Elina Murtazina, homework 4

1 Task 1

1.1 Tools

Overleaf, Google Collab

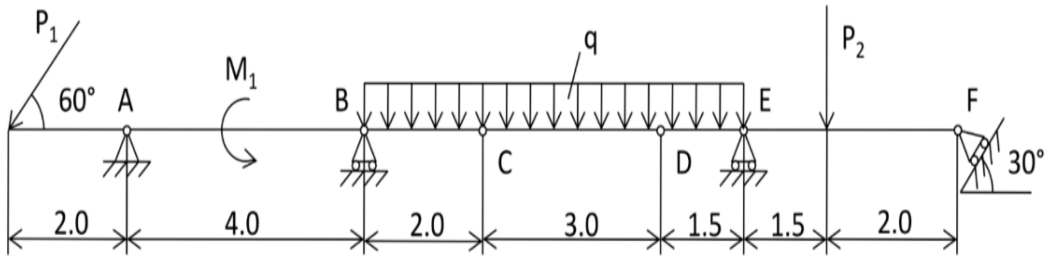
1.2 Task description

Task 1

Determine the reaction forces and the forces in the interim pins of the composite stud. The studs and acting forces are shown.

Needed variables:

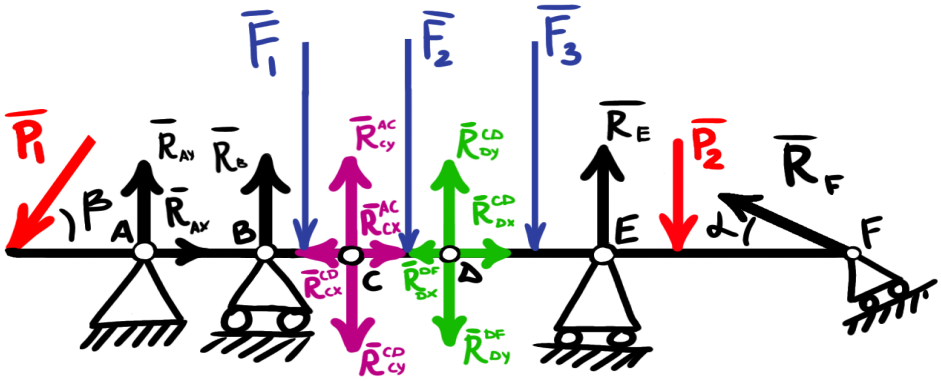
$P_1 = 6,\ P_2 = 10,\ M_1 = 30,\ q = 1.5.$



Task 1
(Yablonskii (eng) S3)

1.3 Task explanation

Let's divide given pole on 3 parts - 3 rigit bodies and see how forces acting on it. 1st - AC, 2nd - CD, 3rd - DF. We have to mention the left-hand from point A part, on which force P_1 is acting, it's also the part of the first body. Here is updated picture with all needed information:



Let's do force analysis. Given: $P_1 = 6$, $P_2 = 10$, $M_1 = 30$, q $= 1.5$, $\beta = 60$, $\alpha = 30$. $F_1 = 2\text{q} = 3$, $F_2 = 3\text{q} = 4.5$, $F_3 = 1.5\text{q} = 2.25$

We have to find: $R_B, R_E, R_F, R_{Ax}, R_{Ay}, R_{Cx}, R_{Cy}, R_{Dx}, R_{Dy}$, 9 unknowns. 3 bodies, 3 equation for each and 9 unknowns, that means we can solve this problem.

For the 1st body: $\begin{cases} x : -P_1 cos\beta + R_{Ax} + R_{Cx}^{AC} = 0 \\ y : -P_1 sin\beta + R_{Ay} - F_1 + R_{Cy}^{AC} = 0 \\ M_A : 2P_1 sin\beta + M_1 + 4R_B - 5F_1 + 6 + R_{Cy}^{AC} = 0 \end{cases}$

For the 2nd body: $\begin{cases} x : -R_{Cx}^{CD} + R_{Dx}^{CD} = 0 \\ y : -R_{Cy}^{CD} + R_{Dy}^{CD} - F_2 = 0 \\ M_C : -1.5F_2 + 3R_{Dy}^{CD} = 0 \end{cases}$

