CDR: LAB 2

ASEN 2001, STATICS AND STRUCTURES

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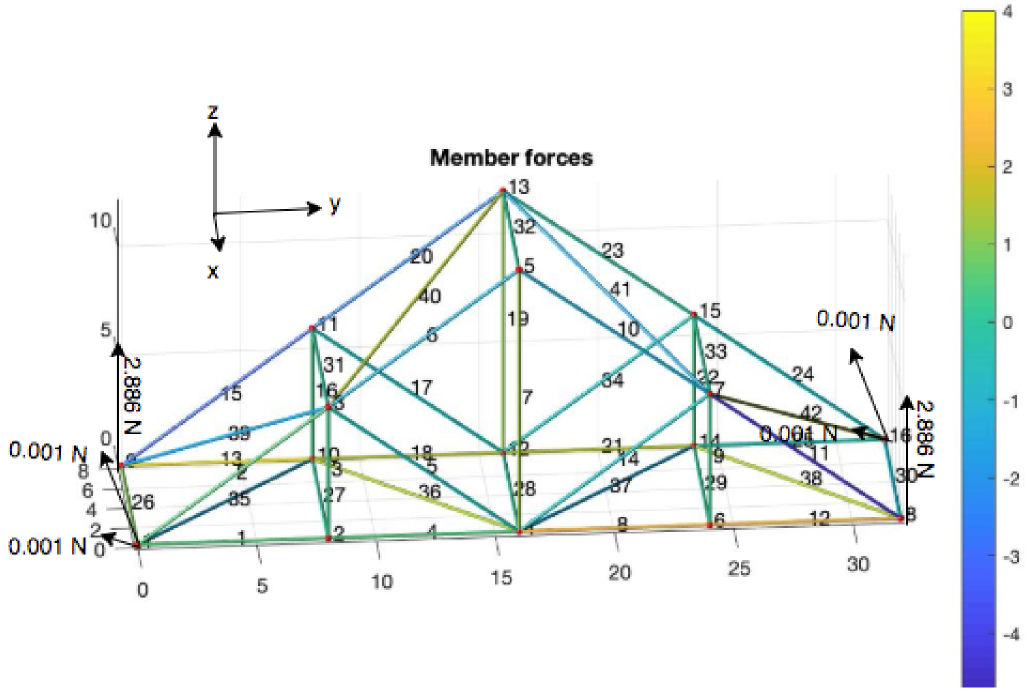
MECHANICAL MODELING

ESSENTIAL FREE BODY DIAGRAMS, EXTERNAL LOAD

Figure 1: FBD for Design 1 and 2 respectively.

