PCET's & NMVPM's

Nutan College of Engineering & Research (NCER)

(Affiliated to Dr. Babasaheb Ambedkar Technological University, Lonere)

Assignment No: 01 of Subject

Finite Element Method (FEM)

By

Mr. Chaudhry Sufiyan Ahmad Imtiyaz Ahmad

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Guided By

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Department of Mechanical Engineering

NCER, Talegaon Dabhade

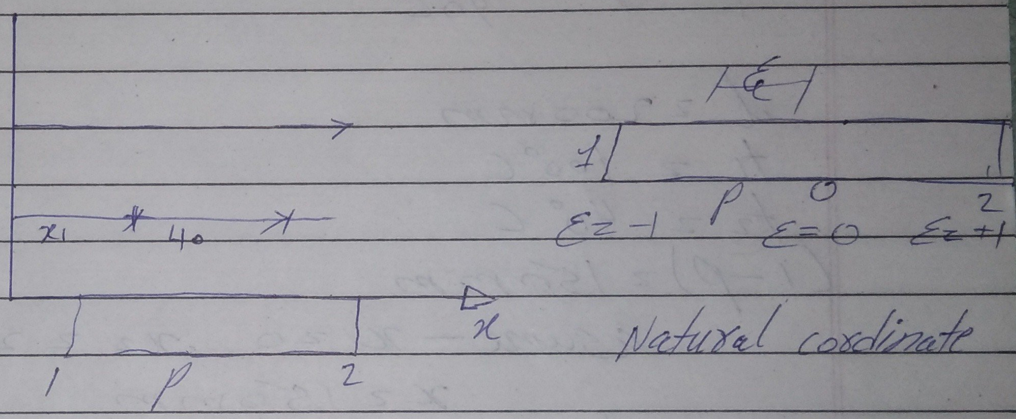
(2021-2022)

Name:- Sufiyan Ahmad Chaudhary
Roll No:- 06
PRN :- 50641920181162511002
Semister :- 07

Assignment NO:- 01

Exp 1)

Ans →



local co-ordinate

$x_1 = 200\,mm$ $\qquad$ $U_1 = 303\,mm$

$x_2 = 360\,mm$ $\qquad$ $U_2 = -0.05\,mm$

$1-P = 40\,mm$

$$x = x_1 + 1 + P = 200 + 40 = 240\,mm$$

Natural co-ordinate

$$\xi = 2\frac{(x-x_1)}{x_2-x_1} = 2\frac{(240-200)}{(360-200)} - 1 = \underline{\underline{-0.5}}$$

Shape function

$$N_1 = \frac{1-\xi}{2} = \frac{1-(-0.5)}{2} = 0.75$$

$$N_2 = \frac{1+\xi}{2} = \frac{1+(-0.5)}{2} = 0.25$$

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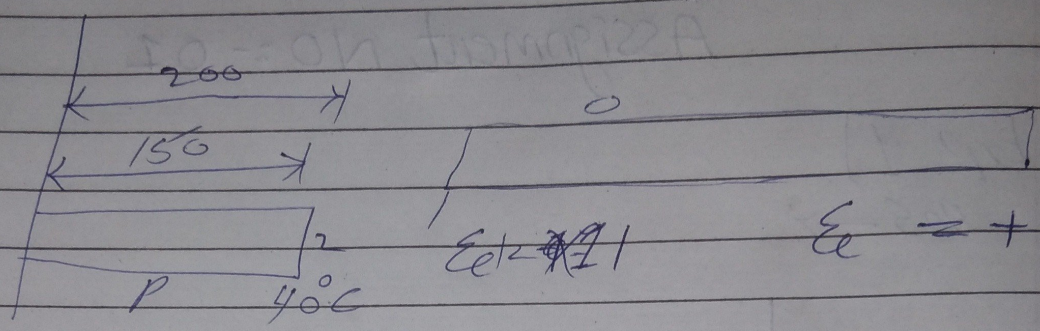
Displacement

$u = N_1 u_1 + N_2 u_2 = 0.75(0.03) + 0.25(0.0$

$u = 0.01 mm$



$l = 200 mm$

$t_1 = 100°C$

$t_2 = 40°C$

$(l-p) = 150 mm$

asume $- x_1 = 0 \quad x_2 = 200$

$x = 150 mm$

Natural Co ordinate

$$\varepsilon = \frac{2(x - x_1)}{x_2 - x} - 1 = \frac{2(150 - 0)}{200 - 0} - 1 = 0.5$$

