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Concept of Quadratic Equation of Rectangle to Relation all Mathematics Method

Research Article

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Abstract: In this research paper, the equation of rectangle explained in the form of quadratic equation. In this research paper, the main quadratic equation of rectangle is $x^2 - B(\square PQRS)x + A(\square PQRS) = 0$, which is outcome of 'Basic theorem of perimeter relation of square-rectangle'. If the value of **a** is not equal to 1 ($a \neq 1$), then the quadratic equation of rectangle is $ax^2 - B(\square PQRS)x + a.A(\square PQ'R'S') = 0$ $[ax^2 - bx + c = 0]$ and if the value of **a** is 1 ($a = 1$), then quadratic equation of rectangle is $x^2 - B(\square PQRS)x + A(\square PQRS) = 0$ $[x^2 - bx + d = 0]$. In this Research Paper Three methods of quadratic equation of rectangle are explained i.e. (i) Factorization method of rectangle (ii) Completing square of method of rectangle (iii) Formula method of rectangle. We are trying to give a new concept "Relation All Mathematics" to the world. I am sure that this concept will be helpful in Agricultural, Engineering, Mathematical world etc.

Keywords: Rectangle, Sidemeasurement, Relation, Formula, Quadratic equation.

1. Basic Concept

1.1. Side measurement(B)

If sides of any geometrical figure are in right angle with each other, then those sides or considering one of the parallel and equal sides after adding them, the addition is the side measurement. Side measurement indicated with letter 'B'. Side measurement is a one of the most important concept and maximum base of the 'Relation All Mathematics' depends upon this concept

1.2. Important Points of Square-Rectangle Relation

I) For explanation of square and rectangle relation following variables are used

a) Area – A

b) Perimeter – P

c) Side measurement – B

II) For explanation of square and rectangle relation following letters are used

a) Area of square ABCD – $A(\square ABCD)$

b) Perimeter of square ABCD – $P(\square ABCD)$

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c) Side measurement of square ABCD – $B(\square ABCD)$

d) Area of rectangle PQRS – $A(\square PQRS)$

e) Perimeter of rectangle PQRS – $P(\square PQRS)$

f) Side measurement of rectangle PQRS – $B(\square PQRS)$

1.3. Explanation of Quadratic Equation of Rectangle

Condition I : $a = 1$

when $a = 1$, then quadratic equation of rectangle explain as,

$x^2 - B(\square PQRS)x + A(\square PQRS) = 0$. i.e. $x^2 - bx + d = 0$, here $a = 1$, $b = B(\square PQRS)$ and $d = A(\square PQRS)$ which is constant.

Condition II : $a \neq 1$

when $a \neq 1$, then quadratic equation of rectangle explain as,

$ax^2 - B(\square PQRS)x + a.A(\square PQ'R'S') = 0$. i.e. $ax^2 - bx + c = 0$, here $a \neq 1$, $b = B(\square PQRS)$ and $c = a.c' = a.A(\square PQ'R'S')$ which is constant .

$$ax^2 - bx + a.c' = 0$$

2. Concept of Quadratic Equation of Rectangle

Quadratic equation of rectangle : Quadratic equation of rectangle is defind as, An equation that employs the variable of rectangle l_1 or b_1 having the general form $ax^2 - bx + c = 0$. In this equation multiplication of a and c (a.c') is area and b is side measurement of rectangle also a is never equal to zero and the variable is squared which will not a quire higher power.

Variable of rectangle quadratic equation(x) : Length (l_1) and width (b_1) explain quadratic equation of rectangle, so it is called variable of quadratic equation of rectangle. But when quadratic equation is explained with variable length (l_1) then factors of that equation is in the form of width (b_1) and vise varsa. Variable of quadratic equation of rectangle is two i.e. l_1 and b_1. Assume x instead of variables l_1 and b_1. Now quadratic equation of rectangle written as, $x^2 - B(\square PQRS)x + A(\square PQRS) = 0$.

