300/300

ENGINEERING ANALYSIS 2

Design Report 1

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1. Problem Statement

Use the following diagram and information below to solve the three problems.

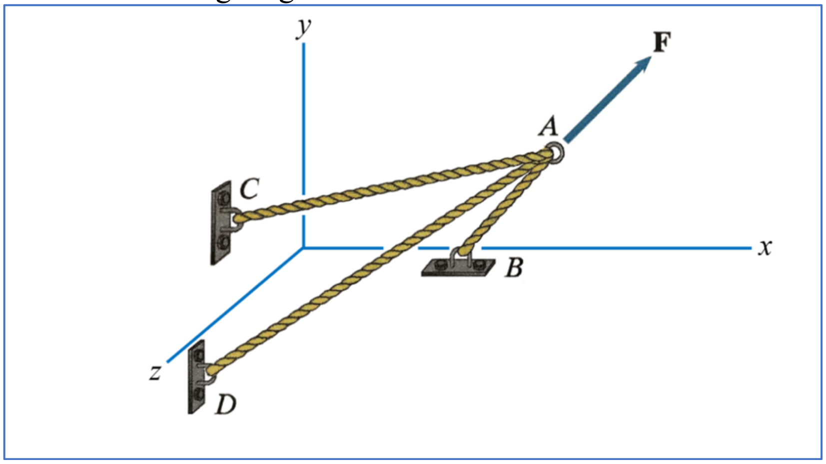

Figure 1.1: Diagram for problems 1,2 and 3

Problem 1:

Given:

- A system of bars supporting a F = 80i + 20j - 30k (kN)
- Fixed points of the bar system A (6,2,1) m, B (4,0,1) m, and D (0, -1,5) m
- Point C with known x coordinate as 0, unknown y coordinate between 1m and 6m, and unknown z coordinate between -1m and 4m
- The diagram shown (Figure 1.1)

Find:

- 3D Plots of T_{AB}, T_{AC}, and T_{AD} versus y and z
- The effects of various the y and z coordinates of C on the tensions of all bars

Problem 2:

Given:

- A system of bars supporting a F = 80i + 20j - 30k (kN)
- Fixed points of the bar system A (6,2,1) m, B (4,0,1) m, and D (0, -1,5) m
- Point C with known x coordinate as 0, unknown y coordinate between 1m and 6m, and unknown z coordinate between -1m and 4m
- The diagram shown (Figure 1.1)
- The cost of bar AC is proportional to the product of the tension and its length

Find:

- The 3D plot of the cost of bar AC
- The optimal location of point C that gives the lowest cost

Problem 3:

Given:

- Fixed points of the bar system A (6,2,1) m, B (4,0,1) m, C (0,2,3) m, and D (0, -1,5) m
- The diagram shown (Figure 1.1)
- A force (F) at point A with magnitude 200 (kN)
- Tensions of bars AB, AC, and AD are equal

Find:

- The components of the unknown force F on A

2. Theory Manual:

Free-body Diagrams

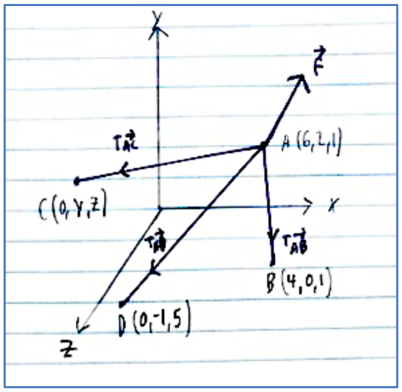

Figure 2.1: Free-body diagram with coordinates

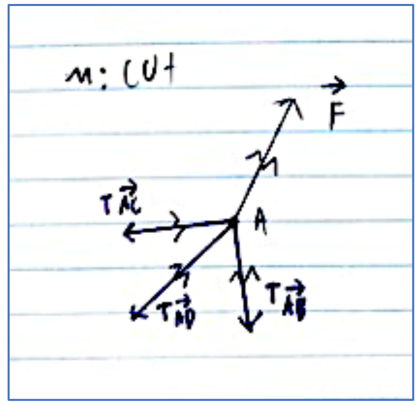

Figure 2.2: Free-body diagram with cuts

*The free body diagrams apply to problems 1 and 2

Equations & Process

Problem 1:

The first step is to take the points given in the problem and calculate the vectors accordingly. These vectors can be seen in the free-body diagram (2.1). This is done by subtracting the terminal point by the initial point (1). This process results in vectors AB (2), AC (3), and AD (4). Since the y and z coordinates of C are unknown, it is best to given them a variable value, which in this case will be treated accordingly as y and z. Additionally, the force vector should be broken down into its components (5).