Shape function

$$N_1 = \frac{1 - \varepsilon}{2} = \frac{1 - 0.5}{2} = 0.25$$

$$N_2 = \frac{1 + \varepsilon}{2} = \frac{1 + 0.5}{2} = 0.75$$

$$N_2 = \frac{1 + \varepsilon}{2} = \frac{1 + 0.5}{2} = 0.75$$

temp at point p

$= t_p = N_1 t_1 + N_2 t_2$

$= 0.25(100) + 0.75(40)$

$= 25°C$

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Assignment No: 02 of Subject

Finite Element Method (FEM)

By

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Assignment : 2

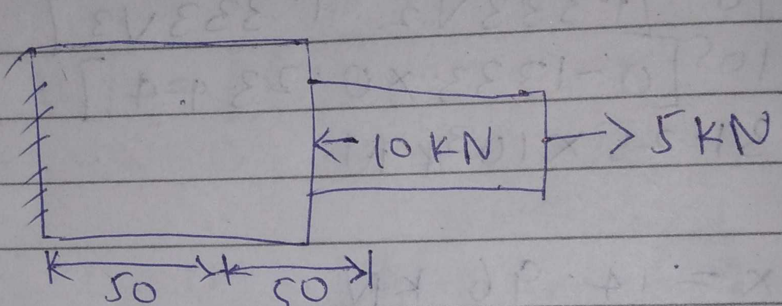
Name: Sufiyan Ahmad Chaudhary

Roll No: 06

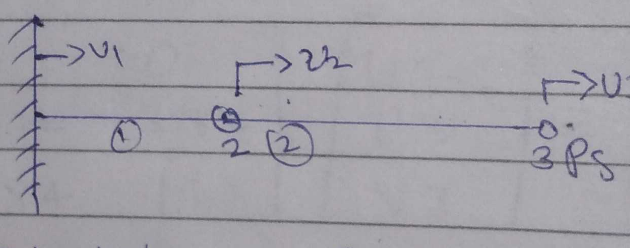
PRN = 50641920181162511002

Given :- $A_1 = 150\ mm^2$ $l_1 = 50 mm$ $E_1 = 200 GPa$

$A_2 = 1000 mm^2$ $l_2 = 50 mm$ $E_2 = 70 GPa$



Discrtization



$P_2 = 10 KN$ $P_3 = 5 KN$

element Connectivity

NO	Gobal local node 1	local node 2
1	1	2
2	2	3

element stiffness matrix.

element 1

$$[K_1] = \frac{A_1 E_1}{L_1}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

$$\frac{150 \times 200 \times 10^3}{50}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

$$= 10^4 \begin{array}{cc} \begin{array}{cc} 1 & 2 \end{array} & \\ \begin{bmatrix} 60 & -60 \\ -60 & 60 \end{bmatrix} & \begin{array}{c} 1 \\ 2 \end{array} \end{array}$$

element 2

$$[K_2] = \frac{A_2 E_2}{L_2}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

$$= \frac{100 \times 70 \times 10^3}{40}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

$$= 10^4 \begin{array}{cc} \begin{array}{cc} 1 & 2 \end{array} & \\ \begin{bmatrix} 14 & -14 \\ -14 & 14 \end{bmatrix} & \begin{array}{c} 1 \\ 2 \end{array} \end{array}$$

Global vector

$$[F] = \begin{Bmatrix} P_1 \\ P_2 \\ P_3 \end{Bmatrix} = \begin{array}{cc} \begin{Bmatrix} R \\ -10 \times 10^3 \\ 5 \times 10^3 \end{Bmatrix} & \begin{array}{c} 1 \\ 2 \\ 3 \end{array} \end{array}$$

Gobal stiffness matrix

$[K] = [K_1] + [K_2]$

$$= \begin{bmatrix} 60 & -60 & 0 \\ -60 & 60+14 & -14 \\ 0 & -14 & 14 \end{bmatrix}$$

load vector

$$[F] = \begin{Bmatrix} P_1 \\ P_2 \\ P_3 \end{Bmatrix} = \begin{array}{c} \begin{Bmatrix} R \\ -10 \times 10^3 \\ 5 \times 10^3 \end{Bmatrix} \end{array} \begin{array}{c} 1 \\ 2 \\ 3 \end{array}$$

Gobal Nodal displacement

$$[U]_n = \begin{Bmatrix} U_1 \\ U_2 \\ U_3 \end{Bmatrix} \begin{array}{c} 1 \\ 2 \\ 3 \end{array}$$

$[K][U] = F$

$$10^4 \begin{bmatrix} 60 & -6 & 0 \\ -60 & 74 & -14 \\ 0 & -14 & 14 \end{bmatrix} \begin{bmatrix} U_1 \\ U_2 \\ U_3 \end{bmatrix} = 0 \begin{Bmatrix} R \\ -10 \times 10^3 \\ 5 \times 10 \end{Bmatrix}$$

