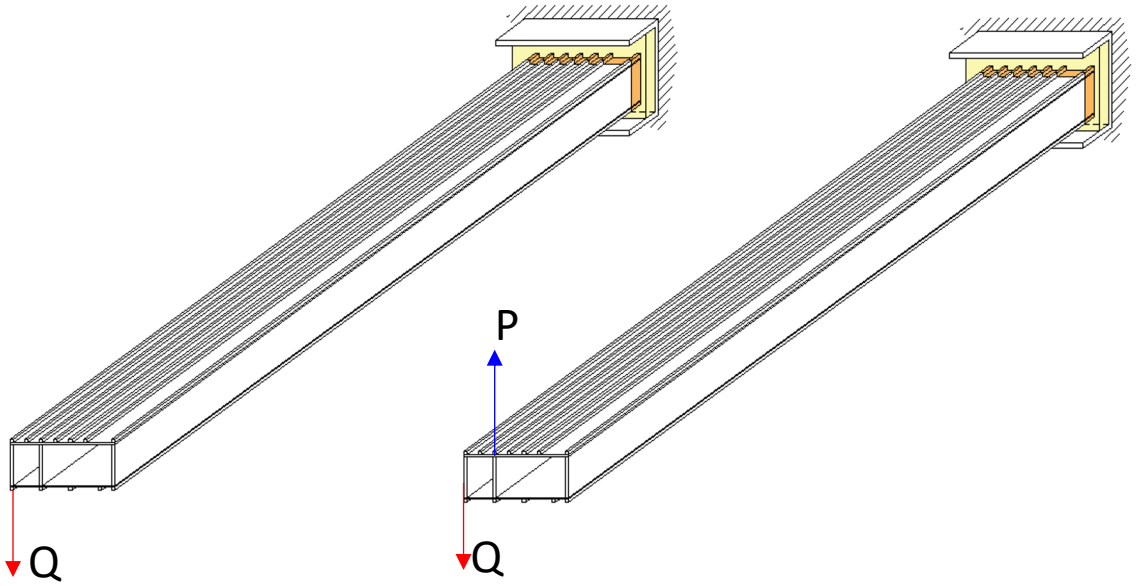
AirBus-A525 Wingbox contest (Fall 2020)

Analyze and **Predict** the performance of a semi-monocoque wingbox subjected to bending and twisting loads. Using the analysis methods from AE525, predict the bending deflections and angle of twist for three loading cases. The wingbox will be tested to failure and the team achieving the highest score based on a weighted rubric will be the winner. The score will be based on your predictions relative to the measured values, and quality of documentation



Eligibility:

Open to student groups (≤ 5) enrolled in the Fall 2020 AE 525 course

Deadlines:

Entry : Enrolled in AE 525

Submission : **12/06/2020**

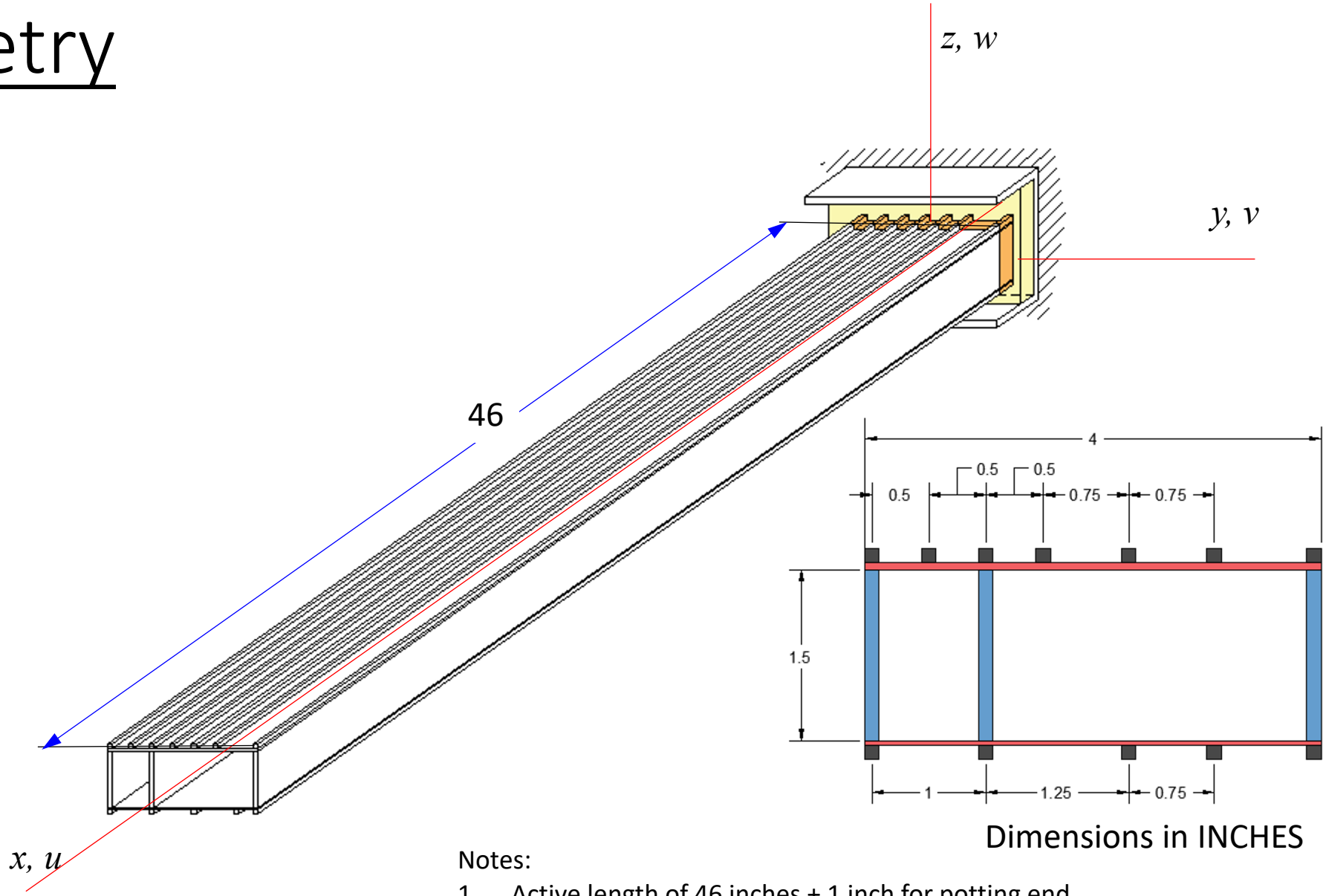
Awards:

1st Place : $1000

2nd Place : $500

3rd Place : $250

Geometry

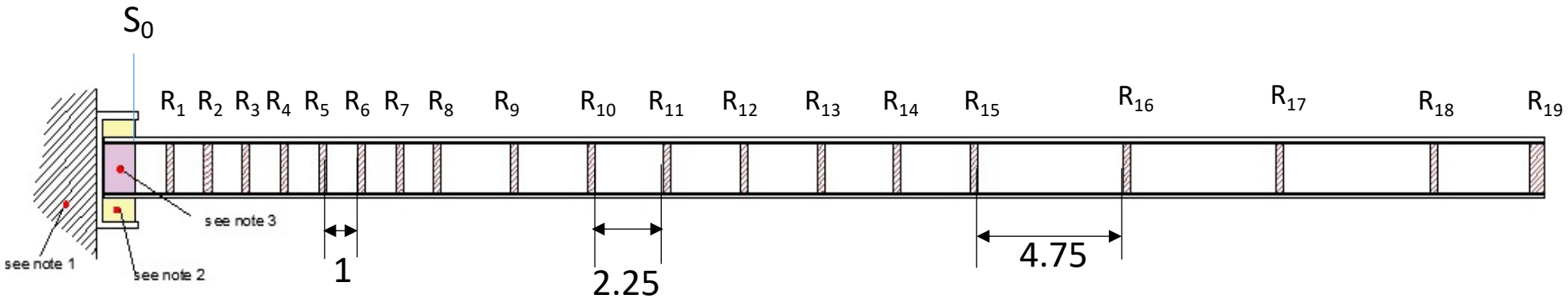


Dimensions in INCHES

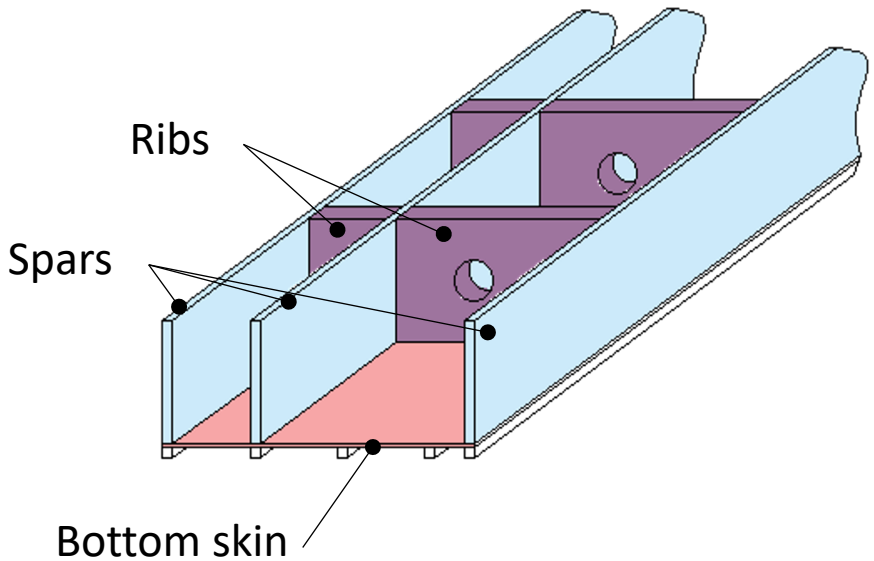
Notes:

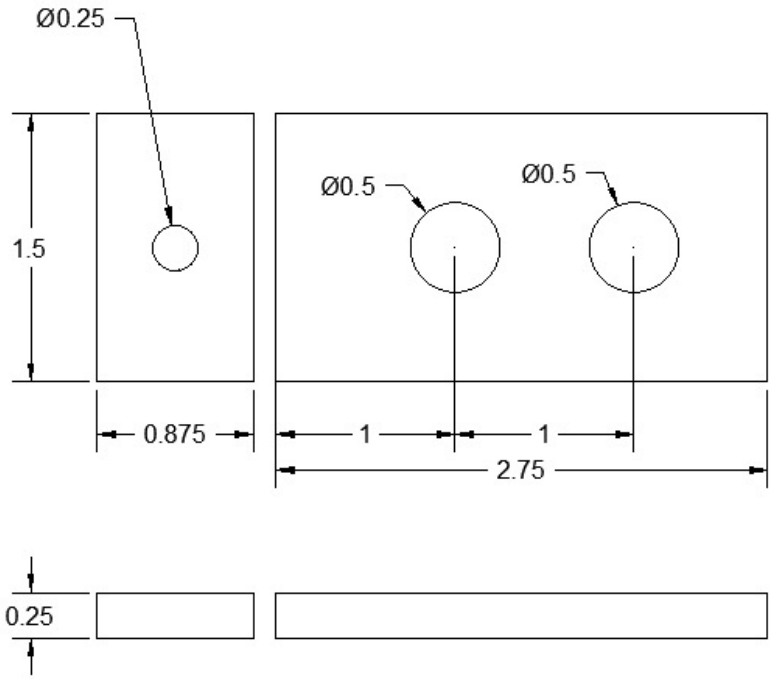
1. Active length of 46 inches + 1 inch for potting end
2. The stringers will be placed on the outside.
3. End will be potted by Flight Structures Lab

Rib geometry and locations



NOTES
1. Rigid support
2. End potted in epoxy resin
3. Ends to be reinforced with balsa rib



