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THE ROLE OF DIFFERENTIAL CALCULUS AND DIFFERENTIAL EQUATIONS IN SOLVING PRACTICAL PROBLEMS AIMED AT IMPROVING THE PROFESSIONAL TRAINING OF CIVIL ENGINEERS

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ABSTRACT

The article explores the solution of practical problems using derivative and differential equations in improving the professional training of civil engineers through a high level of teaching mathematics, which is fundamental in the field of technical education. At the same time, practical problems are given and mathematical solutions are given.

KEYWORDS: *Mathematical Model, Product, Maximum And Minimum Values Of Function, Differential Equations, Equilibrium Equation, Air Exchange Equation, Heat Dissipation Intensity Of Concrete, Free Vibration Processes In Construction.*

INTRODUCTION

In today's fast-paced world, higher education institutions are able to deal with problematic situations with in-depth theoretical and practical knowledge, as well as the ability to work independently in their chosen field, independently improve their knowledge and skills, and take a creative approach. The task is to train specialists who can identify, analyze and adapt quickly to the conditions.

It is impossible to train modern personnel without raising the level of knowledge in mathematics, which is considered fundamental. Therefore, the science of mathematics is of great importance in the formation of a wide range of builders, architects and designers. In addition, mathematics serves as a tool for the successful mastery of many techniques and special disciplines related to economics. In particular, the use of professionally oriented tasks in the teaching of mathematics to students of construction specialties allows forming the necessary professional qualities of the future specialist.

THE MAIN FINDINGS AND RESULTS

The purpose of studying mathematics in higher education in the field of engineering (architecture and construction) is to acquaint students with the mathematical bases used in solving theoretical and practical economic, technical problems, to develop logical thinking skills, to get used to independent study of scientific literature, raising the level of general knowledge, the ability to analyze technical processes, practical problems with mathematical methods and to translate projects into the language of mathematics. The study of economic processes in construction, industry, agriculture and other areas is carried out using mathematical models. In order to be able to construct mathematical models of these processes and to be able to economically analyze the constructed models, the future specialist must have sufficient mathematical knowledge.

The main requirements for the mathematical training of a civil engineer in accordance with the program of mathematical science are:

• Strict assimilation of basic theoretical concepts of mathematics;

• understand the definitions, affirmations and theorems given in the mathematics course;

• be able to apply basic mathematical facts, formulas in practice;

• understand the relationship of mathematical models with the considered material phenomena;

• Analyze and interpret the results in accordance with the practical guidelines.

The above requirements for the mathematical training of a civil engineer imply not only to equip students with a certain set of mathematical knowledge and methods, but also to consider their practical application.

Thus, a career-oriented problem is a mathematical problem, the condition and requirement of which determines the model of a particular situation that arises in the professional activity of a civil engineer, and the study of this situation with the help of mathematics contributes to professional development.

The above allows you to formulate the requirements for the professionally oriented tasks used in the mathematical training of the future builder:

• the issue should describe the situation that arises in the professional activity of a civil engineer;

• The assignment should have the unknown properties of some professional object or event, which should be studied according to the known properties available using mathematical tools;

• In solving problems, the construction engineer should help to master the mathematical knowledge, techniques and methods that form the basis of his professional activity;

• Tasks should ensure the mastery of the interaction of mathematics with general technical and special disciplines;

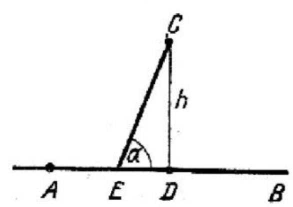
• The content of a professionally oriented mathematical problem determines the propaedeutic stage of the study of the concepts of special disciplines;

• Solving a practical problem should ensure the mathematical and professional development of the civil engineer's personality.

Here are some examples of professionally oriented tasks that use mathematical hardware.

1. In the practice of designing a network of highways, it is often necessary to design branching nodes.

The location of the intersection and the relative condition of the roads passing through it are determined by a set of economic and geographical conditions, but the first step in solving this problem is to save only the time spent on transportation. Therefore, the following auxiliary task is solved first.



