal distribution

We then added slots at the bottom to limit the rollers and so the whole assembly is connected together as one part. These slots were designed to have exactly the length the members need to move to fit both the most compressed and the most extended cases. Using ST50 having a yielding stress of 500MPa and a factor of safety of 1.3 the following calculations were carried to design the dimensions.

Analysis and Calculations

I. Take 1 – The first dimensions were derived ignoring the welding in the members.

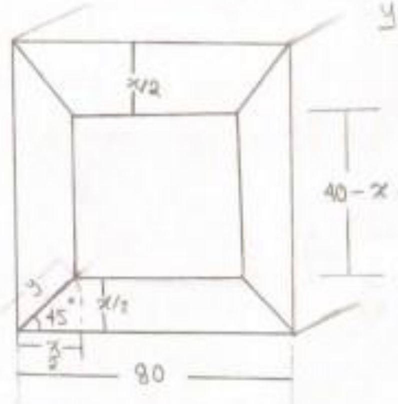


Both the table and the base have a thickness of 80mm and the wheels height is 133mm. To achieve a maximum height of a 1000mm and a minimum height of 500mm, the maximum and minimum distance between the table and the base need to be 707mm and 207mm respectively.

Y – the area where to motion takes place – is found to be 427mm, which means that each member is free to roll in the slots about a distance 186mm.

$F_{total} = 500\,Kg$

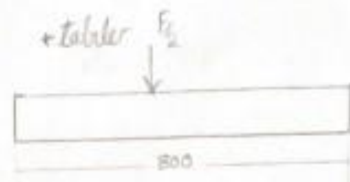
* cross-sectional area (base)



$y = x\frac{\sqrt{2}}{2}$, $\frac{x}{2} = 2.5mm$ $x = 5mm$

$\therefore y = \frac{5}{2}\sqrt{2}\,mm$

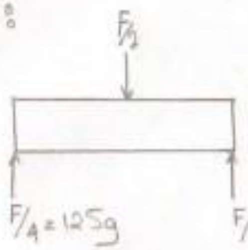
* table

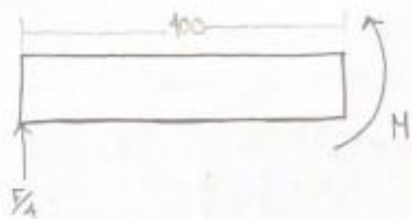


* bending

$$\sigma = \frac{Mc}{I} = \frac{M(40)}{\frac{1}{12}\left(80^4 - (80-5)^4\right)}$$

for M:





$-125g(400) + M = 0$

$M = 125g(400)$

$= 490500\,Nmm$

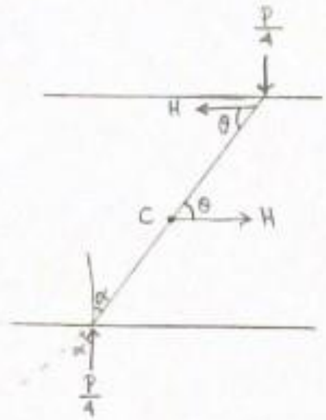
$$\frac{490500(40)}{\frac{1}{12}(80^4 - 75^4)} = 25.26\,MPa$$

$25.26 < 384.6$

accepted

Picking the cross section with b=40 and h=80 and a thickness of 2.5 yields stresses more than 1.3 times less meaning the dimensions are accepted.

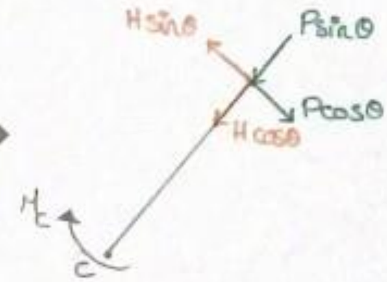
ⓐ extended (most critical)



$\sin\theta = \frac{707}{826}$

$\underline{\theta = 58.86^\circ}$

$\alpha = 90 - \theta$



$M_c = H\sin\theta\,(413) - P\cos\theta\,(413)$

* $S_y = 500\,MPa$

$n = \frac{500}{1.3}$

$= 384.6$

$$384.6 = \frac{M_c C}{I} = \frac{(H\sin\theta(413) - P\cos\theta(413))(15)}{\frac{1}{12}\left(30(50)^3 - 22(42)^3\right)}$$

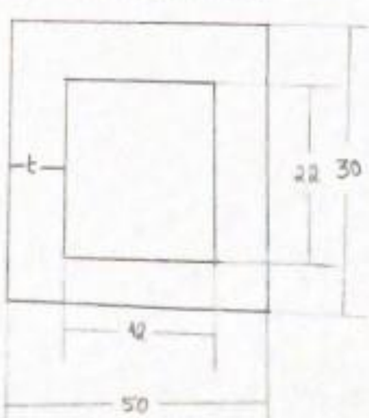
$$384.6 = \frac{\left(413H\sin(58.86) - 413(125(9.81))\cdot\frac{427}{826}\right)(15)}{\frac{1}{12}\left(30(50)^3 - 22(42)^3\right)}$$

$H = 22.6\,kN$

$F = 2H$

$= 45.2\,kN$

Cross sectional Area (members)



* average human Torque = 4 Nm

= 4000 Nmm

let: $p = 4$

$f = f_c = 0.12$

$d_c = 60\,mm$

→ for a single threaded screw : $l = 4$

$$T_{total} = \frac{F d_m}{2}\left(\frac{1 + \pi f d_m}{\pi d_m - f l}\right) + \frac{F f_c d_c}{2}$$

$$T_R + T_c$$

$$4000 = \frac{45200 d_m}{2}\left(\frac{1 + \pi (0.12) d_m}{\pi d_m - 0.12(4)}\right) + \frac{45200 (0.12)(60)}{2}$$

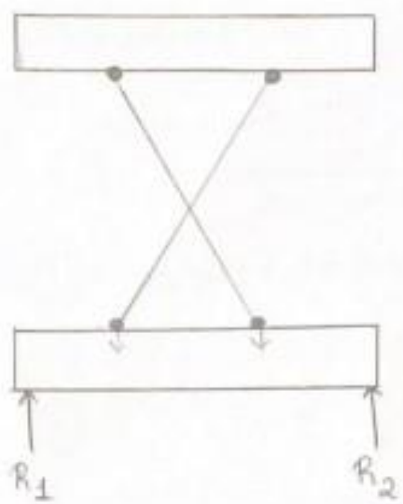
$d_m = 61.2\,mm$

$\approx 62\,mm \approx M64$

We used the average human torque normally applied and designed a single threaded screw with the mentioned properties and calculated the needed power screw diameter. We then picked the nearest available standard diameter.

II. Take 2 – The welding as well as the bearing were then put into consideration. Using the derived dimensions, we checked to make sure the maximum stresses are yet allowed for the welding. And the bearing calculations were carried on normally.

