

TASK MODELLING OF STATICALLY DETERMINATE SYSTEM OF BEAM USING “EXCEL” SPREADSHEET

Jurgis Maciulevičius
Kaunas College

Abstract

This paper provides methodology that can be applied by students both for classroom and individual work as well as by teachers to prepare and test homework assignments and control tests. This methodology integrates two subjects - Mechanics and Information Technology. Some samples of problem solution of different loading cases are provided in this paper.

Keywords: statically determinate system of beam, excel spreadsheet, reaction forces, initial and calculation data

INTRODUCTION

Problem - with the rapid development of Informational Technologies, this tool (IT) is more widely integrated into delivery of the content of different academic subjects. This is the main reason why it is useful to have the methodology allowing acquisition of calculation results and graphical solution immediately after entering initial data.

Aim - To apply the Excel and the principles of Mechanics in order to develop the methodology for flexible modelling of a chosen assignment and to provide a student with a possibility to

start from the simpler and move towards more complicated tasks related to calculations of statically determinate system of beam.

METODOLOGY

1. Algorithm of the task

In the scheme provided in Fig. 1 two mutually joined beams (*AC* and *BC*) subjected to external force, *F*. Angles, which bars and force forms with *x*-axis, are as follows, respectively – α_1 , α_2 , α_3 . Variation of angular ranges, setting angles by turning in counterclockwise is presented in Figs. 2a, 2b, and 2c.

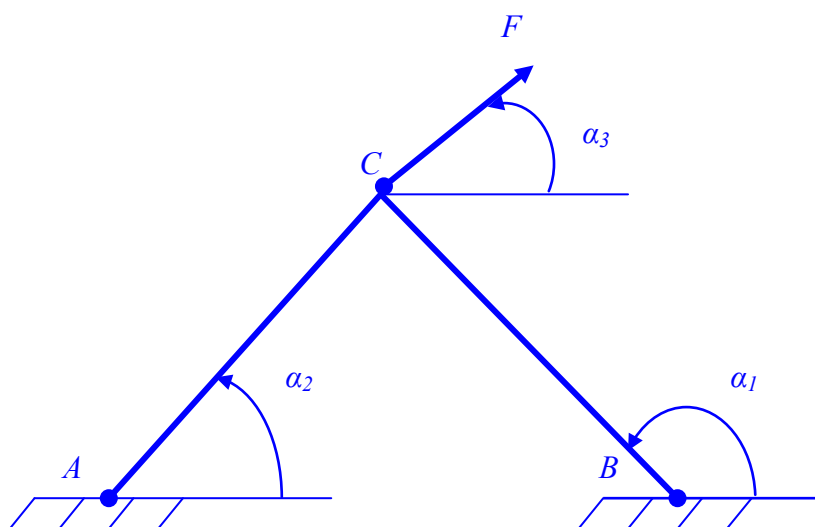


Fig. 1. Task model

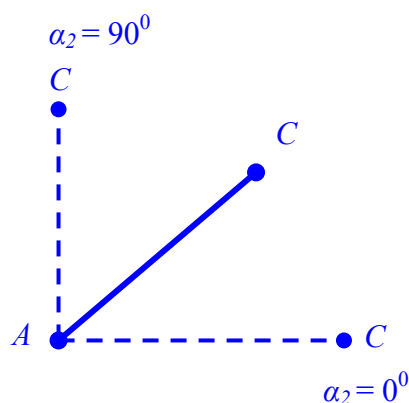


Fig. 2a. α_2 - angle variation

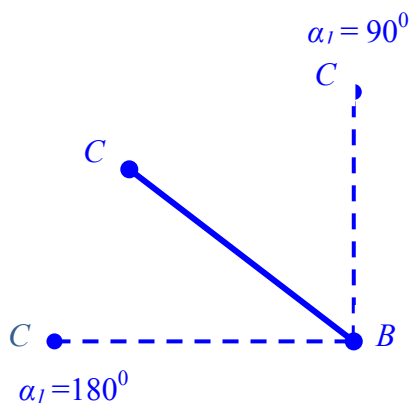


Fig. 2b. α_1 - angle variation

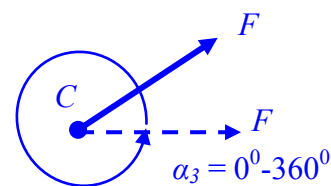


Fig. 2c. angle α_3 - variation

Reaction forces within the beams, R_A and R_B are taken freely, and can be computed on the basis of statics argument (Fig. 3). For

mathematical description of the task, we use the following statics equilibrium equations in the coordinate axes x and y :

