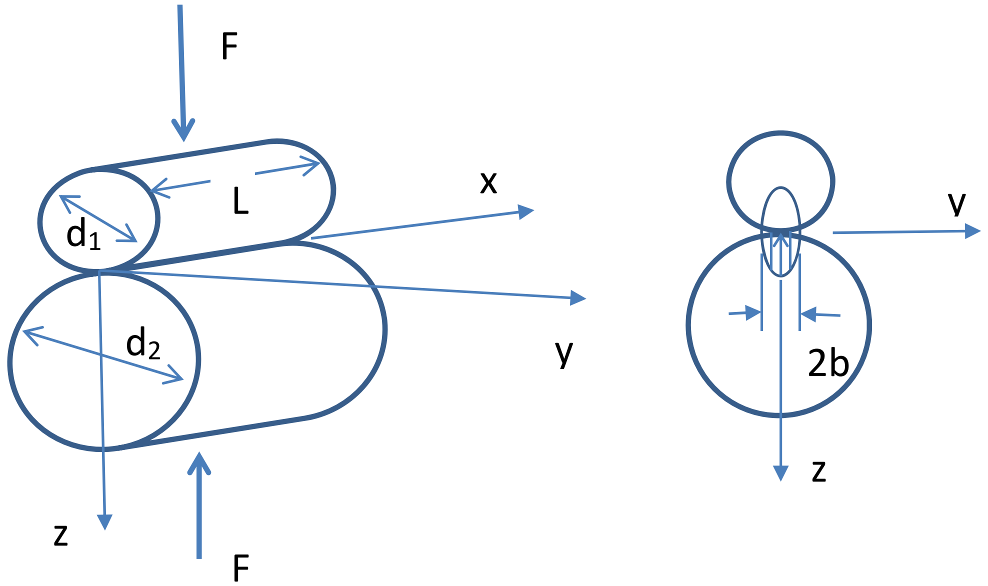
Week 8 Application Activity
ME219 Computer Programming for Engineers

Consider the diagram below, which depicts two cylinders being held in contact by a force (F) that is uniformly distributed along the length (L) of the cylinders. The resulting stress distribution will be elliptical in shape, such that the maximum stress occurs along the line of contact where $y = z = 0$.



We are interested in calculating the magnitude of the principal stresses in the larger cylinder for points beneath its surface, i.e. for increasing values of z. These may be calculated as follows[1]:

$$\sigma_x = -2\nu_2 p_{max}\left(\sqrt{1+\frac{z^2}{b^2}} - \frac{z}{b}\right) \quad (1)$$

$$\sigma_y = -p_{max}\left[\left(2 - \frac{1}{1+\frac{z^2}{b^2}}\right)\sqrt{1+\frac{z^2}{b^2}} - 2\frac{z}{b}\right] \quad (2)$$

$$\sigma_z = \frac{-p_{max}}{\sqrt{1+\frac{z^2}{b^2}}} \quad (3)$$

where b is the half-width of the elliptical distribution, given by

$$b = \sqrt{\frac{2F}{\pi L}\frac{(1-\nu_1^2)/E_1 + (1-\nu_2^2)/E_2}{1/d_1 + 1/d_2}} \quad (4)$$

and p_{max} is the maximum pressure, given by

$$p_{max} = \frac{2F}{\pi b L} \quad (5)$$

The following table summarizes the properties of the cylinders we're interested in evaluating.

Symbol	Description	Value
v_1, v_2	Poisson's Ratios for both cylinders	0.3 (both)
E_1, E_2	Young's Modulus for both cylinders	$200 \times 10^9\ N/m^2$
d_1	Diameter of top cylinder	$38\ mm$
d_2	Diameter of bottom cylinder	$70\ mm$
L	Length of both cylinders	$50\ mm$
F	Compressive force	$450\ N$
z	Distance below surface of bottom cylinder	$0.025\ mm$ $0.25\ mm$ $2.5\ mm$

Please follow the instructions below to complete this problem. ***Be sure to suppress all output to the command window except for the principal stresses in equations (1)-(3).***

1. Open MATLAB, navigate to the directory where you want to save your work, and create a new script file called "pstress.m".
2. **PART 1**: create variables for the constants in the table above. Note that you will be running your program once for each separate value of z.
3. **PART 2**: Using equations (4) and (5), calculate b and p_{max}, respectively, and assign them to appropriate variables.
4. **PART 3**: calculate the following intermediate variables, which will simplify the process of calculating your principal stresses:

$$a_1 = \frac{z}{b} \qquad a_2 = \sqrt{1 + \frac{z^2}{b^2}} \qquad (6)\ (7)$$

5. **PART 4**: calculate your 3 principal stress values using equations (1)-(3), using the intermediate variables you defined using equations (6) and (7).
6. **PART 5**: add comments to your code describing in detail what each part of your program does.
7. **PART 6**: in the command window, type the command 'diary output.txt'. This will create a file called output.txt where the command window text will be stored. Next, run your file once for each of the 3 z values above. When finished, type 'diary off' in the command window.
8. **PART 7**: open your 'output.txt' file and confirm that you have a total of nine outputs (3 principal stress values for each of the 3 runs of your program). Below this output, type a brief paragraph explaining what happens to principal stress at increasing distances from the cylinder surface.

When finished, please upload both files (pstress.m, output.txt) to Blackboard using the link provided.

REFERENCE

1. Shigley and Mischke, *Mechanical Engineering Design*, 5th ed., McGraw-Hill, New York, 1989.