* welding



$\tau_y = \frac{S_y}{2} = 250\,MPa$

$R_1 = R_2 = 1226.25\,N$

$\tau_y = \frac{P}{A} = \frac{R_1}{A}$

$= \frac{1226.25}{163}$

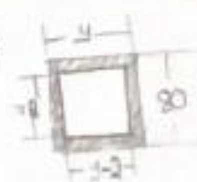
$= 7.52\,MPa$

$7.52 < 250$

$\longrightarrow$ accepted

for A (the area welded) @ a thickness of 1mm

$y = \frac{5}{2}\sqrt{2}$



$A = A_o - A_i = 80y - \left(78\left(\frac{5}{2}\sqrt{2} - 2\right)\right)$

$= 163\,mm$

• bearing force = H

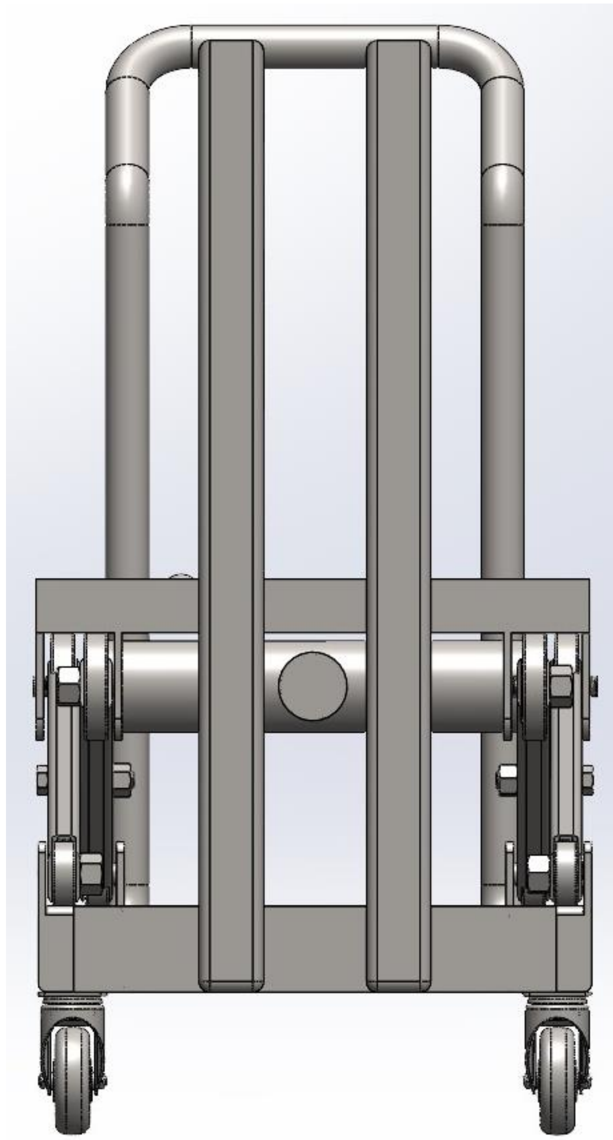
$$384.6 = \frac{H}{4d}$$