Nodal displacement

$$10^4 \begin{bmatrix} 74 & -14 \\ -14 & 14 \end{bmatrix} \begin{bmatrix} U_2 \\ U_3 \end{bmatrix} = \begin{Bmatrix} -10 \times 10^3 \\ 5 \times 10^3 \end{Bmatrix}$$

$R_2 + \frac{14}{74} R_1$

$$10^4 \begin{bmatrix} 74 & -14 \\ 0 & 14 \end{bmatrix} \begin{Bmatrix} U_2 \\ U_3 \end{Bmatrix} = \begin{Bmatrix} -10\times10^3 \\ 0.3\times10^3 \end{Bmatrix}$$

$10^4 \times 11.35 U_3 = 0.311 \times 10^3$

$10^4 (74U_2 - 14U_3) = 10\times10^3$

$U_3 = 27.4\times10^3$ mm

$U_2 = -8.33\times10^{-3}$ mm

$U_1 = 0$ mm

Stress in element

1) $\sigma_1 = \frac{E_1}{l_1} \begin{bmatrix} -1 & 1 \end{bmatrix} \begin{Bmatrix} U_1 \\ U_2 \end{Bmatrix} = \frac{E_1}{l_1} (-U_1 + U_2)$

$= \frac{200\times10^3}{50} (0 - 8.33\times10^{-3})$

$\sigma_1 = -33.33$ N/mm^2

$\times10^3$

10

2) $\frac{E_2}{U_2} (-U_2 + U_3)$

$= \frac{70\times10^3}{50} [-8.333\times10^{-3} + 274\times10^{-3}]$

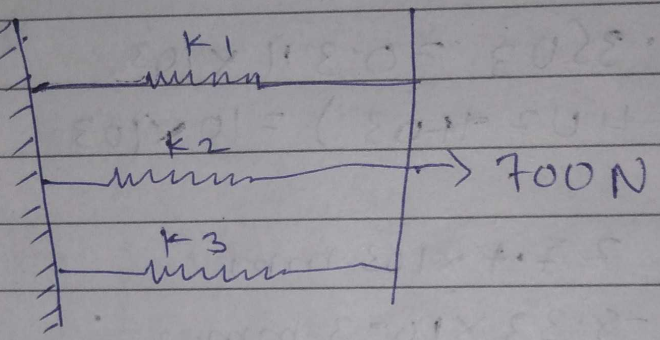
$\sigma_2 = 50$ N/mm^2

Reaction at Support

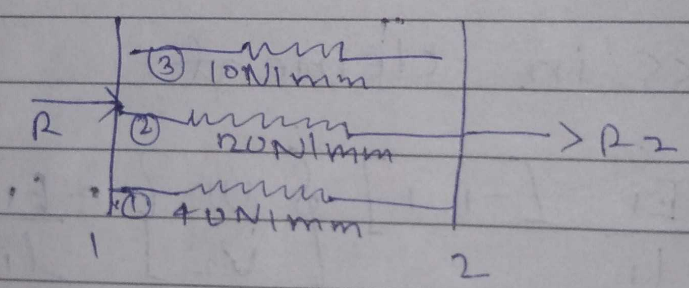
$10^4 (60u_1 - 60) = R$

$10^4((60(0) - 60(-8.33 \times 10^3)) = R$

$R = -5 \times 10^3$ N



Discretization



element connectivity

number	Global local Node①	number local node②
1	1	2
2	1	2
3	1	2

element Connectivity

$$\text{element } 1 \; [k] = k_1 \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} = \begin{bmatrix} k_1 & -k_1 \\ -k_1 & k_1 \end{bmatrix} = \begin{array}{c c} 1 & 2 \\ \end{array} \begin{bmatrix} 10 & -10 \\ -10 & 10 \end{bmatrix} \begin{array}{c} 1 \\ 2 \end{array}$$

$$\text{element } 2 \; [k_2] \; k_2 \begin{bmatrix} k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix} = \begin{array}{c c} 1 & 2 \\ \end{array} \begin{bmatrix} 20 & -20 \\ -20 & 20 \end{bmatrix} \begin{array}{c} 1 \\ 2 \end{array}$$

$$\text{element } 3 \; [k_3] \; k_3 \begin{bmatrix} k_3 & -k_3 \\ -k_3 & -k_3 \end{bmatrix} = \begin{array}{c c} 1 & 2 \\ \end{array} \begin{bmatrix} 40 & 40 \\ -40 & -40 \end{bmatrix} \begin{array}{c} 1 \\ 2 \end{array}$$

