

NETS OF BRICKS

Cat 08 - Mathematics

Group 08-25

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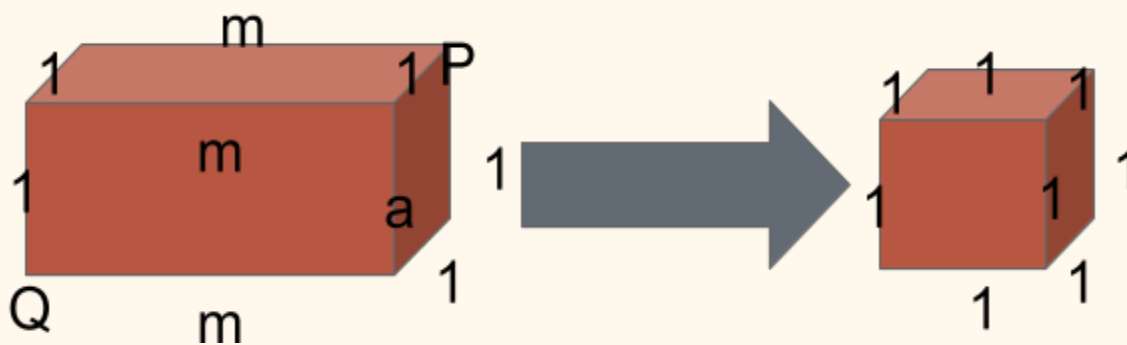
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1 Introduction

Consider the “brick”, a rectangular solid which is $1 \times 1 \times m$ where m is a positive integer. When $m = 1$, we have a cube. a is the height of the brick. Let’s say Point P and Point Q are 2 edges of the brick and they are opposite to each other. If the brick is opened, it becomes a net, and the brick becomes a surface rather than a solid.



1.1 Research questions

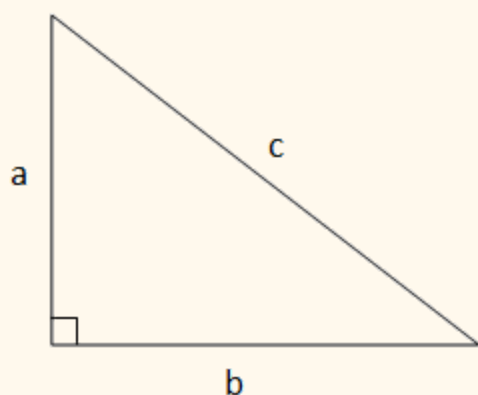
- 1) To find the relationship between PQ , the length of m and length of a .
- 2) Can the formula still be applied if m is not a integer? (e.g. a fraction)
- 3) Will the formula still apply if it is used on a cube?
- 4) How can our formula be applied in real life?

2 Literature review

Pythagoras' Theorem

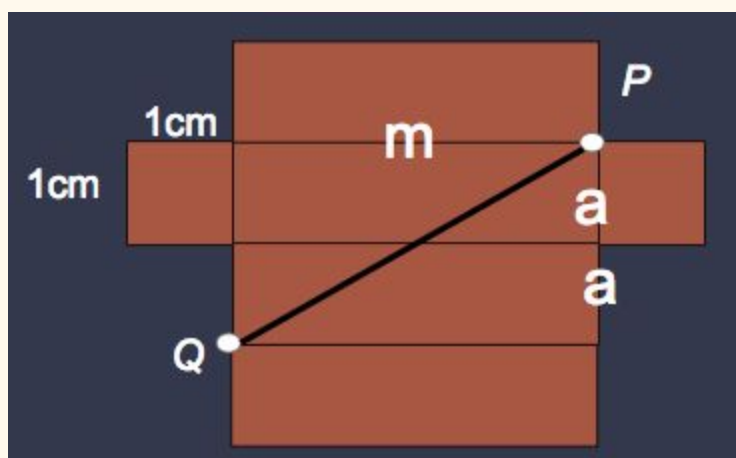
It is a theorem developed by the famous Greek mathematician, Pythagoras. In a right angled triangle, the longest side $c = \sqrt{b^2 + a^2}$.