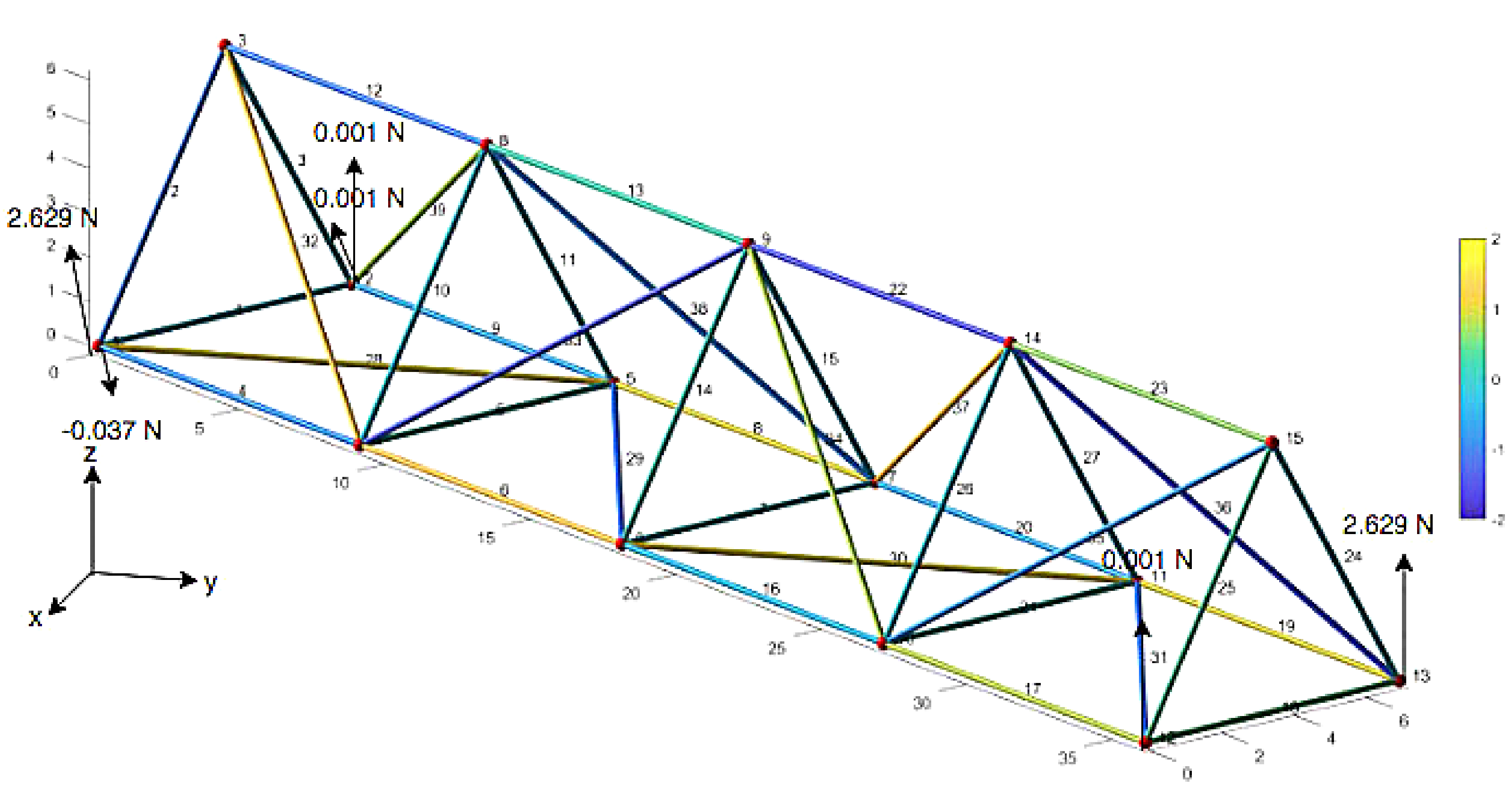
Design 1:

- LENGTH: 32 INCH
- MASS: 0.6311 KG
- # BARS : 42
- # JOINTS : 16
- CRITICAL POINTS: BAR 11 (JOINT 7 AND 8)



Design 2:

- LENGTH: 36 INCH
- MASS: 0.5424 KG
- # BARS : 39
- # JOINTS : 15
- CRITICAL POINTS: BAR 22 (JOINT 9 AND 14)



EXTERNAL LOAD ASSUMPTIONS

We are assuming that the only external load acting on our truss is the weights of the items used to make it. In addition, we assume that the bars have uniform linear density. The weight of the bars, magnets, joints, and sleeves act equally on both joints that it is connected to. The weights is to be distributed equally on each joint (for instance the weight of the bars will be carried by each joint the bars connected to, each joint takes half of the load).

