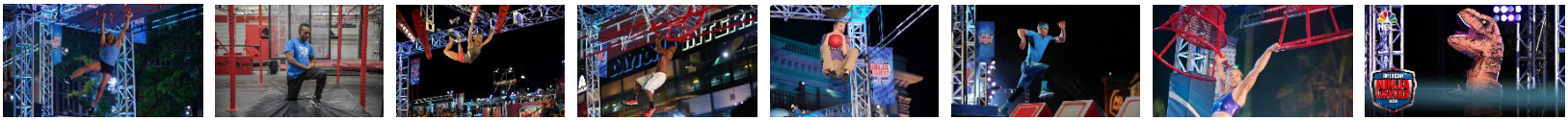


ES 2502 B'18– Stress Analysis Term Project

American Ninja Warrior Obstacle Design

Submission 3 – Bending Stresses

Introduction:

For submission 3, you and your team will be analyzing the bending normal and shear stresses on some region of your design. You will also calculate deflection of that bending member. For submission 1 you should have had a FBD (or multiple FBDs) that had bending loading. You will use one these FBDs for this submission 3 analysis. If you did not have a FBD that had a bending load, you will either need to define another FBD in your current design where a bending load exist, or modify your obstacle such that a bending load can be analyzed. If you made changes to your design during submission 2, you can use your FBDs from either submission 1 or 2 for this analysis (or new FBDs if necessary). Your torsional and axial stresses from submission 2 should not be included in this submission. You only need to include the content necessary to analyze normal and shear stresses due to bending, beam deflection, and anything needed to pitch your ideas to the obstacle selection committee.

Submission Requirements:

The objective of this project submission is to give you and your teammates the opportunity to apply the bending stress calculations you have been learning in class to your project. You will be submitting:

1. Normal stress calculations due to bending loading
2. Shear stress calculations due to bending loading
3. Beam deflection due to bending loading

For each of these sets of calculations you need to evaluate the loads on your FBDs to solve for reactions and determine the location along the member where the maximum loading occurs. You will draw shear and bending moment diagrams for your structure to find the maximum shear loading and moment loading. Based on the cross sectional properties of your system, you will calculate the maximum shear stress and normal stress due to bending. Based on the equations for bending moment, and appropriate boundary conditions, you will calculation the deflection of the member.

Your calculations should be clear and easy to follow. Use comments as you go through your calculations to explain your work. While submission 3 is related to submissions 1 and 2, it needs to be a standalone document. Anything that you need to include in submission 3 that is related to content from submissions 1 and 2 should be incorporated into this submission. This may include images of the obstacle, FBDs, or other earlier developed content.

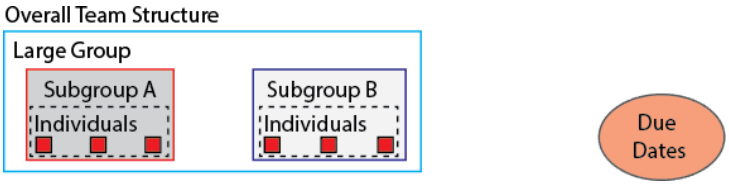
Teams and Team Roles For Submissions:

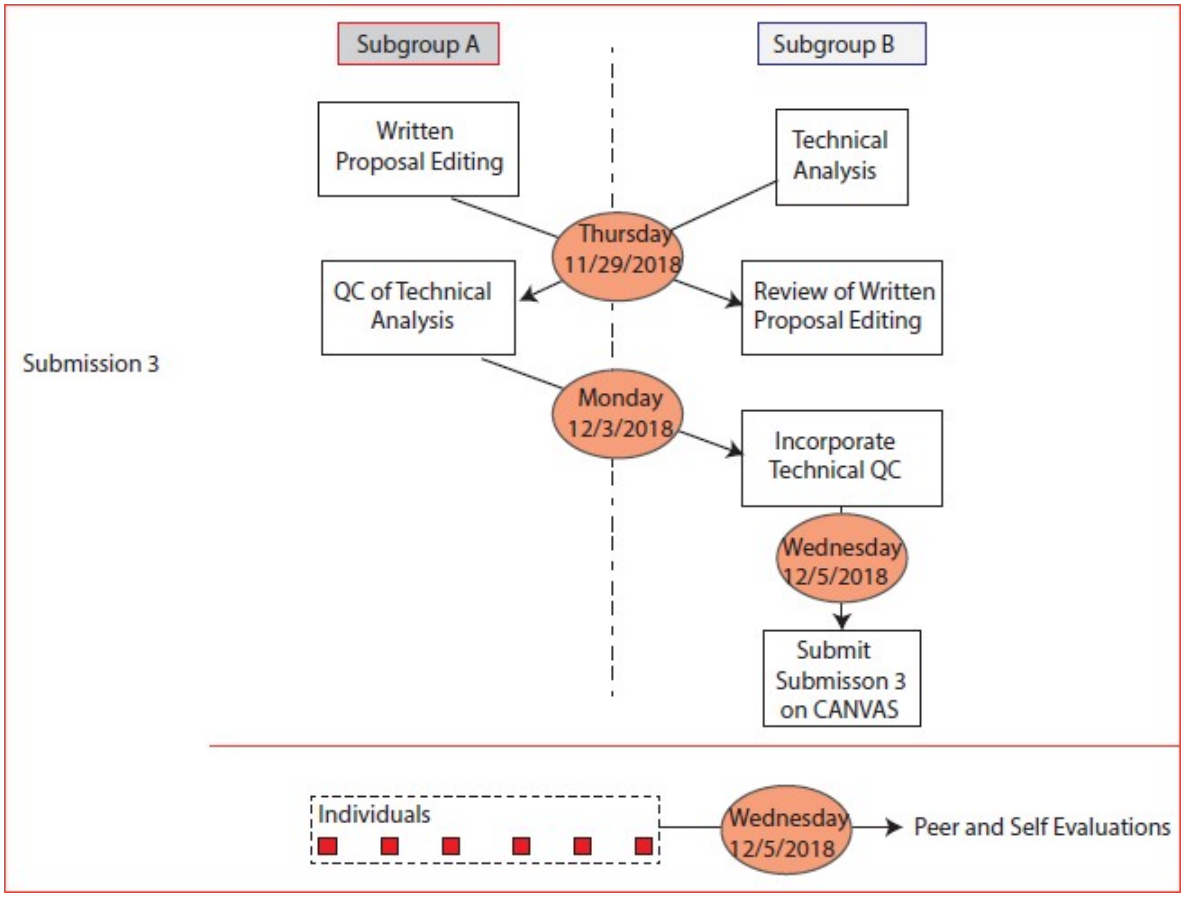
The graphic below displays the Subgroup and Large Group Roles for Submission 3.