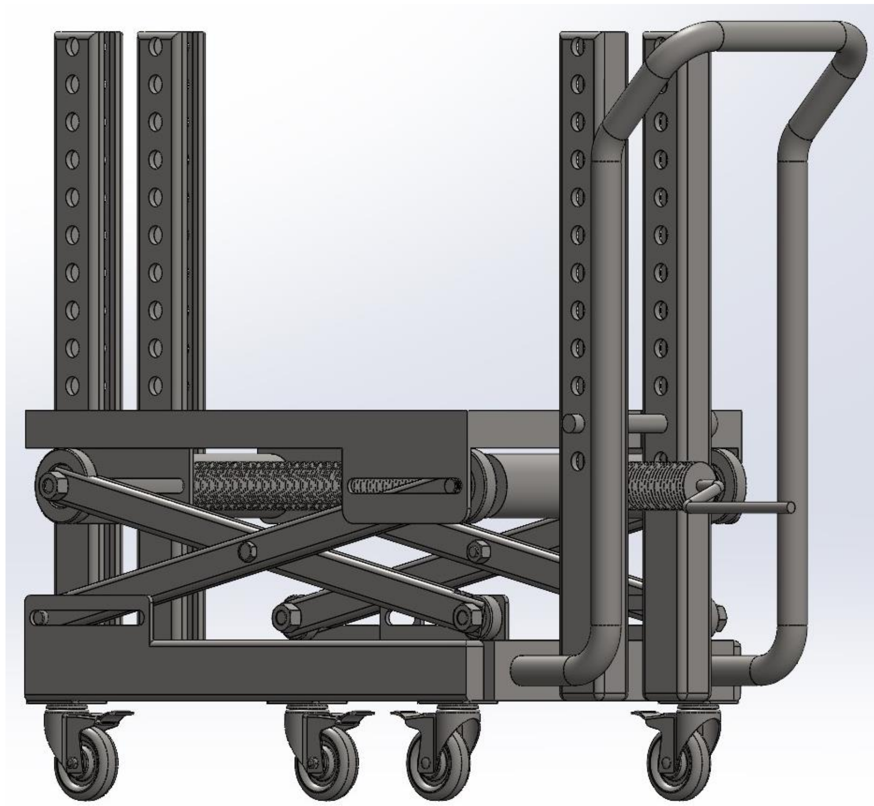
$$d = 14.7$$

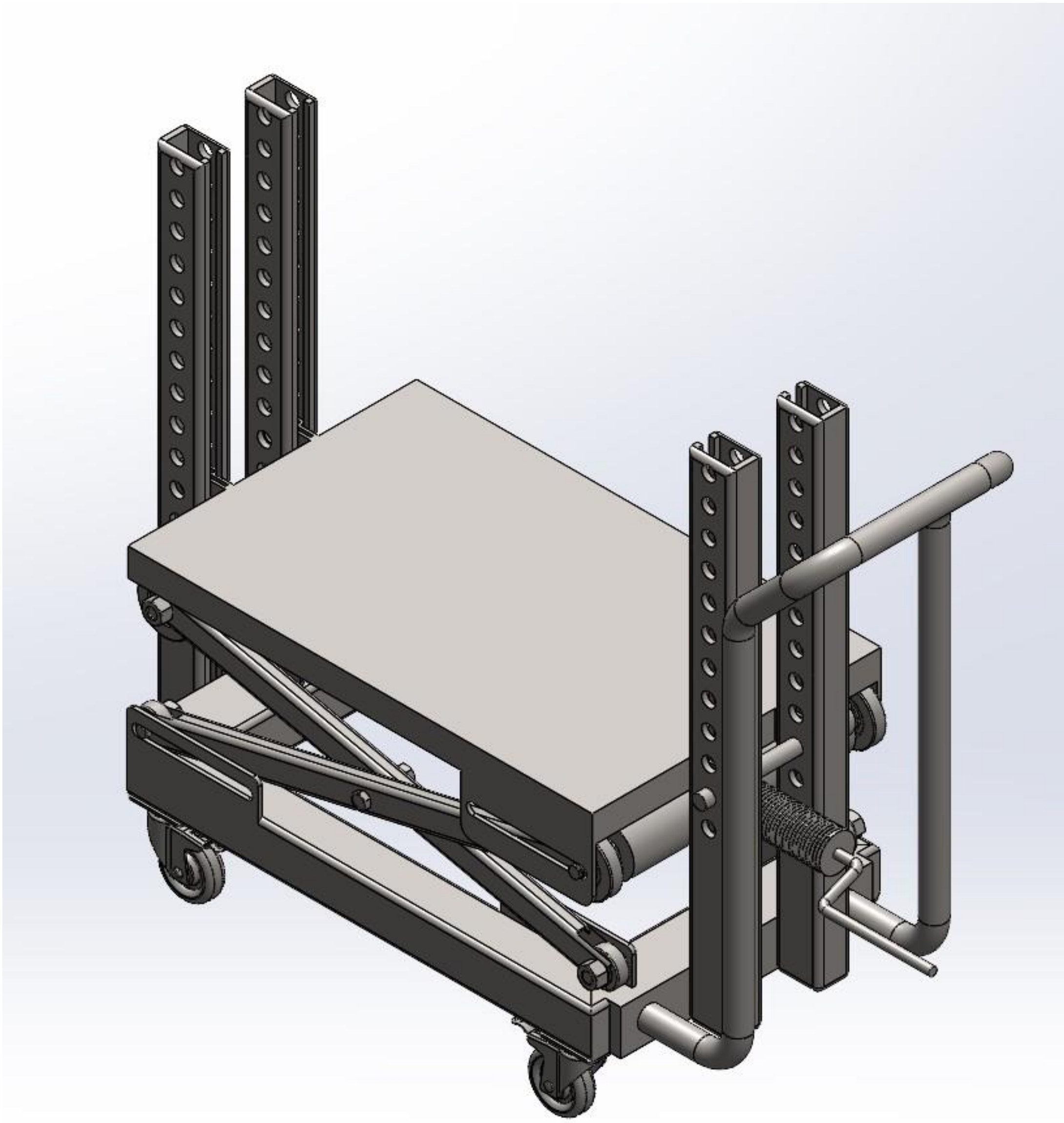
$$\approx 15 \qquad \therefore M16$$

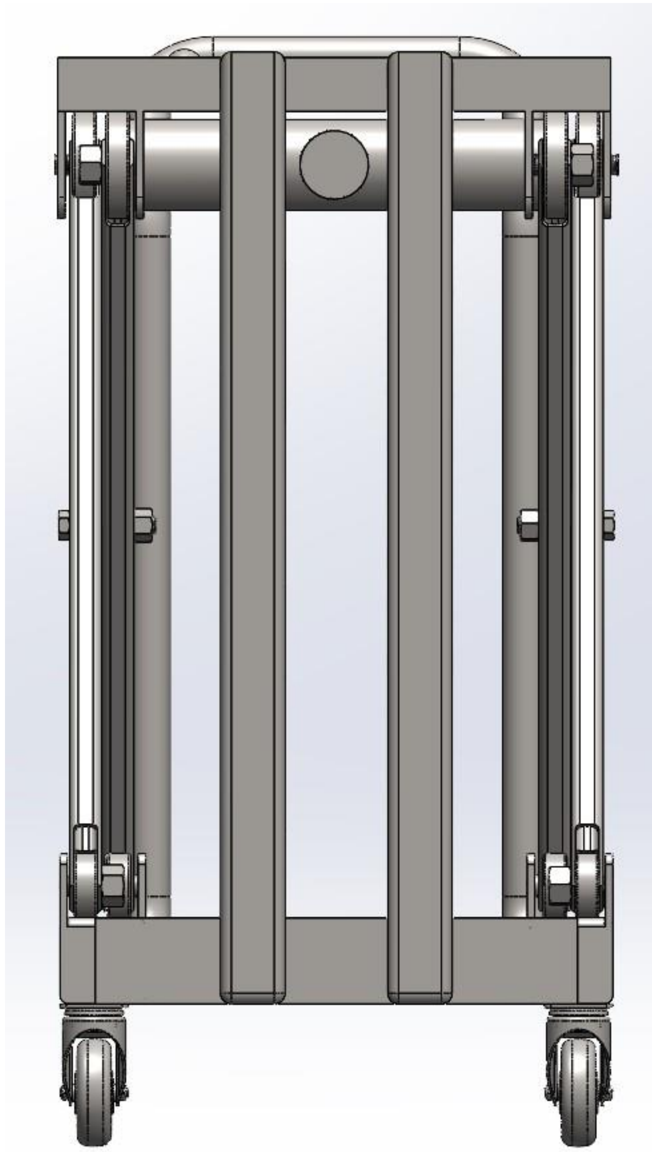
Rounding up to the nearest larger standard showed that we needed an M16 as a minimum diameter but as the moment resulted in more critical dimensions the larger M64 was picked for safety.

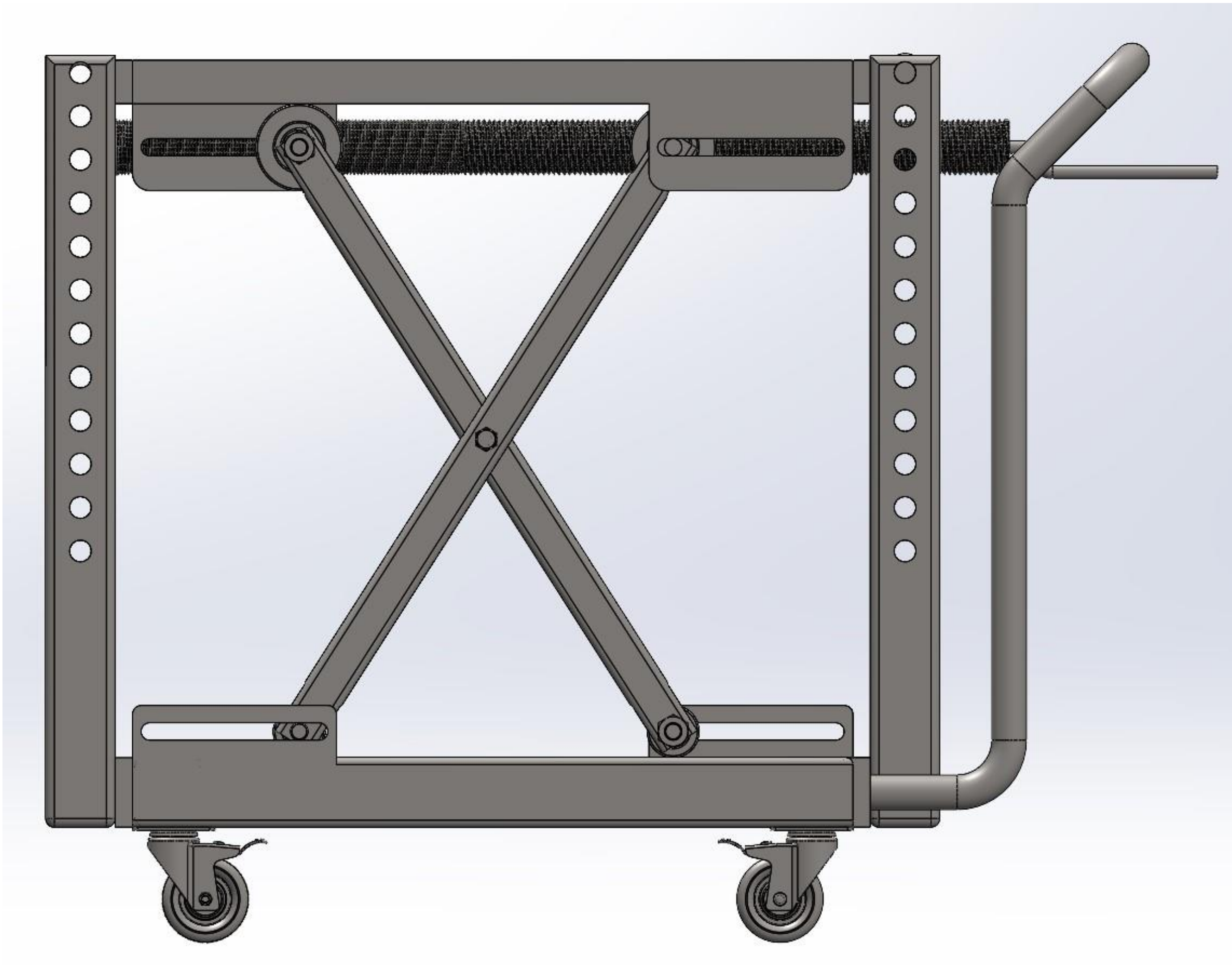
III. Conclusion: The dimensions were picked to be the larger ones so that they safely withstand all applied stresses.

