Calculating a 5G Load On a Roll Bar

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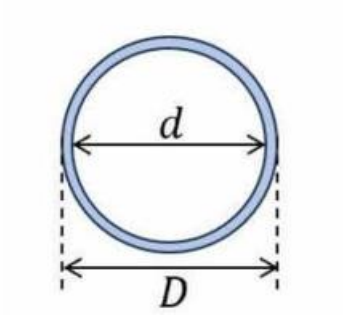
SOLAR CAR CHALLENGE®

The Roll Bar Rule

5.2.2.2 **Minimum Dimensions** – The roll bar must be sized to withstand a 5G vertical load without yielding, based on the weight of the vehicle with the driver and all support equipment included. Teams must provide this calculation as part of their registration documentation. Teams not calculating for 5G vertical load must have roll bar tubing with a minimum outside diameter of 5 cm. and minimum wall thickness of 1.0 mm for chromoly steel, 1.5 mm for carbon steel, and 3.2 mm for aluminum.

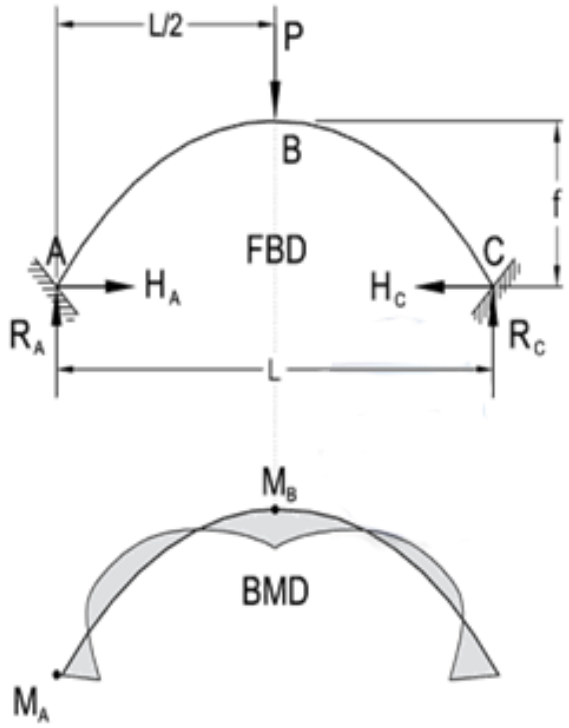
How do I do this?

- **Strength of Materials Calculation to bending stress from 5G load is less than yield strength of rollbar material**