(Weisstein, Eric W. "Pythagorean Theorem." From MathWorld--A Wolfram Web Resource. <http://mathworld.wolfram.com/PythagoreanTheorem.html>(Retrieved 13/4/18))



Nets

When a block is cut along the edges of a solid such that the sides of the solid can be laid flat onto a plane. The resulted shape is a net.



The picture on the left shows the layout of the brick we are examining when turned into a net.

(Shinglee New Syllabus 7th Edition Mathematics Textbook)

3.0 Methodology

We intend to find out the actual length of PQ using the Pythagorean theorem. We will then test our formula and find out if its results are similar to those of the Pythagorean theorem.

We also created a C++ program to help us calculate the length of PQ more efficiently and if the value of a changes.

The following is the C++ program.

```
#include <bits/stdc++.h>
using namespace std;
int main() {
    long double c;
    long long choice, a, b, trial[2], into;
    trial[0] = 0;
    trial[1] = 0;
    cout << "Choice 1, find length of m with side 'a' up to..." << "\n" << "Choice 2, find length of m (longest side)..." << "\n"
    << "Enter only 1 or 2" << "\n" << "Choice 3, find length or m if its a cube" << "\n";
    cin >> choice;
    cout << "Ans corrected to ??? decimal places: ";
    cin >> into;
    cout << fixed << setprecision(into); [Correcting the numbers all to "into" decimal places]
    cout << "Enter m ";
    if(choice != 1){
        cout << ":";
    }
    else{
        cout << "up to... :";
    }
    cout << "\n";
    cin >> a;
    cout << "Enter 2nd side (The other side): " << "\n";
    cin >> b;
    if(choice == 1){
        for(long double i = 0; i < a + 1; i++){
```

```
cout << sqrt(i * i + b * b * 4); [Outputting the result of  $PQ$  from when “ $i$ ” is 0 to when “ $i$ ” is at the required number  $m$  (in the program it is indicated as “ $a$ ”).]
```

```
}
```

```
}
```

```
else if(choice == 2){
```

```
c = sqrt(a*a + b*b*4); [Outputting the result of  $PQ$  from when “ $i$ ” is  $m$ (in the program it is indicated as “ $a$ ”).]
```

```
cout << c << "\n";
```

```
}
```

```
else if(choice == 3){
```

```
for(long long i = 0; i < a + 1; i++){
```

```
trial[0] = sqrt(i * i * 5);
```

```
cout << trial[0] - trial[1]; [Outputting difference in the consecutive results of  $PQ$  from when “ $i$ ” is 0 to when “ $i$ ” is at the required number  $m$  (in the program it is indicated as “ $a$ ”).]
```

```
trial[1] = trial[0];
```

```
}
```

```
}
```

```
else{
```

```
cout << "Invalid choice."; [In case the user inputs other characters e.g. alphabets]
```

```
}
```

```
}
```

3.1 The relationship between PQ and m and a :

$$PQ = \sqrt{m^2 + (2a)^2}$$

After many researches, experiments and tests, this formula was developed. Our formula calculates the length of PQ on the side of the brick facing front, added to the length of PQ on the upwards facing side of the brick. We also compared the results against those of the Pythagorean theorem and they match.

Therefore we can conclude that our formula is correct.