2.1. Basic proof of quadratic equation method in quadratic equation of rectangle

Known information: In $\square ABCD$ and $\square PQRS$,

$A(\square ABCD) = A(\square PQRS)$ $l^2 = l_1 \times b_1$ (here $l_1 > l$)

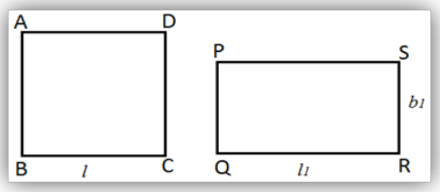

Figure 1. **Basic proof of quadratic equation of rectangle**

To prove : $l_1^2 - B(\square PQRS)l_1 + A(\square PQRS) = 0$

Proof : In $\Box ABCD$ and $\Box PQRS$, $P(\Box PQRS) = P(\Box ABCD) \times \frac{1}{2}[\frac{(n^2+1)}{n}]$ (Basic theorem of perimeter relation of square and rectangle)

$$P(\Box PQRS) = \frac{1}{2}(4l) \times \left[\frac{l_1^2 + l^2}{l.l_1}\right] \ldots \left[\frac{(n^2+1)}{n}\right] = \left[\frac{l_1^2 + l^2}{l.l_1}\right] = \left[\frac{b_1^2 + l^2)}{l.b_1}\right]$$

$$P(\Box PQRS) = 2\left[\frac{l_1^2 + l^2}{l_1}\right]$$

$$\frac{P(\Box PQRS)}{2} l_1 = l_1^2 + (l_1 \times b_1) \ldots l^2 = l_1 \times b_1$$

$$\frac{P(\Box PQRS)}{2} l_1 l_1 = l_1^2 + A(\Box PQRS)$$

$$l_1^2 - \frac{P(\Box PQRS)}{2} l_1 + A(\Box PQRS) = 0 \quad \text{but,}$$

$$\frac{P(\Box PQRS)}{2} = B(\Box PQRS)$$

$$l_1^2 - (l_1 + b_1)l_1 + l_1.b_1 = 0$$

$$l_1^2 - B(\Box PQRS)l_1 + A(\Box PQRS) = 0$$

This is basic proof of quadratic equation of Rectangle.

When area and side measurement of Rectangle are given then with the help of Quadratic equation of rectangle, we can find length and width of the Rectangle. Here $l_1^2 - B(\Box PQRS)l_1 + A(\Box PQRS) = 0$ and $b_1^2 - B(\Box PQRS)b_1 + A(\Box PQRS) = 0$ are two types of explanation which give basic proof of quadratic equation of Rectangle.

I) Concept of Factorization method of rectangle

Roots of quadratic equation of rectangle by factorization method of rectangle is length (l_1) and width (b_1) of that rectangle.

2.2. Basic proof of Factorization method of rectangle

I) Concept of factorization method of Rectangle in first quadrant

Known information In $\Box PQRS$, $A(\Box PQRS) l^2 = l_1 \times b_1$ (here, $l_1 > l$). Side measurement of $\Box PQRS = B(\Box PQRS)$

$a = 1$, $b = B(\Box PQRS) = (l_1 + b_1)$, $d = A(\Box PQRS) = l_1.b_1$

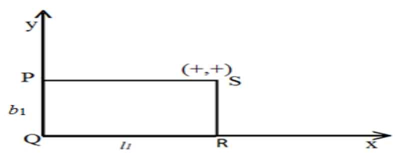

Figure 2. **Factorization method of Rectangle in first quadrant**

To prove : Factors of Rectangle= $\{l_1, b_1\}$

Proof : In first quadrant of $\Box PQRS$, $x^2 - B(\Box PQRS)x + A(\Box PQRS) = 0$. Basic proof of quadratic equation of rectangle

