Preston Gomersall
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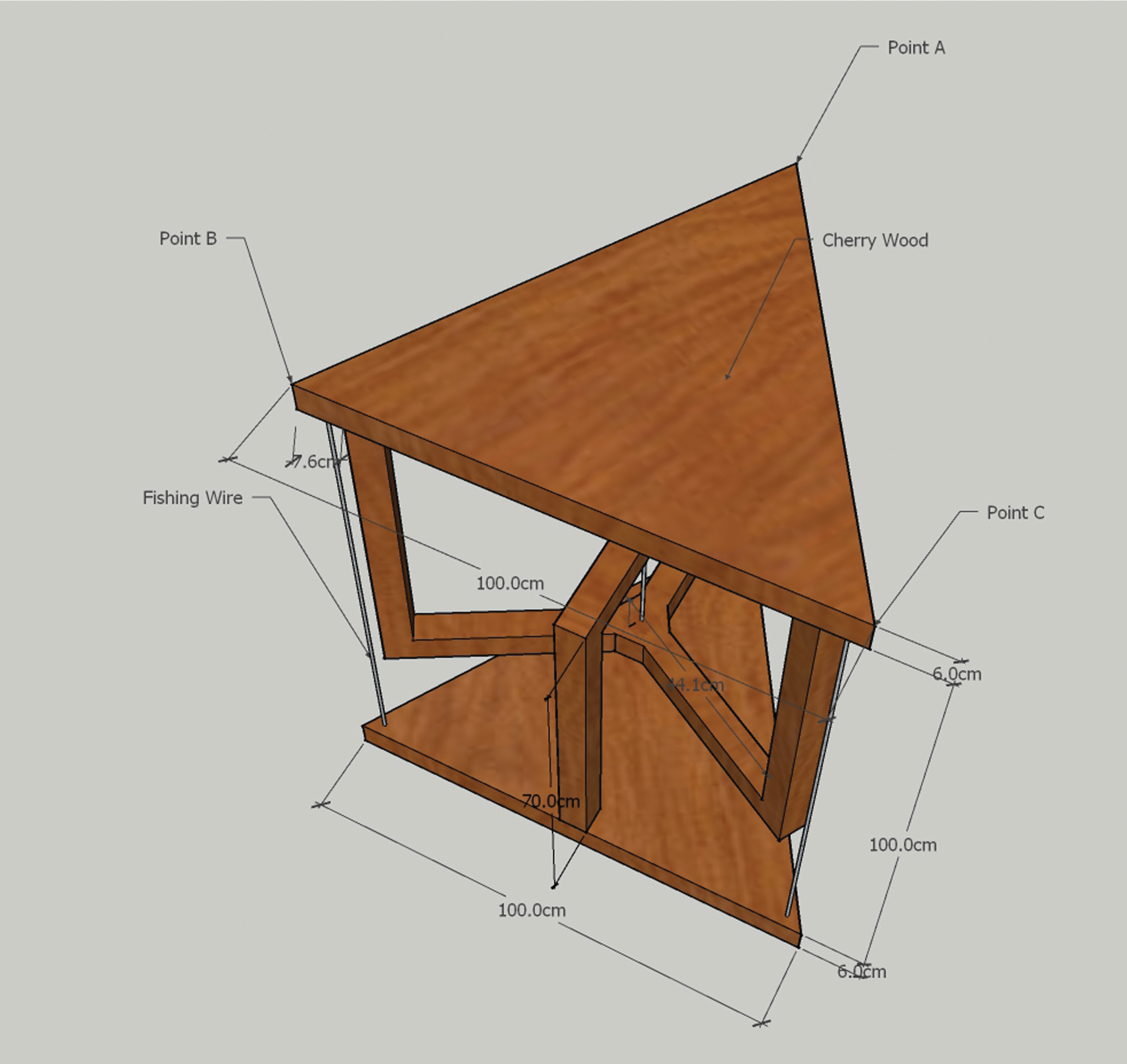
ENGR 115