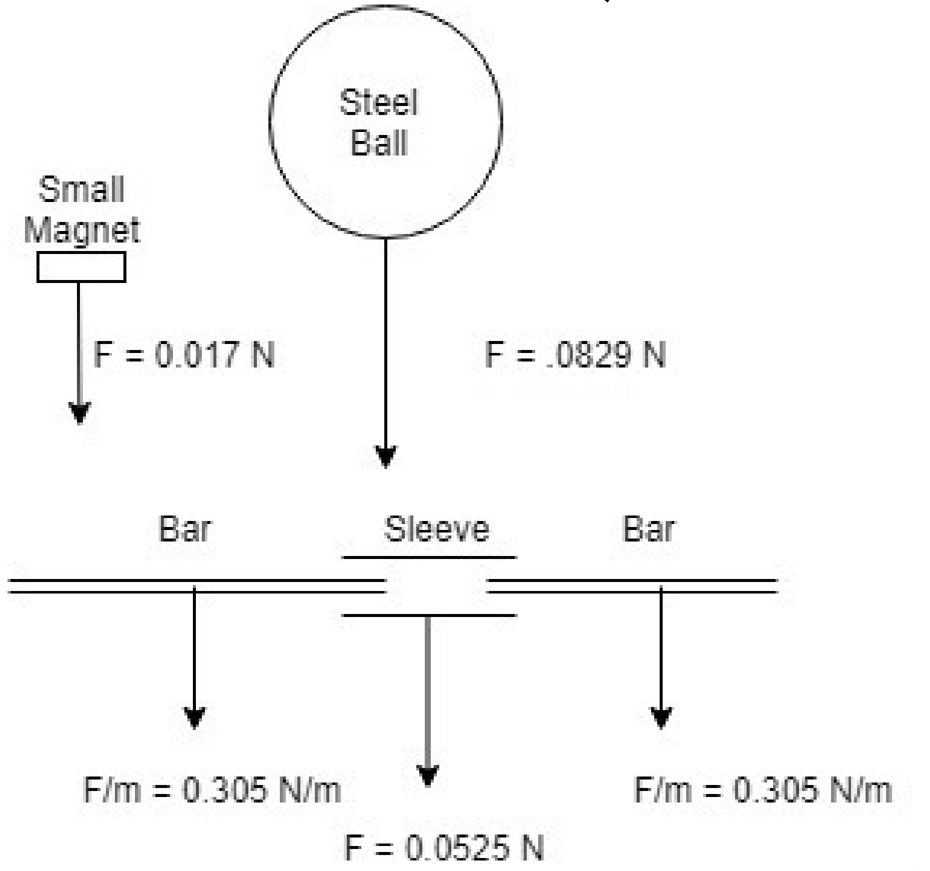


Figure 2: FBD For the truss components and their weight contribution.

CODE VERIFICATION

CLASS EXAMPLES

The following examples were used to test the validity of the MATLAB code, provided a picture from the the output file and the resultant plot, adjusted by adding the reaction forces. The external loads are not displayed but they can be seen at the output file

EXMAPLE 1

```
BOBBY 3-D Truss analysis
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Date: 08-Oct-2018 11:43:03

Input file: test3d_2.inp

Joints:          Joint-id  x-coordinate y-coordinate
                 1          0.00         4.00         0.00
                 2         -3.00         4.00         0.00
                 3         -3.00         0.00         3.00
                 4          0.00         0.00         3.00
                 5          0.00         0.00         0.00
                 6         -3.00         0.00         0.00


External loads: Joint-id  Force-x      Force-y
                 1       200.00       300.00      -500.00
                 2         0.00       400.00         0.00

Bars:            Bar-id    Joint-i      Joint-j      Force     (T,C)
                 1         1            2          300.000     (C)
                 2         1            5          366.667     (C)
                 3         1            3          971.825     (T)
                 4         1            4            0.000     (C)
                 5         2            3            0.000     (C)
                 6         2            5          500.000     (T)
                 7         2            6            0.000     (C)
                 8         3            4          500.000     (C)
                 9         3            6          300.000     (C)
                10         4            5            0.000     (C)
                11         4            6          424.264     (T)
                12         5            6          300.000     (C)

Reactions:       Joint-id  Uvec-x       Uvec-y       Uvec-z       Force
                 3         0.00         1.00         0.000      -666.667
                 3         0.00         0.00         1.000       200.000
                 4         1.00         0.00         0.000      -200.000
                 4         0.00         1.00         0.000         0.000
                 4         0.00         0.00         1.000       300.000
                 5         0.00         1.00         0.000       -33.333
```

