

The following is required for all Excel (or MATLAB, or whatever “programming language” you choose) based analysis in engineering classes (proper communication):

- By hand, develop the necessary equations to be used in Excel. Be sure to use the standard problem-solving format (given, find, assume, etc). Be sure to include all equations in variable form first. Include units at every step of the hand calculations. NEVER do programming (Excel, MatLab, etc.) without FIRST working it out on paper!
- The equations in Excel (MatLab, by hand, etc.) should be “basic” equations, not “combined” equations – keep each equation as simple as possible (see example discussion below).
- Do NOT embed numeric data into the spreadsheet equations. You should have input variables (such as given material properties) in individual spreadsheet cells – and then refer to those cells in the spreadsheet equations.
- To check the spreadsheet, by hand do sample a calculation for one line of the spreadsheet. Do not use the top line as the example, only lines that have been “cut/pasted.”
- Discuss the results (what do you conclude from the graph).
- It is NOT necessary to submit all pages of the spreadsheet! Submit ONLY the top lines – this may require one or more pages (use Landscape mode to minimize the number of pages). Multiple pages of numbers tell me nothing – important data should generally be in the graph(s).
- If you are trying to show a relationship, include a properly formatted graph (or graphs) showing the results (the intended relationships). Proper graphs include axes labels, etc. For most assignments, the graphs **may be on the same page as the spreadsheet.**
- Include a brief problem statement in the top left of the spreadsheet.

The following illustrate incorrect, and then correct adherence to this process:

**What not to do:**

**Neither** your hand calculations or the spreadsheet equations should look like this:

$$\sigma = (0.5*3000N)*(0.5*5000mm)*(0.5*d)/\{\pi(d)^4/64\}$$

Or even **worse**:

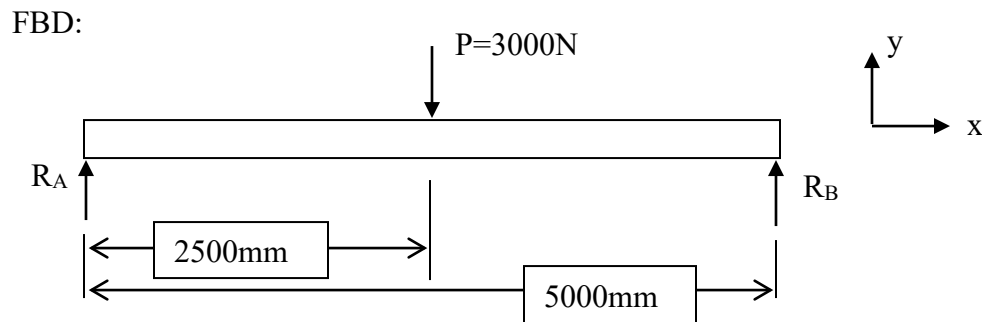
$$\sigma = 9325.49/d^3$$

Combining equations such as this must be AVOIDED! Putting specific values (such as 3000N or 5000mm or 9325.49) should always be AVOIDED in the spreadsheet! When so doing, it complicates trouble shooting, it is less clear what is being done, it increases opportunity for mistakes, and it reduces the flexibility of the spreadsheet. For example, there may be a future problem that is very similar, but has a different force applied. You will then have to search all of your equations to find where force is applied. **It is better to keep equation in variable form as much as possible, then refer to the appropriate cell that contains the value.**

It is not clear in either of the above equations what is being done and they are difficult to troubleshoot. Judge this for yourself: Compare the above equations with the example below where each equation ( $R_A$ ,  $M$ ,  $y$ ,  $I$ ,  $\sigma$ ) is entered into individual spreadsheet cell/columns. **Done much better:**

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Given: Bending load on a circular beam shown below.  
Find: Relation between beam diameter and maximum bending stress.  
Assume: Small deflections, elastic deformation  
Solution:



$$R_A = 0.5 * P = 1500\text{N (due to symmetry, } R_A = R_B \text{ and } R_A + R_B = 3000\text{N)}$$

$$\sigma = My/I$$

$$M = \text{moment at load application} = R_A * L_A = 1500\text{N} * 2500\text{mm} = 3,750,000 \text{ N-mm}$$

$$y = \frac{1}{2} * \text{Dia (distance from neutral axis to top/bottom of beam)}$$

$$I = \pi D^4 / 64 \text{ (back cover of Shigley's Machine Design text)}$$

See attached Excel spreadsheet and graph. Sample calculation:

$$\text{Let dia} = D = 6\text{mm}$$

$$y = \frac{1}{2} * D = 3\text{mm}$$

$$I = \pi D^4 / 64 = \pi(6)^4 / 64 = 63.6 \text{ mm}^4$$

$$\sigma = My/I = (3,750,000 \text{ N-mm}) * (3\text{mm}) / 63.6 \text{ mm}^4 = 176,800 \text{ MPa}$$

Conclusion: based off the attached graph, it can be seen that the stress decreases rapidly with an increase in diameter. Therefore, a small decrease in diameter can significantly weaken the beam, and small increases can significantly increase the factor of safety.

