Homework 4

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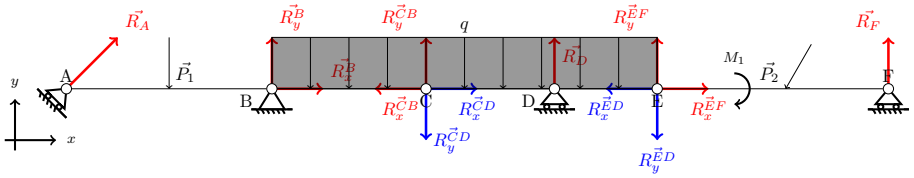
Homework 4 webpage
Homework 4 notebook

1 Task 1

This is not just copy pasted image. (still do not know why did I do this)



Research object:

1. 3 rigid bodies: AC, CE, EF.
2. A, D, F are roller supports
3. B is a hinge support
4. C and E are pin connections

Method:

Statics, the whole stud is in equilibrium.

Force analysis:

1. A — $R_x^A = R_y^A = R^A \cdot \frac{\sqrt{2}}{2}$
2. B — R_x^B, R_y^B
3. C — $|R_x^{CB}| = |R_y^{CD}| = |R_y^C|$, $|R_x^{CD}| = |R_x^{CB}| = |R_x^C|$
4. D — R_y^D

5. E — $|R_x^{ED}| = |R_x^{EF}| = |R_x^E|$, $|R_y^{ED}| = |R_y^{ED}| = |R_y^E|$
6. F — R_y^F
7. P_1 — $P_{1x} = 0$, $P_{1y} = -P_1$
8. $F_q = q \cdot BE$
9. M_1
10. P_2 — $P_{2x} = -P_2 \cdot \cos(\pi/4)$, $P_{2y} = -P_2 \cdot \sin(\pi/4)$

Unknowns:

1. R^A, R_y^B, R_x^C, R_y^C, R_y^D, R_x^E, R_y^E R_y^F

Solution:

1. Body AC Equations by axis and moment around A:

$$\begin{cases} R^A \cos(\pi/4) + R_x^B - R_x^C = 0 \\ R^A \sin(\pi/4) - P_1 + R_y^B + R_y^C - q \cdot BC = 0 \\ -P_1 \frac{AB}{2} + R_y^B \cdot AB + R_y^C \cdot AC - q \cdot BC \cdot \frac{BC}{2} = 0 \end{cases} \tag{1}$$

2. Body CE Equations by axis and moment around C:

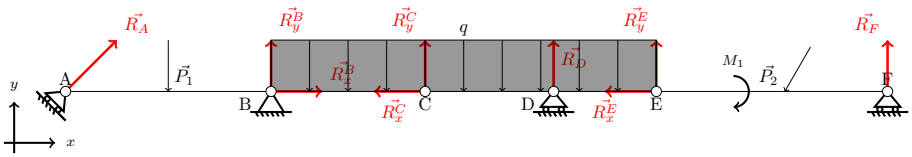
$$\begin{cases} R_x^C - R_x^E = 0 \\ -R_x^C + R_y^E - q \cdot CE + R^D = 0 \\ R_y^E \cdot CE - q \cdot CE \cdot \frac{CE}{2} + R^D \cdot CD = 0 \end{cases} \tag{2}$$

3. Body EF Equation by axis and moment around E:

$$\begin{cases} R_x^E - P_2 \cos(\pi/3) = 0 \\ -R_y^E - P_2 \sin(\pi/3) + R^F = 0 \\ -M_1 - 2.5 P_2 \sin(\pi/3) + R_y^F \cdot EF = 0 \end{cases} \tag{3}$$

