Composite Materials **March 17, 2021**
Aerospace Engineering AER 827 Due: **March 31, 2021**

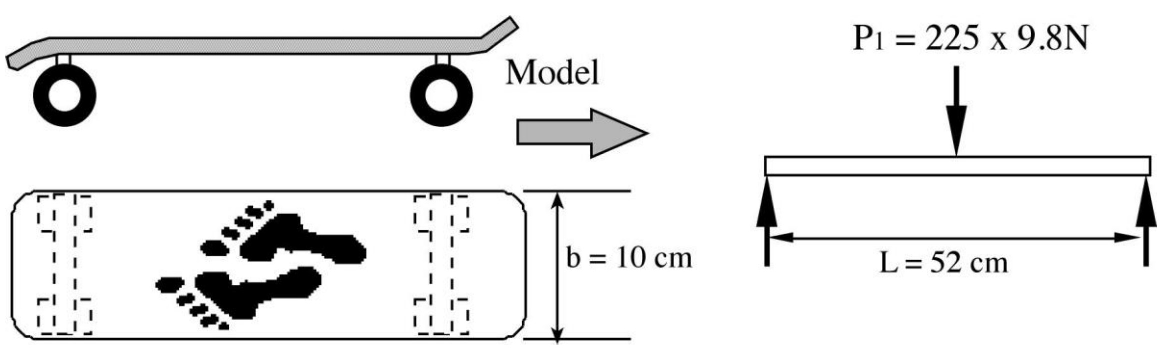
Project, Assignment #4
Laminate Properties [D], [d]

Add the capability of calculating the overall in-plane flexural modulus and in-plane flexural compliance for a given laminate, i.e., the [D] and [d] matrix. The [D] matrix can be calculated using the formulation of Table 5.3. From this table, the V quantities are given by Eq.5.43. For the [d] matrix, you must invert the 3x3 [D] matrix. Be careful of the units of [D] and [d].

• Add to the input parameters, an applied moment resultant vector (M_1, M_2, M_6), so now with (N_1, N_2, N_6), there are 6 possible applied loads.

• Be able to calculate the 3 curvatures k_i, off axis strain using superposition, Eq. 6.26 ($\varepsilon_i(z)=\varepsilon_i^o+zk_i$) (different for each layer), on-axis strains and stresses for each layer.

Illustrative Example "The High-tech Skateboard"



To save weight, a designer uses AS4/PEEK carbon thermoplastic material. The designer has chosen a design and wants to know if it is feasible.

Not willing to settle for the quasi-isotropic layup, the designer chooses a $[0_2/+45/-45/90_2]_s$ layup with a honeycomb core of 1cm (half-core z_c= 0.005m!), with AS4/PEEK carbon thermoplastic material, and ply thickness = 0.125mm. On a good day, the designer weighs 90kg (estimated), but the designer uses a worst-case condition of having to jump up and down on the board, that is estimated to be 2.5 times the weight, 225kg, concentrated on the center.

Problem Setup: Use the bending example in section 5.7 to calculate the effective M_1 moment applied and note that since we will get compression on the top, the applied M_1 should be **negative**.

• Input M_1, with M_2=M_6=0, N_1=N_2=N_6=0

• Print out [A], [D], [a] and [d] matrices, in SI units. Find ε_i^o, k_i. Then calculate the resulting off-axis strain, and on-axis strains and stresses for the top and bottom of each layer (values will not be the same at top and bottom, but either top or bottom will be largest).

Design evaluation for this assignment

** Look at the on-axis strain list for maximum fiber strain ε_x. From the d_{11} term and Eq. 5.121, calculate midpoint deflection δ, as shown in Fig. 5.18.

** The designer wants to meet the following two criteria:

(1) No more than 0.5cm midpoint deflection δ,

(2) A safety criterion no more than 0.002 strain (unitless!) on any fibers (ε_x).

Will the design meet the requirements?

Note #1: Items marked with "**" are for **this assignment only**, thus they can be "hand-calculations" not necessarily included in the overall computer program) and can be "hand written".