$$(1)\ \overrightarrow{AB} = (4-6)i - (0-2)j + (1-1)k$$

$$(2)\ \overrightarrow{AB} = -2i - 2j + 0k$$

$$(3)\ \overrightarrow{AC} = -6i + (y-2)j + (z-1)k$$

$$(4)\ \overrightarrow{AD} = -6i - 3j + 4k$$

$$(5)\ \vec{F} = 80i + 20j - 30k$$

The second step would calculate the unit vectors. This is done by taking the magnitude of the bar (6) and dividing the vector by it. This process gets the unit vectors for AB (7), AC (8), and AD (9).

$$(6)\ \sqrt{(-2)^2 + (-2)^2 + (0)^2} = \sqrt{8}$$

$$(7)\ e_{\overrightarrow{AB}} = \frac{-2i - 2j + 0k}{\sqrt{8}}$$

$$(8)\ e_{\overrightarrow{AC}} = \frac{-6i + (y-2)j + (z-1)k}{\sqrt{36 + (y-2)^2 + (z-1)^2}}$$

$$(9)\ e_{\overrightarrow{AD}} = \frac{-6i - 3j + 4k}{\sqrt{61}}$$

The next step would be to write the equilibrium equations for the system. Since the system is in complete equilibrium, equations can be written for the x (10), y (11), and z (12) directions. All the forces acting upon A must equal zero. This is shown in the free-body diagram (2.1). Each equation would include the unit vector component for that tension in that direction multiplied by the tension, as well as the force vector component in that direction. Since the tensions are unknown for AB, AC, and AD, they are instead just treated as variables.

$$(10)\ \sum F_x:\ 0 = \frac{-6}{\sqrt{36 + (y-2)^2 + (z-1)^2}} T_{\overrightarrow{AC}} + \frac{-6}{\sqrt{61}} T_{\overrightarrow{AD}} + \frac{-2}{\sqrt{8}} T_{\overrightarrow{AB}} + 80$$

$$(11)\ \sum F_y:\ 0 = \frac{(y-2)}{\sqrt{36 + (y-2)^2 + (z-1)^2}} T_{\overrightarrow{AC}} + \frac{-3}{\sqrt{61}} T_{\overrightarrow{AD}} + \frac{-2}{\sqrt{8}} T_{\overrightarrow{AB}} + 20$$

$$(12)\ \sum F_z:\ 0 = \frac{(z-1)}{\sqrt{36 + (y-2)^2 + (z-1)^2}} T_{\overrightarrow{AC}} + \frac{4}{\sqrt{61}} T_{\overrightarrow{AD}} + \frac{0}{\sqrt{8}} T_{\overrightarrow{AB}} - 30$$

Since the problem will be solved in MATLAB, it is best to convert this system of equations into a matrix equation. Each equilibrium equation from before is used in order to build the matrix equation (16). A 3x3 matrix (13) contains the coefficients for the tensions with the 3x1 (14) matrix containing the variables for tensions, and these equal a 3x1 matrix (15) with the constants found from the original force vector.

$$(13)\ \begin{bmatrix} \frac{-6}{\sqrt{36 + (y-2)^2 + (z-1)^2}} & \frac{-6}{\sqrt{61}} & \frac{-2}{\sqrt{8}} \\ \frac{(y-2)}{\sqrt{36 + (y-2)^2 + (z-1)^2}} & \frac{-3}{\sqrt{61}} & \frac{-2}{\sqrt{8}} \\ \frac{(z-1)}{\sqrt{36 + (y-2)^2 + (z-1)^2}} & \frac{4}{\sqrt{61}} & 0 \end{bmatrix}$$

$$(14)\ \begin{bmatrix} T_{\overrightarrow{AC}} \\ T_{\overrightarrow{AD}} \\ T_{\overrightarrow{AB}} \end{bmatrix}$$

$$(15)\ \begin{bmatrix} -80 \\ -20 \\ 30 \end{bmatrix}$$

$$(16)\begin{bmatrix} \frac{-6}{\sqrt{36+(y-2)^2+(z-1)^2}} & \frac{-6}{\sqrt{61}} & \frac{-2}{\sqrt{8}} \\ \frac{(y-2)}{\sqrt{36+(y-2)^2+(z-1)^2}} & \frac{-3}{\sqrt{61}} & \frac{-2}{\sqrt{8}} \\ \frac{(z-1)}{\sqrt{36+(y-2)^2+(z-1)^2}} & \frac{4}{\sqrt{61}} & 0 \end{bmatrix} \cdot \begin{bmatrix} T_{\overrightarrow{AC}} \\ T_{\overrightarrow{AD}} \\ T_{\overrightarrow{AB}} \end{bmatrix} = \begin{bmatrix} -80 \\ -20 \\ 30 \end{bmatrix}$$

We are told in the problem that the y value (17) for C ranges from 1 to 6, and that the z value (18) for C ranges from -1 to 4. Using these ranges values, the possible tensions for AB, AD, and AB can be calculated accordingly.

$$(17)\ 1 \leq y \leq 6$$

$$(18)\ -1 \leq z \leq 4$$

The possible tensions for AC, AD, and AB will vary depending on the y and z values. This data can then be plotted on a 3D graph.

