Design Project 1 Solution

Wednesday, January 3, 2024 11:26 AM

Problem 1

Taking the equilibrium of forces,

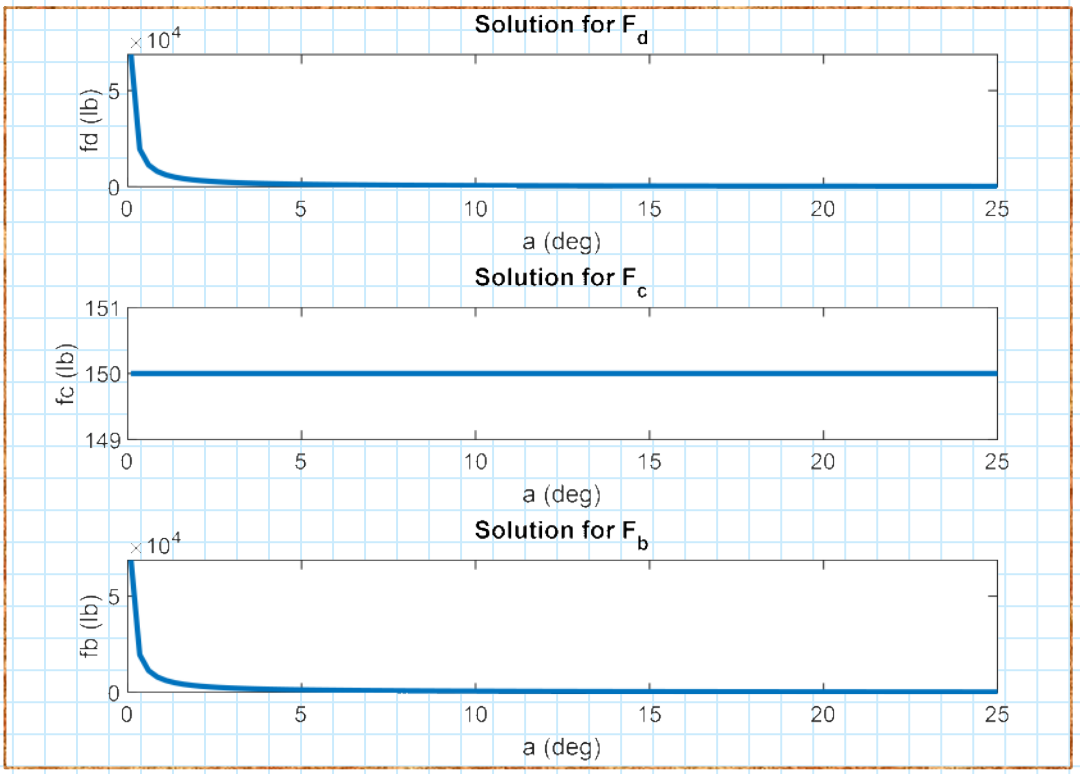
$\Sigma F_x = 0 \Rightarrow F_D \sin a - (4/5) F_C = 0$

