Project 1a – Treehouse Design Analysis

- How high off of the ground should the treehouse sit?
- Size of the trunk → are there diameter restrictions? Making people feel safe vs making it monolithically large
- Weight of the treehouse
- Should cost be considered? How high end vs practical is the structure?
- Aesthetics → tree bark? Limbs?
- Climate → elevation, rainfall, foundation, landscape and ground erosion
- Will there be plumbing, and should a hollow trunk be utilized to house the pipes?
- Shape of the trunk or cross section → is the treehouse meant to fit in with its surroundings?
- How is it accessed? Stairs? Ladder? How physically able is Aunt Ada to reach the treehouse and how long does she intend to use it for?
- How is the trunk connected to the treehouse, and how would this impact the design; ie. Supports from the base of the treehouse, is it welded on, is it bolted in place, etc.
- Purpose of the treehouse→ business vs pleasure? How leisurely is the treehouse?
- Can more than one trunk be utilized (in 1D loading) to reduce stress?
- Future restoration ability of the trunk if it is a long term structure → should the trunk be built in such a way that if something fails, it can be easily repaired?
- What is the foundation? What is constraining the base? Are we assuming the base will not deform?
- Access to the necessary tools for construction
- Using a composite material to create tree rings
- Column buckling
- Temperature changes that could cause expansion and contraction (especially relevant for composites)
- Factor of Safety for a treehouse
- Lightning → Aunt Ada's treehouse should NOT be a lightning rod
- Fatigue, deflections, strain limit
- Fracture toughness (relevant to small children throwing baseballs)
- Material availability, material processing for this size structure, seams/welds for metal, other methods of joining material.
- Appropriate taper angle for a tapered trunk
- Weight of the trunk on itself
- Material wear based on estimated lifespan of the treehouse (relevant for wood)
- Plastic limits

Project 1b: Most important Criteria

The most important criteria for the design of the treehouse are the weight of the treehouse, the distribution of this weight throughout the treehouse, and the shape and material of the trunk. The weight of the treehouse is expected to be around 400kips (for a 2000ft^2 house, at 200lb/ft^2). Then, using this number, the next important factor is how this weight is distributed throughout the trunk. Dividing the load throughout the trunk would be the most helpful in avoiding buckling, and there is also the option to reduce the load through the use of artificial limbs. Depending on both of these factors, the next most important factors are cross section shape of the tree trunk, and the way this area varies over the entire height. Using a circular cross section would provide equal resistance to bending in the occasion of high winds, and some form of tapering would be efficient as the weight of the trunk itself compiles on the base. Lastly, the material used for the trunk will be critical, and will depend on the decisions made regarding all of the above criterion. The material's yield stress, Young's Modulus, and density will all be relevant in determining the forces throughout the structure, the deflections within the structure, and whether or not the material will buckle. The material, therefore, should be decided upon last, once these prior decisions have been made for the trunk and treehouse design.

1c – development of a code flowchart

Constants:

Sect = #elements	m = slope
Nodes = #elements+1	b = intercept
H = height	$r_{avg} = h_{avg} - b / m$
L = H/sect	bf = base fixed = 0/1
$A = \pi * r_{avg}^2$	tf = top fixed = 0/1
H_{avg} = (sect# + 0.5) * L	fmat = forces
E = Young's Modulus	dmat = displacements
Kcoe = zeros(1,sect)	Amat = areas
Kcoe = AE/L for each section	stresses = stress matrix

Kbase = $\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$

KMAT = zeros(nodes, nodes)

dmat = (for n sections)

Section number	0	1	2	N
Nodes	1	2	3	N+1
Node location	0	L	2L	H
h_{avg}	#	#	#	#
R_{avg}	#	#	#	#
Length of section	H/sect	H/sect	H/sect	H/sect
Area of section	#	#	#	#

<u>Trunk Parameters</u>

m, b, L, sect, H

⇩

r_{avg}, h_{avg} — <u>Dimensions</u>

⇩

A, E, L — <u>Material Properties</u>

⇩

Kcoe, kbase, tf, bf — <u>Element Matrices</u>

⇩

KMAT — <u>Global Matrix</u>

<u>Analysis Matrices</u>

KMAT

⇩

$KMAT^{-1}$, fmat

⇩

dmat, amat

⇩

stresses