Problem 2:

Problem 2 builds off a lot of problem, mainly the way to calculate tension for bar AC in particular. Equations 1 through 18 are identical. The same method needs to be used to calculate the tension in bar AC. This includes the steps of getting the vectors and forces (1-5), the steps of getting the unit vectors (6-9), the steps of creating the equilibrium equations (10-12), and then the steps of calculating the tension through a matrix equation (13-16). Though, additionally the length for bar AC needs to be calculated. This can be done using an equation (19) derived from the distance formula in order to get the bar length.

$$(19)\ Length_{\overrightarrow{AC}} = \sqrt{(-6)^2 + (y-2)^2 + (z-1)^2}$$

For each tension of AC calculated, a corresponding length needs to be calculated. Then in the problem we are given the equation (20) to calculate the cost of the bar using the tension and the length.

$$(20)\ Cost_{\overrightarrow{AC}} = T_{\overrightarrow{AC}} \cdot Length_{\overrightarrow{AC}}$$

Thus, by taking the same steps as before from problem 1 though focusing solely on the tension for bar AC and additionally adding the step to calculate the lengths for bar AC at each y and z point the possible costs for bar AC can be calculated. This data can additionally be 3D plotted. This then allows for the lowest possible cost for bar AC to be found. This also means that the exact point for this cost or any cost of bar AC can additionally be found.

Problem 3:

Problem 3 is different from the first two as it has a defined point C. The first step though is to still calculate the vectors for AB (22), AC (23), and AD (24). This again is done by subtracting the terminal point by the initial point (21). This is nearly identical to (1-4) of problem 1.

$$(21)\ \overrightarrow{AC} = (0-6)i - (2-2)j + (1-3)k$$

$$(22)\ \overrightarrow{AB} = -2i\ - 2j\ +\ 0k$$

$$(23)\ \overrightarrow{AC} = -6i + 0j + 2k$$

$$(24)\ \overrightarrow{AD} = -6i\ - 3j\ +\ 4k$$

The next step is again to calculate the unit vectors for AB (25), AC (26), and AD (27). This is done by getting the magnitude of the vectors and dividing the vector by that magnitude. This process is the exact same that is done in problem 1 (6-9). Though, because of the natural of this problem it is more important to get the actual decimal values for the components.

$$(25)\ e_{\overrightarrow{AB}} = \frac{-2i - 2j + 0k}{\sqrt{8}} = -0.707i - 0.707j + 0k$$

$$(26)\ e_{\overrightarrow{AC}} = \frac{-6i + 0j + 2k}{\sqrt{40}} = -0.949i + 0j + 0.316k$$

$$(27)\ e_{\overrightarrow{AD}} = \frac{-6i - 3j + 4k}{\sqrt{61}} = -0.768i - 0.384j + 0.512k$$

Next, the sum of unit vectors needs to be calculated. This is done simply by adding together the corresponding unit vector components (28) of AB, AC, and AD. This gets the sum of unit vectors (29.

$$(28)\ e_{sum} = [(-0.949i - 0.768i - 0.707i) + (0j - 0.384j - 0.707j) + (0.316k + 0.512k + 0k)]$$

$$(29)\ e_{sum} = -2.424i - 1.091j + 0.828k$$

Then, the magnitude of the sum of unit vectors needs to be calculated (31). This is again done in the same way as before by taking the components, squaring them, adding them, and then taking the square root (30).

$$(30)\ |e_{sum}| = \sqrt{(-2.424)^2 + (-1.091)^2 + (0.828)^2}$$

$$(31)\ |e_{sum}| = 2.784$$

Then, by dividing the magnitude of force by the magnitude of the sum of unit vectors (32), the tension for all the bars can be found (33).

$$(32)\ T = \frac{200}{|e_{sum}|}$$

$$(33)\ \ T = \frac{200}{2.784} = 71.829$$

Finally, after getting the tension value when combining all the bars as one, the components for the force vector F (36) can be calculated as they must equal the opposite of that of the bars (34-35). This is because the system is in equilibrium.

$$(34)\ F = T * -e_{sum}$$

$$(35) F = T * -e_{sum} = 71.829 * -(-2.424i - 1.091j + 0.828k)$$

$$(36)\ F = 174.113i + 78.365j - 59.474k$$

This is the calculated value for the components of the force vector F (36) given the information.

3. Programmer Manual

Flowchart & Stepwise Explanation

Problem 1:

1. Create the arrays that will store the bar tension for AC, AD, and AB.
2. Initialize the lowest values for both y and z.
3. Loop through the possible y and z tensions in increments.
4. Calculate the resulting tensions on bars AC, AD, and AB.
5. Store these values back into the matrices from before.
6. Graph the tension values for AC, AD, and AB against the corresponding y and z value.