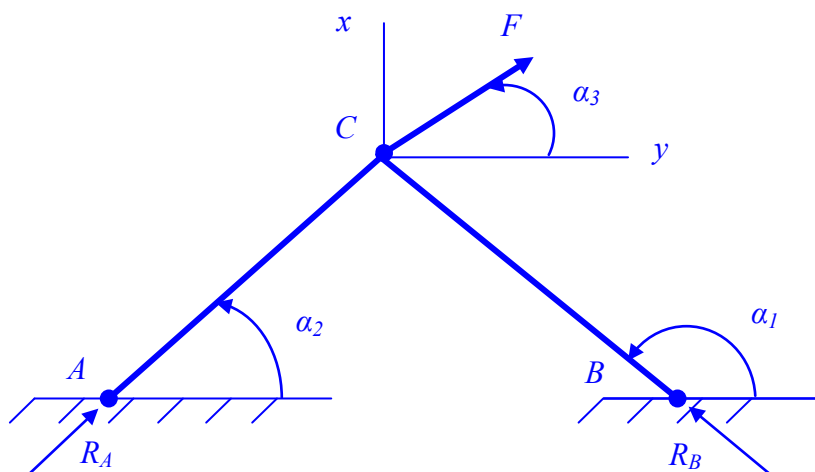


Fig. 3. Task of computational scheme

$$\sum F_x = 0, R_B \cdot \cos \alpha_1 + R_A \cdot \cos \alpha_2 + F \cdot \cos \alpha_3 = 0 \quad (1)$$

$$\sum F_y = 0, R_B \cdot \sin \alpha_1 + R_A \cdot \sin \alpha_2 + F \cdot \sin \alpha_3 = 0 \quad (2)$$

By solving the system of equations with two unknown variables, we obtain values of reactions R_A and R_B :

$$R_B = (-1) \cdot (R_A \cdot \cos \alpha_2 + F \cdot \cos \alpha_3) / \cos \alpha_1 \quad (3)$$

$$R_A = F \cdot (\cos \alpha_3 \cdot \tan \alpha_1 - \sin \alpha_3) / (\sin \alpha_2 - \cos \alpha_2 \cdot \tan \alpha_1) \quad (4)$$

2. Development of applied programme

Further solution of the task is performed by applying Eqs. (1-4) and Excel spreadsheet. Having used using the general sketch for plane system of at one point intersecting forces and

the table of initial data, one can create a wide range of tasks, changing the initial data parameters. This task is modelled in computer-aided addresses using an Excel spreadsheet, and all four mathematical equations.

Computer-aided task solution is presented in the table 1 and Figs. 4 (a, b, c, d). If values of reactions R_A and R_B are positive, then Fig. 3 shows that their directions are chosen correctly. If we obtain negative values in the table, it means that actual direction will be reverse.

Having changed the direction of reactions, the result is rewritten with a plus sign. Solving the task manually students have a possibility to verify the correctness of calculation comparing with the computer solution. Changing initial data in the table in accordance with variation

of angles range, one can obtain various variants of solution. Tasks modelling allow preparing assignments for control works of various complexities.

In Fig. 4 is presented a graphical solution of the task on the basis of forces balance condition, which states that in the case of equilibrium must be the closed triangle of forces. By solving the task graphically, a student must not only accurately depict the known force F in the scale, but correctly to set directions of all three forces as well.

