ENGINEERING MECHANICS

(E MECH-02)

QUESTION-2

Project Submitted to-

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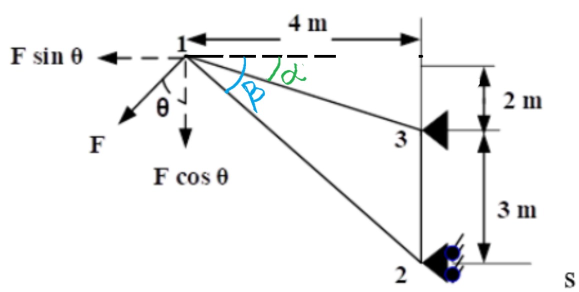
Given Problem Statement:

Q. Analyse the truss subjected to load shown with the specified magnitude of F as 1000 N and direction. Open a table in Excel for Sl No, designation, Force F_{13}, F_{12}, F_{23}, θ in degrees, and θ in radian. Find the forces in various members of the truss by varying θ from 0^o to 90^o with a step increment of 5^o. With the help of the chart draw the graph between θ: F_{13}, θ: F_{12}, and θ: F_{23}.



Given Data -
The truss in the above diagram is given with the above-shown dimensions. Also, F=1000 N is given which is inclined to the vertical with an angle θ. The angle varies from 0^o to 90^o.

What is to be found-
We need to find the forces in each member of the truss given as F_{12}, F_{13}, and F_{23}, with variations in the angle θ from 0^o to 90^o with a step increment of 5^o.

Assumptions -

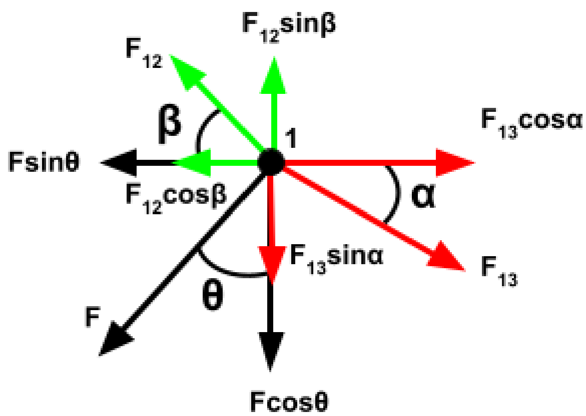
Angles α and β are assumed by us as the angles shown in the figure.

F_{13} and F_{23} are assumed to be tensile and F_{12} is assumed to be compressive

Introduction and Theory

The truss problems are solved by considering different joints in equilibrium. (Method of joint)

FBD at joint 1:



Considering joint 1 at equilibrium:

$F\sin\theta + F_{12}\cos\beta = F_{13}\cos\alpha$

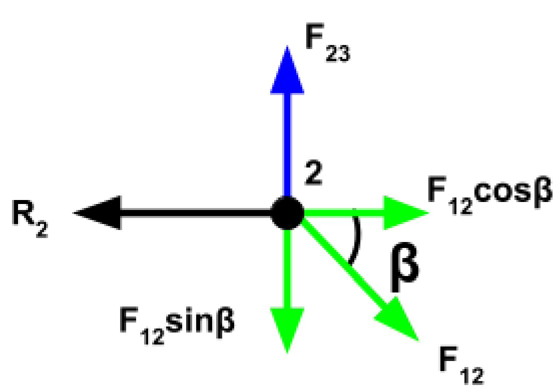
$F\cos\theta + F_{13}\sin\alpha = F_{12}\sin\beta$

Solving this we get the →

$F_{12} = F(\sin\alpha\sin\theta + \cos\alpha\cos\theta)/(\sin\beta\cos\alpha - \cos\beta\sin\alpha)$

$F_{13} = F(\sin\beta\sin\theta + \cos\beta\cos\theta)/(\sin\beta\cos\alpha - \cos\beta\sin\alpha)$

FBD at joint 2:



Considering joint 2 at equilibrium:

$F_{12}\cos\beta = R_2$ and $F_{23} = F_{12}\sin\beta$

// We have got the expressions for F_{12}, F_{13}, and F_{23}. Now we vary θ from 0^o to 90^o with a step increment of 5^o and check out changes in F_{12}, F_{13}, and F_{23} from the Python program that we have made.

