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USE OF MODERN PEDAGOGICAL TECHNOLOGIES IN TEACHING THE SUBJECT "TWO MAIN PROBLEMS OF DYNAMICS"

A. G. Qodirov,
Y. V. Rojkova
I. U. Abduazimova.
Tashkent State Transport University, Tashkent, Uzbekistan

A B S T R A C T	K E Y W O R D S
The article presents the methodology of conducting lectures on theoretical mechanics on the topic "Two main problems of dynamics" in the dynamics department. Examples of solving typical problems are given. The use of pedagogical technologies that allow systematic presentation of theoretical material is shown. "Insert" technology allows to evaluate students' knowledge. To strengthen their knowledge, students are invited to solve crossword puzzles and answer questions on the topic of the lecture.	Dynamics, point dynamics, mechanical system dynamics, analytical mechanics, inertial force, first and second problems of dynamics, second order differential equation, integral constants, velocity projection, separation into variables.

Introduction

Type of training: LECTURE

Topic: Two main issues of dynamics

The purpose of the training session is to teach students the purpose of the dynamics section, the laws, differential equations of motion and the two main problems of dynamics, to explain to students how to solve the second main problem of dynamics.

The result of educational activity:

Pedagogical tasks:

- To explain the basic concepts and laws of dynamics.
- Explain the differential equation of motion of a material point.

-Explaining the two main issues of material point dynamics and explaining their difference.

-Explains the manifestations of the second problem of dynamics (in Cartesian and natural coordinates).

- Teaches how to determine integral constants in differential equations.
- Develops issues related to the second (inverse) issue;

Students will achieve:

- Understands the basic concepts and laws of the dynamics section.
- A material point understands the derivation of the differential equations of motion.
- Understands two main issues of material point dynamics and their

identifies the differences.
- Understands the appearance of the second problem in coordinates.
- Understands the projections of the differential equation on the coordinate axes, learns to determine the integral constant.
- Learns to solve the inverse problem in special cases.

Technology of educational process implementation:
Style: Visual lecture, blitz - survey, statement, cluster, "INSERT", B/B/B. method
Form: Conversation-discussion, work in pairs, work in teams and groups.
Tools: Text of lectures, projector, handouts, graphic organizers.
Method: ready-made written materials and drawings, notes.
Supervision: Quick survey test, oral test, questions and answers and practical instructions, etc.
Basic concepts and laws of material point dynamics. Newton's laws. Basic issues of dynamics
The text of the lecture
"He who is not familiar with the laws of motion cannot study nature"
G. Galileo
PLAN:
1. Basic concepts of dynamics.
2. Laws of dynamics.
3. Differential equation of material point motion.
4. Two main issues of material point dynamics.
4.1. The first fundamental question of dynamics.
4.2. Solving the inverse problem of dynamics.
4.3. General instructions for solving the correct and inverse problems of dynamics. Solving procedure.
4.5. Inverse problem solving exercises.

Lesson content
Dynamics is a part of theoretical mechanics that studies the movement of bodies under the influence of forces.
This part consists of three sections:

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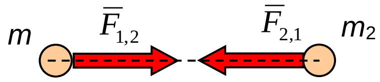
Nuqta dinamikasi – Moddiy nuqta harakatini, uni vujudga keltiruvchi kuchni hisobga olib o'rganadi.
O'rganish sohasi – moddiy nuqta – massaga ega bo'lgan lekin o'lchamlari e'tiborga olinmaydigan moddiy jism.
Mexanik sistema dinamikasi – harakati tekshirilayotgan moddiy nuqtalar yoki jismlar sistemasini harakatga keltiruvchi kuchlarni hisobga olib o'rganadi.
Analytical mechanics studies the movement of non-free mechanical systems using general analytical methods.

