Forces: 86 42 75 -51 0 0

Stack angles: [5 0 50 2 50 0 5]

1. Used For loops running all possible combinations till 5 plies
2. After 5 plies, manually looked at local stresses, and changed theta according to requirments
3. Applied a hit & Trial Approach and came up with the final solution in 7 plies, with the above given angles.
4. All the data written down is for the current stack described by the angles mentioned above.

Full Stiffness Matrix:

50.7545	4.5943	4.6780	-1.4060	0.3795	0.1025
4.5943	10.1254	4.2053	0.3795	0.6469	0.5061
4.6780	4.2053	6.1630	0.1025	0.5061	0.3795
-1.4060	0.3795	0.1025	3.7129	0.1383	0.2322
0.3795	0.6469	0.5061	0.1383	0.3897	0.0716
0.1025	0.5061	0.3795	0.2322	0.0716	0.2364

Strain at mid plane = strain in 4(the center plate)

Plies	1	2	3	4	5	6	7
Strain(global)	-4.796	-3.138	-1.479	0.179	-1.479	-3.138	-4.796
	-4.592	-3.080	-1.569	-0.057	-1.569	-3.080	-4.592
	11.690	12.326	12.963	13.600	12.963	12.326	11.690
Sigma(Global)	-495.693	-401.288	217.741	75.480	217.741	-401.288	-495.693
	-56.336	-37.739	306.455	1.618	306.455	-37.739	-56.336
	25.756	67.795	325.645	77.290	325.645	67.795	25.756
Tsai-Hill	0.9634	0.8447	0.6514	0.6946	0.6514	0.8447	0.9634
Tsai-Wu	0.9289	0.7195	-0.3998	0.6360	-0.3998	0.7195	0.9289

AS it can be seen, for the arrangement, the closest to failing is the edges, and as we move to the center, the stress loading

and the chances to fail, both decrease, resulting in a lower absolute value of both the Tsai-hill and Tsai-wu criterion.

Practical Considerations are taken while designing this laminate:

1. Temperature Effects should be taken into consideration while designing for practical life.
2. Moisture sensitivity can be a significant issue in some conditions
3. Fabrication practicality(Rod example given in class by the professor) is an integral part of design considerations.
4. Proper design to avoid delamination needs to be done apart from deciding the stack angles
5. A proper stress analysis using FEA should be performed for validation and further fine-tuning.

```
clear all;
%% Background Information
stu_no = 1008247531;
          %TUVWXYZ

TU = 82;
V = 4;
WX = 75;
YZ = 31;

AF = 250 - (2*TU);
BF = 10 + (8*V);
CF = WX;
DF = -20 - YZ;

t = 0.125;

% Initially tried using For loops but not enough computational power, so
% went on with manual trials after 5. Looked at the local stresses for
each plies and tried to optimize them.

%theta = [5 0 45 45 0 5]; % In Degrees - For six it doesn't converge for
any solution - breaks off in all arrangements

% after several tries on optiming the stress vectors, Finally recieved
the combination written down here for theta

theta = [5 0 50 2 50 0 5]; % Works for Both Tsai-hill and Tsai-wu with
equally distributed loads around the center -any further distribution
around this works nicely
theta = theta.*(pi/180); % Conversion to Radians - I my system Default is
radians

E1 = 125;
E2 = 9.8;
G12 = 5.5;
nu_12 = 0.24;

sl_up = 900;
sl_down = 800;
st_up = 55;
st_down = 170;
tau = 90;

S = [1/E1 -nu_12/E1 0; -nu_12/E1 1/E2 0; 0 0 1/G12];

Q_local = S^-1;

T = @(x) [(cos(x))^2 (sin(x))^2 2*cos(x)*sin(x); (sin(x))^2 (cos(x))^2 -
2*cos(x)*sin(x); -cos(x)*sin(x) cos(x)*sin(x) (cos(x))^2 - (sin(x))^2];

%% 1.) Calculating ABD Matrix
A = zeros(3);
B = zeros(3);
```

```
D = zeros(3);

for k = 1:4
   z_k = (k-2)*0.125;
   z_k1 = z_k - 0.125;
   Q_global =
((inv(T(theta(k))))*(Q_local)*(inv(transpose(T(theta(k))))));
   A = A + 0.125*Q_global;
   B = B + (0.125*(z_k + z_k1))*Q_global;
   D = D + (0.125*(z_k^2 + z_k1^2 + z_k*z_k1))*Q_global;
end

abd = [A B;B D];

fm = [AF;BF;CF;DF;0;0];
e_mat = abd\fm;

%% 2.) Using epsilon matrix for calculations of Stresses

tsai_hill = zeros(length(theta),1);
tsai_wu = zeros(length(theta),1);
sigma_all = zeros(length(theta),3);
strain_global_all = zeros(length(theta),3);
sigma_global_all = zeros(length(theta),3);

for p = 1:length(theta)

curr_stack = p;
center = t*(length(theta)/2); % Calculating center from bottom
dist = t*((2*curr_stack-1)/2); % Calculating Dist from bottom
epsilon = e_mat(1:3) + (abs(center-dist))*e_mat(4:6);
qbar = ((inv(T(theta(p))))*(Q_local)*(inv(transpose(T(theta(p))))));
sigma_global = qbar*epsilon;

sigma_global_all(p,:) = sigma_global;
strain_global_all(p,:) = epsilon; %capturing sigma global for each ply

F11 = abs(1/(sl_up*sl_down));
F22 = abs(1/(st_down*st_up));
F66 = abs(1/(tau^2));
F1 = (1/sl_up - abs(1/sl_down));
F2 = (1/st_up - abs(1/st_down));
F12 = 0.5*sqrt(F11*F22);

    sigma = T(theta(curr_stack))*sigma_global;
    sigma_all(p,:) = sigma;

    if sigma(2) >= 0
        st = 55;
    else
        st = 170;
    end

    if sigma(1) >= 0
```

```
        sl = 900;
    else
        sl = 800;
    end


    tsai_hill(p) = (sigma(1)^2)/(sl^2) - (sigma(1)*sigma(2))/(sl^2) +
(sigma(2)^2)/(st^2) + (sigma(3)^2)/(tau^2);

    tsai_wu(p) = F11*sigma(1)^2 + F22*sigma(2)^2 + F66*sigma(3)^2 +
F1*sigma(1) + F2*sigma(2) + 2*F12*sigma(1)*sigma(2);

end

transpose(fm)
transpose(strain_global_all)
transpose(sigma_global_all)
transpose(tsai_hill)
transpose(tsai_wu)

----------------------------------------Code Ends------------------------
----------------------------------------------------
```