ISSN NO: 2770-4491
Date of Publication:28-05-2022

# The use of Software Tools in Solving some Mathematical Problems

**Z.U. Tursinboyeva**
Senior Lecturer, Department of Higher Mathematics and Information Technology, Navoi State University of Mining and Technology, Uzbekistan

**Z.T. Ismoilova**
Senior Lecturer, Department of Higher Mathematics and Information Technology, Navoi State University of Mining and Technology, Uzbekistan

**Annotation:** This article presents recommendations for combining the concepts of physics and computer science in teaching mathematics.

**Key words:** Calculate work, pump, elementary works, additivity, linearity, infinitesimal, programming languages, software product.

**A task.** Calculate the work required to pump the liquid out of a vertical cone-shaped vessel. The bowl of the cone faces the end to the ground, the radius of its base is equal to R, and the height is equal to H.

**Decision:**

The work performed when lifting a body with a weight P to a height h is equal to Ph. Complicating the work in our business is the fact that some layers of liquid have different depths, and the lifting height is not the same for different layers. Therefore, using planes parallel to the base of the cone, we divide the cone container into thin horizontal layers with a thickness of $\Delta h_i$ (Fig.1). The figure shows a section of a cone-shaped vessel passing through the axis of the cone. Denote by $\Delta E_i$ the work required to lift the $i$ - th layer of liquid to the surface. Then the work E required to pump the liquid out of the vessel is equal to the sum of the elementary works:

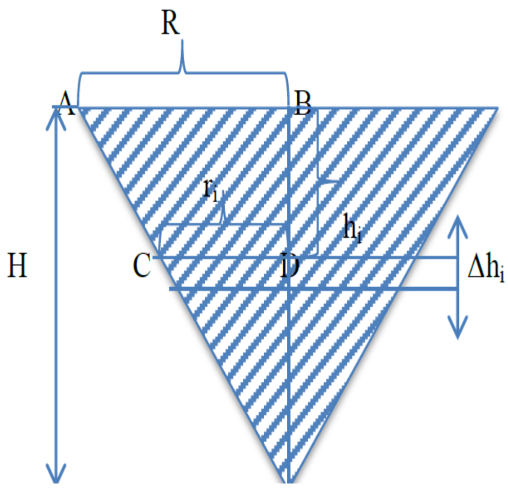

Fig.1

$$E = \sum_{i=1}^{n} \Delta E_i$$

that is, it has the property of additivity. If $\Delta h_i$ is taken small enough, then it can be estimated approximately that all the liquid in the $i$ - th layer is at the same depth $h_i$. $\Delta E_i$ the mass of the $i$ - th layer of liquid is equal to the product of $\Delta P_i$ by the height of the rise $h_i$:

$$\Delta E_i \approx \Delta P_i h_i \quad (*)$$

To calculate the weight $\Delta P_i$, we calculate the volume $\Delta \vartheta_i$ of the $i$ - th layer. Given that $\Delta h_i$is small, we can assume that it is a cylinder with the height of the layer $\Delta h_i$ and the radius of the base $r_i$. From the similarity of triangles AEB and SED (see Figure) we find $r_i = \frac{R}{H}(H - h_i)$. Therefore,

$$\Delta V_i \approx \pi r_i^2 \Delta h_i = \pi \frac{R^2}{H^2}(H - h_i)^2 \Delta h_i \;\; \Delta P_i = \rho g \Delta V_i$$

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As where $p$ - is the density of the liquid, $g$ - is the acceleration of gravity. Substituting the found value of $\Delta P_i$ into the formula (*), we get:

$$\Delta E_i \approx \pi\rho g \frac{R^2}{H^2}(H - h_i)^2 h_i \Delta h_i$$

that is, the work has the property of linearity in the infinitesimal. All the work

$$E \approx \sum_{i=1}^{n} \Delta E_i \approx \sum_{i=1}^{n} \pi\rho g \frac{R^2}{H^2}(H - h_i)^2 h_i \Delta h_i \qquad (**)$$

the smaller $\Delta h_i$, the more accurate this equality is.