Floating Table Report

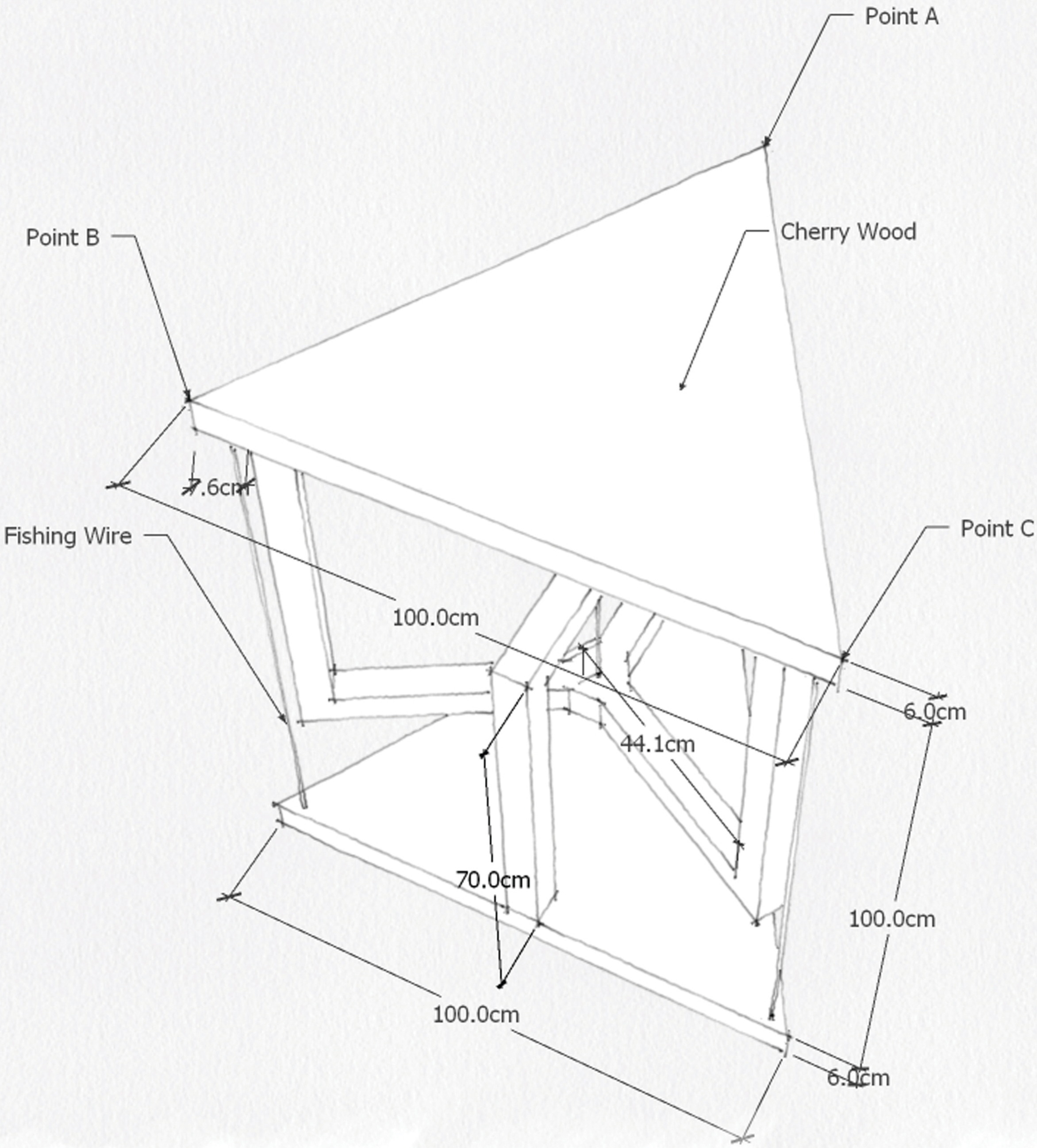
For my final project I picked a floating table designed by John Malecki, who is a former football offensive guard for the Tennessee Titans and now creates his own furniture projects and posts them on YouTube. Malecki was fascinated by the concept of "Tensegrity" and he decided to take on the challenge of building a floating table for himself. I picked Malecki's design because I think he did a good job of achieving the floating effect with his table and really making it appear as if the table defies the laws of gravity and static equilibrium. A picture of his table is attached. There was also a lot of information to back up the design of his table. He made a 20 minute video detailing the process of how he makes the table and in addition to that he posted a list of the materials that he used and the tools you might need if you were going to build a similar table for yourself (the video of him making the table can be found at IMPOSSIBLE Floating Table Build - Will It Work? - YouTube).

His table is made up of an equilateral triangle tabletop and base, with two arms connected by fishing wire in tension. The tension in the wire between the two arms is what keeps the weight of the tabletop up and gives the table the appearance of floating. The wires in tension are tied to a bolt which is secured tightly to the table. There are also three wires at each corner connecting the tabletop to the base in tension. The purpose of the three wires is to keep the table stabilized in case a concentrated load is placed off center on the tabletop. In my Analysis I test three 50lb concentrated loads that are located off the center of Gravity and compute the different tensions required to stabilize the table. Check out my work in the analysis.

To make calculating the forces a little easier, I decided to modify Malecki's design and make it so that the weight of the table top, which acts through the Center of Gravity, would be collinear with the tension pulling the tabletop up. To achieve this, I made it so that there were three L shaped arms coming from each vertex of the triangular tabletop that all meet at the center of mass of the triangle. The weight of the table was calculated by using the density of Cherry wood and the volume of the tabletop. I also examined the internal forces within the L shaped arm by treating each arm like a cantilever beam. The bolt connection at the top secures the arm in place and prevents any movement through shear, bending and axial forces. These are the exact properties of a cantilever beam. The L shaped design also made it easier to find these forces within the arm because I no longer had to deal with difficult angles for the shear and axial forces. All my angles were either 90 degrees or 0 degrees. Overall, it may seem like the floating table is just simply a wire holding up a tabletop but really there is a lot more going on with internal forces when an applied load is added.



Point A
Point B
Cherry Wood
7.6cm
Fishing Wire
Point C
100.0cm
6.0cm
44.1cm
70.0cm
100.0cm
100.0cm
6.0cm