$\Sigma F_y = 0 \Rightarrow -F_D \cos a + F_B = 0$

$\Sigma F_z = 0 \Rightarrow (3/5) F_C - 90 = 0$

Solving these set of equations,

$F_D = 120/\sin a$; $F_B = 120 \cos a / \sin a$; $F_C = 150$



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Problem 2

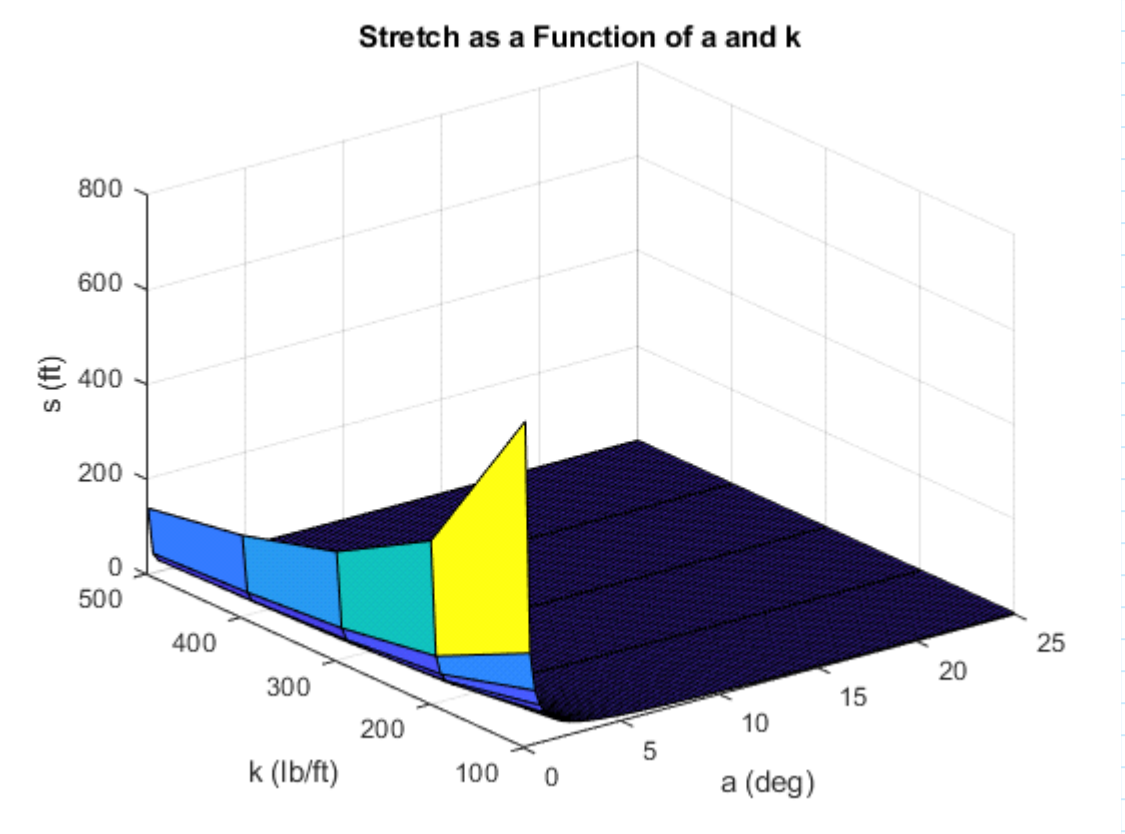
$F_B = ks \quad (F_B \equiv f_{AB})$

From previous problem,

$F_B = 120\cos\alpha / \sin\alpha$

$\Rightarrow ks = 120\cos\alpha/\sin\alpha$

$\Rightarrow \boxed{s = 120\cos\alpha/k\sin\alpha}$



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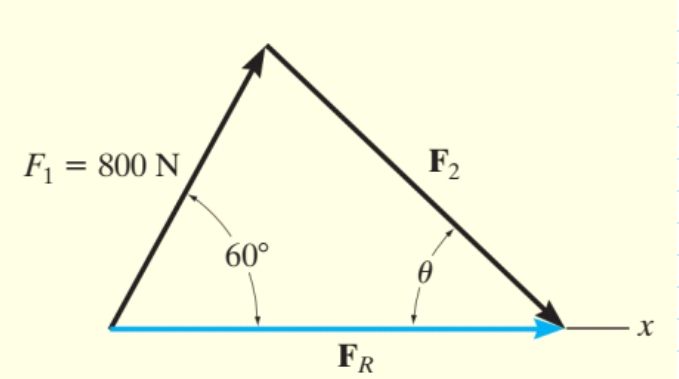
Problem 3