*See Figure 2.1

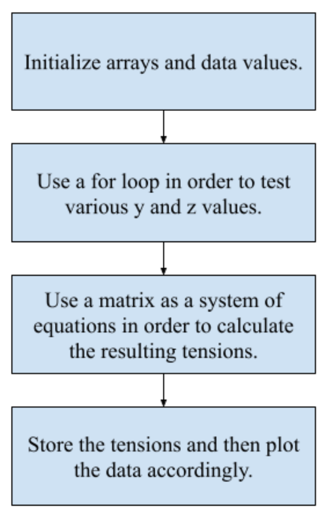

Figure 2.1: Flowchart of Problem 1

Problem 2:

1. Initialize the matrices that will store the costs of bar AC, the lengths of bar AC, and the tensions of bar AC.
2. Initialize the lowest values of both y and z.
3. Loop through the possible values of y and z in increments.
4. Calculate the resulting tensions specifically focusing on bar AC.
5. Calculate the resulting bar length for bar AC.
6. Calculate the costs of bar AC by multiplying corresponding bar lengths and tensions.
7. Find the lowest value of these costs.
8. Graph the costs against the y and z coordinates, print the lowest cost, and print the location at which the lowest cost occurs.

*See Figure 2.2

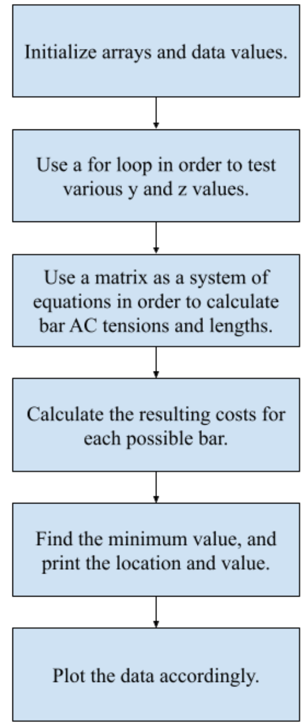

Figure 2.2: Flowchart of Problem 2

Problem 3:

1. Initialize the points A, B, C, and D.
2. Initialize the force F.
3. Calculate the vectors AB, AC, and AD.
4. Calculate the unit vectors AB, AC, and AD as well as the sum of these vectors.
5. Calculate the tension of all the bars in the system.
6. Use the calculated tension for all the bars and the sum of the unit vectors to get the components of the force F.

*See Figure 2.3

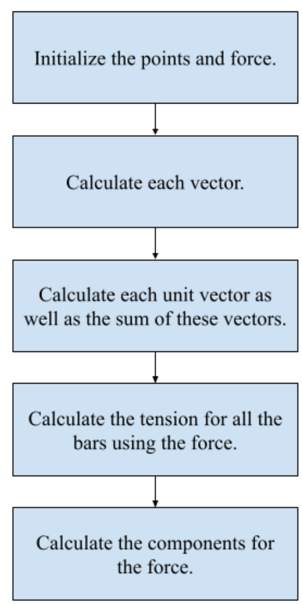

Figure 2.3: Flowchart of Problem 3

The table (3.1) shows the variables used in the MATLAB program.

Variables Used

Variable	Description of Variable
Bar_AC_Tension	A 51x51 dimension matrix that stores all potential tension values of bar AC based on the different possible y and z coordinate values for C.
Bar_AD_Tension	A 51x51 dimension matrix that stores all potential tension values of bar AD based on the different possible y and z coordinate values for C.
Bar_AB_Tension	A 51x51 dimension matrix that stores all potential tension values of bar AB based on the different possible y and z coordinate values for C.
Y_Coord	Initialized as 1, and changes between values 1 to 6 to represent all possible y coordinate values for C.
Z_Coord	Initialized as -1, and changes between values -1 to 4 to represent all possible z coordinate values for C.
System_of_Equations	The matrix that takes the y and z coordinates to calculate the tensions in each of the bars through the use of a system of equations.
Force_Totals	The components of the force in problem 1.
Reduced_Matrix	Stores the tensions for the bars at that specific y and z coordinate.
AC	Stores the individual value for the tension in bar AC at a certain point, so it can be then stored into the larger matrix Bar_AC_Tension based on that point.
AD	Stores the individual value for the tension in bar AD at a certain point, so it can be then stored into the larger matrix Bar_AD_Tension based on that point.
AB	Stores the individual value for the tension in bar AB at a certain point, so it can be then stored into the larger matrix Bar_AB_Tension based on that point.
Y_Values	A 1x51 dimension matrix that stores the potential values of y for C (1 to 6) with intervals of 0.1.
Z_Values	A 1x51 dimension matrix that stores the potential values of z for C (-1 to 4) with intervals of 0.1.
AC_Costs	A 51x51 dimension matrix that stores all potential cost values of bar AC found by multiplying the tension by the length of bar AC.
AC_Bar_Lengths	A 51x51 dimension matrix that stores all potential bar lengths for AC based upon the different y and z coordinate values.
lowest_cost	Holds the value of the lowest possible cost for the bar AC.
pt_A	Coordinates for point A in problem 3.

pt_B	Coordinates for point B in problem 3.
pt_C	Coordinates for point C in problem 3.
pt_D	Coordinates for point D in problem 3.
r_AB	The vector for bar AB.
r_AC	The vector for bar AC.
r_AD	The vector for bar AD.
e_AB	The unit vector for bar AB.
e_AC	The unit vector for bar AC.
e_AD	The unit vector for bar AD.
e_Sum	The sum of the unit vectors AB, AC, and AD.
T	The tensions for all the cables in problem 3.
Fcomps	The components of vector F in problem 3.
F	The given vector F in problem 3.

