ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
MATHEMATICS, PHYSICS, THEORETICAL MECHANICS
FASCICLE II, YEAR XVII (XLVIII) 2025, No. 2
DOI: https://doi.org/10.35219/ann-ugal-math-phys-mec.2025.2.11

Mathematics – an interdisciplinary bridge

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Abstract
This study presents a few practical mathematical applications concerning the way to achieve interdisciplinarity between high school and other subjects that are found in the students' curriculum. I consider that it is an essential condition of modern education, therefore contributing to the development of integrated skills (transversal or key) which prepare students for the real and professional life.

Keywords: Mathematics, co-teaching, practical problems.

1. INTRODUCTION

I have been a Mathematics teacher for over 35 years, for many students, of different ages, in highschools with different profiles and specialisations, from technological to mathematics and computer science, with different individual potential, not only from the perspective of cognitive abilities, but also from the point of view of emotional intelligence. But many times, I was asked the same questions: "Why do we need to learn this?", "What do we need … for?". Mathematics, especially the one taught in highschool, is presented very abstractly in textbooks, the notions taught are purely theoretical, without correlations with real life or students' experiences. Just the ones with certain abilities manage to exceed the level of formality of information, and to understand, in depth what they are learning.

2. MATHEMATICS IN EXAMS

Even in the end-of-cycle exams, the Baccalaureate Exam, for example, the problems are algorithmic, they do not illustrate real situations. A medium level student, who learnt certain formulas, theorems, rules by heart, could get a reasonable grade – at least eight out of ten. This encourages memorizing, learning by templates.

The fact that things are different is demonstrated by the comparison between two Baccalaureate exam subjects, one from the exam in France, and the other from Romania.

SUBIECTUL al III-lea **(30 de puncte)**

1. Se consideră funcția $f:\mathbb{R}\to\mathbb{R},\ f(x)=\frac{x^2+6}{\sqrt{x^2+1}}$.

5p a) Arătați că $f'(x)=\frac{x(x^2-4)}{(x^2+1)\sqrt{x^2+1}},\ x\in\mathbb{R}$.

5p b) Determinați ecuația tangentei la graficul funcției f în punctul de abscisă $x=0$, situat pe graficul funcției f.

5p c) Arătați că $f(7x)-f(x)\le 2\sqrt{2}$, pentru orice $x\in[0,1]$.

Ministerul Educației și Cercetării
Centrul Național pentru Curriculum și Evaluare

Examenul național de bacalaureat 2025
Proba E. c)
Matematică *M_mate-info*

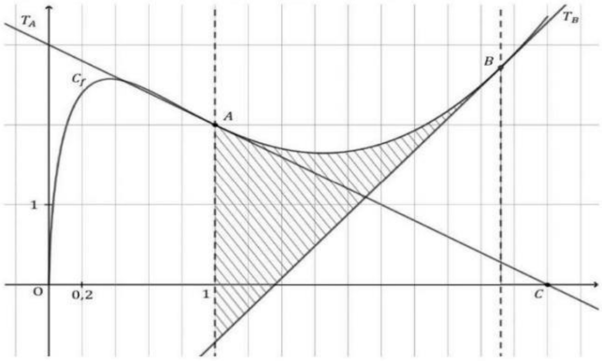
Exercice 2 (6 points)

On considère une fonction f définie sur l'intervalle $]0\,;+\infty[$. On admet qu'elle est deux fois dérivable sur l'intervalle $]0\,;+\infty[$. On note f' sa fonction dérivée et f'' sa fonction dérivée seconde.

Dans un repère orthogonal, on a tracé ci-dessous :

- la courbe représentative de f, notée C_f, sur l'intervalle $]0\,;3]$;
- la droite T_A, tangente à C_f au point $A(1\,;2)$;
- la droite T_B, tangente à C_f au point $B(e\,;e)$.

On précise par ailleurs que la tangente T_A passe par le point $C(3\,;0)$.



Partie A : Lectures graphiques

On répondra aux questions suivantes en les justifiant à l'aide du graphique.

1. Déterminer le nombre dérivé $f'(1)$.
2. Combien de solutions l'équation $f'(x) = 0$ admet-elle dans l'intervalle $]0\,;3]$?
3. Quel est le signe de $f''(0{,}2)$?

ÉPREUVE D'ENSEIGNEMENT DE SPÉCIALITÉ

SESSION 2025

MATHÉMATIQUES

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Many more examples of exercises could be given, correctly formulated from a mathematical point of view, but coming from another field/subject.

Exercice 1 (7 points) **Thèmes : fonction exponentielle, suites.**

Dans le cadre d'un essai clinique, on envisage deux protocoles de traitement d'une maladie. L'objectif decet exercice est d'étudier, pour ces deux protocoles, l'évolution de la quantité de médicament présente dans le sang d'un patient en fonction du temps.

Les parties A et B sont indépendantes.

