

Theoretical Mechanics Homework 4

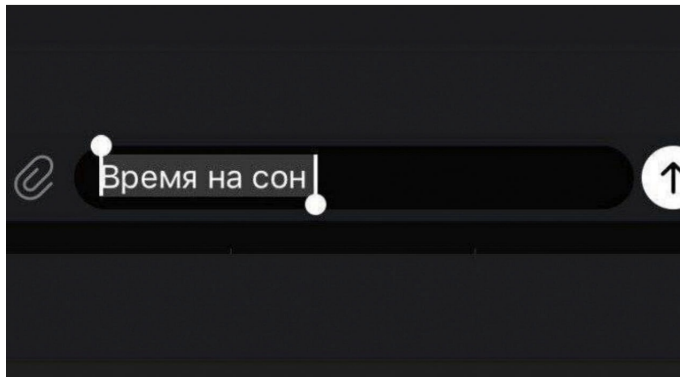
Leonid Novikov, B22-RO-01

February 2024

1 MEME

Me, while doing all the homeworks (i'm slow) and preparing for theoretical mechanics midterms:

**КОГДА НАКОНЕЦ-ТО СМОГ
ВЫДЕЛИТЬ ВРЕМЯ НА СОН:**

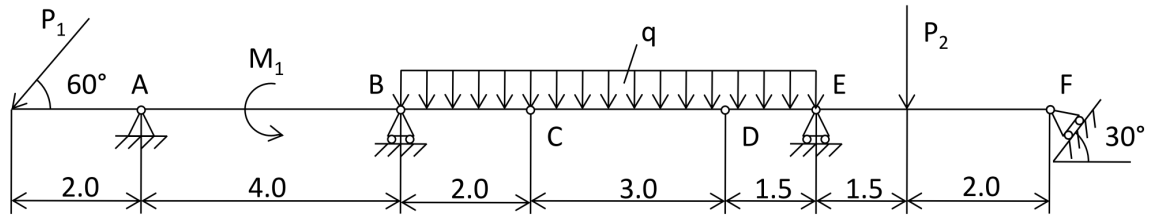


2 LINKS

[Link back to GitHub](#)

3 Task 1

3.1 Task description

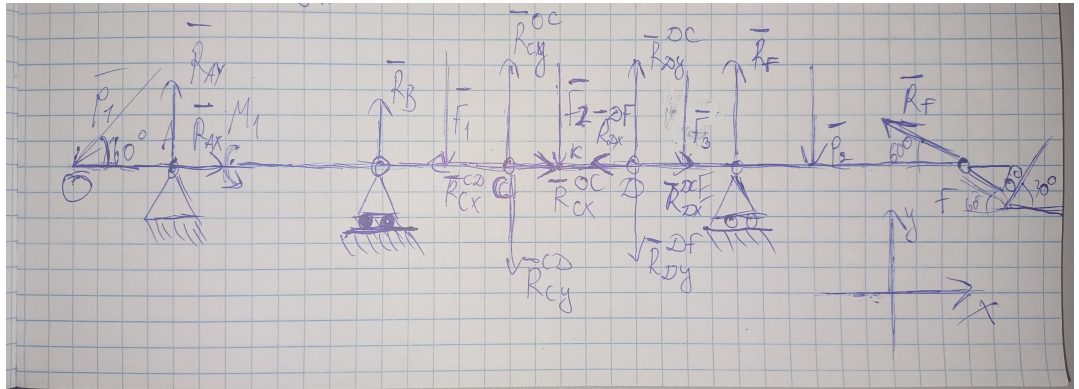


Given:

$$1. P_1 = 6, P_2 = 10, M_1 = 30, q = 1.5$$

Find all reaction forces on A, B, C, D, E, F

3.2 Solution



Research object: 3 rigid bodies: rods OC , CD , DF

Force analysis:

Points C and D are in equilibrium, it means that reaction forces that are applied on them are compensated, hence, we get:

$$\vec{R}_{CX}^{CD} = -\vec{R}_{CX}^{OC}; \vec{R}_{CY}^{CD} = -\vec{R}_{CY}^{OC}$$

$$\vec{R}_{DX}^{DC} = -\vec{R}_{DX}^{DF}; \vec{R}_{DY}^{DC} = -\vec{R}_{DY}^{DF}$$

Let's clarify that:

$$R_{CX}^{OC} = R_{CX} \text{ and } R_{CY}^{OC} = R_{CY}$$

$$R_{DX}^{DC} = R_{DX} \text{ and } R_{DY}^{DC} = R_{DY}$$

3 equations for rod OC :

$$O_x : -P_1 \cdot \cos 60^\circ + R_{CX}^{OC} + R_{AX} = 0$$

$$O_y : -P_1 \cdot \sin 60^\circ + R_{CY}^{OC} + R_B - F_1 = 0$$

$$M(a) : 2 \cdot P_1 \sin 60^\circ + M_1 + 4 \cdot R_B - 5 \cdot F_1 + 6 \cdot R_{CY}^{OC} = 0$$

