Pythagoras
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<table>
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<tr><td>Competences to be developed</td><td>Reasoning and modelling
Develop thinking strategies to solve real problems
Explore, analyse, and apply mathematical ideas using reason and technology
Estimate reasonably and demonstrate fluent, flexible, and strategic thinking about graphs
Model with mathematics in situational contexts
Think creatively and with curiosity and wonder when exploring problems

Understanding and solving
Develop, demonstrate, and apply conceptual understanding of mathematical ideas through play, story, inquiry, and problem solving
Visualize to explore and illustrate mathematical concepts and relationships
Apply flexible and strategic approaches to solve problems
Solve problems with persistence and a positive disposition
Engage in problem-solving experiences connected with real-life examples.</td></tr>
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	Communicating and representing Explain and justify mathematical ideas and decisions in many ways Represent mathematical ideas in concrete, pictorial, and symbolic forms Use mathematical vocabulary and language to contribute to discussions in the classroom Take risks when offering ideas in classroom discourse **Connecting and reflecting** Reflect on mathematical thinking Connect mathematical concepts with each other, other areas, and personal interests Use mistakes as opportunities to advance learning
ICT tools to be used	Excel Spreadsheets for calculation
Context: project estatement	Greenhouse gases, particularly CO2, are the primary drivers of climate change. Increased levels of CO2 in the atmosphere trap heat, leading to rising global temperatures and disrupted weather patterns. This results in more frequent and severe natural disasters, such as hurricanes, wildfires, and droughts. Addressing greenhouse gas emissions is crucial to mitigating the effects of climate change and preserving the health of our planet for future generations. Implementing policies to reduce carbon emissions, transitioning to renewable energy sources, and promoting sustainable practices are all essential steps in combating climate change.
Tasks and problems	The three largest emitters of CO2 are China, the United States, and India. These countries have a significant impact on global greenhouse gas emissions and must play a key role in reducing their carbon footprint. The file CO2.xlsx contains data from 1990 to 2022 about the CO2 emissions (millions of tonnes) in China, the United States, India and World. **Task 1**

	Represent the trendlines of CO_2 emissions in the 3 countries. Interpret the graphs and discuss any notable patterns or changes. Summarize your conclusions in a few sentences. **Task 2** For each country, use Riemann sums to calculate the total emissions from 1990 to 2022 considering intervals with range equal to 8. Use left, right, and midpoint rules. **Task 3** Repeat the previous task considering the range equal to 4. Compare the results. **Task 4** Using the Excel Solver add-ins find the best polynomial curve that fits the given data for USA applying the least squares method. Comment on the quality of the fitting. **Task 5** Based on task 4, obtain the prediction of CO_2 emissions for the year 2024. **Task 6** Calculate the area under the curve obtained in task 4. Comment on the results comparing with the values in task 3. **Task 7** Do you know your carbon emission? Calculate your ecological footprint by accessing the link https://carbonfootprintcalculator.streamlit.app
Outcomes	• Interpret the graphs and discuss any notable patterns