Truss Analysis using Python

Interpreter Version - Python 3.10
Libraries Used - math, prettytable, matplotlib.pyplot.

Code -

```
import math
from prettytable import PrettyTable
import matplotlib.pyplot as plt

#finding angle alpha
a = round(math.atan(2 / 4), 5)
adeg = round(math.degrees(a), 5)

#finding angle beta
b = round(math.atan(5 / 4), 5)
bdeg = round(math.degrees(b), 5)

print("Angle α is: ",a," radians OR ",adeg," degrees")
print("Angle β is: ",b," radians OR ",bdeg," degrees")

#defining function for F12, F13 and F23 by change in θ
def column(th1):
    # finding F12, F13 and F23 by the given formulas
    f = 1000
    th = round(math.radians(th1),3)
    f12 = round( f * ((math.sin(a) * math.sin(th) +
    math.cos(a) * math.cos(th)) / (math.sin(b) *
    math.cos(a) - math.cos(b) * math.sin(a))), 3)
```

```
    f13 = round( f * ((math.sin(b) * math.sin(th) +
    math.cos(b) * math.cos(th)) / (math.sin(b) *
    math.cos(a) - math.cos(b) * math.sin(a))), 3)
    f23 = round(f12 * math.sin(b), 3)
    table.add_row([th1,th,f12,f13,f23])
    y12.append(f12)
    y13.append(f13)
    y23.append(f23)

#running loop for variation in the value of θ and
printing table
table = PrettyTable(["θ (in deg)","θ (in rad)","F12
(compressive)","F13 (tensile)","F23 (tensile)"])
x = []
y12 = []
y13 = []
y23 = []
for th1 in range(0, 95, 5):
    x.append(th1)
    column(th1)
print(table)

#graphing the graphs of θ with F12, F13, and F23
print('''Enter 1 for all plots separately
Enter 2 for all plots separately in the same window
Enter 3 for all plots in the same graph''')

ch = int(input("Enter your choice: "))

if (ch == 1):
    plt.plot(x, y12, color = 'springgreen')
    plt.xlabel('θ (in degrees)')
    plt.ylabel('F12 (in Newtons)')
    plt.title("Variation of F12 with θ")
    plt.show()
```

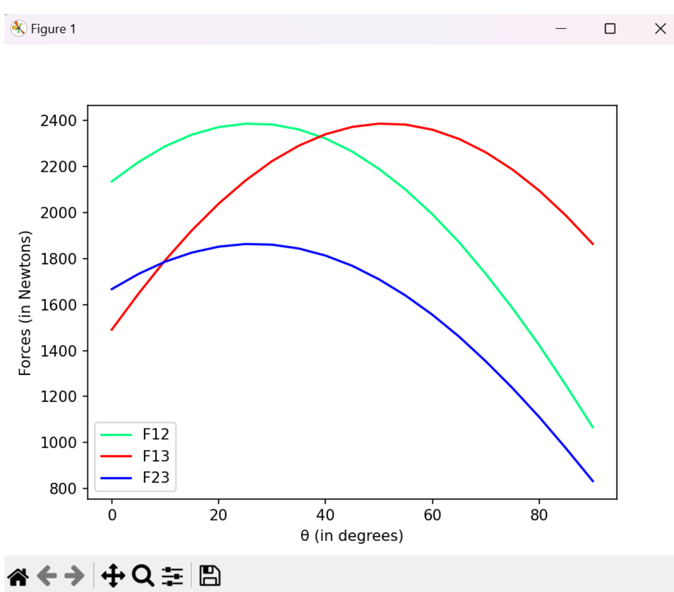
```
        plt.plot(x, y13, color = 'red')
        plt.xlabel('θ (in degrees)')
        plt.ylabel('F13 (in Newtons)')
        plt.title("Variation of F13 with θ")
        plt.show()

        plt.plot(x, y23, color = 'blue')
        plt.xlabel('θ (in degrees)')
        plt.ylabel('F23 (in Newtons)')
        plt.title("Variation of F23 with θ")
        plt.show()

    elif (ch == 2):

        figure, axis = plt.subplots(1, 3)
        axis[0].plot(x, y12, color = 'springgreen')
        axis[0].set_title("Variation of F12 with θ")

        axis[1].plot(x, y13, color = 'red')
        axis[1].set_title("Variation of F13 with θ")

        axis[2].plot(x, y23, color = 'blue')
        axis[2].set_title("Variation of F23 with θ")

        plt.show()

    elif (ch == 3):
        plt.plot(x, y12, color = 'springgreen')
        plt.plot(x, y13, color = 'red')
        plt.plot(x, y23, color = 'blue')
        plt.xlabel('θ (in degrees)')
        plt.ylabel('Forces (in Newtons)')

        plt.legend(["F12","F13","F23"], loc="lower left")

        plt.show()
```