$$x^2 - (l_1 + b_1)x + l_1.b_1 = 0$$

$$x^2 - (b_1 + l_1)x + l_1.b_1 = 0$$

$$x^2 - b_1 x - l_1 x + l_1.b_1 = 0$$

$$x(x - b_1) - l_1(x - b_1) = 0$$

$$(x - l_1)(x - b_1) = 0$$

$$x - l_1 = 0, \quad x - b_1 = 0$$

$$x = l_1, \quad x = b_1$$

Factors of Rectangle= (l_1, b_1). In this concept factorization method of Rectangle is used to solve quadratic equation of Rectangle.This method clears, when area and side measurement of Rectangle are given and to find length and width of Rectangle in first quadrant.

In short:

i) Concept of factorization method of Rectangle in first quadrant

Side measurement of Rectangle	–	$(l_1 + b_1) = B(\square PQRS)$
Area of Rectangle	–	$l_1.b_1 = A(\square PQRS)$
Basic formula of factorization method of Rectangle in first quadrant	–	$x^2 - B(\square PQRS)x + A(\square PQRS) = 0$
Factors of Rectangle	–	(l_1, b_1)

ii) Concept of factorization method of Rectangle in second quadrant

Side measurement of Rectangle	–	$(b_1 - l_1) = B(\square PQRS)$
Area of Rectangle	–	$-(l_1.b_1) = A(\square PQRS)$
Basic formula of factorization method of Rectangle	–	$x^2 - B(\square PQRS)x - A(\square PQRS) = 0$
Factors of Rectangle	–	$\{-l_1.b_1\}$

$x^2 - (b_1 - l_1)x - l_1.b_1 = 0$

iii) Concept of factorization method of Rectangle in third quadrant

Side measurement of Rectangle	–	$-(l_1 + b_1) = B(\square PQRS)$
Area of Rectangle	–	$(l_1.b_1) = A(\square PQRS)$
Basic formula of factorization method of Rectangle	–	$x^2 - B(\square PQRS)x + A(\square PQRS) = 0$
Factors of Rectangle	–	$\{-l_1. - b_1\}$

$x^2 + (l_1 + b_1)x + l_1.b_1 = 0$

iv) Concept of factorization method of Rectangle in forth quadrant

Side measurement of Rectangle	–	$(l_1 - b_1) = B(\square PQRS)$
Area of Rectangle	–	$-(l_1.b_1) = A(\square PQRS)$
Basic formula of factorization method of Rectangle	–	$x^2 - B(\square PQRS)x + A(\square PQRS) = 0$
Factors of Rectangle	–	$\{l_1. - b_1\}$

$x^2 - (l_1 - b_1)x - l_1.b_1 = 0$

2.3. Coefficient relation of rectangle

$x^2 - bx + d = 0$ is basic proof of quadratic equation of rectangle. Inside it coefficient of x^2 is 1. That mean area of rectangle is $A(\square PQRS)$ which is indicated with letter 'd'and side measurement $B(\square PQRS)$ which is indicated with letter 'b'. At this time that rectangle length l_1 and width b_1 respectively. If we change the length and width of rectangle in ratio 1:1, then coefficient of x^2 i.e. a is created and multiplication of a^2 & c is the area i.e. 'd'. Now the new coefficient relation of factorization method of rectangle is explained below.

i) Relation : Proof of Coefficient relation of rectangle

Known information:

In $\square PQRS$, $a = 1$ and quadratic equation of rectangle is, $x^2 - B(\square PQRS)x + A(\square PQRS) = 0$. In this equation length and width of rectangle is l_1 and b_1. But, when $\square PQRS$ is converted in the form of $\square PQ'R'S'$ where $a \neq 1$, then length and width of that rectangle is l_1/a and b_1/a. With the help of this equation, length and width of rectangle change in equal ratio, then changes occurred in their area are explained in this coefficient relation of rectangle