expected	• Numerical results explained and put in context • Capture of ICT tools solutions used • Provide complete tasks' solutions • All the results must be presented in the context of the problem
Guide for Learning	• Read carefully the problem statement and the tasks posted. Always maintain a global view of all the projects. • Identify, or try to do a first draft match, the content units of your lecture notes involved in every task. • Take your lecture notes open and review before starting to solve the problems. • Match output expected with the tasks posted, at least as first draft approach. This will give you ideas about which tools are needed (ICT tools, hand calculations, data collection, …). • Follow the order of the tasks, try to increase the knowledge of the problem while you are solving the activities. • Always think that maybe there are different ways to solve a problem. • Use ICT tools to avoid hard computations and check your solutions are correct in different ways if possible. • The solutions are always part of a context, expressing such a final solution totally integrated in the problem posted. • Be sure you answer the complete questions. Partial solving could generate missing information for the following questions. • Always try to solve the questions by yourself. If the project can be done in groups, discuss in groups to confirm and detect fails or weaknesses, confront strategies, discuss presentation format, etc. Working in groups doesn't mean work less but work better.
Guide for Teaching	• Do a small Introduction concerning CO2 emissions, in the context of the climate change crisis we are currently living in. • The teacher owner proposes a list of tasks (input tasks). • Students are asked to form groups of 4 members each (the team). After forming the groups, students will choose a Student Master, who is responsible for distributing the tasks to each member of the group. The Student Master is expected to lead the team to the desired outcome. This means, he should provide an environment so that the correct solution of the tasks is found. In this way, he should be able to cope with distractions, disruptions, and obstacles that may appear, so the team reaches the goal. • Students should have studied the theoretical materials provided earlier. • The teacher provides each group with a Scrum sheet to record • The students should do each exercise in a sequential order, starting from Task 1. • The students should be able to thoroughly read and interpret the results from a mathematical and the real-life example point of view. They should include also a discussion of the climate change crisis and enumerate some strategies they could apply

	at home or even at university to save resources, namely reduce energy consumption. They should also mention how this mini-PBL relates with Sustainable Development Goals. • The teacher do not interfere with the discussions. • The teacher should walk around the room observing what each group is doing.
Assessment	The sprint assessment consists of the following 3 components: 1) assessment of tasks performed - calculating the weighted average of accepted tasks; 2) activities not accepted have a 0 (for these activities, the teacher gives hints for the correct solution); 3) assessing students' individual contribution by analyzing the team's Scrum board. In the Sprint retrospective students discuss key points of the solved tasks and make a brief report of what went well; what went wrong; what should be improved in the next Sprint. • Final report; • Oral presentation; • Peer-assessment: students will apply peer-assessment for their periodic performance.
Others: References	https://www.sfu.ca/math-coursenotes/Math%20158%20Course%20Notes/sec_riemann.html https://sustainabilitymath.org/ https://eduscrum.org/about-us-and-how-we-try-to-make-it-happen/ https://data.worldbank.org

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<tr><td>Tasks and problems</td><td>The three largest emitters of CO2 are China, the United States, and India. These countries have a significant impact on global greenhouse gas emissions and must play a key role in reducing their carbon footprint.

The file CO2.xlsx contains data from 1990 to 2022 about the CO2 emissions (millions of tonnes) in China, the United States, India and World.</td></tr>
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Task 1

Represent the trendlines of CO_2 emissions in the 3 countries. Interpret the graphs and discuss any notable patterns or changes. Summarize your conclusions in a few sentences.

Task 2

For each country, use Riemann sums to calculate the total emissions from 1990 to 2022 considering intervals with range equal to 8. Use left, right, and midpoint rules.

Task 3

Repeat the previous task considering the range equal to 4. Compare the results.

Task 4

Using the Excel Solver add-ins find the best polynomial curve that fits the given data for USA applying the least squares method.

Comment on the quality of the fitting.

Task 5

Based on task 4, obtain the prediction of CO_2 emissions for the year 2024.

Task 6

Calculate the area under the curve obtained in task 4. Comment on the results comparing with the values in task 3.

Task 7

Do you know your carbon emission?

Calculate your ecological footprint by accessing the link https://carbonfootprintcalculator.streamlit.app