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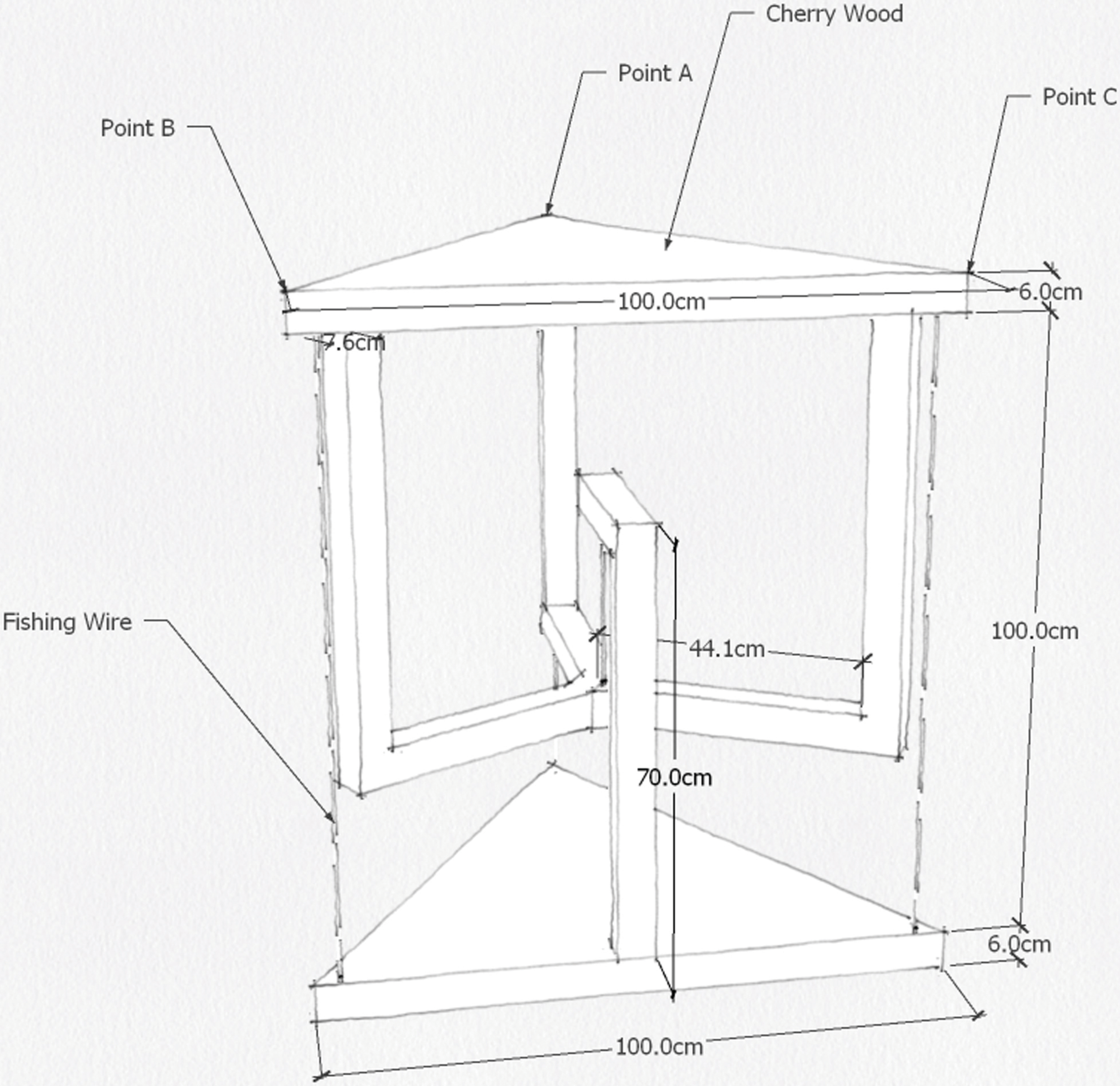

Cherry Wood
Point A
Point C
Point B
100.0cm
6.0cm
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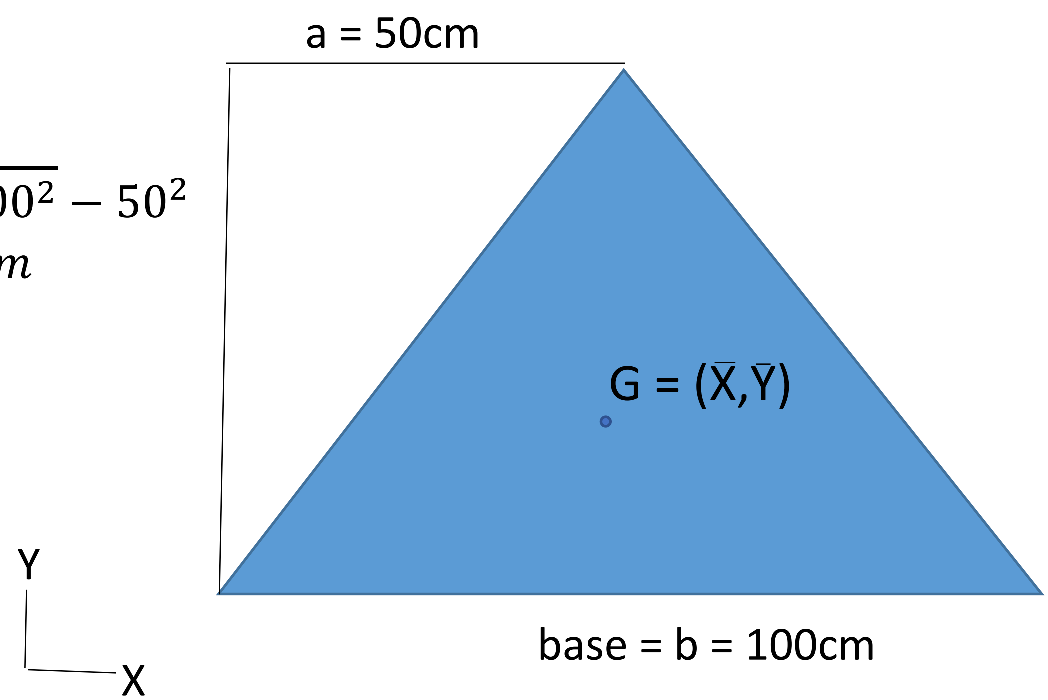
Fishing Wire
44.1cm
100.0cm
70.0cm
6.0cm
100.0cm