$$d = D - (2 * t)$$

$$I = \frac{(D^4 - d^4) * \pi}{64}$$



Support Reactions

$$R_A = R_C \ldots\ldots = \frac{P}{2}$$

$$H_A = H_C \ldots\ldots = \frac{15PL}{64f}$$

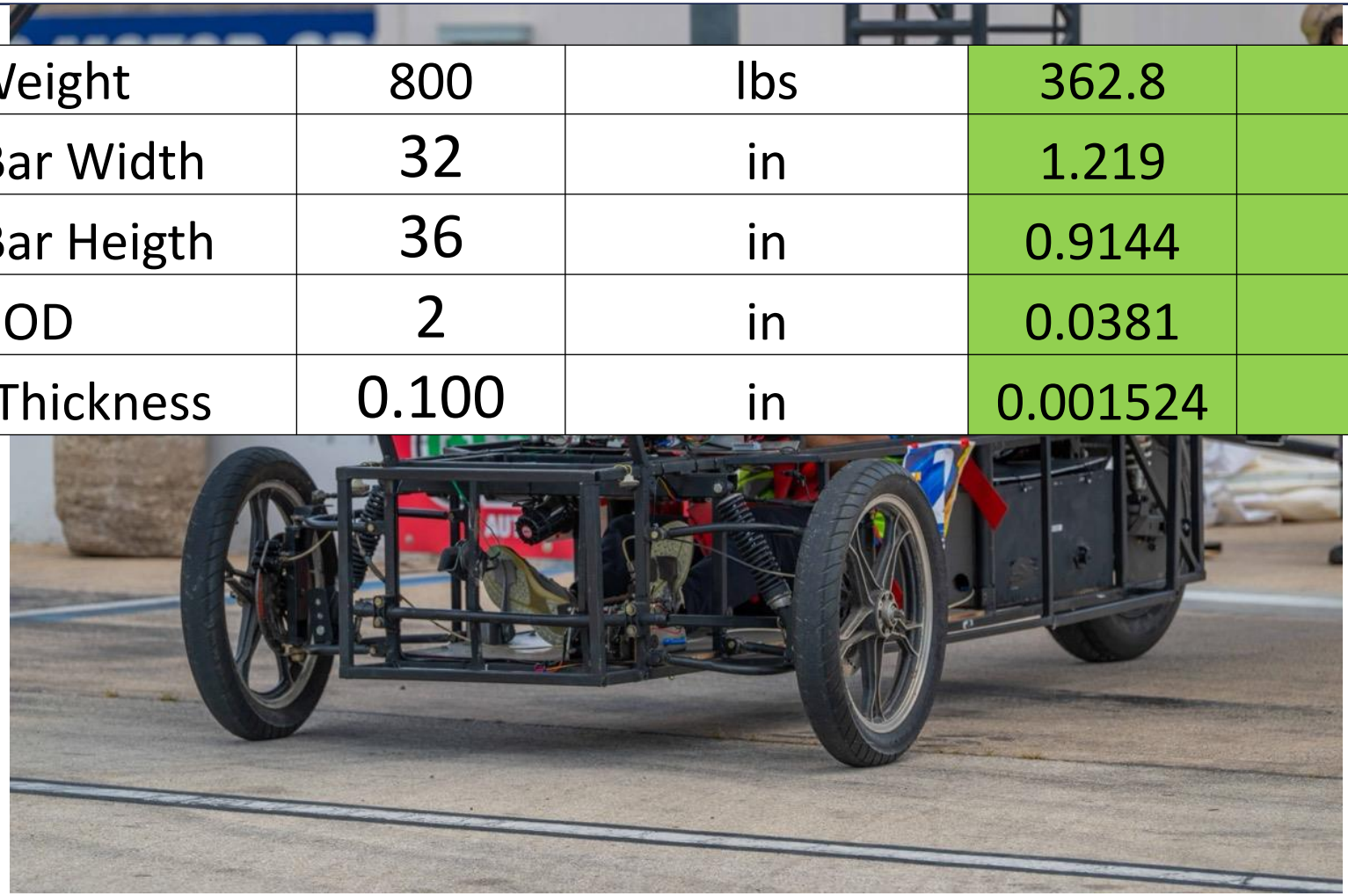
Bending Moments

$$M_A = M_C \ldots\ldots = \frac{PL}{32}$$

$$M_B \ldots\ldots = \frac{3PL}{64}$$

Our Car Example

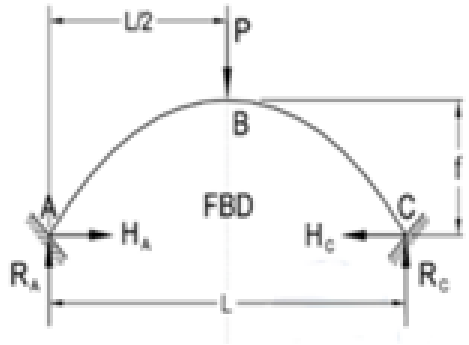
Car Weight	800	lbs	362.8	Kg
Roll Bar Width	32	in	1.219	m
Roll Bar Heigth	36	in	0.9144	m
Tube OD	2	in	0.0381	m
Wall Thickness	0.100	in	0.001524	m



Let's Write Down What We Know

Warning: Information will be verified at scrutineering. Cars weighing more then the listed value or not matching the given information will be disqualified.