Figure 3.1: Programming Variables and their descriptions

The table (3.2) shows the functions used in the MATLAB program.

Functions Used

Function	**Description of Function**
meshgrid	Creates a 2d grid using the two vectors inputted as the domains allowing for functions of two variables and 3d mesh plots to be created.
xlabel	Creates the label for the x-axis of a graph.
ylabel	Creates the label for the y-axis of a graph.
zlabel	Creates the label for the z-axis of a graph.
title	Creates the label for the title of a graph.
mesh	Creates a mesh plot using the values given as the x axis, y axis, and z axis respectively.
min	Is used to return the minimum element in a matrix
norm	Takes a vector and returns the vector magnitude.
fprintf	Outputs chosen texts and variable values to the user.

sqrt	Square root operator
/	Division operator
*	Multiplication operator
+	Addition operator
-	Subtraction operator
=	Assigns a value

Figure 3.2: Programming Functions and their descriptions

4. Results and Analysis

Problem 1:

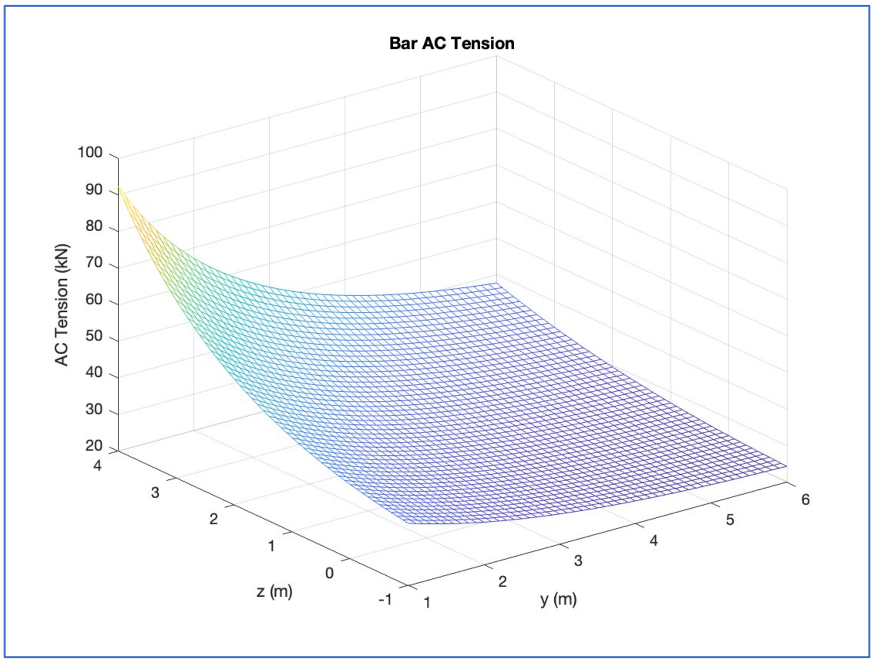

Figure 4.1: 3D plot of the tension for bar AC

Figure 4.1 Analysis:

By examining the plot, the greatest AC tension occurs when the z value is the greatest and the y value is the least. This translates to the greatest amount of possible tension occurring with the minimum y-coordinate and the maximum z-coordinate for C. This is shown throughout the test of the graph as when z decreases, so does the tension. A similar relationship is also seen when y increases as tension decreases along with it.