Gobal stiffness + [k3]

$$\begin{bmatrix} 10+20+40 & -10-20-40 \\ -10-20-40 & 10+20+40 \end{bmatrix} = \begin{bmatrix} 70 & -71 \\ -70 & 71 \end{bmatrix}$$

Gobal load vector

$$\{F\} = \begin{Bmatrix} P_1 \\ P_2 \end{Bmatrix} = \begin{Bmatrix} R \\ 700 \end{Bmatrix}$$

Gobal Nodal displacement

$$\{U\} = \begin{Bmatrix} U_1 \\ U_2 \end{Bmatrix} \begin{array}{c} 1 \\ 2 \end{array}$$

$$[k]\,[U] = [F]$$

$$\begin{bmatrix} 70 & -70 \\ -70 & 70 \end{bmatrix} \begin{bmatrix} U_1 \\ U_2 \end{bmatrix} = \begin{bmatrix} R \\ 700 \end{bmatrix}$$

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Assignment No: 03 of Subject

Finite Element Method (FEM)

By

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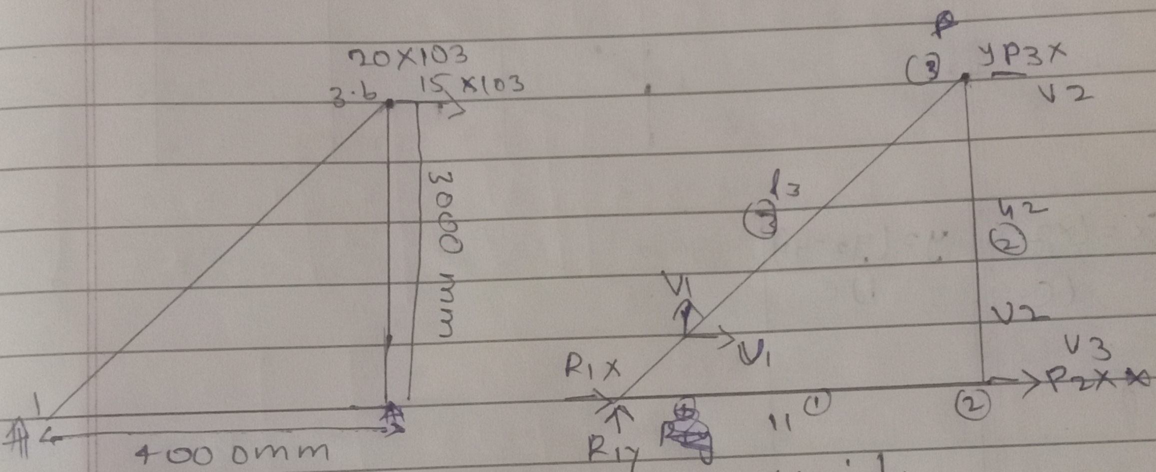
(2021-2022)

Assignment No : 3
Name- Sufiyan Ahmad Chaudhary
Roll No : 06
PRN- 50641920181162511002

Given :- $E = 200 \times 10^3 N/mm^2$ $P_{3x} = 15 \times 10^3$
$P_{3y} = -20 \times 10^3 N$ $J_1 = 4000 mm$
$U_2 = 3000 mm$ $A_1 = A_2 = A_3 = 2000 mm^2$
$U_3 = \sqrt{l_1^2 + J_2^2} = \sqrt{(4000)^2 + (3000)^2} = 5000 mm$



element Connectivity.

element No	Gobal local node1	node 2 local node
1	1	2
2	2	3
3	1	3
4	1	1

Values of C_x and C_y

element number	length of element	Global co-ordinate local node x_1	y_1	local node x_2	y_2	$C_x = (x_2 - x_1)/l_e$	$C_y = (y_2 - y_1)/l_e$
1	4000	0	0	4000	0	1	0
2	3000	4000	0	4000	3000	0	1
3	5000	0	0	4000	3000	0.8	0.6

element stiffness matrix

$$[k_e] = \frac{A_e E_e}{l_e} \begin{array}{c} \begin{bmatrix} C_x^2 & C_x C_y & -C_x^2 & -C_x \cdot C_y \\ C_x \cdot C_y & C_y^2 & -C_x C_y & C_y^2 \\ -C_x^2 & -C_x C_y & C_x^2 & C_x C_y \\ -C_x C_y & -C_y^2 & C_x \cdot & C_y^2 \end{bmatrix} \\ 2j-1 \quad 2i \quad 2j-1 \quad 2j \end{array} \begin{array}{c} 2j-1 \\ 2j \\ 2j-1 \\ 2j \end{array}$$