For the 3rd body: $\begin{cases} x : -R_{Dx}^{DF} - R_F cos\alpha = 0 \\ y : -R_{Dy}^{DF} - F_3 + R_E - P_2 + R_F sin\alpha = 0 \\ M_D : -0.75F_3 + 1.5R_E - 3P_2 + 5R_F sin\alpha = 0 \end{cases}$

After substituting given values we get:

For the 1st body: $\begin{cases} x : -3 + R_{Ax} + R_{Cx}^{AC} = 0 \\ y : -3\sqrt{3} + R_{Ay} - 3 + R_{Cy}^{AC} = 0 \\ M_A : 6\sqrt{3} + 30 + 4R_B - 15 + 6 + R_{Cy}^{AC} = 0 \end{cases}$

For the 2nd body: $\begin{cases} x : -R_{Cx}^{CD} + R_{Dx}^{CD} = 0 \\ y : -R_{Cy}^{CD} + R_{Dy}^{CD} - 4.5 = 0 \\ M_C : -6.75 + 3R_{Dy}^{CD} = 0 \end{cases}$

For the 3rd body: $\begin{cases} x: -R_{Dx}^{DF} - \frac{R_F\sqrt{3}}{2} = 0 \\ y: -R_{Dy}^{DF} - 2.25 + R_E - 10 + \frac{R_F}{2} = 0 \\ M_D: -1.6875 + 1.5R_E - 30 + \frac{5R_F}{2} = 0 \end{cases}$

And now we can find all of the unknown. Note: R_{Dy}^{DF} is the same as R_{Dy}

Since we are humans and can make mistakes, I'd rather trust computer to solve this task, so here is the LINK with all of the values in the end solution.

2 Task 2

2.1 Tools

Overleaf

2.2 Task description

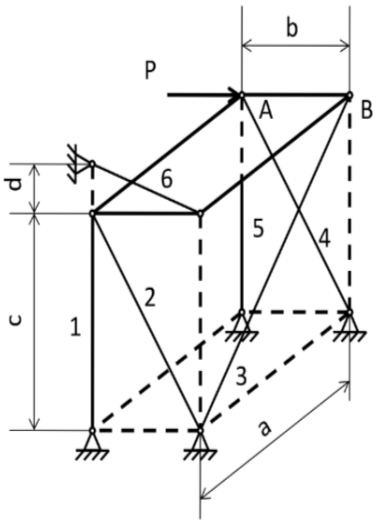
Task 2

Determine the reaction forces in rods supporting a thin horizontal rectangular plate of weight G under action of force P applied along the side AB. The constructions and the acting forces are shown.

Needed variables:

$G = 10,\ P = 20;$

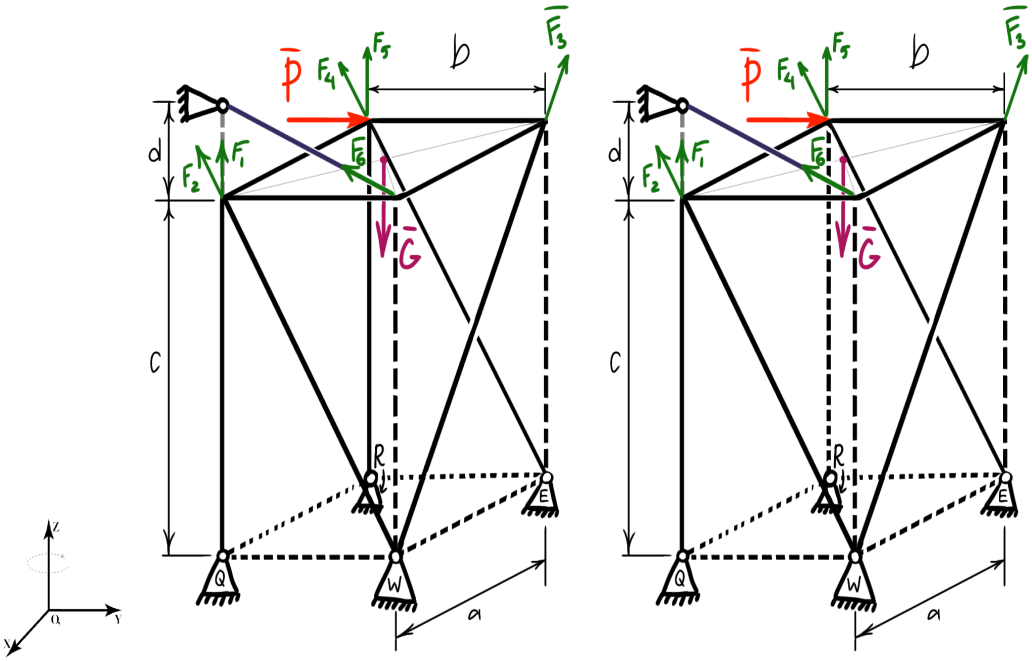
$a = 8.5,\ b = 2.5,\ c = 3.5,$ d=2



Task 2
(Yablonskii (eng) S6)

2.3 Task explanation

The first thing I want to introduce new scheme with forces and other additional vectors:



I have to mention what that task has some flaws in the original explanation drawing, such as misleading information about edge AR (where R is the point below point A). Is that real rope or just an imaginary line? To prevent misunderstandings I drew 2 versions and will use the second one in solving. Also it's not clear what do numbers 1-6 mean. I'll say they are the names of edges, so I'll allow myself to call them like e_1, e_2 and so on.

Let's do force analysis. Given: G = 10, P = 20, a = 8.5, b = 2.5, c = 3.5, d=2. Model does rotation motion along vector z, vector G facing to the ground. We treat the whole figure as 1 rigit body.

We have to find 6 forces, F_{1-6}. Since we have 1 body in 3 dimentional system, we can calculate all variables, since 6 unknowns =¿ 6 equations. Let's define such system of equations:

$$\begin{cases} x: -F_3\frac{a}{e_3} = 0 \\ y: -F_2\frac{b}{e_2} - F_6\frac{b}{e_6} - F_4\frac{b}{e_4} + P = 0 \\ z: F_1 + F_2\frac{e_1}{e_2} + F_3\frac{c}{e_3} + F_4\frac{c}{e_4} + F_5 + F_6\frac{d}{e_6} - G = 0 \\ M_0^x: bF_3\frac{c}{e_3} + bF_6\frac{d}{e_6} - \frac{bG}{2} = 0 \\ M_0^y: -aF_1 - aF_2\frac{e_1}{e_2} - aF_6\frac{d}{e_6} + \frac{aG}{2} = 0 \\ M_0^z: bF_3\frac{a}{e_3} - aF_2\frac{b}{e_2} - aF_6\frac{b}{e_6} = 0 \end{cases}$$

Let's calculate all edges (I still don't understand what edge 5 is ~~and I feel like assembling Ikea furniture rn~~)

$e_1 = c = 3.5$

$e_2 = \frac{\sqrt{74}}{2}$

$e_3 = \frac{13\sqrt{2}}{2}$
$e_4 = e_2 = \frac{\sqrt{74}}{2}$
$e_5 = ??maybe = e_1 = 3.5$
$e_6 = \frac{\sqrt{41}}{2}$

Substituting found edges and other given values to the system of the equations:

$$\begin{cases} x : -F_3\frac{17}{13\sqrt{2}} = 0 \\ y : -F_2\frac{5}{\sqrt{74}} - F_6\frac{5}{\sqrt{41}} - F_4\frac{5}{\sqrt{74}} + 20 = 0 \\ z : F_1 + F_2\frac{7}{\sqrt{74}} + F_3\frac{7}{13\sqrt{2}} + F_4\frac{7}{\sqrt{74}} + F_5 + F_6\frac{4}{\sqrt{41}} - 10 = 0 \\ M_0^x : F_3\frac{17.5}{13\sqrt{2}} + F_6\frac{10}{\sqrt{41}} - 12.5 = 0 \\ M_0^y : -8.5F_1 - F_2\frac{59.5}{\sqrt{74}} - F_6\frac{34}{\sqrt{41}} + 42.5 = 0 \\ M_0^z : F_3\frac{42.5}{13\sqrt{2}} - F_2\frac{42.5}{\sqrt{74}} - F_6\frac{42.5}{\sqrt{41}} = 0 \end{cases}$$

Yet again, to solve it correctly, I'll use Python, which should give us the right answer in a beautiful manner, you can see answers through this LINK

Now for memes of the week, since I forgot to send one at week 3 here are two of them: