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Are the Cans in the Store “Volume Optimized”? [Mathematics]

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Assignment reflective narrative

This is one of LaGuardia's Project Connexion STEM Team's experiential learning activities. I want to thank my team members: Drs. Tao Chen, Danjel Gertner, Midas Tsai and Ingrid Veras for their invaluable ideas and feedback. Project Connexion's purpose is to promote creative thinking on how to engage students in the classroom. As part of this, the STEM team developed Experiential/co-curricular activities that demonstrated to students how their work in class connects to the world around them. These activities were embedded into the syllabus to ensure the participation of all students. Each professor designed a Co-curricular activity for their courses, ensuring that the Co-curricular activity directly linked course material to the outside world.

This Calculus I Experiential Learning Project aligns with one of the main course objectives: *Compute maxima and minima of functions using calculus and solve optimization problems arising in applications and other fields of study.* The project also supplements three of LaGuardia's Core Competencies: The Global Learning proficiency, Inquiry and Problem Solving and Written Communication Ability.
Global Learning asks students to approach the world's challenges and opportunities from multiple perspectives and engage with issues of diversity, identity, democracy, power, privilege, sustainability, and ethical action. Students completing this assignment look at the application of calculus into can production and investigate if the material is used at its highest efficiency level in order to minimize the environmental issues that come with can production. The learning objectives include not only mathematical precision but also climate change education. It raises awareness on how the actions of students and their communities could impact the environment and on how each one of us can contribute towards minimizing the effect of environmental issues faced by not only New York City, but the entire world.
The assignment supplements LaGuardia's Inquiry and Problem-Solving Core Competency, because it requires a process of exploring the environmental issues that come with can production through the collection and analysis of evidence and data that result in informed conclusions or judgments. The completion of the project goes through all dimensions of this competency: *Framing the Issues, Evidence Gathering, Analysis and Conclusions.*
The reflection part of the project includes *communicating messages to others, knowledge construction, fosters understanding and/or influences theirs and others' opinion* on environmental issues as pertaining to can use, which makes this assignment suitable for assessing LaGuardia's Written Communication Ability Core competency as well.

The project completion would normally take 4-5 hours and it is suggested to be 10-15% of their final grade.The assessment demonstrated a higher level of conceptual understanding and knowledge retention as a result of this Experiential Learning Project. Calculus 1 is taken by students majoring in different disciplines. Students participating in the above project were mainly from Engineering, Computer Science, Business Administration, Liberal Arts Math and Science, Undecided, etc.

The project offers students meaningful opportunities to analyze and explore complex global challenges, communicate respectfully in diverse environments, and apply learning to take responsible, ethical action in contemporary global contexts. The project raises awareness about the issue of climate change. It helps with understanding of the interrelationships among the self, local and global communities, promotes the recognition of responsibilities at the local level and the perspectives on ethics and power locally and globally. Exploring the efficiency of can production and their use will make students self-aware of how theirs and the greater community actions affect climate change.

Mathematics and Global Learning: Are the cans in the store "volume optimized"?

Introduction: One of LaGuardia's Core Competencies is Global Learning, as described below: Global Learning asks students to approach the world's challenges and opportunities from multiple perspectives and engage with issues of diversity, identity, democracy, power, privilege, sustainability, and ethical action.

This experiential learning assignment will focus on the global issue of climate change and environmental activism from a local perspective. Students will reflect and inquire about their roles and responsibilities to minimize effects of climate change by applying their knowledge of calculus in real life settings. The United Nations Sustainable Development Goal 13 (UNSDG13) helps students gain awareness of the global issue of climate change from diverse perspectives by allowing them to reflect on their own responsibilities of protecting their environment, an aspect significant to LaGuardia's Gen Ed competencies.
Climate Change - United Nations Sustainable Development

Calculus I – Experiential Learning Project
Raising awareness about the environmental problems

- Why do you think it is important to raise awareness on climate education?
- How do our actions impact the environment? (for ex. garbage disposal, deforestation, etc.)

Please, read and watch the videos before completing the following assignment. The link below provides some of the pros and cons of the use of cans and canned food.
23 Pros & Cons Of Cans and Canned Food - E&C

Part I. Question. Are the cans in the store "volume optimized"?