Figure 3: Output results for test case 1

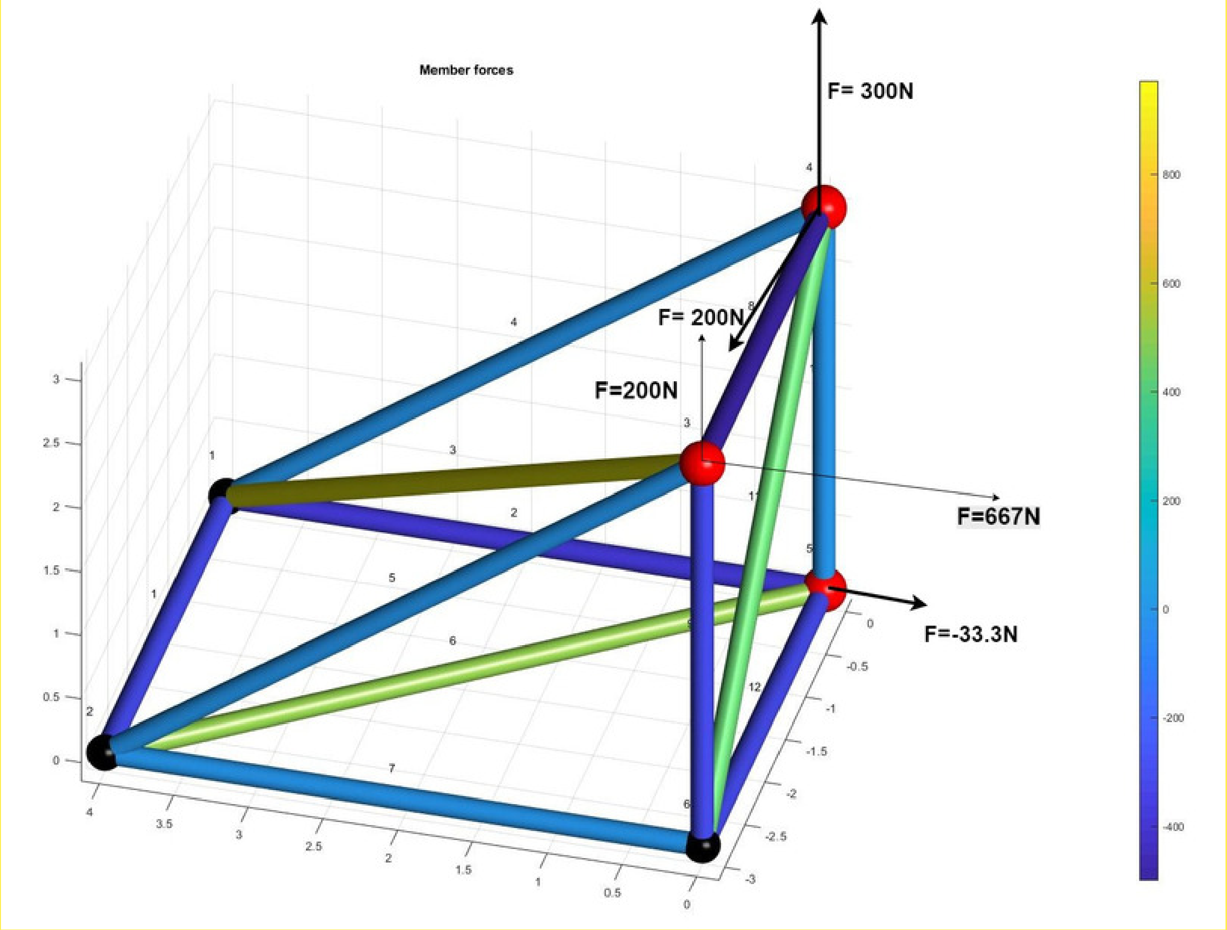

Figure 4: 3D Plot and FBD for test case 1

EXMAPLE 2

```
3-D Truss analysis
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Date: 21-Oct-2018 20:28:55

Input file: test3d_1.inp

Joints:          Joint-id  x-coordinate y-coordinate z-coordinate
                 1         6.00         0.00         0.00
                 2         3.00         4.50         0.00
                 3         0.00         0.00         0.00
                 4         3.00         2.00         6.00


External loads: Joint-id  Force-x      Force-y      Force-z
                 4         0.00         0.00        -8.00

Bars:            Bar-id    Joint-i      Joint-j      Force     (T,C)
                 1         1            2            0.890     (T)
                 2         2            3            0.890     (T)
                 3         3            1            0.617     (T)
                 4         1            4            2.593     (C)
                 5         2            4            3.852     (C)
                 6         3            4            2.593     (C)

Reactions:       Joint-id  Uvec-x       Uvec-y       Uvec-z       Force
                 1         1.00         0.00         0.00        -0.000
                 1         0.00         1.00         0.00        -0.000
                 1         0.00         0.00         1.00         2.222
                 2         0.00         0.00         1.00         3.556
                 3         0.00         1.00         0.00         0.000
                 3         0.00         0.00         1.00         2.222
```