Table 1. Table of initial and calculation data

Data					Results					
No.	F	α_1	α_2	α_3	R_A	R_B	$CtrlX$	$CtrlY$	R_A	R_B
Ex.	kN	degrees	degrees	degrees	kN	kN	kN	kN		
1	60	132	33	278	34,0	55,1	0	0	actual	actual

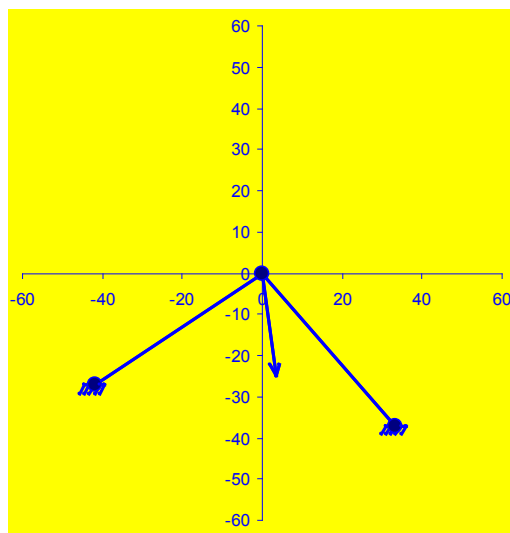


Fig.4a. Calculation scheme

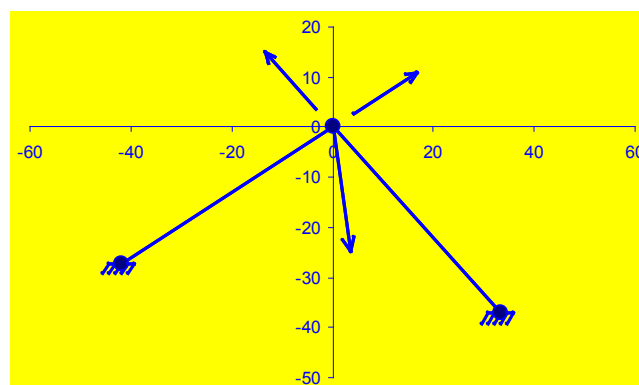


Fig.4b. scheme with free directions

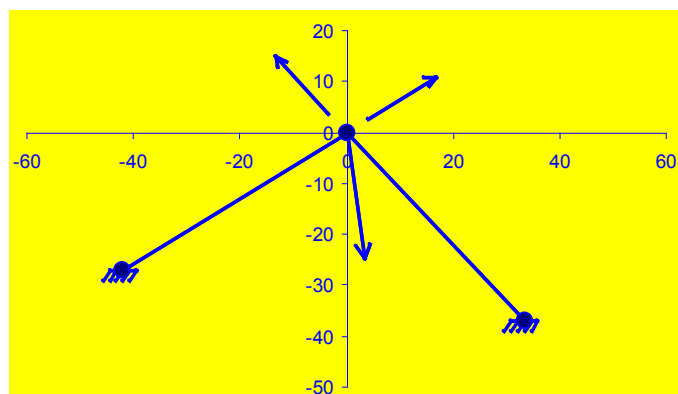


Fig. 4c. scheme with correct directions



Fig.4d. Triangle of forces

As it is seen from the above-presented computer-aided solution, that both directions of reactions R_A and R_B are correct, because values calculation results in the table are positive (chosen directions coincided with the computer analysis directions). By solving the

task graphically, actual directions are shown according to forces directions acting in the triangle of forces. Manually solving this task, it is necessary to transform (rotate) axis, otherwise it would be obtained the equation with two unknown variables.

Table 2. Table of initial and calculation data

Data					Results				Directions	
No	F	α_1	α_2	α_3	R_A	R_B	CtrX	CtrY	R_A	R_B
Ex.	kN	degrees	degrees	degrees	kN	kN	kN	kN		
2	59	132	90	77	-72,3	19,8	0	0	opposite	actual