Submission 3: Subgroup B will be the lead technical group. They will complete the stress analysis and send their work to subgroup A for QC. Subgroup A will review the work from subgroup B and provide written feedback. This feedback must be clear and easy to follow. It will be part of the overall final submission. Subgroup B will incorporate the feedback from subgroup A and submit Submission 3. In addition to the technical work, subgroup A will start by editing the written proposal (next draft after Submission 2). Subgroup A will send the edited draft to subgroup B for a final edit before adding the written proposal to Submission 3.

You may decide as a team how you would like to divide up the work of making the poster.

Peer and Self-Evaluations: For each submission, each team member must fill out the peer and self-evaluation form on CANVAS in order for the team to receive a grade for the submission.





Deliverables:

For Submission 3 you will be delivering the following content using the template provided on CANVAS (the peer and self-evaluation will be submitted individually through a CANVAS survey).

- Poster draft (digital submission as a separate .pdf)
    - Your poster is your chance to visually explain your obstacle to the obstacle selection committee. It should include information that would help the selection committee choose your design. This may include:
        - How your obstacle will be used
        - How your obstacle is different from others that already exist
        - Why the viewing audience would like your design
        - How the design can be portable between different cities
        - What factors you used to make decisions about geometries, materials, or other specifications
    - The poster should be visually appealing and should be clearly understood
    - The poster should have dimensions of 4'x3' or 3'x4'. You can make this poster in whatever program you choose, but it should be converted to .pdf for the submission. If you would like to use other dimensions, you may, but email me or ask for permission before making this change.
- Written proposal
    - This is the next draft of the written proposal from Submission 2. This has a <u>maximum length of 2.5 pages</u>. This does not include your bibliography. Be sure to include your inline citations to refer back to your bibliography!
- Final Normal and Shear bending stress calculations and deflection calculation
    - Normal stress due to bending calculations must include
        - plotting the bending moment diagram (note, for many of your obstacles, the weight cannot be neglected and this should be reflected in your plots.)
        - locating the point(s) with maximum normal stress based on the cross-sectional area properties and loading
        - calculating this maximum normal stress and <u>drawing the distribution of stress across the cross section at that location</u>
    - Shear stress due to bending calculations must include
        - plotting the shear force loading along the axis of the object
        - locating the point(s) along the axis of the object with maximum shear stress due to bending based on the cross-section and loading
        - calculating this maximum shear stress and <u>drawing the distribution of stress across the cross section at that location</u>
    - Deflection calculations
        - Integration of moment equation(s)
        - Determination of appropriate boundary conditions
        - Plots for slope and defection of the beam along the length of the beam (this would be a function of x for most in-class examples but will depend on the orientation of your individual analysis)
    - All assumptions for each set of calculations must be included with the calculations.

    - Any additional information needed to explain the scenario that was contained in submissions 1 and 2 should be included in submission 3. Submission 3 should be a standalone document.
- Original calculations from subgroup B
- QC from subgroup A of the original calculations
- Written set of bullet points from subgroup B for all the ways in which the QC from subgroup A was incorporated into the final submission
- Individual submissions of peer and self-evaluations
    - This is submitted separately on CANVAS and is not part of the team submission.

The same late submission criteria will be used for this submission as for the previous 2 submissions.

