JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN: 2581-4230, Website: journalnx.com, June 18th & 19th, 2020

USE OF SCIENCE INTEGRATION IN TEACHING MATHEMATICS

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Annotation

This paper presents and solves the problem of determining the amount of liquid in a cylinder with a vertical and convex hemisphere. The integration of mathematics, physics and computer science can be seen in solving the problem.

Keywords: Cylinder, convex hemispherical cylinder, exact integral, mass of liquid, density of liquid, Pascal ABCNET programming language.

Introduction

In our country, mathematics has been identified as one of the priorities for the development of science in 2020. In recent years, a number of measures have been taken to bring mathematics science and education to a new level of quality. In particular, the urgent need to address the priorities of science, strengthening the integration of science, education and industry has been identified as a priority at the governmental level.

At the same time, a number of unresolved issues in the field highlight the need to take measures to improve the quality of mathematics education and research efficiency. In particular, the relevance of mathematical research to practice and production remains weak [1].

This article provides guidelines for linking the concepts of physics and computer science in the teaching of mathematics. The guidelines are based on a single solution. The problem was to determine the amount of liquid in a cylinder with a vertical and convex hemispherical base. In calculating the problem, from the Cartesian coordinate plane of mathematical science, from the elements of integral calculus, from the formula for calculating the volume of a spherical segment; from concepts such as mass, density, and volume in physics; elements of the PascalABCNET programming language of computer science were used. The final calculated formulas were developed, a program that allows to determine the amount of liquid in the container when entering the parameters given in the programming language PascalABCNET.

Task definition

Task. A cylinder with a vertical and a convex hemispherical base has a base radius equal to R and a maker in the equality of L (see Figure 1). If the distance between the lower and upper levels of the liquid in the container is h and the density of the liquid is p, how much liquid is in the container?

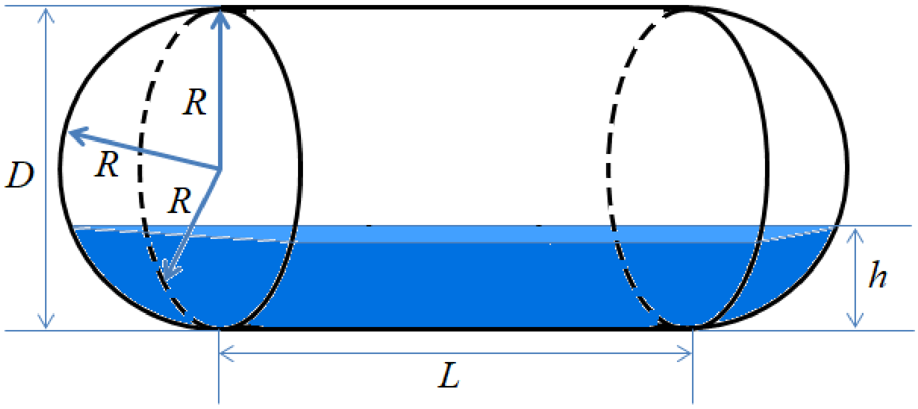

Figure 1.

Mathematical solution of the problem

Divide the given object into hemispheres and cylinders, find the amount of liquid in these objects and add them. We know from physics that the mass of a body is found by multiplying the density of the body by its volume. So it is enough for us to find the volume occupied by the liquid. We divide the volume finder into two parts, the first part calculates the volume of the liquid in the hemispheres, and the second part considers the calculation of the volume of the liquid in the cylinder whose bases are vertical and circular.

Let's look at the execution of both parts below.

1. In this section, we are asked to find the volume of fluid in two hemispheres. If we combine the two hemispheres, we get a whole sphere. By the way, the volume of the liquid we need to determine is equal to the volume of the segment of the sphere. To find the size of the segment, we use the formula given in [2], i.e.

$$V_{segment} = \pi h^2 \left(R - \frac{h}{3}\right).$$

2. To solve this part of the problem we need to find a segment of the circle. To do this, we do the following. We can place the base of the cylinder in Fig. 2a in the Cartesian coordinate plane as in Fig. 2b. We also place points A, B, C, and D. The shapes ABC and ABD are symmetrical and the equality of the surfaces is obvious. So if we find the face of the shape ABC and multiply it by two, we get the surface of the segment ACD. We use the exact integral to find the face of this shape. As a function, we take the part of the circle whose center is at the beginning of the O coordinate and whose radius is R above the axis Ox, and it is $y = \sqrt{R^2 - x^2}$. We put the abscissa of point A, $-R$, on the lower bound of the definite integral, and the abscissa of point B, $h - R$, on the upper bound.