Outcomes expected	Guide of minimum output expected: • Graphics fitting the solution • Tables of data used/obtained in solutions • Numerical results explained and put in context • Capture of ICT tools solutions used • Sequence of steps followed • Remark computations done by ICT tools • Provide complete answer to questions • All the results must be presented in the context of the problem
Guide for learning	• Read carefully the problem statement and the tasks posted. Always maintain a global view of all the projects. • Identify, or try to do a first draft match, the content units of your lecture notes involved in every task. • Take your lecture notes open and review before starting to solve the problems. • Match output expected with the tasks posted, at least as first draft approach. This will give you ideas about which tools are needed (ICT tools, hand calculations, data collection, …). • Follow the order of the tasks, try to increase the knowledge of the problem while you are solving the activities. • Always think that maybe there are different ways to solve a problem. • Use ICT tools to avoid hard computations and check your solutions are correct in different ways if possible. • The solutions are always part of a context, expressing such a final solution totally integrated in the problem posted. • Be sure you answer the complete questions. Partial solving could generate missing information for the following questions. • Always try to solve the questions by yourself. If the project can be done in groups, discuss in groups to confirm and detect fails or weaknesses, confront strategies, discuss presentation format, etc. Working in groups doesn't mean work less but work better.
Assessment	See ANNEX 1 for Rubric
Others: References	https://www.sfu.ca/math-coursenotes/Math%20158%20Course%20Notes/sec_riemann.html https://sustainabilitymath.org/ https://eduscrum.org/about-us-and-how-we-try-to-make-it-happen/ https://data.worldbank.org

ANNEX 1: RUBRIC

Category	4=Excellent	3=Good	2=Low	1=Poor
Mathematical Concepts	Explanation shows complete understan- ding of the mathe- matical concepts used to solve the problem(s).	Explanation shows substantial understan- ding of the mathema- tical concepts used to solve the problem(s).	Explanation shows some understan- ding of the mathe- matical concepts needed to solve the problem(s).	Explanation shows very limited unders- tanding of the underlying concepts needed to solve the problem(s) OR is not written.
Mathematical Terminology and Notation	Correct terminology and notation are always used, making it easy to understand what was done.	Correct terminology and notation are usually used, making it fairly easy to understand what was done.	Correct terminolo- gy and notation are used, but it is sometimes not easy to understand what was done.	There is little use, or a lot of inappropriate use, of terminology and notation.
Strategy/Procedure	Typically, uses an efficient and effective strategy to solve the problem(s).	Typically, uses an effective strategy to solve the problem(s).	Sometimes uses an effective strategy to solve problems, but does not do it consistently.	Rarely uses an effective strategy to solve problems.
Completion	All problems are completed.	All but one of the problems are completed.	All but two of the problems are completed.	Several of the problems are not completed.
Mathematical Errors	90-100% of the steps and solutions have no mathematical errors.	Almost all (85-89%) of the steps and solu- tions have no mathematical errors.	Most (75-84%) of the steps and solu- tions have no mathematical errors.	More than 75% of the steps and solu- tions have mathe- matical errors.

Sources Checking				
Working with Others	Student was an engaged partner, listening to sugges- tions of others and working coopera- tively throughout lesson.	Student was an enga- ged partner but had trouble listening to others and/or working cooperatively.	Student coopera- ted with others, but needed prompting to stay on-task.	Student did not work effectively with others.
Neatness and Organization	The work is presen- ted in a neat, clear, organized fashion that is easy to read.	The work is presen- ted in a neat and organized fashion that is usually easy to read.	The work is presented in an organized fashion but may be hard to read at times.	The work appears sloppy and unorga- nized. It is hard to know what information goes together.
Diagrams and Sketches	Diagrams and/or sketches are clear and greatly add to the reader's unders- tanding of the procedure(s).	Diagrams and/or sketches are clear and easy to understand.	The work is presented in an organized fashion but may be hard to read at times.	Diagrams and/or sketches are difficult to understand or are not used.
ICT tools used				

Sources of examples

Special interest for any teacher is to have access to a high variety of sources for examples and problems to supply the mini-PBL projects. In fact, it is enough to give a basic applied problem to generate a bigger list of activities based on that.

Every course, in all universities around the world, graduate students present thousands of degree, master and PhD thesis where you can find for sure a list of examples/applications where a graphic or dataset can be the start point for constructing a mini-PBL project.

We encourage you to find your own sources, ask colleagues from your university for precise use of mathematics in any scientific area. Then connect such applications with SDG and construct your mini-PBL.