Think about calculus through a shopping trip and investigate its hidden use behind everyday objects, like cans.
Each can in the store is made of a certain amount of metal. Think like you will melt that metal down and reforge it into a *different sized cylinder* which holds even *more volume*. In other words, does that metal (used for the actual can) enclose the *most* volume it could?

Find three different sized right cylindrical cans (e.g., soda can, soup cans, red bull cans, Arizona iced tea, tuna fish cans, etc.), calculate the actual volume and the amount of material used to make each can. The surface area will suffice – we are not going to take into account the thickness of the cans and will ignore the edges. For each can, you need to calculate (*by solving an optimization problem*) what is the maximum amount of volume the metal used for the can (expressed as area) could hold *in theory*. Then you're going to calculate how "volume optimized" each can is, by calculating the ratio:

$(The\ actual\ volume\ of\ can) \div (Best\ possible\ volume\ of\ can)$

Which, as a percent, represents how close the actual volume of the can is to the "highest volume" possible (for the given surface area of the metal).

Part II. Report - Mathematically communicating the findings
The final report of your investigation should include:
- A more interesting (clever) title, i.e., a title that appeals to your readers.
- Photographs of each of your cans,
- The height, radius, surface area, and volume of each can labeled,
- *The maximum* possible volume for your cans with a clear explanation of how you used optimization theory to algebraically calculate it
- Show how "volume optimized" each can is
- Make a graph of the *can's volume* versus the *can's radius*, and mark the point on the graph with the maximum possible volume, and mark the point on the graph which represents your actual can**.**

Notes:
- We'll use *surface area* to talk about how much metal is used to build the can. The assumption is that all cans are made of metal with the same thickness, which I know is not true. It's a simplifying assumption.
- When measuring the radius of each can, you need to be as accurate as possible. You can get the most accurate radius if you measure the circumference of the can. You may wrap a piece of paper around the can and mark the circumference, and then calculate the radius using $C=2\pi r$.
- Round to the nearest *hundredth* and keep π in all calculations until the end.
  When graphing, you should use www.desmos.com

The report should be neatly put together, organized in a logical, coherent way, and free from calculation/algebraic/calculus errors.

After working out the problem for a couple of cans, you should be able to come up with a way to show how you'd get the answer (max volume) for a can with *any surface area*. Putting that on the report, with some explanation of what you're doing in each stop, is appreciated.

Reflection - Communicating in English project's awareness
Should include the following:
- Date that you visited the store and the name of the store.
- Why do you think most of the canned food in the store is in **cylindrical** cans? Is the cylinder the best way to maximize the volume for a given surface area of a metal sheet? Or is there something else that is being optimized here by the use of cylindrical cans?
- How is this investigative assignment relevant to your studies at LaGCC?

- What did you learn by completing the assignment? And do you see this being important in your life or education?
- Did completing this assignment change the way you think about climate change education? In other words, briefly discuss how your application of classroom learning helped you to gain awareness on your role towards the environment.
- Have you considered how your, and the greater community actions, can impact the environment?
- Provide some examples as to how you or the community can help minimize the environmental issues faced by not only the New York City, but the entire world. You are welcome to share ideas on volunteering, community outreach activities that students could partake to support your answer.

Good Luck!

Grading
As mentioned above this project is 10% of the course final grade
The report will be graded out of 100 points as follows.

- Can analysis - 75% of project's grade, each can $i \in \{1, 2, 3\}$ is 25 points

Can i: _____/25
- Height, radius, surface area, and volume of each can (in cm, to the nearest tenth) _____/4
- Derivation for how to calculate the maximum possible volume for each can (both first and second derivative tests are applicable here):
  Derivation must be neatly written; each step must be clearly explained. ______/10
- Calculation of how "volume optimized" each can is (the percent) _____/5
- A graph with the Volume vs. Radius graphed _____/6
  Graph must have a proper x_{min}, x_{max}, y_{min}, y_{max} and axes must be labeled. Graph has a clearly marked point which represents the most "volume optimized" and the point which represents the actual volume

- The written reflection after the assignment's completion - 25% of the project's grade.

This project supplements three of LaGuardia's Core Competencies: The Global Learning proficiency, Inquiry and Problem Solving and Written Communication Ability. There is a possibility of earning a Digital Badge upon successful completion of this project which can be included in your ePortfolio and LinkedIn Profile. A Digital Badge is one way to recognize an achievement, serves both as recognition of learning and digital proof of that accomplishment.