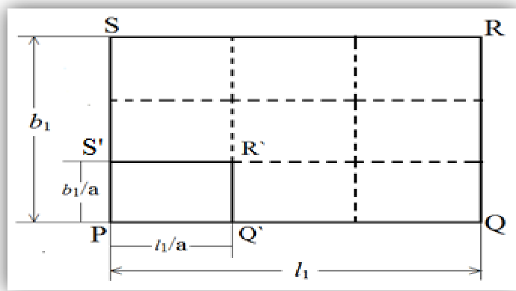

Figure 3. **Coefficient relation of rectangle**

To prove : $\frac{A(\square PQRS)}{A(\square PQ'R'S')} = a^2$

Proof : In rectangle $\square PQRS$,

$$A(\square PQRS) = l_1.b_1 \tag{1}$$

In rectangle $\square PQ'R'S'$,

$$A(\square PQ'R'S') = \frac{l_1}{a}.\frac{b_1}{a} \tag{2}$$

$$\frac{A(\square PQRS)}{A(\square PQ'R'S')} = \frac{l_1 b_1}{\left[\frac{l_1}{a}.\frac{b_1}{a}\right]} \text{ from equation (1) and (2)}$$
$$\frac{A(\square PQRS)}{A(\square PQ'R'S')} = a^2$$

This formula clears if the change in length and width happens in equal ratio and Side measurement of rectangle in equation no changed then we can find change in area with the help of this formula .

ii) Concept of coefficient relation in quadratic equation of rectangle

Coefficient relation of Rectangle, cleared that $A(\square PQRS) = a^2.A((\square PQ'R'S') = d$. So now quadratic equation Rectangle explained as, $a.x^2 - B(\square PQRS)x + a.A(\square PQ'R'S') = 0$. Inside this equation, coefficient of $x^2 = a$, coefficient of $x = b$, and constant = c. i.e. When quadratic equation of rectangle explained then its explanation given in the form of, $ax^2 - bx + a.c' = 0$.

Part of 'a' in quadratic equation of rectangle - Inside $ax^2 - bx + a.c' = 0$, a is "Area coefficient of rectangle" which is has coefficient of x^2.

Area coefficient of rectangle: Area coefficient of rectangle is defined as, a real number which indicate that length and width of rectangle is divided in how many equal parts in equal ratio.

Part of 'b' in quadratic equation of rectangle - In $ax^2 - bx + a.c' = 0$, b is coefficient of x and its value b is $B(\square PQRS)$ i.e. Side measurement.

Part of 'c' in quadratic equation of rectangle - Inside $ax^2 - bx + a.c' = 0$, a.c' is constant of the quadratic equation of Rectangle. Here $a^2.c' = A(\square PQRS) = d$. Area of Rectangle is made up from multiplication of coefficient of x^2 and constant of equation .i.e. $a.c' = c$.

In this quadratic equation a=1, then constant is indicated area of Rectangle $A(\square PQRS)$, at that time length and width of Rectangle is l_1 and b_1. But if $a\square 1$ then length and width of Rectangle is b/a and h/a. Here, $A(\square PQRS) = l_1.b_1 = a^2.c = a^2 x A(\square PQ'R'S') = d$.

$x^2 - bx + d = 0$ is main proof of quadratic equation rectangle. At this time 1 is a coefficient of x^2. i.e. area and Side measurement of rectangle is d i.e. $A(\square PQRS)$ and b i.e. $B(\square PQRS)$. In this condition length and width of rectangle is l_1 and b_1. Now this length and width incrigeous and decrigeous then coefficient of x^2 is a and divided by c to a. Now become quadratic equation of rectangle is a $x^2 - bx + c = 0$, here $a \neq 1$, $b = B(\square PQRS)$ and $c = a.c'$ is constant.