For $\{\Delta h_i, \Delta h_2, \cdots, \Delta h_n\} \to 0$ we get:

$$E = \lim_{\lambda \to 0} \sum_{i=1}^{n} \pi\rho g \frac{R^2}{H^2}(H - h_i)^2 h_i \Delta h_i$$

(**) amount

$$\rho g \frac{R^2}{H^2}(H - h)^2 h$$

Therefore, the limit of this sum is equal to the integral from h=0 to h=H.

$$E = \int_0^H \frac{\pi\rho g R^2}{H^2}(H - h)^2 h dh = \frac{\pi\rho g R^2}{H^2}\int_0^H (H^2 h - 2Hh^2 + h^3) dh =$$

$$= \frac{\pi\rho g R^2}{H^2} \frac{H^2 h^2}{2} - \frac{2Hh^3}{3} + \frac{h^4}{4}\bigg|_0^H = \frac{\pi\rho g R^2 H^2}{12}$$

In practice, the application of the above formula is much more difficult for students. In this regard, it is more efficient to use programming languages, practical packages or a calculator. In our article, we use the C++ programming language and the MathCad software product.

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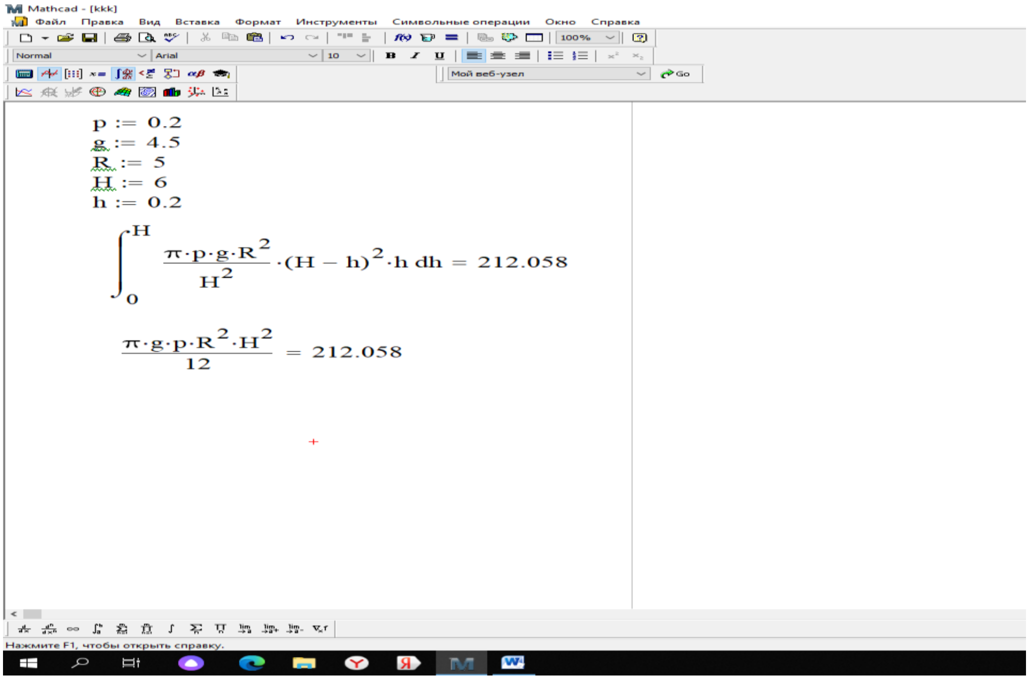
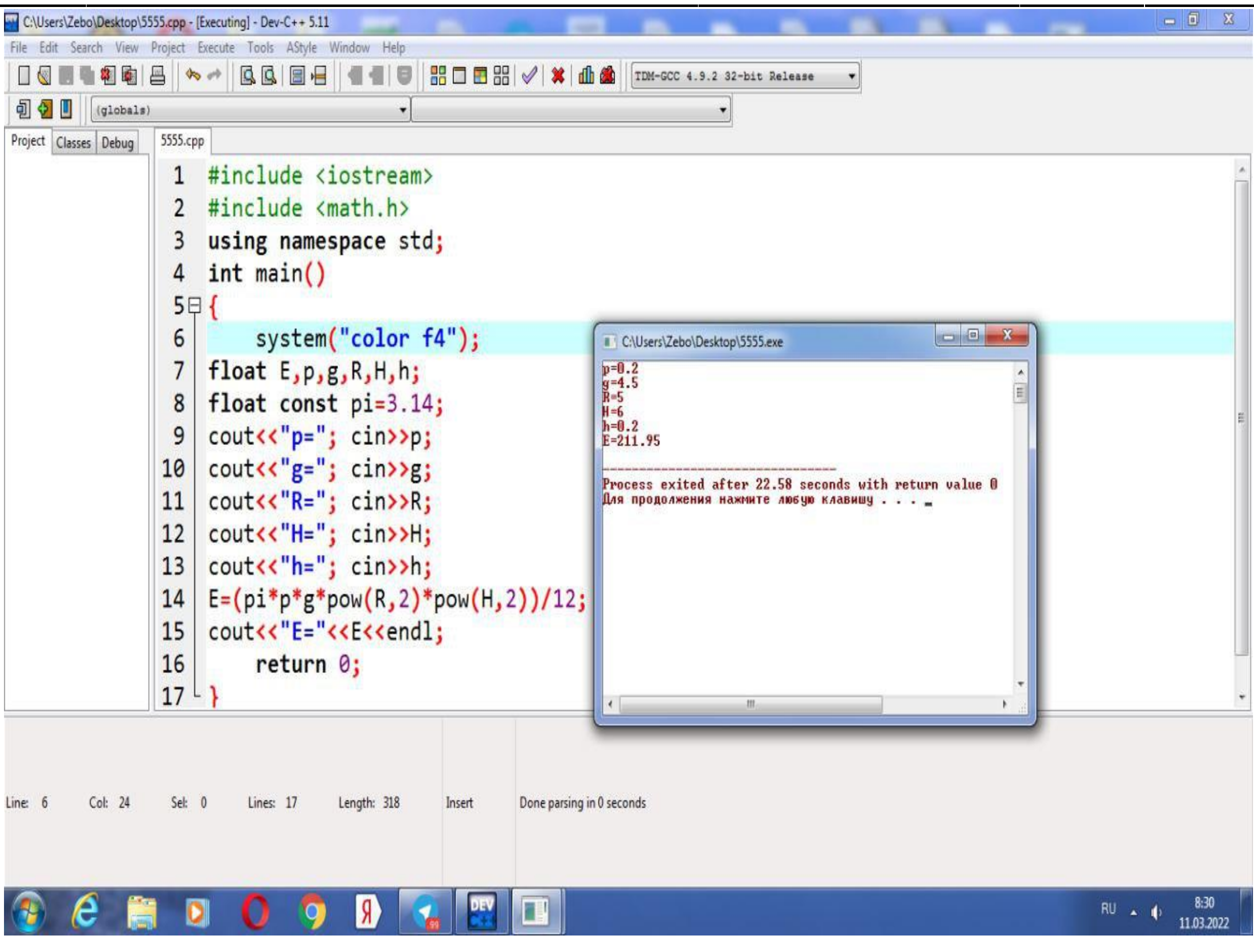
**Solving the problem in the Mathcad program**




**The program that determines the solution of the task**

```
#include <iostream>
#include <math.h>
using namespace std;
int main()
{
system ("color  f4");
float E, p, g, R, H, h;
float const pi=3.14;
cout<<"p="; cin>>p;
cout<<"g="; cin>>g;
cout<<"R="; cin>>R;
cout<<"H="; cin>>H;
cout<<"h="; cin>>h;
E=(pi*p*g*pow(R, 2)*pow(H, 2)) / 12;
cout<<"E="<<E<<endl;
return 0;
}
```

**Program result:**




With the use of interdisciplinary integration in teaching mathematics in educational institutions, the quality of lessons will be much higher, and the interest of students will increase. It also improves students' creativity.

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