4. Solved these systems using python

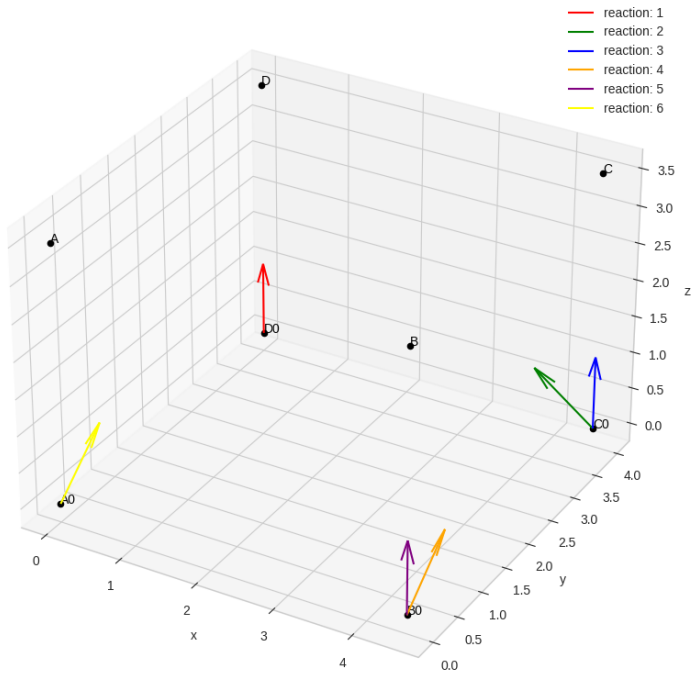
Answer:



$$R^A = 4.680229388568428$$
$$R_x^B = 5.690578061834697$$
$$R_y^B = 14.378015477614287$$
$$R_x^C = 9.000000000000002$$
$$R_y^C = -1.4874374157795929$$
$$R^D = 3.7407658144959157$$
$$R^F = 16.660254037844386$$
$$R_x^E = 9.000000000000002$$
$$R_y^E = 1.0717967697244912$$

2 Task 2

Research object:



1. One rigid body $ABCD$ - plate
2. A_0A, B_0B, C_0C, D_0D - rods supporting the plate
3. A_0, B_0, C_0, D_0 - hinge supports - R_{ix}, R_{iy}, R_{iz}

Force analysis:

1. Rods will have reaction force codirected with the rod
2. Thus, we have 6 forces: $\vec{R}_i, i \in [0, 5]$ to determine.
3. $\vec{G}$ - gravitational force (given)
4. $\vec{P}$ - action force (given)

Solution:

1. We have to construct 2 equations because body should be static in terms of forces and moments.

2. Forces equilibrium:

$$\sum_{i=0}^{5} \vec{R}_i + \vec{G} + \vec{P} = 0 \tag{4}$$

3. Let $\vec{r}_i, i \in [0, 5]$ be vector from A perpendicular to the force.

4. Moments equilibrium:

$$\sum_{i=0}^{5} \vec{r}_i \times \vec{R}_i + \begin{bmatrix} b/2 \\ a/2 \\ 0 \end{bmatrix} \times \vec{G} = 0 \tag{5}$$

5. We have 6 equations and 6 unknowns, so we can solve the system.

Answer:

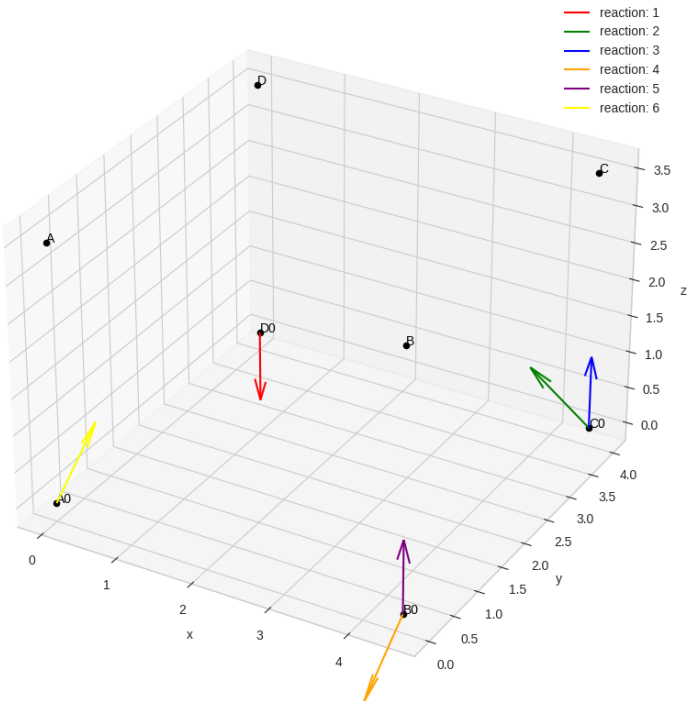


Image has already correct directions of reactions. Negative sign in the answer means that the force is directed from top end of rod to its beginning. Shown reactions are only unit vectors for conviniency.

Obtained using python:

1. $R_1 = -37.66$
2. $R_2 = 38.01$
3. $R_3 = 23.33$
4. $R_4 = -35.43$
5. $R_5 = 9$
6. $R_6 = 35.43$