Think it over : If Area of rectangle is $c[A(\square PQRS)]$ and side measurement $b[B(\square PQRS)]$ at that time value of a is 1. As,

$$\begin{aligned} A(\square PQRS) &= a^2 \times c' \\ &= a^2 \times A(\square PQ'R'S') \\ &= a \times a \times A(\square PQ'R'S') \\ &= a \times c \ \text{ but}, a = 1 \\ &= dc = d \ \ (a = 1) \\ &= A(\square PQRS) = l_1.b_1 \end{aligned}$$

iii) Proof of coefficient relation of factorization method in quadratic equation of rectangle

Known information : Quadratic equation of rectangle is $ax^2 - bx + c = 0$. $a \neq 1$, $b = B(\square PQRS)$, $c =$ constant

To prove : $ax^2 - bx + c = 0$

Proof : In rectangle $\square PQRS$, $x^2 - bx + d = 0$ Concept of quadratic equation of rectangle

$$\begin{aligned} x^2 - B(\square PQRS)x + A(\square PQRS) &= 0 \\ A(\square PQRS) &= A(\square PQ'R'S').a^2 \quad \text{Proof of Coefficient relation of rectangle} \\ x^2 - B(\square PQRS)x + A(\square PQ'R'S').a^2 &= 0 \ldots a \neq 1 \\ x^2 - bx + c'.a^2 &= 0 \\ ax^2 - bx + c'.a &= 0 \\ ax^2 - bx + c &= 0 \end{aligned}$$

Hence, we are proof that coefficient relation of factorization method in quadratic equation of rectangle. In this proof explained that when coefficient of x^2 is 'a' then a is cleared that length and width of rectangle is l_1/a and b_1/a. At that time area of rectangle $A(\square PQ'R'S')$ is $l_1.b_1/a^2$.

II) Concept of completing square method of rectangle

If critical to find length and width with factorization method of rectangle. At that time we can easy to find length and width with the help of completing square method of rectangle. Now we are study about completing square method of rectangle.

2.4. Basic proof of completing square method in quadratic equation of rectangle

Known information : In $\square PQRS$,

Side measurement of $\square PQRS = B(\square PQRS)$.

Area of $\square PQRS = A(\square PQRS)$,

$A = 1$, $b = B(\square PQRS) = (l_1 + b_1)$, $d = A(\square PQRS) = l_1.b_1$

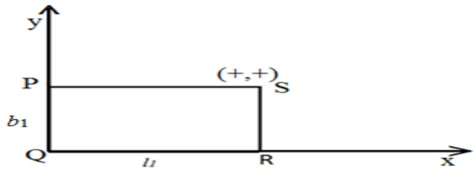

Figure 4. **Completing square method in quadratic equation of rectangle**

To prove : $\left[x - \frac{B(\square PQRS)}{2}\right]^2 = \frac{[B(\square PQRS)2 - 4A(\square PQRS)]}{4}$

Proof : $x^2 - B(\square PQRS)x + A(\square PQRS) = 0$. Basic proof of quadratic equation method of rectangle

$$x^2 - B(\square PQRS)x = -A(\square PQRS) \tag{3}$$

$$\begin{aligned}\text{Third term} &= \left[\frac{1}{2}x \ \text{ coefficient of } \ x\right]^2 \\ &= [\frac{1}{2}x - B(\square PQRS)]^2 \\ &= \frac{[B(\square PQRS)]^2}{4}\end{aligned}$$

Add the $\frac{[B(\square PQRS)]^2}{4}$ in both sides of equation (3),

$$\begin{aligned}x^2 - B(\square PQRS)x + \frac{[B(\square PQRS)]^2}{4} &= \frac{[B(\square PQRS)]^2}{4} - A(\square PQRS) \\ \left[x - \frac{B(\square PQRS)}{2}\right]^2 &= \frac{[B(\square PQRS)]^2 - 4A(\square PQRS)}{4}.\end{aligned}$$

Hence we are proof Basic proof of completing square method in quadratic equation of rectangle.