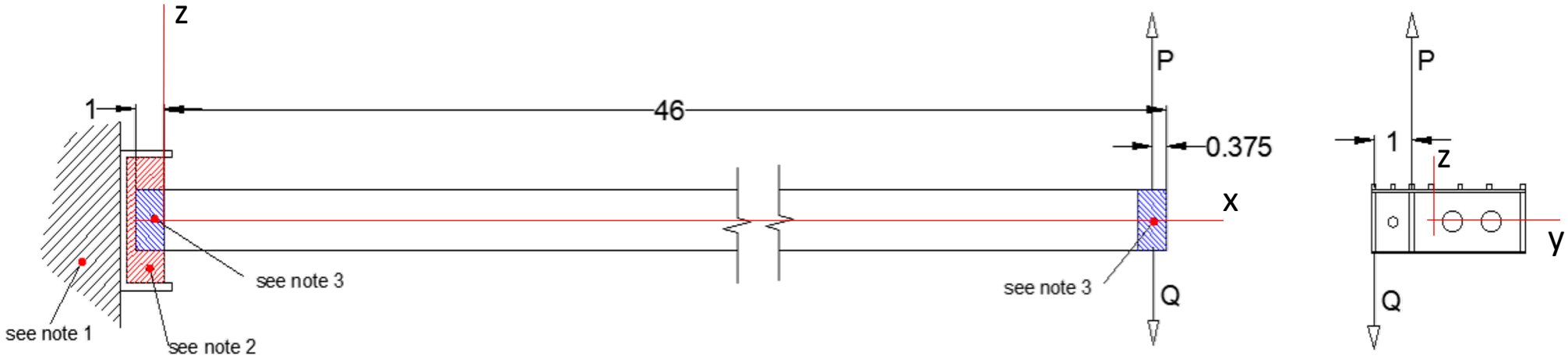


Dimensions in INCHES

MATERIALS

- The wingbox will utilize the following materials.
- Balsa wood
    - Sheets (for skins, spars, ribs)
        - Thicknesses of bottom skin is 1/32 inch
        - Thickness of top skin is 1/16 inch
        - Thickness of spars is 1/8 inch
    - Sticks (for stringers)
        - 1/8 x 1/8 only
  - Pre-cut balsa ribs (1/4 thick)
  - 5/15/30 minute epoxy
- Material properties for balsa sheets and sticks will be provided.
- Grain direction for spars, skins and stringers are parallel to the length (x-direction) of the wingbox

Loading



Dimensions in INCHES

NOTES
1. Rigid support
2. End potted in epoxy resin
3. Ends to be reinforced with 1.00 in thick rib

Load Case	Q (lbf)	P (lbf)
1	1	0
2	1	10
3	1	P_{fail}

Scoring rubric

The designs were scored based on the following formula

$$Score = S_{analysis} + S_{report}$$

$$S_{analysis} = S_1 + S_2 + S_3$$

$$S_1 = 10\left(1 - f\left(w_Q, w_{Q\_pred}, 0.05\right)\right) + 10\left(1 - f\left(\theta_Q, \theta_{Q\_pred}, 0.05\right)\right)$$

$$S_2 = 10\left(1 - f\left(w_{PQ}, w_{PQ\_pred}, 0.05\right)\right) + 10\left(1 - f\left(\theta_{PQ}, \theta_{PQ\_pred}, 0.05\right)\right)$$

$$S_3 = 10\left(1 - f\left(P_{fail}, P_{pred}, 0.1\right)\right) + 5\left(1 - f\left(w_{fail}, w_{fail\_pred}, 0.1\right)\right) + 5\left(1 - f\left(\theta_{fail}, \theta_{fail\_pred}, 0.1\right)\right)$$

$$f\left(A, A_{pred}, \beta\right) = \begin{cases} 0 & \dfrac{\left|A - A_{pred}\right|}{A_{pred}} \le \beta \\ \dfrac{\left|A - A_{pred}\right|}{A_{pred}} - \beta & otherwise \end{cases}$$

Note : The tolerances for strength and stiffness are based on variability in material properties.

w_Q, θ_Q ~ Measured end deflection and twist angle at Q=1 lbs

$w_{Q\_pred}, \theta_{Q\_pred}$ ~ Predicted end deflection and twist angle at Q=1 lbs

w_{PQ}, θ_{PQ} ~ Measured end deflection and twist angle at P=10 lbs (+Q=1lbs)

$w_{PQ\_pred}, \theta_{PQ\_pred}$ ~ Predicted end deflection and twist angle *at* P=10 lbs (+Q=1lbs)

P_{fail} ~ Measured failure load

P_{pred} ~ predicted failure load (lbs)

w_{fail}, θ_{fail} ~ Measured end deflection and twist angle at P_{fail} (+Q=1lbs)

$w_{fail\_pred}, \theta_{fail\_pred}$ ~ Predicted end deflection and twist angle at P_{pred} (+Q=1lbs)