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In general, the surface of the ACD segment is determined using the following exact integral:

$$S_{ACD} = 2\int_{-R}^{h-R} \sqrt{R^2 - x^2}dx.$$

In calculating the abovegiven integral, we introduce the following substitutions: $x = Rcost$, $dx = -Rsintdt$, $t = arccos\frac{x}{R}$. We also replace the integral boundaries: lower bound $t = arccos\frac{-R}{R} = \arccos(-1) = \pi$, upper bound $t = arccos\frac{h-R}{R}$. As a result,

$$S_{ACD} = -2\int_{\pi}^{arccos\frac{h-R}{R}} \sqrt{R^2 - (Rcost)^2} \cdot Rsintdt = -2R^2\int_{\pi}^{arccos\frac{h-R}{R}} sin^2tdt =$$

$$= 2R^2\int_{\pi}^{arccos\frac{h-R}{R}} \frac{cos2t - 1}{2}dt = \left(R^2 \cdot \frac{sin2t}{2} - R^2t\right)\Big|_{\pi}^{arccos\frac{h-R}{R}} =$$

$$= R^2 \cdot \frac{sin\left(2arccos\frac{h-R}{R}\right)}{2} - R^2 arccos\frac{h-R}{R} - R^2 \cdot \frac{\sin 2\pi}{2} + \pi R^2 =$$

$$= R^2 \cdot \frac{2sin\left(arccos\frac{h-R}{R}\right)cos\left(arccos\frac{h-R}{R}\right)}{2} - R^2\left(\frac{\pi}{2} - arcsin\frac{h-R}{R}\right) + \pi R^2 =$$

$$= R^2 \cdot arcsin\frac{h-R}{R} + (h-R) \cdot \sqrt{2hR - h^2} + \frac{\pi R^2}{2}.$$

Hence, the surface of the ACD segment

$$S_{ACD} = R^2 \cdot arcsin\frac{h-R}{R} + (h-R) \cdot \sqrt{2hR - h^2} + \frac{\pi R^2}{2}$$

is determined by the formula.

Hence, the volume of liquid in this case is found using the following formula

$$V_{\text{cylinder}} = S_{ACD} \cdot L.$$

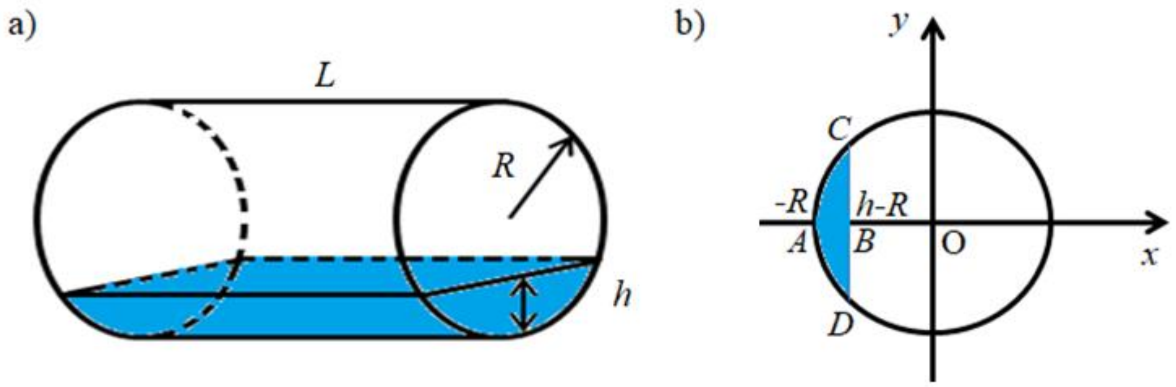

Figure 2.