Now with the help of this proof we are try to understand length and width in each quadrant when we are know the area and Side measurement of rectangle.

In this equation, value of a is 1 ,that‘s mean area of rectangle is d. Now value of a is $a \neq 1$, then quadratic equation reference is a $x^2 - bx + c = 0$, here $a \neq 1$, $b = B(\square PQRS)$ and $c = a.c'$ is constant. So Basic proof of completing square method of rectangle explain as below.

$$\begin{aligned}\left[x - \frac{B(\square PQRS)}{2}\right]^2 &= \frac{[B(\square PQRS)]^2 - 4A(\square PQRS)}{4} \\ A(\square PQRS) &= A(\square PQ'R'S').a^2. \text{ Proof of Coefficient relation of rectangle} \\ \left[x - \frac{B(\square PQRS)}{2}\right]^2 &= \frac{[B(\square PQRS)]^2 - 4.a^2.A(PQ'R'S')}{4}\end{aligned}$$

Now we are find coefficient relation in completing square method in quadratic equation of rectangle.

2.5. Proof of quadratic equation of Seg-rectangle

In a quadratic equation of Rectangle, if the width of Seg- area Rectangle is zero then length is equal to side-measurement of Rectangle.

Known information : In $\square PQ - RS$, $b = 0$

$A(\square PQ - RS) = 0$ and $B(\square PQ - RS) = 2l$

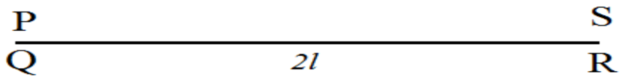

Figure 5. **Quadratic equation of Seg-rectangle**

To prove : $x^2 - B(\square PQ - RS)x = 0$ is zero rectangle equation

Proof : In $\square PQ - RS$,

$$x^2 - B(\square PQ - RS)x + A(\square PQRS) = 0. \text{ Basic proof of factorization method of rectangle}$$

$$x^2 - (l_1 + b_1)x + 0 = 0$$

$$x^2 - (2l)x = 0. \text{ Given}$$

$$x(x - 2l) = 0$$

$$x - 2l = 0, x = 0$$

$$x = 2l, x = 0$$

Hence we have proof that, quadratic equation of Seg-rectangle. In this equation, width of rectangle is zero i.e length of rectangle is $2l$. Here equation is gives support to seg-rectangle theorem. Hence this equation is called quadratic equation of seg-rectangle. So that $x^2 - B(\square PQ - RS)x = 0$ is zero rectangle quadratic equation

III) Concept of formula method of rectangle

Formula method of rectangle is a one of a great concept, to find length and width of rectangle. Area and side measurement of rectangle known then with the help of that equation we can be find length and width of rectangle. So we are proof formula method of rectangle. This method through length and width explained as below

2.6. Proof of formula method of rectangle

Known information : In, $\square PQRS$, Side measurement of $\square PQRS = B(\square PQRS)$, Area of $\square PQRS = A(\square PQRS)$, $a = 1$, $b = B(\square PQRS)$, $d = A(\square PQRS)$

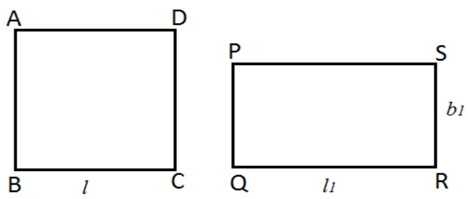

Figure 6. **Formula method of rectangle**

To prove : $x = \frac{B(\square PQRS) \pm \sqrt{B(\square PQRS)^2 - 4A(\square PQRS)}}{2a}$