Analysis Problem 1

Problem Statement: Find the center of mass of the table and arms combined

FBD of Equilateral Triangle in Z Plane

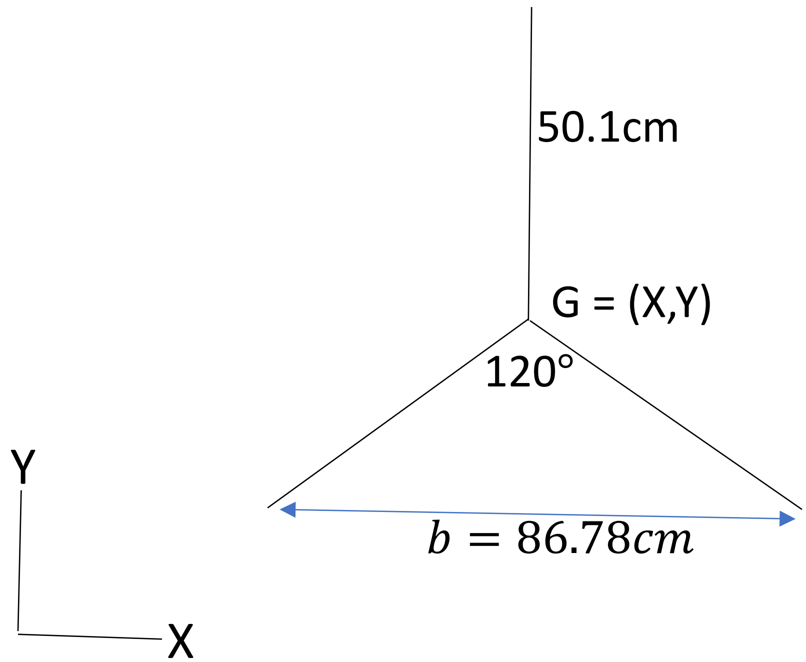
$$h = \sqrt{100^2 - 50^2} = 86.6cm$$



Solution: Because the thickness is constant the center of mass can be thought of as a two-dimensional problem. According to textbook Pg. 502 the Center of mass of a triangle is:

$$X = \frac{a+b}{3} = 50\text{cm} \qquad Y = \frac{h}{3} = 28.87\text{cm}$$

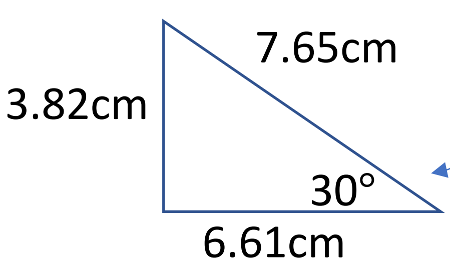
<u>FBD Horizontal Arms in Z plane</u>



Solution: Because the arms have a constant area, the arms can be thought of as 1 dimensional line and where the arms overlap at the center the density of the cherry wood will be twice or three times as dense.

$$X1 = \ .5b = 43.39$$

$$\text{Y1} = \frac{(50.1*50.1)+2*(25.05-25.05*\sin(30°))*50.1}{3*50.1} = 25.05cm$$

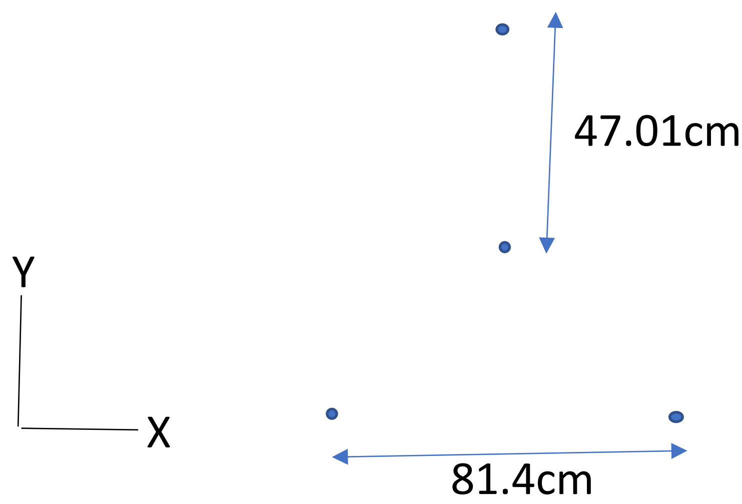


This is how for a way the arms are from the corner

X = X1 + 6.61cm = 43.39cm + 6.61cm = 50cm

Y = Y1 + 3.82cm = 25.05cm + 3.82cm = 28.87cm

<u>FBD Vertical Arms in Z plane</u>

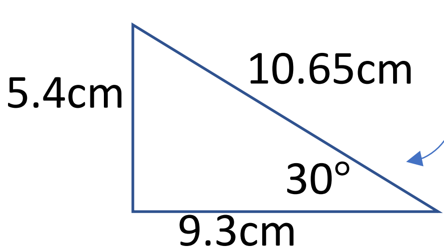


The volume of the vertical rods can be thought of as single points carrying all of the volume and mass of the rod.

$$V = 6cm * 6cm * 64cm = 2304cm^3$$

$$X2 = \frac{40.7 * 2304cm^3 + 81.4cm * 2304cm^3}{3*2304cm^3} = 40.7cm$$

$$Y2 = \frac{70.515cm * 2304cm^3}{3*2304cm^3} = 23.505cm$$



This is how for a way the arms are from the corner

$$X = X2 + 9.3cm = 43.39cm + 9.3cm = 50cm$$

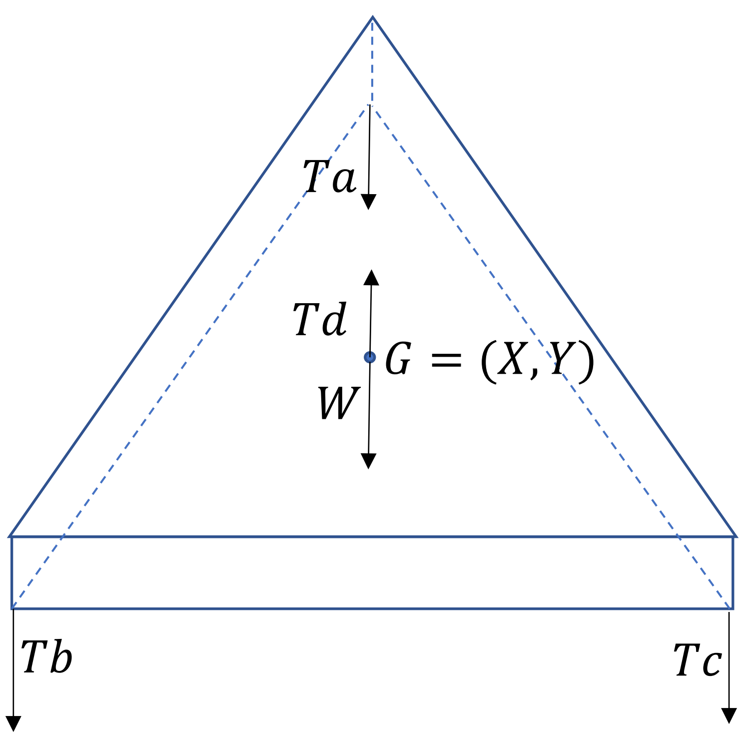
$$Y = Y2 + 5.47cm = 25.05cm + 5.47cm = 28.87cm$$