Adding the volumes found in the above sections to the density of the liquid, we obtain the mass m of the liquid in the vessel, i.e.

$$m = p \cdot (V_{segment} + V_{\text{cylinder}})$$

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or:

$$m = p \cdot \left[\pi h^2 \left(R - \frac{h}{3}\right) + L \cdot \left(R^2 arcsin\frac{h-R}{R} + (h-R) \cdot \sqrt{2hR - h^2} + \frac{\pi R^2}{2}\right)\right].$$

Determining the mass using this found final formula is much more difficult for man to perform. For this reason, it is best for students to demonstrate arithmetic using programming languages or in practical packages or calculators. We use a programming language in our article.

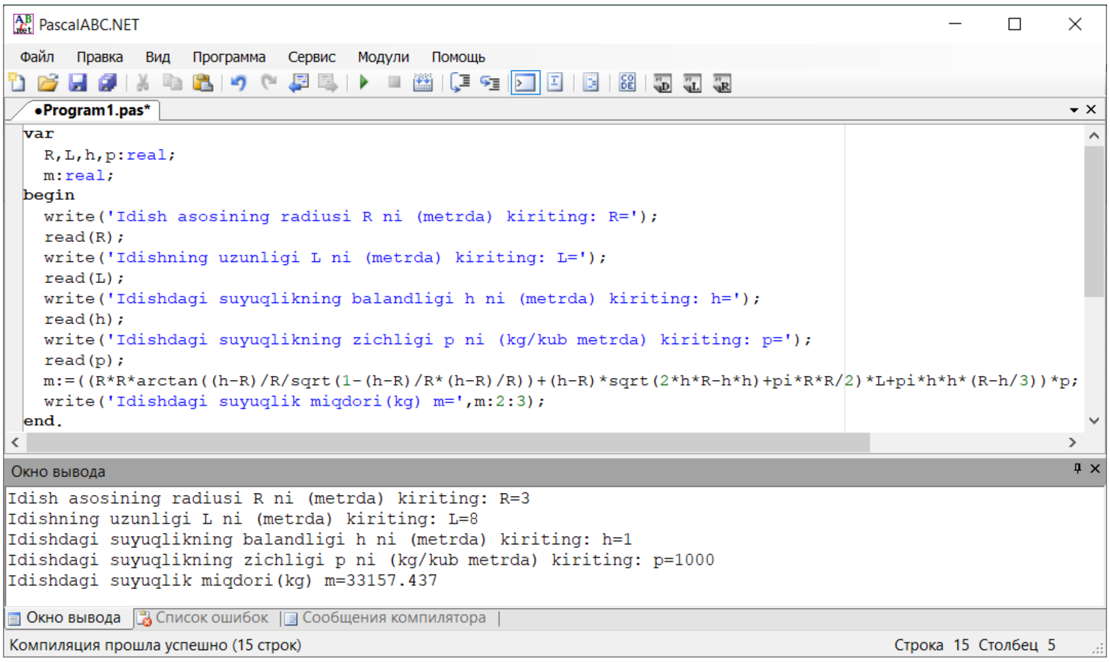
Here is a solution to the abovementioned problem using the formula found above in the **PascalABCNET** programming language.

A program that identifies the solution to a problem

```
var
  R,L,h,p:real;
  m:real;
begin
  write('Idish asosining radiusi R ni (metrda) kiriting: R=');
  read(R);
  write('Idishning uzunligi L ni (metrda) kiriting: L=');
  read(L);
  write('Idishdagi suyuqlikning balandligi h ni (metrda) kiriting: h=');
  read(h);
  write('Idishdagi suyuqlikning zichligi p ni (kg/kub metrda) kiriting: p=');
  read(p);
  m:=((R*R*arctan((h-R)/R/sqrt(1-(h-R)/R*(h-R)/R))+(h-R)*sqrt(2*h*R-
h*h)+pi*R*R/2)*L+pi*h*h*(R-h/3)*p;
  write('Idishdagi suyuqlik miqdori(kg): m=',m:2:3);
end.
```

When interdisciplinary integration is used in the teaching of mathematics in educational institutions, the quality of lessons will be much higher and the interest of students will increase. It also enhances the creative approach of learners.

It would be useful to include issues similar to those discussed above in school textbooks on mathematics and in higher education textbooks.



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