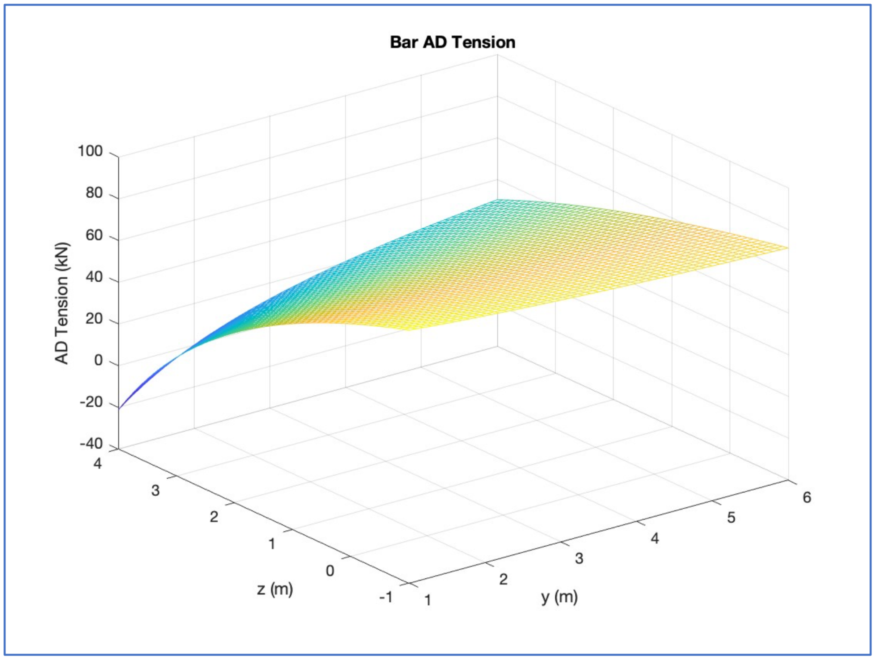

Figure 4.2: 3D plot of the tension for bar AD

Figure 4.2 Analysis:

When examining the plot, the greatest tension for bar AD seems to occur with the greatest value of y and the least value of z. This translates the maximum tension occurring at the maximum y coordinate and the minimum z coordinate. This relationship can be seen throughout the graph as when the y increases, so does the tension for AD. While when z increases the tension for AD decreases.

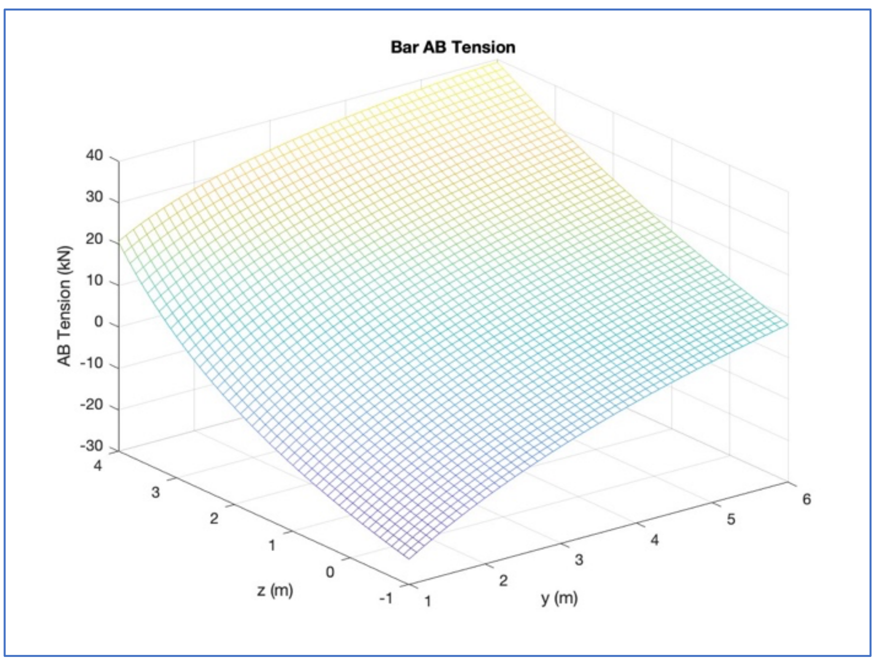

Figure 4.3: 3D plot of the tension for bar AB

Figure 4.3 Analysis:
When examining the plot, the greatest tension for bar AB seems to occur with the greatest value of y and the greatest value of z. This translates to the maximum tension occurring at the maximum y coordinate and the maximum z coordinate. This relationship can be seen throughout the graph as when y or z increase so does the tension, and the inverse occurs when either y or z decreases.

Problem 1 Results:
The greatest tension for bar AC occurs when the z value is at its maximum, 4, and the y value is at its minimum, 1.
The greatest tension for bar AD occurs when the z value is at its minimum, -1, and the y value is at its maximum, 6.
The greatest tension for bar AB occurs when the z value is at its maximum, 4, and the y value is at its maximum, 6.

Problem 1 Overall Analysis
These results make reasonable sense as the position of exactly where point C would affect the amount of tension that it takes on. It affects the tension vector that it results in, and thus affecting the rest of the system. Since the system is in equilibrium, one of the forces changing would affect how the other forces react thus explaining why all the tensions are affected by the changing y and z values. It also reasons that the bars all have their own unique locations for where their greatest tensions occur due to the relationship, they have with each other in terms of their location and resulting joint force.