The main limitation conditions:
- the existence of absolute space (it has geometric properties and does not depend on matter and its movement).
It follows that:
- the existence of an absolutely fixed number system.
- time does not depend on the movement of the calculation system.
- the non-dependence of the point mass in motion on the movement of the calculation system.
These permutations are used in classical mechanics by Galileo and Newton. It has a very wide field of use to this day.
The main laws of dynamics - discovered by Galileo and described by Newton, are the basis for writing, analyzing all methods of expressing the movement of mechanical systems and their dynamic interaction with various forces.
The law of inertia (Galileo's and Newton's law) - the forces applied to a material point protected from the influence of the external environment will maintain its position or straight line movement. From this it follows that the states of motion and equilibrium are equivalent in terms of inertia (Galileo's law of relativity). The accounting system in which the law of inertia is applicable is called the inertial accounting system. The tendency of a material point to keep its speed of movement (kinematic state) unchanged is called its inertia.
The law of proportionality of force and acceleration (Newton's second law - the basic equation of dynamics) - the acceleration of a material point under the influence of force is directly proportional to the force and inversely proportional to its mass

$m\bar{a} = \bar{F}.$ $\bar{a} = \frac{1}{m}\bar{F}$

Here m is the point mass (a measure of inertia), measured in kg, quantitatively equal to the weight divided by the acceleration of free fall. F is the impact force, measured in N (1 N is such a force that under its influence a body with a mass of 1 kg receives an acceleration of 1 m/c 2, 1 N = 1.102 kgk).

The law of equality of action and reaction (Newton's III law) - the forces of impact of two material points on each other, located on the line connecting these points, have equal modules, but opposite directions:



$\bar{F}_{1,2} = -\bar{F}_{2,1}$

KThe law of mutual independence of the action of forces - If several forces act on a material point, the acceleration of the point is equal to the geometric sum of the accelerations that the point receives from the individual action of each force:

$\bar{a}(\bar{F}_1, \bar{F}_2, ...) = \bar{a}_1(\bar{F}_1) + \bar{a}_2(\bar{F}_2) + ...$ or $\bar{a}(\bar{R}) = \bar{a}_1(\bar{F}_1) + \bar{a}_2(\bar{F}_2) + ...$

The basic equation of dynamics:

$m\bar{a} = \sum \bar{F}_i.$ -corresponding to the vector method of point movement.

Differential equations of motion of a material point

If we put the expression of acceleration in the main equation of dynamics:

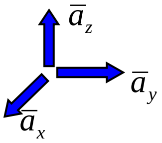
$$\bar{a} = \frac{d^2\bar{r}}{dt^2}.$$

$$m\frac{d^2\bar{r}}{dt^2} = \sum \bar{F}_i \qquad (1).$$

-(1) the differential equation of point motion in vector form is formed.

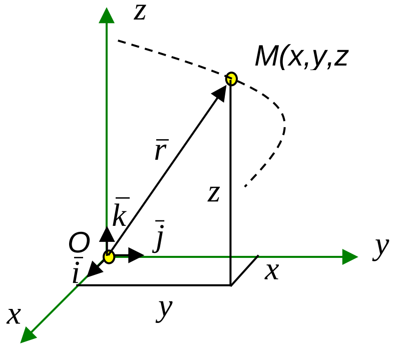
In the method of coordinates: we use the connection of the radius vector with coordinates and the expression of the force vector through its projections::

$$\bar{r}(t) = x(t)\bar{i} + y(t)\bar{j} + z(t)\bar{k} \qquad F_i = X_i\bar{i} + Y_i\bar{j} + Z_i\bar{k}$$



$$m\frac{d^2}{dt^2}(x\bar{i} + y\bar{j} + z\bar{k}) = \sum (X_i\bar{i} + Y_i\bar{j} + Z_i\bar{k}).$$

After grouping, the vector expression is separated into three scalar



equations:

$$(x): m\frac{d^2x}{dt^2} = \sum X_i;$$

$$(y): m\frac{d^2y}{dt^2} = \sum Y_i;$$

i $$(z): m\frac{d^2z}{dt^2} = \sum Z_i.$$

or

$$m\ddot{x} = \sum X_i; \quad m\ddot{y} = \sum Y_i; \quad m\ddot{z} = \sum Z_i.$$

differential equation of point motion in coordinate method.

This result can also be obtained by projecting the vector differential equation (1) onto the Cartesian coordinate axes.