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*Notices in the spreadsheet example that follows, that variables such as the loads are clearly identified in the blue shaded cells and NOT in the equations themselves. The equations call upon the values in those cells. It makes the spreadsheet much easier to troubleshoot, and to revise for future use. The equations are applicable for all cantilever beams regardless of load and length.*

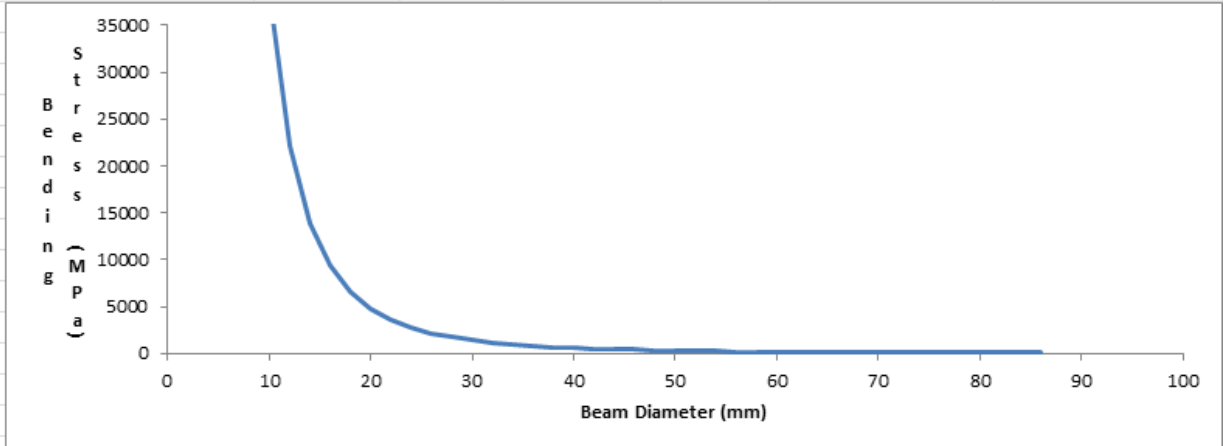
Determine maximum bending stress as a function of beam diameter						
Given		Diameter mm	y mm	Moment of inertia (I), mm <sup>4</sup>	bending stress, MPa	
Maximum load, N	3000	2	1	1	4774648	
Reaction at A, N	1500	4	2	13	596831	
Beam length, mm	5000	ex: 6	3	64	176839	
Moment arm, mm	2500	8	4	201	74604	
Max Bending M, N-mm	3750000	10	5	491	38197	
		12	6	1018	22105	
		14	7	1886	13920	
		44	22	183984	448	
		46	23	219787	392	
		48	24	260576	345	
		50	25	306796	306	
		52	26	358908	272	
		54	27	417393	243	
		56	28	482750	218	

*Notice: the spreadsheet is continued onto multiple pages for diameters greater than 56mm, but is not included here since it adds nothing! No one wants to look at multiple pages of numbers when the graph shows the data!*

*NOTE: see next page for what the spreadsheet equations look like. To show equations: CTRL~ (hold "control" and "tilde" keys)*

Determine maximum bendin

Given		Diameter mm	y mm	Moment of inertia (I), mm <sup>4</sup>	bending stress, MPa
Maximum load, N	3000	2	=D4/2	=PI()*D4 <sup>4</sup> /64	=B\$8*E4/F4
Reaction at A, N	=B4/2	=D4+2	=D5/2	=PI()*D5 <sup>4</sup> /64	=B\$8*E5/F5
Beam length, mm	5000	ex: =D5+2	=D6/2	=PI()*D6 <sup>4</sup> /64	=B\$8*E6/F6
Moment arm, mm	=B6/2	=D6+2	=D7/2	=PI()*D7 <sup>4</sup> /64	=B\$8*E7/F7
Max Bending M, N-mm	=B7*B5	=D7+2	=D8/2	=PI()*D8 <sup>4</sup> /64	=B\$8*E8/F8
		=D8+2	=D9/2	=PI()*D9 <sup>4</sup> /64	=B\$8*E9/F9
		=D9+2	=D10/2	=PI()*D10 <sup>4</sup> /64	=B\$8*E10/F10



		=D24+2	=D25/2	=PI()*D25 <sup>4</sup> /64	=B\$8*E25/F25
		=D25+2	=D26/2	=PI()*D26 <sup>4</sup> /64	=B\$8*E26/F26
		=D26+2	=D27/2	=PI()*D27 <sup>4</sup> /64	=B\$8*E27/F27
		=D27+2	=D28/2	=PI()*D28 <sup>4</sup> /64	=B\$8*E28/F28
		=D28+2	=D29/2	=PI()*D29 <sup>4</sup> /64	=B\$8*E29/F29