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SOLVING PHYSICAL PROBLEMS USING THE DERIVATIVE CONCEPT OF ALGEBRA

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It is known that the important concept of mathematical analysis - derivation is widely studied in the science of "Basics of Algebra and Analysis". This important concept serves as a tool for revealing the essence of many (physical, technical, mechanical, geometrical, etc.) issues in the world around us. Using the concept of derivative, one of the most important branches of physics, mechanics (mechanical motion), can find a solution by finding speed, acceleration, mass, and force and performing calculations. The fact that pupils and students mastering specific sciences have a solution to physical problems using this method serves as a solid foundation for connecting their knowledge and skills from both disciplines.

For this purpose, we will look at the solution of such problems below.

Issue 1. The path traveled by the moving body in the time interval t is given by the expression $s(t) = 4t^2 + 3t$. Find the speed and acceleration of the body at $\boldsymbol{t = 3\ s}$.

Solution: It is known that the velocity $v(t)$ of a moving object is the derivative of the traveled path $s(t)$ in time t, i.e. $v(t)$, $v(t) = \frac{ds(t)}{dt}$, and the acceleration $a(t)$ is the time derivative of the velocity $v(t)$, i.e. $a(t) = \frac{dv(t)}{dt}$.

We perform calculations by putting amounts instead of expressions. $v(t) = \frac{ds(t)}{dt} = (4t^2 + 3t)` = 8t + 3$ and $a(t) = \frac{dv(t)}{dt} = (8t + 3)` = 8$. If $t = 3\ s$, then $v(3) = 8 \cdot 3 + 3 = 27\ m/s$ and $a(3) = 8\ m/s^2$. Answer: $v = 27\ m/s$ and $a = 8\ m/s^2$

Issue 2. After t time after the locomotive left the station, it was at a distance of $s(t) = 2t^3 + 2t^2 + 3t$ (km) from the station. Find the speed and acceleration of the locomotive after 2 hours.

Solution: It is known that $v(t) = \frac{ds(t)}{dt} = (2t^3 + 2t^2 + 3t)` = 6t^2 + 4t + 3$ and $a = \frac{dv(t)}{dt} = (6t^2 + 4t + 3)` = 12t + 4$. If $t = 2$ hours, $v(2) = 6 \cdot 2^2 + 4 \cdot 2 + 3 = 35$ (*km/soat)* and $a(2) = 12 \cdot 2 + 4 = 28$ *km/soat*^{2}

Answer: $v = 35$ *km/h* and $a = 28$ *km/h*^{2}

Issue 3. The dependence of the body's path *s(t)* on time t is given by the formula $s(t) = 10 - 5t + 2{,}5t^2$. Find the average speed and average acceleration between $t = 1$ *s* and $t = 4$ *s*.

Solution: It is known that $v(t) = \frac{ds(t)}{dt} = (10 - 5t + 2{,}5t^2)` = 5t - 5$ and $a(t) = \frac{dv(t)}{dt} = (5t - 5)` = 5$. If $t = 1$ *s*, $v(1) = 5 \cdot 1 - 5 = 0$, $a(1) = 5$ *m/s*^{2}, $t = 4$ s, then $v(4) = 5 \cdot 4 - 5 = 15$ *m/s* $a(4) = 5$ *m/s*^{2}. From these results, we find the average speed and average acceleration of the body.

$$v_{o`rt} = \frac{v(t\ ) + v(t\ )}{2} = \frac{0 + 5}{2} = 7{,}5\ m/s$$

$$a_{o`rt} = \frac{v(t\ ) + v(t\ )}{2} = \frac{5 + 5}{2} = 5\ m/s^2$$

Answer: $v = 7{,}5$ *m/s* va $a = 5$ *m/s*^{2} .

After acquiring the skills and competence to solve these problems, it is possible to solve problems of a wider content.

Issue 4. The wheel is spinning. The relationship between the turning angle φ of the radius R of the wheel and the time *t* is given by the motion formula in the form $\varphi(t) = t^3 + 3t^2 + 2t + 5$. If the normal acceleration of the points on the wheel flange at the end of the 2nd second of movement is equal to $a_n = 3{,}5 \cdot 10^2$ *m/s*^{2}, find the radius of the wheel.

Solution: It is known that the normal acceleration in a linear variable circular motion is represented by the formula $a_n = \frac{\vartheta^2}{R}$. From this, if we consider that $R = \frac{\vartheta^2}{a_n}$ and $\vartheta = \omega R$, then $R = \frac{(\omega R)^2}{a_n}$, $\omega^2 R^2 = a_n R$, $\omega^2 R \cdot R = a_n R$, $\omega^2 R = a_n$, $R = \frac{a_n}{\omega^2}$. (where $\vartheta(t)$ is the angular velocity and ω(t) is the linear velocity.) The linear velocity ω(t) is found from the relation $\omega(t) = \frac{d\varphi(t)}{dt}$. So, $\omega(t) = \frac{d\varphi(t)}{dt} = (t^3 + 3t^2 + 2t + 5)` = 3t^2 + 6t + 2$, $\omega(2) = 3 \cdot 2^3 + 6 \cdot 2 + 2 = 26$ *rad/s*; Putting the values of an and φ(2) to $R = \frac{a_n}{\omega^2}$, we calculate the radius of the wheel:

$$R = \frac{3{,}5 \cdot 10^2}{(26)^2} = 0{,}52\ m.$$

Answer*: 0,52 m =* 52 *sm*

Issue 5. A body with a mass of 1 kg moves in a straight line according to the formula $s(t) = 5 - 3t + 7t^2 - 2t^3$. Here *s(t)* is the path traveled by the body, t is the time it took to travel this path. Find the force acting on the moving body at the end of 1 second.

Solution: to solve this problem, we use the formula of Newton's 2nd law of mechanics *F* =

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$ma = m = \frac{dv(t)}{dt}$. It is known that acceleration in variable motion is the time derivative of speed, that is, $a(t) = \frac{dv(t)}{dt}$; where $v(t) = \frac{ds(t)}{dt}$. Let's count them;

$v(t) = \frac{ds(t)}{dt} = (5 - 3t + 7t^2 - 2t^3)` = -3 + 14t - 6t^2$;

$a(t) = \frac{dv(t)}{dt} = (-3 + 14t - 6t^2)` = 14 - 12t$;

if $t = 1s$, $a(1) = 14 - 12 \cdot 1 = 2\ m/s^2$ will be.

Then $F = m \cdot a = 1\ kg \cdot 2\ m/s^2 = 2\ kg \cdot m/s^2 = 2\ N$. Answer: $F = 2\ N$.

Issue 6. The body moves in a straight line under the influence of a constant force equal to 20 N. In this case, the dependence of the body's path on time t is expressed by the formula $s(t) = 5 - 3t + t^2$. Find the mass of this object.

Solution: it is known that the mathematical expression of Newton's 2nd law is $m = \frac{F}{a}$ if we find its mass from $F = ma$. It can be seen that in order to determine the mass of the body, it is necessary to find its acceleration a.

It is known that the time derivative of the velocity $a = \frac{dv(t)}{dt}$ gives the acceleration. Taking the time derivative from the path, we get $v = \frac{ds(t)}{dt} = (5 - 3t + t^2)` = 2t - 3$. Putting this result into $a = \frac{dv(t)}{dt}$ we get $a = \frac{dv(t)}{dt} = (2t - 3)` = 2\ m/s^2$. We set this value of α to $m = \frac{F}{a}$, then $m = \frac{20\ N}{2\ m/s2} = \frac{20\ kg \cdot m/s^2}{2\ m/s^2} = 10\ kg$. *Answer: 10 kg.*

The applied problems that we considered above are the problems of physical content. Developing the skills and abilities to solve such problems is an important tool for students of these subjects (physics and algebra) to develop their thinking skills, to expand their mathematical knowledge, to understand the role of the derivative concept and its practical application.

At this point, it is important to solve such problems, not only to form students' interest in algebra and physics, but also to increase their interest in majors, which are considered basic (fundamental) sciences. These problems can be solved not only in physics and algebra lessons, but also in circle and extra lessons, as well as applicants who are preparing to enter universities in order to have solid skills.