Rubric:

Category	Exceeds Expectations (95% ±5%)	Meets Expectations (85%±5%)	Acceptable (75%±5%)	Needs Improvement (50%±25%)
Professional Appearance (5 points)	Final submission is clean, polished, professional. Draft work is in draft form, but the overall document still appears professional	Final submission is clean, polished, professional. Draft work is in draft form but cannot be followed easily due to its integration into the overall report	Final submission is somewhat clean, but either due to messy work or poor scanning does not look polished and professional.	Final submission is not clean and does not meet a professional standard.
Poster submission (5 points)	-The size and distribution of text and graphics are balanced. -It is visually attractive in terms of color, design, and flow.	-The size and distribution of text and graphics are balanced. There are 1 or 2 problem areas -It is generally visually attractive in terms of color, design, and flow. -There are one or two problem areas	-The size and distribution of text and graphics makes the poster difficult to read. There are 2 or 3 problem areas -It is often not visually attractive in terms of color, design, and flow. -There are two or three problem areas	-The size and distribution of text and graphics makes the poster difficult to read. There are more than 3 problem areas -It is not visually attractive in terms of color, design, and flow. There are more than three problem areas.
V and M diagrams (5 points)	Diagrams are correct, fully labeled, and clear.	Diagrams have minor errors. There is 1 minor error in the calculations	Diagrams have major errors. There are 2 minor errors or 1 major error in the calculations.	Diagrams are omitted or cannot be read. There are more than 2 minor errors or more than 1 major error in the calculations.
Stress Calculations (15 points)	Calculations were error free and included plots, maximum stress, and drawn stress distributions.	Minor errors were made and/or one of the required elements was limited (plots, max stress, stress distributions).	Major errors were made and/or one of the required elements was limited or omitted (plots, max stress, stress distributions).	Major errors were made and/or two or more of the required elements was limited or omitted (plots, max stress, stress distributions).
Evaluation of Calculations (5 points)	Calculations are evaluated for both mathematical correctness and realistic nature.	Calculations are reviewed but the values are not fully assessed relative to the reasonable nature of the values determined.	Calculations are checked, but not completely. Evaluation of the numerical solution is lacking.	Calculations are not evaluated, or evaluations is minimal.
Written Proposal (5 points)	Writing is strong, formal, and clearly conveys a logical message.	Writing is somewhat strong and/or somewhat formal and/or conveys a message but it is not completely clear.	Writing is weak and/or informal but a message, while possibly not completely clear, is conveyed.	Writing is weak and/or informal and/or a clear logical path cannot be followed.
Draft Work /QC (10 points)	All draft work and QC work shows a high level of effort was put in by both Subgroups. All errors were caught by QC.	Draft work and QC work shows a moderate level of effort was put in by both Subgroups. Most errors were caught by QC.	Draft work and QC work shows some effort was put in by one or both Subgroups. Many errors were not caught by QC.	Draft work and QC work shows minimal effort was put in by one or both Subgroups. Many errors were not caught by QC.

QC Process:

The goals of the QC process include:

1) Find errors in project understanding
2) Find errors in modeling mathematical calculations
3) Ensure alignment between the submission and the project expectations as outlined in the rubric
4) Ensure effective communication of ideas within the submission
5) Practice communication between groups of engineers

To ensure that the conducted QC meets all of these goals, the QC should include the following: (aligned with the goals listed above)

1) A check of the overall submission. Does the overall logic and flow of the analysis meet the project criteria?
2) All calculations should be checked to ensure there are no errors ranging from poor assumptions, to errors in modeling the system, to calculator errors.
3) The submission aligns with the project expectations. The rubric can be used as a guideline to be sure that the expectations are met.
4) The project submission is delivered in such a way that it is easy for a reviewer to follow. There is a logical flow to the content that leaves no gaps between points made. The submission looks clean, polished, and professional.
5) The QC information must be conveyed to the original group in a manner that is effective and efficient. You should keep a positive tone when critiquing your peers. It should be easy for them to look at your QC and know exactly what it good, what needs improving, and how those improvements should be made. There are a number of methods that can be useful in communicating your QC.
    a. Using screenshots
    b. Printing documents, writing directly on them, and scanning your written work
    c. Video recordings showing your comments
    d. Many other options
    e. In addition to your other feedback, your QC should have at least ½ page written to summarize your groups' feedback. This should highlight both strengths and weaknesses of their work as well as summarize your overall impression.

The following rubric will be used to evaluate the quality of your QC

QC Points Rubric

	5 pts	**3 pts**	**1 pts**	**0 pts**
Errors Identification	All calculation errors were found	1 calculation error was not identified	2 calculation errors were not identified	3 or more calculation errors were not identified
Clear and Legible Feedback	The root cause of the error is identified, and the change required to correct this action is shown. Corrective actions have clear feedback.	The root cause is not always identified, but changes are shown. Corrective actions have clear feedback.	Corrective actions are not clear, some changes are unclear or incorrect	Incorrect changes/corrections are given. Feedback is unclear/not decipherable.