

ENGINEERING MECHANICS

(E MECH-02)

QUESTION-2

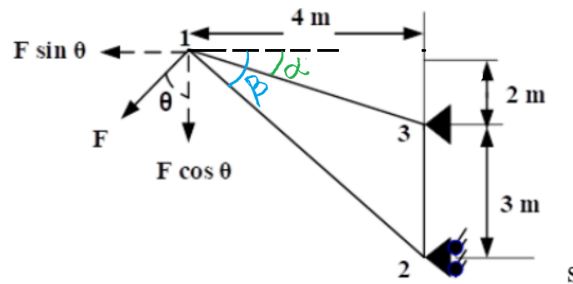
Project Submitted to-

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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° to 90° with a step increment of 5° . 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° to 90° .

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° to 90° with a step increment of 5° .

Assumptions -

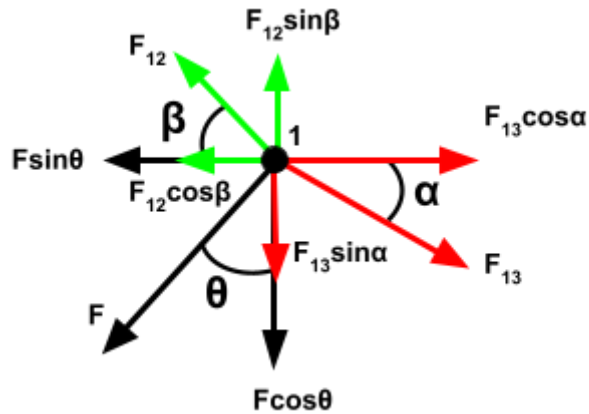
Angles α and β are assumed by us as the angles shown in the figure.

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:

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

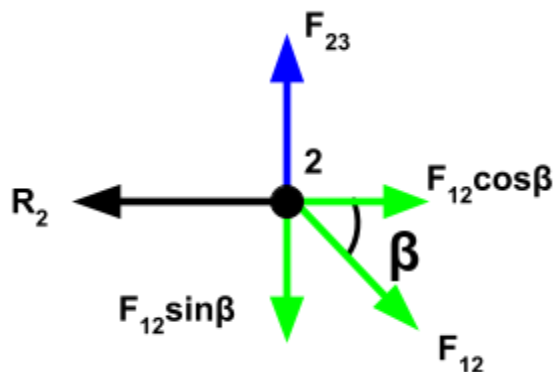
$$F \cos \theta + F_{13} \sin \alpha = F_{12} \sin \beta$$

Solving this we get the \rightarrow

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

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

FBD at joint 2:



Considering joint 2 at equilibrium:

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

// We have got the expressions for F_{12} , F_{13} , and F_{23} . Now we vary θ from 0° to 90° with a step increment of 5° 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  $\alpha$  is: ",a," radians OR ",adeg," degrees")
print("Angle  $\beta$  is: ",b," radians OR ",bdeg," degrees")

#defining function for F12, F13 and F23 by change in  $\theta$ 
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()

```

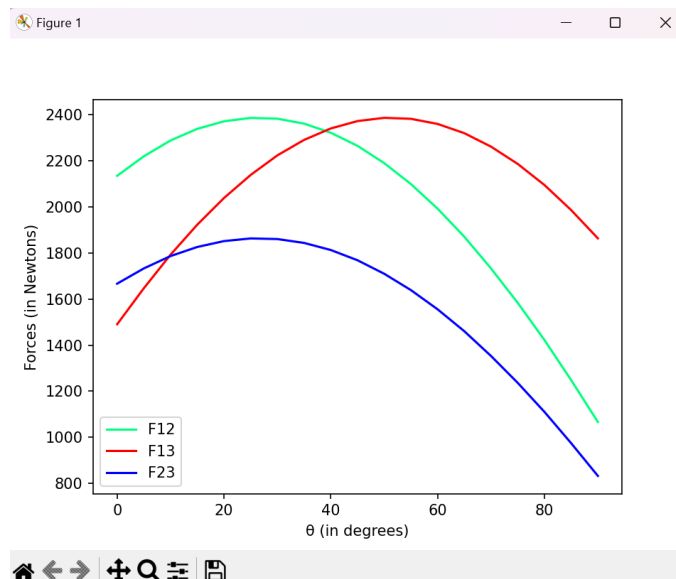
Output -

Run main x

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 separately
Enter 2 for all plots separately 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 varying 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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