Analysis requirements

- The analysis used for the design of wingbox must be based on the methods learnt in AE 525.
- The following must be clearly stated in the report.
  - Free body diagrams with loadings for each case.
  - Internal loads diagrams for each case
  - The assumptions, idealizations, etc.,
  - section properties
  - material properties, Failure criteria
- The following predictions must be summarized
  - Failure load , Failure mode and location
  - End deflections (round to nearest 0.01 inches); End twist (round to nearest 0.1 degrees)
  - % bending loads resisted by each component (spars, skins and stringers) for each load case
  - End deflections and rotations computed
    - At P_{fail} (with Q applied)
    - At P=10 lbs (with Q applied)
    - At Q = 1 lbs and P=0

Report Requirements

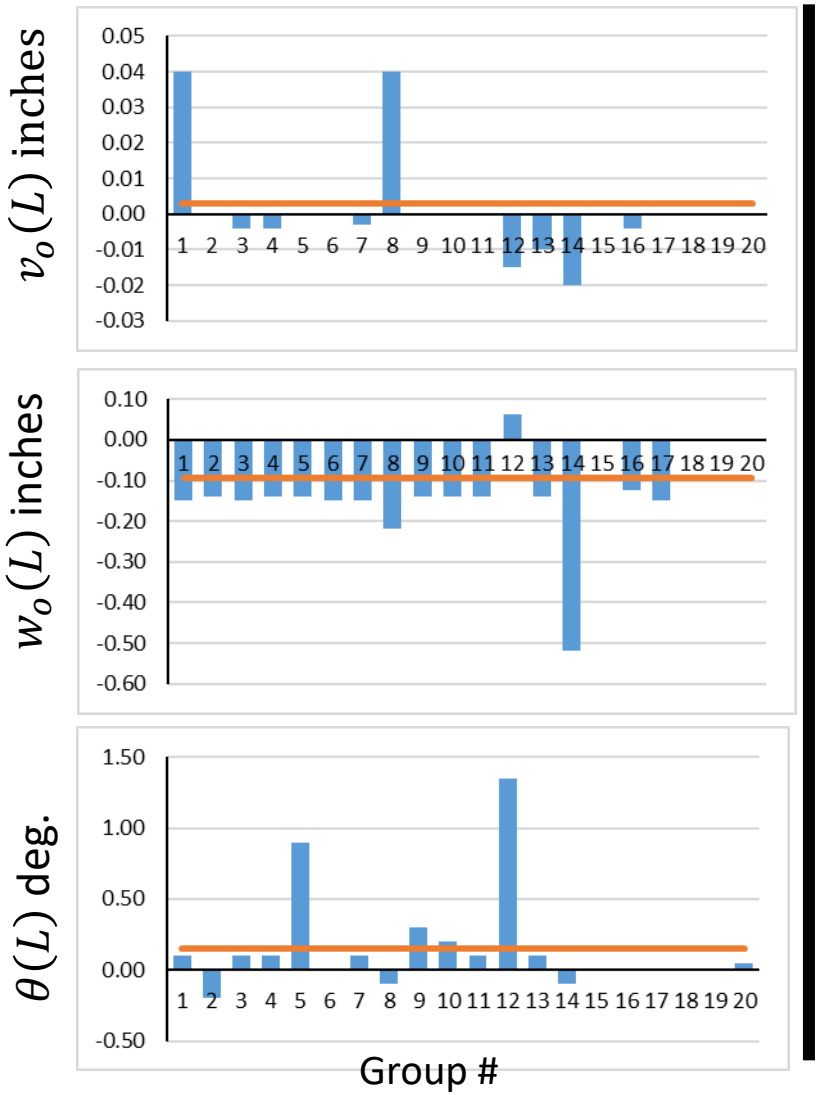
- The final report must be submitted in power point format with no more than 15 slides
  - Title slide : Group #, list of team members
  - Slides 2 through 12 :
    - Problem statement (2 slides)
      - Includes FBD's, boundary conditions, section geometry, load cases
    - Summary of material properties (1 slide)
    - Analysis
      - You decide what goes in here. A person reading this portion must be able to understand and replicate your analysis and results.
    - Summarize of predictions (use template)
  - Slides 13 and 14:
    - Dimensional drawings of components and assembly using (Catia/Solidworks/AutoCAD). Hand drawings will be penalized by 20 points
- The final report must be provided in pdf format. The report pages shall be numbered and arranged in a logical sequence. All slides must have 'landscape' orientation. No part of the report shall be handwritten. (20 points penalty for not complying with these requirements)
- Plagiarism will result in automatic disqualification from the contest and a fail grade for the project