Figure 5: Output results for test case 2

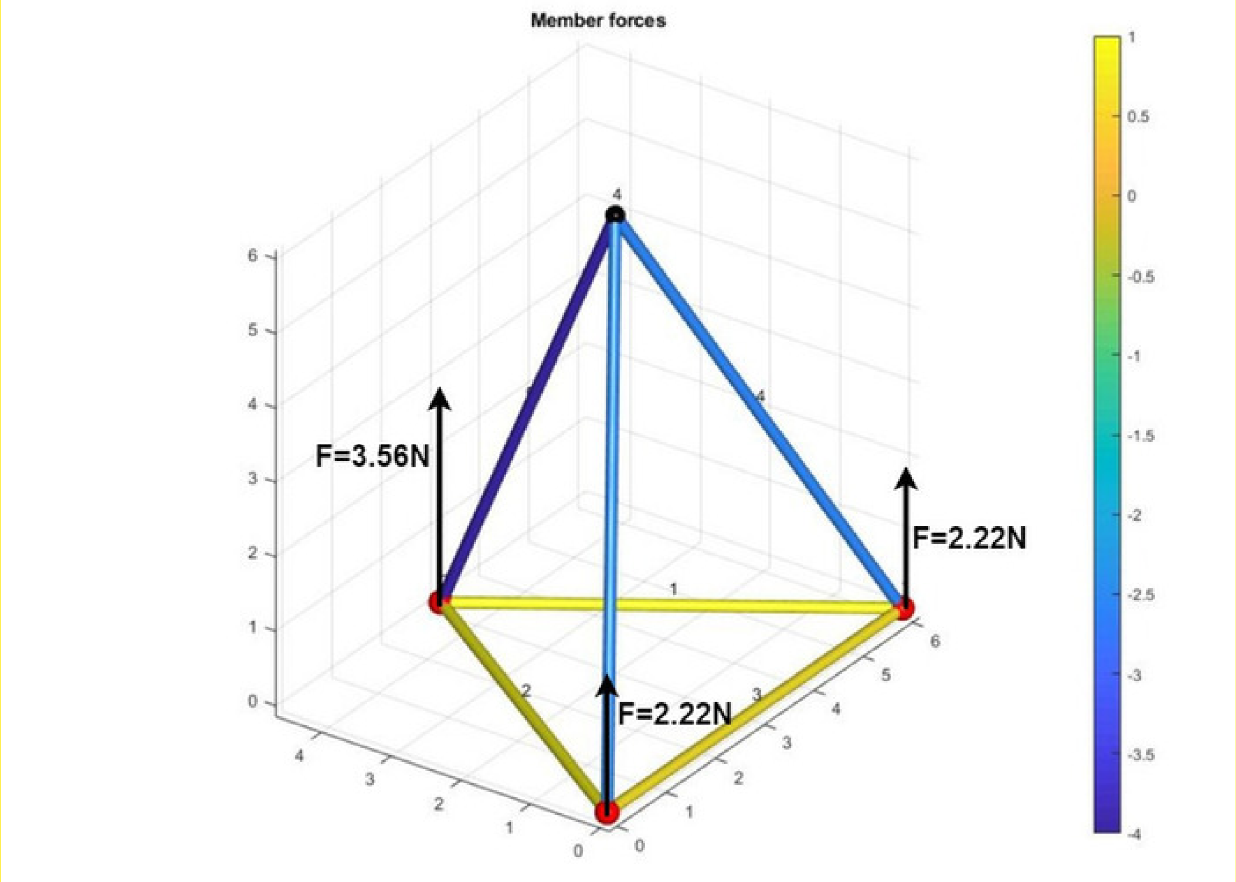


Figure 6: 3D Plot and FBD for test case 2

It is important to differentiate between the chosen safety factor and the actual applied safety factor that is calculated and predicted from the code. The chosen safety factor should be taken into consideration before proceeding into design. It is clear to us that the first design is less likely to fail based on the obtained data from the analysis and failure simulations. The lowest possible safety factor is a safety for Aerospace applications is 1.3, and thus something around that range was chosen. For Design 2 Monte Carlo simulations predicted a very high chance of fail, and thus to stay within the safe range a higher safety factor must be considered. Although the range for Aerospace applications goes up to 2, for this application we are allowed to go beyond that, and thus 2.5 was chosen. The implied Safety factors are not the same as the chosen, for the implied is what is actually there based on the analysis.