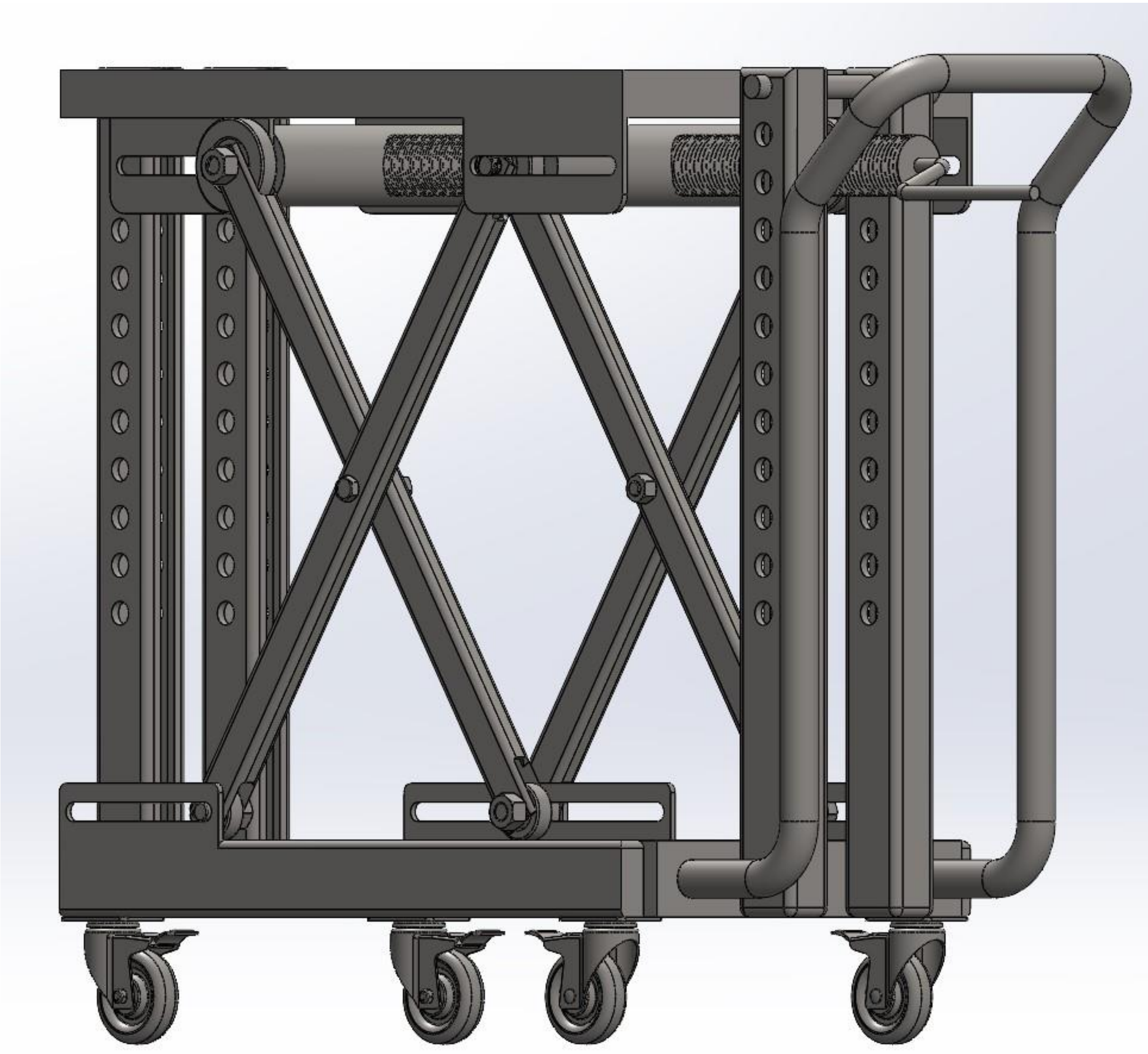


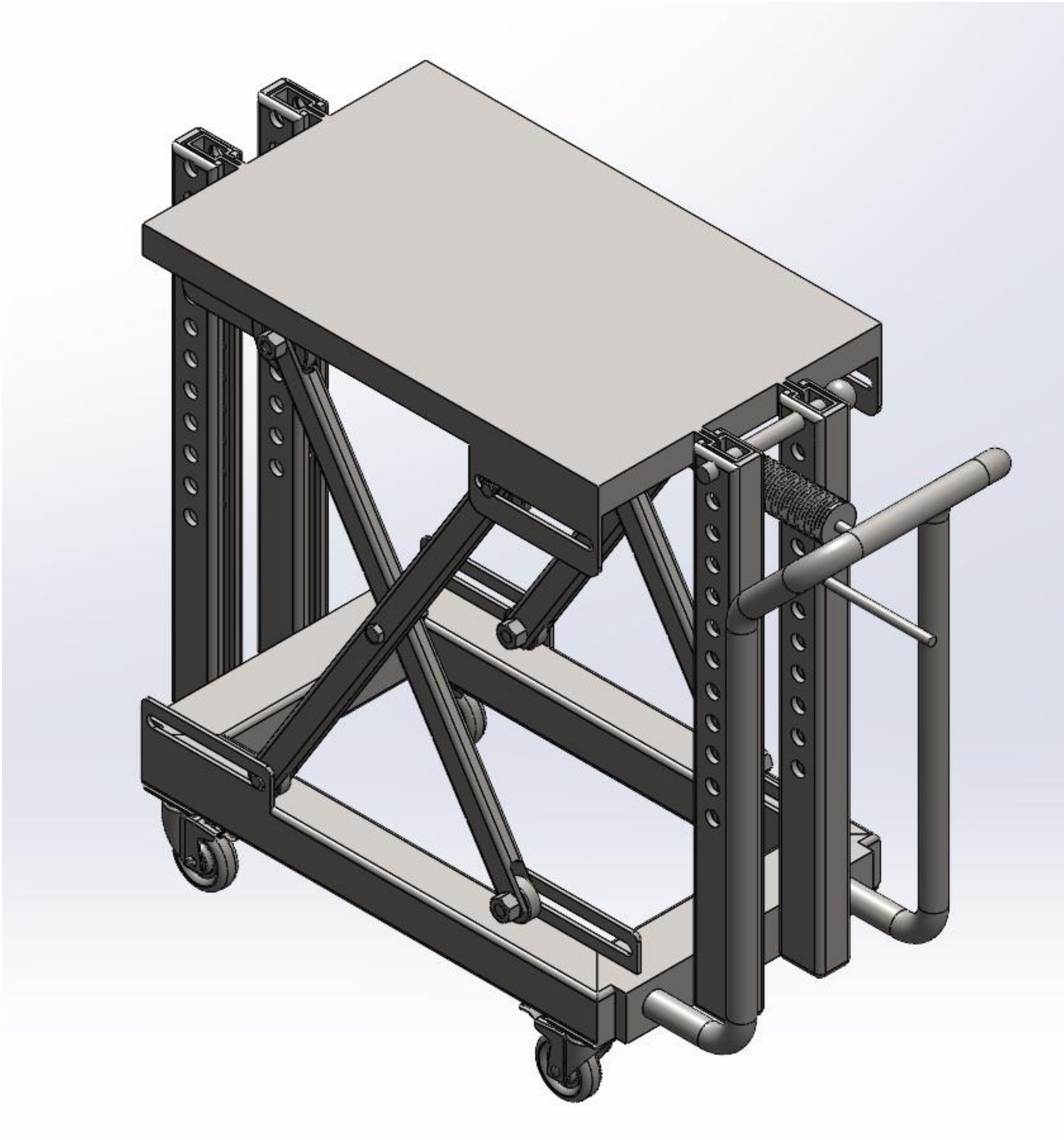


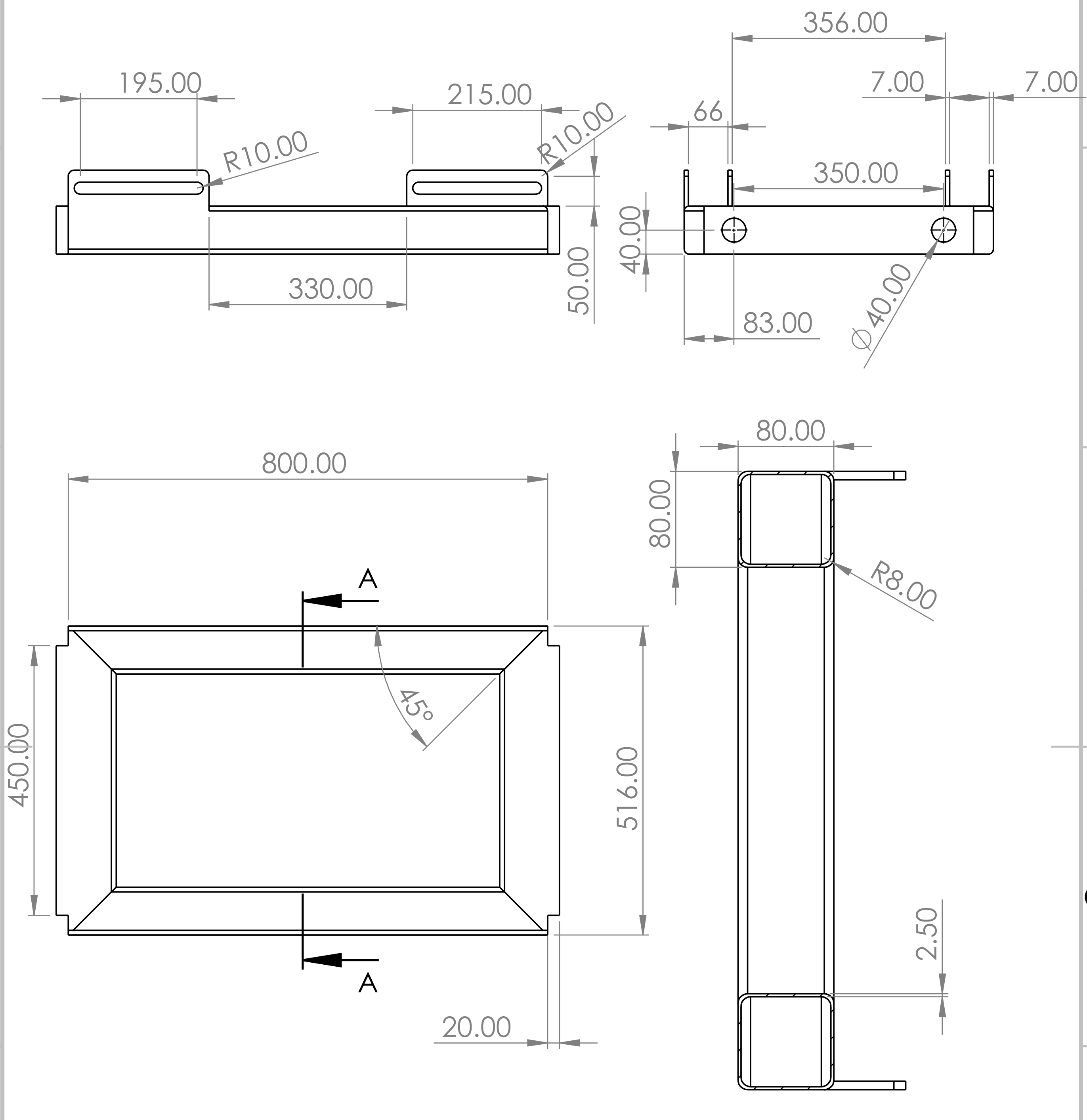












SECTION A-A
SCALE 1 : 5

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:	FINISH:	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING / REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

MATERIAL:

DWG NO.

