The ME111 Way to Solve “Like Totally Impossible” Problems

1. Draw a Free Body Diagram (FBD) – Look at the EXTERNAL forces and moments acting on the whole object, then break it down into sub-assemblies. **GOAL: ALL EXTERNAL FORCES & MOMENTS.**
   a. Shear and bending moment diagrams
   b. Method of joints/sections
   c. Static equilibrium conditions (\(\Sigma F = 0, \Sigma M = 0\) \(\Leftarrow\) in 3-D even!)
   d. Right Hand Rule to figure out moments – use pens, tinker toys…
   e. Make basic assumptions (no deformation under load…)
   f. Make a mock-up of it…cardboard, paper, foam, wood

2. Get Data – Tables in the book, the Web, other books, your company.
   a. Things like E, I, Z, c (listed as \(\bar{y}\) sometimes in the back), \(S_{tu}, S_y\)
   **GOAL: KNOWLEDGE ABOUT SPECIFIC PROBLEM**

3. Based on educated guesses/directions cut assembly into pieces and analyze critical sections.
   a. Often sections with curves, notches, cracks, holes, parts attached to walls…
   b. Look at Bending, Torsion, Shear (Juvinall 4.2 – 4.8) See where the stresses add up (look at #1)
   **GOAL: INTERNAL FORCES & STRESSES**

4. Find maximum stresses and strains.
   a. Mohr’s circle in 2 & 3-Dimensions
   b. Maximum Stress Theories
   **GOAL: FIND IF IT’LL BEND OR BREAK**

5. Use fracture mechanics and failure theory to check other failure modes
   **GOAL: FIND IF IT’LL BREAK OVER TIME**

6. Optimize for safety factors, weight constraints, cost, color, etc…
   **GOAL: MAKE IT BE THE BEST IT CAN BE!**
ANALYZING A SWING AERIAL

© Ben 2000
\[ \Sigma F_x = 0 \]
\[ R_x + F \sin 45^\circ = 0 \]
\[ R_x = -50N \]

\[ \Sigma F_y = 0 \]
\[ R_y - 50N = 0 \]
\[ R_y = 50N \]

\[ \Sigma M = 0 \]
\[ -(50N)(1m) - (50N)(1m) + M = 0 \]
\[ M = 100 \, N.m \]
\[ \frac{R_y}{F_y} = E_y = \frac{V}{3} \frac{V}{x} \]

\[ \frac{R_x}{F_x} \quad \sigma_{xx} = \frac{E}{A} \]

\[ M \quad \sigma = \frac{F_r}{J} = \frac{Mc}{I} \]

\[ \frac{R_3}{F_y} \quad R_x/F_x \]

\[ \frac{R_3}{F_y} \quad R_x/F_x \]

\[ \frac{R_3}{F_y} \quad R_x/F_x \]

**NOTE:** These stresses might not be maxima! ...