Calculus Semester Project

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CS-A

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Objective:

Our objective is to provide a comprehensive solution that will output the optimal amount of surface area or volume whichever is needed. We will provide the pizzeria with a program which will help them calculate the surface area and volume along with the boxes that can be made.

Introduction of the Problem:

The problem which we are tackling is that, a pizzeria wants to know in what way they can use their resources in the best way to find the volume or surface area of a triangular pizza box which they want to use in their pizza shop. They want to be able to input a value either the surface area or volume, and receive the corresponding value such as the volume in case surface area is inputted and vice versa. Then at the end, the max amount of boxes should be outputted that can be made within the given budget.

Solution to problem:

③

Since length cannot be negative

$a = +7.788$ cm

According to domain

$$\frac{a(182-a^2)}{2(\sqrt{2}+2)} \geq 0$$

$$a(182-a^2) \geq 0$$

so

$a = 0$

$182 - a^2 = 0$

$a^2 = 182$

$a = \sqrt{182}$

$a = \pm 13.5$

since a cannot be negative

$a = 13.5$ cm

so Domain will be

$$0 \leq a \leq 13.5$$

$$V(a) = \frac{182a - a^3}{2(\sqrt{2}+2)}$$

$$V(0) = \frac{182(0)-(0)^3}{2(\sqrt{2}+2)} = 0 \text{ cm}^3$$

$$V(13.5) = \frac{182(13.5)-(13.5)^3}{2(\sqrt{2}+2)} = -0.49 \text{ cm}^3$$

$$V(7.78) = \frac{182(7.78)-(7.78)^3}{2(\sqrt{2}+2)} = 138.4 \text{ cm}^3$$

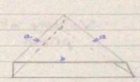
PAP

①

Since it is an isosceles triangle

length = width = a

base = b



length = a

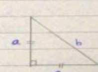
width = b

height = h

base = a

Using Pythagorean theorm

$$(\text{Hypotenuse})^2 = (\text{Perpendicular})^2 + (\text{base})^2$$



$$b^2 = a^2 + a^2$$

$$b^2 = 2a^2$$

Taking underroot of both sides

$$b = \sqrt{2a^2}$$

$$b = a\sqrt{2} \text{ cm}$$

Now

$$\text{Surface area} = b \times h + 2\left(\frac{1}{2}a^2\right) + 2(a \times h)$$

surface area = 182 cm^2

So

$$182 = b \times h + a^2 + 2ah$$

$$182 - a^2 = bh + 2ah$$

$\because b = \sqrt{2}\,a$

$$182 - a^2 = \sqrt{2}\,a\,h + 2ah$$

$$182 - a^2 = ah(\sqrt{2}+2)$$

$$ah = \frac{182-a^2}{\sqrt{2}+2}$$

$$h = \frac{182-a^2}{a(\sqrt{2}+2)}$$

PAPERWORK

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Volume of prism = Area of base × height

$$V = \frac{1}{2} \times a^2 \times h$$

$$V = \frac{1}{2} \times a^2 \times \frac{182 - a^2}{a(\sqrt{2} + 2)}$$

$$V = \frac{a(182 - a^2)}{2(\sqrt{2} + 2)}$$

$$V(a) = \frac{a(182 - a^2)}{2(\sqrt{2} + 2)}$$

Taking derivative w.r.t a

$$\frac{d\,V(a)}{da} = \frac{d}{da}\left[\frac{182a - a^3}{2(\sqrt{2}+2)}\right]$$

$$\frac{d(V(a))}{da} = \frac{1}{2(\sqrt{2}+2)} \cdot \frac{d}{da}(182a - a^3)$$

$$\frac{d(V(a))}{da} = \frac{1}{2(\sqrt{2}+2)} \cdot (182 - 2a^2)$$

since $\frac{d(V(a))}{da} = 0$

$$0 = \frac{(182 - 2a^2)}{2(\sqrt{2}+2)}$$

$$0 = 182 - 2a^2$$

$$2a^2 = 182$$

$$a^2 = 60.667$$

$$a = \sqrt{60.667}$$

$$a = \pm 7.788 \text{ cm}$$

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Now taking Volume as input:

Let the input volume be the previously derived volume

Volume = 138.4 cm^3

$$\text{Volume} = \frac{1}{2} \times b \times a \times h$$

since $b = \sqrt{2}\,a$

$$\text{Volume} = \frac{1}{2} \times \sqrt{2}\,a \times a \times h$$

$$138.4 = \frac{1}{2} \times \sqrt{2} \times a^2 \times h$$

$$\frac{2(138.4)}{\sqrt{2}} = a^2 \times h$$

$$193.727157 = a^2 h$$

$$h = \frac{195.73}{a^2}$$

Now

$$\text{surface area} = a^2 + bh + 2ah$$

$$S.A = a^2 + (\sqrt{2}\,a)\left(\frac{195.73}{a^2}\right) + 2a\left(\frac{195.73}{a^2}\right)$$

$$S.A = a^2 + \frac{\sqrt{2}(195.73)}{a} + \frac{2(195.73)}{a}$$

$$S.A = a^2 + \frac{276.8}{a} + \frac{391.46}{a}$$

$$S.A = \frac{a^3 + 276.8 + 391.46}{a}$$

$$S.A = \frac{a^3 + 713.8}{a}$$

Taking derivative of both sides w.r.t a

⑤

$$\frac{d(S.A(a))}{da} = \frac{d}{da}\left[\frac{a^3 + 713.8}{a}\right]$$

$$\frac{d(S.A(a))}{da} = \frac{a\frac{d}{da}(a^3+713.8) - (a^3+713.8)\frac{d}{da}(a)}{(a)^2}$$

$$0 = \frac{a(3a^2) - (a^3+713.8)}{a^2}$$

$$0 = \frac{3a^3 - a^3 \mp 713.8}{a^2}$$

$$0 = \frac{2a^3 \mp 713.8}{a^2}$$

$$2a^3 \mp 713.8 = 0$$

$$a^3 = \frac{713.8}{2}$$

$$a^3 = 356.9$$

$$a = 7.04 \text{ cm}$$

So domain will be

$$0 \le a \le 7.09$$

~~S.As~~ =

since derivative of surface area is equal to volume

$$V(a) = \frac{a^3+713.8}{a}$$

$V(0) = 0 \text{ cm}^3$ $V(7.09) = 150 \text{ cm}^3$

⑥

Cost

$$\text{Total cost} = \frac{\text{Total Budget}}{\text{surface area} \times \text{cost per length}}$$

Total Budget $= 2 \times 10^6$ (2 million dollars)

cost per length = 5 dollars

Surface area $= 182 \text{ cm}^2$

So

$$\text{Total cost} = \frac{2{,}000{,}000}{182 \times 5}$$

$$= 2197.8$$

$$\approx \textbf{2198 Boxes}$$

The company will be able to manufacture approximately 2198 boxes.

The Octave code:

```
clear all
clc
disp("I21-2544, I21-0705, I21-0520");
disp("Aizex Corporation");
disp("Program Started");
a = 0
b = 0
    f = @(x) ((182.*x) - (x.^3))
    pkg load symbolic
    syms x;
    ff = f(x);
% now calculate the derivative of the function
    ffd = diff(ff, x)
    ffd = ffd ./ (2 .* (sqrt(2) + 2))
g = @(y) ((y^3) + 668.26) ./ (y)
    pkg load symbolic
    syms y;
    gf = g(y);
  % now calculate the derivative of the function
   gfd = diff(gf, y)
   gfd = gfd
 dec = input("Enter 1 for Surface area or 2 for Volume --- ")
if(dec == 1)
```

```
if(dec == 1)
 %optimization of Surface Area. Find Volume
        a = input("Enter surface area in meters : ")
        arr = [a-5:1:a+5]
        dfh = function_handle (ff)
        vol = dfh (arr) ./ (2 .* (sqrt(2) + 2))
        plot(vol);
endi
if(dec == 2)
       %optimization of Volume. Find Surface Area.
       b = input("Enter Volume : ")
       brr = [b-5:1:b+5]
       dgh = function_handle (gf)
       sa = dgh (brr)
       plot(sa);
endif
disp("Now to find estimated cost of 2 million pizza boxes")
surArea = input("Enter surface area")
boxes = (2000000 ./ (surArea.*5))
```

Demonstration of the code:

1. The code start with the company name and the Developers introduction.

2. Then the program takes the general function of Volume and Surface Area.

3. It derivatives these functions. Getting the side of the isosceles triangle.

4. It then asks the user to select finding Surface Area or Volume.

5. It outputs the desired results with graphs.

6. After this the user is asked to enter Surface Area.

7. Using the surface area our program calculates how many pizza boxes can be made under a budget of 2 million.

Instruction manual:

1. Enter 1 to find Volume or 2 to find Surface Area.

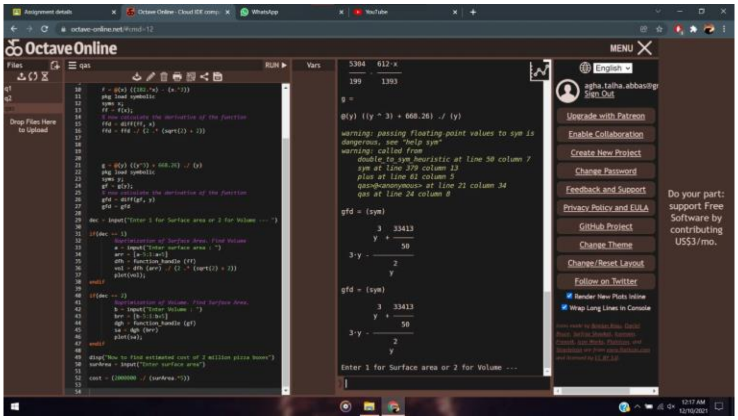
2. Surface Area is calculated in meters so it should be under 0.1m - 19m.