Problem 1 answer: The combined center of mass if the triangle top and arms will be the X = 50cm and Y = 28.87cm. The horizontal and vertical arms and triangle all have the same center of mass and the tension will pull directly in line with the center of mass.

Analysis Problem 2

Problem Statement: Find the tensions and different forces on the table top when a 50lb load is placed in an (x,y) location on the table.

FBD of Forces Acting on Triangle Top



Solution:

Cherry wood P = 0.80 g/cm^3 according to engineeringclicks.com

V(triangle) = (thickness)(height)(.5base) = (6cm)(86.6cm)(50cm) = 25,980cm^3

V(arm) = (6cm)(6cm)(70cm)+(6cm)(6cm)(44.1cm) = 4,108cm^3

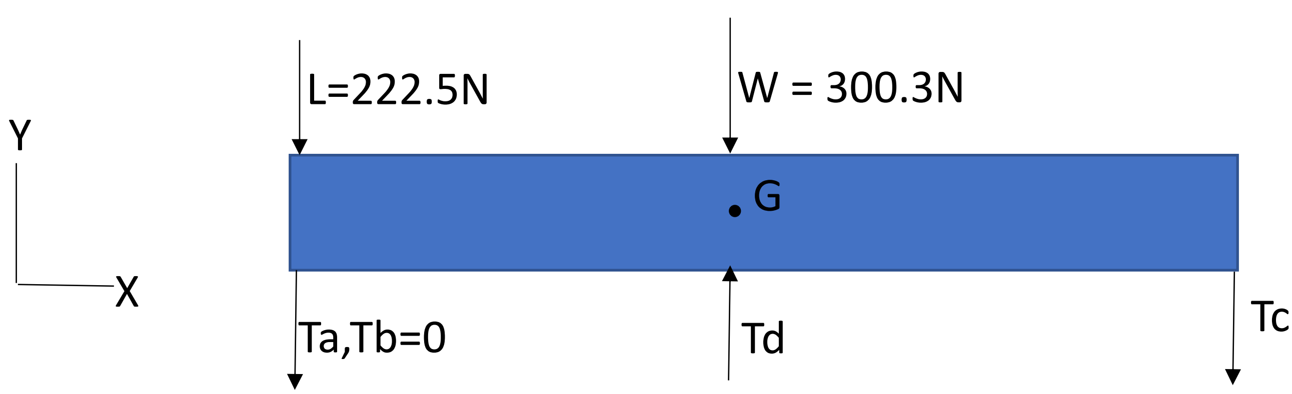
V(total) = V(triangle) + 3 * V(arm) = 25,980cm^3 + 3 * 4,108cm^3 = 38,304cm^3

Mass = (P)(V(total)) = (.80g/cm^3)(38,304cm^3) = 30,643g = 30.64kg

Weight = W = Mass * g = 30.64kg * 9.8m/s^2= 300.3N

Load = L = 50lb = 222.5N

Case 1 FBD



Solution: the Load, L lies along the lone AB and because Ta and Tb are in compression they are approximately = 0.

$$\sum M \ about \ G = 0; Tc = L = 222.5N$$

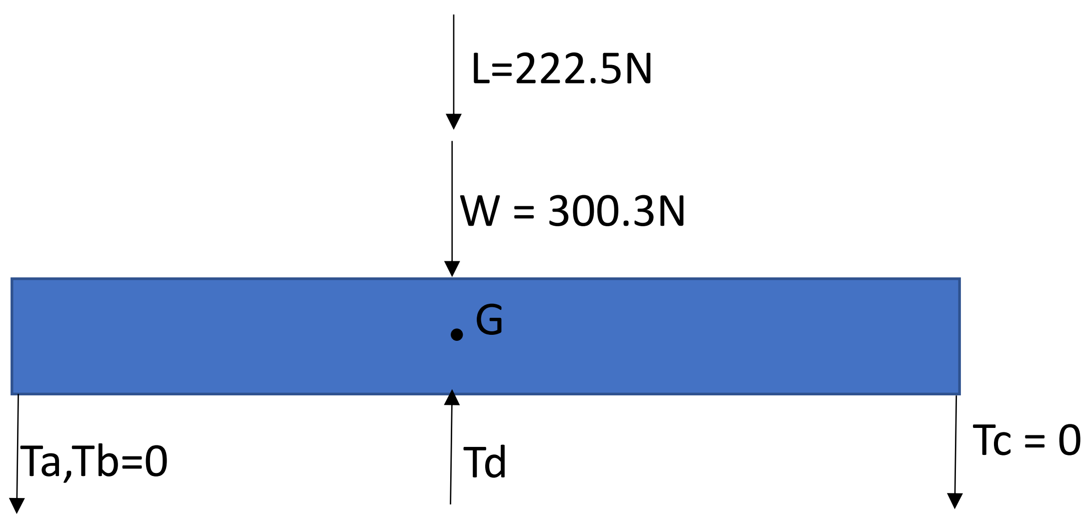
$$\sum Fy \ = 0; Td = L + W + Tc = 745.3N$$

The forces would be the same for the other extreme cases where the load is placed on the corner of the triangle top.