The equation of the motion of a material point on the natural axes is obtained by projecting the differential equation in vector form onto the natural (moving) coordinate axes:

$$(\tau): ma_{\tau\tau} = \sum F_{i\tau};$$

$$(n): ma_n = \sum F_{in};$$

$$(b): m \cdot 0 = \sum F_{ib}.$$

or - obtained by the equation of motion of the material point in the three-sided natural axes:

$$m\ddot{s} = \sum F_{i\tau};$$
$$m\frac{\dot{s}^2}{\rho} = \sum F_{in}.$$

Two main issues of dynamics:

1. The first main issue: Motion is given (equation of motion, trajectory). The force that causes this action is found.
2. The second main issue of dynamics: given the force causing the movement. Motion parameters (motion equation and trajectory) must be defined.

Both of these problems are solved using the basic equations of dynamics or their projections on coordinate axes. If the material point is not free, the principle of freedom from binding is applied to them, as in statics. As a result, reaction forces are added to the ranks of forces affecting the material point. The first problem of dynamics is solved by differentiation. The solution of the second problem of dynamics is carried out by integrating the corresponding differential equations, and this way is more complicated than differentiation.

So, the solution of the second basic problem of dynamics is more complicated than the solution of the first basic problem.

We will see how to solve the first basic problem of dynamics in examples.
Issue 1. An elevator car weighing g is being lifted with an acceleration a using a rope. Determine the rope tension**.**
1. We determine the area (since the elevator cabin is in forward motion, we consider it a material point).
2. Discard the connection (rope) and replace it with R-reaction force.
3. We construct the main equation of dynamics:
4. We project the main equation of dynamics onto the Y axis:

$$(y): \; ma_y = R - G.$$

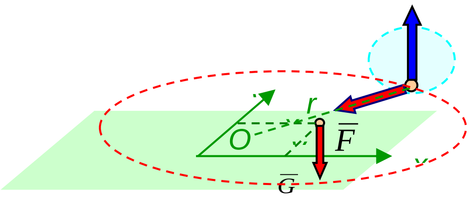
We determine the reaction force of the rope

We determine the tension of the rope:

$$\overline{T} = -\overline{R}; \;\; T = R = G(1 + \frac{a_y}{g}).$$

For smooth movement of the cabin $a_y = 0$ For smooth movement of the cabin: T = G.
When the cable breaks, T = 0 and the acceleration of the cabin is equal to the acceleration of free fall: ay = -g.

2-masala. m mass point horizontal plane x=a·coskt, y= b·coskt moving by law. Determine the force causing this motion of the point.We determine the projections of force:



$$F_x = m\ddot{x} = -mak^2 \cos kt = -mk^2 x;$$
$$F_y = m\ddot{y} = -mak^2 \sin kt = -mk^2 y.$$

module of three::

$$F = \sqrt{F_x^2 + F_y^2} = mk^2 \sqrt{x^2 + y^2} = mk^2 r.$$

Direction cosines:

$$\cos(\overline{F}, x.) = \frac{F_x}{F} = -\frac{x}{r}; \quad \cos(\overline{F}, y.) = \frac{F_y}{F} = -\frac{y}{r}.$$

Thus, the amount of force is proportional to the distance from the point to the coordinates of the center and is directed toward the center along the line connecting the point with the center.

The center of the motion trajectory of a point consists of an ellipse located at the coordinate origin:

$$x^2 = a^2 \cos^2 kt; \quad y^2 = b^2 \sin^2 kt. \quad \Rightarrow \quad \left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2 = 1$$

The second main issue of dynamics

Solving the second main problem of dynamics, the total force of the movement of a point is variable depending on time, coordinates and speed. The motion of a point is expressed by a system of three differential equations of the second order:

$$\dot{x} = f_1(t, C_1, C_2, C_3);$$
$$\dot{y} = f_2(t, C_1, C_2, C_3);$$
$$\dot{z} = f_3(t, C_1, C_2, C_3).$$

after integrating the equations, six integral constants C1, C2,..., C6 are formed.

$$x = f_4(t, C_1, C_2, ..., C_6);$$
$$y = f_5(t, C_1, C_2, ..., C_6);$$
$$z = f_6(t, C_1, C_2, ..., C_6).$$

The value of integral constants C1, C2, C3, C4, C5, C6 is found from six t=0 initial conditions. After replacing the found constants:

$$\dot{x} = f_1(t, \dot{x}_0, \dot{y}_0, \dot{z}_0);$$
$$\dot{y} = f_2(t, \dot{x}_0, \dot{y}_0, \dot{z}_0);$$
$$\dot{z} = f_3(t, \dot{x}_0, \dot{y}_0, \dot{z}_0).$$

$$x = f_4(t, \dot{x}_0, \dot{y}_0, \dot{z}_0, x_0, y_0, z_0);$$
$$y = f_5(t, \dot{x}_0, \dot{y}_0, \dot{z}_0, x_0, y_0, z_0);$$
$$z = f_6(t, \dot{x}_0, \dot{y}_0, \dot{z}_0, x_0, y_0, z_0).$$

Thus, a material point under the influence of the same system of forces can create a class of actions of different forms, depending on the variety of initial conditions.