That should be the angle of contact of the road (CE) with the highway (AB) α to minimize the time spent on transportation along the AEC route.

Speed v_m on the highway and v_y on the roundabout. $v_m > v_y$

Draw a CD of length h perpendicular to the line AB through point C. Let the length of the section AD is l .

It is known that $CE = \dfrac{h}{\sin\alpha}$ and $DE = hctg\alpha$ $CE = \dfrac{h}{\sin\alpha}$.

On the AEC route we find the travel time of the car:

$$t = \frac{l}{v_m} - \frac{hctg\alpha}{v_m} + \frac{h}{v_y \sin\alpha}$$

Point A is conditionally assigned, only it determines the direction of movement along the trunk.

Angle α can vary in the range of $(0;\frac{\pi}{2})$.

We came to the problem of finding the smallest value of $(0;\frac{\pi}{2})$ intervals of $t(\alpha)$ functions.

We take this $t(\alpha)$.

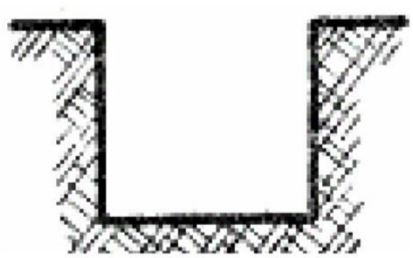
$$t'(\alpha)=\frac{h}{v_d\sin^2\alpha}\left(\frac{v_d}{v_m}-\cos\alpha\right).$$

Since $0<\frac{v_y}{v_m}<1$ and $\alpha\in(0;\frac{\pi}{2})$, we see that $\alpha_0=\arccos\frac{v_y}{v_m}$ is $t'(\alpha)=0$.

Since $\alpha\in(\alpha_0;\frac{\pi}{2})$ is $\alpha\in(0;\alpha_0)$ and $t'(\alpha)<0$, we see that $\alpha\in(0;\alpha_0]$ functions decrease in $t'(\alpha)>0$ and $\alpha\in\left[\alpha_0;\frac{\pi}{2}\right)$ functions increase in $t(\alpha)$. So $t(\alpha)$ functions reach the smallest value in $\alpha_0=\arccos\frac{v_y}{v_m}$.

2. The length of the boundary of the cross-sectional area of the channel is called the wet perimeter of the channel. Theoretical calculations and experimental cross-section revealed that the smallest wetted channels of all channels differed in maximum permeability and at the same time in minimum filtration. Experts note that such channels have the most hydraulically optimal profile. In reclamation practice, canals or trays are often built in the form of rectangular, triangular, trapezoidal and circular segments. Therefore, it is interesting to calculate the most hydraulically profitable profile for channels of this shape.

a) What is the ratio of the width and depth of a channel with a rectangular cross-section to have the most hydraulically optimal profile?



Let the width of the channel be x and the cross-sectional area be ω.

The wetted perimeter of the canal is $\lambda(x)=x+\frac{2\omega}{x}$.

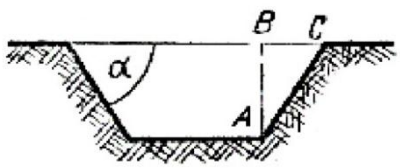
We come to the problem of finding the smallest value of function $\lambda(x)$ in the interval $(0;\infty)$.

That can be $\lambda'(x)=\frac{x^2-2\omega}{x^2}$.

Solve $\lambda'(x) = 0$ equations to get $x = \sqrt{2\omega}$.

Since $x \in (0; \sqrt{2\omega})$ is $\lambda'(x) < 0$ and $x \in (\sqrt{2\omega}; \infty)$ is $\lambda'(x) > 0$, $\lambda(x)$ functions have the lowest value at $x = \sqrt{2\omega}$. This means that the width of the channel should be $\sqrt{2\omega}$ and the depth $\frac{\omega}{\sqrt{2\omega}}$. The ratio sought is $\frac{1}{2}$.

b) The angle of inclination of a channel with a cross-sectional area of ω and an equilateral trapezoid is α ($ctg\alpha = m$). What is the ratio of the width of the bottom of the channel to its depth, which has the most hydraulically optimal profile?



Let the bottom of the channel be b feet wide and h feet deep.

In that case $BC = hctg\alpha = hm$, $AC = \sqrt{AB^2 + BC^2} = h\sqrt{1+m^2}$

Cross-sectional area $\omega = \frac{1}{2}h(2b + 2hm) = bh + mh^2$.

The wetted perimeter of the channel is $\lambda = b + 2AC = b + 2h\sqrt{1+m^2}$.

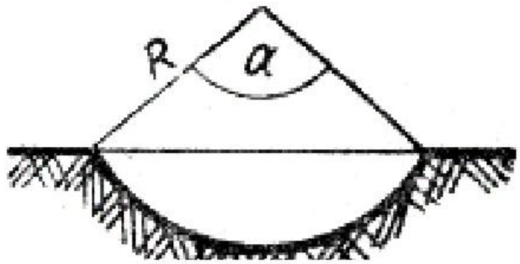
We find $b = \frac{\omega - mh^2}{h}$ on the surface of the cross section.

As a result, we get $\lambda(h) = \frac{\omega}{h} - mh + 2h\sqrt{1+m^2}$.

We come to the problem of finding the smallest value of the function $\lambda(h)$ -in the range $(0; \infty)$. Solving using the product we get $h_0 = \sqrt{\frac{\omega}{2\sqrt{1+m^2} - m}}$ results.

The resulting ratio is $\frac{b}{h_0} = 2\sqrt{1+m^2} - m$.

c) Let the cross-sectional area of the channel be a segment.



What is the central hydraulic profile of the channel at a central angle of α ?

Let be the radius of circle R . The cross-sectional area of the channel is $\omega = S_{sek} - S_{\Delta} = \frac{R^2}{2}(\alpha - \sin\alpha)$. From it $R = \sqrt{\frac{2\omega}{\alpha - \sin\alpha}}$.

Wet perimeter of the channel $\lambda(\alpha) = R\alpha = \sqrt{2\omega}\sqrt{\frac{\alpha^2}{\alpha - \sin\alpha}}$.

Instead of checking the $\lambda(\alpha)$ -function, we can find that the simpler $f(\alpha) = \frac{\alpha^2}{\alpha - \sin\alpha}$ function is $\alpha = \pi$ by checking the minimum using the product.

This means that the cross-sectional area of the channel should be a semicircle.

3. Mixing problems are common in the sewage system (water supply, sewerage, chemical industry).

We explain how to solve a basic problem involving a single reservoir.

The tank in the picture contains 1000 liters of water, which dissolves 100 kg of salt.

The mixture (salted water) operates at a rate of 10 liters / min and contains 5 kg of dissolved salt. The mixture in the tank is kept flat by stirring. The tank runs out in 10 minutes. Find the amount of salt in the container at any time t .

Let us determine the amount of salt t time $y(t)$ in the tank.

Its t time changes rate.

$y'(t) =$ Salt infiltration rate-Salt exit rate

5 kg of dissolved salt is 50 kg of dissolved salt in 10 minutes.

As 10 liters of mixture is expelled every minute, $\frac{10}{1000} = 0.01$ parts of the total amount is expelled. The result is $0.01y(t)$ salts.

In the above we come to the following simple differential equation.

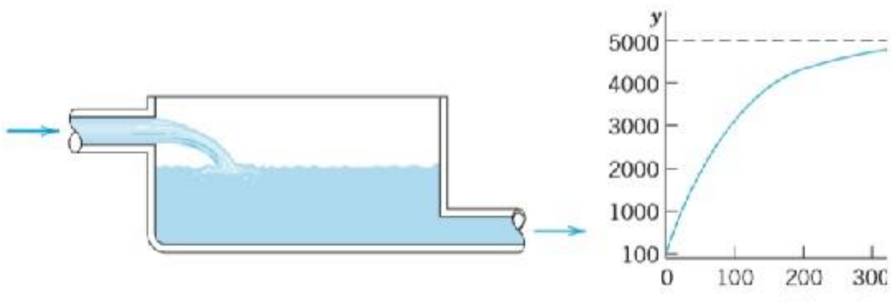
$y' = 50 - 0.01y$. Solve the equation for which this variable is divisible by $\frac{dy}{dt} = -0.01(-5000 + y)$

$$\frac{dy}{y-5000} = -0.01dt\ ;\ \ln|y-5000| = -0.01t + \ln C \Rightarrow y - 5000 = Ce^{-0.01t}.$$

We find the variable using $y(0) = 100$ (initially 100 kg of salt) starting balls.

$$100 - 5000 = Ce^{0} \Rightarrow C = -4900$$

We have $y = 5000 - 4900e^{-0.01t}$ solutions.



4. The rate of heat dissipation of concrete in proportion to the amount of heat released at a given time: $q = \frac{dQ}{d\tau} = m(Q_{\max} - Q)$ views.

With complete hydration of cement $Q_{\max}$, the maximum amount of heat that can be released in the concrete of this composition, parameter m, varies depending on the type of cement (for concrete in cement it is in the range of 0.010 - 0.015 1 / h). Determine the heat generation function of concrete.

5. In construction work, great attention should be paid to various issues related to vibration. Earthquakes can shake buildings, their structures, and the foundations on which engines and machinery are installed. The buildings in which they are located must be constructed in such a way as to exclude vibrations for the normal operation of the mechanisms and the integrity of the structure. All the practical problems associated with vibrations, despite their natural properties, are combined with general principles and methods that constitute the essence of the theory of vibrations. Vibration processes, which are practically completely different in nature and nature, are characterized by differential equations of motion that are uniform in form. The following differential equation $x''(t) + 2hx'(t) + \varpi_0^2 x(t) = 0$, $h = \frac{b}{2m}$, $\varpi_0^2 = \frac{k}{m}$ represents the process of free oscillation in construction constructions.

The solution of this equation is illustrated in the figure.

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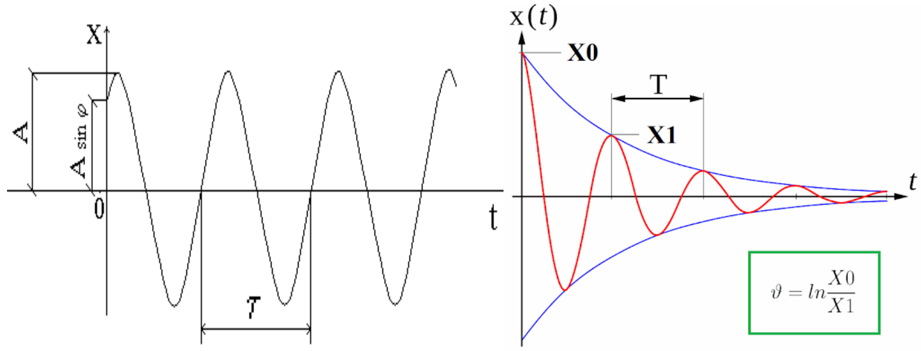

The specificity of each specific problem is determined by the constants included in these equations, which depend on the physical nature of the phenomenon being studied. Using the given parameters of the problem (construction), we can analyze the integral curve and determine the nature of the oscillation.

6. In winter, the daytime temperature in a particular office building is maintained at 24 °C.

The heating was turned off at 10:00 a.m. and turned on again at 6:00 p.m. At 14:00 on a certain day, the temperature inside the building was found to be at 20 °C. The outside air temperature was 18 °C at 10:00 a.m., and dropped to 10 °C at 6:00 p.m. What was the temperature inside the building when the heat was turned on at 6:00 in the morning?

CONCLUSION

Analysis of the solution to the problem allows determining the degree of formation of the professional qualities of the construction engineer personality. Along with providing professional motivation, it strengthens the connection between mathematics and practice.

The practice of teaching in technical higher education institutions shows that the educational process, organized in terms of the regular demonstration of the professional direction of students' mathematical training, shapes the professional qualities of the individual. The specialist will always be able to continue the education in the right direction with a good knowledge base.

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