Predictions vs. Test data

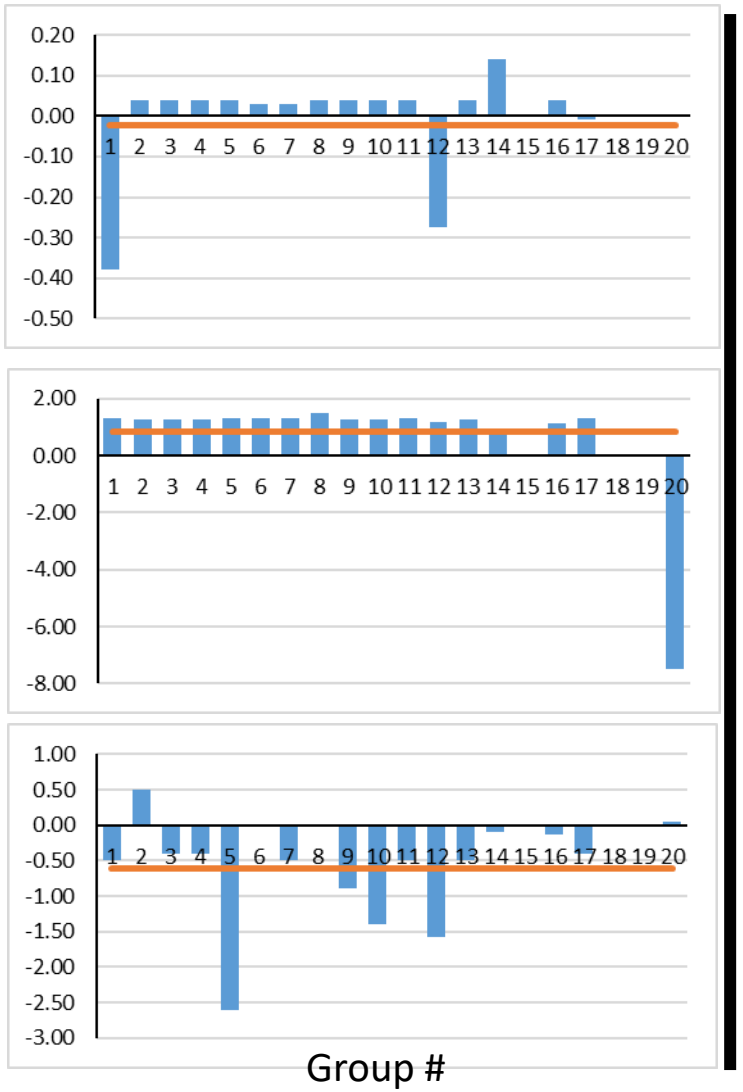
Quantity	Units	Test	Group #															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17	20
End deflection 'v' at Q= 1 lbf, P=0	in	0.003	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	-0.02	-0.01	-0.02	0.00	0.00	0.00
End deflection 'w' at Q=1 lbf, P=0	in	-0.092	-0.15	-0.14	-0.15	-0.14	-0.14	-0.15	-0.15	-0.22	-0.14	-0.14	-0.14	0.06	-0.14	-0.52	-0.12	-0.15	0.00
Angle of twist at free end, 'θ' at Q=1 lbf, P=0	deg	0.147	0.10	-0.20	0.10	0.10	0.90	0.00	0.10	-0.10	0.30	0.20	0.10	1.35	0.10	-0.10	0.02	0.00	0.04
End deflection 'v' at Q= 1 lbf + P=10 lbf	in	-0.0219	-0.38	0.04	0.04	0.04	0.04	0.03	0.03	0.04	0.04	0.04	0.04	-0.27	0.04	0.14	0.04	-0.01	0.00
End deflection 'w' at Q=1 lbf, + P=10 lbf	in	0.862	1.33	1.28	1.28	1.27	1.30	1.34	1.34	1.51	1.28	1.28	1.30	1.18	1.28	0.78	1.12	1.34	-7.48
Angle of twist at free end, 'θ' at Q=1 lbf + P=10 lbf	deg	-0.61	-0.50	0.50	-0.40	-0.40	-2.60	0.00	-0.50	0.00	-0.90	-1.40	-0.50	-1.58	-0.50	-0.10	-0.14	-0.40	0.04
Failure load 'P'	lbf	50.7	32.75	33.72	22.36	15.91	21.95	24.49	18.13	22.33	33.58	20.10	32.38	31.20	33.60	19.60	41.07	52.20	17.60
End deflection 'v' at Q=1 lbf, + failure load P	in	-0.134	-1.34	0.15	0.09	0.09	0.09	0.08	0.06	0.09	0.14	0.08	0.14	-0.95	0.14	0.29	0.17	-0.06	0.00
End deflection 'w' at Q=1 lbf, + failure load P	in	5.19	4.70	4.67	3.05	2.11	3.03	3.12	2.56	3.59	4.65	2.73	4.53	4.13	4.65	2.03	4.98	7.64	-13.16
Angle of twist at free end, 'θ' at Q=1 lbf + failure load P	deg	-3.32	-1.80	2.20	-1.10	-0.70	-5.00	0.10	-0.90	0.00	-3.70	-3.00	-2.00	-17.90	-1.90	0.00	-0.62	-2.00	0.04