Case 2: Ta = 222.5N, Tb = 0, Tc = 0, Td = 745.3N

Case 3: Ta = 0, Tb = 222.5N, Tc = 0, Td = 745.3N

<u>Case 4 FBD</u>



Solution: Ta, Tb and Tc approximately equal 0 because the load is placed at the center of mass where the tabletop is balanced. Tensions Ta, Tb and Tc are only there to stabilize the table from an off-center load.

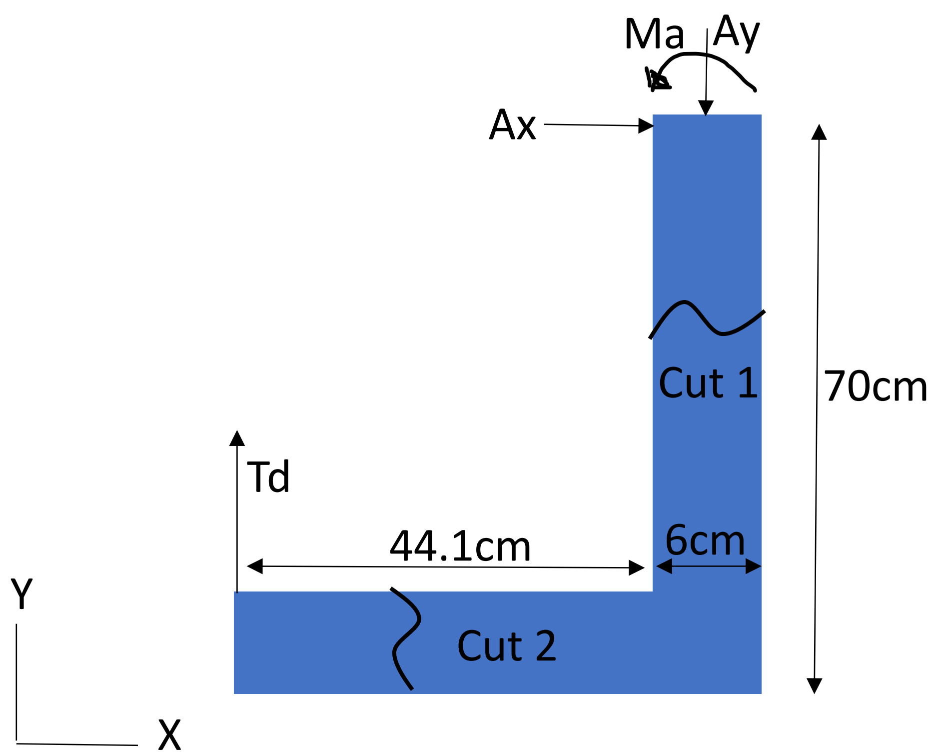
$$\sum Fy = 0;\ Td = L + W + Ta + Tb + Tc = 522.8N$$

For all other cases, the forces are statically indeterminant because there are 4 unknown tensions Ta, Tb, Tc and Td and only three equilibrium equations.

Analysis Problem 3

Problem Statement: Find the internal forces of each arm. You can treat the L shaped arm like a cantilever beam because it is bolted to the table

FBD of Arm



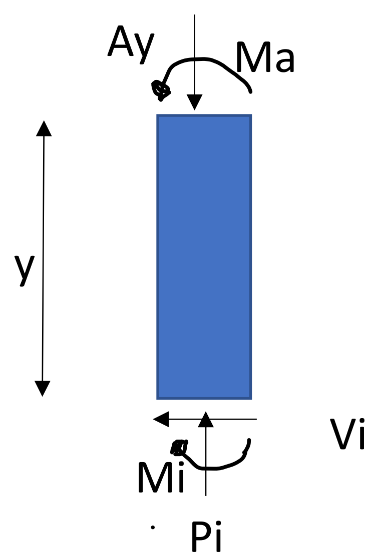
Ax = 0 because there are no other horizontal forces

There are no external loads on the tabletop in this case so Td = W = 300.3N

$$\sum Fy \ = 0; Ay = Td = 300.3N$$

$$\sum Mtop \ = 0; Ma \ = .471m * 300.3N = 141.4Nm$$

FBD Cut 1 (0 < y < 70cm)

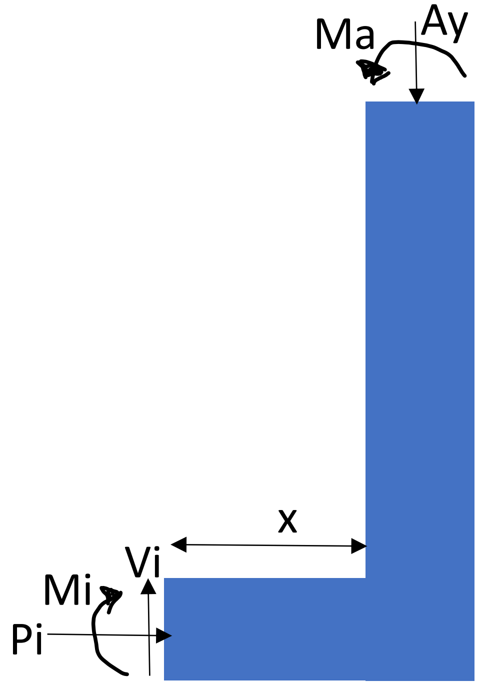


$$\sum M = 0; Mi = Ma + Ay * X = 141.4Nm + 300.3N * X$$

$$\sum Fy = 0; Pi = Ay = 300.3N$$

$$\sum Fx = 0; Vi = 0$$

FBD Cut 2 (0 < x < 44.1cm)