Problem 2:

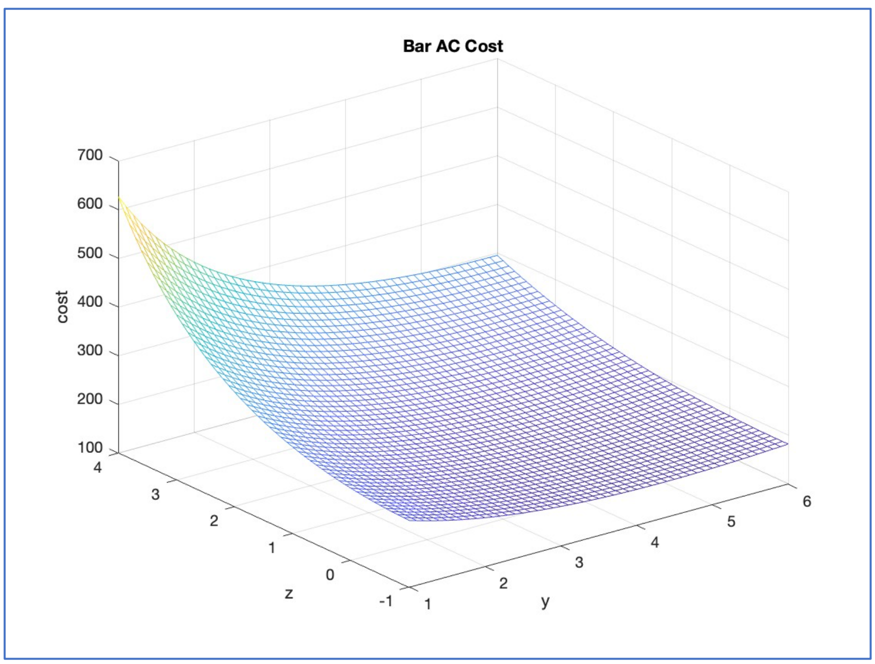

Figure 4.4: 3D plot of the tension for cost of bar AC

Figure 4.4 Analysis:

The greatest cost of AC is when the y value is the lowest and the z value is the greatest. This means the maximum cost of AC is when the y-coordinate is the maximum and the z-coordinate is the minimum. The lowest cost of AC appears to be around the area with a low z value and a high y value.

```
>> projectq2
The lowest cost of bar AC is 173.029 kNm.
This optimal location is at (0, 4.3, -0.7) [m].
```

Figure 4.5: MATLAB output for problem 2

Figure 4.5 Analysis:

The output shows that the lowest cost for bar AC would be 173.029 kNm, and that this occurs at the location of (0, 4.3, -0.7) [m].

Problem 2 Results:

The lowest cost is 173.029 kNm.
The lowest cost occurs at (0, 4.3, -0.7) m.

Problem 2 Overall Analysis:

This is due to the lower tensions occurring for bar AC occurring around that point. Due to the tension being proportional to the overall cost of the bar, the idea that the minimum cost would be found at the same point where the minimum tension also occurs makes sense. Though, the reason that the lowest tension is not the same as the lowest cost is because of the bar length affecting cost as well, so the lowest cost for bar AC would have to optimize both the length and tension.

Problem 3:

```
>> projectq3
The X component of F is 174.115 kN.
The Y component of F is 78.381 kN.
The Z component of F is -59.502 kN.
```

Figure 4.6: MATLAB output for problem 3

Figure 4.6 Analysis:

The output shows the individual components of force F.

Problem 3 Results:

The x component is 174.115 kN.
The y component is 78.381 kN.
The z component is -59.502 kN.
$\vec{F} = (174.115i + 78.381j - 59.502)kN$

Problem 3 Overall Analysis:

The resulting components calculated through MATLAB match up extremely well with the predicted values in the theory manual. This gives support to the results as being strong as there are two results supporting the same general numbers.

5. Appendix

Problem 1:

```
% Initializing the matrices that will store the bar tensions.
Bar_AC_Tension = [];
Bar_AD_Tension = [];
Bar_AB_Tension = [];

% Initializing the lowest value for the y and z coordinate of point C.
% They are 1 and -1 respectively.
Y_Coord=1;
Z_Coord=-1;

% Looping through every single possible value of y and z from the range
% given in the problem to test possible tensions.
for ii = 1:1:51
   for jj = 1:1:51
      % The system of equations utilized to solve for the tensions of the
      % bars given the y and z coordinates.
      System_of_Equations = [(6/(sqrt(36 + (Y_Coord-2)^2 + (Z_Coord-1)^2))), 6/(sqrt(61)), 2/(sqrt(8));
         (Y_Coord-2)/(sqrt(36 + (Y_Coord-2)^2 + (Z_Coord-1)^2)) , -3/(sqrt(61)), -2/(sqrt(8));
         ((Z_Coord-1)/(sqrt(36 + (Y_Coord-2)^2 + (Z_Coord-1)^2))), 4/sqrt(61), 0];
      Force_Totals = [80; -20; 30];
      Reduced_Matrix = System_of_Equations\Force_Totals;
      % Getting the calculated values for possible tensions of each bar.
      AC = Reduced_Matrix(1);
      AD = Reduced_Matrix(2);
      AB = Reduced_Matrix(3);
      % Storing those calculated values into a corresponding part of the
      % matrix that it belongs in.
      Bar_AC_Tension(jj,ii) = AC;
      Bar_AD_Tension(jj,ii) = AD;
      Bar_AB_Tension(jj,ii) = AB;
      Z_Coord = Z_Coord + 0.1;
   end
   Y_Coord = Y_Coord + 0.1;
   Z_Coord = -1;
end
% Graphing the points collected on labeled graphs.
Y_Values = 1:0.1:6;
Z_Values = -1:0.1:4;
[X,Y] = meshgrid(Y_Values,Z_Values);

figure;

mesh(X,Y,Bar_AC_Tension);
title('Bar AC Tension');
```

```
xlabel('y (m)');
ylabel('z (m)');
zlabel('AC Tension (kN)');

figure;
mesh(X,Y,Bar_AD_Tension);
title('Bar AD Tension');
xlabel('y (m)');
ylabel('z (m)');
zlabel('AD Tension (kN)');

figure;
mesh(X,Y,Bar_AB_Tension);
title('Bar AB Tension');
xlabel('y (m)');
ylabel('z (m)');
zlabel('AB Tension (kN)');
```