1. Mass of the vehicle (*m*)	362.8	Kg
2. Roll Bar Height (*f*)	1.219	m
3. Roll Bar Width (*L*)	0.9144	m
4. Roll Bar Outside Diameter (*D*)	0.0381	m
5. Roll Bar Wall Thickness (*t*)	0.001524	m
6. Material Type	AISI 1010 Mild Steel	
7. Yield Strength	305	MPa



m is the mass of the solar car in Kg including the driver

Yield strength can be found on the data sheets from your metal distributor or ASTM/ASME guidelines

Step 1 – Calculate 5G Load

Step One

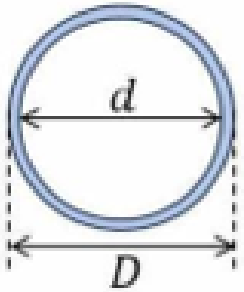
Calculate 5G Load

Load (*P*) $P = 5 * 9.8 \frac{m}{s^2} * m$ 17778 N

m is the mass of the solar car in Kg including the driver

Step 2 – Calc Moment of Inertia

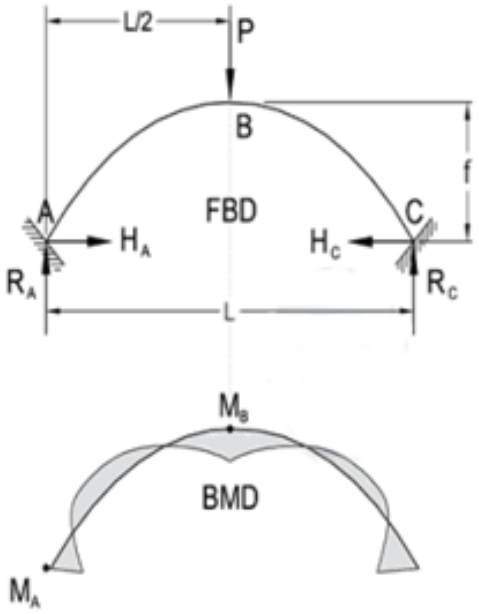
Calculate Moment of Inertia for tube



Roll Bar inner diameter (*d*)	$d = D - (2 * t)$	0.04826	m
Moment of Inertia (*I*)	$I = \frac{(D^4 - d^4) * \pi}{64}$	6.06E-08	m^4

Step 3 – Calc Forces and Moments

Calculate Reaction Forces and Moments



Support Reactions

$$R_A = R_C \ldots\ldots = \frac{P}{2}$$

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Bending Moments

$$M_A = M_C \ldots\ldots = \frac{PL}{32}$$

$$M_B \ldots\ldots = \frac{3PL}{64}$$

Vertical Reaction Force (R_a)	8889	N
Horizontal Reaction Force (H_a)	3704	N
Peak Moment (M_B)	677	N*m

Step 4 – The Stress

Calculate Resulting stress

Bending Stress (σ_b)

$$\sigma_b = \frac{M_B * \frac{D}{2}}{I}$$

284 MPa

Sheer Stress (σ_s)

$$\sigma_s = \frac{H_a}{\pi\left(\left(\frac{D}{2}\right)^2 - \left(\frac{d}{2}\right)^2\right)}$$

19 MPa

Step 5 – Will it Work?

Step Five

Determine Suitability

$$\frac{284\ \text{MPa}}{\text{Bending Stress } (\sigma b)[Line\ 14]} \ \& \ \frac{19\ \text{MPa}}{\text{Sheer Stress } (\sigma s)[Line\ 15]} < \frac{305\ \text{MPa}}{\text{Yield Strength } [Line\ 7]}$$

The bending stress [284 MPa] is less than the yield strength [305 MPa] So the Rollbar will not yield under a 5G Load

Questions?