Output -

Run main

```
Angle α is:  0.46365  radians OR  26.56519  degrees
Angle β is:  0.89606  radians OR  51.34046  degrees
+------------+------------+------------------+---------------+---------------+
| θ (in deg) | θ (in rad) | F12 (compressive) | F13 (tensile) | F23 (tensile) |
+------------+------------+------------------+---------------+---------------+
|     0      |    0.0     |     2134.362     |   1490.696    |   1666.663    |
|     5      |   0.087    |     2219.018     |   1646.969    |   1732.768    |
|     10     |   0.175    |     2287.569     |   1792.359    |   1786.298    |
|     15     |   0.262    |     2337.94      |   1922.466    |   1825.631    |
|     20     |   0.349    |     2370.626     |   2038.031    |   1851.155    |
|     25     |   0.436    |     2385.38      |   2138.179    |   1862.676    |
|     30     |   0.524    |     2381.948     |   2223.023    |   1859.996    |
|     35     |   0.611    |     2360.433     |   2289.993    |   1843.195    |
|     40     |   0.698    |     2321.064     |   2339.64     |   1812.453    |
|     45     |   0.785    |     2264.137     |   2371.59     |    1768.0     |
|     50     |   0.873    |     2189.136     |   2385.658    |   1709.434    |
|     55     |    0.96    |     2098.33      |   2381.416    |   1638.526    |
|     60     |   1.047    |     1991.652     |   2359.16     |   1555.225    |
|     65     |   1.134    |     1869.909     |   2319.06     |   1460.159    |
|     70     |   1.222    |     1732.381     |   2260.654    |   1352.767    |
|     75     |   1.309    |     1583.232     |   2185.712    |   1236.301    |
|     80     |   1.396    |     1422.107     |   2094.237    |   1110.483    |
|     85     |   1.484    |     1248.192     |   1985.598    |   974.678     |
|     90     |   1.571    |     1066.753     |   1863.084    |   832.997     |
+------------+------------+------------------+---------------+---------------+
```

```
Enter 1 for all plots seprately
Enter 2 for all plots seprately in same window
Enter 3 for all plots in same graph
Enter your choice: 3
```



Results and Discussion - From the graph it can clearly be observed that all the forces, when carying with the angle θ, first reach a maximum and then decrease.

Conclusion - The analysis of the particular given truss has been done successfully and the relation between the angle θ and the forces have been found.

Bibliography -

Making table in Python-
https://www.geeksforgeeks.org/how-to-make-a-table-in-python/

Plotting graph in Python-
https://www.tutorialspoint.com/how-to-plot-a-graph-in-python

Plotting multiple graphs-
https://www.geeksforgeeks.org/plot-multiple-plots-in-matplotlib/

Using colors in graphs-
https://matplotlib.org/stable/gallery/color/named_colors.html

GitHub Link -
https://github.com/KumarShresth/Truss_Analysis_with_Python

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