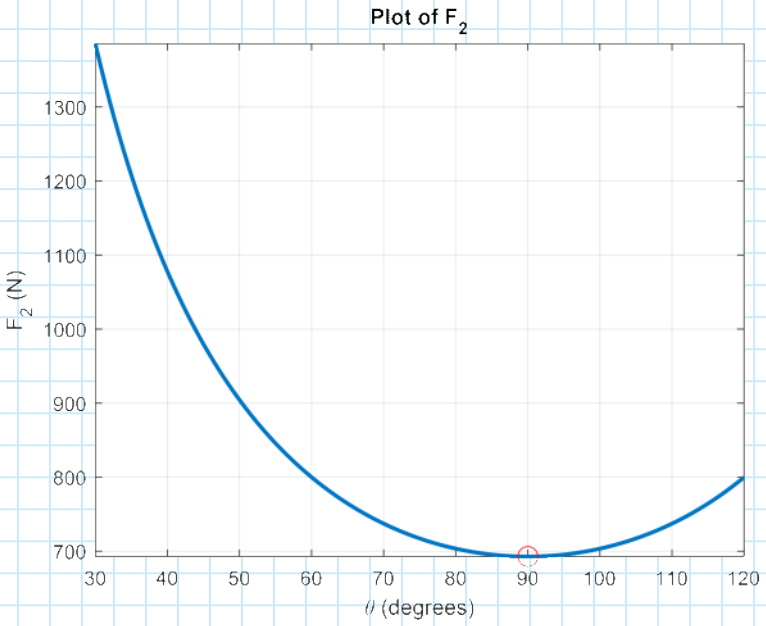
This is the force triangle where F_R = resultant force vector

$\vec{F}_R = \vec{F}_1 + \vec{F}_2$

Using sine law,

$$\frac{F_1}{\sin\theta} = \frac{F_2}{\sin 60^\circ}$$

$$\Rightarrow \boxed{F_2 = \frac{800\sin 60^\circ}{\sin\theta}}$$




```
Minimum F2 value: 692.820323
Corresponding theta for minimum F2: 90.000000 degrees
```

Design Project 1 Solution - Problem 1 and 2 Codes

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```
clc
clear all

% Symbolic variables
syms a fd fc fb k s

% Define the equations
eq1 = fd*sind(a)-(4/5)*fc == 0;
eq2 = -fd*cosd(a)+fb == 0;
eq3 = (3/5)*fc-90 == 0;

% Additional equation for fb = k * s
eq4 = fb - k*s == 0;

% Solve the system of equations
solutions = solve([eq1, eq2, eq3, eq4], [fd, fc, fb, s]);
disp('Solutions:')
```

```
Solutions:
```

```
disp(solutions)
```

```
    fd: 120/sin((pi*a)/180)
    fc: 150
    fb: (120*cos((pi*a)/180))/sin((pi*a)/180)
     s: (120*cos((pi*a)/180))/(k*sin((pi*a)/180))
```

```

% Extract the symbolic expressions for fb, fc, and fd
% from the strcture
fb_solution = solutions.fb;
fc_solution = solutions.fc;
fd_solution = solutions.fd;
s_solution = solutions.s;

% Coordinates for plotting
a_values = linspace(0.1, 25, 100);
k_values = linspace(100, 500, 5);
[a_grid, k_grid] = meshgrid(a_values, k_values);

% Evaluate the solutions for different values of x
fb_values = double(subs(fb_solution, a, a_values));
fc_values = double(subs(fc_solution, a, a_values));
fd_values = double(subs(fd_solution, a, a_values));

figure;

