ENGINEERING MECHANICS (E MECH-02)

QUESTION-2

GROUP MEMBERS:

22051611 - Sancharika Behera
22051612 - Satwick Sinha
22051618 - Shibangi Subhalakshmi Das
22051625 - Shresth Kumar
22051626 - Shresth Soni

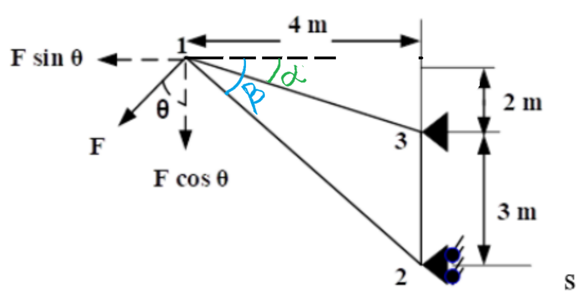
Project Submitted to-

Dr. Bharat Chandra Routra

(Professor & Dean, School of Mechanical Engineering, KIIT)

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}.

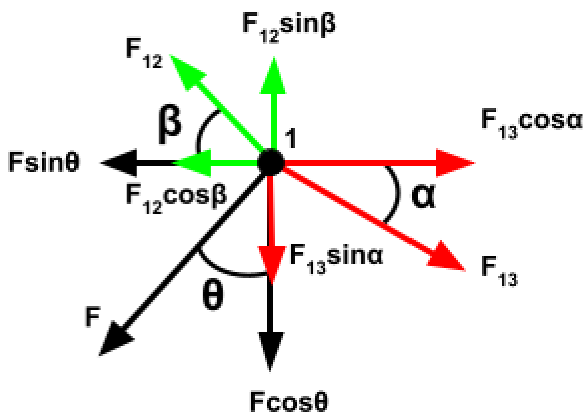


Angles α and β are assumed by us as the angles shown in the figure.

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

Solving the truss

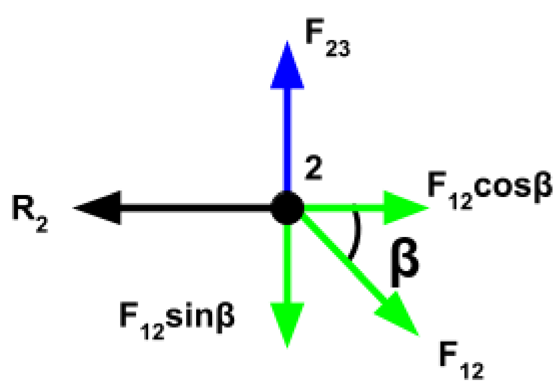
FBD at joint 1:



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)
```

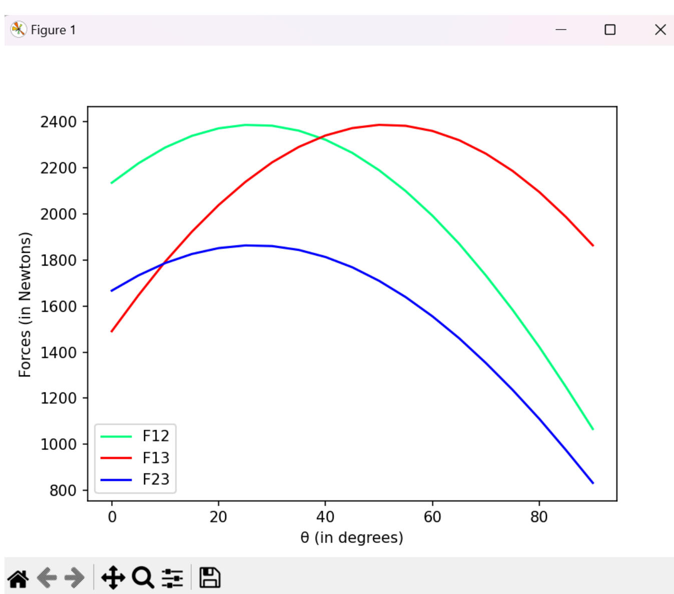
```
    f13 = round( f * ((math.sin(b) * math.sin(th) +
    math.cos(b) * math.cos(th)) / (math.sin(b) *
    math.cos(a) - math.cos(b) * math.sin(a))), 3)
    f23 = round(f12 * math.sin(b), 3)
    table.add_row([th1,th,f12,f13,f23])
    y12.append(f12)
    y13.append(f13)
    y23.append(f23)

#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 -

```
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
```



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