3 equations for rod CD :

$$O_x : -R_{CX}^{CD} + R_{DX}^{DC} = 0$$

$$O_y : -R_{CY}^{CD} + R_{DY}^{DC} = 0$$

$$M(C) : -1.5 \cdot F_2 + 3 \cdot R_{DY}^{DC} = 0$$

3 equations for rod DF :

$$O_x : -R_{DX}^{DF} - R_F \cdot \cos 60^\circ = 0$$

$$O_y : -R_{DY}^{DF} - F_3 + R_E - P_2 + R_F \cdot \sin 60^\circ = 0$$

$$M(D) : -0.75 \cdot F_3 + 1.5 \cdot R_E - 3 \cdot P_2 + 5 \cdot R_F \cdot \sin 60^\circ = 0$$

After feeding everything to sympy, it gave me:

$$R_{AX} = 4.639$$

$$R_{AY} = 13.419$$

$$R_B = -2.973$$

$$R_{CX} = -1.639$$

$$R_{CY} = -2.25$$

$$R_{DX} = -1.639$$

$$R_{DY} = 2.25$$

$$R_E = 11.660$$

$$R_F = 3.278$$

3.3 Answer

$$R_{AX} = 4.639$$

$$R_{AY} = 13.419$$

$$R_B = -2.973$$

$$R_{CX} = -1.639$$

$$R_{CY} = -2.25$$

$$R_{DX} = -1.639$$

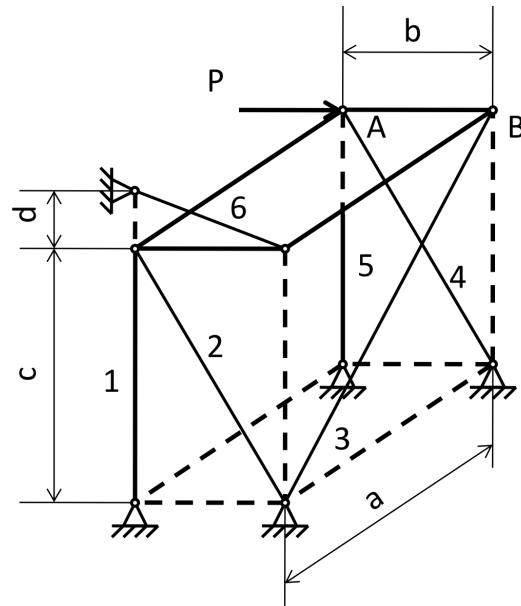
$$R_{DY} = 2.25$$

$$R_E = 11.660$$

$$R_F = 3.278$$

4 Task 2

4.1 Task description

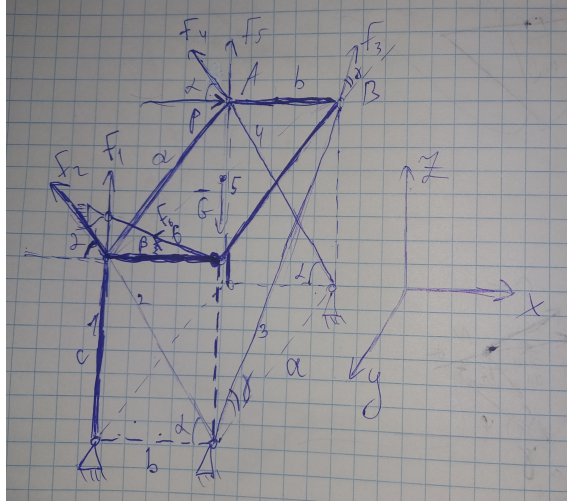


Given:

1. $G = 10$, $P = 20$;
2. $a = 8.5$, $b = 2.5$, $c = 3.5$, $d = 2$

Find reaction forces in rods 1 – 6

4.2 Solution



Object of study: 1 rigid body.

Force analysis:

Firstly, I need to find angles α , β , γ .

$$\alpha = \arctan \frac{c}{b};$$

$$\beta = \arctan \frac{d}{b};$$

$$\gamma = \arctan \frac{c}{a}.$$

Then I can write down projection of forces on O_x , O_y , O_z :

$$O_x : -F_2 \cdot \cos \alpha - F_r \cdot \cos \alpha - F_6 \cdot \cos \beta + P = 0$$

$$O_y : -F_3 \cdot \cos \gamma = 0$$

$$O_z : F_1 + F_2 \cdot \sin \alpha + F_3 \cdot \sin \gamma + F_4 \cdot \sin \alpha + F_5 + F_6 \sin \beta - G = 0$$

And I can write equations of momentums that rotate the plate around x, y, and z axes in point A:

$$M_A^x : -F_2 \cdot a \cdot \sin \alpha - F_1 \cdot a - F_6 \cdot a \cdot \sin \beta + G \cdot \frac{a}{2} = 0$$

$$M_A^y : b \cdot F_3 \cdot \sin \gamma + b \cdot F_6 \cdot \sin \beta - G \cdot \frac{b}{2} = 0$$

$$M_A^z : b \cdot F_3 \cdot \cos \gamma - a \cdot F_2 \cdot \cos \alpha - a \cdot F_6 \cdot \cos \beta = 0.$$

After feeding those 6 equations to sympy, I got this answer:

$$F_1 = 8.750;$$

$$F_2 = -10.752;$$

$$F_3 = 0.000;$$

$$F_4 = 34.409;$$

$$F_5 = -23.000;$$

$$F_6 = 8.003$$

4.3 Answer

$$F_1 = 8.750;$$

$$F_2 = -10.752;$$

$$F_3 = 0.000;$$

$$F_4 = 34.409;$$

$$F_5 = -23.000;$$

$$F_6 = 8.003$$