% Increase the font size of axis titles
ax = gca;
ax.FontSize = 14;
titleFontSize = 18;
```

Design Project 1 Solution - Problem 1 and 2 Codes

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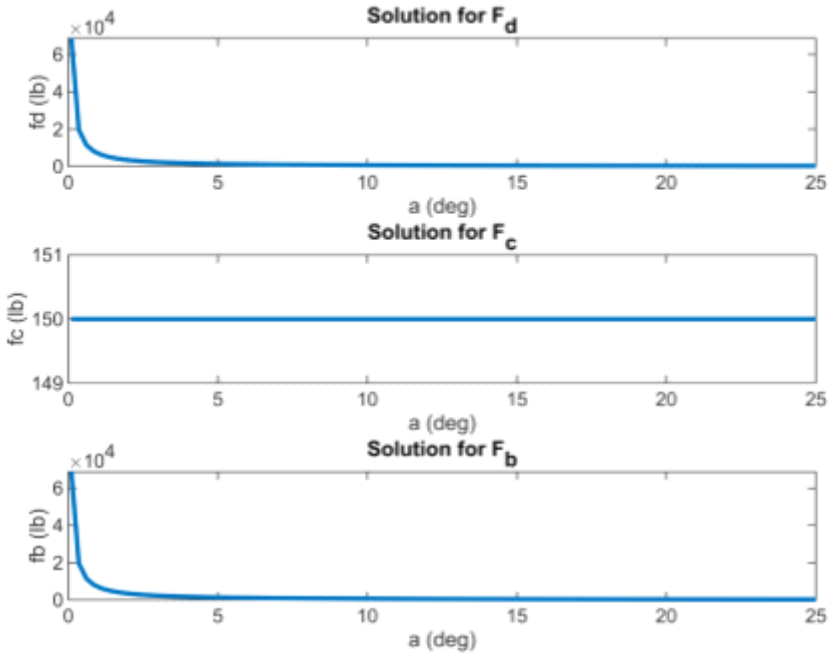
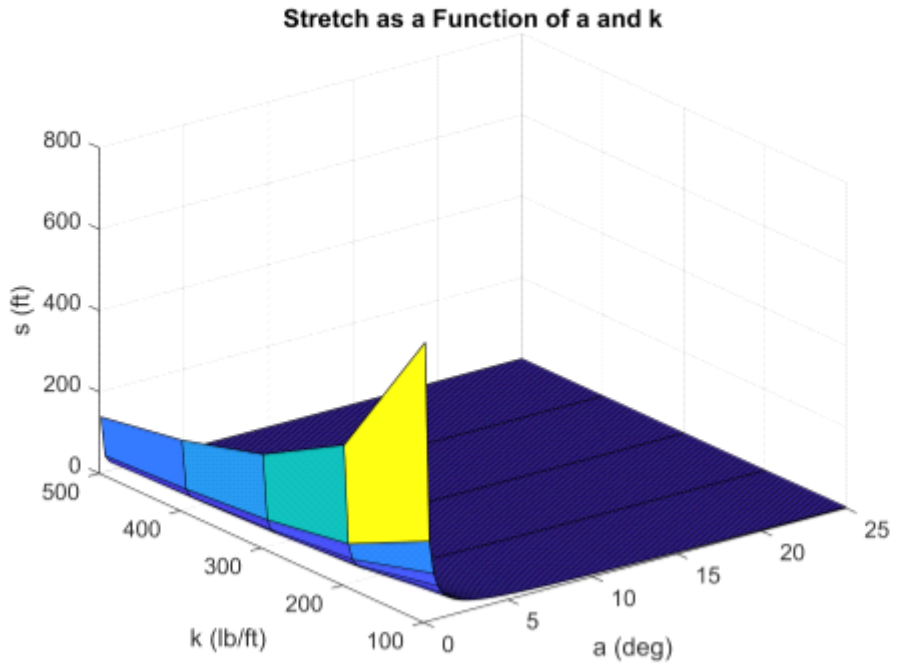
```
subplot(3, 1, 1);
plot(a_values, fd_values, 'LineWidth', 2);
xlabel('a (deg)');
ylabel('fd (lb)');
title('Solution for F_d');

subplot(3, 1, 2);
plot(a_values, fc_values, 'LineWidth', 2);
xlabel('a (deg)');
ylabel('fc (lb)');
title('Solution for F_c');

subplot(3, 1, 3);
plot(a_values, fb_values,'LineWidth', 2);
xlabel('a (deg)');
ylabel('fb (lb)');
title('Solution for F_b');
```