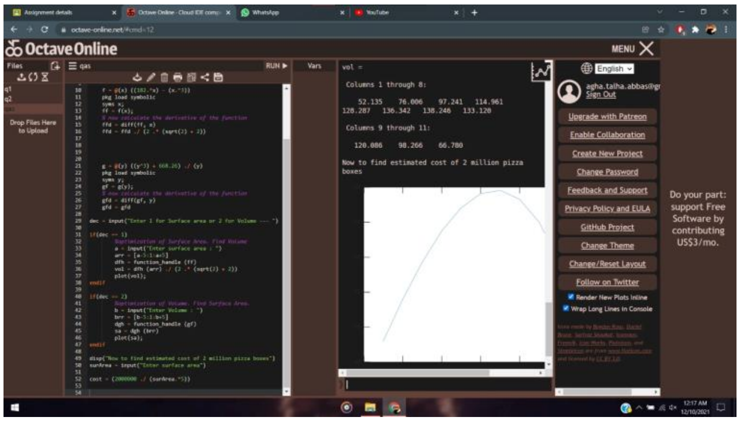
3. Volume is calculated in meters so it should be under 0.1m - 9m

4. At the end the box count is displayed. The surface area is in cm.

So it should be greater than 100

Octave code execution:





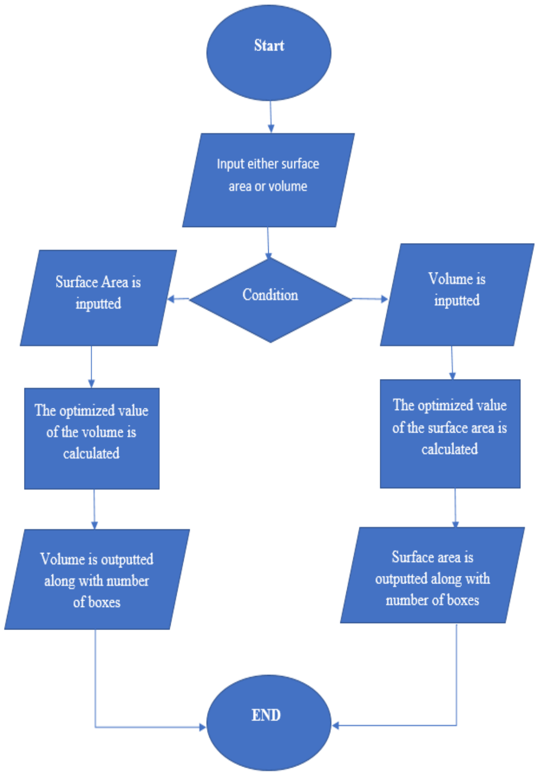
Real Life Demonstration:

According to my results and the comparison between the stats and the graph it shows that the Surface Area has the maximum value at 7.81.

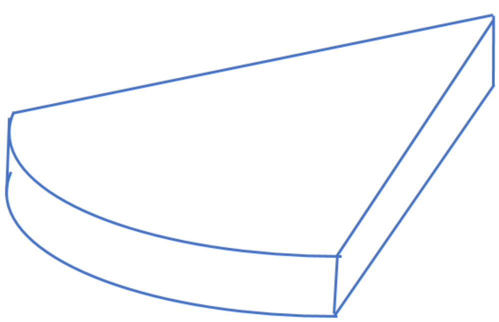
The maximum volume attained is 186.04.

And the boxes you can make with 2 million budget and surface area of 182(optimal) is 2198

Flowchart;



Shape:



Conclusion:

With the help of graph and answers provided by Octave it is easier to find precise answers which is hard to achieve in hand solutions as there can be errors in calculations. The problem was to determine the volume of a triangular box if surface area was given and the results of the solution were provided above. Difficulties faced were the running and writing of the code in octave as differential was difficult to find due to an error in the equation created which was fixed later by creating the hand written solution again. This is the end of the report all examples and process were thoroughly explained.

Contribution:

This was a group effort created which consisted of three members named Munib, Rafey and Talha. The tasks were divided almost evenly so that each member had a role to play but each member had a major role in 1 part of the project as Raffay created the equation which was proof read by Munib and Talha. In the same way Talha created the Octave solution with the help of his other team members as they tried to find errors in his code. At last Munib, while understanding the whole project created the report with some help of his team members. We decided it was best to assign the roles each team member was best at and did a group effort to complete this project.