The below picture shows a sample output of one of our tests. Calculated by the C++ program.

```
Choice 1, find length of m with side 'a' up to...
Choice 2, find length of m (longest side)...
Enter only 1 or 2
Choice 3, find length or m if its a cube
1
Ans corrected to ??? decimal places:
3
Enter m up to... :
350
Enter 2nd side (The other side):
1
2.000 2.236 2.828 3.606 4.472 5.385 6.325 7.280 8.246 9.220 10.198 11.180 12.166 13.153 14.142 15.133 16.125 17.117
18.111 19.105 20.100 21.095 22.091 23.087 24.083 25.080 26.077 27.074 28.071 29.069 30.067 31.064 32.062 33.061
34.059 35.057 36.056 37.054 38.053 39.051 40.050 41.049 42.048 43.046 44.045 45.044 46.043 47.043 48.042 49.041
50.040 51.039 52.038 53.038 54.037 55.036 56.036 57.035 58.034 59.034 60.033 61.033 62.032 63.032 64.031 65.031
66.030 67.030 68.029 69.029 70.029 71.028 72.028 73.027 74.027 75.027 76.026 77.026 78.026 79.025 80.025 81.025
82.024 83.024 84.024 85.024 86.023 87.023 88.023 89.022 90.022 91.022 92.022 93.022 94.021 95.021 96.021 97.021
98.020 99.020 100.020 101.020 102.020 103.019 104.019 105.019 106.019 107.019 108.019 109.018 110.018 111.018 112.018
113.018 114.018 115.017 116.017 117.017 118.017 119.017 120.017 121.017 122.016 123.016 124.016 125.016 126.016
127.016 128.016 129.016 130.015 131.015 132.015 133.015 134.015 135.015 136.015 137.015 138.014 139.014 140.014
141.014 142.014 143.014 144.014 145.014 146.014 147.014 148.014 149.013 150.013 151.013 152.013 153.013 154.013
155.013 156.013 157.013 158.013 159.013 160.012 161.012 162.012 163.012 164.012 165.012 166.012 167.012 168.012
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225.009 226.009 227.009 228.009 229.009 230.009 231.009 232.009 233.009 234.009 235.009 236.008 237.008 238.008
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253.008 254.008 255.008 256.008 257.008 258.008 259.008 260.008 261.008 262.008 263.008 264.008 265.008 266.008
267.007 268.007 269.007 270.007 271.007 272.007 273.007 274.007 275.007 276.007 277.007 278.007 279.007 280.007
281.007 282.007 283.007 284.007 285.007 286.007 287.007 288.007 289.007 290.007 291.007 292.007 293.007 294.007
295.007 296.007 297.007 298.007 299.007 300.007 301.007 302.007 303.007 304.007 305.007 306.007 307.007 308.006
309.006 310.006 311.006 312.006 313.006 314.006 315.006 316.006 317.006 318.006 319.006 320.006 321.006 322.006
323.006 324.006 325.006 326.006 327.006 328.006 329.006 330.006 331.006 332.006 333.006 334.006 335.006 336.006
337.006 338.006 339.006 340.006 341.006 342.006 343.006 344.006 345.006 346.006 347.006 348.006 349.006 350.006
```

3.2 What happens if m is not a integer? (e.g. a fraction)

The formula will still work. Here are some examples. These data are gotten from a test of our C++ program.

	length of PQ	length of a	dimensions of the cuboid
when m is $\frac{1}{2}$	2.061552813	1	$\frac{1}{2} \times 1 \times 1$
when m is $\frac{1}{3}$	2.02758751	1	$\frac{1}{3} \times 1 \times 1$
when m is $\frac{1}{4}$	2.015564437	1	$\frac{1}{4} \times 1 \times 1$

3.3 What happens if the formula is used on a cube?

The formula will still work as cubes and cuboids have similar properties. For example, both cubes and cuboids have six faces, 12 edges and eight vertices, or corners, and cubes and cuboids contain exclusively right angles.. Each edge is shared by two faces. At each vertex, three faces join together.

	length of PQ	length of M
2 cm cube	2.82842712474619	2
3 cm cube	4.242640687119285	3
4 cm cube	5.65685424949238	4

Data collected from calculating the length of PQ in a cuboid using our formula, where its dimensions are $1 \times 1 \times m$:

	length of PQ	dimensions of cuboid
when m is 3 cm	3.605551275463989	$1 \times 1 \times 3$
when m is 4 cm	4.472135954999579	$1 \times 1 \times 4$
when m is 5 cm	5.385164807134504	$1 \times 1 \times 5$

4 Conclusion

We have successfully calculated a formula to find the relationship of the distance between points P and Q and the length of m . This is another method alternative to the Pythagorean theorem, with a C++ programming algorithm to go with it, to allow people to use it more efficiently.

A possible outcome to this project could be involved in designs of architecture e.g. Expressionist architecture as it involves brick expressionism and amount of material needed to insert or paint something on the side of the building.

5 References

Black, Kat. "Similarities & Differences of Cubes & Cuboids." Sciencing, <https://sciencing.com/similarities-differences-cubes-cuboids-8639117.html>. Retrieved 15/8/18.

Weisstein, Eric W. "Pythagorean Theorem." From MathWorld--A Wolfram Web Resource. <http://mathworld.wolfram.com/PythagoreanTheorem.html>. Retrieved 13/4/18