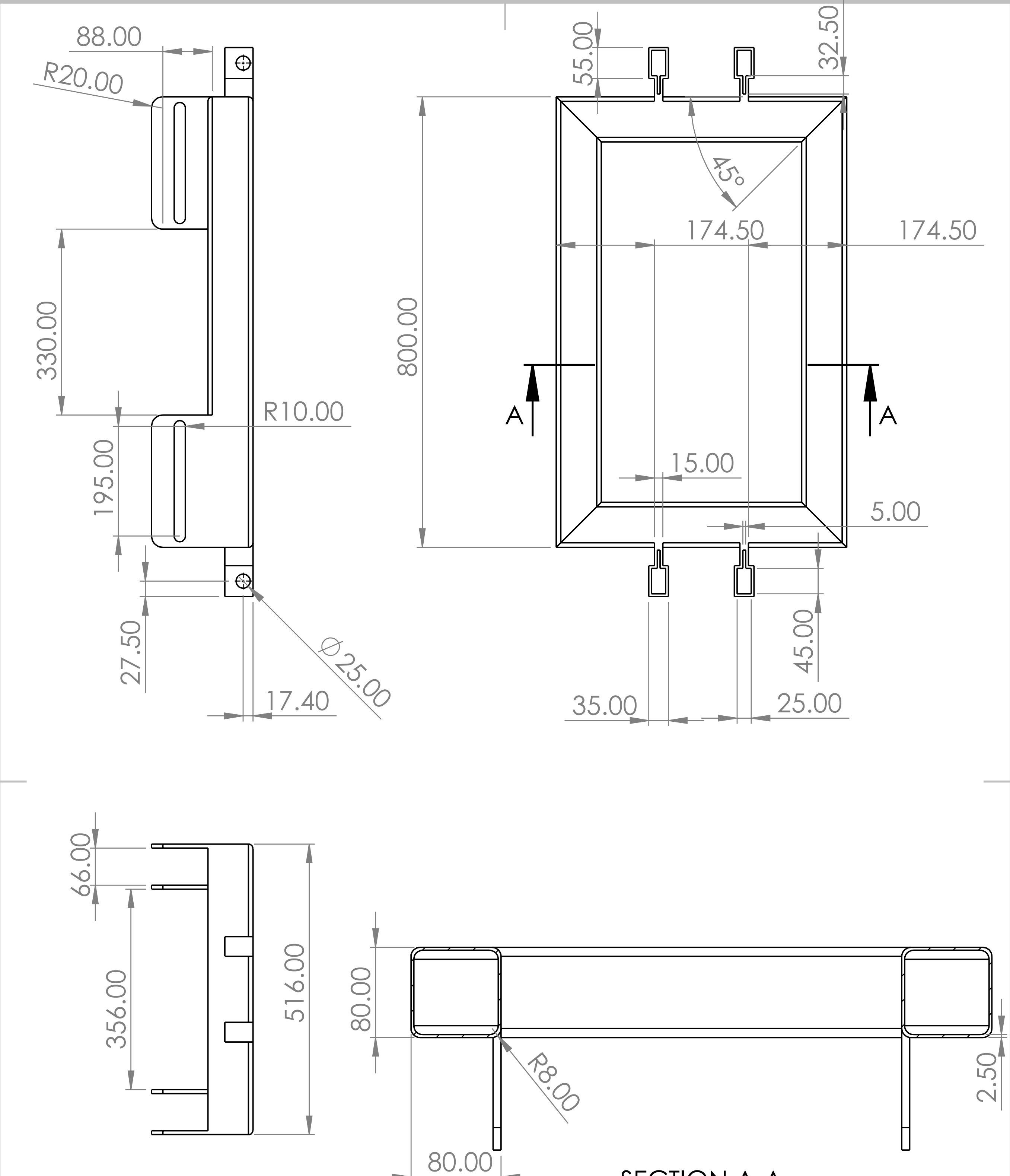
Base

A4

WEIGHT:

SCALE:1:20

SHEET 1 OF 1



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SCALE 1 : 5

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MATERIAL:

DWG NO.

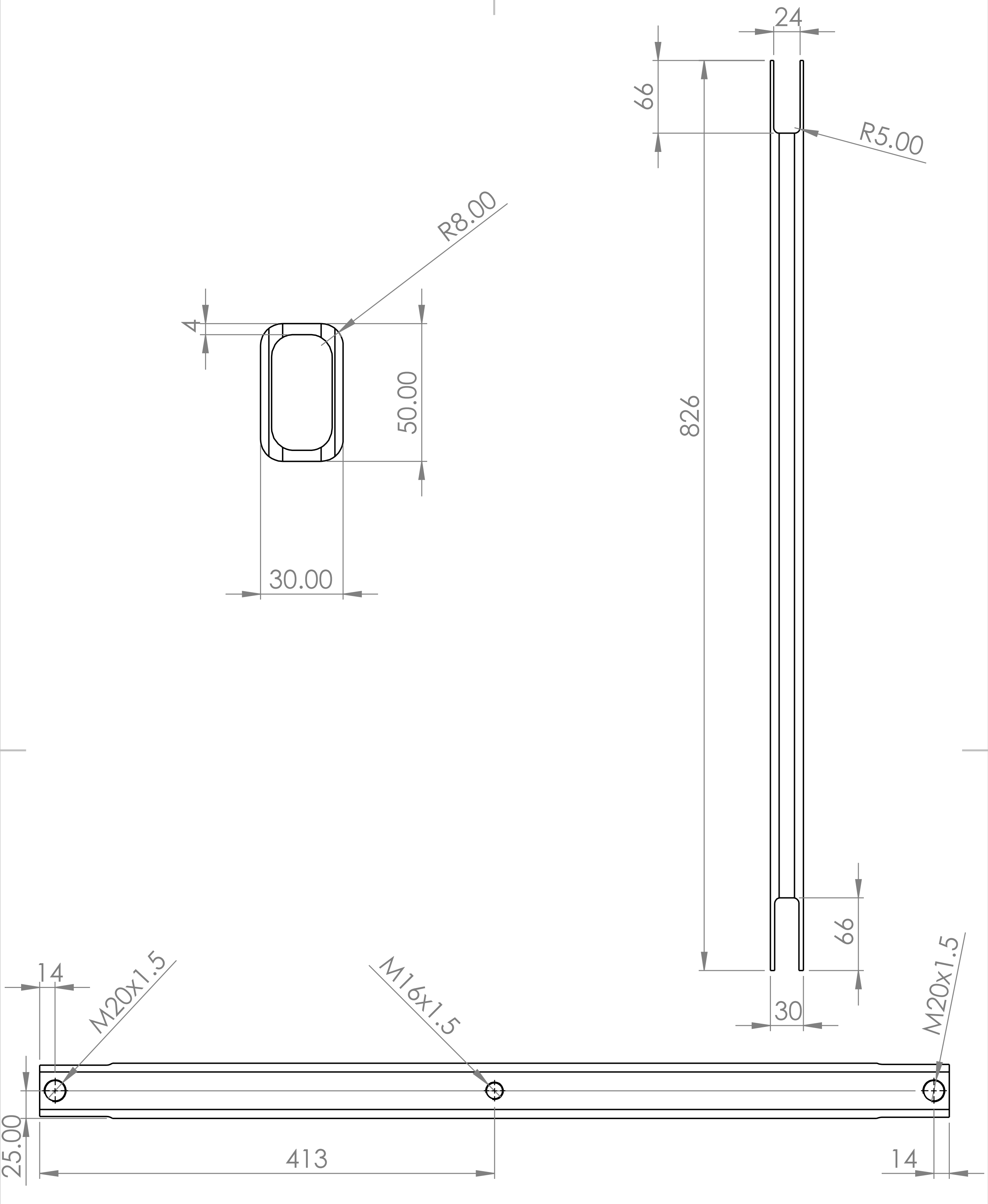
Top

A4

WEIGHT:

SCALE:1:10

SHEET 1 OF 1



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DEBURR AND BREAK SHARP EDGES

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REVISION

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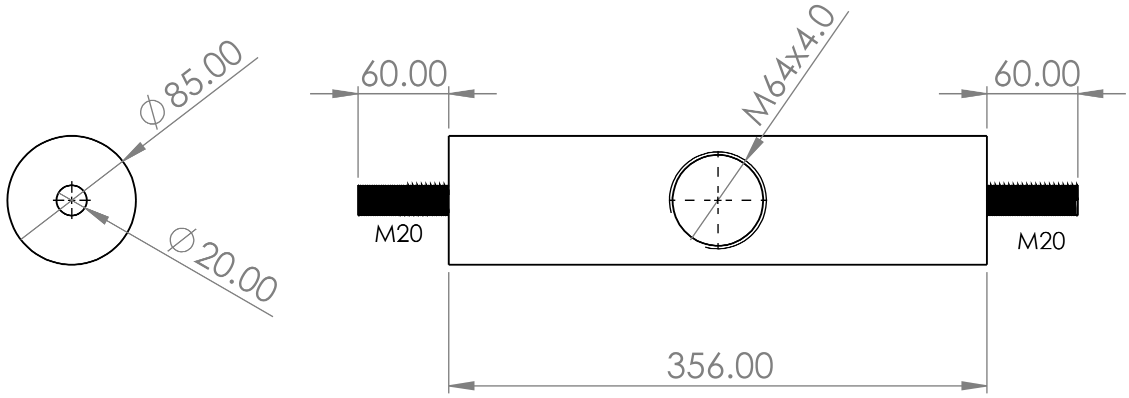
Members

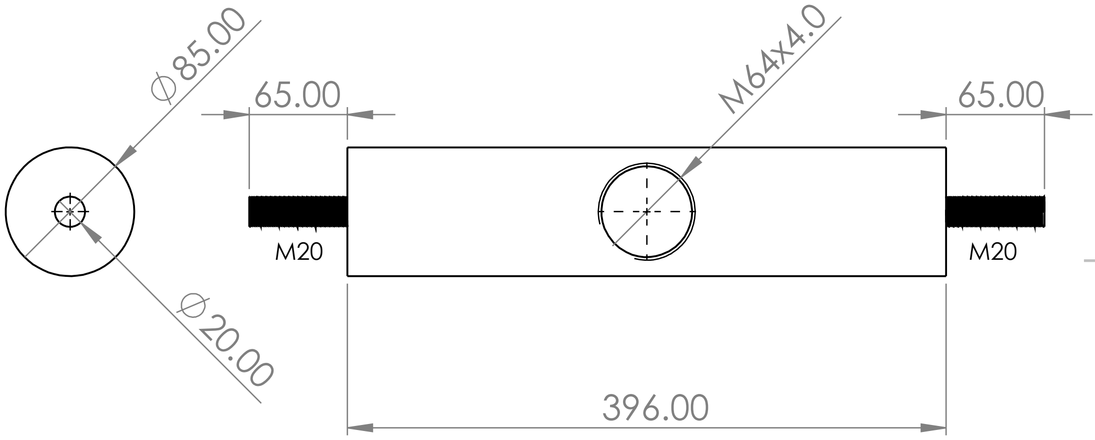
A4

WEIGHT:

SCALE:1:10

SHEET 1 OF 1





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DEBURR AND BREAK SHARP EDGES

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TITLE:

MATERIAL:

DWG NO.

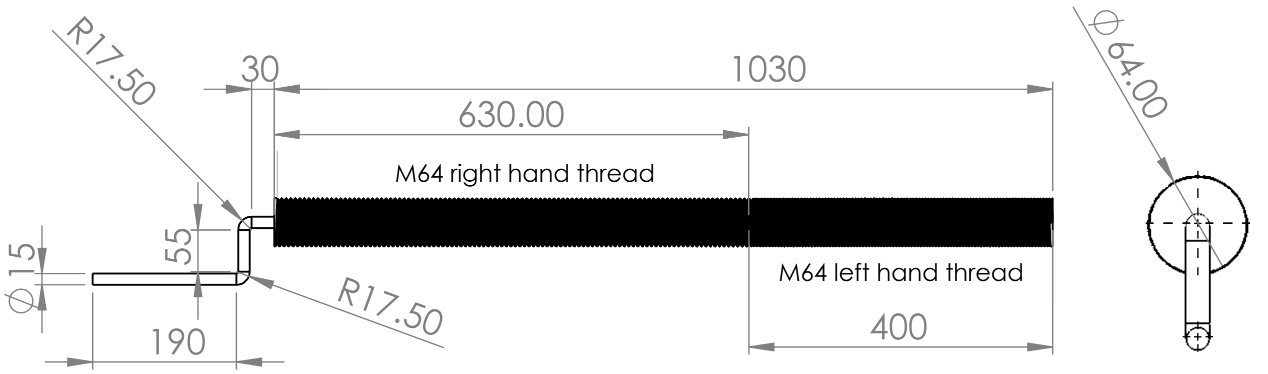
Member Links

A4

WEIGHT:

SCALE:1:5

SHEET 1 OF 1



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DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

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TITLE:

MATERIAL:

DWG NO.

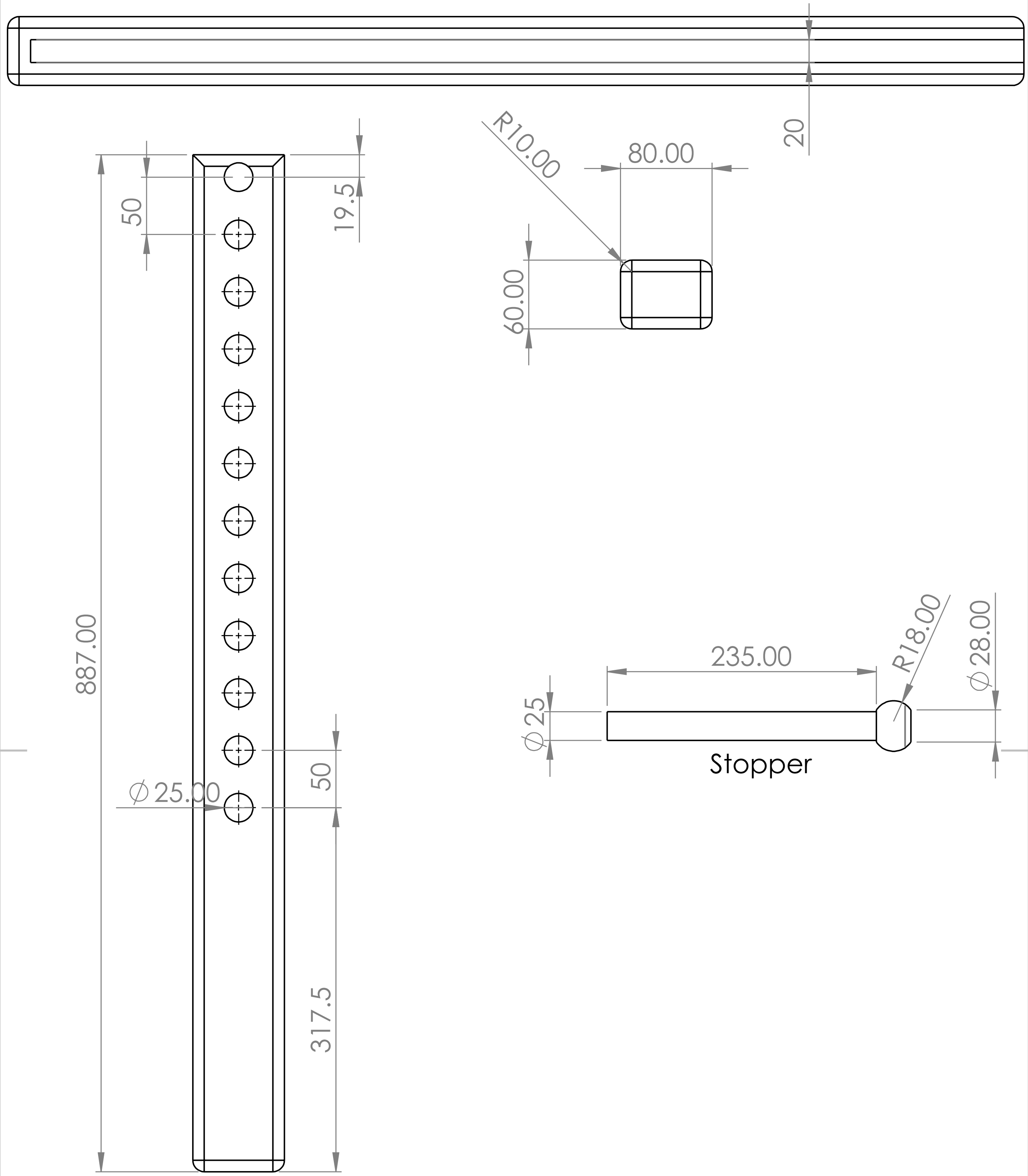
Power Screw

A4

WEIGHT:

SCALE:1:20

SHEET 1 OF 1



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TITLE:

MATERIAL:

WEIGHT:

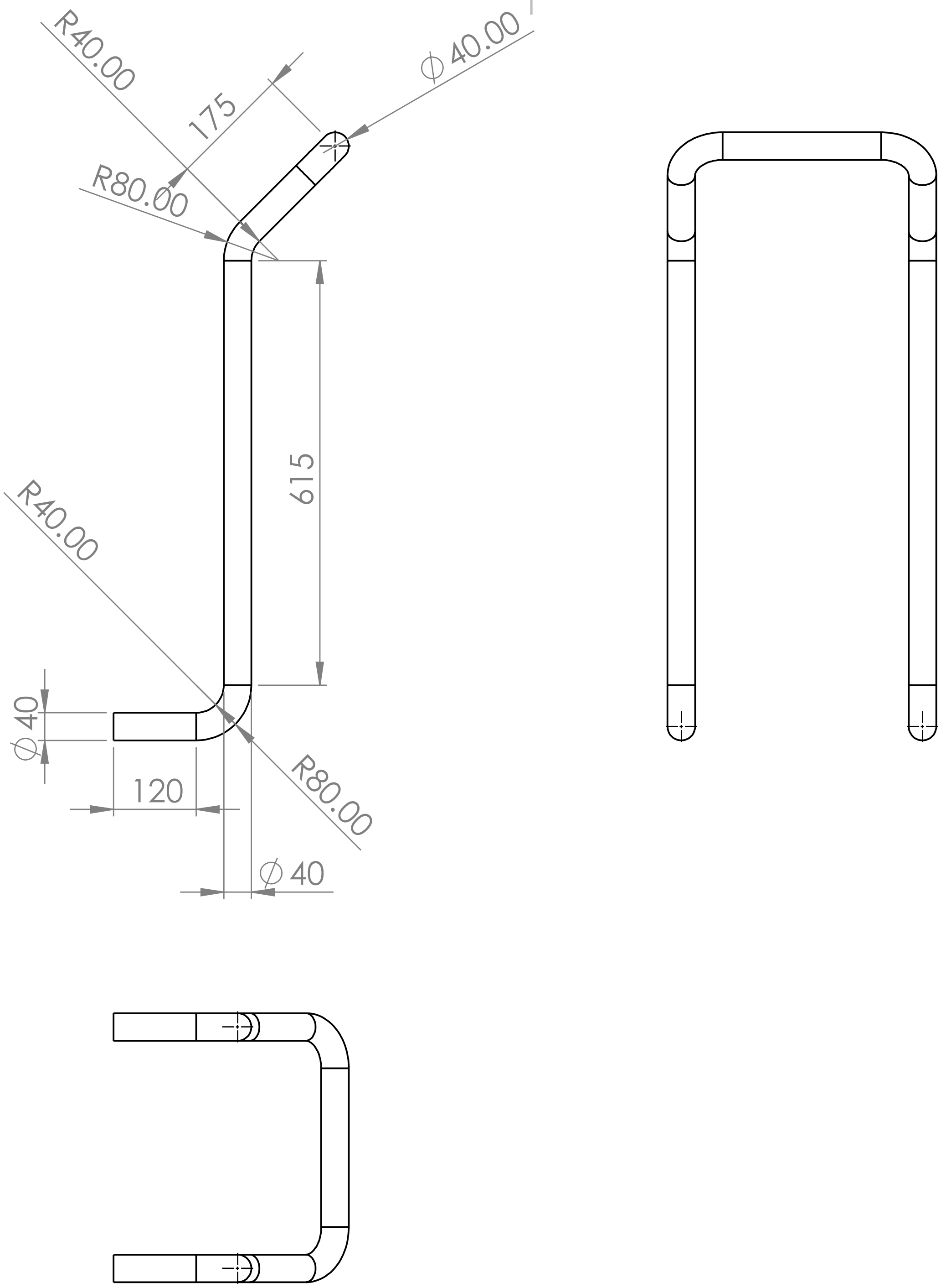
DWG NO.

Support

A4

SCALE:1:10

SHEET 1 OF 1



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TITLE:

MATERIAL:

WEIGHT:

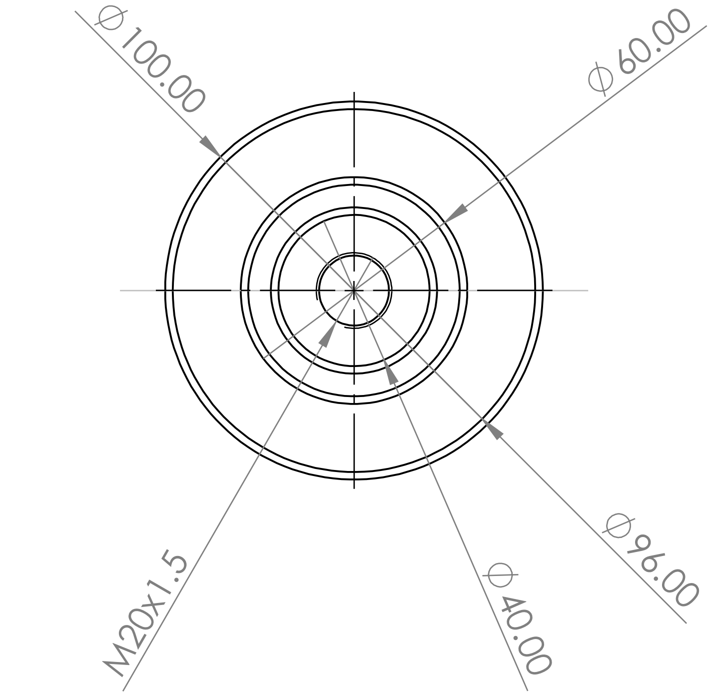
DWG NO.

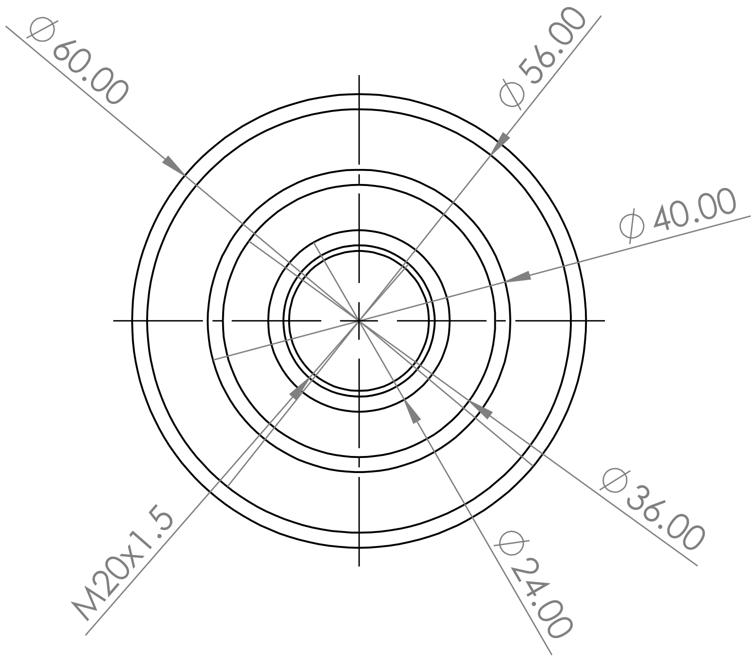
Handle

A4

SCALE:1:10

SHEET 1 OF 1





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REVISION

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MFG			
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TITLE:

MATERIAL:

DWG NO.