The initial position of the point is taken into account through its initial coordinates. The initial speed given by the projection reflects how the point moves in a certain area (section), the result of the forces acting on it until it reaches this section, that is, it depends on the initial kinematic position of the point shows.

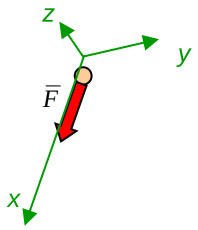
Example 1 of solving the inverse problem. A free material point of mass m is moving under the influence of a force F of constant direction and modulus. At the initial time, the speed of the point is equal to v0, and its direction coincides with the direction of the force.

Example 1 of solving the inverse problem: A free material point module with mass m and direction F is moving under the influence of force. At the initial time, the speed of the point is equal to v0, and its direction coincides with the direction of the force. Find the equation of motion of the point.

1. We construct the main equation of dynamics:

$$m\bar{a} = \sum \bar{F}_i = \bar{F} = \overline{const}.$$

We direct the x-axis of the Cartesian coordinate system along the direction of force and project the main equation of dynamics onto this axis:



$$(x):\ \ ma_x = F_x = F. \qquad m\ddot{x} = F. \ \text{yoki} \qquad m\frac{dv_x}{dt} = F.$$

3. Lower the differential order:

4. Divide into variables:

5. We integrate both sides of the equation.

6. We express the projection of the speed by the time derivative of the coordinate:

7. We divide into variables:

$$dx = (\frac{F}{m}t + C_1)dt.$$

8.We integrate both sides of the equation

9. Using the initial conditions, we determine the constants C1 and C2:

t = 0, vx = v0 , x = x0:

$$v_x\big|_{t=0} = \frac{F}{m}\cdot 0 + C_1 = v_0. \qquad \Rightarrow \qquad \boxed{C_1 = v_0; \quad C_2 = x_0.}$$

As a result, we get the equation of linear variable motion along the x-axis:

•General instructions for solving forward and reverse problems of dynamics. Solution:

• 1. We construct the differential equation of motion:

1.1. If the trajectory of the point is unknown, we choose a rectangular (fixed) coordinate system, if the trajectory is known, we choose a natural (moving) coordinate system.

1.2 We should choose the position of the point so that its coordinates are positive (s > 0, x > 0) for any time (pri t>0).Shu bilan birga tezlik proeksiyasi ham shu holat uchun musbat qiymatga ega deb hisoblaymiz. Tebranma harakatda during the return to equilibrium, the velocity projection changes its direction. In this case, the point is considered to be moving away from its equilibrium position. The implementation of this recommendation is very necessary for the process that is being studied by connecting the resistance force to the speed.

1.3. Freeing a material point from binding, replacing its influence with a reaction force, placing active forces.

1.4. Writing the basic law of dynamics in vector form, projecting it onto a selected axis, expressing them through these variables if the given or active forces depend on time, coordinate, and speed.

2. Solving the differential equation:

2.1. If the equation does not take the canonical (standard) form, the differential order should be reduced. For example

$$\ddot{s} = \frac{dv_\tau}{dt}.$$

2.2. Separation into variables. For example:

$$\frac{dv_x}{dt} = -\frac{1}{m}kv_x, \Longrightarrow \frac{dv_x}{v_x} = \text{yoki } \frac{1}{m}kdt \qquad \frac{dv_\tau}{dt} = g - \frac{k}{m}v_\tau^2, \Longrightarrow \frac{dv_\tau}{g - \frac{k}{m}v_\tau^2} = dt.$$

2.3. If there are three variables in the equation, the variables must be replaced. For example:

$$\frac{dv_x}{dt} = -\frac{1}{m}cx, \qquad \frac{dv_x dx}{dtdx} = \frac{v_x dv_x}{dx} = -\frac{1}{m}cx$$

and then assign to variables.