For help in such searching, in the following table we group basic scientific areas with the SDG to provide a list of suggestions for search math applications with SDG's interest label. Obviously, this is not a closed list, the items are interchangeable, and anyone can find an application of interest in the thousands of research papers and reports published every year all round the world.

SUSTAINABLE DEVELOPMENT GOALS	**Scientific areas or studies**
1 NO POVERTY	❖ Population studies and databases ❖ Incomes & Costs reduction ❖ Logistic & Transportation ❖ Equality studies
2 ZERO HUNGER	❖ Agriculture ❖ Nutrition ❖ Plagues ❖ Pollution
3 GOOD HEALTH AND WELL-BEING	❖ Medical databases ❖ Epidemiology ❖ Pharmacokinetic ❖ Microbiology ❖ Genetic ❖ Sports ❖ Aging

4 QUALITY EDUCATION	❖ Education databases ❖ Psychology ❖ Neuroscience ❖ Human & childhood behavior ❖ Economy of Education ❖
5 GENDER EQUALITY	❖ Incomes inequalities ❖ Population proportion on labor sectors ❖
6 CLEAN WATER AND SANITATION	❖ Water supply databases ❖ Pollution ❖ Microbiology ❖ Engineering ❖
7 AFFORDABLE AND CLEAN ENERGY	❖ Energy production and consume databases ❖ Engineering ❖ Consume ❖ Optimization of resources ❖ Penetration of renewable energies
8 DECENT WORK AND ECONOMIC GROWTH	❖ Labor databases ❖ Social studies ❖ Share market ❖ Bank products ❖ Economy and enterprise ❖ Tourism ❖ Digital business
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	❖ Industry and production databases ❖ Engineering ❖ Mobility ❖ Artificial Intelligence ❖ New Materials ❖ Nanotechnology ❖ Connectivity ❖ Logistic & Transportation ❖ 4th Industrial Revolution: Industry 4.0

10 REDUCED INEQUALITIES	❖ Social lacks and gaps databases ❖ Social studies ❖ Population studies ❖ Incomes/costs reduction ❖ Digital access
11 SUSTAINABLE CITIES AND COMMUNITIES	❖ Quality living databases ❖ Population studies ❖ Optimization ❖ Logistic & Transportation ❖ Civil Engineering ❖ Architecture ❖ Baggage management ❖ Energy ❖ New materials for urban furniture: maintenance, cleaning, preventing damage,... ❖ Electric and autonomous mobility ❖ Air pollution ❖ Noise reduction ❖ Mobility ❖
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	❖ Consume and human behavior databases ❖ Marketing ❖ Social networks ❖ Raw and new materials ❖ Energy ❖ Engineering
13 CLIMATE ACTION	❖ Climate change databases ❖ Deforestation ❖ Desertification ❖ Atmospheric physics ❖ Overheating ❖ CO2 reduction ❖ Carbon footprint
14 LIFE BELOW WATER	❖ Climate change and oceans ❖ Acidification of oceans ❖ Sustainable fishing ❖ Microbiology on oceans ❖ Microplastic and oceans ❖ Waste and biodegradable materials

15 LIFE ON LAND	❖ Climate change and land sustainability ❖ Sustainable farming ❖ Residues and waste processing ❖ Waste and biodegradable materials
16 PEACE, JUSTICE AND STRONG INSTITUTIONS	❖ Social studies databases ❖ Economy ❖ Cooperation for development ❖
17 PARTNERSHIPS FOR THE GOALS	❖ Social studies ❖ Social networks ❖ Civil movements ❖

References

Cannon, R. (2000). *Guide to support the implementation of the Learning and Teaching Plan Year 2000.* Australia: The University of Adelaide.

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McCombs, B. & Whistler, J. (1997). The learner-centered classroom and school: Strategies for increasing student motivation and achievement. San Francisco: Jossey-Bass Publishers.

Moffett, J., & Wagner, B. J. (1992). Student-centered language arts, K-12. Portsmouth, NH: Boynton/Cook Publishers Heinemann.