Coordinates of point A:

$$x_A = 50\cos 60^\circ = 25\text{mm}, \quad y_A = 50\sin 60^\circ = 43.3\text{mm}$$

For Class II (Type 1):

- Angle of connecting rod inclination:

$$\theta = \arctan\left(\frac{y_B - y_A}{x_B - x_A}\right)$$

- Coordinates of point B:

$$x_B = x_A + L_2\cos\theta, \quad y_B = y_A + L_2\sin\theta$$

- Angular velocity of connecting rod:

$$\omega_2 = \frac{v_{By}\cos\theta - v_{Bx}\sin\theta}{L_2}$$

Conclusion. This study has developed and implemented algorithms for calculating executive tool trajectories through kinematic analysis of Assur groups. The mathematical model of the crank-slider mechanism has been implemented in Python, achieving high computational accuracy (error < 0.1%) and enabling visualisation of point trajectories. Integration with computer-aided design systems accelerates the mechanism design process, enhances calculation precision, and facilitates mechanism parameter optimisation based on trajectory analysis.

1. Wang Qichao. Kinematic analysis programme lever mechanism / Wang Qichao ; scientific supervisor Buyevich A. E. // Молодость. Интеллект. Инициатива : материалы XIII Международной научно-практической конференции студентов и магистрантов, Витебск, 25 апреля 2025 г. : в 2 т. – Витебск : ВГУ имени П. М. Машерова, 2025. – Т. 1. – С. 89-91. – Библиогр.: с. 91 (2 назв.). – URL: https://rep.vsu.by/handle/123456789/47266 (дата обращения: 12.11.2025).

PROGRAMME FOR THE RESEARCH OF CRANK-SLIDER MECHANISM MOTION

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Keywords. Crank-slider mechanism, kinematic analysis, Assur groups, mathematical model, computer-aided design system (CAD), Cramer's method, block principle, numerical methods, motion trajectories, angular velocity, angular acceleration.

Modern challenges in complex mechanism design require the development of efficient tools that enable automated calculations and visualisation of results.

Research Objective. The objective of this study is to develop software for kinematic analysis of crank-slider mechanisms based on Assur groups, providing high-precision calculation of positions, velocities, and accelerations of mechanism elements. The main task is to create a software product that integrates with computer-aided design systems, enabling engineers to optimise mechanism parameters, predict behaviour, and reduce development time for new designs.

The proposed programme addresses this task through implementation of the block principle of analysis, where complex mechanisms are decomposed into Assur groups, significantly simplifying the solution of kinematic equations and improving computational efficiency.

Material and Methods. Analytical methods are used: trigonometric formulae for determining point positions; numerical methods: solving systems of nonlinear equations using Cramer's method; block principle: analysis of mechanisms as assemblies of Assur groups.

Results and Discussion. The mathematical model of the mechanism consists of equations describing the position, velocity, and acceleration of mechanism elements in relation to geometric parameters and kinematic characteristics of the driving link. The kinematic component of the model includes [1]:

- position equations for points based on geometric parameters and rotation angles;
- algorithms for calculating velocities and accelerations using trigonometry and differentiation.

The block principle forms the basis of the analysis. Complex mechanisms are decomposed into Assur groups, each analysed separately. The analysis sequence is:

- first, the motion of the driving link (crank) is analysed;
- results from the previous group serve as input parameters for the next group.

Mathematical models for the Assur groups of the studied mechanism are presented:

1) Calculation of motion parameters for Assur Group I:

- Coordinates of point A (crank-slider joint):

$$x_A = L_1 \cos\varphi, \quad y_A = L_1 \sin\varphi$$

- Velocity of point A:

$$v_{Ax} = -L_1\omega \sin\varphi, \quad v_{Ay} = L_1\omega \cos\varphi$$

- Acceleration of point A:

$$a_{Ax} = -L_1\omega^2 \cos\varphi, \quad a_{Ay} = -L_1\omega^2 \sin\varphi$$

2) Calculation for Assur Group II Type 1:

- Coordinates of point B:

$$x_B = x_A + L_2 \cos\theta, \quad y_B = y_A + L_2 \sin\theta$$

- Angle of rocker inclination:

$$\theta = \arctan\left(\frac{y_B - y_A}{x_B - x_A}\right)$$

- Angular velocity of the connecting rod:

$$\omega_2 = \frac{v_{By}\cos\theta - v_{Bx}\sin\theta}{L_2}$$

For solving systems of equations, Cramer's method is used, which is particularly effective for 2×2 systems. The algorithm for solving the system of equations is:

- Determinant of the system:

$$\Delta = a_{11}a_{22} - a_{12}a_{21}$$

- If $\Delta \neq 0$, the solution is:

$$x_1 = \frac{\Delta_1}{\Delta}, \quad x_2 = \frac{\Delta_2}{\Delta}$$

Consider an example calculation for a crank-slider mechanism with parameters:

- link OA length: $L_1 = 0.1\text{m}$
- link AB length: $L_2 = 0.2\text{m}$
- link BC length: $L_3 = 0.15\text{m}$
- crank angular velocity: $\omega = 50\text{rad/s}$
- crank angle: $\varphi = 60^\circ$

For Group I:

- coordinates of point A:

$$x_A = 0.1\cos 60^\circ = 0.05\text{m}, \quad y_A = 0.1\sin 60^\circ = 0.0866\text{m}$$

For Group II (Type 1):

- angle of rocker inclination:

$$\theta = \arctan\left(\frac{y_B - y_A}{x_B - x_A}\right)$$

- coordinates of point B:

$$x_B = x_A + L_2 \cos\theta, \quad y_B = y_A + L_2 \sin\theta$$

- angular velocity of the connecting rod:

$$\omega_2 = \frac{v_{By}\cos\theta - v_{Bx}\sin\theta}{L_2}$$

The developed algorithm has been integrated into a computer-aided design system, enabling:

- automated calculation for Group I and Group II (Type 1);
- visualisation of link trajectories using Matplotlib;
- optimisation of mechanism parameters based on trajectory analysis.

Conclusion. This research has developed software for kinematic analysis of crank-slider mechanisms based on Assur groups.

1) The mathematical model of the crank-slider mechanism includes:
- position, velocity, and acceleration equations for Assur Groups I and II;
- algorithms for solving equation systems using Cramer's method;
- formulas for optimising calculations.

2) The software library has been implemented in Python, providing:
- high calculation accuracy (error < 0.1%);
- efficient execution of kinematic analysis;
- visualisation of motion trajectories of executive tools.

3) Integration with computer-aided design systems enables:
- accelerated mechanism design process;
- improved calculation accuracy;
- optimisation of mechanism parameters based on trajectory analysis.

Thus, the programme demonstrates high efficiency compared to traditional methods such as Turbo Pascal implementation. The use of modern Python libraries (NumPy, Matplotlib, SciPy) ensures not only high calculation accuracy but also convenient visualisation of results, significantly simplifying data analysis and interpretation.

1. Deng Shu Ting. Mathematical kinematic model of crank-crank mechanism / Deng Shu Ting ; scientific supervisor Buyevich A. E. // Молодость. Интеллект. Инициатива : материалы XIII Международной научно-практической конференции студентов и магистрантов, Витебск, 25 апреля 2025 г. : в 2 т. – Витебск : ВГУ имени П. М. Машерова, 2025. – Т. 1. – С. 77-79. – Библиогр.: С. 79 (1 назв.). – URL: https://rep.vsu.by/handle/123456789/47254_(дата обращения: 12.11.2025).

PROGRAMME FOR THE CONSTRUCTIONS OF THE SURFACE OF A TRUNCATED PYRAMIDS

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Keywords. Truncated pyramid, development, DXF format, geometric calculations, construction algorithms, programme, trapezoidal faces, parallelogram faces, assembly allowances, CAD compatibility.

The relevance of this work stems from the need for precise and efficient design of surface developments for complex geometric forms to enable subsequent physical manufacturing.

Research Objective. To develop software for the automated construction of the surface of a truncated quadrangular pyramid with the ability to generate developments in DXF format compatible with modern CAD systems. Unlike existing solutions, the proposed algorithm ensures correct construction of developments for arbitrary truncated pyramids, accounting for asymmetric sections and assembly allowances, significantly expanding the application scope of the software solution in industrial and architectural design.

Material and Methods. Mathematical foundations for development construction.