Proof : In $\square PQRS$,

$$ax^2 - bx + c = 0$$

$$ax^2 - B(\square PQRS)x + a.A(\square PQ'R'S') = 0$$

$$ax^2 - B(\square PQRS)x = -a.A(\square PQ'R'S') \quad (4)$$

Divided both sides of equation (4) by a . . . $(a \neq 1)$

$$x^2 - \frac{A(PQRS)}{a}x = -\frac{a.A(PQ'R'S')}{a}$$

$$x^2 - \frac{A(PQRS)}{a}x = -A(\square PQ'R'S') \tag{5}$$

$$\begin{aligned} \text{Third term} &= \left[\frac{1}{2} \text{ x coefficient x}\right]^2 \\ &= \left[\frac{1}{2}x - \frac{B(\square PQRS)}{a}\right]^2 \\ &= \frac{B(PQRS)^2}{4a^2} \end{aligned}$$

Both sides of equation (4) added by $\frac{B(\square PQRS)^2}{4a^2}$

$$\begin{aligned} x^2 - \frac{B(\square PQRS)}{a}x + \frac{B(\square PQRS)^2}{4a^2} &= \frac{B(\square PQRS)^2}{4a^2} - A(\square PQ'R'S') \\ x^2 - 2\frac{B(\square PQRS)}{2a}x + \frac{B(\square PQRS)^2}{4a^2} &= \frac{B(\square PQRS)^2}{4a^2} - \frac{4a^2.A(PQ'R'S')}{4a^2} \\ \left[x - \frac{B(\square PQRS)}{2a}\right]^2 &= \frac{B(\square PQRS)^2 - 4a^2.A(PQ'R'S')}{4a^2} \\ \left[x - \frac{B(\square PQRS)}{2a}\right] &= \pm\frac{\sqrt{B(\square PQRS)^2 - 4a^2.A(PQ'R'S')}}{2a} \\ \ldots A(\square PQRS) &= a^2.A(\square PQ'R'S') = d \\ x &= \frac{B(\square PQRS)}{2a} \pm \frac{\sqrt{B(\square PQRS)^2 - 4.A(\square PQRS)}}{2a} \\ x &= \frac{B(\square PQRS) \pm \sqrt{B(\square PQRS)^2 - 4.A(\square PQRS)}}{2a} \end{aligned}$$

Hence we are proof that formula method of rectangle. Length and width of rectangle outcomes form quadratic equation of rectangle which explain as bellow

$$\begin{aligned} l_1 &= \frac{B(PQRS) + \sqrt{B(PQRS)^2 - 4A(PQRS)}}{2a} \\ b_1 &= \frac{B(PQRS) - \sqrt{B(PQRS)^2 - 4A(PQRS)}}{2a} \end{aligned}$$

This method explain that, we are know area and side measurement of rectangle then we can be find length and width of rectangle with the help of this quadratic equation. But here value of a is 1, that's means area of rectangle is $c = (\square PQRS)$. But when $a \neq 1$ then formula method explained as below.

$$\begin{aligned} x &= \frac{B(\square PQRS) \pm \sqrt{B(\square PQRS)^2 - 4.A(\square PQRS)}}{2a} \\ \frac{A(\square PQRS)}{A(\square PQ'R'S')} &= a^2 \\ A(\square PQRS) &= a^2 \times A(\square PQ'R'S') \\ x &= \frac{B(\square PQRS) \pm \sqrt{B(\square PQRS)^2 - 4.a^2.A(PQ'R'S')}}{2a} \end{aligned}$$

This formula is used to find length and width of rectangle so that this formula is also known as proof of coefficient relation in formula method of rectangle. As formula method of rectangle outcomes length and width is bellow.

$$\begin{aligned} l_1 &= \frac{B(PQRS) + \sqrt{B(PQRS)^2 - 4A(PQRS)}}{2a} \\ b_1 &= \frac{B(PQRS) - \sqrt{B(PQRS)^2 - 4A(PQRS)}}{2a} \end{aligned}$$

3. Conclusion

Quadratic equation of rectangle (Relation All Mathematics) this research article conclude that relation of area and Side measurement of rectangle with the form of quadratic equation.

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