Problem 2:

```
% Initializing the matrices that will store the possible lengths of bar
% AC, the tensions, and the costs.

AC_Costs = [];
AC_Bar_Lengths = [];
Bar_AC_Tension = [];

% Initializing the lowest value for the y and z coordinate of point C.
% They are 1 and -1 respectively.

Y_Coord= 1;
Z_Coord= -1;

% Looping through every single possible value of y and z from the range
% given in the problem to test possible tensions.
for ii = 1:1:51
   for jj = 1:1:51
      % The system of equations utilized to solve for the tensions of the
      % bars given the y and z coordinates.
      System_of_Equations = [(6/(sqrt(36 + (Y_Coord-2)^2 + (Z_Coord-1)^2))), 6/(sqrt(61)), 2/(sqrt(8));
         (Y_Coord-2)/(sqrt(36 + (Y_Coord-2)^2 + (Z_Coord-1)^2)) , -3/(sqrt(61)), -2/(sqrt(8));
         ((Z_Coord-1)/(sqrt(36 + (Y_Coord-2)^2 + (Z_Coord-1)^2))), 4/sqrt(61), 0];
      Force_Totals = [80; -20; 30];
      Reduced_Matrix = System_of_Equations\Force_Totals;
      % Stores the tension of bar AC, and then calculates the
      % corresponding length based on the coordinates.
      Bar_AC_Tension(jj,ii) = Reduced_Matrix(1);
      AC_Bar_Lengths(jj,ii) = sqrt(36 + (Y_Coord-2).^2 + (Z_Coord-1).^2);
      Z_Coord = Z_Coord+0.1;
   end
   Y_Coord = Y_Coord + 0.1;
   Z_Coord = -1;
end
%Calculates the costs of all the possible bars by multiplying the tension
%by its length.
```

```
AC_Costs = AC_Bar_Lengths.*Bar_AC_Tension;
% Finds the lowest possible cost of the bar
lowest_cost = min(AC_Costs, [], 'all');

% Graphing the points collected on labeled graphs.
Y_Values = 1:0.1:6;
Z_Values = -1:0.1:4;
[X,Y] = meshgrid(Y_Values,Z_Values);

Y_Cost = X(AC_Costs == lowest_cost);
Z_Cost = Y(AC_Costs == lowest_cost);

fprintf("The lowest cost of bar AC is %.3f kNm.\nThis optimal location is at (0, %.1f, %.1f) [m].\n",
lowest_cost, y_cost, z_cost);
figure;
mesh(X,Y,AC_Costs);
title('Bar AC Cost');
xlabel('y (m)');
ylabel('z (m)');
zlabel('cost (kNm)');
```

Problem 3:

```
% Initializes the points for A, B, C, and D as they were given in the
% problem.
pt_A = [6,2,1];
pt_B = [4,0,1];
pt_C = [0,2,3];
pt_D = [0,-1,5];
% Initializes the force given in the problem.
F = 200;

% Using the points, calculates the vectors for AB, AC, and AD.
r_AB = (pt_B-pt_A);
r_AC = (pt_C-pt_A);
r_AD = (pt_D-pt_A);

% Using the vectors, calculates the unit vectors.
e_AB = (r_AB/norm(r_AB));
e_AC = (r_AC/norm(r_AC));
e_AD = (r_AD/norm(r_AD));
% Takes the unit vectors, and calculates the sum of all of them.
e_Sum = e_AB + e_AC + e_AD;

% Takes the force and the the sum of the units vectors in order to
% calculate what the tensions need to be for the bars.
T = F/norm(e_Sum);
% The components of F are calculated.
norm(e_Sum);
Fcomps = -T * e_Sum;

% The results are printed.
fprintf("The X component of F is %.3f kN.\nThe Y component of F is %.3f kN.\nThe Z component of F is
%.3f kN.\n", Fcomps(1), Fcomps(2), Fcomps(3))
```