Design 1:

Assumed probability of fail: 17%
Monte Carlo Probability of fail: 18.03%
Chosen safety factor: 1.4
Applied safety factor: 1.0863

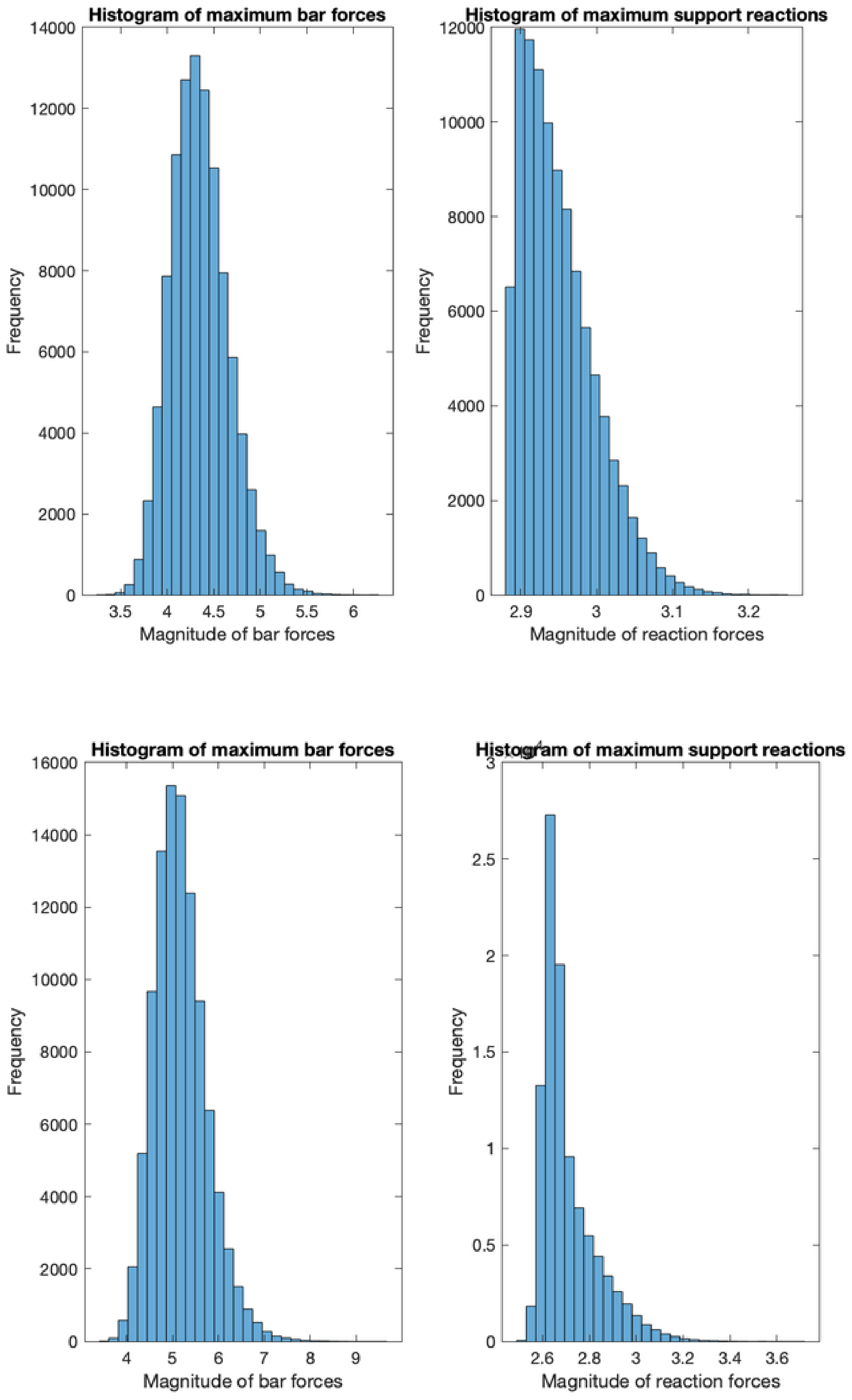
Maximum loading capacity (theoretical): 36 magnets and and 36 spheres

Design 2:

Assumed probability of fail: 50%
Monte Carlo Probability of fail: 60%
Chosen safety factor: 2.5
Applied safety factor: 1.00

Maximum loading capacity (theoretical) : 24 magnets and 24 spheres

Figure 7: Monte Carlo simulations result for Design 1 and 2 respectively.