① $i = 1 \quad J = 2 \quad C_x = 1 \quad C_y = 0$

$$[K]_1 = \frac{2000 \times 200 \times 10^3}{4000} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = 10^5 \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array} \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array}$$

② $i = 2 \quad J = 3 \quad C_x = 0 \quad C_y = 1$

$$K_2 = \frac{2000 \times 200 \times 10^3}{3000} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 1.33 & 0 & 1.33 \\ -1 & 0 & 1 & 0 \\ 0 & 1.33 & 0 & 1.33 \end{bmatrix} = 10^5 \begin{array}{c} \begin{array}{cccc} 3 & 4 & 5 & 6 \end{array} \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 1.33 & 0 & 1.33 \\ -1 & 0 & 1 & 0 \\ 0 & 1.33 & 0 & 1.33 \end{bmatrix} \end{array} \begin{array}{c} \\ 3 \\ 4 \\ 5 \\ 6 \end{array}$$

③ $i = 1 \quad j = 3 \quad C_x = 0.8 \quad C_y = 0.6$

$$k_3 = \frac{2000 \times 200 \times 10^3}{5000} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = 10^5 \begin{array}{c} \begin{array}{cccc} 1 & 2 & 5 & 6 \end{array} \\ \begin{bmatrix} 054 & 04 & \cdot 046 & \\ 48 & 03 & \cdot 24 & 03 \\ 4064 & 04 & 383 & \\ 048 & 036 & 078 & \end{bmatrix} \end{array} \begin{array}{c} 1 \\ 2 \\ 5 \\ 6 \end{array}$$

$$[K] = [K_1] + [K_3] + [K_3]$$

$$= 10^5 \begin{array}{c} \begin{bmatrix} 1.512 & 0.384 & -1 & 0 & -0.312 & -0.384 \\ 0.384 & 0.288 & 0 & 0 & -0.384 & -0.288 \\ -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1.333 & 0 & -1.333 \\ -0.512 & -0.384 & 0 & 0 & 0.512 & -0.384 \\ 0.384 & -2.88 & 0 & -1.333 & 0.384 & 1.621 \end{bmatrix} \\ \begin{array}{cccccc} 1 & 2 & 3 & 4 & 5 & 6 \end{array} \end{array} \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{array}$$

load vector

$$[F] = \begin{bmatrix} P_{1x} \\ P_{1y} \\ P_{2x} \\ P_{2y} \\ P_{3x} \\ P_{3y} \end{bmatrix} = \begin{bmatrix} R_{1x} \\ R_{1y} \\ 0 \\ R_{2y} \\ 15 \times 10^3 \\ -20 \times 10^3 \end{bmatrix} \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{array}$$

Nodal displacement

$$[U] = \begin{array}{c} \begin{bmatrix} U1 \\ V1 \\ U2 \\ V2 \\ U3 \\ V3 \end{bmatrix} \end{array} \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{array}$$

$$[k][U] = [f]$$

$U1 = 0 \quad V2 = 0 \quad V3 = 0$

$$105 \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.5120 & 0384 \\ 0 & 0.384 & 0612 \end{bmatrix} \begin{bmatrix} U2 \\ V3 \\ V3 \end{bmatrix} = \begin{bmatrix} 0 \\ 15 \times 10^3 \\ -20 \times 103 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 5.12 & 3.84 \\ 0 & 3.84 & 1.62 \end{bmatrix} \begin{bmatrix} U2 \\ U3 \\ V3 \end{bmatrix} = \begin{bmatrix} 0 \\ 1.5 \\ -3125 \end{bmatrix}$$

$U2 = 0$

$5.12 U3 + 3.84 V3 = 1.5$

$13.33 V3 = -3.125$

$V2 = 0$

$V3 = -0.2354 \text{ mm}$

$5.12 U3 + 3.84(-0.2334) = 1.3$

$U3 = 0.468 \text{ mm}$

Support · Reaction

$$R_{1x} = 105 [1.52 U_1 + 0.384 U_1 - U_2 - 0.512 U_3 - 0.384 U_3]$$
$$= 105 [0 + 0 + 0.384 + 0.288 \times 0.2344]$$
$$= -11.22 \times 10^3 \ kN$$

$$R_{2y} = 10^5 [1.333 V_2 - 1.333 V_3]$$
$$= 10^5 [0 - 1333 \times 0.2344]$$
$$= 31.25 \times 10^3 \ kN$$

$R_{1x} = 14.96 \ kN$

$R_{1y} = -11.25 \ kN$

$R_{2y} = 31.25 \ kN$