2.4. Calculation of indefinite integrals on the left and right sides of the equation, for example:

$$\int \frac{dv_x}{v_x} = -\int \frac{1}{m}kdt \Longrightarrow \ln v_x = -\frac{1}{m}kt + C_1$$

Using the initial conditions (for example, t = 0, vx = vx)0), it is necessary to determine the integral constants:

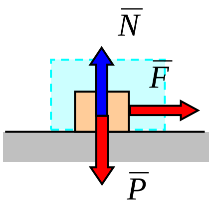
$$\ln v_x\Big|_{v_{x0}} = -\frac{1}{m}kt\Big|_0 + C_1; \quad C_1 = \ln v_{x0}$$

2.5. Express the speed by the time derivative of the coordinate, i.e.

and repeat points 2.2-2.4.

$$v_\tau = \frac{ds}{dt} = e^{-\frac{1}{m}kt + \ln v_{\tau 0}}$$

Example 2 of solving the old problem (force-time-dependent case): a load with weight P is moving along a smooth horizontal plane under the influence of force F. The force F changes proportionally to time (F=kt). Find the path traveled by the load at time t.



1. SWe choose the number system (Cartesian coordinate) so that the body coordinates are positive.
2. 1. We consider a moving object as a material point.

(since it is a smooth plane) we replace it with the normal reaction force:

3. We construct the main equation of dynamics:

$$m\bar{a} = \sum \overline{F_i} = \overline{F} + \overline{P} + \overline{N}.$$

4. We project the main equation of dynamics onto the x-axis:

$$m\bar{a} = \sum \overline{F_i} = \overline{F} + \overline{P} + \overline{N}.$$

$$(x): \quad ma_x = F = kt \quad \text{yoki} \qquad \boxed{\ddot{x} = \frac{k}{m}t.}$$

5.We lower the differential order: $m\frac{dv_x}{dt} = kt.$

6. We divide into variables: $dv_x = \frac{k}{m} tdt.$

7. We integrate both sides of the equation:

$$\int dv_x = \int \frac{k}{m} tdt. \Rightarrow \boxed{v_x = \frac{k}{m}\frac{t^2}{2} + C_1.}$$

8. t = 0, $v_x = v_0=0$ we find the integral constant C1 from the initial conditions:

$$\Rightarrow v_x\big|_{t=0} = \frac{k}{m}\cdot\frac{0^2}{2} + C_1 = v_0 = 0. \Rightarrow \boxed{C_1 = 0.}$$

9. we replace the density projection with the time derivative of the coordinate:
10. We divide into variables:

$$\frac{dx}{dt} = \frac{k}{m}\frac{t^2}{2}. \qquad dx = \frac{k}{m}\frac{t^2}{2}dt.$$

11. Let's integrate both sides of the equation:

$$\int dx = \int \frac{k}{m}\frac{t^2}{2}dt. \Rightarrow \boxed{x = \frac{k}{m}\frac{t^3}{6} + C_2.}$$

12. t = 0, x = x_0=0 constant C2 from the initial conditions:

$$x\big|_{t=0} = \frac{F}{m}\frac{0^3}{6} + C_2 = x_0 = 0. \Rightarrow \boxed{C_2 = 0.}$$

As a result, we get the equation of motion that represents the path traveled along the x-axis during time t:.

Control questions.
1. State the first law of dynamics.
2. State the second law of dynamics.
3. State the third law of dynamics.
4. What is the mechanical quantity of force (F) in SI (International System of Units).
 measured in units?
5. Explain the first problem of point dynamics.
6. State the second problem of point dynamics.
7. What is the unit of acceleration in SI (International System of Units).
 measured?
8. What is the unit of mass (m) in SI (International System of Units).
 measured?

Conclusions and Suggestions

In conclusion, it can be said that the advanced pedagogical experiments carried out on the basis of the topic "Two main issues of dynamics" serve to make students work independently, develop the ability to think freely, use time effectively, master the subject well and increase the level of knowledge.

Ensuring unity and consistency in the teaching of subjects, improving textbooks and study guides, reflecting in them the innovations in the field of science, highlighting current and future tasks, independent education, advanced pedagogical and It is appropriate if it is covered using modern information and communication technologies.

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