SENSITIVITY ANALYSIS
AND CHOSEN DESIGN

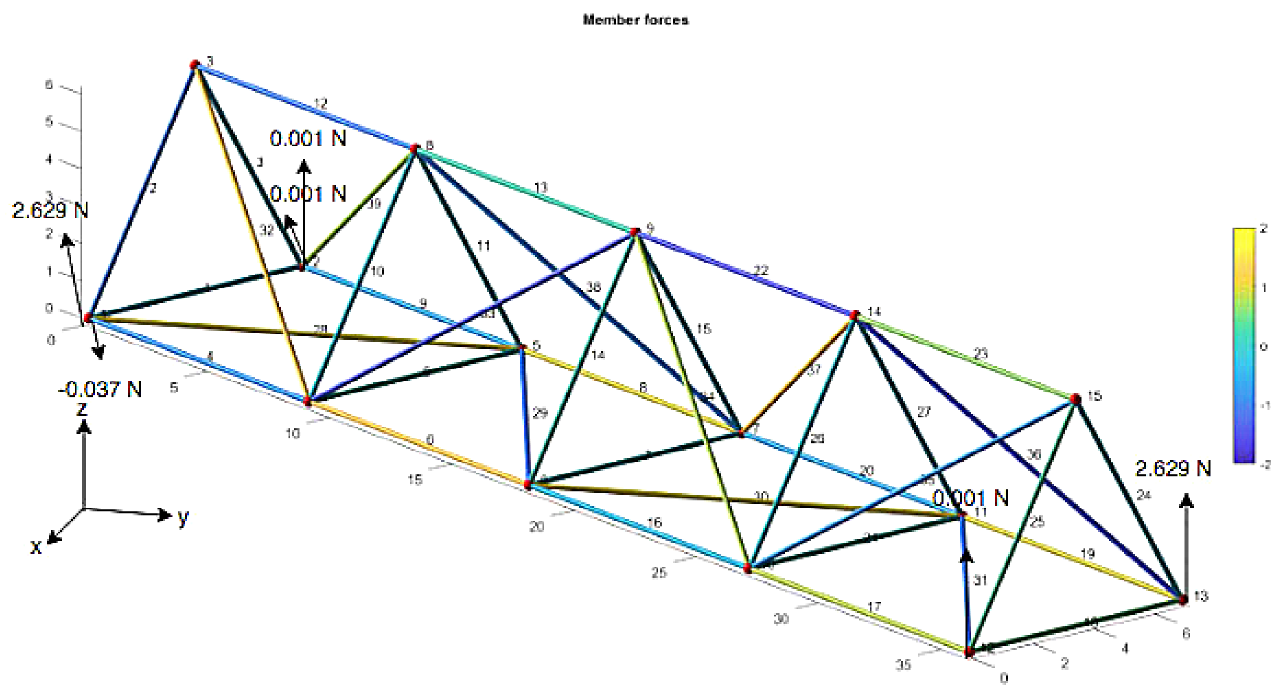
After looking through the truss designs, their free-body diagrams, their factors of safety, and their Monte Carlo simulations, we ended up choosing design 2.

This was because the design was easier to build with the added error of the size of the bar with the magnets. Moreover, when this design inevitably failed due to too much stress on a point, it was easier to put back together since all the triangles are the same.

This design was also longer, which made up for its higher probability of failure. We are confident that the truss will still stand under its own weight.

Along with these reasons, when checking over the final design for design 1, we found an error in some of the member length calculations.. The diagonals along the base of the truss should be about 11.3 in but this length is not possible. Design 2 is perfectly viable.

DESIGN 2



BUILDING AND FABRICATION PLAN

YES!

Design 2 can be made with the truss bars and sleeves given to us.

	Design 1	Design 2
Bar Lengths / Item	Number used	Number used
12"	2	0
10"	12	12
8"	18	12
6"	18	15
Sleeves	8	0

Table 1 : Initial Design Material Use Estimations

All the lengths of our bars were checked by looking at the data from our MATLAB code and found that in Design 2 every bar complies with the lengths of the bars which will be given to us. In addition, we don't exceed the amount of each bar given to us.