Partie A : Etude du premier protocole

Le premier protocole consiste à faire absorber un médicament, sous forme de comprimé, au patient. On modélise la quantité de médicament présente dans le sang du patient, exprimée en mg, par la fonction f définie sur l'intervalle $[0; 10]$ par $f(t) = 3te^{-0{,}5t+1}$, où t désigne le temps, exprimé en heure, écoulé depuis la prise du comprimé.

This is just a part form an exercise of 2022, in which the study of the variation of a function is solicitated, but the starting point is medicine.

3. MATHEMATICS IN DAILY LIFE

I have always been preoccupied by justifying the study of mathematical notions and showing how they are utilized in day-to-day life. I have not always succeeded: I may have had neither the necessary information, nor the time to do it. The syllabus is very dense, the students are preoccupied with achieving good results in an easy way, without understanding very well.

Lately, in our school, co-teaching hours have been held in which two teachers collaborate to teach a subject at the same time to the same students. In this way, history and Romanian, geography and economics, mathematics and geography/economics have “met”. For me, a mathematics teacher, these experiences have helped me a lot, making it possible for me, in this way, to explain to the students why they need to learn logarithms or radical expressions.

An interesting subject is Human Development Index (Rom. *Indicele Dezvoltării Umane*). This subject is studied by 10th graders, in geography class. I held a lesson for class 10D majoring in mathematics and computer science, together with the geography teacher. The documenting part was challenging. All the articles in Romanian were old, outdated. I had to search for resources in English- https://hdr.undp.org/data-center/human-development-index#/indicies/HDI-un exemplu.

Human Development Index (Rom. HDI or IDU) is a method of analyzing, comparatively, the life expectancy, literacy rate, and level of education, respectively the standard of living of a country's population. The three factors, together, illustrate better the rate of development of a country than GDP (Rom. PIB). The last one measures just the rate of development from a material point of view. This index was defined by the Pakistani economist Mahbub al Haq in 1990. It is updated annually by the United Nations Development Programme, published in the Human Development Reports.

How can you calculate this? It is a comparative measure of life expectancy, literacy and education, and standard of living. The value of the Human Development Index is situated between 0-1. Every index can be calculated with the following formulas:

$$index = \frac{current\ value - min\ value}{max\ value - min\ value}$$

$$health\ index = \frac{life\ expectancy\ at\ birth - 20}{85 - 20}$$

$$education\ index = \frac{literacy\ rate + gross\ rate}{2}$$

$$literacy\ rate = \frac{expected\ years\ of\ schooling - 0}{18 - 0}$$

$$gross\ coverage\ rate\ in\ education\ of\ all\ levels = \frac{exp\ e\ cted\ years\ of\ schooling - 0}{15 - 0}$$

$$income\ index = \frac{\ln(national\ income\ per\ capita) - \ln(100)}{\ln(75000) - \ln(100)}$$

$$HDI = \sqrt[3]{health\ index \cdot education\ index \cdot income\ index}$$

After I have found the formulas, the following questions arose:

- How are the minimum/maximum index values established?
  For example, the life expectancy at birth is equal to 20 years of age, based on historical analysis. No country had it lower than 20 in the 20^{th} century.
- Why is the natural logarithm used in the calculation of the income index? - I came across documents that used decimal logarithm.
  The tendency measured in natural logarithm units is approximatively equal to percentage growth. Income increases provide a greater importance for the life of the population of poorer countries. The logarithm takes this aspect into account, offering a greater value to lower lever incomes.
- Why is the geometric mean used for the HDI and not the arithmetic mean?
  Initially, the HDI was calculated as the arithmetic mean of the 3 indexes (in some

Romanian articles from the 2000's the formula remained the same). The geometric mean is less affected by the extreme values. I demonstrated this to the pupils by calculating a school subject's average grade.

The numbers 2,7,9,10 ⇒ arthimetic mean = 7	The numbers 2,7,9,10 ⇒ geometric mean = 5,95
The numbers 2,7,9 ⇒ arthimetic mean = 6	The numbers 2,7,9 ⇒ geometric mean = 5,01
The numbers 7,9,10 ⇒ arthimetic mean = 8,66	The numbers 7,9,10 ⇒ geometric mean = 8,57

It is, at the same time, observed that the geometric mean is more sensible to the lower values.

The advantages of using the geometric mean in economy:

- It reduces the impact of substantial values;
- It is very precisely based on all the observations and terms of sequences;
- It offers more weight to the smaller values;
- It is not so influenced by sampling fluctuations;
- It is more precise when it comes to percentual modification;

Disadvantages:

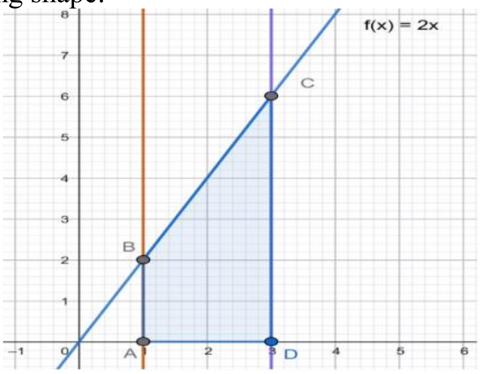
- Using it is more difficult;
- If one of the observations turns out negative, the geometric mean will be imaginary, despite the other observation set.