Predictions vs. Test data

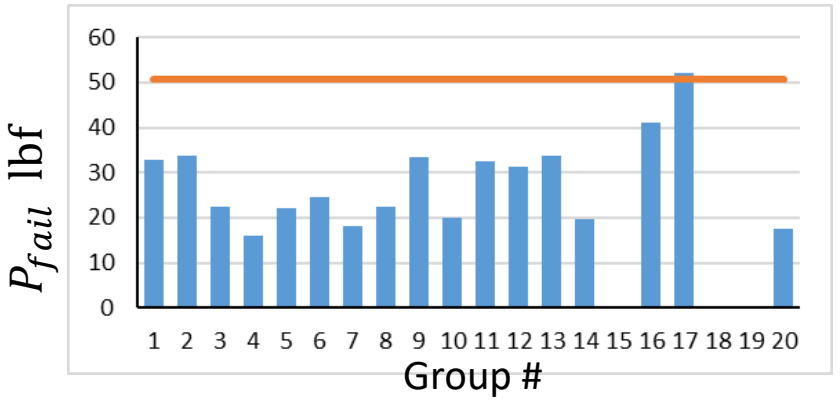
Q=1 lbf, P=0



Q=1 lbf, P=10 lbf



Q=1 lbf, P (Loaded to failure)



Predictions

Test

Summary of Scores

Score	Group #																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17	20
S_1	12.43	0.22	12.43	12.87	9.20	7.13	12.43	-9.52	12.47	14.92	12.87	-12.63	12.87	-11.93	-69.58	7.13	-13.19
S_2	15.28	-4.47	12.48	12.54	9.98	7.43	15.23	6.71	14.51	12.09	15.43	12.17	15.53	-31.05	-15.85	12.18	-142.01
S_3	11.78	3.86	-4.27	-25.89	3.66	7.48	-14.55	2.07	15.81	1.74	12.31	14.75	12.59	-2.15	-2.41	16.10	2.19
$S_{analysis}$	39.49	-0.38	20.64	-0.48	22.84	22.05	13.12	-0.74	42.79	28.75	40.62	14.28	41.00	-45.13	-85.44	19.32	-155.20
S_{report}	54	62	73	75	82	62	70	44	56	78	66	41	60	79	48	62	28
Total	93.49	61.62	93.64	74.52	104.84	84.05	83.12	43.26	98.79	106.75	106.62	55.28	101.00	33.87	-37.44	81.32	-127.20
Rank	7	12	6	11	3	8	9	14	5	1	2	13	4	15	16	10	17

Winners

- 1st Place
  - Foster, Jagadheeswaran, Pathak, Reiling, Timmons
- 2nd Place
  - Borges, Valencia, White, Miller
- 3rd Place
  - Anderson, Gutierrez, Schmid, Ziegler