$$\sum M = 0; Mi = Ma = 141.4Nm$$

$$\sum Fy = 0; Vi = Ay = 300.3N$$

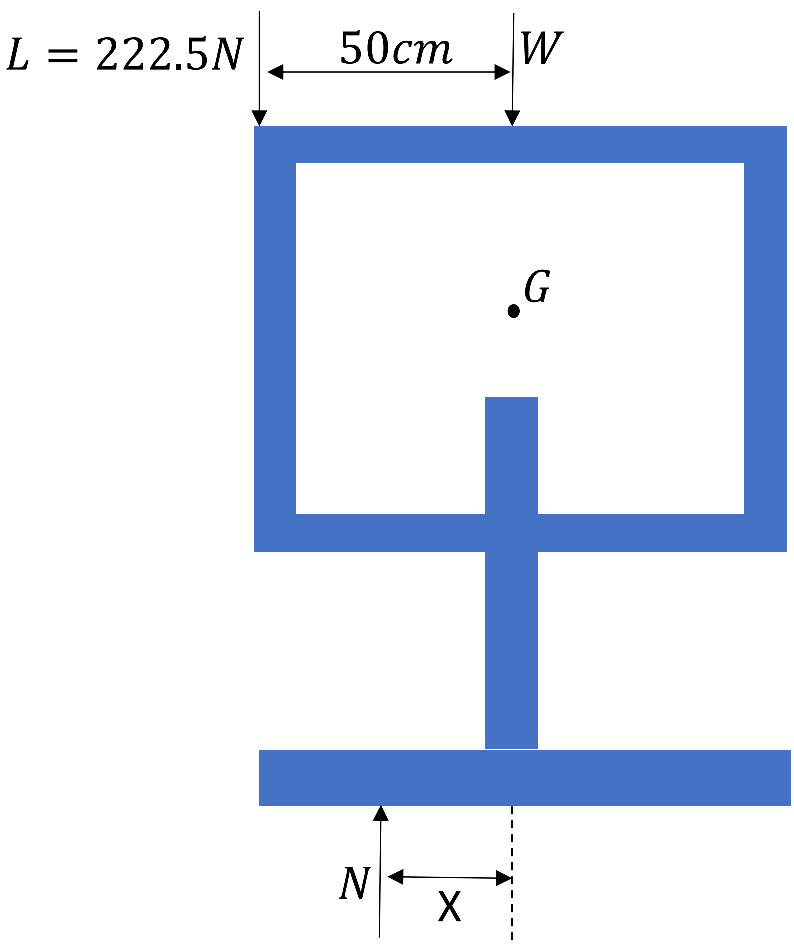
$$\sum Fx = 0; Pi = 0$$

The internal forces will be the same for all three of the arms

Analysis Problem 4

Problem Statement: Determine whether the external 50lb force will tip the table

FBD of External Forces



Solution:

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V(total) = 2*V(triangle) + 4 * V(arm) = 2 * 25,980cm^3 + 4* 4,108cm^3 = 68,392cm^3

Mass = (P)(V(total)) = (.80g/cm^3)(68,392cm^3) = 54,710g = 50.74kg

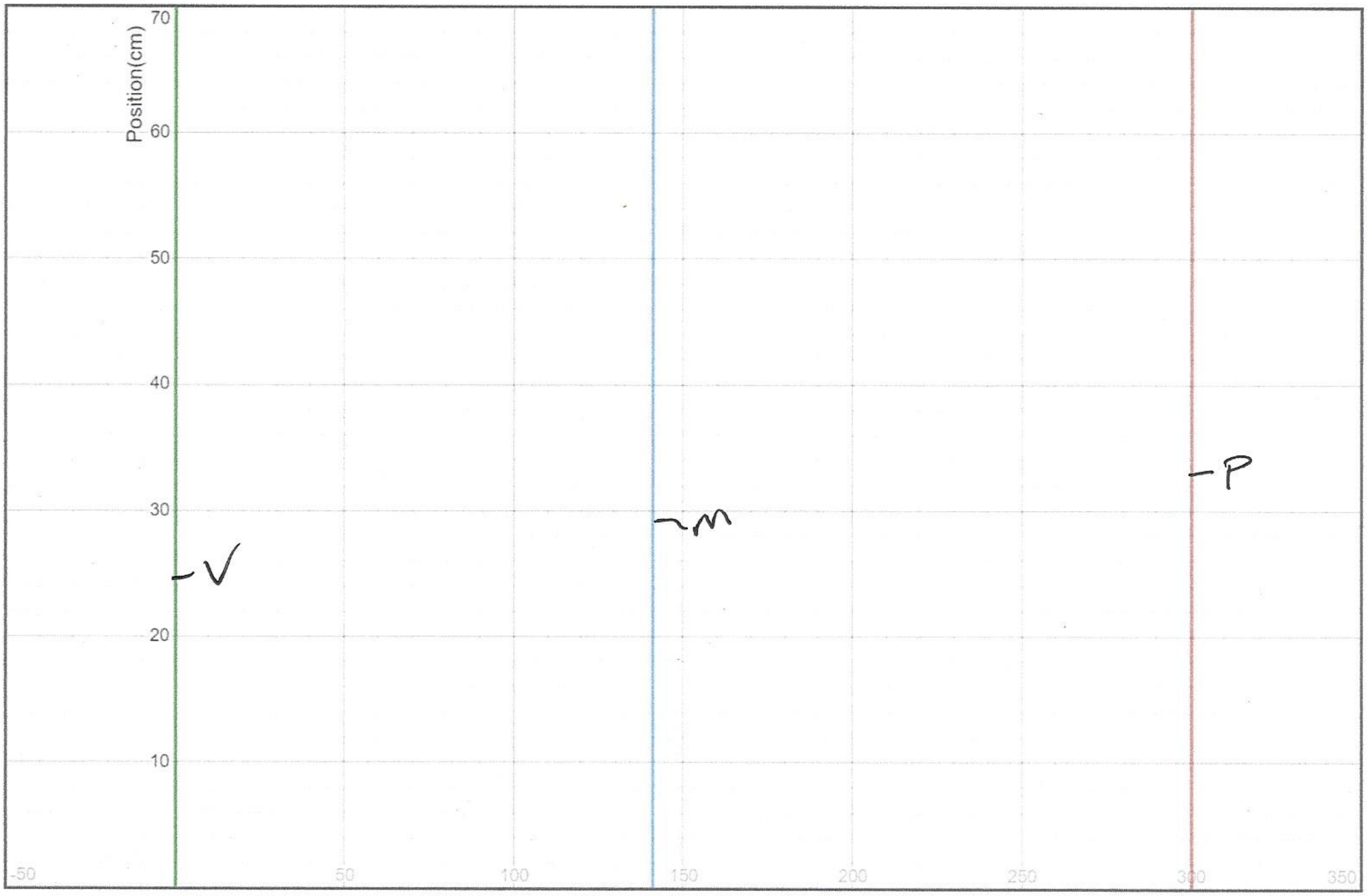
Weight = W = Mass * g = 50.74kg * 9.8m/s^2= 536.16N