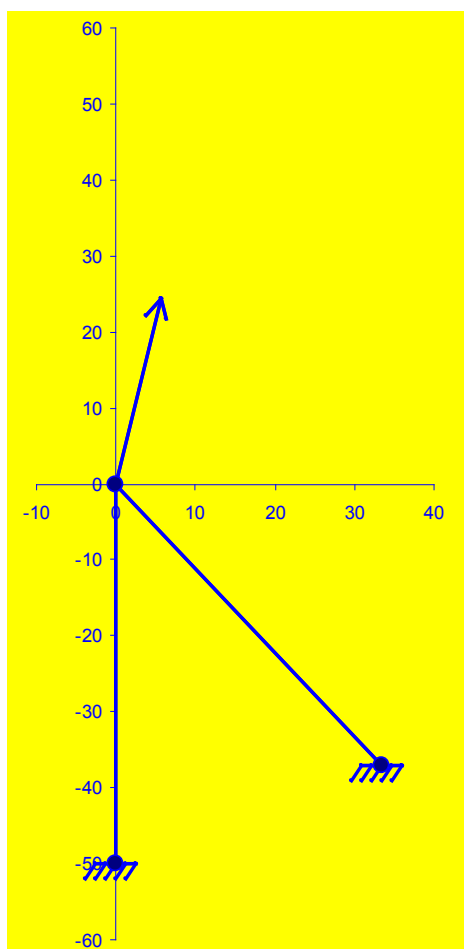


Fig.5a. Calculation scheme



Fig.5b. Triangle of forces

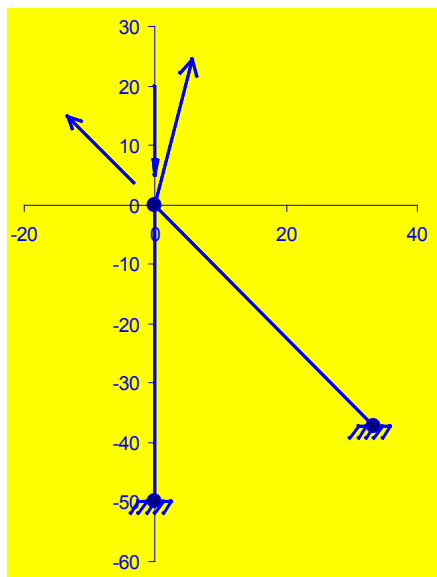


Fig.5c. Scheme with correct directions

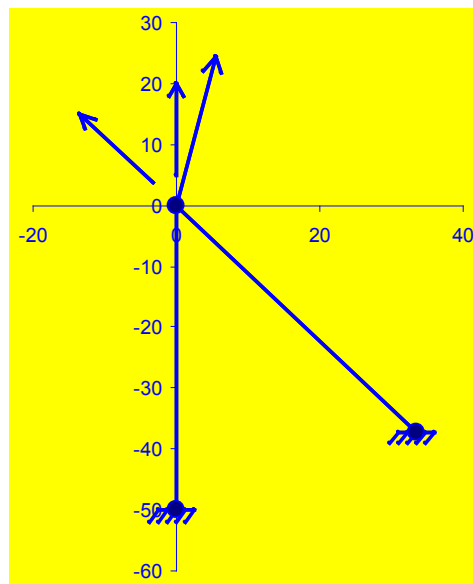


Fig.5d. Scheme with free directions

The above presented computer-aided model shows that the R_B is in the right direction, because values of the calculation results in the

table are positive and the direction of reaction R_A is changed in the reverse direction than was chosen. That is seen from the negative value of

calculation. By solving the problem manually, it is not necessary to rotate coordinate axes, because one of reactions has a full size of projection on the coordinate axis y , and is a point on the x -axis (Figs. 5a, b, c, d). By writing the balance equations of statics in one of them (on the x -axis) would remain only one unknown variable and right away it would be obtained the result of solution.

CONCLUSIONS

1. Provided examples prove that this methodology allows flexible modelling of basic/general model, starting from the simplest and moving towards more complicated assignments as well as. It (methodology) also provides possibility to choose directions of the loadings by changing their inclination angles from 0 to 360 degrees.

2. Two ways of a task solution are possible:

a) Using values from the table of initial data, to calculate and draw a scheme manually (on paper) and compare it with computer-aided

solution.

b) Using different modelling variants, to model correctly the table of data (applying the same scheme) and obtain the same computer-aided solution.

3. Application of IT helps to save time and leads to better quality of tasks of statically determinate system of beam.

4. This methodology requires both a student and a teacher to possess specific knowledge and skills in the fields of mechanics and informational technologies.

REFERENCES

- [1] Paliūnas V. Teorinė mechanika. Kaunas: Technologija, 1997.
- [2] Šakys V. Microsoft „Excel“ 2000 ir 2002. Kaunas: Smaltija, 2002.
- [3] Maciulevičius J. „Gėminės sijos atraminių reakcijų nustatymas „Excel“ skaičiuoklės pagalba. Mokslinės praktinės konferencijos „Informacinės technologijos: aktualijos ir perspektyvos“ pranešimų medžiaga. Alytus, 2004.