After completing the lesson, I enquired my pupils for opinions. They liked it. They told me they finally understood the importance of logarithms and radicals, for example. At the same time, it was a challenge for me. I do not believe that many maths teachers are aware of what HDI is, the same as not all geography teachers know how to determine it. The geography textbooks do not present this information. (the lesson plan for this activity can be found in annex 1).

In the 12^{th} grade, pupils are preoccupied with the baccalaureate exam, but even so, we must find the time to justify the taught notions, as they are not too simple.

Why do we learn about definite integrals?

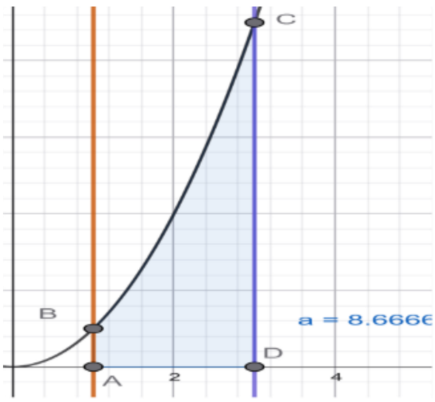
We can start by solving the following problem: Calculate the marked surface area from the following shape:



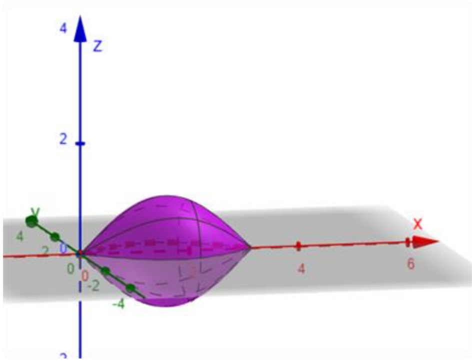
The pupils know: Find the coordinates for A, B, C, D. Calculate the lengths of the base and height of the trapezoid and then, the formula for its area.

But what if the function is not $f:\mathbb{R}\to\mathbb{R}, f(x)=2x$?

What if we modify it a little? f:R⟶R, $f(x)=x^2$.

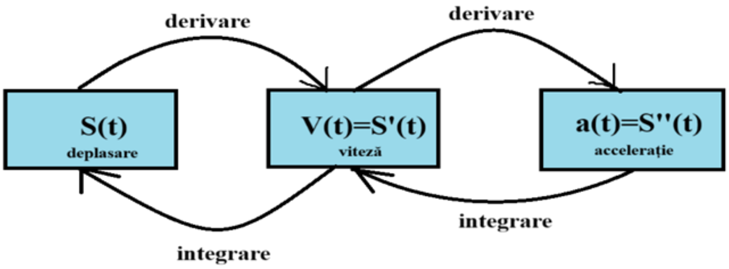


Here, This time we cannot use the geometry formulas. the definite integral is needed.



Or, we can use technology to illustrate what we are actually calculating when using the $\pi\int_0^{\pi}(\sin x)^2\,dx$ formula.

Statements can be formulated in which derivatives and integrals are used to solve problems that have a physical starting point. In this way, students better understand the meaning of the derivative and the integral.



Problem: A lion is hunting down a zebra. The zebra notices the lion when it is at a 50-meter distance from it. From that moment, the lion approaches the zebra with the speed of $v_l(t)=10\cdot e^{-0,1t}ms^{-1}$ and the zebra runs with the speed of $v_z(t)=15\text{-}15\cdot e^{-0,1t}ms^{-1}$.

a) Find the speed of both animals after 1 second;
b) Establish which animal increases its speed and which diminishes it;
c) Find $\int_0^3 v_l(t)dt$ and interpret the result;
d) Find $\int_0^3[v_l(t)-v_z(t)]dt$ and interpret the result;
e) Explain why the lion will be closest to the zebra when $v_l(t)=v_z(t)$;
f) Establish if the lion catches the zebra!

4. CONCLUSIONS

There are many examples where mathematics helps to solve practical problems. I found most of them in English. They can be used successfully in the classroom. The students know English very well.

There are a few so-called "brakes":

-Time. Or rather, the lack of it. As I mentioned before, the curriculum is very dense and there are not enough classes, especially, from next year, when the new framework plans will be implemented;

- Mentality. Students, but especially teachers, have a hard time adapting to change: "Practical applications? We don't need them!".

- Exams. The structure should be modified or at least, the templates and algorithmic problems should be removed.

Lately, with small steps, an adaptation to real life has been attempted. In this sense, Romania's implication in the European Statistics Competition is welcome. Students have shown themselves delighted with this type of Olympiad while some teachers have not been enthusiastic about it.

In our school, in addition to co-teaching lessons, this year, for the second time, the 11th grade students have the opportunity to participate in integrated optional courses. One of them is *Elements of Applied Mathematical Statistics*.

All these things are time-consuming, and they require quite a lot of effort to achieve. In addition to all this, something else is needed: the desire to learn something new.

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