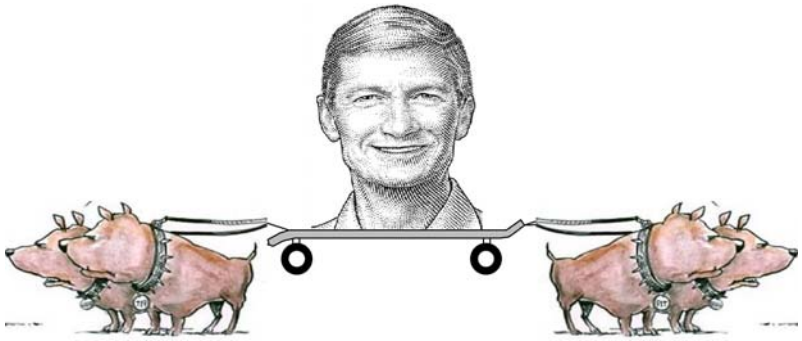
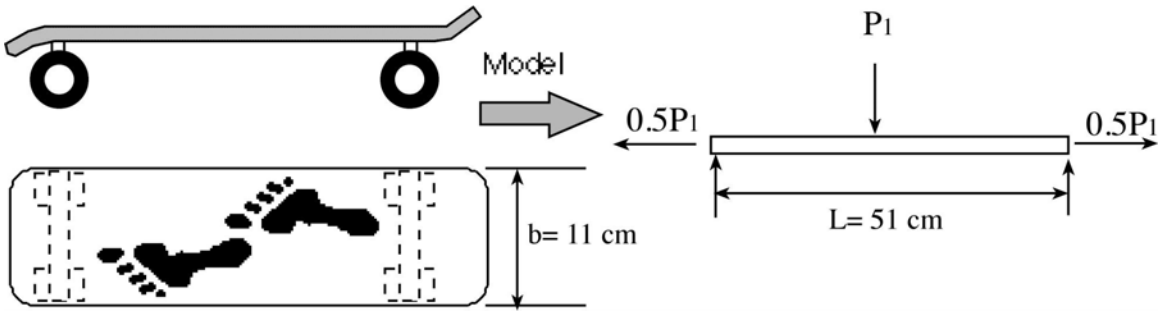
Project, Assignment #5

While skateboarding, Tim Cook realizes the worst of his fears. The high-tech skateboard has been kidnapped by ferocious competitors' beasts!



Due to this highly unexpected situation an applied moment resultant vector (M_1,M_2,M_6), and an in-plane load vector (N_1,N_2,N_6), is simultaneously applied to the skateboard. Calculate the 3 curvatures k_i due to the moments M_i and the three in-plane strains $\{\varepsilon_i^o\}$ due to N_i, Both loads and moments cause strain. Off axis strain is calculated using superposition Equation 6.26 (top and bottom of each layer), then on-axis strains and stresses for the top and bottom of each layer should be calculated.



The same $[0_2/+25/-25/0_2]_s$ layup with honeycomb core = 1.0 cm (half-core z_c= 0.005m!), AS4/PEEK carbon thermoplastic material, ply thickness = 0.125mm (same as previous assignment).

Similar to the example at the end of chapter 5, M_1 moment is applied, M_1= -P_1L/4b, but in addition we have the in-plane tensile load N_1=0.5P_1/b. So far, everything in this assignment is possible from assignment #4.

Add Failure Criteria

• We now wish to use failure criteria to examine this situation, using the information obtained for the on-axis stresses at the top and bottom of each layer. Three criteria will be tried (1) Maximum stress, (2) Quadratic Polynomial and (3) Hashin Failure Criteria. Recall that the input values for X, X', Y, Y', and S, the strength properties, should already be inputs to your program. The program need only be run once at an arbitrary load. We will use P_1=1000 Newtons. Solve for on-axis stresses at the top and bottom of each layer.

(1) After solving for on-axis stresses at the top and bottom of each layer, use the 5 Maximum Stress criteria and find the **lowest** "R" value that will satisfy one of the criteria. This lowest R-value will be the ratio for which we multiply P_1 in order to get first ply failure.

(2) Calculate the 6 coefficients of the Tsai-Wu Quadratic failure criterion, F_{xx}, F_x, F_{yy}, F_y,and F_s. F_{xy} is calculated using equation 7.15 with F^*_{xy}=-1/2 as in equation 7.22. The "R" value which leads to failure using this criterion can be found by solving a quadratic equation, as explained in the notes. The procedure goes as follows:

- The solution at P_1=1000 Newtons gives us on-axis stresses in each layer (σ_x, σ_y, σ_s)
- Since our formulation is a linear one, a load of R x P_1=1000 Newtons gives us on-axis stresses at the top and bottom of each layer ($R\sigma_x$, $R\sigma_y$, $R\sigma_s$). These stresses can be substituted into the quadratic failure criterion, equation 7.8, giving a quadratic equation with a term in R^2, R, and a constant term. Solve the quadratic for R, which should give a positive and a negative root for each layer. In our case, only the positive root is valid since the load at failure must be a positive multiple of P_1=1000 N.
    - The **lowest** positive "R" value will be the one which causes first ply failure.

(3) Calculate the "R" values using the set of four 2D plane stress Hashin Failure Criteria. Each of the four parts of the Hashin Failure Criteria is treated like a quadratic equation to solve for R (similar to the Tsai-Wu Quadratic failure criterion).
    - The **lowest** positive "R" value will be the one which causes first ply failure.

For each of the failure criteria, you should output the results of your failure analysis. At the end you should have an output summary which gives the following information:

(1) Maximum stress failure criteria
- which layer fails first
- which of the 5 modes caused the failure (fiber tension or comp, matrix tension or comp, shear). Print out the R values.
- the load vectors R(M_1,M_2,M_6), and R(N_1,N_2,N_6) which cause the failure

(2) Quadratic
- which layer fails first. Print out the R values.
- the load vectors R(M_1,M_2,M_6), and R(N_1,N_2,N_6) which cause the failure

(the quadratic failure criterion cannot distinguish mode of failure)

(3) Hashin failure criteria
- which layer fails first
- which of the 4 modes causes failure (fiber tension or comp, matrix tension or comp). Print out R values.
- the load vectors R(M_1,M_2,M_6), and R(N_1,N_2,N_6) which cause the failure

Example of Table of Safety Factors (R-Factors)

Top of laminate

		Max					Quad		Hash			
Ply	T/B	FT	FC	MT	MC	S	(+)	(-)	FT	FC	MT	MC
12	T	x		x		x	x	x’	x		x	
12	B	x		x		x	x	x’	x		x	
11	T		x		x	x	x	x’		x		x
11	B		x		x	x	x	x’		x		x
10	T		x		x	x	x	x’		x		x
etc						x	x	x’				
1	T		x	x		x	x	x’		x	x	
1	B		x	x		x	x	x’		x	x	

Bottom of laminate