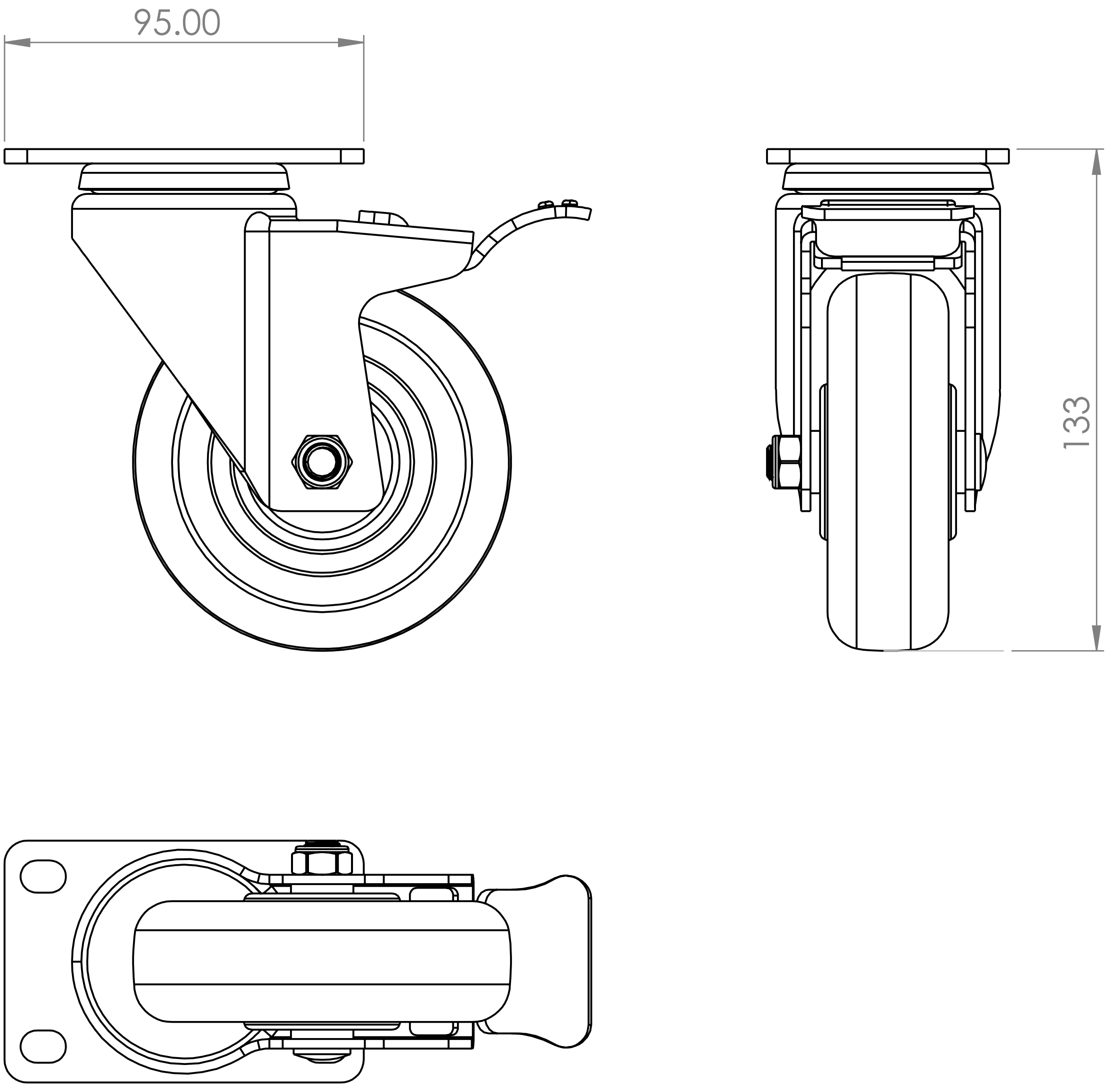
Member Wheels

A4

WEIGHT:

SCALE:1:2

SHEET 1 OF 1



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REVISION

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DRAWN			
CHK'D			
APPV'D			
MFG			
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TITLE:

MATERIAL:

DWG NO.

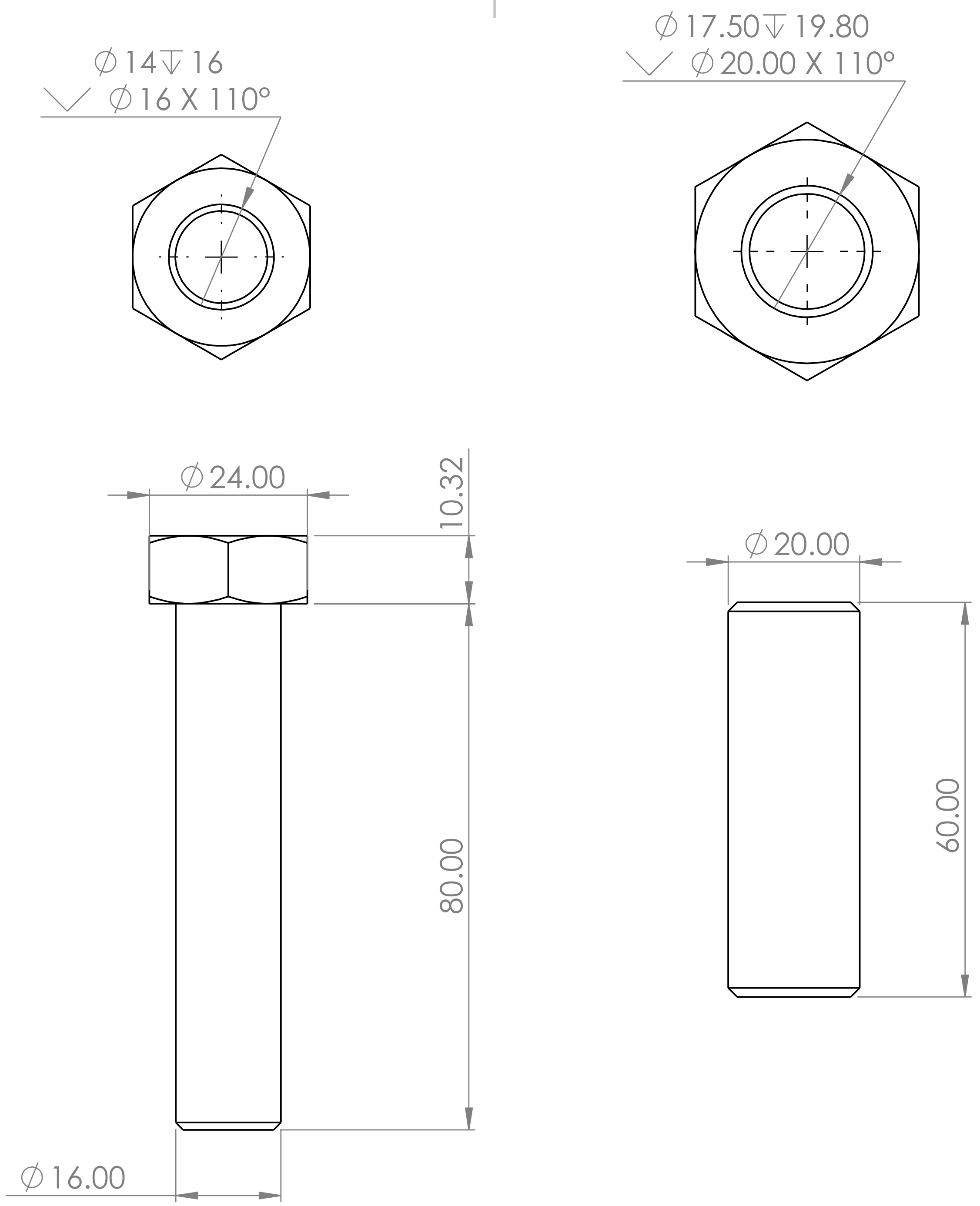
WH-5024H-76 Wheel

A4

WEIGHT: 299.32

SCALE:1:2

SHEET 1 OF 1



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REVISION

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DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

MATERIAL:

WEIGHT:

DWG NO.

Bolts & Nuts

A4

SCALE:1:1

SHEET 1 OF 1