```
% Evaluate the symbolic expression for s over the grid
s_values = double(subs(s_solution, {a, k}, {a_grid, k_grid}));

% Create a 3D plot
figure;
surf(a_grid, k_grid, s_values);
xlabel('a (deg)');
ylabel('k (lb/ft)');
```

```
zlabel('s (ft)');
title('Stretch as a Function of a and k');
```



Design Project 1 Solution - Problem 3 Code

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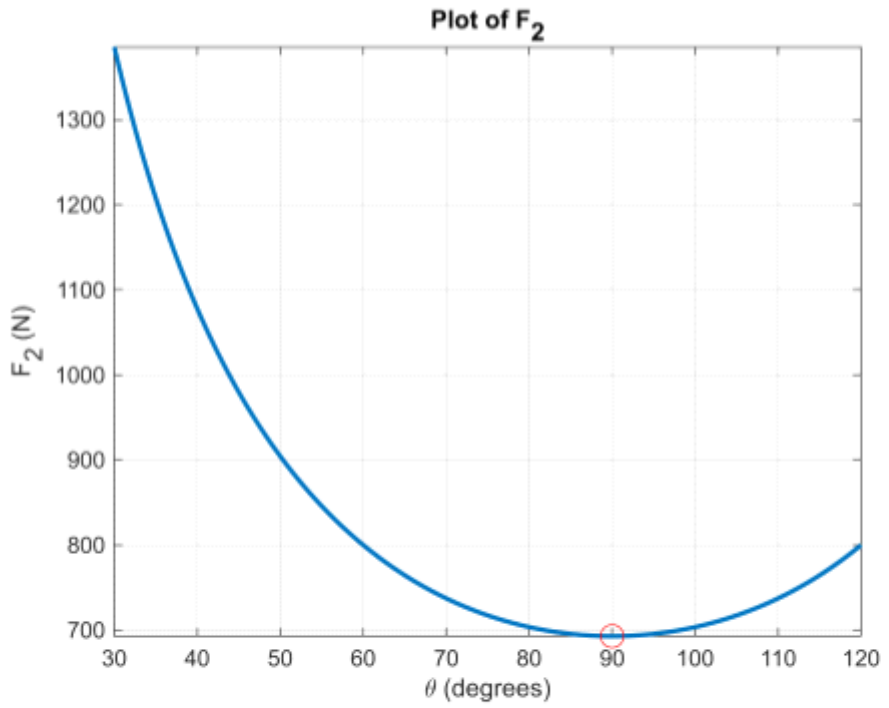
```
clc
clear all

% Define the range of theta values in degrees
theta_degrees = 30:0.5:120;

% Calculate f2 for each theta value
f2 = 800*sind(60)./sind(theta_degrees);

% Find the minimum value of f2 and its index
[min_f2, min_index] = min(f2);

% Corresponding theta value for the minimum f2
theta_min_f2 = theta_degrees(min_index);

% Plot the function
figure;
plot(theta_degrees, f2, 'LineWidth', 2);
hold on;
plot(theta_min_f2, min_f2, 'ro', 'MarkerSize', 10); % Mark the minimum point

title('Plot of F_2');
xlabel('\theta (degrees)');
ylabel('F_2 (N)');
grid on;
axis tight;
```



1

Design Project 1 Solution - Problem 3 Code

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```
% Display the minimum f2 and corresponding theta
fprintf('Minimum F2 value: %f\n', min_f2);
```

```
Minimum F_2 value: 692.820323
```

```
fprintf('Corresponding theta for minimum F2: %f degrees\n', theta_min_f2);
```

```
Corresponding theta for minimum F2: 90.000000 degrees
```