Load = L = 50lb = 222.5N

$$\sum Fy \ = 0; N = W + L = 536.16 + 222.5 = \ 758.66N$$

$$\sum M \ about \ G \ = 0; \ X = \frac{L * 50cm}{N} = \frac{222.5N * .5m}{758.66N} = 0.15m$$

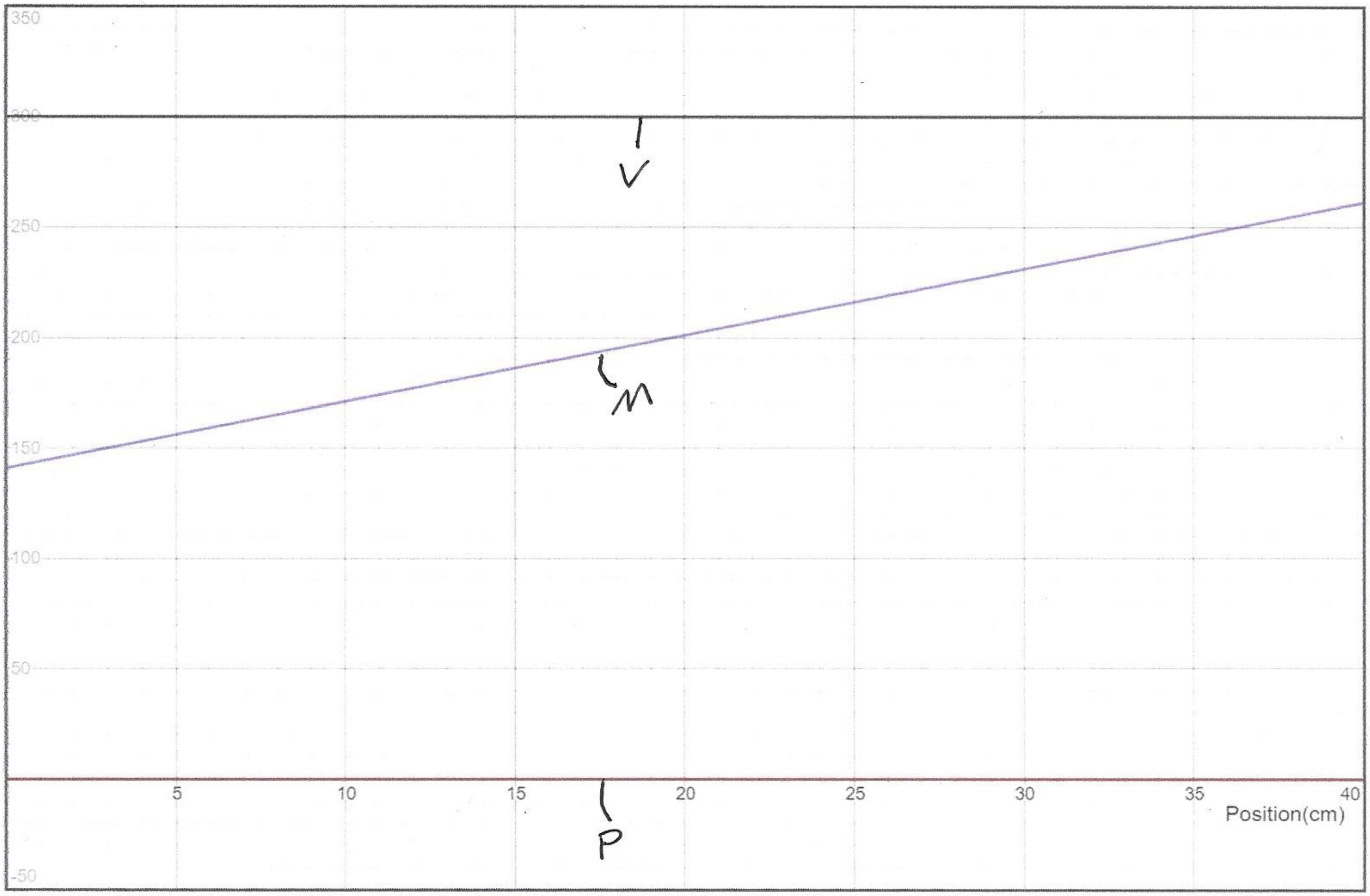
X < .5m so the table will not tip with an applied load of 50lb on the edge of the table



1 $x = 300.3\{0 < y < 70\}$ = P

2 $x = 141.1\{0 < y < 70\}$ = M

3 $x = 0\ \{0 < y < 70\}$ = V



1

$y = 141.1 + 3.003 \cdot x\{0 < x < 44.1\}$ = M

2

$y = 300.3\{0 < x < 44.1\}$ = V

3

$y = 0\{0 < x < 44.1\}$ = P